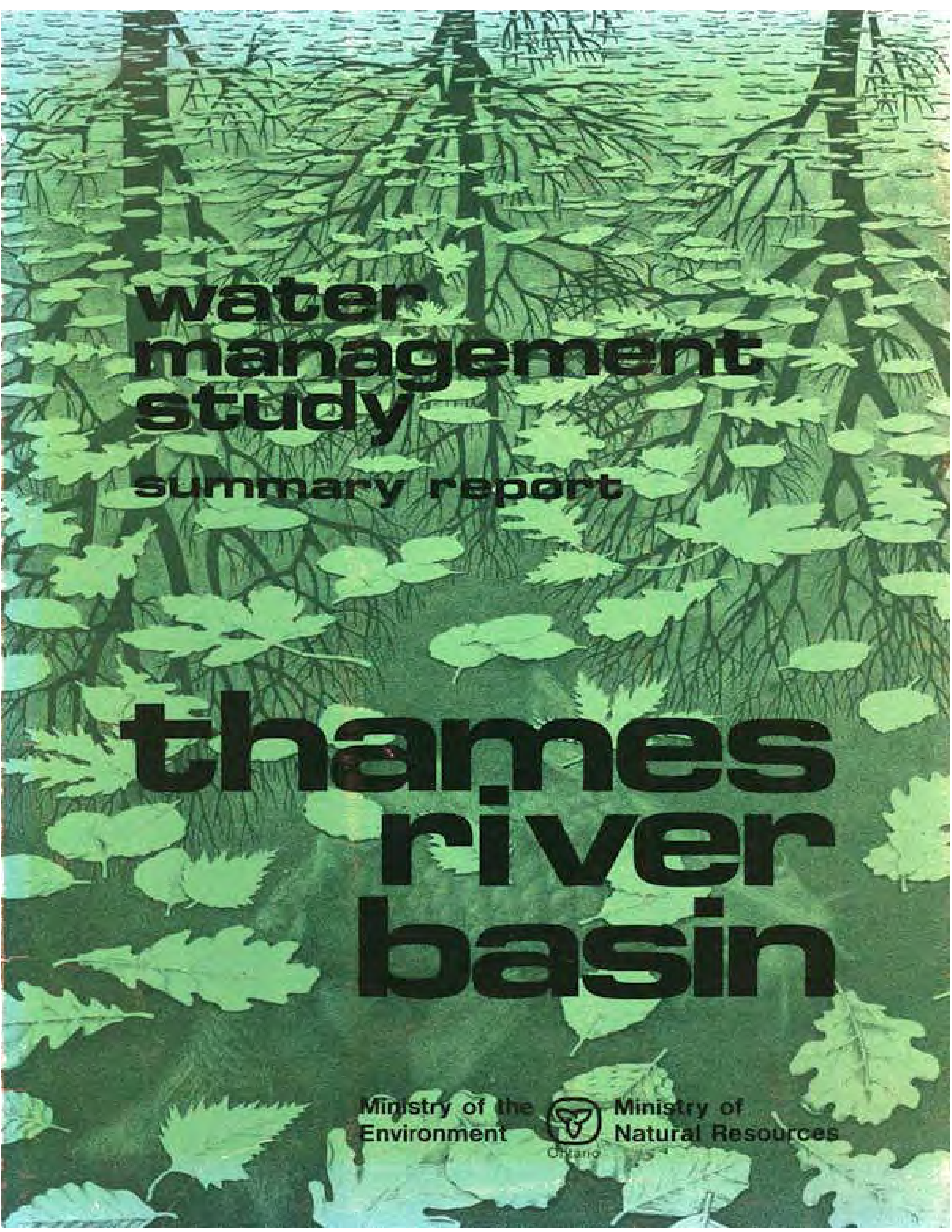

water management study

summary report

thames river basin

Ministry of the Environment

Ontario

Ministry of Natural Resources

WATER MANAGEMENT STUDY

SUMMARY REPORT

THAMES RIVER BASIN

Ministry of the Environment

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TORONTO ONTARIO

1975

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FOREWORD

This summary report describes the nature and objectives of the Thames River basin water management study, summarizes the water resource problems encountered in the study area, and presents options and proposals for water management in the Thames River basin.

A description of the geographical and water resource characteristics of the watershed and a more detailed discussion of the study findings and conclusions are available in the full length report. Also to be published as part of the study findings are several technical reports presenting detailed results of individual studies conducted by the study team. These, it was felt, would be useful as support documents for those who wish to delve more deeply into any one aspect of the Thames basin water management. The Table of Contents for the full length report can be found in Appendix A.

Map 1. Location and extent of the Thames River basin.

INTRODUCTION

This report presents the findings of the Thames River basin water management study, undertaken jointly by the Ontario ministries of the Environment and Natural Resources. The study was initiated in response to growing concern over existing problems relating to water quality, flooding and erosion in the watershed, and over potential problems anticipated as a result of future population growth and economic development.

The Thames River basin is the second largest in Southwestern Ontario (Map 1), and drains an area of approximately 2,250 square miles. Its total length from the source of the North Thames River to Lake St. Clair is approximately 125 miles. Major water uses in the basin include water supply for agricultural, domestic, municipal and industrial purposes; waste disposal and assimilation; recreation, and fish and wildlife habitat. Inherent conflicts among these uses are prevalent in the basin. Moreover, proposed solutions to the problems may themselves create additional conflicts.

BACKGROUND

Extensive studies of water resource problems in the Thames watershed have been carried out by the Conservation Authorities Branch for the Upper Thames River Conservation Authority (UTRCA) and the Lower Thames Valley Conservation Authority (LTVCA), established in 1947 and 1961 respectively. A major flood control program was undertaken involving the construction of dams and channel improvements, which, together with the existing dike system along the river, provided a partial solution to the flooding problems.

Since its creation in 1957, the Ontario Water Resources Commission, (now a part of the Ministry of the Environment), has been actively involved in water supply and pollution control programs in the basin. As population growth in the watershed continued, the surface and ground water supplies of the basin became inadequate to meet municipal water requirements and major water supply pipelines were developed. Extensive construction of municipal sewage treatment plants was also undertaken. The Ministry of Natural Resources has been extensively involved in fish, wildlife and forestry resource management in the basin.

However, a variety of water management problems remained to be resolved. In several reaches of the river, water uses such as recreation and water supply were significantly curtailed because of stream water quality degradation. Additional water quality problems due to the continued growth of municipalities were foreseen. Flooding continued to be a problem at several locations in the basin. Record high water levels in the Great Lakes aggravated existing erosion problems.

The conservation authorities and local and provincial governments all undertook studies of the continuing water resource problems facing the basin. However, it became apparent that resolution of these complex, inter-related problems required a co-ordinated, interdisciplinary effort. As a result, in early 1972, the Ontario ministries of the Environment and Natural Resources launched a detailed study of the Thames River System.

In order to develop effective and realistic water management guidelines, a detailed, comprehensive study has been undertaken. This involved an assessment of the availability and quality of both surface and ground water, an inventory of water uses and related land uses, and an evaluation of existing and potential water resource problems in the basin. This information was used to select and evaluate water management alternatives on which recommended water management guidelines are based.

One feature of the study is the extensive use of mathematical modelling in the evaluation of waste treatment and reservoir alternatives with regard to the effect on water quality parameters and flood control benefits.

Another feature of the study is the Public Consultation Program (PCP), designed to provide municipal officials and the residents of the basin with an opportunity to express their views concerning the management of their water resources. During the first phase of the PCP, interviews and meetings were held with municipal officials and a variety of interest groups. Phase 2 involved a series of ten meetings in five municipalities held under the auspices of the Environmental Hearing Board.

This report summarizes the findings of the study and outlines recommended courses of action for water management in the Thames River basin. More detailed information concerning the study can be found in the main report, and in technical reports to be published on such topics as water quality data, hydrologic data, water uses, mathematical models, and the Public Consultation Program.

Two aspects of the report should be noted. First, the planning horizon to which the conclusions and recommendations herein are directed is the year 2001. Factors arising beyond this period which may affect present day decisions, for example, a change in population growth and distribution patterns, are too far in the future to be predicted with any degree of accuracy.

Secondly, it should be noted that this is a water management study, which has considered land use planning, urban population and industrial growth from a water management point of view. Several other provincial ministries and agencies, including Treasury, Economics and Intergovernmental Affairs, Transportation and Communications, Housing, Hydro, and Agriculture and Food are also concerned with land use, population and industrial development planning.

Nevertheless, the water resources of the basin are now well defined and their limitations are known. If the objectives of good water quality and adequate flood control are to be met, then the conclusions and recommendations in this report can be considered to form a basis for further planning in the Thames River basin.

STREAM TERMINOLOGY

In this report, the names of streams in the Thames River basin as designated by the Geographic Names Board have been followed. As this terminology does not always coincide with local usage, particularly upstream from London, the following points should be noted (Map 2).

Above London, the channel which flows through Dorchester, Ingersoll and Woodstock is called the Thames River. The stream on which Mitchell, St. Marys and the Fanshawe Reservoir are located is called the North Thames River. The stream on which Thamesford is located is designated as the Middle Thames River.

CHAPTER 1

SUMMARY AND RECOMMENDATIONS

The two main water management problems in the Thames River basin are water quality impairment and flooding. Impairment of surface water quality is primarily caused by excessive inputs of nutrients, oxygen consuming materials, bacteria and suspended solids. Major urban sources of these contaminants include sewage treatment plant effluent, storm and combined sewer discharges and runoff from urban areas. Municipal drains, field tile systems, surface runoff from fertilized fields, drainage from intensive feedlots, treated effluent from rural industries, and the free access of cattle to streams are major rural sources of water quality impairment. Excessive aquatic plant growth and unpleasant aesthetic conditions are the most visible signs of water quality impairment; however, the less visible problems of low dissolved oxygen levels and high bacteria levels are also significant. This impairment has led to the curtailment or restriction of legitimate water uses in the watershed. Most severely affected by this impairment are fish and aquatic life and recreational water uses.

Recurrent flooding is the other most significant problem in the watershed, particularly in St. Marys, Woodstock, London, and the area from Thamesville through Chatham to Lake St. Clair. Average annual flood damages in the watershed were calculated to be over 1.5 million 1975 dollars, of which 57 percent is in Chatham and 20 percent in the vicinity of London. Related in part to flooding is erosion of streambanks and dikes, primarily in the lower watershed. Erosion of topsoil is also a significant problem.

The inadequacy of water-based recreational facilities to meet demands and the potential loss of prime agricultural land were also identified as problems common to the watershed. Other water management problems of local importance include negative effects of artificial land drainage, water supply interference and ground water quality impairment. Communication and co-ordination problems were also noted.

In order to develop effective courses of action to resolve these problems, water management objectives were developed and alternative courses of action were evaluated. With respect to water quality objectives, it was concluded that the short term objective should be to maintain existing water quality where it is satisfactory for fish and aquatic life and recreation, and to improve quality to this level where it is presently degraded. The long term objective is to upgrade water quality as much as possible in order to enhance conditions for fish and aquatic life, as well as to maximize other beneficial water uses. Dissolved oxygen criteria and other specific water quality criteria which would allow this objective to be met were developed.

It was concluded that flood control in the basin would require the construction of one or more large dams, and a detailed flood control benefit-cost analysis of proposed major dams was carried out. Moreover, as flood control and water quality improvement options are closely interrelated, various combinations of the proposed reservoirs and waste management options were examined in a systems context.

As provincial studies of both the Lake Erie and Southwestern Ontario regions recognized London to be a major growth centre, and recommended it continue in that role, one objective was to develop a water management plan which would allow London to expand to its projected 2001 population while maintaining satisfactory stream water quality. This will also allow for the re-direction to London of population growth from other areas of the watershed where the capacity of resources to sustain growth will be reached within the planning horizon.

However, it is recognized that a variety of other considerations must be taken into account in determining the most desirable distribution of growth. Population projections based on official plans and 1961-71 trends, giving a 2001 population of 500,000 at London, were used in evaluating water management options. However, a significantly lower growth rate, such as a recent TEIGA estimate of a 2001 population at London of 338,000 to 350,000, would fundamentally alter the evaluation of options. Thus, options which would meet water quality objectives at lower projected populations were also considered. On this basis, the major waste management options available to. the City of London were reduced to: tertiary treatment (to stream quality effluent); diversion of sewage by pipeline to Lake Erie; or the operation of the Glengowan dam, primarily for flow augmentation, with the continued use of conventional sewage treatment.

The proposed reservoirs and the sewage treatment options for London were then evaluated in system configurations. The primary evaluation criteria for this analysis were flood control benefit-cost ratios and the total system net cost in present value terms. Twenty-two system options were evaluated in detail. The next analytical stage involved evaluation of non-quantifiable factors such as recreation and environmental effects of capital works. Additional objectives utilized at this stage were: to minimize both the loss of prime agricultural land and environmental disturbance due to capital construction projects, especially dams; and to increase water-based recreational facilities in the basin.

When all these factors had been considered, it was concluded that the preferred option is to construct the Thamesford dam primarily for flood control, the Glengowan dam primarily for flow augmentation, and to utilize conventional treatment at London. However, if it is decided that development of a limestone deposit precludes construction of the Thamesford dam, the preferred option is to construct the Wardsville dam for flood control, the Glengowan dam primarily for flow augmentation, and to utilize conventional treatment at London. If the growth limitation of 480,000 for London associated with this option is decided to be unacceptable, then other options, such as provision of tertiary treatment or construction of a sewage pipeline to Lake Erie can be considered.

