Environmental Protection Service
Department of the Environment
Government of Canada

CONTRIBUTION OF SEDIMENTS AND OTHER POLLUTANTS TO RECEIVING WATERS FROM MAJOR URBAN LAND DEVELOPMENT ACTIVITIES

April, 1974.

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PREFACE

This report on the Contribution of Sediments and Other Pollutants to Receiving Waters from Major Urban Land Development Activities has been completed in accordance with the terms of reference provided in the Agreement, departmental reference SS03.KE204-3-EP12 dated November 19, 1973.

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1.0 INTRODUCTION

This report provides a preliminary evaluation of soil erosion and pollution problems and soil conservation practices appropriate to major land development activities within the Canadian portion of the Great Lakes Basin. The studies have been based upon an extensive review of published literature and other source documentation provided by government and private sources both from Canada and the United States. In addition discussions have been held with various government agencies and private developers in Ontario as well as with the U.S. Soils Conservation Service in Washington and with State and County officials in Maryland.

1.1 Terms of Reference

The terms of reference for this study have been as hereunder.

To conduct an inventory and literature review to determine and assess the extent to which major urban land development activities contribute sediments and other pollutants to the receiving water and to develop a test program for actual field surveys at existing land development sites.

Unless the context otherwise requires, land development activities will include: major subdivision construction, the construction of transportation facilities and utilities construction such as subways, roads, bridges and pipelines, etc., as well as the construction of large urban buildings such as apartments, office buildings and shopping centres.

The specific tasks identified as forming the work program are:

1. *Determine the approximate acreage which is involved or is being disrupted by construction activities by:*
   a) *Interpretation from recent small to medium scale colour photography of approximately 5,000 sq. miles of the Great Lakes basin centered upon Toronto and extending to the Georgian Bay area.*
   b) *Interpretation from sequential large scale photography (1" to 2000 feet) of the Don River catchment area.*
   c) *extending the knowledge gathered from aerial photography with information from agencies of both Federal and Ontario government as well as from the private sector.*

2. *Investigate current practices for sediment loss control both during and after construction.*

3. *Review all relevant information on existing guidelines for sediment control, such as those developed by the Soil Conservation Service of the U.S. Department of Agriculture, and determine their applicability for Canadian construction situations.*

4. *Make recommendations which should be carried out in order to minimize sediment losses from construction activities.*

5. *Develop a test program for further studies involving actual field surveys at existing land development sites, covering a variety of soil conditions, in order to obtain quantitative data on the amount of sediments and other pollutants. This program should consist of detailed site analysis, including comparisons with non-construction or completed sites which exhibit similar soil conditions.*

The test programme will maximise output information from proposed level of input by investigating alternatives and suggesting study schedules budget estimates, etc.

1.2 Resume of Studies

The study was thus directed toward an assessment of the current status of activities in major developments within the Great Lakes Basin, a review of soil conservation practices and the development of proposals for appropriate follow-up studies.

The first aspect has been considered at three levels of interpretation. A detailed evaluation of the effects of urbanization on sediment yields for the Don River catchment indicates that during the 25-year period from 1947 to 1973 development activities occasioned a very significant increase in sediment yields and, even yet, stabilization of urban lands has not reduced yields to those obtaining before the post-war expansion of Metropolitan Toronto. As a direct consequence the Toronto Harbour Commission has been and continues to face a substantial increase in their costs for maintenance dredging from the outlet Keating Channel. Moreover, other studies have shown that the river channels and steep valley slopes in a number of sub-reaches of both the east and west branches of the Don have become unstable. Thus, the consequences of alterations to drainage and streamflow characteristics are posing substantial costs for remedial works to the Metropolitan Toronto Regional Conservation Authority.

The character of development activities was observed to change during the 25-year period. In the earlier years open subdivisions remained under development for some years, whereas during latter years a much more rapid completion was more typical. It is, however, concluded that the situation represented by the Don River development process, in terms of the severity of erosion losses, would not be repeated under application of now current practices.

An attempt was made to evaluate the level of current activities across an area of some 5,000 sq. miles of south-central Ontario from photo-interpretative study of recent small-scale NASA photo cover. However, only the larger areas of development activity could be identified, as determined from comparision with overlap coverage of the Don Basin study. It is concluded that interpretation based upon photography at a scale of less than about 1:25,000 does not provide a reliable basis for identifying or monitoring the significant areas undergoing change in land use.

An estimate has been developed from analysis of statistical information of development activities which indicates that about 40,000 acres is representative of the order of magnitude of lands currently undergoing transformation from rural to urban uses and for utility and highway construction within the Great Lakes Basin. The comparable figure for the Province of Ontario is about 50,000 acres per year. While some limitations in the statistical approach have precluded consideration of certain types of development activity, particularly those of an intermittent nature, it is concluded for the province as a whole, and for that part within the Great Lakes Basin, that the acreage defined is reasonably representative.

A review has been made of soil conservation practices in construction and development of major urban areas, of power utilities and of highways in the Province of Ontario. Current practices commonly adopted in the United States were reviewed with the U.S. Soil Conservation Service and representatives of Maryland State and Montgomery County. In addition an extensive review has been made of published material dealing with sedimentology and the application of soil conservation measures to the control of erosion in urban environments and from other major construction activities. The administrative and jurisdictional approach adopted in the United States, as well as the sequencing of development differ somewhat from those followed in the Province of Ontario. However, from the technical standpoint it appears there is little significant difference in approach. Within Ontario, apart from federal and provincial statutes affording control over all forms of environmental impacts, the establishment of watershed conservation authorities facilitates the evaluation and control of development activities in terms of natural physiographic drainage units, an aspect which is regarded as essential in the United States but subject to considerable jurisdictional difficulties there on account of the historic development of authority and responsibility at state and county levels.

As a consequence of the creation of a separate soil conservation service there has been a specific focus of attention upon soil erosion within the United States leading to considerable research into erosion control measures. An extensive body of literature on research and applied practices has been published which is readily available in Canada. All organizations within Ontario and the Federal Government, who have been contacted, appear to be aware of this technical documentation and have adapted much of this material together with the results of research appropriate to Canadian conditions to their own specific agency requirements.

The moderate levels of sediment yield typical of broad areal erosion throughout the Province of Ontario support the view that development activities have not occasioned widespread erosion problems. Nevertheless, as is illustrated by the case study of the Don Basin, the accumulative effects of soil erosion can pose significant environmental, social and economic problems. Although practices now adopted would likely preclude a repetition of the intensity of problems experienced in the Don Basin, this will be so only to the extent potential hazards are recognized prior to development and sites presenting special problems reserved for non-intensive use.

The federal Department of Public Works has published a general guideline as to best practice with respect to site selection and development. The Ontario Ministry of Transport and Communications has published a general guide for highway routing and landscaping. Other documentation is principally in the form of internal design standards adapted to the specific functional responsibility of each agency. Development of a broad set of guidelines and standards for soil conservancy does not appear warranted or necessary within the Canadian context. It would appear more appropriate that each agency continue to adopt policies and practices appropriate to its own sphere of activities.

In general we are unable to suggest or recommend specific erosion control measures supplementary to those already adopted or considered by the various government and private agencies concerned with implementation of major developments. From our review it appears that the agencies concerned with planning, design and review are well acquainted with current technology and generally-accepted sound development practices. Some improvement in the monitoring of activities does appear warranted to ensure compliance with established requirements, and formal certification of compliance by the developer's engineer/architect would provide an additional check supplementing the local works department inspections.

The development of a test program of field studies to obtain quantitative information on the yield of sediments and other pollutants from development sites has been rejected as a means of enhancing the knowledge of urban sedimentology in favour of recommendations for the broader development of taxonomic soils interpretations which would find widespread direct application in the assessment of erosion hazards and selection of appropriate construction practices. In this regard we point out that a very considerable number of such site investigations taking into account different soil conditions, sequences of climatic events, construction practices and other parameters would be necessary to develop meaningful insights. Such a program would, in fact, represent an unnecessary duplication of erosion test studies which have already accumulated many thousands of plot-years of data in the United States.

Development of the "universal soil loss equation" and its application to the analysis of potential soil losses under different management and control practices has evolved from this broadly-based United States research effort. The applicability of this approach has already been demonstrated throughout the United States for all areas east of the Rocky Mountains. The U.S. Soil Conservation Service, which originally developed the universal soil loss equation to improve agricultural practices, has in recent years successfully adapted the methodology to analysis of urban sedimentology. It therefore appears redundant to initiate, at this time, a basic data program which would contribute only marginally to the extensive body of data already accumulated.

We have, therefore, concluded that a more appropriate follow-up to this study would involve development of parameters, particularly rainfall and soil erodibility factors, to facilitate application of the universal soil loss equation and associated methodology for the analysis of different physiographic and soil conditions throughout southern Ontario. The basic soils and climatic data required have already been accumulated. The work necessary requires an extension of the taxonomic interpretations and broad correlations of these with climatic records. Provision of these interpretative parameters would facilitate the application of the large body of interpretative information already available from United States sources concerning land management and construction practices to the planning and assessment of the effects of all manner of land disturbing activities.

The control of erosion, as with most other aspects of environmental conservation, either finds place at the planning and design stages or not at all. Within the context of recent developments in soil surveys there is a trend toward enhancing the usefulness of pedologic soils interpretations and mapping through correlation with physical and engineering soils data. We believe the expansion of soil survey taxonomy to include such interpretations would be of considerable assistance in the planning and evaluation of developments and recommend that the federal and provincial government give favourable consideration to proposals which it is understood have been made to this end.

Although various soil conservation practices, developed initially for application to agriculture, have been successfully adapted to the control of erosion from urban sites, it is concluded that the pollutional impact of fine-grained materials and dissolved contaminants from such urban developments has not yet been fully assessed. The effectiveness of small sediment traps, as widely used to control soil losses from construction sites in the United States, must, therefore, be questioned. Preliminary research into means of improving sediment trap efficiency has been initiated recently by the Soil Conservation Service.

Adverse impacts of the aquatic ecology of receiving waters suggests that a significant portion of such impacts are likely to be associated with the fine-grained materials. As a consequence of the concern over adverse effects arising from dredging activities, a program of studies have been initiated by Canadian and U.S. agencies focusing upon the degradation of water quality within the Great Lakes through dredging and redeposition of primarily fine-grained sediments.

A research program currently underway at Guelph University is assessing the impact of sedimentation on the ecology of the Hanlon Creek watershed. A part of the research program involved the construction of two sediment ponds designed to achieve 90 percent efficiency in removal of solids. Since much of the basic research has already been completed, or is in hand, it would appear worthwhile considering an increase in the research grant to enable the Hanlon Creek study team to undertake design modifications and conduct evaluations of the significance of various levels of trap efficiency in terms of adverse impacts on stream ecology.

1.3 Acknowledgements

This report has been compiled from an extensive review of published material, internal technical memoranda of a number of government and private agencies and the generous assistance of a great many individuals from government and private industries, who have contributed both their time and experience as well as providing essential data and information.

To all who have contributed the authors are indebted. Although not all these are named we would be remiss in failing to acknowledge the generous assistance provided by:

Mr. T. M. Kurtz	Conservation Authorities Branch, Ministry of Natural Resources.
Messrs. J. B. Wilkes, E.W. Orr, I. Oliver, H. Spear and S. Cant	Ministry of Transport and Communications, Ontario.
Messrs. D. N. Jeffs and J. Ralston	Ontario Ministry of Environment.
Mr. W. Webb	Ontario Housing Corporation.
Mr. C. Shrok	City of Toronto Engineering Department.
Mr. K. S. Fricbergs	Toronto Harbour Commission.
Mr. A. Duperon	Intergovernmental Committee on Urban and Regional Research.
Mrs. D. Santo	Plans, Administration Branch, Ontario Municipal Board.
Messrs. R. Westwood and T. B. Reynolds	Ontario Hydro.
Mr. J.P.C. Elson	Minto Corporation.
Mr. T. M. Gatszegi	Campeau Corporation.
Professors J.B. Milliken, P.S. Chisholm and R.S. Rodd	University of Guelph.
Mr. G. B. Welsh and colleagues	United States Soil Conservation Service, Washington, D.C.
Mr. W. P. Weldon	State Resource Conservation Office, Maryland.
Mr. G. Stem	District Conservationist, Montgomery County, Maryland.

2.0 SEDIMENTATION AND POLLUTION OF WATER COURSES

The erosion, transportation and deposition of soil materials, organic debris and cultural wastes are inter-related processes in the sedimentology of streams and rivers. Soil formation, erosion and sedimentation are natural processes in the geomorphologic evolution of the landscape and continue at a background level throughout the undisturbed portions of the environment. However, we are not greatly concerned by such slow changes which under most circumstances impose only slight impacts upon the biosphere. To be sure there are examples of natural disasters of catastrophic proportions in which extreme and rapid change is imposed through occurrence of major storms, landslides, floods, volcanic eruptions, earthquakes and forest fires. The impact of such events may be very severe and nowadays result in significant damages. Fortunately, however, most such events are relatively infrequent and are by nature specifically unpredictable. Only in local areas, where the hazard appears high and the potential damage excessive, is there justification for special works to mitigate the worst effects anticipated.

Herein, we are concerned with an intermediate level of land disturbance which over a short to medium term impose significant, though not catastrophic, environmental, social and economic damages. The acceleration of erosion being induced through man's activities is essentially subject to man's control.

An increase in the rate of sedimentation occurs as forests are cleared and the land plowed for agricultural use. A further increase in the rate of erosion generally occurs as the landscape is more severely modified to build roads, develop towns and cities and construct other facilities essential to economic and social development. Studies of the relative rates suggest that in the process of changing from forest to agricultural use, erosion rates typically increase tenfold. In converting agricultural lands to urban uses the sediment yields may be increased by two to three orders of magnitude, with the highest rates prevailing throughout the active development period but nonetheless continuing to yield sediments at rates several times that from less intensive forms of land use. (14).

Many aspects of soil conservation practices have ancient origins. However, understanding of the severe problems which can arise in watersheds undergoing changes in the intensity and types of land use are much more recent. Loss of soil fertility and, through downstream accumulation and blockage of stream-flows, increased flood levels are the most obvious consequences of poor land management practices. The contamination of natural sediments with cultural wastes and chemical pollutants is currently recognized as posing a potential hazard to the environment with consequent stress damages to the ecology of streams and lakes.

In North America significant problems arose in the mid-western semi-arid regions of both the U.S. and Canada during the 1920's and 1930's where deep tillage and other cultivation practices suited to more humid climates exposed the soils to severe wind erosion and resulted in widespread loss of fertile topsoils. Considerable attention has been focused upon development of good soil-husbandry practices for agriculture under varying climatic conditions and soil formations. These include contour plowing and terracing of steeper-sloped lands, planting of fast-growing cover crops, fall planting of some cereal grains and other conservation measures such as planting of windbreaks, and reforestation of marginal agricultural lands.

Although there have been particular instances of sedimentation problems in urban areas, the focus of attention on soil erosion and conservation under urbanizing processes has been more recent in terms of a general concern. Much of the technology generated from the management of agricultural and forestry lands has been successfully applied. However, the more substantial reshaping of the land surface involved in high density development activities imposes conditions which require their own specific solutions, both to mitigate losses during construction and to stabilize the land and drainage following development.

In addition to the ecologic impacts resulting from increased yield of sediments derived through regrading of the landscape is the alteration of the hydrologic regime imposed upon natural watercourses - an alteration which may be so rapid as to drastically overload smaller systems. As areas are urbanized a large proportion of the land is rendered impervious through the roofing of buildings, the paving of streets, driveways and parking lots. This reduction of infiltration capacity results in a more rapid concentration of short runoff which is conveyed from the streets through storm sewer systems to the receiving streams. Thus flood peaks tend to be higher and the time of concentration more rapid. The total volume of direct runoff also increases. This enhancement of storm-runoff characteristics provides for an increase in sediment transport capacity. The continuing imposition of high rates of sediment loadings to receiving streams leads to final deposition in a lake or artificial reservoir. In the meantime transient bars and shoals impede the river during low and normal flow periods and increase flood stages over those previously experienced. The receiving stream will likely suffer prolonged instability as it attempts to adjust to the altered regime conditions.

2.1 Sources of Sediments

Sedimentation is a natural process which reduces the parent rocks to smaller fragments and, through the forces of wind and run-off, transports these mineral soil fractions together with the weathered and decomposed organic detritus and solution products to streams and receiving lakes.

Although the primary focus of this report is directed to sedimentation effects arising through major land development activities, it must be recognized that the most severe effects are transient phenomena arising during the period when lands are being converted from agriculture or forest uses to urban uses or when highways or other utilitites are under construction disrupting the drainage along linear paths across the landscape. In most instances the direct sediment and pollutant yield has not been measured, although this may sometimes be inferred from differences between yields prior to development and thereafter.

Sediments are erosion products and include soil particles, organic detritus and by-products from decomposition and fragmentation of cultural wastes. Soil particles, particularly fine-grained materials, have significant adsorption capacities and may combine with anions and cations of metals, sulphates, phosphates, nitrates or other chemical components as may be available. These adsorption complexes and other dissolved solids are conveyed from the land surface through overland sheet flow, rill flow and finally stream flow. Depending upon the nature of these contaminants, environmental impacts within streams and in the receiving waters involve excess oxygen demands, nutrient stimulation and toxicity effects.

The removal of vegetation and topsoils exposing the subsoil strata and the re-grading of natural land forms, which are essential steps in the development of highways and cities, can give rise to vastly increased sedimentation rates. (In various locations of the USA urbanization has been reported to occasion an increase in yields from a few hundred to more than 25,000 tons per sq. mile per year). (14). Erosion rates vary markedly with intensity of rainfall and runoff although as has been reported by Guy and Jones (53), there is considerable evidence accumulating which indicates the maximum difference in sediment yield rates between developing and natural areas occurs during the more frequent storms. Glymph and Storey (44) cite a study of the records of 72 watersheds in the United States ranging in size from 100 to 100,000 acres which showed that storms with a return period greater than two years caused from 3 to 46 percent of the total average annual suspended sediment yield; storms with a one to two year return period caused 3 to 22 percent of the total; and storms with a return period of less than one year caused 34 to 92 percent of the total suspended sediment yield. In contrast with the foregoing, which are derived from studies of the river basins within the humid eastern region of the country, Glymph and Storey report sediment yields from southern California which indicate that 75 percent of average annual sediment totals are produced by storms having return periods greater than three years. The basic difference is accounted for by the nature of the sediments which in the eastern portion of the country are typically fine-grained materials derived as wash-load, whereas in southern California sediments typically consist of sand, gravel and boulders transported as bed-load and hence more directly related to the rate of stream discharge.

Erosion losses are much influenced by climate. Humid conditions usually give rise to sheet and rill losses. Semi-arid conditions promote the development of only shallow soil profiles and do not provide sufficient moisture for development of a complete vegetation cover so that erosion potential from wind as well as from storm rainfall is high. In considering the effects of sedimentation upon receiving waters it must be borne in mind that, with few exceptions, recorded data represent aggregate effects which combine the geologic processes of erosion and deposition with sediment yields enhanced through man's continuing alteration and modification of the land surface. Except in the remote north and the western mountains of Canada there is probably very little of the country which has not been altered in some respect through man's activities: deforestation and cultivation, urbanization, construction of communication corridors, modification of streams and rivers, creation of artificial reservoirs and diversion of water to consumptive use both from surface sources and from the groundwater. All these activities impinge upon the natural environment and result in modification to sediment yields and stream morphology.

To understand the role of major development activities in modifying natural processes it is useful to review briefly the sources of natural sediments and of other pollutants. Sediments derive from the decomposition of rock materials. The principal agents promoting this decomposition are temperature, rainfall and runoff, wind and mechanical abrasion. Decomposition may be hastened by acidic soil moisture conditions, glaciation and cycles of freezing and thawing. Soils are formed in situ over the parent rock or from unconsolidated glacial debris or alluvial deposits. All of the parent soils of Ontario have been considerably modified and redistributed by the mechanical forces of glaciation. Thus the landscape of southern Ontario is dominated by glacial deposits superimposed upon which are wave-built deposits, shoreline formations, wind deposits as well as fluvial, lacustrine and marine deposits from inter-glacial and recent periods. For an overview of the Pleistocene glacial period and its influences upon the landscape and soils of Ontario, the reader is referred to the Origin, Classification and Use of Ontario Soils (37) and for more comprehensive detail to the definitive treatise on the physiography of southern Ontario by Chapman and Putnam (38).

Soil formation is a progressive action. Somewhat arbitrarily, two stages of soil formation may be distinguished, the first involving the accumulation of parent soil materials, in Ontario principally by ice and water during deglaciation, and secondly the differentiation of the surface material into soil horizons or layers.

Horizon differentiation in a soil is attributable to four main processes: additions, removals, transformations and transportation. Additions include energy from solar radiation, matter as gases, water from precipitation and groundwater movements, solids dissolved in water, solids transported by wind and water, and many forms of pland and animal life. Removals include energy radiated and reflected, evapotranspiration losses as gases, solids dissolved or suspended by water, plant and animal life by emigration and harvesting. Transformations result from chemical reactions such as solution, oxidation, carbonation, hydration and hydrolysis, while translations commonly consist of illuvial relationships among the horizons and consist mainly of losses from upper-layers which are balanced in part by gains in lower-layers. Organic matter which is added to the soil as fresh residue may be transferred by microbial oxidation or lost by decay. Other portions may be translocated from one horizon to another, as, for example, nutrients taken up by plants from the parent soil which are returned in part as leaves littering the soil surface at different locations. At the same time a part of the carbon assimilated in the leaves is transferred to the roots and finally to the soil (37).

Topsoils are bound together by the cohesion of the clay soil fraction, organic materials, soil moisture tension and the rooting system of the vegetation which also protects the ground surface from the direct dislodgement of soil particles by falling rain and wind. Substrata soils are generally more friable and, when exposed, offer less natural resistance to erosion forces. Although many of the sub-soils of southern Ontario contain a substantial amount of binding clay materials, upon prolonged exposure and drying, the loss of soil moisture renders even dense till materials liable to be readily eroded.