As the Glengowan dam is common to each of the preferred options, construction of the Glengowan dam first would offer maximum flexibility in choosing other capital construction projects. Decisions as to whether to construct the Wardsville dam or the Thamesford dam could then be made. The decision as to whether to utilize conventional treatment or eventually a sewage pipeline from London to Lake Erie could be deferred to the early 1990's. **Accordingly, it is recommended that the Glengowan dam should be constructed first, for the primary purpose of flow augmentation. Furthermore, a study should be made of what type and level of recreational use, if any, could be provided at the reservoir.**

...Recommendation no. 1

It is further recommended that the Upper Thames River Conservation Authority and the Ministry of Natural Resources investigate in detail, as soon as possible, the question of the limestone deposit at the Thamesford dam site to determine the opportunity cost associated with its development, so that a decision can be made as to the feasibility of constructing the Thamesford dam.

...Recommendation no. 2

If construction of the Thamesford dam is feasible, then the Thamesford dam should be built primarily for flood control purposes. Furthermore, a study should be made of the desirable level of recreational use of the reservoir, ensuring that such use would not seriously constrain the primary use of the reservoir.

...Recommendation no. 3

If construction of the Thamesford dam is not feasible, then the Wardsville dam should be constructed for flood control purposes only. A flow retarding structure rather than a conventional dam should be constructed to minimize the loss of agricultural land and to protect the yellow pickerel runs and spawning grounds. Detailed studies should be undertaken to ensure the design will permit the safe passage offish, and to determine on a benefit-cost basis whether a 43,000 acre-foot or a larger retarding structure is the more economical. The environmental effects and the effects on road communications of the larger versus the smaller structure should be considered. There should also be close consultation with Indian bands concerning the effects on reservation lands.

...Recommendation no. 4

Prior to construction of any major dam, detailed studies should be undertaken to examine environmental effects, to determine methods of minimizing such effects, and to determine what type of discharge structure and operating practices would best protect both reservoir and downstream water quality.

...Recommendation no. 5

As noted above, implementation of any one of the preferred options allows deferral for several years of a decision by the City of London as to whether to continue discharging treated sewage to the Thames River or to utilize a sewage diversion pipeline to Lake Erie. **Accordingly, the City of London should immediately institute plans to upgrade its sewage treatment facilities to meet the waste loading guidelines outlined in this report. Specifically, this involves providing an effluent from all treatment plants equivalent in quality to the effluent from the Greenway sewage treatment plant as defined in this report.**

...Recommendation no. 6

Although the major options have great significance to basin wide water management, they by no means deal with all the basin's water resource problems. Local water management problems can have a cumulative effect, so that a localized type of problem, recurring at several different locations, can have basin wide implications. A wide range of management options to deal with urban, rural, reservoir-related and flooding problems has been considered and applied on a stream reach and municipality basis.

Urban oriented options include varying levels of treatment of sewage and industrial wastes, and growth restrictions. In areas where the remaining waste assimilative capacity of streams is limited, municipalities proposing additional growth can consider the installation of advanced tertiary waste treatment plants producing a highly polished effluent equivalent to stream water quality, or waste storage for summer spray irrigation or discharge during periods of adequate flow. However, for smaller municipalities, the costs of the required tertiary treatment may be prohibitive. Moreover, the costs of property acquisition for waste storage can make this uneconomical and this approach often involves the use of prime agricultural land. The alternative to the above treatment options is growth restrictions. **At several municipalities in the basin, the waste assimilative capacity of the receiving stream has been reached or exceeded. Accordingly, it is recommended that the municipalities of Mitchell, Stratford, Tavistock, Glencoe, Tilbury and Ridgetown should not increase their waste loadings from all sources to the receiving stream, and in some cases should reduce these loadings, as described in chapter 8 of this report.**

...Recommendation no. 7

Receiving streams at other municipalities in the basin have varying capacities to assimilate additional waste loadings. The additional assimilative capacity at the municipalities of Woodstock, Beachville, Ingersoll and Lambeth is limited and long term growth would be inadvisable from a water quality viewpoint. At the municipalities of Dorchester, St. Marys, Bothwell, Thamesville, and Chatham the additional waste assimilative capacity is not as limited. **Accordingly, these municipalities should adopt sewage treatment techniques selected from approved options as described in this report, either to provide immediately required upgrading or to accommodate additional growth if such growth is found to be desirable when other factors are considered.**

...Recommendation no. 8

Control of urban runoff is an important consideration in the basin. Although the significance of pollution loads from this source at each municipality was not documented during this study, urban runoff is recognized as a source of stream impairment. **Thus, all municipalities should immediately undertake studies to determine the significance of existing urban runoff and runoff associated with future development as a source of pollutants, and take steps to control this waste input where it is found to constitute a water quality problem.**

...Recommendation no. 9

Most industries in the basin lie within municipal boundaries and discharge wastes and non-polluted process waters to municipal sanitary and storm sewage systems respectively. Most municipalities have enacted sewer use bylaws to control the volumes and strength of these wastes in order to prevent polluting materials from gaining direct access to watercourses. **It is recommended that all affected municipalities enact and enforce sewer use bylaws to prevent industrial pollution problems. Industries discharging treated wastes and process waters directly to watercourses in the basin should implement waste treatment necessary to meet water quality objectives as outlined in this report.**

...Recommendation no. 10

Rural oriented management practices for water quality improvement include limiting fertilizer application rates, channel protection programs, restricting free access of cattle to streams, control of farm waste discharges, particularly from intensive feedlot operations, and control of illegal septic tank connections to drains. Surface runoff to streams from fertilized land is a significant diffuse source of nutrients which contribute to excessive aquatic weed growth. Although accurate statistical information is not available, fertilization of cropland beyond recommended rates was found to be a general practice in the basin. **It is therefore recommended that fertilizer application rates be limited to those recommended by the Ontario Ministry of Agriculture and Food, using services such as those at the University of Guelph for determining appropriate rates. Individual and group activity by the agricultural community and the active support of government agencies is important to implement this practice.**

...Recommendation no. 11

A program of restricting free access of livestock to streams should be commenced. It is recommended that the Ontario Department of Agriculture and Food take the lead role in undertaking detailed study of the implications of such a program to farmers, of the best methods such as fencing or vegetative barriers, and of the feasibility of provincial subsidies to encourage such a program.

...Recommendation no.12

It is recommended that increased environmental surveillance and enforcement be undertaken by appropriate government agencies to control farm waste discharges, particularly from intensive feedlot operations, and illegal septic tank connections to municipal drains.

...Recommendation no. 13

It is recommended that channel protection programs as described in this report be implemented, with initial emphasis on areas of greatest need which should be identified in detail by appropriate government agencies.

...Recommendation no. 14

Recommendations 11 to 14 are generally relevant to the entire watershed; however, particular attention is drawn to headwater areas, where the need to maintain streamflows at the best possible quality and quantity is especially important. Any lessening of flows and stream quality in these areas will aggravate downstream problems. **Rural oriented management practices and conservation practices should be applied with special rigor in headwater areas, and municipalities in these areas must pay special attention to sewage disposal practices to safeguard both local and downstream water uses.**

...Recommendation no.15

It is recommended that resolution of water quality problems in existing reservoirs be achieved by the two conservation authorities through appropriate combinations of bottom draw, destratification, algae control, disinfection of swimming areas, or modified operating policies as outlined in this report for each reservoir.

...Recommendation no. 16

In evaluating water management options, the assumption was made that, as specified in operation manuals, discharges from Wildwood and Pittock reservoirs would be maintained at minimum rates of 40 cfs and 15 cfs respectively for flow augmentation, and that Fanshawe Dam would be operated on a flow- through basis during low flow periods. An analysis of historical flow data indicated that these rates of flow have generally been maintained on a monthly basis, but that on a daily basis, flows have been less than specified for significant periods. **Accordingly, it is recommended that these reservoirs be operated in such a manner as to ensure the maintenance of the specified minimum flows on a daily basis. It is also recommended that there be close liaison between the Ministry of Natural Resources and the Ministry of the Environment to ascertain if alterations to these operating schedules would optimize the use of existing reservoirs for flow augmentation, without adversely affecting other uses.**

...Recommendation no. 17

Water based recreation relates largely to existing and proposed reservoirs. Improved water quality will enhance recreational use of streams, but this use is restricted by limited public access. Although a significant increase in recreational use of existing reservoirs is not practical without jeopardizing their primary use for flood control and flow augmentation**, it is recommended that the Upper Thames River Conservation Authority and the Ministry of Natural Resources undertake a detailed computer analysis to determine what modifications of reservoir operating practices would optimize their flood control and flow augmentation use and enhance their recreational use potential.**

...Recommendation no. 18

Channel erosion problems in the lower watershed below Chatham are presently the subject of a $7 million streambank and dike stabilization and rehabilitation project. **It is recommended that a program of corrective action concerning bank erosion from Chatham, upstream as far as Delaware, should be initiated by the Lower Thames Valley Conservation Authority in line with the recommendations in the 1971 report by James F. MacLaren Limited entitled "Flood And Erosion Control Works On The Lower Thames River From Chatham To Delaware".**

...Recommendation no. 19

Soil erosion control programs including strip cropping, crop rotation, diversion terraces, grassed waterways and vegetative buffer zones or reforestation should be implemented throughout the watershed, with initial emphasis on areas that should be identified by staff of the Ministries of Agriculture and Food, Natural Resources, and Environment.

...Recommendation no. 20

It is recommended that environmental impact assessments of land drainage proposals be undertaken to screen out or modify proposals which would damage the environment and that selected wetlands of ecological importance, such as the Zorra swamp, be protected from further drainage.

...Recommendation no. 21

Prevention of water supply interference and ground water quality impairment, rather than remedial action after the problem has occurred, should be practised using procedures detailed in chapter 7 of this report.

...Recommendation no. 22

To overcome communication and co-ordination problems relating to water management in the basin, and to implement planning on a watershed basis, a joint committee of government agencies and other appropriate bodies should be established. The committee should include representatives of the Ministries of Agriculture and Food, Environment, Housing, Natural Resources, and Treasury, Economics and Intergovernmental Affairs, the two conservation authorities, municipalities, citizen groups and the agricultural community.

...Recommendation no. 23

Another aspect of communication and co-ordination, raised during the Public Consultation Program, related to the division of the watershed into two conservation authorities, **because of the interrelationships of water resource problems and solutions in the upper and lower watershed, and in order to further the basin wide approach to water management advocated in this report, it is recommended that consideration be given to the amalgamation of the Upper Thames River Conservation Authority and the Lower Thames Valley Conservation Authority into a single authority.**

...Recommendation no. 24

Regulation of new floodplain development is a vital aspect of flood control. Controls of such development have already been implemented in some areas of the watershed. **It is recommended that further controls of floodplain development under the planning act and through regulations administered by the conservation authorities be developed.**

...Recommendation no. 25

Flood warning, which can be an effective measure in reducing flood losses through temporary evacuation of people and damageable goods, requires an efficient flood warning system to be successful. **It is recommended that the Conservation Authorities Branch and The Conservation Authorities consider the development of an improved flood warning system.**

...Recommendation no. 26

For long term flood control, flow augmentation and erosion control benefits, it is recommended that sound conservation measures such as reforestation, sound agricultural tillage, use of appropriate ground cover, and preservation of water retaining areas be encouraged and implemented. Reforestation and establishment of shrub cover along streambanks should be directed to areas where they would specifically aid in erosion control, streambank stabilization, and the improvement of fish habitats.

...Recommendation no. 27

It is recommended that municipalities and government agencies encourage and enforce careful construction practices during drainage ditch installations and other construction activities in and along watercourses.

...Recommendation no. 28

It is recommended that development in areas of sand and gravel not be permitted to hinder infiltration or to degrade the quality of infiltrating water. This is particularly true of areas of municipal water supply, such as the Woodstock well field. In addition, areas providing significant baseflow such as the Harrington-Lakeside moraine should be protected.

...Recommendation no. 29

CHAPTER 2

WATER RESOURCE PROBLEMS

Several major water related problems which have long been identified in the Thames River basin led to the implementation of this study. Specifically, these are the impairment of surface water quality throughout many areas in the basin, recurrent flooding causing considerable damages, particularly in developed sections of the flood plain, and erosion of topsoil and stream and river banks. In addition to these, during the course of the study, and through the Public Consultation Program (PCP), the inadequacy of recreational facilities to meet demand and the danger of prime agricultural land being lost to production through urbanization, reservoir construction or other activities were identified as problems common to the watershed. Other problems of local importance include negative effects of artificial land drainage, water supply interference and ground water quality impairment. Major water management concerns are depicted on Map 2.

2.1 SURFACE WATER QUALITY IMPAIRMENT

Impairment of surface water quality has been identified as the major water resource problem in the watershed. Results of the PCP showed that this view is shared by the residents of the basin, and that water quality is the only concern for which there exists a basin wide consensus of opinion. Technical studies were conducted determining the sources and effects of nutrients, oxygen consuming materials, bacteria, and suspended solids in the Thames River and its tributaries resulting from activities in both urban and rural areas. A detailed study of toxic materials in surface waters was not carried out. However, problems relating to materials toxic to aquatic life do not appear to be common in the watershed nor to be chronic at specific locations.

Table 2.1 gives an indication of the type and location of surface water quality impairment in the Thames River system. These problems are most severe in summer when the combined effects of meteorological conditions (low flows, elevated temperatures, sunlight for plant growth), physical conditions (shallow waters, adequate substrate, limited shading of watercourses, lowered oxygen saturation levels), and biological conditions (excess plant growth, increased respiration of all organisms) can lead to critical stress situations for fish life.

Contaminants from both urban and rural sources contribute to these water quality problems. Bacteria dangerous to public health obtain access to the water through failing septic tanks, improper waste management of intensive livestock and poultry operations, and direct access of cattle to streams. Phosphates, nitrates and chemicals applied to soils and crops in rural areas enter the streams along with soil particles in runoff waters and through the drainage systems. Waste discharges from agricultural-related industries in rural areas are a further source of nitrogen and phosphorus inputs to streams. A study of streamflow and nutrient levels in the Thames River system indicated that 76 percent of the annual total phosphorus load and 95 percent of the total nitrogen load contributions to the watershed originated from rural sources.

Urban sources of water pollution include industrial effluents, treated sewage, and runoff waters entering the river through storm and combined sewers. Those constituents in treated sewage which are of concern include: the remaining portion of BOD_5 and suspended solids; heavy metals such as copper, zinc and lead; oil and phenolic compounds; ammonia nitrogen; free chlorine and chloramines; viruses; plant nutrients (nitrogen and phosphorus). As population increases, sewage flows increase and dilution ratios of streamflow to sewage decrease, creating increasingly severe problems.

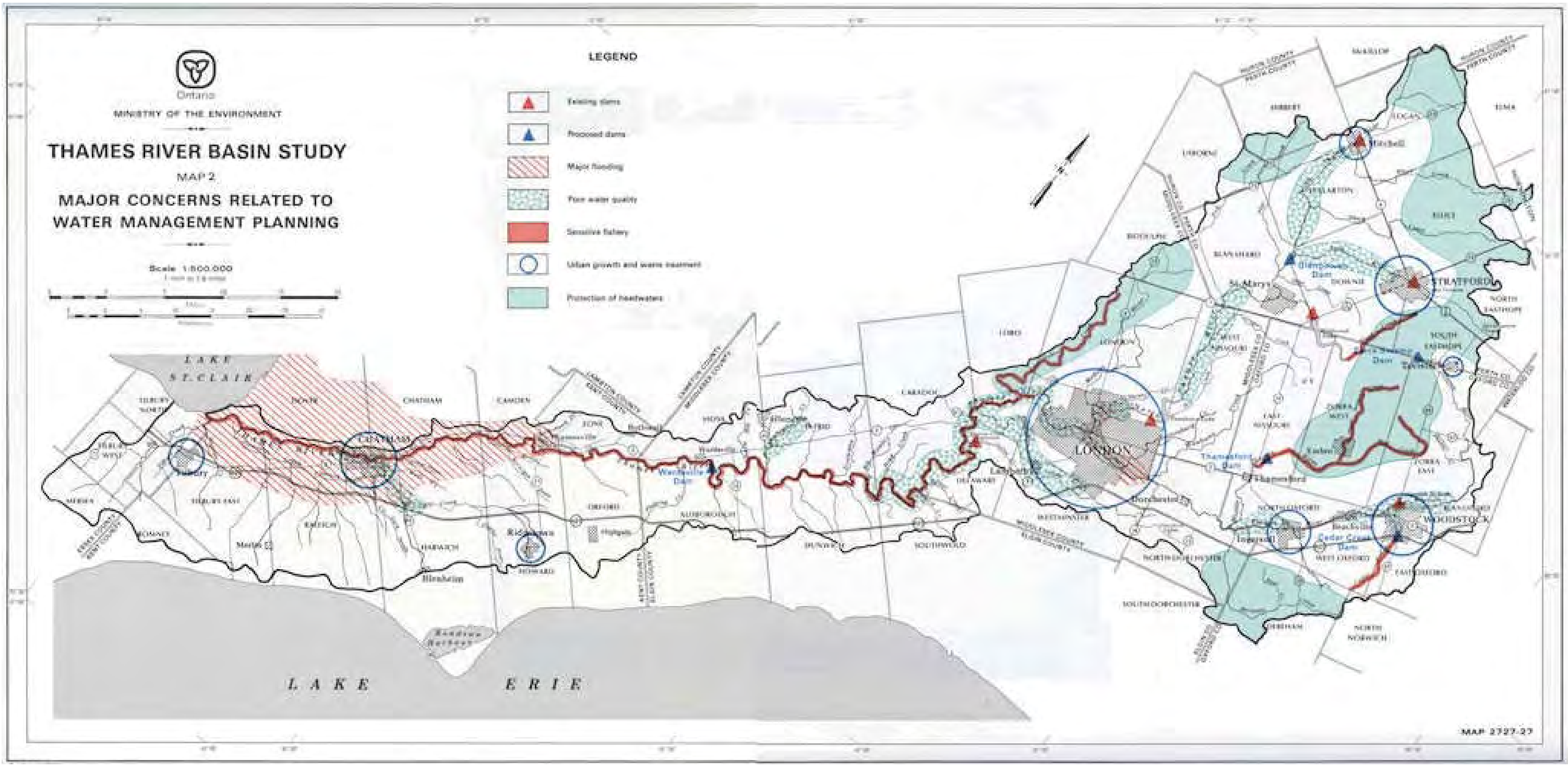
2.2 FLOODING

The most frequent flooding in the Thames watershed occurs in springtime and is caused by the combined effect of rain and ice and snowmelt. However, severe summer and autumn floods due to thunderstorms and hurricanes can occur. The earliest recorded flood occurred in 1791 and major recent floods took place in 1937, 1947, 1948, 1963 and 1968.

Table 2.1: Water quality problems in the Thames Basin (based on Surveys 1971-73)

Location	Bacteriological Contamination	High Nutrient Levels (NO_3, PO_4)	Profuse Aquatic Vegetation	Sub-standard Levels of Dissolved Oxygen	Other
North Thames River					
Mitchell	X-reservoir closed to swimming, 1973)				- intermittent streamflow upstream of Mitchell
St. Marys	X-(septic tank failures)	X	X	X-1.7 mg/L	
Hwy 7 to Fanshawe		X			- anaerobic conditions in sediment
Fanshawe			X-algal blooms	X-(bottom waters)	
Adelaide STP		X	X	X-(diurnal fluctuations)	
Richmond St. Bridge		X	X		- poor macroinvertebrate variety; - anaerobic conditions
Avon River					
Upstream of Stratford	X	X	X-algae		- extended low flows
Stratford to river mouth	X	X	X		- poor fish variety
Trout Creek					
Upstream of Wildwood	X				
St. Marys	XX			X	- impaired bottom fauna
Medway River	X				
Main Thames River					
Greenway STP					- chlorine toxicity
Muncey to Wardsville					- natural turbidity
Wardsville to Thamesville		X			
Chatham to Mouth	X			X	- septic odour; unstable conditions for bottom fauna; raw sewage bypasses; sludge banks; sedimentation
Dingman Creek	X			X-periodic	
Sharon Creek					- sulphur levels high
Newbiggen Creek	XX			XX	
McGregor Creek	XX	X			- garbage in stream
Jeannette Creek					- unstable conditions for bottom fauna, sedimentation
Thames River Above London					
Tavistock				X	- impaired bottom fauna upstream of Tavistock
Gordon Pittock	X	XX	XX-(algae blooms, sludge mats)		- chronic fish kills
Woodstock to Beachville	X	XX	X		- heavy sedimentation; poor colour and odour
Ingersoll		X	X		
Vauxhall STP to confluence with North Thames River				X	- impaired bottom fauna; sewage fungus
Pottersburg Creek					- poor odour; oil film; biological impairment
Waubano Creek	XX				- garbage in creek
Cedar Creek	XX		XX-(1.0 Mg/L)		- toxic conditions
Main Thames River					
London to Muncey		X		X	- poor representation of pollution intolerant benthic community throughout London

X - Poor XX - Severe


Ontario
MINISTRY OF THE ENVIRONMENT
THAMES RIVER BASIN STUDY
MAP 2
MAJOR CONCERNS RELATED TO WATER MANAGEMENT PLANNING
Scale 1:500,000
LEGEND
Existing dams
Proposed dams
Major flooding
Poor water quality
Sensitive fishery
Urban growth and waste treatment
Protection of headwaters
LAKE ST. CLAIR
LAKE ERIE
CHATHAM
LONDON
STRATFORD
WOODSTOCK
St. Marys
Mitchell
Ingersoll
Thamesford
Dorchester
Ridgetown
Wardsville Dam
Glengowan Dam
Thamesford Dam
Cedar Creek Dam
MAP 2727-27

Together with man's activities, the topography, soils and other natural features of the watershed contribute in great measure to flooding. Impervious clay soils, high gradient of river channels in the upper basin, and extensive artificial drainage all combine to increase the rate of runoff and thereby heighten peak river flows. The shape of the basin is another significant factor. The roughly circular upper watershed, with three main channels and numerous major tributaries, results in cumulative peak flows at the confluence in London and downstream. Man's encroachment in the form of factories, buildings and bridge abutments close to the river channel aggravate the flooding situation by preventing the free passage of water and causing ice jams during spring break-up. Increasing urbanization in the river's flood plain and increased runoff due to the clearing of woodlands and extension of drainage systems on farmlands has further aggravated the flooding problem.

The construction of Fanshawe, Gordon Pittock and Wildwood dams as well as channel improvements at Mitchell, Stratford, St. Marys and Ingersoll and dikes in London and along the lower reaches of the Thames River have considerably reduced flooding problems in the basin. However, regular flooding still occurs in Woodstock, St. Marys, London and the stretch of the river from Thamesville downstream through Chatham to Lake St. Clair.

The average annual damage due to flooding in the watershed is about $1.5 million of which 57 per cent occurs in Chatham and 22 percent in the vicinity of London. With respect to damage to agricultural land, a report on Thames River flood damages (Acres Consulting Services Limited, 1973) stated: "In the case of the Thames River, it appears that flooding is not a significant variable in land costs. It is recognized as a problem, but its impact on land values is not pronounced. This may indicate that the severity of flood damage to agricultural crops is not significant."

2.3 EROSION

Two categories of erosion problems are identifiable in the Thames watershed; soil erosion in the upper watershed and channel erosion in the lower watershed.

The more serious long term threat is posed by soil erosion, which in addition to the loss of valuable top soil and hence crop land productivity, can result in water quality impairment and reduced capacity of the soil to retain moisture. Soil erosion in the Thames watershed is most frequently the result of water runoff from cultivated land. Factors affecting the degree of such erosion include: slope of the land, intensity of rainfall, land cultivation practices, and degree of forest and brush cover. A recent report study estimated that 11 percent of the Thames watershed is presently forested (International Joint Commission, 1975).

Channel erosion is primarily caused by the scouring activity of flood waters and large ice masses on river bed and river banks in spring time. Other causes include variations in the levels of Lake St. Clair and erosion from surface waves, particularly those caused by the wake of motor boats. A large portion of the lower Thames lands lie well below the high water marks of both the Thames River and Lake St. Clair. These areas are presently protected by a system of dikes including 16' miles along the Thames River from Chatham to Lake St. Clair. These dikes, many constructed early in this century, are threatened by erosion which has already seriously undermined their stability. A report to the Lower Thames Valley Conservation Authority (James F. MacLaren, 1967) indicated that flood waters and continuous wave action represent the major erosive threat and recommended a dike stabilization program. Such a program has since been instituted from Chatham to the mouth of the river. A 1971 report by the same firm documented bank erosion problems between Chatham and Delaware.

The problems of erosion were also recognized by the inhabitants of the Thames basin as expressed through the Public Consultation Program. Comments received in this regard centered around recommendations for streambank protection and improving cultivation practices.

2.4 RECREATION

In the course of the Public Consultation Program, the lack of water-based recreation facilities was repeatedly expressed as a problem. Recreational water use focuses upon two aspects of water management; water quality and reservoir use. While an improvement in stream and river water quality will enhance their recreational benefits, the general public will have only limited benefit because of restricted public access. Recreational use of major reservoirs conflicts with their operation for the primary purposes of flood control and flow augmentation which dictate a lower than desired water level in reservoirs, especially during late summer and fall. At present, techniques are under development by the Ministry of Natural Resources which will allow optimization of all uses of reservoirs. However, trade-offs are inescapably inherent in multiple use reservoir operation and, under existing operating policy, little additional recreational benefits can be realized from existing reservoirs.

2.5 OTHER PROBLEMS

Other water resource problems in the Thames River basin include water supply interference, ground water quality impairment, and communication and co-ordination problems in watershed management.

Major ground-water takings by municipalities, and the impact of road construction, industrial activity and mineral extraction and processing, represent the main causes of water supply interference.
Ground water quality impairment has been found to be significant in certain locations in the watershed. The installation of septic tanks in surficial sands and gravels has caused bacterial contamination of shallow domestic wells in the Komoka and Granton areas. High nitrate concentrations have been found in water wells on the Moraviantown Indian Reserve, and in the Komoka area. Localized contamination of wells by gasoline or other petroleum products has also

occurred in the basin.

Throughout the course of the Public Consultation Program, the belief was expressed that lack of communication and co-ordination significantly contributed to water management problems in the basin. Lack of communication, both among and between local, regional and provincial agencies was cited. Many municipalities welcomed consultation of the kind undertaken by the study team and expressed the desire for increased consultation with the Province in the future. The Environmental Hearing Board concluded from its hearings that the people of the Thames River watershed do not perceive the basin as an entity and there was a serious lack of communication between citizens and the various formal organizations as well as between agricultural and urban communities in the basin. Perhaps these problems are epitomized by the split jurisdiction over the watershed into two separate conservation authorities.

CHAPTER 3

WATER MANAGEMENT OBJECTIVES

Since environmental and study objectives are fundamental to the selection of effective water management proposals, an outline of these objectives is warranted. The overall objective of the study is:

> **To develop guidelines for water management planning in the Thames River basin which would ensure that an adequate quantity of water at a satisfactory quality is provided for the recognized water uses in the river basin at the lowest cost and that flood and erosion protection is provided consistent with appropriate benefit-cost criteria.**

As indicated earlier, stream water quality is the major water resource problem in the basin. Water quality improvement depends upon the identification of appropriate water quality objectives and the implementation of courses of action selected to achieve these objectives.