Turbidity and siltation are detrimental to aquatic life. Siltation often traps organic matter on the beds of waterbodies and may result in anaerobic conditions. Turbidity,through limiting light penetration,delays the self-purification of water and thus promotes transport of organic wastes and other pollutants over long distances. It is reported that silt often destroys eggs in fish spawning gravels by reducing water seepage and hence oxygen supply and occasions further losses through burial or suffocation of eggs and larvae. Numerous instances of the impact of siltation and turbidity upon the ecology of streams and lakes in both Canada and the United States are reviewed by Hollis et al (113).

2.2 Sources of Other Contaminants

A variety of contaminants including oils and greases, heavy metals from automotive exhaust fumes and precipitates from industrial sources, salts from snow-clearing programs, fertilizers, pesticides, herbicides, decaying organic matter and other cultural wastes find their way into receiving waters through surface runoff from the roofs, streets and vegetated areas within an urbanized zone, along our highways and from industrial sites. Many of the dissolved solids are adsorbed into complexes, particularly with the finer-grained soil particles, and these impinge upon the water quality of the stream and its ecology during transport and while in transient shoal deposits.

The concentration of such materials in natural watercourses is determined for some 760 locations throughout Ontario by the Water Quality measurements of the Ontario Ministry of the Environment. These records do not, in most instances, permit a direct interpretation of the contribution of pollutants which originate from disturbance of the landscape during development although they do provide for an identification of trends indicating deterioration of water quality. As is discussed in Section 3.4, the contribution of sediments can be quite high during active construction and level off thereafter at rates rather higher than under conditions prior to development. Although few specific data have been recorded, it is reasonable to assume that the concentrations of chemical contaminants would be higher following development as a greater potential loss of pollutants is associated with intensive occupancy and land use.

Dust fallout is also a source of solids eventually reaching the stream courses. During 1966 the average dustfall loading in Chicago was 0.7 tons per acre. It was estimated that the street refuse components (rags, papers, dirt, vegetation, organics) would average approximately 1.3 tons per acre per year and of this amount the dust and dirt fraction was approximately 0.8 tons per acre per year. (14).

2.3 Sedimentology of Urban Environments

The sediments from an urbanizing area derive largely from erosion of substrata exposed during cut and fill operations required for the formation of streets, building sites and installation of underground utilities. During the period of construction, unless some control is exercised, more land clearing and grading may be done than is actually required. In the past, development has often been allowed to encroach upon steep slopes resulting in the disruption of the natural drainage, and not infrequently introducing seepage which precipitated land slides. During wet weather a good deal of soil is conveyed onto streets by trucks and other construction equipment where it is subsequently washed into the storm sewer system. Particularly during subdivision development, unless catch basins are cleaned regularly, the excess materials are carried directly to the receiving stream.

Following construction, and now more commonly as construction progresses, exposed areas are covered with top soils and stabilized with grasses and other vegetation. Nevertheless, even following stabilization, city streets in commercial and residential areas produce substantial quantities of debris and dirt. Data from U.S. sources indicate the following typical urban situation (14).

Dust and Dirt

Land Use	Lbs. per day per 100 feet of curb	Equivalent Tons per acre per year
Commercial	3.3	2.2
Industrial	4.6	3.0
Multiple Family Residential	2.3	1.5
Single Family Residential	7.0	0.5

Under winter climatic conditions in Ontario the widespread use of both sand and salt considerably augments the supply of sediments to the streets and ultimately the water courses draining the urban area. Although no representative data have been developed for Canadian conditions, it may be reasonably presumed that even from a well-stabilized urban area somewhat more than one ton per acre per year of sediments and cultural debris are washed into the storm sewage system.

The USGS has documented a number of instances of increased sedimentation resulting from urbanization. In the suburban area of Philadelphia and Reading, Pennsylvania, drained by Wissahickon Creek some 780 tons of sediments were discharged per square mile per year during active development in the watershed whilst the nearby Perkiomen Creek draining an area with similar topographic, geologic and hydrologic characteristics discharged about 210 tons of sediments per square mile per year. In another study of residential construction effects at Kensington, Maryland, the USGS determined an annual yield rate of 47,000 tons of sediments per square mile from a small suburban development. (14).

Studies of the effect of urbanization on flows in suburban Washington streams indicated an increase of 80 percent in flood peaks (45). During construction in suburban Maryland it was found that in most instances more land was exposed than appeared necessary. A sample survey indicated that some 40 percent of the lands being developed for residential accommodation remained unstabilized for more than one year.

Some typical data reported by Dawdy (45) indicates sediment yields as high as 140,000 tons per square mile per year from smaller construction sites and annual yields ranging from 1,000 to 25,000 tons per square mile from small river basins of up to 70 square miles in extent. These are compared with predominantly rural catchments yielding from 200 to 500 tons of sediment per square mile per year.

Numerous other studies of small catchment basins undergoing active transformation of land-use have indicated substantial increases in the yield of sediments (15, 32 and 41).

2.4 Sedimentology of Agricultural Lands and Forested Areas

Mature forests afford the greatest protection against soil erosion. Sediment yields for forested areas as low as 15 tons per square mile per year are reported by Dawdy (45) for lands with over 80 percent forest cover ranging up to 500 tons per square mile per year for areas of 10 percent or less forest cover. The relationship between sediment discharge and croplands in sub-basins of the Potomac River System showed an increase from about 80 tons per square mile per year for areas with 10 percent croplands to 300 tons per square mile per year for 50 percent cropland.

A detailed study of sediment yields of forested land in Colorado showed annual yields of sediments of only a few pounds per acre and demonstrated that, while such losses increased during and immediately following harvesting, the area stabilized rapidly towards pre-harvested levels within a few years (49).

Moore and Smith (76) estimate that erosion and sedimentation problems in the United States account for an annual loss on the order of $1 billion and consider that about one-third of all lands are susceptible to, or already badly damaged by, erosion. In general, sheet erosion is considered the most significant mechanism precipitating soil losses in humid regions whereas channel erosion is dominant in arid zones. Wind erosion occasions the greatest losses in semi-arid regions as well as causing serious local problems in humid regions (2).

Sediment yield rates are usually determined from measurements of suspended sediments in stream flow or occasionally from measurements of sediment deposits in reservoirs. Representative data for the United States are reported by Glymph and Storey (44) who indicate the average annual mean sediment concentration in various rivers ranges from about 200 to 50,000 ppm, being less than 600 ppm across 50 percent of the continental United States and less than 800 ppm over 90 percent of the country. Stichling (97) indicates typical concentrations in eastern Canada of between 50 and 200 ppm with a few smaller catchments in Ontario having yields of 200 to 400 ppm. Typical yields across western Canada range from 200 to 1,000 ppm with other higher rates in south central Alberta and southern Saskatchewan.

Evidence of the substantial increase in erosion as a consequence of man's activities is reported by Jonys (16) who cites recent studies of the Great Lakes which indicate a significant increase in the rate of accumulation of bottom sediments starting approximately 140 years ago which corresponds approximately with the period when early settlers began to clear land for agricultural purposes. Using the ragweed pollen horizon as an indicator, an average rate of modern sedimentation at a single location in Lake Ontario was estimated at 320 gms per square metre per year. The average rate of sedimentation at the same location, estimated using carbon-dating techniques, for a period of 3,000 years immediately preceding the 1830's, was indicated to have been 100 gms per square metre per year.

Since 1930, control studies on field plots and smaller watersheds have been extensively collated and have led to development of the Universal Soil Loss Equation for predicting rainfall erosion from croplands. (100).

The soil-loss equation is

$$A = R\ K\ L\ S\ C\ P$$

where A is the computed soil loss per unit area.

R, the rainfall factor, is the number of erosion-index units in a normal year's rain. The erosion index is a measure of the erosive force of specific rainfall.

K, the soil-erodibility factor, is the erosion rate per unit of erosion index for a specific soil in cultivated continuous fallow, on a 9-percent slope 72.6 feet long.

L, the slope-length factor, is the ratio of soil loss from the field slope length to that from a 72.6-foot length on the same soil type and gradient.

S, the slope-gradient factor, is the ratio of soil loss from the field gradient to that from a 9-percent slope.

C, the cropping-management factor, is the ratio of soil loss from a field with specified cropping and management to that from the fallow condition on which the factor K is evaluated.

P, the erosion-control practice factor, is the ratio of soil loss with contouring, stripcropping, or terracing to that with straight-row farming, up-and-down slope.

Soil loss tolerance, T, is a measure of the maximum rate of soil erosion (A) which will permit the indefinite sustaining of a high level of crop productivity. The U.S. Department of Agriculture have analyzed and correlated data and publish K, T and R factors for all regions of the United States east of the Rocky Mountains (86, 87). The U.S. Soil Survey taxonomic interpretations include these data together with qualitative interpretations of drainage and erodibility characteristics as well as physical properties of the soil series (82).

Soil Conservation Service officials report that they make extensive use of the Universal Soil Loss Equation in assessing the hazards from land use transportations, and have current research programs specifically directed to develop "C" and "P" factors for use in assessing the effectiveness of various construction practices and soil conservation measures applicable to small areas undergoing urbanization. (88).

The Soil Surveys of Ontario have not, as yet, made use of this approach although it is understood proposals have been made to correlate data and develop parameters for application of the Universal Soil Loss Equation to conditions in southern Ontario. At the present time, however, qualitative assessments of soil erodibility are being added to the taxonomic interpretations.

3.0 THE GREAT LAKES BASIN

The Great Lakes Basin occupies a total area of nearly 300,000 square miles of which the water surface area of the Lakes themselves and their connecting channels comprise some 95,000 square miles. The land area tributary to the Great Lakes is 203,000 square miles of which 88,800 square miles is within Canada*.

The Canadian portion of the basin contains nearly one-third of the country's population, much of which is concentrated within the Toronto-centred region and in southwestern Ontario. By far the majority of the population are urban residents and the trend in Ontario, as elsewhere, is to an increasing proportion of urban population.

Statistical data on population and economic activities are compiled for administrative subdivisions rather than for natural physiographic regions or catchment areas. In much of the discussion which follows reference to Figure 1 will indicate the administrative area under discussion.

3.1 Geography and Demography

The portion of the Great Lakes basin lying within Canada falls entirely within the borders of the Province of Ontario. The basin boundary north of Lakes Superior and Huron is often indeterminate, many of the streams draining to these lakes originating in swampy depressions which also give rise to Arctic drainage. The planed surface of the Precambrian Shield abounds with lakes and bog-filled depressions.

Southern Ontario includes portions of the Precambrian Shield within Hastings, Lennox and Addington and the southern extremities of

*The foregoing data are measured above Iroquois Dam, as reported by the Cornwall Office, Water Survey of Canada, March, 1974.

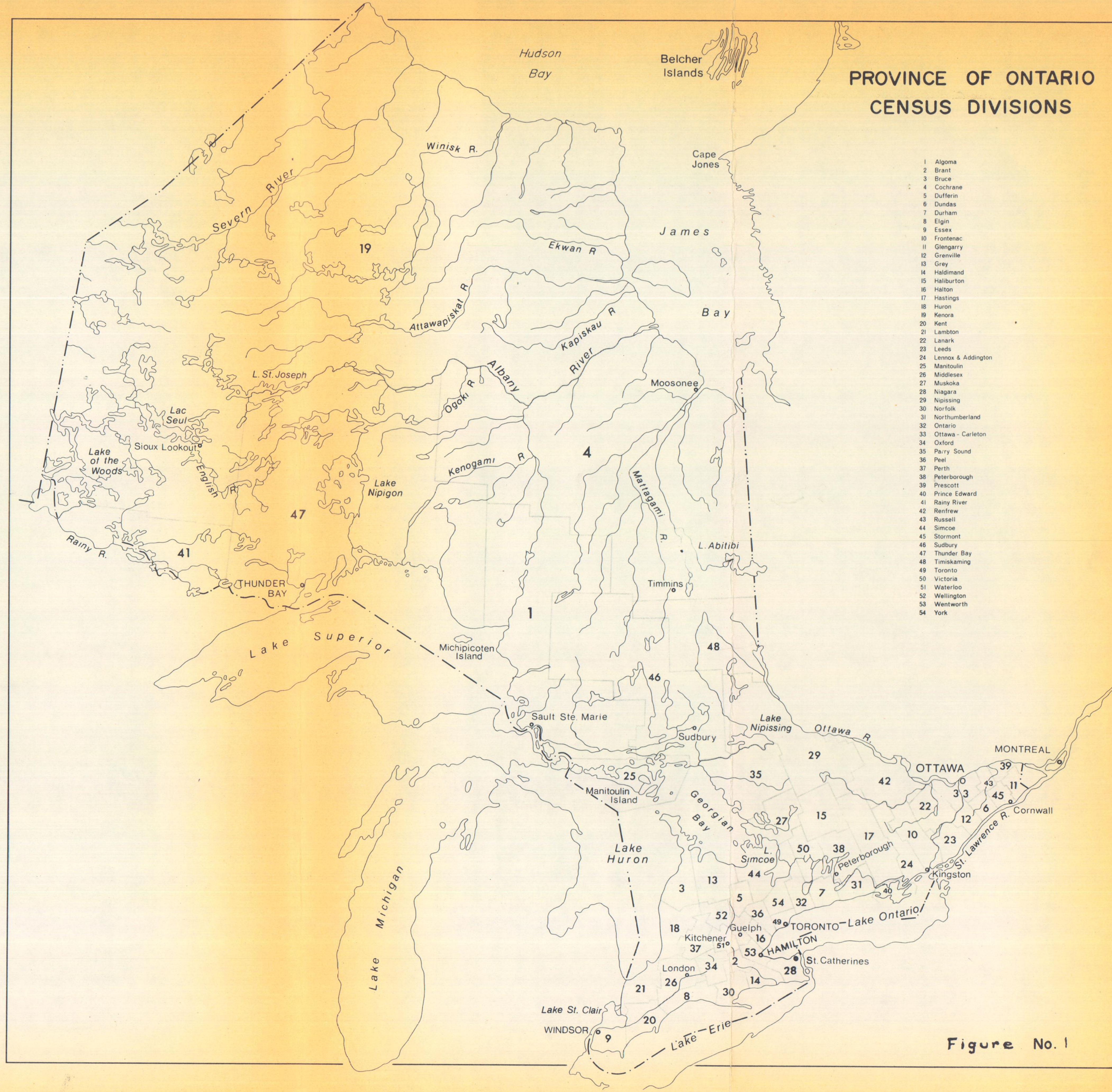

PROVINCE OF ONTARIO
CENSUS DIVISIONS
1 Algoma
2 Brant
3 Bruce
4 Cochrane
5 Dufferin
6 Dundas
7 Durham
8 Elgin
9 Essex
10 Frontenac
11 Glengarry
12 Grenville
13 Grey
14 Haldimand
15 Haliburton
16 Halton
17 Hastings
18 Huron
19 Kenora
20 Kent
21 Lambton
22 Lanark
23 Leeds
24 Lennox & Addington
25 Manitoulin
26 Middlesex
27 Muskoka
28 Niagara
29 Nipissing
30 Norfolk
31 Northumberland
32 Ontario
33 Ottawa - Carleton
34 Oxford
35 Parry Sound
36 Peel
37 Perth
38 Peterborough
39 Prescott
40 Prince Edward
41 Rainy River
42 Renfrew
43 Russell
44 Simcoe
45 Stormont
46 Sudbury
47 Thunder Bay
48 Timiskaming
49 Toronto
50 Victoria
51 Waterloo
52 Wellington
53 Wentworth
54 York
Hudson Bay
Belcher Islands
Cape Jones
James Bay
Winisk R.
Severn River
Ekwan R.
Attawapiskat R.
Kapiskau R.
Albany River
Ogoki R.
Kenogami R.
Mattagami R.
Moosonee
L. Abitibi
Timmins
L. St. Joseph
Lac Seul
Sioux Lookout
English R.
Lake of the Woods
Lake Nipigon
Rainy R.
THUNDER BAY
Lake Superior
Michipicoten Island
Sault Ste. Marie
Sudbury
Lake Nipissing
Ottawa R.
OTTAWA
MONTREAL
Cornwall
St. Lawrence R.
Kingston
Peterborough
Manitoulin Island
Georgian Bay
Lake Huron
L. Simcoe
Lake Michigan
Kitchener
Guelph
TORONTO
Lake Ontario
HAMILTON
St. Catherines
London
Lake St. Clair
WINDSOR
Lake Erie

Figure No. 1

Frontenac and Leeds counties. East of the divide bisecting Haliburton and Hastings counties, drainage flows to the Ottawa River. To the northwest, most of the Parry Sound and Muskoka districts are tributary to Lake Huron. The drainage basins within Ontario, as defined by the Ontario Water Resources Commission, are illustrated in Figures 2 and 3.

The population distribution and density at the 1971 Census are indicated in Table 3-1. As may be noted from this table, some 27 percent of the population were resident within the limits of Metropolitan Toronto while as shown in Table 3-3, page 37, more than 82 percent of the population reside in urban concentrations of more than 1,000 population.

3.2 Physiography and Drainage

The underlying build of southern Ontario can be traced to the warping, faulting and pre-Pleistocene erosion of the Paleozoic bedrock formations which extend throughout the region south and west of the Trent River system and east of the Frontenac axis which divides the Ottawa River basin from Great Lakes Basin drainage in southeastern Ontario. The Precambrian outcrops in the International section of the St. Lawrence River extends into and across Northern Ontario. The northern drainage to the Great Lakes lies wholly within the Shield area.

The present land forms of the Great Lakes Basin are the result of massive planing of the bedrocks during the Pleistocene epoch. During successive advances of the glaciers, soils were moulded, ground, transported and redeposited as hetrogeneous mixtures of stones and pebbles within a sand, silt and clay matrix. The present-day landscape is only slightly modified from that which emerged upon the retreat of the Wisconsin period glacier. Till moraines, eskers, drumlins, kames, flutings and glacio-lacustrine plains dominate the surface features of southern Ontario. (37)