The basic philosophy of the Ministry of the Environment is that there should be a constant effort to improve water quality, recognizing that improving the quality of water makes it available for more uses. However, there are certain minimum levels of water quality generally acceptable to the province which must be met. In this regard, water quality requirements established for the protection of aquatic life are normally selected. Higher levels of quality are required in areas where more demanding uses such as swimming and bathing occur.

Maintaining areas of presently high quality waters and upgrading quality elsewhere to a level which would protect fish and aquatic life was taken as a realistic and obtainable water quality objective for purposes of this study. However, it must be stressed that the long term objective of the Ministry of the Environment is to upgrade water quality in the basin as much as possible.

Having established the objective of maintaining water quality necessary for the protection of fish and aquatic life, appropriate criteria to achieve this objective and to protect other uses such as recreation and aesthetics, were also identified. A basin wide study was carried out into fish distribution and corresponding dissolved oxygen requirements. It was then estimated, in probabilistic terms, what the minimum dissolved oxygen concentrations should be on a daily, monthly and seasonal basis to maintain a viable fishery. Specific dissolved oxygen objectives are defined by application of criteria to specific stream reaches as described in Appendix B of this report. The implications of meeting these criteria in terms of loading guidelines for urban areas are discussed in Chapters 4 and 5. Other water quality criteria applicable to fish and aquatic life, recreation and other water uses are specified in the main report and the publication "Guidelines and Criteria for Water Quality Management in Ontario" (Ministry of the Environment, July, 1974).

The objective of flood control activity is to minimize the average annual flood damage with the least cost. The primary constraint on this evaluation is that the average annual flood damage reduction must exceed the average annual cost of achieving that reduction. The cost in this respect must reflect the actual costs of constructing a flood control facility, and the conflict costs which can be allocated to any interference that the flood control facility may have with other uses or any other part of the system. This cost figure is reduced appropriately by other benefits which accrue, such as flow augmentation and recreation.

The main emphasis in the planning of water control facilities in the Thames River basin to date has been on flood protection. However, the final design and operations have usually incorporated and developed the multiple purposes of flood control, water supply, pollution abatement and recreation. The emphasis in this study has been towards the integration of all water management activities within the watershed to reflect the optimum system and operating policy.

CHAPTER 4

ANALYSIS OF MAJOR WATER MANAGEMENT OPTIONS

After considering the various water resource problems in the Thames River basin in relation to the management objectives outlined above, the first step in the derivation of an overall management plan was an evaluation of major options— those options having readily identifiable implications for the greater portion of the basin in terms of both flood control and water quality improvement, the two primary objectives. As described in Appendix E of the main report, it was concluded that additional major flood control structures are required, and that non-structural methods provide valuable complementary flood protection. Moreover, flood control options and waste treatment options for the City of London are closely interrelated. Thus, the evaluation of major options essentially involved a detailed analysis of the merits and liabilities of constructing any or all of the Glengowan, Thamesford, Wardsville, Cedar Creek and Zorra Swamp dams, and also evaluating the sewage disposal options for the City of London.

Although these major options have great significance to water management in the basin, they by no means deal with all water resource problems of the watershed. A variety of other options pertaining largely to water quality improvement in urban areas, rural areas and reservoirs were considered, as well as proposals for control of local flooding, erosion, land drainage, water supply interference, and ground-water quality impairment. These are described in detail in the main report and summarized in Chapter 5 of this report.

4.1 EVALUATION CRITERIA AND PROCEDURES

The primary evaluation criteria used in this study were the flood control benefit-cost ratio and "total system net cost" (in present worth terms) of the major management options considered. This approach was complicated by the interrelationship of the various individual options with respect to the flood control and water quality benefits derived. For example, construction of a dam provides economic benefits in terms of both flood control and water quality, the latter accruing from deferral of capital expenditures for sewage treatment facilities due to flow augmentation provided from the reservoir. This means that all major options had to be evaluated in terms of total system configurations. Some configurations could be immediately dismissed for one of two reasons:

1. They totally failed to meet one or both of the required primary objectives of improving water quality and increasing flood control; or
2. They placed severe growth restrictions upon the City of London.

The reason for discarding options falling into category 2 above requires some explanation. The approach taken toward the overall water resource management of the basin was to optimize water resource use. Accordingly, in areas where the limit to the capacity of resources to sustain growth is reached within the planning horizon, a policy of growth limitations may be appropriate, with excessive growth redirected to designated centres, primarily the City of London. Provincial planning studies have recognized London as a major growth centre of this region and have recommended it continue in that role. Thus, only those options were considered which would permit London to expand to its projected 2001 population.

Population projections based on official plans and 1967-71 trends suggest a 2001 population for London of 500,000, and this figure was used in evaluating water management options. However, as a significantly lower growth rate such as a recent trends analysis suggesting a 2001 population of 338,000 to 350,000 at London would fundamentally alter these evaluations, options which would meet water quality objectives at lower future population levels were also considered.

Once the major option configurations had been determined and evaluated on the total system cost basis, secondary evaluation of major options began. At this stage, as yet unquantified parameters as well as those factors which cannot be quantified were considered. The results of the Public Consultation Program provided considerable support in this procedure by removing some of the subjectivity from the evaluation process. An imputed value for non-quantified factors can be derived, however. If the decision maker chooses an option which is not least-cost on the basis of the total system net cost analysis, then the added cost of the option chosen can be considered to be equal to the net unquantified benefits which the option offers over the least-cost option.

4.2 COSTING

At the primary evaluation stage, capital construction costs and flood control benefits have been used in deriving total net costs for each system option. In simplified terms this consists of estimating the capital costs for construction of engineering works (dams, pipelines, treatment plants) and the year in which they are to be constructed. The total cost in present value terms is then calculated using various discount rates - 2, 4, and 7 percent. Flood control benefits in similar present value terms are then subtracted, as they represent negative costs, to produce the total net cost for each system option. Costs are presented in present value terms so that they can be compared at a single point in time. The present value takes account of the time when costs and benefits occur by weighting near-term dollars more heavily than those far off in the future.

Intangible benefits and costs are introduced at the secondary evaluation stage later in this chapter.

The costs used in this analysis should be considered approximate reconnaissance estimates only, since they are not based on detailed engineering studies. Care has been taken, however, to use consistent assumptions in estimating the costs for each system option. Accordingly, it is felt that while the absolute costs may not be accurate, the least-cost ordering of options is correct.

4.3 EVALUATION OF OPTIONS

The five dams which have been proposed in the past and the sewage treatment options for London are discussed below both individually and in system configurations such that all associated benefits and costs, economic, environmental and social, are brought to light. Preliminary screening of several hundred theoretical combinations reduced to 22 the number of options to be evaluated in detail. These 22 system options are listed in Table 4.3. For brevity of presentation, all planning options in this section are presented in compact notation form as follows:

Gg: Construct Glengowan dam and reservoir primarily for flood control;

Gg*: Construct Glengowan dam and reservoir primarily for flow augmentation;

Th: Construct Thamesford dam and reservoir;

W: Construct Wardsville retarding structure;

CC: Construct Cedar Creek dam and reservoir;

ZS: Construct Zorra Swamp Dam and reservoir;

P: Construct a sewage trunk pipeline from London to Lake Erie with secondary treatment plus phosphorus removal at Lake Erie;

T: Provide tertiary sewage treatment for the City of London in order to meet effluent requirements.

In all cases, dam construction is assumed to be completed in 1981. For "T" and "P", the number following the notation refers to the year when that option would be operational. A system option is designated by a combination of two or more single options. For example, option Gg+Th+P:94 indicates that the Glengowan and Thamesford dams would be constructed to be operational in 1981 and the London-Lake Erie pipeline and accompanying treatment plant would be constructed to be operational in 1994.

4.4 FLOOD CONTROL BENEFIT-COST ANALYSIS

Table 4.1 presents the benefit-cost analysis of the single and system options for flood control derived from computer analysis.

Table 4.1: Flood Control Benefit-Cost Evaluation (in $1,000; 1975)

Option (operational in 1981)	Present Value of Reservoir Cost *			Average Annual Benefit	Net Present Value for 50 Yrs.			Benefit/Cost		
	2%	4%	7%		2%	4%	7%	2%	4%	7%
Gg	10,900	9,700	8,200	530	14,800	9,000	4,900	1.4	0.9	0.6
Th	6,700	6,000	5,000	1116	31,100	18,900	10,300	4.6	3.2	2.1
W	10,400	9,300	7,800	1016	28,400	17,300	9,300	2.7	1.9	1.2
CC	2,344	2,086	1,760	13	366	222	120	0.16	0.1	0.07
ZS	4,165	3,707	3,125	0	0	0	0	0	0	0
Gg+Th	17,600	15,700	13,200	1208	33,700	20,500	11,100	1.9	1.3	0.8
Gg+W	21,300	19,000	16,000	1048**	39,300	17,800	9,500	1.4	0.9	0.6
Th+W	17,100	15,300	12,800	1396*	39,000	23,700	12,800	2.3	1.5	1.0
Gg+Th+W	28,000	25,000	21,000	1428	39,900	24,200	13,100	1.4	1.0	0.6

* Assuming construction in 1981.

** Derived from (Gg + Th + W)-((Gg + W)-W) = Th + W
i.e. (1428) - (1048-1016) =1396. In this calculation, the maximum possible marginal benefit is ascribed to Gg. In reality, where Th is in the system, the marginal benefit of Gg would be less than 32 (1048-1016) and therefore, the Average Annual Benefit, Net Present Worth and Benefit-Cost of Th + W is likely higher than stated.

All figures are discounted to present value at 2 percent, 4 percent and 7 percent rate as shown. The cost or outlay for each of the dams is estimated as follows in 1975 dollars: Glengowan, $12.2M; Thamesford, $7.6M; Wardsville, $11.7M; Cedar Creek, $2.6M; Zorra Swamp, $4.7M.

In those options requiring more than one dam, a further analysis was carried out to determine the marginal benefit-cost ratio of building the second and/or third dam after the first has been completed.

From the flood control aspect only, the above analysis indicates that the preferred option is to construct the Thamesford dam alone. Not only is it the least costly, but it also provides the most flood protection of any single dam, resulting in a high benefit-cost ratio. Construction of the Thamesford dam would eliminate 75 percent of the $1.5M average annual flood damages. Furthermore, once the Thamesford dam is operational, the construction of either the Wardsville or the Glengowan dam cannot be justified on the basis of a flood control benefit-cost evaluation.

However, the benefit-cost ratio of the Thamesford dam option will be reduced if its construction prevents the mining of limestone deposits situated there, in which case an "opportunity cost", the cost of foregoing the opportunity to mine these deposits, would have to be added to this option. This is reportedly the only unexploited deposit of this high chemical grade limestone remaining in Southwestern Ontario. The opportunity costs would include royalties to the Province, wages and profits associated with the mining, and the lack of alternative sources of this grade of limestone close to markets in Southern Ontario. Mining would reportedly not commence for at least five years, and could take 20 to 25 years to complete. Decisions on exploitation of the deposit would be based on future economic conditions including demand and the prevailing market price in relation to the costs of extraction. Because this opportunity cost has not been included in the evaluation, the following analyses fall into two categories. The first assumes that any option including the Thamesford dam is not eliminated by this opportunity cost; the second assumes that the Thamesford dam options are no longer feasible because of this added cost.

If those options including the Thamesford dam are not feasible, then on the basis of the above flood control benefit-cost evaluation, the only other feasible option is to construct the Wardsville dam alone. It was found that, once "W" is built and operating, it is not advantageous to construct "Gg". Table 4.1 shows that to construct "Gg" alone is not advantageous because it has a benefit-cost ratio less than 1 at discount rates of 4 percent or higher, and eliminates only 35 percent of the $1.5M annual flood damages. In contrast, the "Th" and "W" options eliminate 75 percent and 68 percent of the flood damages respectively.

Regarding the Wardsville dam option, the above analysis was carried out for the proposed retarding basin having a capacity of 43,000 acre-feet. A higher dam with a retarding basin capacity of 80,000 acre-feet has also been proposed. Approximately 75 percent of flood damages occur downstream of Wardsville. An analysis shows that a low dam at Wardsville would eliminate 68 percent of all flood damages, leaving only 7 percent of damages remaining downstream of Wardsville. The advantage of constructing the higher Wardsville dam would have to be carefully evaluated in light of the minimal additional benefit it would provide.

4.5 LONDON SEWAGE DISPOSAL OPTIONS

The waste management alternatives available to the City of London in order to meet and maintain water quality objectives in future can be reduced to the following options:

1. Implement tertiary treatment (discharging an effluent of approximately stream quality) and continue discharging to the Thames River;
2. Export sewage via pipeline to Lake Erie for secondary treatment and phosphorus removal prior to discharge;
3. Build and operate Glengowan reservoir primarily for flow augmentation, and continue discharging to the Thames River using conventional treatment providing an effluent equivalent in quality to the Greenway plant.

In either case, expansion of existing sewage treatment plants is required to handle sewage flows until the option can be implemented.

An economic analysis of these options similar to that for flood control options is not possible. The benefit of water quality improvement or maintenance cannot be readily quantified, unlike flood control benefits, and hence, benefit-cost analysis is not possible. Minimum water quality criteria must be met, however. Given this objective, economic analysis is applied to determine the least-cost method of achieving it. As previously explained, the costs of sewage treatment alternatives for London are related to upstream reservoir construction options and must therefore be evaluated in a total system context, presented in Section 4.6.