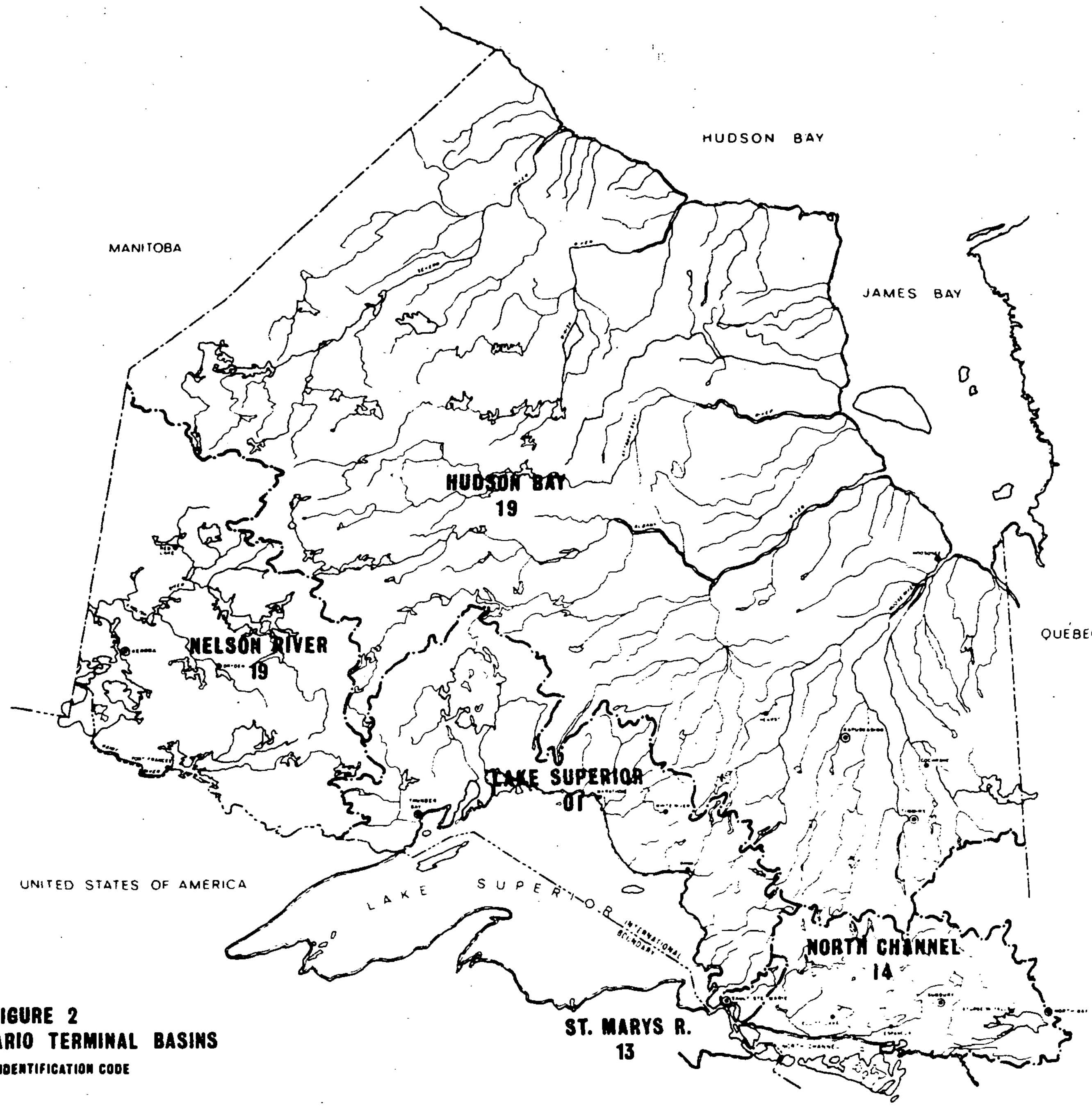


FIGURE 2
NORTHERN ONTARIO TERMINAL BASINS
19 — BASIN IDENTIFICATION CODE

Source - Ontario Water Resources Commission

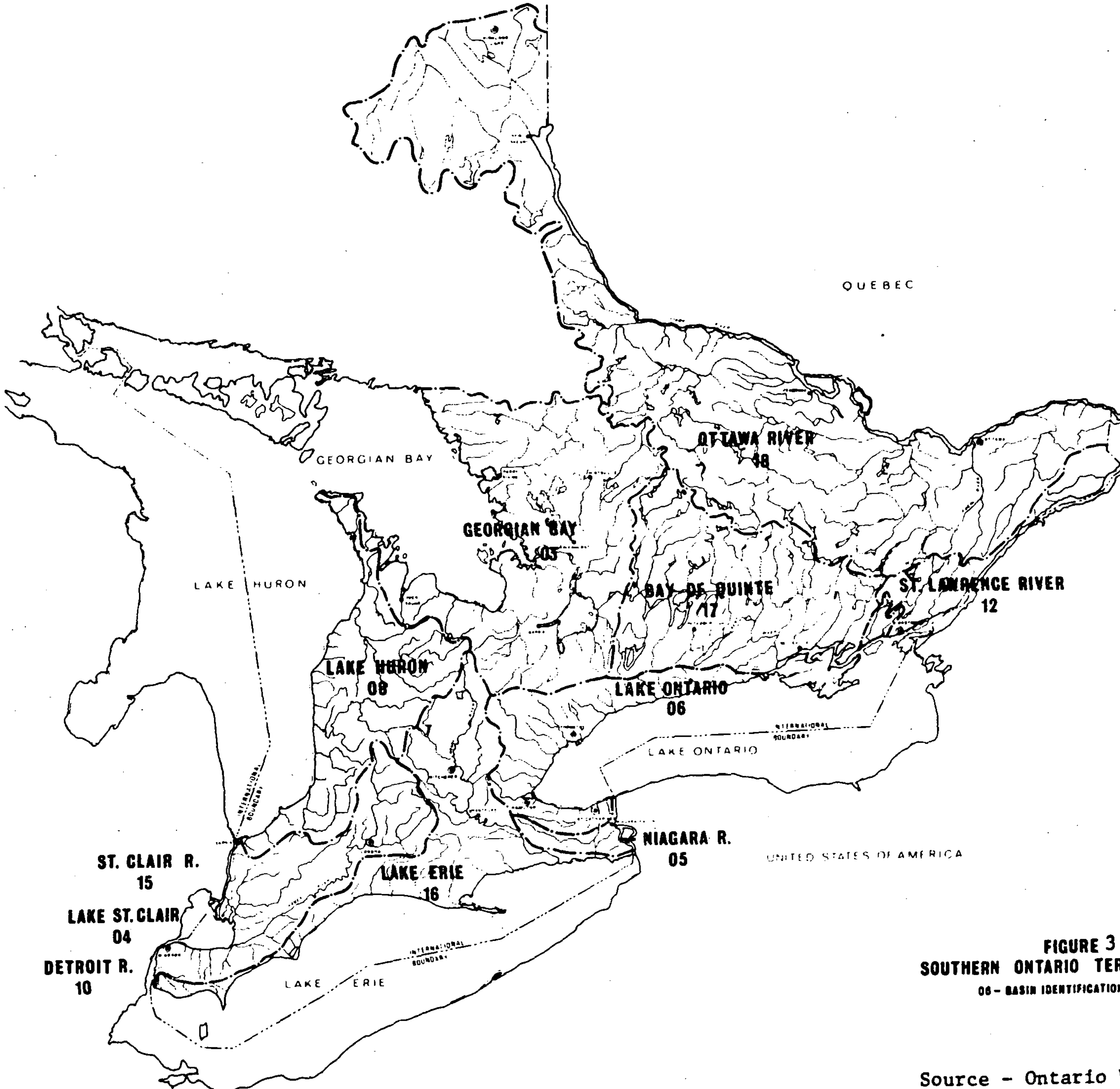


FIGURE 3
SOUTHERN ONTARIO TERMINAL BASINS
06 – BASIN IDENTIFICATION CODE

Source - Ontario Water Resources Commission

TABLE 3-1

Area and Density of Population, Province of Ontario, for Census Division, 1971

Census division	Population	Land area in square miles	Population density(3)
Ontario	7,703,106	354,223(2)	21.75
Algoma	121,937	19,771	6.17
Brant	96,767	422	229.56
Bruce	47,385	1,563	30,31
Cochran	95,836	55,584	1.72
Dufferin	21,200	575	36.86
Dundas	17,457	393	44.37
Durham	47,494	619	76.70
Elgin	66,608	726	91.77
Essex	306,399	719	426.16
Frontenac	101,692	1,475	68.95
Glengarry	18,480	481	38.40
Grenville	24,316	462	52.68
Grey	66,403	1,739	38.18
Haldimand	32,673	484	67.48
Haliburton	9,081	1,610	5.64
Halton	190,469	380	500.63
Hastings	99,393	2,304	43.14
Huron	52,951	1,314	40.30
Kenora	53,230	153,220	0.35
Kent	101,118	963	105.02
Lambton	114,314	1,157	98.80
Lanark	42,259	1,183	35.72
Leeds	50,093	847	59.12
Lennox & Addington	28,359	1,097	25.86
Manitoulin	10,931	1,421	7.70
Middlesex	282,014	1,298	217.29
Muskoka (1)	31,938	1,558	20.49
Niagara (2)	347,328	715	486.04
Nipissing	78,867	7,022	11.23
Norfolk	54,099	642	84.28
Northumberland	48,162	737	65.31
Ontario	196,257	833	235.63
Ottawa - Carleton (3)	471,931	1,065	443.34
Oxford	80,349	782	102.72
Parry Sound	30,244	3,815	7.93
Peel	259,402	463	559.78
Perth	62,973	846	74.47
Peterborough	87,804	1,394	62.98
Prescott	27,832	480	57.93
Prince Edward	20,640	405	51.00
Rainy River	25,750	6,493	3.97
Renfrew	90,875	2,952	30.78
Russel	16,287	293	55.62
Simcoe	171,433	1,704	100.58
Stormont	61,302	400	153.15
Sudbury	198,079	17,715	11.18
Thunder Bay	145,390	42,281	3.44
Timiskaming	46,485	5,850	7.95
Toronto (4)	2,086,017	242	3,632.75
Victoria	34,242	1,070	32.00
Waterloo	254,037	513	495.11
Wellington	108,581	1,026	105.80
Wentworth	401,883	442	910.02
York (5)	166,060	678	245.00

(1) District municipality, comprising the former Territorial District of Muskoka as well as part of Unorganized in the Territorial District of Nipissing.

(2) Regional municipality, comprising the former counties of Lincoln and Welland.

(3) Regional municipality, comprising the former county of Carleton as well as Cumberland Township in Russel County.

(4) Metropolitan municipality, formerly part of York County - that part previously known as Toronto Metropolitan Corporation.

(5) Regional municipality, formerly part of York County - that part outside the former Toronto Metropolitan Corporation.

Source: Statistics Canada

The physiography of southern Ontario, based primarily upon glacial drift deposits, has been defined in detail by Chapman and Putnam (38). Although Chapman and Putnam have defined some 52 local physiographic regions outside the Shield area of Southern Ontario, the major natural divisions are the broad half-dome which slopes from the Niagara escarpment to Lakes Huron and Erie, the Niagara escarpment, south-central Ontario between the edge of the Canadian Shield and Lake Ontario, the lowlands between the St. Lawrence and Ottawa Rivers, and the Canadian Shield itself.

Following retreat of the Wisconsin glacier about 10,000 years ago, the present imperfect drainage system developed. West of the Niagara escarpment the larger rivers rise in an extensive till plain, down-cutting through moraine and esker deposits bordering the central Dundalk highlands as they approach the shores of Lakes Huron and Erie. The larger rivers in this area are the Grand, flowing into Lake Erie, and the Thames into Lake St. Clair. In their head-water areas many of the tributary streams disappear underground. Smaller rivers such as the Sauble, Lucknow, Bayfield and Ausable flow into Lake Huron, while Kettle Creek, Catfish Creek and Big Otter Creek drain into Lake Erie. East of Pointe-aux-Pins the drainage becomes deeply incised as the streams traverse the abandoned bluffs of former Lake Algonquin in their descent to the present-day shoreline of Lake Erie.

The boundaries of several of the smaller watersheds along the Niagara cuesta remain in doubt because of the number of disappearing streams in the area. West of the Beaver Valley in Euphrasia Township there are several examples. Wodehouse Creek goes underground near Wodehouse, another creek disappears near Harkaway while two others find underground channels north of Goring. In general, the Niagara escarpment is much better drained than the Dundalk plain. The Nottawasaga, Beaver and Bighead rivers and smaller streams such as the Sydenham and Pottawatomi drain the northern portion of the escarpment and the Bruce Peninsula.

Drainage to Lake Ontario includes the Welland River which rises on the back slope of the Niagara cuesta west of Hamilton. A great many small streams descend the Niagara escarpment through narrow valleys finding their way directly to Lake Ontario. These include Four Mile Creek, Twelve Mile Creek, Twenty Mile Creek, Stoney Creek and Redhill Creek. Above the escarpment these streams drain depressions between clay moraines. They are sluggish streams having cut only shallow valleys. In the descent of the escarpment they have cut deep V-shaped gorges.

Drainage of the lands lying between the escarpment and the Trent River valley is divided by the Great Oak Ridges moraine. Flowing to the north, the Severn and several small sluggish rivers drain into Georgian Bay. To the south many short rivers including Bronte Creek, Oakville Creek, Credit River, Etobicoke Creek, Humber River, Don River, Highland Creek, Rouge River, Duffin's Creek, Lynde Creek, Oshawa Creek, Bowmanville Creek, Wilmot Creek, Ganaraska River and Cobourg Creek drain small catchments along the north shore of Lake Ontario.

The Trent River, which is the largest of all southern Ontario rivers, enters Lake Ontario at the western end of the Bay of Quinte. Several smaller rivers, including the Moria, Salmon and Napanee, rise in the Shield region west of the Frontenac axis and flow into the Bay of Quinte and the International section of the St. Lawrence River. East of the Frontenac axis drainage flows to the Ottawa Valley. The Trent system follows the juncture of the Paleozoic limestones with the crystalline rocks of the Shield and the Kawartha Lakes, forming part of the Trent system, occupy portions of preglacial valleys which have been blocked in the south by morainal debris.

Drainage to Lake Huron north of Georgian Bay and to the north shore of Lake Superior consists of numerous smaller rivers interconnecting the myriad small lakes and muskeg-filled depressions scooped out of the crystalline Shield bedrocks by glacial action.

The drainage divide along its northern boundary is imperfectly defined, with many streams flowing to the Arctic and to the north shores of Lake Huron and Lake Superior having common origins.

As may be seen from Figure 2, the land areas draining to the Great Lakes consists of a relatively narrow band across the northerly portion of the basin. The area is studded with many small lakes and swamps which are a common feature throughout the flat Shield landscape. In southern Ontario the Kawartha Lakes and Lake Simcoe afford considerable regulation of natural runoff. Elsewhere drainage systems of southwestern Ontario have developed only a few smaller lakes which offer little natural regulation capacity.

Glacial erosion left behind only a thin mantle of soils over most of the Shield region. The deeper glacial drift deposits overlying bedrocks of the south central, southwestern and Ottawa Valley regions developed fertile toposoils which matured under the climax hardwood forests extending throughout Southern Ontario (37). Under a more severe climate, thin soils and imperfect drainage have limited the development of vegetation successions throughout Northern Ontario to a climax stage represented by the coniferous Boreal forests which extend south of the Arctic tundra to the latitude of the north shore of Lake Superior.

3.3 Soils

The Soil Survey Division of the Ontario Department of Agriculture in cooperation with the Federal Department of Agriculture have classified and mapped the soils throughout most of southern Ontario in detail (35). Reconnaissance level surveys have been completed for soils of northwestern Ontario and other small areas of minor agricultural significance (37, 39).

Basic classification follows the "7th Approximation" system developed by the U.S. Department of Agriculture. The system is based upon the properties and arrangement of horizons within the soil profile (37). County series soil survey reports contain semi-detailed mapping at 1-inch to one-mile (1:63,360) or 1:50,000 scale and indicate the nature of the soil materials, drainage characteristics, topography, surface stoneyness and reaction (acidity/alkalinity) (36). Typical profile descriptions usually provide further detail by horizon, with a description of the soil texture, structure and qualitative assessments of plasticity and other physical characteristics.

These agricultural soil surveys provide the most extensive data available concerning the soils of any location. The taxonomic interpretations provide a consistent basis for evaluation of erosion hazards from potential developments. As is discussed again, comparison with current U.S. Soil Survey taxonomic interpretations suggests there is some opportunity for enhancement of the soil survey information through correlation and presentation of key physical and engineering properties in the taxonomy.

The soils throughout Ontario essentially have been formed on glacial drift deposits or resorted materials transported by fluvial and wind erosion. Few locations derive their soil constituents from in-situ decomposition of the underlying bedrock.

The southern Ontario soils include podzols, brunisols, gleysols, regosols and organic soils (37). Soils of the Podzolic order have developed under a forest where the accumulated leaf litter has formed an organic layer. Decomposition products of the organic matter have a strong leaching effect which results in an eluvial grayish layer near the surface. Three Great Groups (Podzol, Gray Brown Podzolic and Gray Wooded) are found throughout southern Ontario and are dominant on well-drained sites. Brunisolic Order soils in Ontario include the great groups Brown Forest, Brown Wooded and Acid Brown Wooded. These soils have also developed under forested conditions. However, the soil forming processes have not resulted in development of distinct eluvial or illuvial horizons.

The Gleysolic order includes those soils in which the processes of soil development have been influenced by soil moisture conditions, such as high water tables, seasonal fluctuations in the water table, periodic excesses and deficiencies in soil moisture and inadequate soil aeration. Under such a moisture environment reducing conditions are established in a soil. The visible results are a gleyed horizon characterized by dull colors and discolorations of brownish, rusty, or bluish spots, streaks, or mottles. In many of these soils, the high water table restricts the downward movement of soluble materials. In other soils leaching may be significant due to a fluctuating water table. Gleysolic order soils found in Ontario include the Humic Gleysol Great Group, the Gleysol Great Group and the Eluviated Gleysol Great Group.

Within all areas some soils lack distinctive horizon development due to youthfulness, characteristics of a parent material, slope, or climate. Regosolic Order soils include a variety of such soils found in site conditions such as bottom land along stream courses and severely eroded slopes, and include highly calcareous materials,shifting dune sands, disintegrating rock materials and some soils underlain by permafrost.

Organic soils do not possess the horizon differentiation associated with mineral soils. A tentative classification for organic soils has been prepared for Ontario in which an organic soil is defined as one having 30 percent or more organic matter and is at least one foot in depth. While the acreage of organic soils in Ontario is large, there are few extensive individual deposits.

The soils of the Precambrian Shield include depressional areas of organic soils, sand and gravel deposits, thin deposits of coarse to medium-textured Podzols and fine-textured Gray Wooded soils. A narrow band of level clay plains, having the features of a Gleysol occupies a narrow band along the north shore of Lake Huron and another area to the west of Lake Nipissing. An extended area of Gray Wooded and Gleysol clay soils occurs inland and south of

Thunder Bay (37).

3.4 Sediment Yields

3.4.1. Areal Yields. Sedimentation rates vary markedly depending upon soils and climate. Recent studies of sedimentology in Canada indicate rates ranging from less than five tons per square mile per year in the Qu'Appelle Valley of south Saskatchewan to more than 1,000 tons per square mile per year in the Peace and Finlay Valleys of northern British Columbia. Streams in southwestern Ontario derive an estimated 50 to 250 tons per square mile per year from drainage of the Niagara escarpment and south central Ontario. Data for the Thames River valley indicate yield rates from 250 to 1,000 tons per square mile per year (97). Except for southwestern Ontario and streams draining into the eastern part of Lake Ontario, there are no regular sediment measuring stations in Ontario. Miscellaneous sampling, however, indicates that the Shield drainage generally exhibits low levels of suspended sediment concentrations.

It is reported that a test program to evaluate soil loss from sample plots has been in progress for some years at the Ontario Agricultural College, Guelph. Professor Ketcheson* advises that some 15 years of data have been collected for test plots but advised that these apply only to the specific gray Guelph loam soils and further the tests have been specially designed to evaluate cropping practices for corn.

In another research program the University of Guelph has evaluated erosion losses during highway construction. Drainage from a portion of the Hanlon Creek Expressway was directed into two sediment ponds. As reported by Professor P. S. Chisholm* the two ponds drained areas of 0.89 and 1.68 square miles and were designed to effect removal of 90 percent of all inflowing sediments with specific gravities greather than 1.6 and grain-size greater than 0.1 mm. It was concluded from observations and data collected that

*Personal communications.

the ponds were effective as designed and that the combined sediments trapped represented a yield of approximately 115 tons per square mile of expressway corridor. Studies are continuing to assess the impact on its ecology of the fine sediments passed into Hanlon Creek.

In recent years the Department of Environment has initiated sediment surveys of six reservoirs in Ontario. The reservoirs and the dates of the first baseline survey are as follows: Conestogo, 1969; Parkhill, 1970; Bellwood, 1971; Fanshaw, 1972; Finch and Clairville, 1973. It is intended to re-survey these reservoirs at five-year intervals to provide data to evaluate sediment trap efficiency, determine the loss of storage capacity and monitor changes which may arise in sediment yield rates. The first re-survey, of Conestogo Reservoir, is scheduled for 1974. Glymph and Storey (44) report that a 1965 study of United States reservoirs indicated an average annual rate of storage loss due to sediment accumulation of 0.2 percent, with total losses amounting to about one million acre/feet per year.

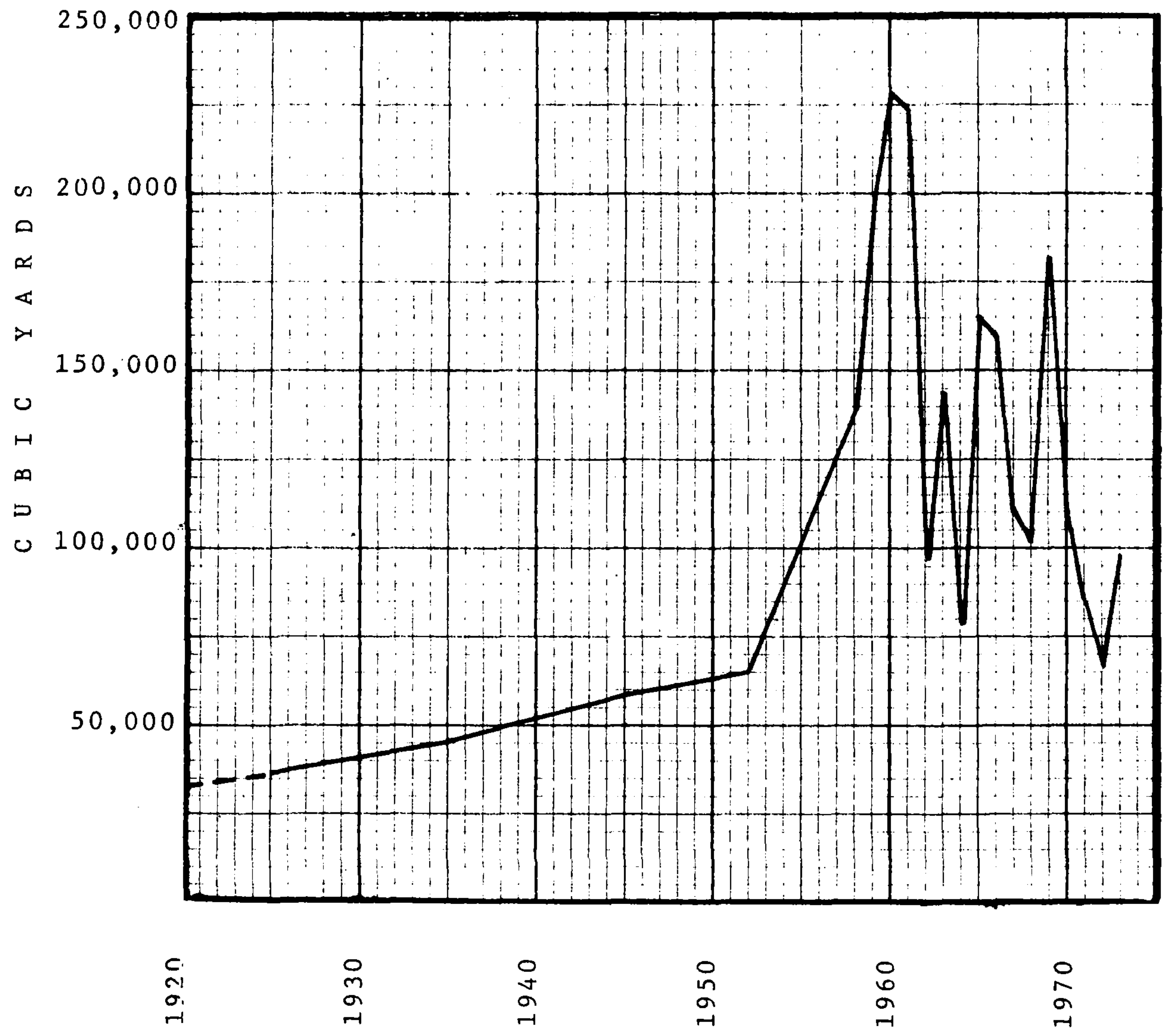
Average annual dredgings from Canadian lake ports in the Great Lakes amount to some 3.6 million cubic yards in recent years. The records, however, do not reflect directly the sediment loads reaching the lakes as much of the shoal materials are derived from beach erosion. Moreover records do not clearly distinguish between maintenance and capital dredgings (112). It may be, however, as a result of current investigations and studies of the environmental effects of dredging activities, that in the future records of dredging will assist in identifying locations receiving high inputs of sediments from tributary drainage.

However, in one instance, dredgings are clearly related to upstream erosion. The Don River, which formerly drained into Ashbridges Bay, was diverted in 1853 to Toronto Bay and the outlet channel enlarged to serve as a docking area. The Keating Channel, as the outlet is known, requires annual dredging to maintain navigable draft. Although over the years this draft has been increased, it is reported that since 1920 dredging has been undertaken to maintain a constant depth. Some materials are washed into Toronto Harbour during high flood flows and therefore not included in the records, however, the bulk of the sediments are trapped in the Keating Channel. The annual dredging volume from the records of the Toronto Harbour Commission are illustrated in Figure 4 and are indicative of a medium-term change in sediment yields induced through development activities.

The City of Toronto maintained responsibility for the Don River upstream from Lakeshore Boulevard and in attempting to alleviate the effects of frequent flooding in the lower reaches, the City dredged the Don River between Lakeshore Boulevard and Queen Street in 1930. Soundings taken in 1932 indicated that the same volume of silt had been deposited as had been removed two years before. Subsequent soundings indicated no appreciable accretion in this reach although in 1939 substantial scouring was indicated. Following dredging in 1952 it is reported that the channel had resilted by the spring of 1953 and within a few days of completing dredging in 1957 the river channel infilled from sediments transported during a single storm. The City ceased dredging of the Don after 1957*. It is apparent from the report that the dredging of the lower channel was not wholly effective. The quantities dredged are not recorded. However the fact that one storm in 1957 was sufficient to refill the dredged reach suggests that the amounts were not significant as compared with the annual dredgings of the Keating Channel.

In a report on erosion control and river bank stabilization prepared for Metropolitan Toronto Regional Conservation Authority by James F. MacLaren Limited in 1970, (25) it is indicated that both the East and West branches of the Don exhibit considerable instability. The West Branch has valley walls of 70 to 100 feet in height with uniformly steep slopes of about 40 percent. The East Branch exhibits a somewhat wider range of characteristic slopes ranging from 28

*Personal communication from C. J. Shrok.



KEATING CHANNEL

DREDGING

Toronto Harbour Commission

Figure 4

percent in the north to 44 percent in the south. Average valley depth ranges from 28 feet in the middle reaches to approximately 100 feet in parts of the southern portion. The report concludes that several sub-reaches of both branches require channel stabilization as well as extensive works to promote slope stability.

It is evident that, for most of the Great Lakes Basin in Ontario, serious sedimentation problems associated with urbanization are not widespread. However, as an indication of the potential hazard, a preliminary case study of the Don Basin has been undertaken as part of this study to relate the dredging data to changes in land use occurring throughout the period 1947 to 1973. As discussed in more detail in Section 4.1 the high yields of sediments indicated by Figure 4 when related to changing land use indicate a thousandfold increase in areal yield rates due to urbanization processes from yields characteristic of adjacent agricultural areas, and undoubtedly underlie the problems of channel and slope instability referred to above.

3.4.2. Water Quality Indicators. In the larger receiving waters, as exemplified by the Great Lakes, gradual mixing and dilution of sediment laden inflows occur, although the near-shore water quality is often markedly different from the open and deep water conditions (111). Over long periods of time changes in water quality reflect the input of increasing levels of contaminants. For example, total dissolved solids have increased by about 12 mg/litre in Lake Huron, 20 mg/litre in Lake Michigan and 15 mg/litre in Lakes Erie and Ontario during a 70-year period up to 1960. Increasingly widespread algal blooms in Lakes Erie and Ontario and the extended anaerobic bottom conditions recorded in the western basin of Lake Erie are evidence of the acceleration of natural eutrophication processes under increasing inputs of contaminant wastes from many sources (111).

A water quality monitoring program was initiated by the

Ontario Water Resources Commission in July 1964 with 89 streams in southern Ontario being sampled. By the end of the 1966/67 water year, a total of 366 stations throughout Ontario had been established. The concentration of dissolved solids and other critical water quality indicators such as dissolved oxygen, temperature and pH are currently determined for some 760 locations throughout Ontario by the Ministry of the Environment. In Table 3-2 a few selected records from observations taken during 1966/67 are presented. Comparison between the sites serves to illustrate the variations in water quality observed at different locations on the same stream and between streams in different locations (26).

3.5 Urbanization

In the Province of Ontario more than 82 percent of the population reside in urban centres of 1,000 or more and nearly 75 percent in centres of 10,000 or more (1971 Census). Of the 17.65 percent residing in rural areas only 4.72 percent were directly engaged in agriculture. By far the largest concentration of population, and hence associated development activities, are centred upon the Metropolitan Toronto region. The population distribution is illustrated in Table 3-3 from 1971 Census data compiled by Statistics Canada (109).

As may be noted from the data in Table 3-3, the Metropolitan Toronto region alone contains some 27 percent of the total provincial population. High population concentrations are also found in the surrounding counties of Ontario, York, Simcoe and Peel with related concentrations in Halton, Wentworth, Niagara and along an axis through Wellington, Waterloo, Oxford, Middlesex, Kent and Essex counties. In eastern Ontario only Ottawa-Carleton and Stormont counties have population densities approaching these of the greater part of southwestern Ontario.

As is axiomatic, the pressure upon land for conversion to

TABLE 3-2

SELECTED WATER QUALITY DATA - ONTARIO - 1966/67

		COLI FORMS /100ML	WATER TEMP C.	DO PPM	5-DAY BOD PPM	TOT SOL PPM	SUSP SOL PPM	TURB-IDITY UNITS	COND 25C UMHO	TOT P AS P	SOL P AS P	NH-3 AS N PPM	TCT KJEL PPM	NO-2 AS N PPM	NO-3 AS N PPM	CHLORIDE PPM	HARDNESS PPM	ALK CACO3 PPM	TOT IRON PPM	PH AT LAB
DON RIVER	MAXIMUM	7800000.	24.0	12.0	42.0	2410	620	410.0	2922	5.22	3.75	10.70	20.00	0.45	1.10	961	146	262	17.90	7.8
STREAM MILEAGE - 0.1	MINIMUM	20.	2.0	4.0	3.4	470	15	9.0	591	0.25	0.15	0.36	2.60	0.00	0.00	70	146	262	0.09	7.8
SAMPLING AT LAKESHORE ROAD	AVERAGE	1127741.	11.5	7.8	11.8	808	96	56.0	1138	1.91	1.33	4.93	7.77	0.15	0.36	189	146	262	3.00	7.8
DON RIVER WEST	MAXIMUM	310000.	21.0	13.0	14.0	1094	222	100.0	1800	0.51	0.27	2.46	4.42	0.25	3.50	358	320	245	0.36	8.3
STREAM MILEAGE - 13.8	MINIMUM	4.	1.0	10.0	0.6	421	8	2.9	594	0.02	0.01	0.05	0.46	0.00	0.05	57	320	245	0.36	8.3
SAMPLING AT SHEPPARD AVE.	AVERAGE	60619.	10.1	11.6	4.4	677	51	28.0	1028	0.20	0.11	0.65	1.64	0.06	0.71	140	320	245	0.36	8.3
DON RIVER EAST	MAXIMUM	600000.	20.5	12.0	7.2	806	262	102.0	1251	0.56	0.52	0.69	1.20	0.10	3.00	199	304	258	0.65	8.1
STREAM MILEAGE - 17.2	MINIMUM	7500.	1.0	7.0	0.8	382	8	10.5	625	0.02	0.00	0.02	0.26	0.00	0.05	32	304	258	0.65	8.1
SAMPLING AT BAYVIEW & STEELES AVE.	AVERAGE	95655.	10.0	8.9	3.5	533	43	28.1	779	0.18	0.11	0.22	0.78	0.03	0.74	71	304	258	0.65	8.1
DON RIVER WEST	MAXIMUM	147000.	22.0	15.0	13.0	1234	171	91.0	2000	0.95	0.65	4.92	7.40	1.50	3.00	427	316	259	3.25	8.0
STREAM MILEAGE - 19.8	MINIMUM	12.	2.0	6.0	2.4	454	15	14.0	534	0.06	0.00	0.23	1.15	0.00	0.05	49	316	259	3.25	8.0
SAMPLING AT HIGHWAY NO. 7	AVERAGE	22018.	10.8	9.5	6.5	753	64	43.8	1115	0.43	0.23	1.51	2.89	0.27	0.93	168	316	259	3.25	8.0
THAMES RIVER	MAXIMUM	70000.	25.0	12.0	6.4	1246	918	840.0	675	0.24	0.18	0.49	1.65	0.22	5.00	36	312	222	37.30	8.2
STREAM MILEAGE - 16.0	MINIMUM	1470.	0.0	5.0	2.0	394	13	14.0	395	0.10	0.03	0.05	0.33	0.01	0.60	12	200	161	0.50	7.7
SAMPLING AT HIGHWAY NO. 2, KIEL DR.	AVERAGE	17497.	9.1	9.2	3.5	528	152	110.5	577	0.18	0.10	0.13	1.02	0.06	2.28	24	277	198	7.76	8.0
THAMES RIVER	MAXIMUM	630000.	24.5	14.0	5.7	680	426	480.0	709	0.35	0.31	0.66	2.10	0.28	3.50	43	310	237	18.80	8.5
STREAM MILEAGE - 122.6	MINIMUM	6000.	1.0	5.0	2.0	328	6	4.0	358	0.11	0.07	0.03	0.15	0.01	0.80	6	180	139	0.30	7.9
SAMPLING AT BRIDGE BELOW DAM, CITY OF LONDON	AVERAGE	153338.	11.2	9.4	3.6	431	74	72.4	571	0.24	0.15	0.18	1.05	0.08	1.89	25	267	202	3.18	8.1
TRENT RIVER	MAXIMUM	70000.	25.5	15.0	8.0	216	22	26.0	331	0.13	0.03	0.23	2.80	0.02	0.90	13	120	100	0.74	8.5
STREAM MILEAGE - 0.2	MINIMUM	140.	0.0	8.0	0.9	130	1	1.8	126	0.00	0.00	0.02	0.49	0.00	0.00	3	106	90	0.11	7.8
SAMPLING AT BRIDGE ON HIGHWAY NO. 2	AVERAGE	12266.	8.0	10.9	4.3	168	11	7.1	247	0.04	0.01	0.14	0.83	0.01	0.13	5	113	94	0.35	8.2
TRENT RIVER (OUSE)	MAXIMUM	670.	25.0	12.0	2.7	374	15	6.5	466	0.06	0.02	0.16	5.30	0.01	2.00	17	218	207	0.20	8.3
STREAM MILEAGE - 64.7	MINIMUM	4.	0.0	5.0	0.6	210	1	0.7	341	0.01	0.00	0.00	0.39	0.00	0.15	3	218	207	0.20	8.3
SAMPLING AT HIGHWAY NO. 45	AVERAGE	269.	9.7	8.6	1.5	259	8	3.2	403	0.02	0.01	0.08	1.12	0.00	0.51	8	218	207	0.20	8.3
TRENT RIVER (CAMERON LOOK-OUT)	MAXIMUM	29000.	22.0	10.0	1.2	126	15	3.3	135	0.05	0.01	0.20	2.80	0.00	0.12	3	60	54	0.23	8.5
STREAM MILEAGE - 155.0	MINIMUM	84.	11.5	8.0	0.4	78	1	1.8	123	0.01	0.00	0.08	0.39	0.00	0.05	3	58	46	0.10	7.2
SAMPLING AT HIGHWAY NO. 35, FENELON FALLS	AVERAGE	7499.	18.3	8.8	0.7	101	8	2.3	129	0.02	0.00	0.13	1.26	0.00	0.08	3	58	50	0.17	7.9

TABLE 3-3

Population of Census Divisions, Urban Size Groups, Rural Non-farm and Rural Farm, Province of Ontario, 1971

Census division	Total	Urban							Rural		
		Total	500,000 and over	100,000 to 499,999	30,000 to 99,999	10,000 to 29,000	5,000 to 9,999	1,000 to 4,999	Total	Non-farm	Farm
Ontario	7,703,105	6,343,630	2,768,475	1,357,385	896,900	605,615	312,440	402,815	1,359,475	995,840	363,640
Percent	100.0	82.35%	35.94	17.62	11.64	7.86	4.06	5.22	17.65	12.93	4.72
Algoma	121,940	102,235	-	-	80,580	-	8,830	12,825	19,700	18,030	1,670
Brant	96,765	74,410	-	-	66,610	-	6,485	1,315	22,360	15,915	6,445
Bruce	47,385	17,570	-	-	-	-	-	17,567	29,815	16,720	13,090
Cochrane	95,835	71,305	-	-	32,965	12,835	7,270	18,230	24,530	22,990	1,540
Dufferin	21,200	9,860	-	-	-	-	8,070	1,790	11,335	5,900	5,440
Dundas	17,455	6,110	-	-	-	-	-	6,110	11,350	6,350	5,000
Durham	47,495	21,040	-	-	-	-	17,820	3,225	26,455	19,965	6,485
Elgin	66,610	34,135	-	-	-	25,545	-	8,590	32,470	21,965	10,505
Essex	306,400	246,560	-	216,305	-	10,435	5,170	14,655	59,840	44,725	15,115
Frontenac	101,690	73,600	-	-	73,605	-	-	-	28,090	23,330	4,760
Glengarry	18,480	3,240	-	-	-	-	-	3.240	15.240	10,065	5,180
Grenville	24,315	9,445	-	-	-	-	5,165	4,280	14,875	11,435	3,435
Grey	66,405	33,505	-	-	-	18,470	5,060	9,970	32,900	17,070	15,825
Haldimand	32,675	12,135	-	-	-	-	5,580	6,560	20,535	13,585	6,955
Haliburton	9,080	-	-	-	-	-	-	-	9,080	8,690	395
Halton	190,470	178,725	56,515	76,700	-	27,380	12,050	6,080	11,750	9,605	2,145
Hastings	99,390	67,125	-	-	35,125	20,060	-	11,940	32,265	24,660	7,605
Huron	52,950	19,590	-	-	-	-	6,815	12,775	33,360	16,605	16,755
Kenora	53,230	26,415	-	-	-	12,705	6,940	6,765	26,820	26,175	640
Kent	101,115	60,825	-	-	35,315	10,550	-	14,960	40,290	25,710	14,580
Lambton	114,315	79,745	-	-	70,665	-	-	9,075	34,570	20,755	13,815
Lanark	42,260	26,500	-	-	-	12,245	10,560	3,695	15,760	10,440	5,320
Leeds	50,090	26,050	-	-	-	19,765	5,215	1,070	24,045	18,340	5,705
Lennox & Addington	28,360	8,795	-	-	-	-	-	8,795	19,565	14,800	4,765
Manitoulin	10,935	1,565	-	-	-	-	-	1,565	9,365	7,595	1,775
Middlesex	282,015	240,325	-	223,225	-	-	6,595	10,515	41,690	25,955	15,735
Muskoka (1)	31,940	23,820	-	-	-	-	23,820	-	8,115	7,865	255
Niagara (2)	347,330	334,875	-	121,815	111,560	87,100	9,995	4,400	12,450	7,745	4,715
Nipissing	78,870	58,730	-	-	49,185	-	6,665	2,880	20,135	17,870	2,265
Norfolk	54,095	20,500	-	-	-	10,795	-	9,705	33,600	21,810	11,790
Northumberland	48,160	20,620	-	-	-	12,560	-	8,065	27,540	20,590	6,955
Ontario	196,255	159,865	19,280	111,360	-	12,515	5,550	11,160	36,390	28,520	7,870
Ottawa - Carleton (3)	471,930	428,940	408,560	-	-	-	6,640	13,745	42,990	34,185	8,810
Oxford	80,350	44,870	-	-	-	26,175	14,390	4,305	35,475	21,775	13,700
Parry Sound	30,245	9,255	-	-	-	-	5,845	3,410	20,995	18,895	2,100
Peel	259,405	238,650	199,330	-	41,210	22,105	13,025	2,985	20,750	16,895	3,855
Perth	62,970	37,575	-	-	-	24,505	-	13,070	25,400	11,310	14,090
Peterborough	87,805	65,390	-	-	59,350	-	-	6,045	22,415	16,975	5,440
Prescott	27,830	13,605	-	-	-	9,275	-	4,325	14,230	8,745	5,485
Prince Edward	20,640	4,875	-	-	-	-	-	4,875	15,765	11,820	3,950
Rainy River	25,750	17,130	-	-	-	-	15,930	1,200	8,625	6,470	2,155
Renfrew	90,875	56,240	-	-	-	29,805	22,515	3,920	34,640	26,410	8,225
Russell	16,285	6,440	-	-	-	-	-	6,440	9,845	6,040	3,810
Simcoe	171,435	104,370	-	-	-	69,375	14,915	20,085	67,060	51,815	15,245
Stormont	61,305	47,115	-	-	47,115	-	-	-	14,185	10,080	4,105
Sudbury	198,080	146,100	-	-	94,620	10,190	13,575	27,705	51,980	49,895	2,085
Thunder Bay	145,390	126,150	-	108,410	-	-	-	17,740	19,235	17,645	1,590
Timiskaming	46,485	31,020	-	-	-	13,625	12,965	4,430	15,465	12,040	3,425
Toronto (4)	2,086,020	2,086,015	2,081,655	-	-	-	-	4,360	-	-	-
Victoria	34,245	15,880	-	-	-	12,745	-	3,135	18,365	11,935	6,430
Waterloo	254,035	222,790	-	150,855	38,895	16,720	6,345	9,975	31,250	21,960	9,290
Wellington	108,580	76,960	-	-	60,085	-	7,335	9,535	31,620	17,675	13,945
Wentworth	401,885	360,285	-	348,720	-	-	7,840	3,725	41,595	34,410	7,185
York	166,160	134,770	43,135	-	-	78,130	7,490	6,010	31,295	27,095	4,200

(1) District Municipality, comprising the former Territorial District of Muskoka as well as part of Unorganized in the Territorial District of Nipissing.

(2) Regional Municipality, comprising the former counties of Lincoln and Welland.

(3) Regional Municipality, comprising the former county of Carleton as well as Cumberland Township in Russell County.

(4) Metropolitan Municipality, comprising that part of the former York County previously known as "Toronto Metropolitan Corporation".

(5) Regional Municipality, comprising that part of the former York County outside the old "Toronto Metropolitan Corporation ".

intensive uses is directly related to population growth and it is therefore around the larger population centres where the influence of urbanization trends are likely to pose environmental conservation problems. The level of activity in building construction for the statistical regions of Ontario during 1972 are summarized in Table 3-4 following. The concentration of building construction in the larger urban centres is also illustrated in this table. From Table 3-3 it may be noted that 71.3 percent of the total population resided in the 69 towns and cities having populations of 10,000 or more and as shown in Table 3-4 accounted for 86.7 percent of the total investment. (21,24).

3.6 Other Major Development Land Uses

Apart from residential, commercial institutional and industrial developments which have similar requirements insofar as the earthwork activities are concerned, communications corridors, as exemplified by roads and transmission lines, disrupt extended tracts of land and interrupt natural drainage features. Activities such as large pipeline construction, being more intermittent, have not been considered herein.

3.6.1. Roads.

An extensive system of provincial, county, township and urban roads has been developed throughout the province. Total mileages for the various classes of roads in Ontario as of December 31, 1972 are presented in Table 3-5*. Based upon information from the Ministry of Transportation and Communications the average rate of development of provincial highways during the five years preceding 1974 has been 330 miles per year. The average for 1971 to 1973 has been 270 miles per year. With an average right-of-way width of 120 feet, recent requirements have been for occupation of approximately 4,000 acres per year. Ministry officials indicate that they anticipate the mileage of new highway construction will decline and that the greater proportion of their

*Data supplied by the Ontario Ministry of Transport and Communications.

TABLE 3-4

BUILDING PERMITS ISSUED

BY REGION - ONTARIO - 1972

	No. of Centres of 10000+ population	Single Dwell-ings	Cot-tages	Double Dwell-ings	Row Hous-ing	Apart-ments	Conver-sions	Total	Residen-tial	Indus-	Commer-	Indus- & Govt.	Total
									(thousands of dollars)				
Ontario	69	35,724	2,047	8,515	9,218	49,124	576	105,204	1,714,080	278,820	564.472	430,965	2,988,407
Eastern	7	3,745	206	448	1,762	8,654	101	14,916	215,652	20,378	77,940	83,757	397,727
Lake Ontario	7	2,449	714	125	104	1,294	143	4,829	69,660	7,569	10,727	21,618	109,574
Metropoliton Region ...	10	10,823	40	5,373	4,384	22,255	75	42,953	783,041	154,489	290,095	164,551	1,392,176
Niagara	12	5,412	4	832	1,194	5,668	51	13,161	199,755	22,065	64,377	24,809	311,006
Lake Erie	3	2,650	7	163	639	2,621	19	6,099	81,600	11,152	23,998	33,698	150,448
Lake St. Clair	9	2,116	35	268	310	1,709	49	4,507	79,041	7,640	26,394	25,774	138,849
Upper Grand River	3	2,999	10	533	559	3,515	21	7,637	105,537	17,630	28,050	16,565	167,782
Georgian Bay	6	2,921	934	248	12	1,267	58	5,440	86,088	8,112	14,456	14,009	122,663
Northeastern	10	1,926	44	355	218	1,597	45	4,185	69,248	27,714	20,835	35,723	153,520
Lakehead, Northwestern	2	680	33	170	36	544	14	1,477	24,458	2,141	7,602	10,461	44,662
Ontario													
i) urban centers with population of10000 plus.		25,452	41	7,719	8,878	42,086	362	89,538	1,434,161	248,238	524,535	385,127	2,592,061
ii) Other areas.		10,272	2,006	796	340	2,038	214	15,666	279,919	30,652	39,937	45,838	396,346

Source Statistics Canada

TABLE 3-5

HIGHWAY AND ROAD MILEAGES, PROVINCE OF ONTARIO

(1) King's Highway

Concrete	369.7 miles
High-class bituminous	8,348.0 miles
Low-class bituminous	763.5 miles
Gravel and Crushed Stone	292.4 miles
TOTAL:	9,773.6 miles

(2) Secondary Highway

High-class bituminous	237.5 miles
Low-class bituminous	761.1 miles
Gravel and Crushed Stone	1,917.2 miles
Earth	2.4 miles
TOTAL:	2,918.2 miles

(3) Tertiary Roads

High-class bituminous	24.4 miles
Gravel and Crushed Stone	193.1 miles
TOTAL:	217.5 miles

(4) County Roads

Concrete	48.0 miles
High-class bituminous	3,950.6 miles
Low-class bituminous	3,189.4 miles
Gravel and Crushed Stone	2,085.4 miles
Earth	0.4 miles
Other	0.6 miles
TOTAL:	9,274.4 miles

(5) Regional Municipal Roads

Concrete	17.6 miles
High-class bituminous	982.7 miles
Low-class bituminous	622.1 miles
Gravel and Crushed Stone	351.2 miles
[illegible]	0.5 miles
TOTAL:	1,974.1 miles

(6) Metropolitan Roads

Concrete	1.8 miles
High-class bituminous	373.4 miles
Low-class bituminous	1.7 miles
Gravel and Crushed Stone	1.8 miles
Other	2.1 miles
TOTAL:	380.8 miles

(7) Organized Township Roads

Concrete	12.8 miles
High-class bituminous	2,918.9 miles
Low-class bituminous	3,772.1 miles
Gravel and Crushed Stone	37,723.4 miles
Earth	2,216.4 miles
Other	3,876.3 miles
TOTAL:	50,519.9 miles

(8) Unorganized Township Roads

High-class bituminous	35.6 miles
Low-class bituminous	27.9 miles
Gravel and Crushed Stone	4,735.5 miles
Earth	894.3 miles
Other	168.7 miles
TOTAL:	5,862.0 miles

(9) Cities, Towns and Village Streets

Concrete	498.2 miles
High-class bituminous	5,850.9 miles
Low-class bituminous	3,868.4 miles
Gravel and Crushed Stone	3,260.3 miles
Earth	300.8 miles
Other	818.3 miles
TOTAL:	14,596.9 miles

(10) Total Road Mileage 95,517.4 miles

program in the future will involve re-surfacing and upgrading of existing routes.