Tertiary Treatment

Tertiary treatment as discussed here is taken to include traditional secondary sewage treatment plus the following processes:

- phosphorus removal
- carbon adsorption
- filtration
- ammonia stripping

The cost of providing tertiary treatment for a 2001 population of 500,000 at London in present value 1975 dollars computed at 4 percent interest rate (plant completion assumed in stages, 1981 and 1991) is $97M. As only one precedent for such treatment exists (South Tahoe Public Utilities District Reclamation Plant), this figure cannot be considered very accurate.

From results of the water quality computer simulation model developed for this study, waste loading guidelines for the City of London have been generated (Table 4.2). The total allowable load (total oxygen demand) varies with the amount of river flow. Hence, loading guidelines are increased for those options which include flow augmentation from Glengowan, Thamesford, or both.

Table 4.2: London Waste Loading Guidelines

Option	Total Allowable Load Oxygen Demand lbs/day			Year Load Limitation Reached [1]	Year Dilution Ratio Reached	
	Total	N. Thames	S. Branch		1.5:1	1:1
Present Conditions (no additional flow augmentation)	8,000	1,000	2,500	1993	1971	1984
Gg	11,000	2,000	2,500	2001 +	1983	1997
Gg*	17,000	4,000	2,500	2001 +	1999	2001 +
Th	11,500	1,000	3,500	2001 +	1986	2001
Gg + Th	14,500	2,000	3,500	2001 +	1994	2001 +
Gg* +Th	21,000	4,000	3,500	2001 +	2001 +	2001 +

[1] At treatment to stream quality.

Gg* Glengowan operated primarily for flow augmentation.

In addition to providing total load guidelines, specific limitations have also been placed on discharges to the North Thames River and the south branch of the Thames River within the city. Furthermore, loading figures apply only to sewage treatment plant effluents and are based upon the assumption that effects of urban runoff do not increase with time. This can only be achieved by control of discharges from combined sewer overflows and, as population increases, by storm water treatment.

Table 4.2 also shows dilution ratios (streamflow/sewage flow) which can be expected to occur under low flow conditions. This factor is important since the effects of pollutants which have not been modelled such as heavy metals and other toxicants are not precisely known and must also be controlled. The current dilution ratio in London is approximately 1.5:1. With increased levels of treatment, this ratio may be allowed to decrease. However, the ratio should not be allowed to decrease below 1:1, at least until the effects of this flow ratio upon water quality and fish life have been determined. For that reason, implementation of additional remedial action is required by the dates at which this dilution ratio is reached.

Population projections based on official plans indicate a 2001 population of 500,000 for London. If this figure is accepted as the maximum population for the city, then it can be seen from Table 4.2 that, with an allowable dilution ratio of 1:1 and construction of one additional dam upstream, tertiary treatment is a viable option. An advantage of this option is that it completely avoids any environmental effects that export of sewage might have upon Lake Erie and any pipeline right-of-way.

Sewage Pipeline Diversion to Lake Erie

For the diversion of London sewage to Lake Erie, it is assumed that the diversion sewer is used as an effluent pipeline for existing treatment plants from 1981 to 1986, at which time these plants would be abandoned and treatment at the lake would commence.

According to the water quality simulation model, the sewage diversion option resulted in higher dissolved oxygen levels in the river than those obtained by advanced secondary treatment to Greenway STP quality. Some criteria violations still occurred, however, indicating that combined sewer overflows will have to be controlled and storm water treatment may eventually be required. The positive effects of removing London's waste loads from the river are partially offset by the reduced flow in the river resulting from diversion.

The advantages of this option are threefold:

1. It removes growth limitations that would be placed on London within the planning period if it were to continue discharging to the Thames River, assuming a 2001 population of 500,000.
2. It could allow the municipalities of Lambeth and St. Thomas to be serviced by the same facility.
3. It removes all sewage constituents including residual toxicants from the river.
4. An additional benefit is that it may be possible to use the existing sewage treatment plants, once abandoned as conventional treatment plants, to treat storm water if this is found to be necessary.

There are also disadvantages, inasmuch as the pipeline option would possibly have some negative environmental effects upon Lake Erie. Moreover, the attendant environmental effects and pressures for additional urban development that the pipeline would generate along the right-of-way must be considered. Detailed planning studies and firm planning controls would be essential to determine the type and location of urban development, if any, desired along the pipeline corridor and to prevent uncontrolled development.

Glengowan Dam Operation Primarily for Flow Augmentation

Previous discussions have considered the primary purpose of the Glengowan dam to be flood control. However, consideration has also been given to operating this dam primarily for flow augmentation. For this analysis, it was assumed that 22,000 of the 27,000 acre-feet of total storage would be used for this purpose. The reservoir would be operated to be full in spring with water released during the summer low flow period. Flood control storage would be available for early spring runoff, and for late summer and fall floods, but no flood control could be provided for late spring floods. Little recreational use, if any, of the reservoir would be possible using the reservoir primarily for flow augmentation.

For a 2001 population of 500,000, treatment to Greenway quality would be acceptable until 1999, when a pipeline to Lake Erie would be needed. Alternatively, by limiting growth at London to 480,000, treatment to Greenway quality would be sufficient.

4.6 TOTAL SYSTEM COST ANALYSIS

4.6.1 Least Cost Analysis

Table 4.3 presents the net cost and least cost order of the various systems options evaluated in this manner.

Table 4.3: Total System Net Costs

Option	Net Cost Present Value ($M)			Least Cost Order		
	2%	4%	7%	2%	4%	7%
1. W + T:81	95.4	89.4	77.2	19	19	22
2. W+Gg+T:83	101.1	91.5	75.8	21	22	20
3. W+Gg+P:83	82.1	71.2	62.6	16	14	16
4. W + P:81	75.2	71.5	61.8	8	15	15
5. W + Th + T:86	83.3	78.7	66.6	17	18	18
6. W + Th + P:86	67.7	65.0	55.2	5	11	12
7. Th + T:86	80.7	74.2	61.4	14	16	14
8. Th + P:86	65.2	60.5	49.9	4	7	10
9. Th + Gg + T:94	76.6	63.7	47.4	11	9	8
10. Th + Gg + P:94	71.1	58.8	43.5	7	5	6
11. Gg + T:83	105.3	91.1	72.7	22	21	20
12. Gg + P:83	86.3	74.7	59.5	18	17	13
13. W + Gg + Th + T:94	81.2	69.3	53.5	15	13	11
14. W + Gg + Th +P:94	75.3	64.4	49.3	9	10	9
15. W+ Gg* + P:99	77.3	60.2	41.3	12	6	4
16. W + Gg* + Conventional Treatment**	23.1	27.0	26.2	3	3	2
17. Th + Gg* + Conventional Treatment	16.6	22.0	22.5	1	1	1
18. W + CC + ZS + T:82	98.9	90.7	76.2	20	20	21
19. W + CC + ZS + P:82	80.0	67.5	63.2	13	12	17
20. Th + CC + ZS + T:93	75.8	63.1	46.4	10	8	7
21. Th + CC + ZS + P:93	70.3	58.2	42.5	6	4	5
22. Th + Gg +CC + ZS + Conventional Treatment	20.1	26.1	26.8	2	2	3

* Involves operation of Glengowan dam primarily for flow augmentation.

** Option 16 involves growth limitation of 480,000 at London.

Note: W, Gg and Th - assume construction in 1981.

As well as taking into account flood control benefits, the figures in Table 4.3 include benefits (negative costs) to London attributable to the flow augmentation, which defers capital construction of a pipeline "P" or tertiary sewage treatment plants "T". For example, with no upstream dam construction as in option 1, "T" is required in 1981; with one upstream dam as in option 2, "T" is required in 1983; and with two upstream dams as in option 13, "T" is not required until 1994. The net costs of options 18 to 22 exclude both the economic benefits of flow augmentation to Woodstock in terms of deferred treatment expenditures and the increased water supply costs resulting from flooding of the Woodstock well field.

It should be noted that the economic analysis undertaken to arrive at the total system least-cost ordering is extremely sensitive to population projections and associated sewage flows and hence, to deferral times of capital expenditures.

In view of this, the phase-timing of each option, and especially of "P" and "T" should be carefully noted as any change in this timing will significantly affect the net cost of the option concerned.

Related to this sensitivity is the relationship of actual capital outlay to net cost. Greater savings result from deferral of expenditures the higher the interest rate chosen. Thus, options offering a long deferral of "P" or "T" become *increasingly* favourable with increasing discount rates in the least-cost analysis. The reverse is true with dam construction where the benefit-cost ratio *decreases* with increasing discount rate, because benefits are being discounted in this case rather than costs (i.e. average annual benefit over 50 years). Since the expenditure associated with dam construction is considerably smaller than that associated with either the pipeline or treatment options, total system options which include "T" and "Gg" and thus offer the longest deferral of or "T" continue to increase in favour with increasing discount rates.

At this point, in order to further reduce the list of options, non-quantifiable costs and benefits are considered.

4.6.2 Evaluation of Non-Quantified Factors

Given the primary objectives of achieving good water quality throughout the watershed at the lowest cost and providing flood control consistent with benefit-cost criteria, there were three additional objectives clearly defined by the public and elected officials of the river basin:

1. To minimize the loss of prime agricultural land.
2. To increase recreational facilities within the watershed, particularly for swimming
3. To minimize environmental disturbance due to capital construction projects, especially dams. These objectives were taken into consideration in the following evaluation.

A preliminary review of the anticipated ecological and environmental effects of the proposed Glengowan, Thamesford, Wardsville, Cedar Creek and Zorra Swamp reservoirs has been carried out. Input to this study was obtained from the regional offices of the ministries of the Environment and Natural Resources and from presentations to the Environmental Hearing Board during its public hearings. As only preliminary engineering studies and limited field data were available, additional detailed studies will be required to evaluate the environmental effects in considerably greater detail.

The Thamesford reservoir would flood an area with extensive stream cover and a resting area for migrant geese. The latter presumably would not be impaired by the presence of a reservoir.

Both the Glengowan and Thamesford reservoirs would flood ruffed grouse and European hare habitat. However, as there are extensive habitats for these species elsewhere in the Upper Thames watershed, this is not considered to be a serious constraint.

The Thamesford and Glengowan reservoirs would have surface areas of 1100 and 1280 acres respectively. A considerable amount of the flooded area is improved pasture and range land. Of the two reservoirs, it appears that the Thamesford reservoir would take up a relatively higher proportion of unproductive farmland.

Depending on the type of discharge structures and operating practices, some water temperature elevation and water quality impairment would likely occur, particularly in and immediately downstream from the Glengowan reservoir.

The initial proposal for the Wardsville reservoir called for a permanent storage dam. Construction of such a reservoir would take up more than 6300 acres, much of it prime agricultural land. It would also have serious detrimental effects on the valuable yellow pickerel commercial fishery for Lake St. Clair-lower Lake Huron-western Lake Erie, to which the Thames River spawning beds from Wardsville to Komoka are the greatest contributors.

During the Thames basin study public hearings, considerable opposition to the Wardsville dam was expressed by municipalities, citizen groups, and individuals. In addition to the above-mentioned factors, effects of the impoundment on roads and bridges, agricultural drains, and rare flora and fauna were reported.

As an alternative to a permanent storage dam, the Ministry of Natural Resources has proposed construction of a retarding basin. This type of structure would provide downstream flood protection by retarding peak flows. During flood flows, it would cause temporary flooding of agricultural land and ruffed grouse, European hare, and pheasant habitat; however, a permanent reservoir would not be created, and the permanent loss of agricultural land would be minimal. It is also reported that this structure would be designed so as not to interfere significantly with the yellow pickerel spawning runs.

There are several fundamental objections to the construction of the Cedar Creek and Zorra Swamp reservoirs, which would have major effects contrary to the objectives of this study.

The most obvious negative effect of construction of the Cedar Creek reservoir is the flooding of the aquifer in which the Woodstock municipal wells are located. Inundation of this aquifer may result in some impairment of ground water quality, as some of the sand and gravel aquifer is exposed at surface. Reservoir water, which would likely be highly organic, would gain access to the aquifer, possibly causing taste and odour problems and bacterial contamination. In addition, the municipal wells themselves would be flooded, and their continued use, while likely feasible from an engineering viewpoint, would involve modifications at an unknown cost and would hamper their operation and maintenance.

Although flooding of the aquifer would likely increase the amounts of water that could be withdrawn, it is possible that water quality impairment of the aquifer could preclude its use for municipal water supply. If this happened, substantial costs would be incurred in locating and obtaining an alternative water supply for the City of Woodstock. (These economic costs are not included in the costs of options involving Cedar Creek and Zorra Swamp dams given below.) Thus, there are major uncertainties as to the continued use of this aquifer and to related municipal supply costs if the Cedar Creek reservoir is constructed.

Environmental effects of the Cedar Creek reservoir include detrimental effects on a stocked and natural coldwater fishery (brown and brook trout) and a major deer-yarding area (Curries) in the proposed reservoir area. The reservoir would occupy the largest surface area of any existing or proposed Upper Thames impoundment (1,460 acres including some agricultural land), and yet provide a relatively small storage capacity. The likelihood that the impounded waters in the Cedar Creek and Zorra Swamp reservoirs would be impaired is another significant objection to their construction. The shallow depth and swampy nature of portions of Cedar Creek and all of the Zorra Swamp reservoir would result in the discharge of warm and highly organic waters.

The Zorra Swamp reservoir would be used solely for flow augmentation purposes, providing no flood control benefits. Only limited flood control benefits (an average of $22 thousand per year) would be obtained from the Cedar Creek reservoir. Neither reservoir would provide recreational benefits, in contrast to the objective of maximizing recreational facilities in the watershed.

Preservation of the Zorra Swamp has been recommended in view of its ecological importance as one of the few remaining wetlands in the watershed. Inundation of the swamp would fundamentally alter its natural ecological characteristics.

The following table summarizes the unquantified costs and benefits, associated with construction of each single option, which are described in more detail in the main report.