No estimate is available for the mileage of new county and township roads currently being developed, however, as may be seen from the data presented in Table 3-5, the majority of township roads as well as a high percentage of county roads are not paved. It is understood that most county activity involves the gradual upgrading of these roads as local funds permit. Municipal roads and streets are constantly being expanded to serve new development areas. No direct information has been obtained concerning the rate of development of urban streets although as explained in Section 4.3 an allowance has been made for this class of activity in the estimate of urban residential expansion.

From information provided by the Ministry of Transport and Communications the annual application of sand and salt to provincial highways in areas tributary to the Great Lakes and St. Lawrence River amount to 750,000 tons and 350,000 tons respectively.

All salt is stock-piled in convered storage sheds. An anti-caking agent mixed with the salt is sodium thio-cyanate. Approximately 37 percent of sand stockpiles is covered by domes and a further 32 percent sprayed with Curosal. It is reported that there has been a significant reduction of incidents of groundwater pollution through the storing of salt under cover as well as substantial reduction of losses from sand stockpiles protected either by direct cover or treatment with Curosal.

Extensive use of salt and sand by municipalities and county road authorities is reported, however, specific data indicating the level of use is not readily available.

3.6.2. Power Stations and Transmission Lines. Information has been provided by Ontario Hydro concerning the area of lands affected by hydroelectric and thermal generating plants for the period prior to 1972 and for the periods 1972 and 1973 and 1974-1979, as hereunder:

	Land Areas Occupied	
	Hydro	Thermal
Prior to 1972	334,235 acres	1,805 acres
1972-1973	2,000 acres	4,525 acres
1974-1979	-	9,715 acres

Transmission line rights-of-way also occupy substantial areas. Up to 1972 approximately 18,000 miles of transmission lines (50 KVA or over) throughout the province occupied approximately 150,000 acres. In 1972, 306 line miles of transmission corridor and in 1973, 336 line miles were constructed, requiring between 30,000 and 38,000 acres of land in rights-of-way. Ontario Hydro advise that their high voltage transmission program during the next five years will require approximately 900 miles of right-of-way of between 400 and 500 feet width. This poses a requirement for between 44,000 and 55,000 acres.

Although up to 1972 a substantial portion of the transmission lines were developed throughout northern Ontario, it is anticipated that future work will be largely concentrated in southern Ontario based upon thermal and nuclear-thermal generation developments.

4.0 CURRENT STATUS OF DEVELOPMENT ACTIVITIES AND SEDIMENT YIELDS

The current status of development activities has been considered at three levels of interpretation herein: a case study of the Don River Basin, a photo-interpretation study of a part of south-central Ontario and an overview of activities within the Great Lakes Basin and the Province of Ontario.

4.1 Don River

Based upon information relating to the annual maintenance dredging of the Keating Channel, as described in Section 3.4.1, it was assumed that the substantial increase in dredged volumes experienced during the 1950's and 1960's could be attributed to the post-war expansion of Metroplitan Toronto within the Don River catchment. In addition to building and subdivision development, other major activities such as construction of the Don Valley Expressway, Highway 401 and the railway marshalling yards in the northwest of the basin were underway during this period. Therefore, a photo-interpretation study was undertaken to determine the extent of these development activities throughout the catchment for a sequence of nine intervals from 1947 to the present. The procedures followed and the areal mensuration developed from this study are described in a report by Northway Consultants Limited presented herein as Appendix A. It may be noted that the catchment for the southern portion of the basin was adjusted to conform to the effective drainage boundaries determined by the storm sewer systems developed by the City of Toronto and the municipalities of Scarboro, North York and East York while to the north of Highway 401 the natural topographic divide was followed.

The annual total acreage of all development activities, as reported in Table 1 Appendix A, have been considered in the derivation of urban sediment yield presented in the upper curve of Figure 5 following, which relates the total area under active development in any year to the incremental quantity dredged from the Keating Channel. The volume of 1945 dredgings was adopted as the base year of reference and incremental volumes determined from a three-year moving average of dredging volumes to reduce annual variations attributable to lag effects in sediment transport within the stream system, and year to year differences in precipitation and runoff, as well as distortions arising from the timing of dredging activities. The lower curve of Figure 5 represents the sediment yield averaged over the entire catchment area. Both curves may be compared with the background yield for Peel, York and Halton counties as indicated in the graph.

The density of dredged spoil has not been determined. However, observations of dredging in progress late in 1973 indicate the material has a high silt-clay content and suggest it is moderately compact. For the purpose of analysis 40 percent solids content has been assumed, representing a dry weight of 0.893 tons per cubic yard of sediments.

It is apparent that development activities have occasioned a considerable increase in the area yield of sediments. Although it must be presumed that much of the material derives from bank erosion and slides of some of the steeper valley sites, these in turn have been triggered in large part by development activities.

The progress of urbanization within the Don basin, as developed from the photo-interpretation study, is illustrated in Plates 1 to 9 of Appendix A. The downturn of yields in recent years as indicated in Figure 5 suggests increasing stabilization of the area. This also reflects the overall reduction of the area effected in recent years as well as an increase in redevelopment activities as may be seen from Plates 6 through 9. Moreover, as noted in Appendix A, the characteristic pattern of subdivision development has changed during the period reviewed, with the extended period of

AREAL SEDIMENT YIELDS
DON RIVER BASIN

Figure 5

open subdivision developments characteristic of the immediate post-war years giving way to a more rapid completion during the 1960's.

The level of interpretation undertaken for this preliminary case study does not allow for analysis of the contribution to sediment yields from the different categories of development activities and indeed would hardly be possible over such a large area. What was intended and, we believe, demonstrated is that urbanization in southern Ontario has a potential for causing a severe change in the regime of a catchment and can result in very substantial costs attributable to soil erosion if not controlled.

The annual maintenance dredging of the Keating Channel, for example, currently exceeds one hundred thousand dollars* and it is apparent that the Toronto Harbour Commission has for many years been obliged to bear a significant increase in maintenance dredging costs as a result of development activities within the Don basin. Extensive stabilization of several reaches of the east and west branches of the Don River and of valley walls has been recommended. (25) The cost of such works has not been investigated in detail but from the range suggested by the consultant, it appears the total program will likely exceed several million dollars.

The Don River basin does not represent a situation typical throughout southern Ontario. The concentration of population and economic activity within Metropolitan Toronto and the surrounding region, however, poses a potential hazard to other catchments to the east and west of the city. The seriousness of such hazard has not been evaluated although it has been determined from information compiled by the Ontario Municipal Board that extensive land separation requests cover a continuous belt from east of Oshawa around the western end of Lake Ontario to St. Catharines. Within

*1973 costs are reported to be $1.00/c.y. for direct dredging by THC plant. In addition trapping and disposal of floating debris has cost from $10-20,000 annually in recent years.

this zone especially, local conservation authorities and municipalities should be aware of the consequences of failure to follow good land management practices.

4.2 South Central Ontario

An attempt was made to assess the current status of development activity in south-central Ontario from photo-interpretation of sequential, colour photographs taken by NASA. This material provides the only recent extensive photo cover of southern Ontario, and two series taken during August 1971 and June 1972 were utilized.

The area analyzed comprises a block of approximately 5,000 sq. miles bordered on the south by the shore of Lake Ontario between Oshawa and Oakville and on the north by an east-west line from Strathnairn through Collingwood to Oro Station. The western boundary of the area extends from Lake Ontario through Cooksville in the south to Strathnairn, and on the east by a line between Oshawa and Oro Station. Photo cover of this area was at a scale of 1:120,000.

During the interval between the two photo series approximately 3200 acres of lands were identified as being under development. Considerable difficulty was experienced in interpreting land-use changes at the small scale of the photography and it is considered that area measurements can only be determined within about ± 25 percent accuracy. All of the areas of active construction during the period were located within Metropolitan Toronto and surrounding areas.

Comparison with the interpretation of recent development activities for the Don River Basin during approximately the same period indicates that only a few of the larger developments could be positively identified. In several areas there was uncertainty as to the interpretation, particularly where recently cultivated fields showed up adjacent to existing urban developments.

As is noted in Appendix A, positive identification required correlation and interpretation between different periods even at the 1:24,000 scale being used for the Don Valley study. It is concluded that photo interpretation from smaller scale photography is of limited value in identifying and assessing the extent of development activities.

Recent advances in the technology for enhancement of ERTS satellite imagery may provide a more suitable means of monitoring development activities over extensive areas. Considerable development work on the application of satellite imagery is in progress. The applicability has not been specifically evaluated in terms of this study, although a few examples of enhanced imagery examined recently for other purposes suggest that if further assessment of the status of development activity is desired consideration should be given to the possibility for application of this developing technology.

4.3 Current Status of Development Activities Great Lakes Basin/ Province of Ontario

As a part of this study an estimate is required of the acreage of lands currently undergoing transformation through major development activities. A direct quantitative determination for major urbanization is not available and resort has been made to indirect correlations, most of which are based upon preliminary indications or broad estimates. The statistical records, however, deficient, provide the most useful source of data indicating the intensity and distribution of building construction activities (21, 22, 24).

The activities which have been included in the analysis are residential, commercial, industrial and institutional buildings, highway construction and development of power generation and transmission facilities. Although this list of activities is not all embracing, it includes most major developments imposing substantial requirements for land. Exceptions to the foregoing involve development activities of an intermittent character such as would be represented by large pipelines and railway relocations as well as occasional large projects such as the proposed international airport at Pickering. The influence of some of these types of activity have been included in the case study of the Don Basin described earlier.

Current status of development activities within the Great Lakes Basin in Canada is not substantially different from that for the Province of Ontario as a whole. Since most of the data defining the situation derives from provincial statistics, the current situation is considered initially on a province-wide basis. A review of available data indicates that reasonably complete information is available for 1972 whilst only forecast or partial data are as yet compiled on several major aspects for 1973. For the purpose of establishing an overview estimate of current activities, the aggregate of 1972 activities is considered to be representative within broad limits which exceed the variation probably experienced over several years of growth.

The construction of both single and multiple residential units, commercial, industrial and institutional facilities are grouped together as the erosion problems associated with land development for any of the foregoing derives from similar land-shaping operations. There are no statistics gathered concerning the area of lands involved in this category of development activity. Specific data would require a search of county and municipal registry office records, a task beyond the scope of this study. A preliminary evaluation of the land-use requirements for residential accommodation has been provided by CMHC which indicate the following averages:

Residential Units Per Acre [1)]

	Urban areas	Rural areas
Single, detached	5/acre	3/acre
semi-detached	7/acre	4/acre
row housing	20/acre	20/acre
apartments 3½ storey	30/acre	30/acre
apartments 4-6 storey	35/acre	
apartments 7 storey	80^{+}/acre	

[1)] net acreage - add 60 percent for roads, sidewalks, parks etc.

Based upon the foregoing and the information on building permits issued in 1972 as presented in Table 3-4, it is estimated that the current area annually required for residential accommodation, including allowances for streets, sidewalks, and parks, would be approximately 20,000 acres.

Data on building permits for commercial, industrial and institutional properties are presented only in terms of declared value. It has been assumed that the gross rate of investment per acre for these categories would be double that for residential accommodation and on this basis some 10,000 acres would represent the land requirements for commercial, industrial and institutional development.

As discussed in Sections 3.6.1 and 3.6.2, substantial acreage is required annually for highway development and construction of power plants and transmission lines. The total, area-disturbing activities in all categories in 1972 are summarized hereunder:

Residential	20,000 acres
Commercial, Industrial & Institutional	10,000 acres
Ontario Hydro:	
Hydro Plants	1,000 acres
Thermal Plants	2,300 acres

HV Transmission Lines	17,000 acres
Ontario Highways	3,600 acres
	53,900 acres

Although the foregoing excludes some common construction activities, 50,to 60,000 acres per year may be considered reasonably representative of current major development activities throughout the Province of Ontario. Based upon the number of residential units, 80 percent are located within the approximate bounds of the Great Lakes basin. The value of all building construction for the same census regions also indicates that about 80 percent is located within the Great Lakes basin. We therefore conclude that from 40, to 50,000 acres per year would represent the land requirements for major development activities within the Basin.

It has been suggested by Kline (14) that in the United States "more than 4,000 acres per day are being ploughed up to complete real estate developments, suburban facilities, highways and industries". On the basis of land use per capita, 50,000 acres per year for the Province of Ontario represents approximately 90 percent of the projected United States rate. Whilst neither the United States nor the Province of Ontario rates of land conversion are known with a high degree of reliability, the foregoing comparison provides some confidence that the estimate is representative of the order of magnitude of current annual conversions of land to urban uses and for other major development within Ontario.

A more accurate determination of the actual rate is perhaps less important than is the recognition that municipal and regional concentrations can give rise to serious potential erosion problems. Having regard to the preponderance of population and economic activities in the Metropolitan Toronto-centered region, along a corridor from Guelph through London to Windsor and within a narrow belt following the north shore of Lake Ontario and the St. Lawrence River, it is in these areas where problems are to be anticipated.

Whilst consideration of changes in agricultural land use are not directly mentioned in the terms of reference for this study, considerable public interest has been focused on the attrition of commercial farms in Ontario. Therefore some brief comments may provide a perspective on this aspect as it relates to urbanization processes.

Census data indicate a loss of land to farming of slightly more than 300,000 acres per year in southern Ontario during the recent period of 1966-71. Between 1951 and 1966 the farmlands in southern Ontario decreased at annual average rates of 0.32 percent for improved lands and 2.00 percent for unimproved lands. Unpublished data for the 1966-71 period indicate a substantial increase in the rate of loss of improved lands (1.85 percent per year) although only a modest increase in the loss of unimproved lands (2.10 percent per year). The 1971 area of lands being farmed in southern Ontario totalled 10.34 million acres of improved lands and 4.36 million acres of unimproved lands and compares with 1966 data which indicate 12.0 million acres of improved lands and 5.82 million acres of unimproved lands.*

It should be noted that differences in statistical methodologies and the definition of commercial farms require some caution in direct comparison of total acreages between censuses. Nevertheless the underlying trend to accelerating loss of farmlands is evident. It should be observed that the loss of farmlands does not necessarily imply an immediate conversion to urban uses, highway construction and other major types of development. A substantial portion of lands lost to farming is believed to represent acreage not counted as commercial farms although remaining in partial production as hobby farms.

Other than such withdrawals from commercial operation, much of the decline in acreage is believed to be accounted for by retirement of marginal lands, conversion to recreational uses, conservation and reforestation as well as lands temporarily idled in anticipation

*Personal communication from Dr. R.S. Rodd, Univ. of Guelph.

of development. As noted in the ARDA report on Planning for Agriculture in southern Ontario (40), census data do not provide directly for interpretation of other categories of land use. Comparable data are not available for northern Ontario, although the farm base and urban population being very much smaller the transfer of farmlands to other uses is not expected to be particularly significant.

5.0 CURRENT SOIL CONSERVATION PRACTICES IN MAJOR LAND DEVELOPMENT ACTIVITIES

There is an increasing awareness and concern over erosion losses which may be incurred in nearly any aspect of development activity. Although most major construction is carried out in compliance with legislative requirements, it must be recognized that existing legislation is mainly prohibitive in context and provides little guidance as to standards and preferred practices.

5.1 Residential, Commercial, Industrial and Institutional Developments.

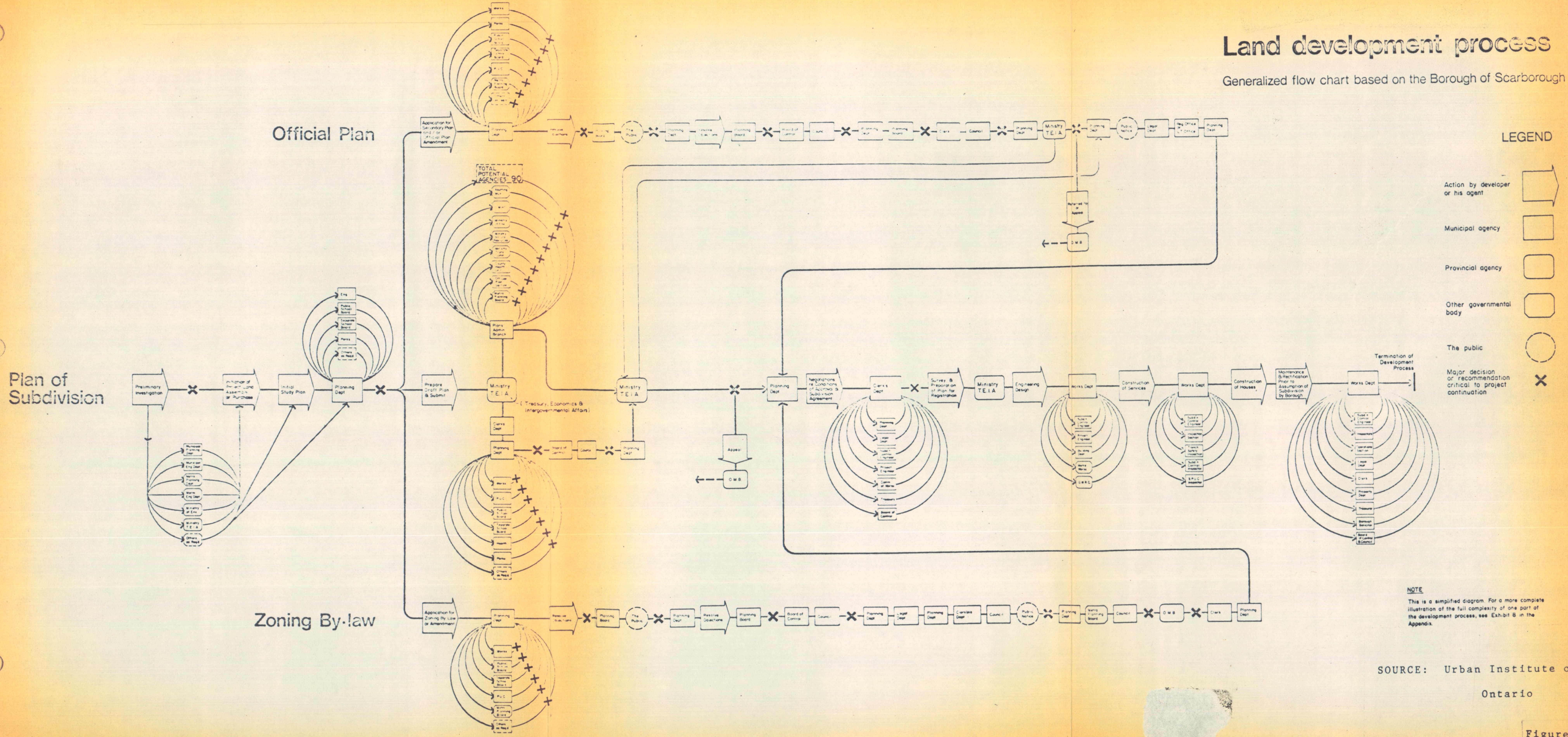
All lands being separated for development are subject to a series of reviews under the coordination of the Ministry of Treasury, Economics, and Inter-Governmental Affairs of Ontario. The typical review process involved in obtaining Ontario Municipal Board approval and implementing subdivision development is illustrated in Figure 6.

During the review of the draft plan of a proposed subdivision, the developer is required to provide a grading plan showing elevations of the natural ground and of the proposed grade at the corner of each lot. Current practice is to prohibit encroachment upon the floodplain of natural stream courses or modification and occupation of steep slopes, ravines or similar features. The developer is also required to provide an engineering appraisal of the effect of his proposed development upon runoff and the natural drainage systems. He may be required to provide on-site storm runoff detention and to construct energy-dissipating control structures in adjacent stream courses to limit peak flows and velocities to those obtaining prior to development.

In general, the opinion expressed in interviews with various government officials and private developers is that the planning

Land development process

Generalized flow chart based on the Borough of Scarborough



NOTE

This is a simplified diagram. For a more complete illustration of the full complexity of one part of the development process, see Exhibit B in the Appendix.

SOURCE: Urban Institute of Ontario

Figure 6

aspects afford adequate attention to soil conservation measures. The technical review considerations appear to take account of the potential hazards presented by soil type, land slope, drainage modifications and attempt to ensure that conditions following development will become stabilized early and not contribute to downstream instability of natural watercourses, or overload existing storm sewer systems. It is now a requirement of subdivision approvals that, prior to construction of housing, roads and streets must be constructed up to base-course level and storm sewers and other underground services installed in advance of clearing and grading of building sites. Several developers have indicated that base-course paving is now done as a matter of routine in their own interest to improve access. This sequence considerably mitagates the potential for erosion losses during construction.

Under most terrain conditions no other special measures are required to control sediment loss during construction. Catch basins at the storm sewer inlets are relied upon to entrap soil and dirt washed off building sites onto street lines. A frequent complaint concerns the nuisance effects of soil carried onto the streets by construction vehicles. Public concern has increasingly forced developers to minimize soil losses to the streets and some municipalities require developers to undertake street cleaning and in certain instances may require the cleaning of construction vehicles before moving off site.

The one aspect of the procedures which does appear deficient with respect to abatement of soil losses is the inspection and control of construction activities. Once a developer's plans have received approval and the conditions of subdivision agreements have been registered with the municipality or county, responsibility for ensuring compliance rests primarily with the local works department. In major metropolitan centres, sufficient technical resources are generally available to carry out regular inspection at all construction sites and, in the event of non-compliance with agreement terms can act under municipal by-laws. However, smaller municipalities may lack the resources to undertake regular inspections. Moreover, previous levels of activity may not have led to adoption of comprehensive by-laws governing all phases of construction activity.

An alternative to expanding the capacities of municipal works inspectorates which has been adopted with success by some municipalities is to require the developer's engineer/architect to submit formal certificates of compliance in accordance with the requirements of the planning approvals. Where this has been done, the developer's engineer/architect can be held professionally responsible for any lack of compliance with requirements.

There are significant differences between Canadian practices and that followed in various parts of the United States. For example, in Montgomery County, Maryland, which is regarded by the Soil Conservation Service as one of the more advanced jurisdictions with respect to soil conservation practices, site grading and soil conservation measures are recommended and approved by the County soil conservation office. Current practices require the developer to complete overall grading and shaping of an area, including the excavation of all building lots, and the formation of street grades prior to installation of storm sewers and other underground services. As a consequence, the county soil conservation office requires the installation of temporary sediment basins, berms and surface drainage modifications as well as temporary seeding of the site as a part of the initial construction activities. A 100-block subdivision development schedule, said to be typical in Montgomery County, is as follows:

Clearing and grading	- start October 9, 1972
Utility construction	- start September 1, 1973
Streets paved	- September 1, 1974
House construction	- start October 1, 1974
Site completed and stabilized	- May 1, 1976.

Thus between October 1972 and September 1974 the entire rough grade site remains exposed and explains in large part the emphasis placed by the SCS on temporary control measures. Although most of these temporary measures as imposed in Montgomery County are necessitated by the friable soils and hilly terrain, local officials recognize that their problems are exacerbated by the sequence of operations which have become normal practice as a consequence of the separated administrative responsibilities for various aspects of development. Moreover, the imposition of soil conservation codes at county level presents problems in adopting consistent approaches between adjacent jurisdictions. Special agreements between all affected counties are required to coordinate conservation measures on a watershed basis.

5.2 Highways and Utilities

The current practices of the Ontario Ministry of Transport and Communications in highway construction provide for a careful assessment of all environmental aspects of development projects. Soil erosion problems have long been recognized and the department has developed a comprehensive program of measures to minimize erosion during and after construction. These include:*

1) Cut and fill slopes designed at angles which should be stable for the given material.

2) Interceptor ditches to collect water at tops of cuts and reduce water flow down cut-slopes.

3) Seeding or sodding of cut and fill slopes to protect the surface.

4) Granular blankets on slopes which have unavoidably steep slopes or particularly erosion susceptible material, reduces or eliminates erosion where subsurface water flows out of erosion susceptible material.

5) Paved gutter at pavement edge on steep grades to protect shoulders.

6) Ditch and paved gutter lead-offs with associated catch basins and culverts to avoid long runs and consequent high discharge volumes in ditches.

*personal communication from J.B. Wilkes, Exec. Dir. Design Division, January 1974.

7) Ditch protection with sodding, seeding with jute mesh, rip rap, paved inverts, etc.

8) Stream bank protection with piling, gabions, sills, etc.

9) Checks and drops with energy dissipaters to reduce velocities in ditches.

10) Culvert end treatment (cut-off curtains and aprons).

11) Rip rap at toes of embankments running into streams and lakes, (e.g. causeways).

12) Paved slopes where slope will not support vegetation, e.g. slope under structures.

13) Perforated pipes and sand drains to intercept water before it reaches surface. Used to stabilize slopes and protect against surface erosion.

14) Settling ponds - used where erosion during construction is anticipated.

15) Rehabilitation of borrow areas - replacement of top soils and seeding.

A recent publication of the Highway Research Board, reproduced herein as Appendix B, provides a useful checklist for assessment of erosion problems and a key to appropriate control practices. The Ontario Ministry of Transport and Communications report their most extensively used treatments and typical costs during 1972 were as presented in Table 5-1.

It is now general practice to avoid clearing of right-of-way allowances adjacent to stream courses and to promote the preservation of aesthetic landscapes adjacent to rights-of-way. (102) In co-operation with Ontario Hydro, the Ministry undertake their own research to select and develop grasses, legumes and tree species suitable for stabilization for highway rights-of-way, transmission corridors and the surrounds of permanent camps, generating stations and other facilities.

Ontario Hydro indicate their awareness of the potential problems of soil losses during construction and have developed

TABLE 5-1

Soil Conservation Practices - Ontario Ministry of Transport & Communications

Item		Quantity 1972 Construction Year	Cost $
Mulch Seeding	Used universally on soil areas disturbed by construction unless otherwise treated by sodding granular blanket or paving.	4,000 acres	968,000
Sodding	Used where immediate cover is required for aesthetic reasons (urban sections) or for immediate erosion control (ditch lines).	1,019,000 sq. yds.	611,000
Gutter and Curb & Gutter (Asphalt and Concrete)	Used to collect and transport concentrated flows of water which would otherwise cause erosion.	659,000 lin. ft.	2,636,000
Spillways (1/2 Pipes)	Usually used to carry high discharge of water down steep slopes.	5,100 lin. ft.	N.A.*
Slope Paving	Used on earth slopes under structures where vegetation will not grow, at culvert outlets or other highly erosion susceptible areas.	59,000 sq. yds.	N.A.*
Granular Blankets	Usually 12" - 24" thick. Occasionally used on cut and fill slopes and in ditches where easily erodeable material which will not support vegetation is encountered or on slopes where seepage must be controlled to prevent erosion. In urban areas it is occasionally covered with top soil and sod.	188,000 tons	282,000
Sub-Drains - Perforated Steel Pipe	Used to draw off subsurface water. Lowers water table, reduces seepage. Partly directed toward stability and erosion control.	312,000 lin. ft.	N.A.*
Rip Rap (Boulders of Shot Rock)	Used to protect erosion susceptible material from erosion by wave action or fast running water.	56,000 c.y	N.A.*
Catch Basins With Sumps	Most catch basins incorporate a sump to collect sediment which is cleaned out periodically.	Extensively used. Total figures not readily available.	
Sediment Ponds	Used in ecologically sensitive locations to collect material eroded during the course of construction.	Limited use.	
Checks and Drops (Energy Dissipators)	Used on steep grades in ditches and channels or to dissipate energy where large volumes are discharged from storm sewers into streams and on stream diversions involving steep grades in erodeable material.	Isolated use. Figures not readily available.	
Groins	Low walls of timber rock concrete or steel constructed into the water at right angles to the shore of lakes or streams to trap sand or other water transported material. Develops beaches and protects shore line from erosive action of waves and currents.	Isolated use, e.g. Great Lakes shorelines. 3,000 lin.ft. 90% M.T.C. Subsidy.	120,000
Sills and Gabions	Shoreline protection. Stream bank protection.	Isolated use e.g. Hwy.59 shoreline protection, London District.	166,000

* N.A. - Not available

internal guidelines for the minimizing of adverse impacts upon the environment. A recent preliminary guide to construction practices for power lines is reproduced in Appendix C. It may be noted from this document that clearing of vegetation is carefully controlled and other disturbances of the landscape are to be minimized.

In reviewing the environmental assessment for a proposed extension to the thermal nuclear generating station at Pickering, it is apparent that similar concern and attention has been accorded to a comprehensive range of environmental aspects (28). Although no soil erosion problems are mentioned, specific provision is made for site stabilization and landscaping as development proceeds. Considerable attention has been given to the control of liquid and gaseous contaminants and to the separation of site drainage and sanitary sewage so that the waters of Lake Ontario will not be impaired either during construction or thereafter. Environmental studies have been made not only of the site proper but also of the impact of development upon the surrounding areas and communities with respect to water and air quality, requirements for road access and aesthetic considerations.

Both the Ministry of Transport and Communications and Ontario Hydro have operational staff groups directly concerned with all environmental aspects of their development activities. In both organizations the environmental units interact between the planning and design groups to ensure continuity of input from conceptual planning through implementation.

It seems quite clear that these agencies are fully aware of the need for appropriate soil conservation measures as well as other aspects of environmental protection and are adequately staffed to ensure their proper consideration. Both Ontario Hydro and the Ministry of Transport and Communications have developed an extensive internal documentation providing guidelines, standards and criteria to their planners and designers with the intent of minimizing erosion losses and avoiding pollution of water courses.

5.3 Other Development Aspects

The Ontario Ministry of Natural Resources administers the Regional Conservation Authorities Act and has presented the establishment of conservation authorities on a watershed basis throughout southern Ontario and the more populated areas of northern Ontario.

The Ministry advise that no specific guidelines have been developed pertaining to soil erosion and conservation practices. However, it seems apparent that these authorities are generally aware of the need for sound conservation measures and of the applicable technology. In many areas they have moved to restrict or prohibit development of floodplain areas and of steeply-sloped lands.

Under the review processes established by the Ministry of Treasury, Economics and Intergovernmental Affairs each major development proposal is referred to the local conservation authority for approval prior to submission to the Ontario Municipal Board. At this stage the conservation authority is able to consider each development proposal in the light of site and overall river basin problems and assess the impact on land management and water quality of all developments within a natural physiographic unit. Obviously the technical capacity of the individual conservation authorities will vary depending upon the level of activity in their area. Most areas experiencing significant development are reasonably staffed and are able to call on the Ministry directly for specialized assistance.

Special legislation has been passed by the Government of Ontario governing the opening and operation of quarries and borrow pits. Proposed legislation will require comprehensive environmental assessments to be prepared for most major projects and under the review procedures proposed it may be expected that soil erosion and drainage will receive appropriate consideration.

The Federal Government through the Departments of Public Works and of National Defence manages extensive areas of land and property throughout Ontario. The Department of Public Works has developed its own guidelines for site development which have received wide acceptance both in Canada and the United States (106). The Department of National Defence has its own environmental control unit, which follow generally accepted practices in site development and stabilization around their camps, airports and other facilities, although specific documentation identifying accepted standards or design practices has not been developed.

6.0 GUIDELINES FOR EROSION CONTROL

It has been suggested by Jonys (96) that environmental guidelines concerning the design of drainage and sediment control measures should serve three main functions:

1) To indicate the scope of the drainage and sediment related environmental problems in time and space.

2) To provide a framework for the assessment of existing or revised conditions necessary for the establishment of environmental standards for a specific site.

3) To identify or suggest design methods for the evaluation and selection of control facilities to meet the environmental criteria.

Because of the design nature of these functions it is suggested by Jonys that certain general aspects might take the form of a code which would have the format of law and that the specific design standards and procedures be designated as "recommended practices" which would, however, not be obligatory in application.

The foregoing approach has been widely adopted throughout the United States where the Soil Conservation Service has sponsored the establishment of state and county soil conservation organizations covering most of the country. In each state and county, soil conservation legislation provides the framework for the establishment of technical guidelines and regulations as well as providing for fines and prohibitions. Reference 12 presents a model act as recommended by the SCS.

In the Province of Ontario legislative requirements are contained in various acts concerning environmental protection. Appropriate design practices for soil conservation and drainage control have been developed by several agencies. These, together with general technical literature concerning current design practices in drainage, sedimentology and soil conservation, provide the technical standards as determined by each agency.

The evaluation of erosion and drainage from urban developments cannot readily be considered separately from other land-disturbing activities, including agriculture and forestry. Thus, U.S. legislation usually provides a broad basis for the preparation of regulatory codes and recommended practices with respect to all forms of land disturbance. Although this study has been directed to a preliminary assessment of the effects of major development activities upon sedimentation, it is apparent that any broad attempt to regulate construction activities with the intent of minimizing the sedimentation and pollution of receiving waters must deal with overall drainage aspects which in part derive from rural land uses. Hence any logical evaluation of problems arising from sedimentation must proceed from an analysis of the regime characteristics of an entire catchment basin.

6.1 Current Legislation

Although there are no federal or provincial statutes which deal specifically with control of soil erosion there appears to be a variety of acts under which such adverse environmental effects may be controlled. The fact that there are a number of statutes which could be applied may present certain difficulties in dealing consistently with problems. However, presuming effective coordination between agencies, the various acts should be adequate to provide such control as may be environmentally desirable. The following discussion of federal and provincial legislation is in large part abstracted from a review of the application of existing law for environmental protection in Canada by MacLatchy (115).

6.1.1. Federal Legislation. The primary federal legislation which appear to apply are the Fisheries Act, the Canada Water

Act and the Navigable Waters Protection Act. The Federal Government has delegated administrative responsibility for the Fisheries Act to the Province of Ontario as has been done with several other provinces. The general anti-pollution provision of this act states "....no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish .....". Deleterious substance is given a very broad meaning under the act and in a recent decision of the British Columbia Supreme Court, it was found that the silt which was put or placed in the water by the activities of a bulldozer was a deleterious substance within the meaning of the act.

The Navigable Waters Protection Act is designed to protect waters as defined in the act by prohibiting the building or placing of any work in, under, through or across a navigable water without approval of the Ministry of Transport. Work includes "any dumping of fill or excavation of materials from the bed of a navigable water". The Canada Water Act provides for the control of effluent qualities discharged into streams and watercourses.

6.1.2. Province of Ontario. Direct control of resources is exercised by the province and provides for jurisdiction over water and air pollution as well as other environmental matters. The Ontario Water Resources Act prohibits the discharge or deposit of material of any kind into water that may impair the quality of the water. The Environmental Protection Act also contains general provisions prohibiting the discharge of any kind of contaminants to any part of the natural environment. Under the Beds of Navigable Waters Act the province owns the bottom of all water beds in the absence of an express grant. Assuming the bottom of any waterbody is owned by the province, the Public Lands Act states it is an offence to deposit any material upon public lands whether or not covered by water without the consent of the Ministry.

6.1.3. Regional and Municipal. The Conservation Authorities Act extends to such conservation authorities broad powers to control watercourses within their jurisdiction and subject to the approval of the Lieutenant Governor in Council, an authority may make regulations applicable in the area under its jurisdiction with respect to:

a) restricting and regulating the use of water in or from rivers, streams, inland lakes, ponds, swamps, and natural or artificially constructed depressions in rivers or streams;

b) prohibiting or regulating the straightening, changing, diverting or interfering in any way with the existing channel of a river, creek, stream or watercourse;

c) regulating the location of ponds used as a source of water for irrigation;

d) providing for the appointment of officers to enforce any regulation made under this section;

e) prohibiting or regulating the construction of any building or structure in or on a pond or swamp or in any area below the high water mark of a lake, river, creek or stream;

f) prohibiting or regulating the placing or dumping of fill of any kind in any defined part of the area over which the authority has jurisdiction in which in the opinion of the authority the control of flooding or pollution or the conservation of land may be affected by the placing or dumping of fill.

Municipalities may also adopt by-laws controlling land use and governing practices and standards of construction activities of all kinds.

6.2 Guidelines for Control of Erosion

The intent of requiring sound soil conservation practices in development activities is by nature largely a local concern. Additional statutory requirements seem less needed than the adoption of consistent standards by local authorities. It appears that there is sufficient statutory authority already enacted to enable conservation and municipal authorities to adopt suitable regulations with this intent provided they are convinced of the necessity. To facilitate coordinated action, the identification of acceptable guidelines, standards and specifications at the provincial level under sponsorship of the Ministry of Natural Resources in cooperation with the Ministry of Environment would seem to be the logical procedure. Several models for such are contained in bibliographic references 1, 3, 11, 12, 80, 83, 92, 93, 96, 103 and 106.

6.2.1. U.S. Soil Conservation Service Practices. The institutional and administrative approach to conservation differs between Canada and the United States. In the United States agricultural soil conservation became a major concern during the 1930's and as a consequence, the Soil Conservation Service of the U.S. Department of Agriculture developed the research and technical capacity to investigate and advise upon a broad range of agricultural practices relating to conserving natural soil fertility. The need for widespread implementation of improved conservation practices led to the development of soil conservancy districts with broad concern over all aspects of sedimentology. Enforcement and educational activities have developed at the county level supported by technical advisory services and broadly-based programs of research and investigation at the state and federal levels.

There is an extensive literature published by United States government sources providing guidelines as to acceptable practices for temporary stabilization of exposed lands, control of drainage, trapping of sediments as well as permanent measures for stabilization and drainage control. Nearly all of such publications draw upon the research undertaken by the United States Soil Conservation Service and their general engineering handbook and manual of conservation practices (1, 80). State and county legislation governing erosion control measures and model specifications for construction has been developed with the assistance of the SCS. A number of these documents have been reviewed as listed in the bibliography (12, 91, 92, 103 and 104).

SCS officials have particularly commended the guidelines, standards and specifications for minimizing erosion control in urbanizing areas developed by the State of Wisconsin and adopted by its various county soil and water conservation districts (3). The SCS recommend the Wisconsin guidelines as being appropriate to continental climatic conditions similar to those experienced throughout southern Ontario. This document provides general guidelines for minimizing erosion in subdivision developments, highways, and road construction, recreational developments and utility construction and contains engineering standards and specifications for the design of storm water removal systems, clearing and snagging, dykes, drains, grade-stabilization structures, lakeshore protection, retaining walls, stream-bank protection and environmental planting. Technical appendices concern the estimation of peak flows, forestry techniques and present a number of typical construction specifications. In reviewing the foregoing publication and other documentation it appears that most technical aspects are also covered in general engineering literature.

6.2.2. Canadian and Province of Ontario Practices. The institutional arrangements in Canada have placed the burden of responsibility for the development and conservation of natural resources upon the provinces, with the federal government assisting in cooperative programs and providing basic research assistance.

Within the Province of Ontario, it was recognized that the river basin is the basic physiographic unit wherein interdependencies between land and water resources require coordinated management. Hence in 1946 the Province initiated the establishments of river basin conservation authorities and provided for more logical consideration of such matters than had been possible on the basis of political subdivision into counties, townships and municipalities.

Since passing of the Conservation Authorities Act some 38 river basin conservation authorities have been formed in Ontario. Of these, 33 are in southern Ontario. The Lakehead, Sault Ste. Marie, Matagami, Nickle Belt and North Bay/Mattawa Conservation Authorities cover the populated areas of northern Ontario. The only significant basins not yet organized within conservation districts are the Muskoka Lakes region and Algonquin Park.

A comprehensive publication covering landscape and site development has been prepared by the Federal Department of Public Works which provides basic guides to currently accepted practices in building site analysis, grading and landscaping and contains considerable information on site stabilization and planning appropriate to various locations across Canada (106). Similar information specifically relating to highway design has been published by the Ontario Ministry of Transport and Communications as "Guidelines for Highway Amenities and Aesthetics" (102). The Ministry of Transport and Communications and Ontario Hydro also have developed extensive internal design documentation covering the design of storm sewers, rainfall intensity analysis, culvert selection as well as forestry and landscape design information.

It is concluded that the essential technical and methodologic aspects are adequately covered by these federal and provincial sources and by standard works on hydrology, hydraulic design of drainage systems, control structures and river training works. All such materials, including U.S. documentation, are readily available and provide an adequate reference for environmental agencies, conservation authorities, municipalities and others who may require such for the evaluation and assessment of development proposals. The sources reviewed in preparation of this report, as listed in the bibliography hereto, provides a guide to appropriate source material. Additional material is in turn referenced in the more technical literature cited.

7.0 RECOMMENDATIONS FOR ABATEMENT OF SOIL LOSSES DURING AND AFTER CONSTRUCTION

From the preceding review of the practices and procedures of various agencies of the Province of Ontario, the Federal Government and the constraints imposed upon private development activities, it is apparent that generally sound conservation practices are being implemented in nearly all aspects of major development activities, or at least are considered at the planning, review and design stages if the established procedures are followed.

Some weaknesses are reported in the implementation of measures called for in design. However, any serious deficiencies in this respect can be remedied by ensuring the understanding of works inspectorate staff of the potential hazards and of requirements established at the subdivision approval stage. Where municipal works departments do not have sufficient capacity to carry out regular inspections, requiring the developer's engineer/architect to submit formal certificates of compliance can provide a means of supplementing direct inspections.

No specific control measures or practices have been determined from our review of U.S. and Canadian practices which appear to be warranted to supplement those measures already generally adopted. Each river basin or sub-catchment may present special problems inherent to its particular landforms and soils. The local conservation authority is the logical focus of responsibility for assessing areas of special hazard and the determination of requirements for overall management of the basic land and water resources.

As an aid to this process, soils and drainage interpretations highlighting limitations for various purposes can be economically represented by ortho-mapping techniques. An example of this application has been published by the Oklahoma County Soil

Conservation District (84). Therein soil limitations with respect to drainage, texture, acidity, electric conductivity and resisitivity, depth to bedrock, shrink-swell potential, flood hazard strength, permeability, clay mineralogy and land slope have been analyzed. Based upon limitations imposed by combinations of the foregoing parameters, interpretive mapping may be compiled classifying areas with respect to suitability for residential accommodation, light industry, heavy industry, roads and streets, parks and playgrounds, sanitary landfills, septic tank fields, storage lagoons, agriculture, forestry, wildlife reserves and other uses. Appropriate basic data are available for most of southern Ontario, and a trial classification of a small catchment near Guelph utilizing this technique is reported to have been of considerable value to both planners and developers.* Compilation of such analyses for those areas subject to significant development pressures would serve to highlight potential hazards which might readily be avoided.

*personal communication, Prof. P. Chisholm.

8.0 PROPOSAL FOR FURTHER STUDIES

There are several aspects which have been discussed in earlier sections which appear to warrant further support. These include:

1) An extension of soil survey activities to develop appropriate factors relating to the soils and climate of southern Ontario for use in the universal soil loss equation would be of considerable assistance in evaluating the potential hazards and the effectiveness of proposed conservation practices. It is recommended that consideration be given to supplementing the existing federal/provincial soil survey program to provide the resources needed to develop basic rainfall and soil erodibility parameters and thereby expand the utility of the provincial soil survey series. It is further suggested that priority of attention should be focused on those counties constituting the Metropolitan Toronto centred region, the counties of the Niagara escarpment and southwestern Ontario where the greater development pressures are already clearly evident.

2) It is also recommended that consideration be given to the collation of physical and engineering soils data with the pedologic taxonomy of the soil survey series. Revision of the series or supplementary publication of such information would provide planners, developers and technical review agencies with basic information for assessment of erosion potential and lead to avoidance of sites requiring excessively costly measures to develop and stabilize. Such information will also be of value to the selection of routes or corridors for

utilities and communications facilities.

Much of the physical and engineering data are available in the records of agencies such as the Department of Transport and Communications, the C.N.R., C.P.R., Ontario Hydro and the various municipal and conservation authorities. It would appear the task of compilation and correlation would logically be developed through the existing soil survey organization.