Summary of Unquantified Costs and Benefits of Major Options

Option	Unquantified Costs	Unquantified Benefits
Glengowan Dam	1. Agricultural land permanently inundated. 2. Water quality deterioration in and immediately downstream from the reservoir. 3. Increased water temperatures. 4. Disruption and destruction of some fish and wildlife habitat.	1. Improved recreational opportunities, either directly through provision of facilities at Glengowan reservoir or indirectly through improved water quality in the Fanshawe reservoir. 2. Improved water quality through flow augmentation in downstream areas. Flow augmentation benefits to London have been included in the economic analysis. 3. Flood control benefits, not included in the economic analysis, if Glengowan is used primarily for flow augmentation.
Thamesford Dam	1. Agricultural land permanently inundated. 2. In-reservoir water quality deterioration. 3. Water temperature increased. 4. Sports fishery disruption. 5. Some disruption and destruction of fish and wildlife habitat. 6. Public opposition voiced. 7. Foregone opportunity to extract limestone deposits.	1. Possible recreation benefits if facilities provided. 2. Water quality improvement through flow augmentation to downstream areas. This benefit to London was included in the economic analysis.
Wardsville Retarding Dam	1. Disruption of road links between Elgin and Middlesex counties during high flows, possibly requiring new bridge construction. 2. Strong public opposition expressed. 3. Occasional inundation of. Indian Reserve lands.	

Option	Unquantified Costs	Unquantified Benefits
Cedar Creek Dam	1. Inundation of the Woodstock well field. 2. Disruption of a stocked and natural coldwater fishery. 3. Destruction of a major deer-yarding area. 4. Agricultural land permanently inundated. 5. In-reservoir and downstream water quality impairment. 6. No recreational benefits.	1. Additional dilution flow for Woodstock and downstream areas through low flow augmentation.
Zorra Swamp	1. In-reservoir and downstream water quality impairment. 2. No recreational benefits. 3. Major changes in the natural ecology of the swamp.	1. Additional dilution flow for downstream areas through low flow augmentation.
Pipeline	1. Environmental effect upon Lake Erie and pipeline corridor, and pressure for urban development along the corridor. 2. Reduction of flow in the Thames River.	1. Possible advantages to municipalities along the pipeline corridor outside the watershed should they tie in to the system. 2. Removal of all London sewage effluent from the river giving improved water quality downstream. 3. Possible benefit of direction of controlled growth away from more sensitive areas.
Tertiary Treatment	1. Eventual growth restraints on London City due to dilution ratio limitations.	1. Allows for any advantages future sewage treatment technology improvements may offer.

Having outlined both the economic and unquantified benefits and costs of various systems options, an evaluation of their relative merits is presented below. It is important to note that the cost and benefit calculations in this study are based on reconnaissance design and preliminary data only.

4.6.3 Options Involving the Thamesford Reservoir

The following evaluation assumes that construction of the Thamesford dam is not ruled out by the added "opportunity cost" of foregoing mining of the limestone deposit at the reservoir site as described in Section 4.4. On this basis, options involving the Thamesford reservoir are listed below in least net-cost order at 4 percent discount rate.

Table 4.4: Ranking in Net Cost Order of Options including the Thamesford Dam

Option No. (from Table 4.3)	Option	Net Cost Present Value ($M) @ 4%	Order (From Table 4.3)
17.	Th + Gg * + Conventional treatment	22.0	1
22.	Th + Gg + CC + ZS + Conventional treatment	26.1	2
21.	Th + CC + ZS + P:93	58.2	4
10.	Th + Gg + P:94	58.8	5
8.	Th + P:86	60.5	7
20.	Th + CC + ZS + T:93	63.1	8
9.	Th + Gg + T:94	63.7	9
14.	W + Gg + Th + P:94	64.4	10
6.	W + Th + P:86	65.0	11
13.	W + Gg + Th + T:94	69.3	13
7.	Th +T:86	74.2	16
5.	W + Th +T:86	78.7	17

*Involves operation of Glengowan dam primarily for flow augmentation.

When both economic and environmental factors are considered, option 17 is the most attractive of all system options which include the Thamesford dam. This option involves construction of the Thamesford dam primarily for flood control, the Glengowan dam primarily for flow augmentation and conventional treatment for London. In net cost terms, it is the least costly of all systems options in Table 4.3 (which excludes the opportunity costs associated with the Thamesford limestone deposits), and represents a net saving of $4.1M over the second-least costly option, number 22. It is also the least costly option in terms of total cost.

Option 17 is also superior to option 22 on environmental grounds as it involves the construction of two fewer dams and thus avoids the environmental problems related to the Zorra Swamp and Cedar Creek dams.

This option also provides considerable flexibility as to the waste treatment facilities that would be needed at London. Based on water quality predictions, neither the sewage pipeline nor tertiary treatment would be required during the planning period. Decisions as to the type of new treatment facilities and the dates by which they would be required could be made in stages, depending on actual population trends and water quality conditions, and on planning decisions as to the desirable size of the City of London. This option should allow growth to 500,000 persons at London by 2001 if necessary.

Flood protection consistent with benefit-cost criteria would also be provided for St. Marys, London, and all areas downstream. Flood control benefits would largely accrue to the Thamesford dam as it provides the most flood control benefits for the largest portion of the basin of any single reservoir. Some flood storage would be available at Glengowan to control flooding in early spring, summer and fall. However, the Glengowan dam would not provide flood storage for late spring floods.

Some recreational use of the Thamesford reservoir would be possible. Although operation for flow augmentation would severely curtail recreational use of the Glengowan reservoir, an indirect benefit in the form of enhanced recreation at Fanshawe due to possible water quality improvement may occur.

Disadvantages of this option include some loss of agricultural land, the previously noted environmental effects associated with the construction of these two dams, and the foregone opportunity to mine the Thamesford limestone deposits.

4.6.4 Options Excluding the Thamesford Reservoir

If it is decided that the limestone opportunity costs eliminate consideration of options involving construction of the Thamesford dam, then options 1, 2, 3, 4, 11, 12, 15, 16, 18, and 19 should be considered. These are listed below in least-cost order of net costs at 4 percent:

Table 4.5: Ranking in Net Cost Order of Options excluding the Thamesford Dam

Option No.	Option	Net Cost Present Value ($M) @ 4%	Order
(from Table 4.3)			(from Table 4.3)
16.	W + Gg *. + Conventional treatment	27.0	3
15.	W + Gg* + P:99	60.2	6
19.	W + CC + ZS + P:82	67.5	12
3.	W + Gg + P:83	71.2	14
4.	W + P:81	71.5	15
12.	Gg + P:83	74.7	17
1.	W + T:81	89.4	19
18.	W + CC + ZS + T:82	90.7	20
11.	Gg +T:83	91.1	21
2.	W + Gg + T:83	91.5	22

* Involves operation of Glengowan dam primarily for flow augmentation.

From an economic viewpoint, option 16 is the least costly in terms of net costs of this group of options. It involves construction of the Wardsville retarding dam for flood control, the Glengowan dam primarily for flow augmentation, and conventional treatment at London. Water quality predictions for this option require a growth limitation of 480,000 persons for the City of London. Provided that such a growth restriction is acceptable, option 16 represents a significant saving in terms of net cost of more than $33 million over option 15, the next least costly option. Option 16 is also the most favourable of the "non-Thamesford" options in terms of total cost.

From an environmental viewpoint, option 16 is also an acceptable option. Options 1 and 11 would have less environmental impact as they involve only one dam rather than two and tertiary treatment rather than the pipeline. However, the additional net cost of at least $62M over option 16 is significant.

Under option 16, the Wardsville retarding dam would provide flood control for the lower watershed, while some flood storage would be available in the Glengowan reservoir for early spring, summer and fall floods, but not for late spring floods. While recreational use of the Wardsville reservoir would not be possible, recreational use of the Fanshawe reservoir may be enhanced by possible water quality improvement due to flow augmentation from the Glengowan dam.

One significant advantage of option 16 is the valuable flexibility it offers to decision makers, as it provides a basis for a variety of future courses of action. For example, if a growth limitation of 480,000 is found to be unacceptable, consideration could be given to construction of a sewage pipeline to Lake Erie in 1999 as in option 15, which is the second least costly of the "non-Thamesford" options.

Moreover, using option 16 as a basis, there are a variety of approaches to sewage disposal at London, which have not been costed. For example, tertiary treatment processes, less expensive than the tertiary treatment system costed in Appendix F, could be evaluated to determine if they could meet water quality objectives and provide for additional growth of London to the size determined to be the most desirable when other factors in addition to water management considerations are taken into account.

4.6.5 Summary

If the Thamesford dam is feasible, the preferred option is to construct the Glengowan dam primarily for flow augmentation, the Thamesford dam primarily for flood control, and to utilize conventional treatment to Greenway quality at London (option 17).

If a decision is reached that the limestone opportunity costs are sufficiently great to eliminate options involving the Thamesford dam, then the preferred option is to construct the Wardsville dam for flood control, the Glengowan dam primarily for flow augmentation, and conventional sewage treatment to Green-way quality at London (option 16). If the growth limitation of 480,000 at London associated with this option is unacceptable then other options such as provision of tertiary treatment or the construction of a sewage diversion pipeline can be considered.

As the Glengowan dam is common to each of the preferred options, construction of the Glengowan dam first would offer maximum flexibility in choosing other capital construction projects. Decisions as to whether to construct the Wardsville dam or the Thamesford dam could then be made. Decisions as to whether to continue to discharge sewage effluent to the Thames River or to construct a sewage diversion pipeline from London to Lake Erie could be deferred to the 1990's. By that time, actual water quality conditions and other water management trends can be documented, population projections will be refined and further information will be available on the desired size for the City of London. The early construction of the Glengowan dam and the use of sophisticated secondary sewage treatment practices thus provides decision makers with valuable flexibility so that new information can be utilized in future planning decisions.

CHAPTER 5

LOCAL WATER RESOURCES MANAGEMENT

Chapter 4 has presented an analysis of major structural water management options for the Thames River watershed. However, these do not deal with many of the more localized problems in the basin. A wide spectrum of management options to deal with urban, rural, reservoir-related and flooding problems has been considered and applied to the basin on a stream-reach and municipality basis. These include:

Urban Areas

1. Treatment or diversion of sewage and industrial wastes.
2. Population and industrial growth restrictions.
3. Alteration of stream assimilation characteristics.

Rural Areas

1. Restriction of cattle access to streams.
2. Limitation of fertilizer application rates.
3. Programs for channel protection.
4. Environmental surveillance and enforcement.

Existing Reservoirs

1. Modification of reservoir operating practices.
2. Algae control.
3. Disinfection of swimming areas.

Flooding

1. Small dam construction.
2. Modification of drainage schemes.
3. Wardsville diversion.
4. Additional dike construction.
5. Modified operation of existing dams.
6. General conservation practices.
7. Regulation of flood plain development.
8. Relocation of structures in the flood plain.
9. Flood proofing.
10. Flood warning.
11. Flood insurance.

These management options are discussed in detail in Appendices C and E of the main report. This chapter presents the conclusions of the application of these options to local problems in the basin. A more detailed discussion can be found in Chapter 8 of the main report.

5.1 HEADWATERS AREAS

Particular attention is drawn to headwater areas whose importance stems from the need to maintain streamflows at best possible quality and quantity. Any lessening of flows and stream water quality would severely aggravate downstream water resource problems as described in Chapter 2. Headwater flows in the North Thames and Avon rivers are often intermittent during the months of June to September and become critically low in the Thames River above Tavistock. Attention is also drawn to the many tributary streams such as Fish Creek, Trout Creek, Medway River, Waubuno Creek, Cedar Creek, and McGregor Creek. These streams provide significant flows to the watershed and should be carefully protected, as much so as the main river.

Those options noted above for rural areas, and conservation practices described in Appendix E of the main report should be applied with special rigor in these areas. The preservation of Ellice and Zorra swamps by the Upper Thames River Conservation Authority deserves serious consideration in this respect. Municipalities in headwater regions must pay careful attention to their water takings and sewage disposal systems to safeguard downstream uses.

5.2 NORTH THAMES RIVER

The major water quality problem in the North Thames River is the critical nature of the dissolved oxygen regime. Additional problems include periodic flooding in St. Marys and water quality degradation in Fanshawe and Wildwood reservoirs.

Mitchell

Low flows and related inadequate year-round waste receiving capabilities, characteristic of the North Thames River at Mitchell, make disposal of municipal wastes from lagoons at this municipality difficult. The lagoons, while providing excellent organic waste reductions, are hydraulically overloaded, necessitating a continuous discharge at present. Improvements in the municipal collector systems and a change to a once-annual discharge are immediate requirements to safeguard water quality in the North Thames River.

The most practical approach to minimize water quality impairment at Mitchell is the addition of a mechanical treatment plant to existing sewage facilities, along with a program to reduce infiltration to the collector system. Other treatment approaches described in the main report are costly in terms of use of agricultural land. Growth restraints will be required in the future at Mitchell because of the extremely limited waste assimilative capacity of the stream.

Stratford

Population projections for the City of Stratford indicate that a population of up to 47,000 could be expected by the year 2001. Water quality studies have shown that even at the present population, and under a streamflow regime 40 times higher than estimated low flow, oxygen criteria are not satisfied. Furthermore, modelling studies have shown that only limited improvements in the oxygen regime would result from the total elimination of oxygen-demanding materials at Stratford and that dissolved oxygen guidelines in the Avon River would not be met.

Excessive weed growth coupled with extremely low streamflows during summer months have created oxygen conditions unsuitable for aquatic life in the Avon River downstream from the city. Alternatives directed towards achieving oxygen objectives for sustaining fish life include: harvesting of aquatic vegetation from the stream; further treatment to remove nitrogeneous organics; stormwater treatment; more advanced phosphorus removal during critical aquatic vegetation growth periods; exportation of wastes to a more appropriate receiving watercourse; restrict further discharge volumes.