It would not be intended that such data substitute for specific engineering soil surveys as required for development design. However, as an aid at the planning stage and in the general review of development proposals, such interpretations would materially facilitate the extended application of the very substantial body of data already compiled from agricultural soils investigations.

3) It seems probable that the more significant level of adverse impacts on aquatic ecology are associated with fine-grained sediments and other dissolved contaminants which are not retained in conventional sediment traps. The studies currently underway at the University of Guelph into the sedimentology and ecology of Hanlon Creek are providing an opportunity to examine this aspect. It is premature at this stage to anticipate the results of these studies. However, should they indicate significant adverse impacts, it may be worthwhile considering an extension to these studies to provide for evaluation of ecologic impacts for different efficiencies of sediment entrapment. This would also provide an opportunity for research into the design and efficiency of sedimentation ponds.

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APPENDIX A

Photo-Interpretative Study of Land Development and Disturbances at Various Time Periods from 1947 to 1974 of the Don River Basin.

L. de Vries, P.Ag.

Northway Consultants Ltd.

Toronto, March 1974

PHOTO-INTERPRETATIVE STUDY OF LAND DEVELOPMENT AND DISTURBANCES AT VARIOUS TIME PERIODS FROM 1947 TO 1974 OF THE DON RIVER BASIN

1. INTRODUCTION

As part of an environmental research project undertaken by R. L. Walker and Partners, Consulting Engineers and Economists, Ottawa, Northway Consultants Limited under the direction of L. deVries, P.Ag., carried out on the Don River Basin a sequential analysis of land development and disturbances during the period from 1947 to 1973. The study involved obtaining copies of the photographic coverage either in mosaic or print form for selected years covering the Don River Basin area. An interpretative appraisal was made of the progress of land development between the various time periods selected, delineating the developments into Commercial and High Density,Residential, Roadways and Miscellaneous categories. An area measurement of the units delineated was made and tabulated.

2. METHODOLOGY

The programme got under way with a search of the availability of aerial photographs and mosaics for the area at various time periods. Search was made of the Photo Library at Northway Survey Corporation as well as Provincial and Federal Government photo libraries.

The southern part of the basin (from Steeles Avenue to the harbour) was covered by mosaics at scales of 1" = 5280', 1" = 2640', 1" = 2000' and 1" = 1,000', for the years 1956, 1960, 1963, 1965, 1967, 1969, 1971 and 1973. The mosaics from the earlier years of 1948 and 1950 had been unfortunately destroyed and the analysis had to be done utilizing the aerial photographs.

The northern part of the basin (from Steeles Avenue to the upper catchment) was handled separately and had to be done on photography obtained from the Federal and Provincial library, as well as coverage held by Northway Survey Corporation.

Except for the coverage earlier than 1956, the same time period sequence was maintained. For the period prior to 1956, because the same period photography was not available, differing periods were used. For the southern portion 1948 and 1950 photography was used. In the northern area 1954 and 1947 photography was used.

In the compilation of the data for the southern part of the basin the mosaics were overlaid on another in the successive stages and the area of new development or lands affected by development were delineated. The designations were often confirmed on the 1973 photography.

In the compilation of the data for the northern part of the basin the Ministry of Natural Resources mosaics prepared in 1954 were used as a basis on which to compile the successive stages of development.

All the data was compiled and measured at a scale of 1" = 2000'. A square inch grid planimeter divided into 100 units was used in the area measurement. At the above scale each square represents an area of .918 acres. The development units were squared off to the full square.

3. RESULTS

The summation of the area measurements are compiled in Table I, IIa, and IIb. This shows the areas under the categories of Commercial and High Density,Residential, Roadways and Miscellaneous for the various time periods. An average figure for the period has been given because of the change in the frequency of the periods, particularly in the early years.

The nomenclature of the categories represent a broadening of the normal definition and for the purpose of this study have been defined as follows:

Commercial and High Density - Developments which are dominantly associated with large excavations. Included in this category are industrial parks, apartment blocks, barns, etc.

Residential - Developments associated with small excavations. This category has been confined to mainly single family dwellings and duplexes. Town houses and small apartments have been included for the most part in the Commercial - High density category.

Roadways - Developments associated with major road construction. Included in this category has been the construction of Highways 400, 401 and the Don Valley Parkway. Also included have been some minor road realignments and early sub-division development.

The development of the railway yards in the west end of the basin and the new railway line across the north of the basin have been included in this category. The open and above ground construction of the subway has also been included in this category.

The widening and repavement of city streets have not been included. The level of abstraction used in the study did not permit consistent identification of this aspect and at the scale used in the measurement would have exaggerated the area under influence.

Miscellaneous - This category was used in the classification of miscellaneous types of development. In the southern section it encompassed urban renewal, erosion, land-slides, new water pipelines or sewer systems, landscaping. In the northern section it encompassed the development of gravel pits, golf courses, drainageway improvements and gas pipelines.

In the identification of the areas of urban renewal only the larger developments (area wise) have been identified essentially conversion of residential to high rise development. The construction of new towers in the downtown core has not been included. The area involved was usually too small and change could only be identified consistently through detailed stereoscopic evaluation.

4. COMMENTS ON THE RESULTS

The area results represent a preliminary estimate and offer a "ball park" appraisal of the land involved. In the examin-ation of new development it was sometimes unkown whether a particular block of a new sub-division was to be commercial or residential when all that was evident on the aerial photographs was a road network layout and the lanforming of the area. Also it was noted that with the progress of time, residential constructional patterns changed. In the early years of the study large blocks were laid out with road networks, but that it was several years before the sub-division was completely built up. This pattern changed in more recent times when blocks are completely built up, landscaped, etc. within a 1-2 year period. This characteristic in the constructional classification accounts for the higher area identified in the 1948-56 period. The higher acreage figures are real since this coincides with the immediate post-war building boom that was experienced in Toronto.

While the study was done systematically, because of different scales of photography different levels of details were discernible. At the smaller scales some developments were overlooked in the "initial scan" but were discernible in the successive periods. Adjustments were made for these discrepancies.

The mosaics for each of the periods in the southern section provided an excellent base on which to compile the information. The northern section proved more difficult and cumbersome. While the 1954 Natural Resources mosaic provided a good base on which to start from, the change between the periods was more difficult to record and keep consistent.

DON RIVER BASIN

TOTAL AREA OF BASIN 89,928 ACRES OR 140 SQ.MILES

TABLE I

TIME SEQUENCE PERIOD	AREAS UNDER DEVELOPMENT (ACRES)									
	COMMERCIAL		RESIDENTIAL		ROADWAYS		MISCELLANEOUS			
	Period Total	Yearly Av.	Period Total	Yearly Av.	Period Total	Yearly Av.	Period Total	Yearly Av.	Period Total	Yearl Av.
N 1947-1954) S 1948-1950)	205	101	3832	1632	101	23	146	40	4284	1796
N 1954-1956) S 1950-1956)	923	163	7026	1349	451	75	90	23	8490	1609
1956-1960	1089	272	3162	790	516	129	251	63	9602	1400
1960-1963	1075	358	2206	736	1275	425	490	163	5046	1682
1963-1965	815	407	1381	690	661	330	726	363	3583	1790
1965-1967	834	332	953	476	810	405	861	431	3287	1643
1967-1969	837	418	595	298	580	290	560	280	2572	1285
1969-1971	890	445	1079	540	181	91	644	322	2794	1397
1971-1973	864	432	1214	607	112	56	677	339	2867	1432
TOTAL									42,525	14,034

N - North section of Basin (above Steeles Ave.)
S - South section of Basin (below Steeles Ave.)

DON RIVER BASIN
SOUTH SECTION

(AREA SOUTH OF STEELES AVE.)
(52,500 ACRES OR 82 SQ.MILES)

TABLE IIa

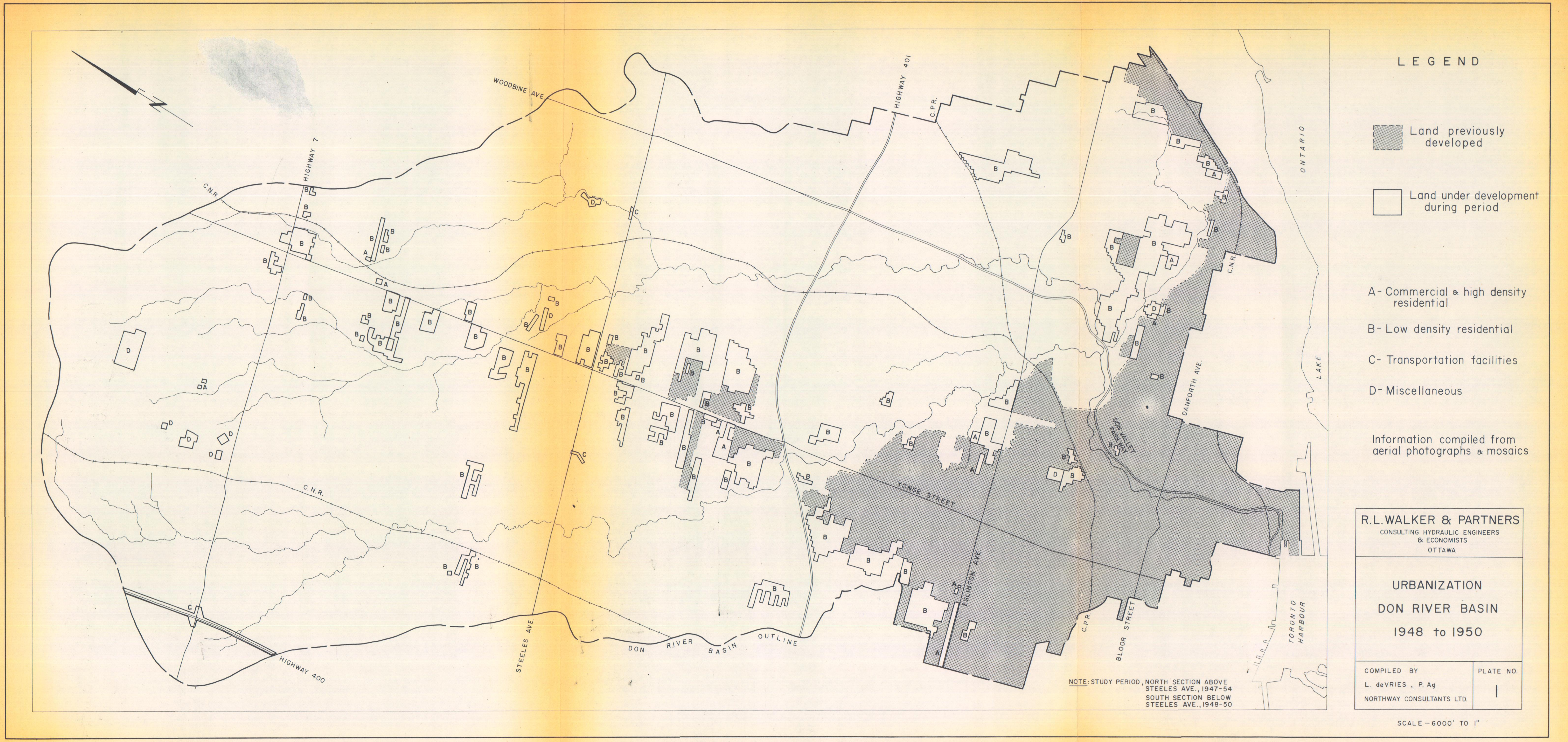
TIME SEQUENCE PERIOD	AREAS UNDER DEVELOPMENT (ACRES)									
	COMMERCIAL		RESIDENTIAL		ROADWAYS		MISCELLANEOUS		TOTAL	
	Period Total	Yearly Av.	Period Total	Yearly Av.	Period Total	Yearly Av.	Period Total	Yearly Av.	Period Total	Yearly Av.
1948-1950	199	100	3036	1518	24	12	51	26	3310	1656
1950-1956	895	149	6493	1082	451	75	67	11	7906	1317
1956-1960	830	207	2530	632	481	120	55	14	3896	973
1960-1963	937	312	1874	625	286	95	126	42	3223	1074
1963-1965	537	268	1349	674	475	237	70	35	2431	1214
1965-1967	492	246	649	324	783	391	84	42	2008	1003
1967-1969	553	276	530	265	565	282	50	25	1698	848
1969-1971	572	286	838	419	116	58	-	-	1526	763
1971-1973	443	221	873	436	73	36	76	38	1465	731
TOTAL									24,153	7,923

TABLE IIb

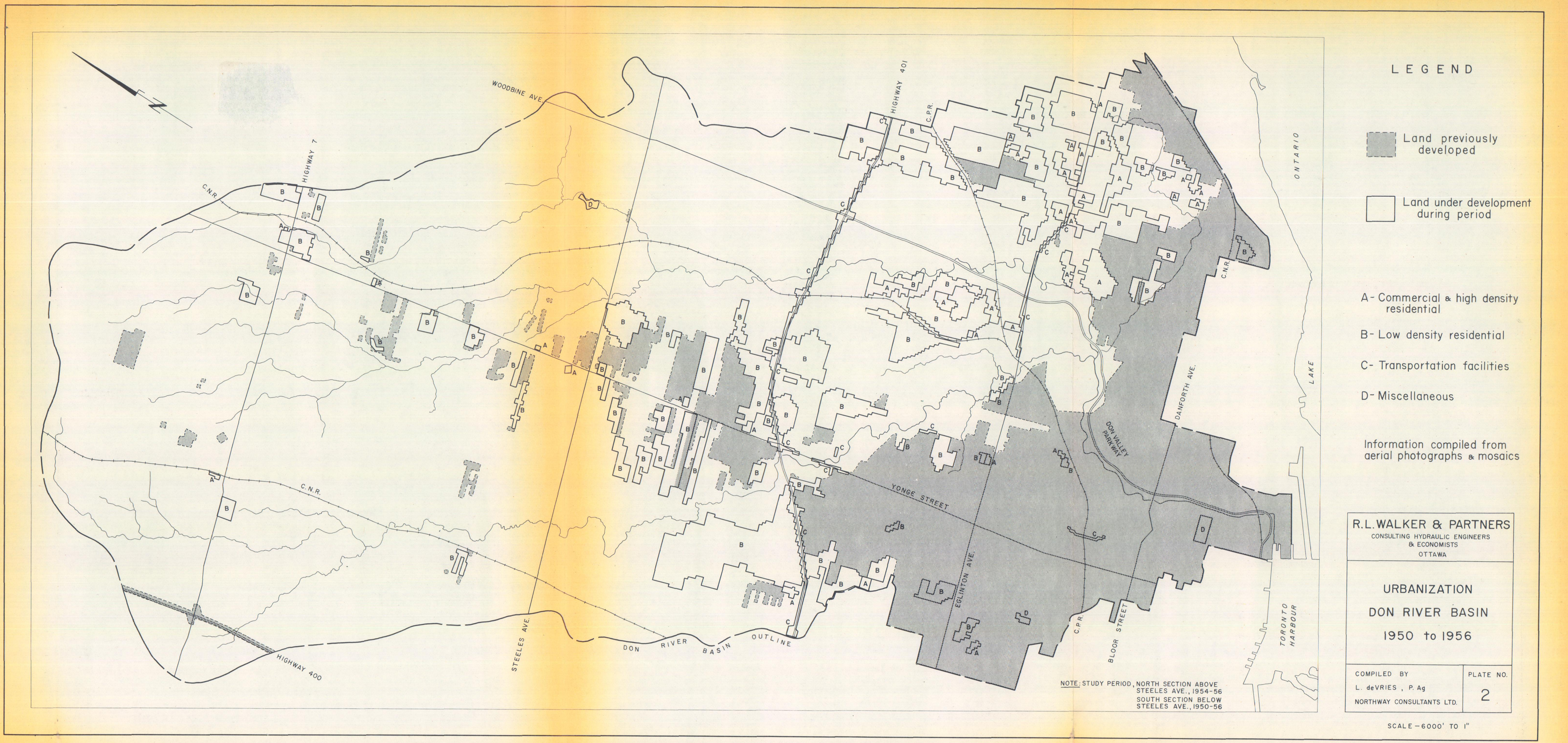
DON RIVER BASIN
NORTH SECTION

(AREA NORTH OF STEELES AVE.)
(37,428 ACRES OR 58.5 SQ.MILES)

TIME SEQUENCE PERIOD	AREAS UNDER DEVELOPMENT (ACRES)									
	COMMERCIAL		RESIDENTIAL		ROADWAYS		MISCELLANEOUS		TOTAL	
	Period Total	Yearly Av.	Period Total	Yearly Av.	Period Total	Yearly Av.	Period Total	Yearly Av.	Period Total	Yearly Av.
1947-1954	6	1	796	114	77	11	95	14	974	140
1954-1956	28	14	533	267	-	-	23	12	584	292
1956-1960	259	65	632	158	35	9	196	49	1706	427
1960-1963	138	46	332	111	989	330	364	121	1823	608
1963-1965	278	139	32	16	186	93	656	328	1152	576
1965-1967	171	86	304	152	27	14	777	389	1279	640
1967-1969	284	142	65	33	15	8	510	255	874	437
1969-1971	318	159	241	121	65	33	644	322	1268	634
1971-1973	421	211	341	171	39	20	601	301	1402	701
TOTAL									11,062	4,455



LEGEND
Land previously developed
Land under development during period
A - Commercial & high density residential
B - Low density residential
C - Transportation facilities
D - Miscellaneous
Information compiled from aerial photographs & mosaics
R.L. WALKER & PARTNERS
CONSULTING HYDRAULIC ENGINEERS & ECONOMISTS
OTTAWA
URBANIZATION
DON RIVER BASIN
1948 to 1950
COMPILED BY
L. deVRIES, P. Ag
NORTHWAY CONSULTANTS LTD.
PLATE NO.
1
SCALE – 6000' TO 1"
NOTE: STUDY PERIOD, NORTH SECTION ABOVE STEELES AVE., 1947-54
SOUTH SECTION BELOW STEELES AVE., 1948-50
WOODBINE AVE.
HIGHWAY 7
HIGHWAY 401
C.P.R.
C.N.R.
YONGE STREET
EGLINTON AVE.
BLOOR STREET
DANFORTH AVE.
DON VALLEY PARKWAY
STEELES AVE
HIGHWAY 400
DON RIVER BASIN OUTLINE
LAKE ONTARIO
TORONTO HARBOUR



LEGEND
Land previously developed
Land under development during period
A- Commercial & high density residential
B- Low density residential
C- Transportation facilities
D- Miscellaneous
Information compiled from aerial photographs & mosaics
R.L.WALKER & PARTNERS
CONSULTING HYDRAULIC ENGINEERS & ECONOMISTS
OTTAWA
URBANIZATION
DON RIVER BASIN
1950 to 1956
COMPILED BY
L. deVRIES , P. Ag
NORTHWAY CONSULTANTS LTD.
PLATE NO.
2
SCALE - 6000' TO 1"
NOTE: STUDY PERIOD, NORTH SECTION ABOVE STEELES AVE., 1954-56
SOUTH SECTION BELOW STEELES AVE., 1950-56
WOODBINE AVE.
HIGHWAY 7
HIGHWAY 401
C.P.R.
C.N.R.
YONGE STREET
DON VALLEY PARKWAY
DANFORTH AVE.
EGLINTON AVE.
BLOOR STREET
STEELES AVE.
HIGHWAY 400
DON RIVER BASIN OUTLINE
ONTARIO
LAKE
TORONTO HARBOUR

LEGEND

Land previously developed

Land under development during period

A - Commercial & high density residential

B - Low density residential

C - Transportation facilities

D - Miscellaneous

Information compiled from aerial photographs & mosaics

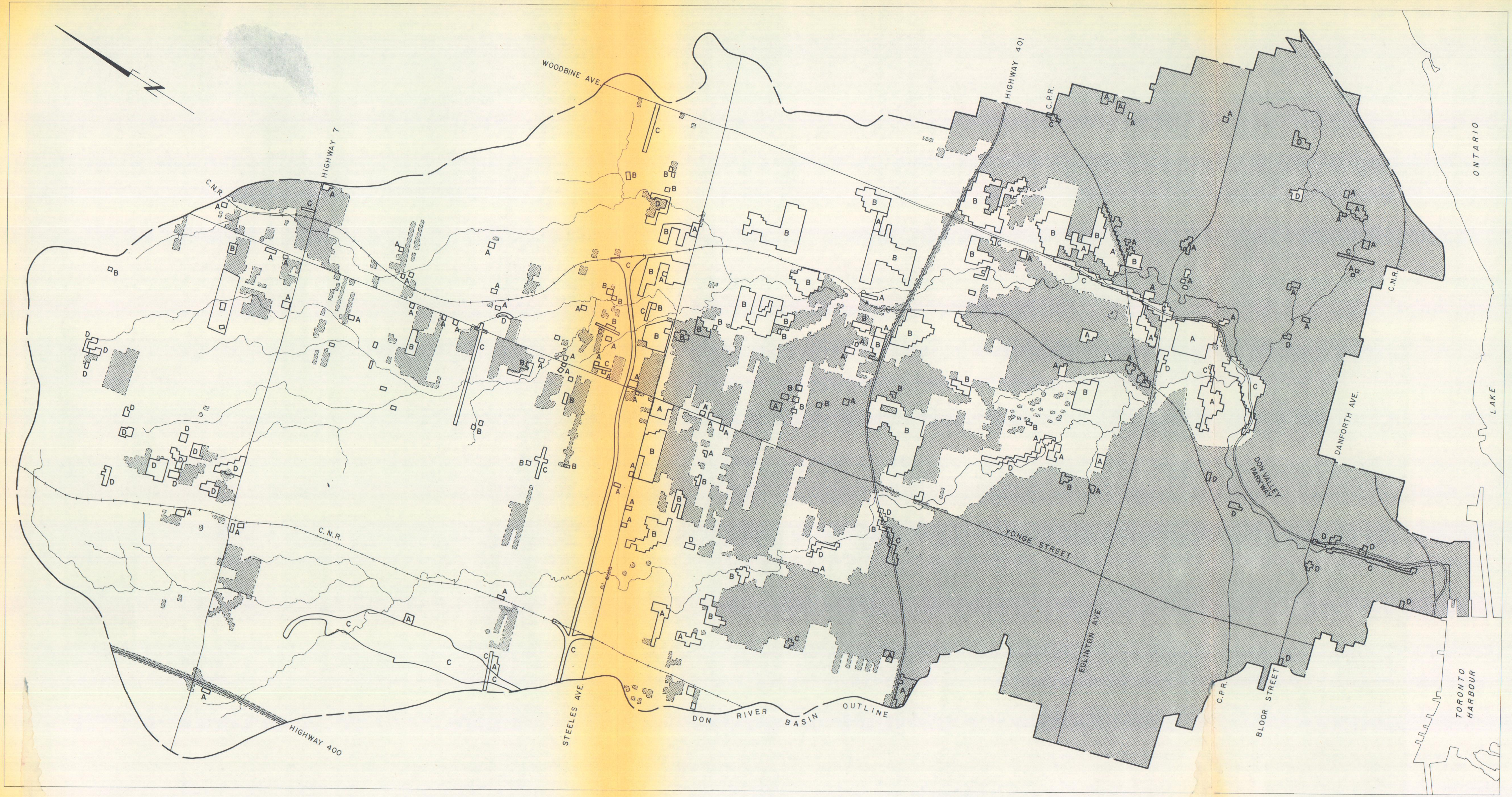
R.L. WALKER & PARTNERS
CONSULTING HYDRAULIC ENGINEERS & ECONOMISTS
OTTAWA

URBANIZATION
DON RIVER BASIN
1956 to 1960

COMPILED BY
L. deVRIES, P. Ag
NORTHWAY CONSULTANTS LTD.