Physical removal of aquatic vegetation would improve the dissolved oxygen regime and produce a more aesthetically pleasing stream. This approach would have to be regarded as experimental and be preceded by an in-depth feasibility study.

Diversion of treated sewage to a receiver with more dilution capacity such as the North Thames River, would involve a costly pipeline and would essentially eliminate flow in the Avon River below Stratford during low flow periods.

Studies indicate that water quality objectives may never be totally attained in the Avon River below Stratford. Despite the advanced degree of sewage treatment provided by the Stratford plant, not all problematic waste water components are recovered. Low levels of such constituents as chloramines, phenols, and heavy metals assume greater significance when essentially no dilution is afforded by the receiving stream during low flows.

Since discharged sewage flows exceed streamflows during summer drought conditions, no increase in waste loadings to the stream should be allowed at Stratford. Action to further minimize phosphorus nutrient inputs from the sewage facility should be undertaken, and the significance of the storm drainage portion of the organic load should be studied and corrective action taken if warranted.

St. Marys

From St. Marys to Fanshawe Lake, excessive aquatic weed growth has contributed to reductions in levels of dissolved oxygen to critically low concentrations. With these problems in mind, water management practices to improve water quality in this reach include more consistent treatment of organic wastes at the Campbell Soup plant, phosphorus removal to lowest possible levels at St. Marys and the Campbell Soup plant, and the provision of increased summer flow through the construction of the Glengowan reservoir. If future growth of St. Marys necessitates expansion of the sewage treatment plant, water quality problems due to organic loadings are not anticipated as streamflow appears adequate to accommodate these loadings at the projected 2001 population.

Flooding problems in St. Marys are still prevalent. Operation of the proposed Glengowan dam would provide some flood protection, but channelizing the river within St. Marys may be required whether or not the Glengowan dam is built.

Wildwood Reservoir

The main problems associated with Wildwood reservoir have concerned conflicts between motor boating and other recreational uses, and waterfowl management. Horsepower restrictions or possible prohibitions of motor boats on the reservoir and management directed at transient waterfowl populations are the recommended approaches to deal with these problems.

Fanshawe Reservoir

Water quality impairment in Fanshawe Lake has been manifest in the past by troublesome blue-green algae blooms during the summer high use period for swimming and bathing. Recent modifications to the partial low level discharge approach, coupled with the continuing reduction in phosphorus inputs from upstream point sources, will reduce interference with recreational uses. Combined with low streamflows available in Wye Creek, the possible detrimental effects of nutrient and bacterial inputs on recreational use in Fanshawe Lake are clearly reasons for discouraging future expansion at Thorndale. Only a no-effluent system would provide water quality protection.

5.3 THAMES RIVER ABOVE LONDON

Water management problems in the Thames River above London are related mainly to water quality impairment associated with urban and rural inputs, along with flooding at Woodstock and Ingersoll.

Tavistock

Constraints on waste discharge methods at Tavistock are imposed mainly by critically low streamflows from May through October and by downstream water uses. During these six months, monthly average streamflows may drop below 1 cfs and discharged wastes would become partially trapped in the Gordon Pittock reservoir. Because of these constraints, the following waste treatment options are available for Tavistock:

1. Waste storage for total land disposal;
2. Waste storage for annual discharge during March and April;
3. A mechanical sewage treatment facility to provide secondary treatment discharging according to streamflow from November through April, with storage of treated effluent throughout the rest of the year.

Storing treated wastes from May through October and discharging daily flows from a secondary treatment plant during November through April, only when streamflows exceed 2.2 cfs, is the most practical approach to future waste treatment at Tavistock. Waste stored in a 35-acre lagoon would be discharged as streamflows permit. The annual burden of nutrients and bacteria originating from Tavistock and being taken into storage by the Gordon Pittock reservoir would be significantly reduced and water quality objectives in this reach of the Thames River would be met.

The three options suggested for Tavistock are typically considered when a receiving stream is fast approaching or already beyond its ultimate capacity to accept wastes. To further tax the receiving watercourse by loadings beyond the 2001 design figure would seriously jeopardize water quality both in the immediate downstream reaches and in the Gordon Pittock reservoir. Since expansion of Tavistock could proceed only at the expense of well over 200 acres of farmland or construction of two costly sewage facilities, the most logical option available to the Village of Tavistock is the application of growth restraints.

Rural water resource management options are particularly important in this reach because of the intensity of cattle and swine production in East Zorra Township. Restriction of range cattle access to watercourses and the close surveillance of manure handling practices and water quality of municipal drains are of particular relevance to this area.

Gordon Pittock Reservoir

Although the major problem in the Gordon Pittock reservoir identified from both data collection and public consultations is one of water quality impairment, management conflicts among existing uses of the reservoir also pose problems.

Programs to control upstream sources of contaminants, such as streambank stabilization, control of livestock waste disposal practices, restriction of livestock access to streams and improved municipal waste treatment or population constraints at Tavistock would contribute to improved water quality in the reservoir.

Utilizing bottom draw to discharge the required 15 cfs for streamflow augmentation and application of algicides to the swimming area should allow continued multi-purpose use of the reservoir.

Woodstock

Issues in the Woodstock area are related to solution of problems of water quality impairment, flooding and water supply.

Management options to improve water quality at Woodstock include flow augmentation, storm water treatment and advanced sewage treatment as well as the basic option of limiting population growth in the future.

Modelling studies, assuming no additional flow augmentation beyond the 15 cfs currently provided by the Gordon Pittock reservoir, indicate that a total oxygen demand of not more than 900 lbs/day may be allowed in order to satisfy dissolved oxygen criteria in immediate downstream reaches.

The model prediction shows that dissolved oxygen objectives will not be met beyond these immediate downstream reaches, because of the overriding effects of respiration from aquatic plants and algae. The dilution ratio of natural low flow to sewage flow is presently 1.8 to 1. Tertiary treatment as defined in Chapter 4 would be required to allow a treatment plant expansion to 8 MGD in Woodstock.

It should also be noted that the 900 lb loading figure assumes no net increase in urban runoff loadings. Thus, the city should implement studies to define methods of reducing existing and future urban runoff loadings to the river. If Zorra Swamp or Cedar Creek reservoirs were built, the tertiary treatment requirement would not be necessary. However, as indicated in Chapter 4, other benefits from these reservoirs are minimal and the environmental costs are considered to be high. Thus, construction of either reservoir solely for flow augmentation is not felt to be justified.

The most meaningful methods of minimizing flood damages in Woodstock appear to be continued restriction of development in the flood plain. Channel improvements proposed in the past by the conservation authority, could be given further consideration.

In Woodstock, 1973 water use averaged 4.3 MGD. The bulk of this water was obtained from five overburden wells located south of Highway 401 in spillway deposits along Cedar Creek. Two additional bedrock wells in the city are also connected to the system; however, iron and hydrogen sulphide problems limit the use of these wells. The pollution potential of the overburden well supply is high. Preservation of this shallow aquifer is essential and development plans adjacent to these well fields should be carefully considered in order that they not jeopardize quality or quantity of the municipal supply. To satisfy future municipal water demand, options available to the City of Woodstock include:

1. Exploitation to the full of the Cedar Creek aquifer;
2. Further test drilling for aquifers west of Sweaburg and northeast of Woodstock;
3. Utilization with appropriate treatment of ground water from the bedrock wells; and
4. Piping water from surface or ground water sources removed from the Woodstock area.

Beachville

Dissolved oxygen levels were observed to be less than the criteria level of 5 mg/1 from Beachville to Ingersoll. At present, plans are being developed for a sewage treatment facility to service a design population of 2,500 including the processing wastes from William Neilson Limited. Two treatment systems have been considered—temporary storage of wastes and continuous discharge.

It has been calculated that under low flow conditions, 38 lbs of BOD_5 may be added continuously to the river without significantly increasing concentrations after mixing. However, it is essential that continuous inputs of phosphorus be limited since aquatic vegetation exerts a great influence on dissolved oxygen levels in this reach. Therefore, to minimize organic and nutrient loadings to this sensitive reach, a treatment plant complete with effluent polishing and phosphorus removal for a design population of 2,500, including 30,000 gpd processing wastes from William Neilson Limited., would be required. Separation of cooling water and processing waste flows at William Neilson Limited and subsequent treatment of processing wastes at the proposed Beachville plant is recommended to remove the present average daily load of 50 lbs/day of BOD_5 originating from the industry. Urban runoff controls should be enforced.

Water supply for the expanding population at Beachville could be obtained from deep bedrock wells. Treatment for hydrogen sulphide and iron will probably be required.

Ingersoll

Downstream from Ingersoll, impaired water quality in the form of dissolved oxygen depletion occurred as a result of discharges from the Ingersoll sewage treatment plant. A temporary upset in the treatment plant caused by toxic industrial wastes was partially responsible for this. Once again, options to improve water quality downstream from Ingersoll include streamflow augmentation and improved sewage treatment.

Provision of streamflow augmentation by construction of the Zorra Swamp and Cedar Creek reservoirs does not appear justified, as previously discussed. Improved treatment for a 2001 population of 12,100 appears to be the only viable management option to ensure water of a satisfactory quality for a warm water fishery. Modelling studies indicated that at summer low flow conditions of 21 cfs, a maximum total oxygen demand of 400 lbs/day would satisfy dissolved oxygen criteria in downstream reaches. This would require additional treatment processes beyond the conventional secondary treatment now installed. Phosphorus should be removed to lowest practical levels in this stream reach where weed growth is particularly heavy. Storm water control should be enforced.

Dorchester

The remaining portion of the Thames River from Ingersoll to London did not receive detailed study. General water quality studies indicated that enriched conditions persisted through Dorchester, although water was of satisfactory quality upon entering London.

The organic loading from a proposed treatment plant at Dorchester is expected to have a negligible effect on the dissolved oxygen regime of the river.

On the Middle Thames River, Thamesford produced no water quality problems. Properly constructed septic tank systems on appropriate sized lots or a communal treatment system would serve the projected 2001 population with negligible impact on the aquatic environment.

5.4 THAMES RIVER IN THE LONDON AREA

The major options for flood control in the watershed and water management in the London area are interdependent and have been evaluated in Chapter 4. Detailed discussion of waste, management options for London can be found in Appendix H of the main report.

Major options are dependent on dam construction upstream. Table 4.2 in Chapter 4 outlines specific loading guidelines which would allow dissolved oxygen objectives to be met, with different dam options. These guidelines are based on the following two provisions which should be followed by the City of London concerning waste loadings to the Thames River:

(i) Existing and future treatment plants discharging to the Thames River should provide a level of treatment equivalent to the quality of effluent from the Greenway treatment plant as defined in Appendix A of the main report. This specifically requires that sewage receive efficient secondary treatment including nitrification such that the average BOD_5 concentration is 11 mg/L or less and that the average total kjeldahl nitrogen level is 1.6 mg/L or less. Alternatively, the total oxygen demand of the effluent as defined in Appendix A should be 27 mg/L or less.

(ii) Other waste loads from the urban area should not increase with future development. The city should accelerate its program of combined sewer separation or institute provision for treatment of sanitary sewage overflows to the Thames River. Studies should be carried out to determine the polluting potential of urban storm runoff and remedial measures undertaken if the problems prove to be significant.

5.5 LOWER THAMES RIVER

Water management options designed to safeguard water quality downstream from municipalities on the Lower Thames River are not complex due to the physical characteristics of the river and adequate streamflow available for waste assimilation purposes. Only on intermittent tributary streams and in the sluggish lower reaches do water management options for water quality protection become more involved. In most of the lower basin, ground water quality and availability pose localized water supply problems which may represent a constraint on future development unless alternative sources are available. This section of the chapter will deal only with the servicing options open to municipalities in the Lower Thames basin ensuring that surface water quality is protected and ground water resources are not exploited beyond their capabilities. Erosion control is discussed in Section 5.6. Other major water management options specifically pertinent to this reach were dealt with in Chapter 4.

Thamesville, Bothwell, Wardsville and Melbourne

Waste treatment and water supply considerations are not anticipated to pose major problems for Thamesville and Bothwell up to the 2001 planning year. The effects of discharges from sewage works proposed at these municipalities are expected to be insignificant. Should community sewage facilities be recommended at Wardsville and Melbourne within the planning period, treated sewage discharges directly to the Lower Thames would have limited effect on water quality. For water supply, the residents of Bothwell, Thamesville and Melbourne presently rely on private wells in shallow or deep aquifers. At each of these locations, test drilling programs have been recommended to establish a municipal supply.

Westminster Township—Lambeth

As a result of limited streamflow in tributary streams or low yield well fields, some municipalities in the lower Thames basin will be confronted with developmental constraints. On Dingman Creek both the Westminster Township and Southland Park (Lambeth) sewage treatment facilities tax the capacity of the receiver to assimilate treated sewage. Expansion of either of these plants should be discouraged due to the low waste assimilation capacities of Dingman Creek. Other than restricting development in the areas serviced by these facilities, the only municipal waste treatment option which will allow continued growth would be to export sewage for discharge to a more suitable receiver.

Ilderton

At Ilderton, the waste assimilative capacity of Oxbow Creek is limited, so that total retention and spray irrigation of wastes is the only practical waste disposal option available should the village increase its population.

Komoka-Kilworth

In Komoka, pollution of private wells by septic tank systems discharging to the same shallow aquifer necessitated consideration of development of a provincial water works scheme. The suggested system is designed to serve a 1994 population of 1,500 persons. Development could proceed on septic tanks once the public health hazard is eliminated through construction of the new water system. Should a sewage treatment facility be deemed necessary in future, various options depending upon London's approach to future development are available. London's future figures prominently at Komoka and Kilworth since effects of discharges from London are most critical in this area. If London opts for a pipeline to Lake Erie, a continuous discharge to the Thames River from Komoka and Kilworth would cause insignificant impairment. If London upgrades treatment and continues to discharge to the Thames, however, the total oxygen demand from Komoka and Kilworth would have to be included in London's allotted daily loading figure.

Glencoe

Both limited water supply availability and the lack of a suitable nearby receiving stream are factors which dictate restricted growth at Glencoe. Two well fields which supply the village provide relatively low yield and prospects for developing a high capacity well in the area are poor. Newbiggen Creek is an unsuitable wastewater receiver because of the inadequate streamflows generated by the small drainage area upstream from the village. Even after construction of the 28-acre sewage lagoon, water quality of the creek will be temporarily impaired when the lagoon is discharged during periods of peak flows. Expansion of the village could only be considered if water were piped to Glencoe and if treated sewage were exported to a more appropriate receiver.

Newbury

The proposed sewage treatment scheme for Newbury has been cancelled. The possibilities of developing a municipal water supply based on ground water sources are remote, posing a constraint on future development. To expand, the community would probably be forced to import water from Lake Erie.

Chatham

Water management problems in Chatham include flooding, erosion, and water quality degradation. Flooding problems are dealt with in Chapter 4.

Water quality problems in the Chatham area are related to upstream organic loadings, but are more directly the result of combined sewer overflows in Chatham and treatment plant bypasses during storms. Options for control of water quality include: control of Chatham's discharges from storm and combined sewers and from the treatment plant; control of upstream waste discharges from urban and rural areas; control of the natural organic waste load from decaying weeds and algae; flow augmentation; and limitation of urban growth.

Water quality criteria can be met within the city limits by control of combined sewer overflows. This may be done by a variety of technical means including: separation of storm and sanitary sewers; reduction of storm flows to the combined sewage system; higher capacity sewer pumping stations and interceptor sewers; higher treatment plant capacity for storm generated flows; and storage of high flows. These proposals are presently under study by a consulting engineering firm and many of them are expected to be implemented by the city.

A treatment plant discharge of 3,300 lbs/day total oxygen demand is the recommended limit. To achieve this would require nitrification of sewage and some reduction of the BOD_5 levels below the secondary treatment level. This limit assumes that waste loadings from storm and combined sewers will not increase in future.

It is concluded that water quality objectives in and downstream from Chatham can be met by the following:

1. Control of storm generated combined sewer overflows in the sewage system. Future controls on storm runoff should be considered.
2. Secondary treatment, including nitrification, following effluent limitations set out above.

Tilbury

At Tilbury, the 36-acre lagoon is hydraulically overloaded. The 17-square mile drainage basin produces inadequate streamflow to assimilate treated wastes from the town even at the present population of 3800, and to expand would either cause further degradation of Tilbury Creek or necessitate the implementation of costly waste treatment approaches. Since flows are insufficient for a continuous discharge, the export of wastes to the Great Lakes or total retention— spray irrigation are the only options which will provide acceptable water quality in the Tilbury-Big Creek system. Secondary treatment facilities, a pipeline and extended outfall would be extremely expensive for Tilbury itself and the total retention option would be costly in terms of the amount of highly productive farmland required.

Pumping treated wastes three miles downstream for discharge to Big Creek below its junction with Baptiste Creek would lessen the degree of water quality impairment. The backwater effect from Lake Erie would likely cause localized impairment because of poor waste dispersion characteristics. Growth constraints at such inland communities as Tilbury would redirect development to other growth centres where water is available for supply and waste disposal purposes and where urban encroachment into prime agricultural areas can be minimized.

Ridgetown is in a similar situation but as a result of its location on the extreme headwaters of McGregor Creek, waste discharge constraints are even more critical. Assuming that spray irrigation or waste exportation to Lake Erie is impractical for the town, future development should be redirected to other areas.

5.6 OTHER WATER MANAGEMENT CONSIDERATIONS

Problems associated with erosion, land drainage, water supply interference, ground water quality impairment, and communication and co-ordination require some further discussion.

With regard to channel erosion, extensive programs for stream and river bank rehabilitation downstream from Chatham have been initiated through the Lower Thames Valley Conservation Authority, the Province of Ontario, and the Government of Canada. In addition, bank erosion problems upstream of Chatham as far as Delaware described in detail in the 1971 MacLaren Report, require further action.

An environmental impact assessment of land drainage proposals, as recommended by the Select Committee on Land Drainage (Final Report, June, 1974) would screen out or modify those proposals which could damage the environment. Because of the widespread drainage of wetlands carried out to date in the Thames River basin, some of the few remaining wetland areas should be identified and protected. One significant example of this type of area is the Zorra Swamp.

Prevention of water supply interference through careful planning rather than restoration of affected supplies is highly desirable both to avoid the problems and inconvenience associated with water supply disruption and to avoid the high costs of undertaking remedial action after interference has occurred. Test drilling and test pumping should precede any firm commitment to develop a large ground-water taking. Proposed stream withdrawals should be considered in the light of possible effects on downstream users. Particular attention should be paid to the flow rate that can be expected during seasonal low flow periods.

Remedial action to restore ground-water quality after impairment has occurred can be extremely difficult, time consuming, and costly. Continued upgrading of the water well inspection program and the existing water well regulations administered by the Ministry of the Environment will assist in preventing ground-water contamination. Where possible, activities such as landfills, feedlots, sludge spreading and lagoons should be sited on soil and material which have significant clay mineral content.

To resolve communication and co-ordination problems it is felt that a committee should be established including representatives of the ministries of the Environment, Natural Resources, Agriculture and Food, Housing, Treasury, Economics and Intergovernmental Affairs, the two conservation authorities, municipalities, citizen groups and the agricultural community. Such a committee could be responsible for the implementation of the recommendations of this report and arranging for the study of such topics as:

1. Land drainage, with a view to determining the proportion of river flow originating from this source and establishing guidelines for optimum levels of land drainage.
2. The operation and maintenance of municipal drains and the quality of municipal drain effluent to determine the most suitable means of maintaining them free of obstruction and pollution.
3. Techniques of farm erosion control.
4. Waste management of intensive livestock operations with a view to establishing closer controls to ensure that waste from these operations does not enter rivers and streams without prior treatment.
5. The implications of stream fencing to farmers.
6. The effects of on-stream ponds on surface water quantity and quality.
7. The effects and optimum levels of application of all chemicals to soil and crops.

Co-ordination could be assisted significantly through any action the committee could take to increase awareness among the basin's municipalities and residents that the watershed is an entity, forming a natural link between them that must be recognized The need for improved communication among organizations directly involved in water management, between these organizations and the public, and between groups such as the agricultural and urban communities could be met by this committee.

A related issue raised during the Public Consultation Program was the division of the Thames basin into two conservation authorities. The complexity of water management on a watershed basis, and the interrelationships of water resource problems and solutions in the upper and lower watershed is obvious. Notwithstanding the historical problems surrounding this issue, it is felt that amalgamation of the two conservation authorities into a single authority could significantly assist the basin wide approach to water management advocated in this report.

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APPENDIX A
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APPENDIX B

DISSOLVED OXYGEN CRITERIA

Dissolved oxygen criteria are narrative definitions of concentrations of dissolved oxygen below which unacceptable stress conditions exist for different species of fish. It is necessary to define for how long and in what period of the year the concentration should be exceeded. Biologists realize that true optimum conditions of dissolved oxygen for fish are those of saturation. Any reduction from saturation represents some stress on fish; different stresses occur for different species at different times of the year. The presence of other stress conditions such as toxic materials, high temperatures, etc., can magnify stress conditions on fish. Dissolved oxygen criteria are chosen high enough so that some safety factor is included to account for chance occurrences of other stress factors.

The criteria defined below were derived from criteria for the protection of fish and aquatic life published in "Guidelines and Criteria for Water Quality Management in Ontario" (Ontario Ministry of the Environment, 1974). Some revision in terminology was necessary because of the requirement that criteria be stated in statistical terms so that output from the water quality simulation model could be evaluated.

Criteria A: "The dissolved oxygen concentration should be above 7 mg/L 95 percent of the time in a given month. Concentrations may range between 7 mg/L and 6 mg/L for periods up to four hours in length within any 24 hour period, provided that water quality is favourable in all other respects."

Criteria A represent a high quality of water with a minimum of stress, to be applied in the spawning periods of sensitive fish species such as pickerel and trout.

Criteria B: "The dissolved oxygen concentration should be above 6 mg/L 95 percent of the time in a given month. Concentrations may range between 6 mg/L and 5 mg/L for periods up to four hours in length within any 24 hour period, provided that the water quality is favourable in all other respects."

Criteria B represent a high quality of water with a minimum of stress, to be applied for warm water fish species in spawning periods and for cold water fish species in non-spawning periods.

Criteria C: "The dissolved oxygen concentration should be above 5 mg/L 95 percent of the time in a given month. Concentrations may range between 5 mg/L and 4 mg/L for periods up to four hours in length within any 24 hour period, provided that water quality is favourable in all other respects".

Criteria C represent an acceptable quality of water with some stress, to be applied for warm water fish species in non-spawning periods.

Criteria D: "The dissolved oxygen concentration should be above 5 mg/L 95 percent of the time in a given month. Concentrations may range between 5 mg/L and 3 mg/L for periods up to eight hours in length within any 24 hour period, provided that water quality is favourable in all other respects".

Criteria D represent a marginally acceptable quality of water with some stress, to be applied for warm water fish species. The criteria would be applied in presently degraded areas where the result would be an upgrading of the water quality to remove existing severe stresses on fish species.

Interpretation

The meaning of the criteria can be shown by considering an example for June. Criteria C would allow dissolved oxygen concentration to fall below 5 mg/L for a total of 36 hours as long as any single occasion does not exceed four hours in duration and as long as the concentration did not fall below 4 Mg/L. All three conditions, therefore, must be met. Meeting the criteria implies that concentrations are much higher than the critical level most of the time and that occurrences of stress conditions would be rare.

Criteria Application

Water quality objectives can be translated into specific dissolved oxygen criteria for a given watercourse by referring to existing and potential aquatic life in a watercourse. Objectives for each watercourse in this watershed can be met if the criteria defined above are applied as outlined in Table B 1. Separate criteria are applied in different seasons of the year only where the requirements of the fishery warrant it.

Table B1: Dissolved Oxygen Criteria

(a) Criteria Definition	Criteria A	Criteria B	Criteria C	Criteria D
Concentration exceeded 95% of time in a given month	7 Mg/L	6 Mg/L	5 Mg/L	5 Mg/L
Max. allowable duration	4 hrs	4 hrs	4 hrs	8 hrs
Critical level, concentration not to fall below	6 Mg/L	5 Mg/L	4 Mg/L	3 Mg/L
(b) Criteria Application				
North Thames River				
Channel Section or Tributary	Spring	Summer	Fall	Winter
Headwaters to the mouth of Avon River	D	D	D	D
Avon River upstream from Lake Victoria	C	C	C	C
Avon River-Lake Victoria to mouth	D	D	D	D
Avon River mouth to St. Marys	C	C	C	C
Trout Creek	A	B	A	B
St. Marys to Fanshawe Reservoir	B	C	C	C
Fish Creek	C	C	C	C
Fanshawe Reservoir	B	C	C	C
Wye Creek	D	D	D	D
Thames River above London				
Channel Section or Tributary	Spring	Summer	Fall	Winter
Headwaters to Gordon Pittock Reservoir	B	C	C	C
Gordon Pittock Reservoir	B	C	C	C
Gordon Pittock Dam to the mouth of the Middle Thames	C	C	C	C
Cedar Creek	A	B	B	B
Reynolds Creek	C	C	C	C
Middle Thames River	A	B	B	B
Mouth of the Middle Thames to London	B	C	C	C
Thames River—London to Lake St. Clair				
Channel Section or Tributary	Spring	Summer	Fall	Winter
North Thames-Fanshawe Dam to the confluence of the North and South branches	C	C	C	C
South branch to the confluence with the North Branch	C	D	D	D
Medway River	C	C	C	C
Confluence to Springbank Park Dam	A	D	D	D
Springbank Park Dam at Wardsville	A	C	C	C
Oxbow (Springers) Creek	A	B	B	B
Dingman Creek	D	D	D	D
Sharon Creek	D	D	D	D
Newbiggen Creek-Komoka Creek	A	B	A	B
Wardsville to Chatham	A	C	C	C
Chatham to Lake St. Clair	A	C	C	C
McGregor Creek	C	C	C	C
Jeannette Creek	C	C	C	C
Big, Tilbury and Baptiste Creeks	C	C	C	C

The expression of criteria in terms of "concentration should be above X mg/L95 percent of the time in a given month", implies that continuous data are required in the form of observations or computer model predictions for full application of the criteria. In locations where continuous data are not available, criteria stated as above are still applied, although a simpler interpretation of the criteria is used.

For example, in setting waste loading guidelines in cases where steady state dissolved oxygen models are used, it will be required that the 95 percent value (e.g. 5 Mg/L for Criteria C) be met or exceeded in the design case. The design case typically consists of mean waste treatment loads and a 7-day mean flow with a 95 percent chance of non-exceedance. The design procedure implies that occurrences of dissolved oxygen concentrations below the 95 percent level are possible but with an unknown frequency.

Definition of Seasons

The seasons referred to in Table B1 are defined as follows: Spring-March 16 to May 31; Summer-June 1 to September 15; Fall-September 16 to November 30; Winter-December 1 to March 15. These dates have been selected according to fish life cycles with particular emphasis on spawning and nursery periods.