PLATE NO.
3

SCALE — 6000' TO 1"



LEGEND

Land previously developed

Land under development during period

A- Commercial & high density residential

B- Low density residential

C- Transportation facilities

D- Miscellaneous

Information compiled from aerial photographs & mosaics

R.L. WALKER & PARTNERS
CONSULTING HYDRAULIC ENGINEERS & ECONOMISTS
OTTAWA

URBANIZATION DON RIVER BASIN 1960 to 1963

COMPILED BY
L. deVRIES , P. Ag
NORTHWAY CONSULTANTS LTD.

PLATE NO. 4

SCALE – 6000' TO 1"

LEGEND

Land previously developed

Land under development during period

A - Commercial & high density residential

B - Low density residential

C - Transportation facilities

D - Miscellaneous

Information compiled from aerial photographs & mosaics

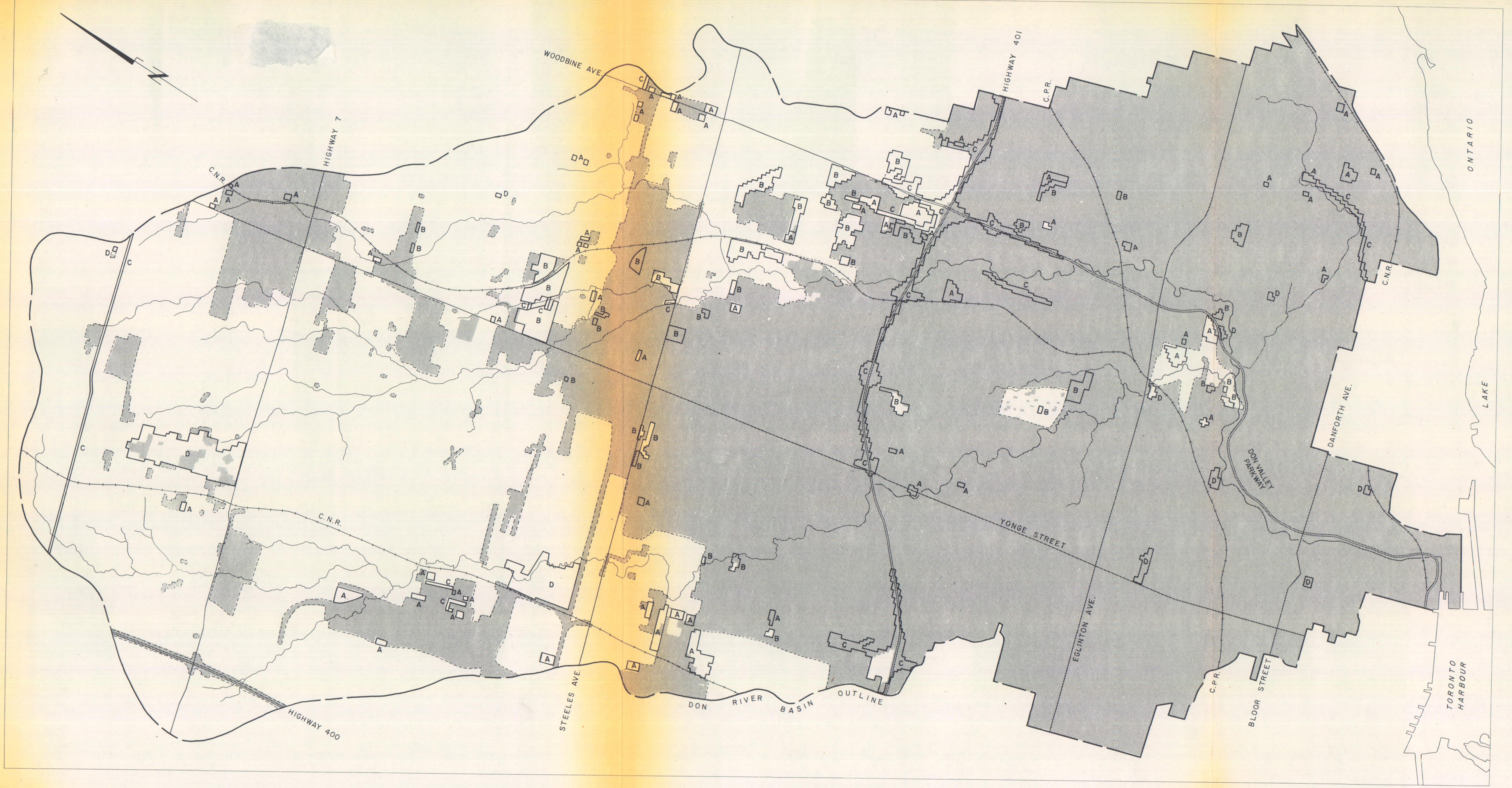
R.L. WALKER & PARTNERS
CONSULTING HYDRAULIC ENGINEERS & ECONOMISTS
OTTAWA

URBANIZATION
DON RIVER BASIN
1963 to 1965

COMPILED BY
L. deVRIES, P. Ag
NORTHWAY CONSULTANTS LTD.

PLATE NO. 5

SCALE - 6000' TO 1"



LEGEND

Land previously developed

Land under development during period

A - Commercial & high density residential

B - Low density residential

C - Transportation facilities

D - Miscellaneous

Information compiled from aerial photographs & mosaics

R.L. WALKER & PARTNERS
CONSULTING HYDRAULIC ENGINEERS
& ECONOMISTS
OTTAWA

URBANIZATION
DON RIVER BASIN
1965 to 1967

COMPILED BY
L. deVRIES, P. Ag
NORTHWAY CONSULTANTS LTD.

PLATE NO.
6

SCALE - 6000' TO 1"

LEGEND

Land previously developed

Land under development during period

A- Commercial & high density residential

B- Low density residential

C- Transportation facilities

D- Miscellaneous

Information compiled from aerial photographs & mosaics

R.L.WALKER & PARTNERS
CONSULTING HYDRAULIC ENGINEERS
& ECONOMISTS
OTTAWA

URBANIZATION
DON RIVER BASIN
1967 to 1969

COMPILED BY
L. deVRIES, P. Ag
NORTHWAY CONSULTANTS LTD.

PLATE NO.
7

SCALE – 6000' TO 1"

LEGEND

Land previously developed

Land under development during period

A - Commercial & high density residential

B - Low density residential

C - Transportation facilities

D - Miscellaneous

Information compiled from aerial photographs & mosaics

R.L. WALKER & PARTNERS
CONSULTING HYDRAULIC ENGINEERS & ECONOMISTS
OTTAWA

URBANIZATION
DON RIVER BASIN
1969 to 1971

COMPILED BY
L. deVRIES, P. Ag
NORTHWAY CONSULTANTS LTD.

PLATE NO.
8

SCALE - 6000' TO 1"

LEGEND
Land previously developed
Land under development during period
A- Commercial & high density residential
B- Low density residential
C- Transportation facilities
D- Miscellaneous
Information compiled from aerial photographs & mosaics
R.L.WALKER & PARTNERS
CONSULTING HYDRAULIC ENGINEERS & ECONOMISTS
OTTAWA
URBANIZATION
DON RIVER BASIN
1971 to 1973
COMPILED BY
L. deVRIES , P. Ag
NORTHWAY CONSULTANTS LTD.
PLATE NO.
9
SCALE – 6000' TO 1"
WOODBINE AVE.
HIGHWAY 7
HIGHWAY 401
HIGHWAY 400
C.N.R.
C.P.R.
STEELES AVE.
YONGE STREET
EGLINTON AVE.
BLOOR STREET
DANFORTH AVE.
DON VALLEY PARKWAY
DON RIVER BASIN OUTLINE
LAKE ONTARIO
TORONTO HARBOUR

APPENDIX B

Erosion Control Check List

and

Erosion Control Practices.

Source: Highway Research Board.

EROSION CONTROL CHECK LISTS

LOCATION, DESIGN AND CONSTRUCTION CHECK LIST

The following is a suggested list of questions. Each agency should develop a list to meet its own requirements.

LOCATION

- Are soil maps and aerial photographs available to help locate areas or sections with high erosion potential? ☐
- Has erosion potential been considered for each alignment alternative? ☐
- How will adjacent and nearby streams, ponds and lakes be affected by project construction? ☐
- Can sediment from construction activities be collected on or near the project? ☐
- Will special erosion control and sediment collection measures be required to protect adjacent properties? ☐

DESIGN

- Has the soil survey or foundation investigation been analyzed to assess erosion potential? ☐
- Are there areas where soil conditions indicate that severe erosion is a possibility? ☐
- Does the adjoining or nearby property require special erosion control or sediment collection methods? ☐
- Should additional ROW or easements be provided to permit sediment allocation? ☐
- Will special easement be required during construction or for maintenance operations? ☐
- What effect will construction sequence, method of operations or season of work have on control measures? ☐
- Are special provisions, plans or plan notes required for construction? ☐
- Is coordination required with others? ☐
- Have sediment traps, settling basins, diversion dikes, berms, slope drains, sodding, ditch paving, slope paving, and other work items been identified on the plans and provided in the contract? ☐
- Are provisions made for sediment removal and disposal? ☐
- Are extra funds included for emergency or unforeseen work? ☐
- Was joint design-construction PS&E erosion check made in field? ☐
- Will a design representative that is familiar with project erosion control measures attend the preconstruction conference? ☐
- Has a design review been established to review project design, including erosion control measures? ☐

CONSTRUCTION

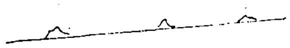
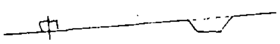
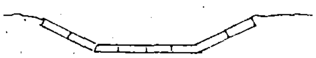
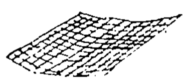
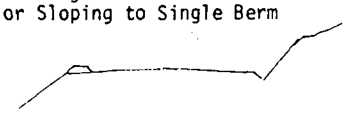
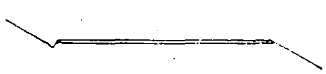
- Has one staff or project member been assigned specific responsibility for discussing erosion control? ☐
- Are there utilities, other agencies or private companies that should participate in erosion control discussion? ☐
- Does the contractor have an acceptable work plan that includes satisfactory provisions for erosion control? ☐
- Has the contractor assigned a specific individual to work with project personnel to monitor erosion control measures? ☐
- What erosion control and sediment collection measures are required before clearing and other work is started? ☐
- Are maximum disturbed area restrictions satisfied? ☐
- Are the plan measures satisfactory? ☐
- What other measures are needed? ☐
- Do they require force account, plan change or supplemental agreements? ☐
- Are joint field checks made by project and contractor personnel during rainstorms? ☐
- Is the maintenance of all devices and measures satisfactory? ☐
- Is the contractor completing stage work such as seeding and mulch, sodding, ditch paving, or riprap as soon as practical? ☐
- Are borrow and/or waste operations, erosion control and sediment collection measures satisfactory? ☐
- Are photographs or other efforts needed to document actual job or adjacent property conditions? ☐
- Will it be desirable that selected sediment devices be incorporated into permanent erosion control measures? ☐
- Have inadequacies in planning, design and construction been identified and reported? ☐

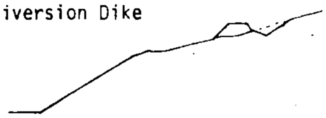
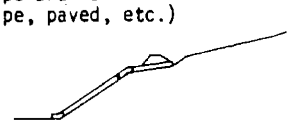
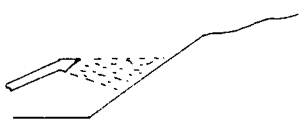
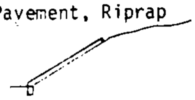
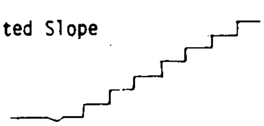
SEDIMENT COLLECTION CHECK LIST

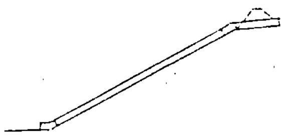
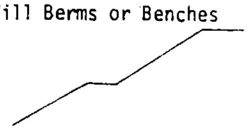
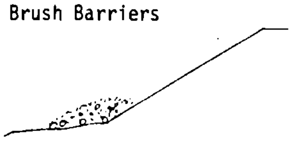
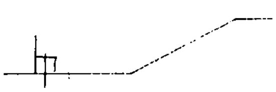
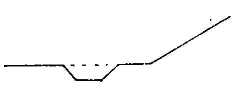
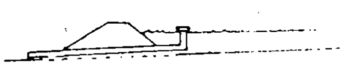
CONSTRUCTION OPERATION	CONTROL MEASURES PRIOR TO OR CONCURRENT WITH CONSTRUCTION														
	A. SETTLEMENT PONDS	B. SEDIMENT BASINS	C. CHECK DAMS	D. FILTER BARRIERS	E. DIVERSION DIKES AND DITCHES	F. BERMS	G. SLOPE DRAINS	H. LEVEL SPREADERS	I. SEEDING/MULCHING	J. MULCHING	K. SODDING	L. DITCH PAVING	M. SLOPE PAVING	N. RIPRAP	O. OTHER
1. CLEARING AND GRUBBING															
2. CULVERTS															
3. CHANNEL CHANGES															
4. BRIDGE STRUCTURES															
5. PIER CONSTRUCTION															
6. STREAM CROSSINGS															
7. HAUL ROADS															
8. EXCAVATION															
9. BORROW															
10. WASTING															
11. EMBANKMENT															
12. SUBGRADE															
13. BASE COURSE															
14. PAVING															
15. SHOULDERS															
16. LANDSCAPING															

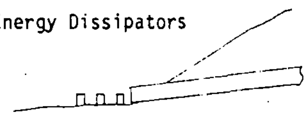
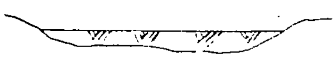
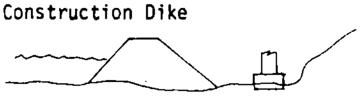
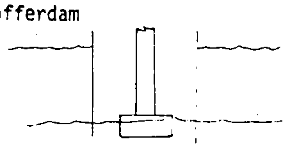
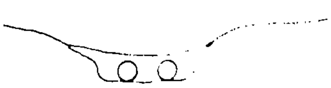
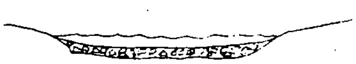
(after PennDot)

EROSION CONTROL PRACTICES

Treatment Practice	Advantages	Problems
ROADWAY DITCHES		
Check Dams 	Maintain low velocities Catch sediment Can be constructed of logs, shot rock, lumber, masonry or concrete	Close spacing on steep grades Require clean-out Unless keyed at sides and bottom, erosion may occur
Sediment Traps/ Straw Bale Filters 	Can be located as necessary to collect sediment during construction Clean-out often can be done with on-the-job equipment Simple to construct	Little direction on spacing and size Sediment disposal may be difficult Specification must include provisions for periodic clean-out May require seeding, sodding or pavement when removed during final cleanup
Sodding 	Easy to place with a minimum of preparation Can be repaired during construction Immediate protection May be used on sides of paved ditches to provide increased capacity	Requires water during first few weeks Sod not always available Will not withstand high velocity or severe abrasion from sediment load
Seeding with Mulch and Matting 	Usually least expensive Effective for ditches with low velocity Easily placed in small quantities with inexperienced personnel	Will not withstand medium to high velocity
Paving, Riprap, Rubble	Effective for high velocities May be part of the permanent erosion control effort	Cannot always be placed when needed because of construction traffic and final grading and dressing Initial cost is high
ROADWAY SURFACE		
Crowning to Ditch or Sloping to Single Berm 	Directing the surface water to a prepared or protected ditch minimizes erosion	None - should be part of good construction procedures
Compaction	The final lift of each day's work should be well compacted and bladed to drain to ditch or berm section. Loose or uncompacted material is more subject to erosion	None - should be part of good construction procedures
Aggregate Cover 	Minimizes surface erosion Permits construction traffic during adverse weather May be used as part of permanent base construction	Requires reworking and compaction if exposed for long periods of time Loss of surface aggregates can be anticipated
Seed/Mulch	Minimizes surface erosion	Must be removed or is lost when construction of pavement is commenced

Treatment Practice	Advantages	Problems
CUT SLOPES		
Berm @ top of cut 	Diverts water from cut Collects water for slope drains/paved ditches May be constructed before grading is started	Access to top of cut Difficult to build on steep natural slope or rock surface Concentrates water and may require channel protection or energy dissipation devices Can cause water to enter ground, resulting in sloughing of the cut slope
Diversion Dike 	Collects and diverts water at a location selected to reduce erosion potential May be incorporated in the permanent project drainage	Access for construction May be continuing maintenance problem if not paved or protected Disturbed material or berm is easily eroded
Slope Benches 	Slows velocity of surface runoff Collects sediment Provides access to slope for seeding, mulching, and maintenance Collects water for slope drains or may divert water to natural ground	May cause sloughing of slopes if water infiltrates Requires additional ROW Not always possible due to rotten material etc. Requires maintenance to be effective Increases excavation quantities
Slope Drains (pipe, paved, etc.) 	Prevents erosion on the slope Can be temporary or part of permanent construction Can be constructed or extended as grading progresses	Requires supporting effort to collect water Permanent construction is not always compatible with other project work Usually requires some type of energy dissipation
Seeding/Mulching 	The end objective is to have a completely grassed slope. Early placement is a step in this direction. The mulch provides temporary erosion protection until grass is rooted. Temporary or permanent seeding may be used. Mulch should be anchored. Larger slopes can be seeded and mulched with smaller equipment if stage techniques are used.	Difficult to schedule high production units for small increments Time of year may be less desirable May require supplemental water Contractor may perform this operation with untrained or unexperienced personnel and inadequate equipment if stage seeding is required
Sodding 	Provides immediate protection Can be used to protect adjacent property from sediment and turbidity	Difficult to place until cut is complete Sod not always available May be expensive
Slope Pavement, Riprap 	Provides immediate protection for high risk areas and under structures May be cast in place or off site	Expensive Difficult to place on high slopes May be difficult to maintain
Temporary Cover	Plastics are available in wide rolls and large sheets that may be used to provide temporary protection for cut or fill slopes Easy to place and remove Useful to protect high risk areas from temporary erosion	Provides only temporary protection Original surface usually requires additional treatment when plastic is removed Must be anchored to prevent wind damage
Serrated Slope 	Lowers velocity of surface runoff Collects sediment Holds moisture Minimizes amount of sediment reaching roadside ditch	May cause minor sloughing if water infiltrates Construction compliance

Treatment Practice	Advantages	Problems
FILL SLOPES		
Berms at Top of Embankment 	Prevent runoff from embankment surface from flowing over face of fill Collect runoff for slope drains or protected ditch Can be placed as a part of the normal construction operation and incorporated into fill or shoulders	Cooperation of construction operators to place final lifts at edge for shaping into berm Failure to compact outside lift when work is resumed Sediment buildup and berm failure
Slope Drains 	Prevent fill slope erosion caused by embankment surface runoff Can be constructed of full or half section pipe, bituminous, metal, concrete, plastic, or other waterproof material Can be extended as construction progresses May be either temporary or permanent	Permanent construction as needed may not be considered desirable by contractor Removal of temporary drains may disturb growing vegetation Energy dissipation devices are required at the outlets
Fill Berms or Benches 	Slows velocity of slope runoff Collects sediment Provides access for maintenance Collects water for slope drains May utilize waste	Requires additional fill material if waste is not available May cause sloughing Additional ROW may be needed
Seeding/Mulching	Timely application of mulch and seeding decreases the period a slope is subject to severe erosion Mulch that is cut in or otherwise anchored will collect sediment. The furrows made will also hold water and sediment	Seeding season may not be favorable Not 100 percent effective in preventing erision Watering may be necessary Steep slopes or locations with low velocities may require supplemental treatment
PROTECTION OF ADJACENT PROPERTY		
Brush Barriers 	Use slashing and logs from clearing operation Can be covered and seeded rather than removed Eliminates need for burning or disposal off ROW	May be considered unsightly in urban areas
Straw Bale Barriers 	Straw is readily available in many areas When properly installed, they filter sediment and some turbidity from runoff	Require removal Subject to vandal damage Flow is slow through straw requiring considerable area
Sediment Traps 	Collect much of the sediment spill from fill slopes and storm drain ditches Inexpensive Can be cleaned and expanded to meet need	Do not eliminate all sediment and turbidity Space is not always available Must be removed (usually)
Sediment Pools 	Can be designed to handle large volumes of flow Both sediment and turbidity are removed May be incorporated into permanent erosion control plan	Require prior planning, additional ROW and/or flow easement If removal is necessary, can present a major effort during final construction stage Clean-out volumes can be large Access for clean-out not always convenient

Treatment Practice	Advantages	Problems
PROTECTION OF ADJACENT PROPERTY (continued)		
Energy Dissipators 	Slow velocity to permit sediment collection and to minimize channel erosion off project	Collect debris and require cleaning Require special design and construction of large shot rock or other suitable material from project
Level Spreaders 	Convert collected channel or pipe flow back to sheet flow Avoid channel easements and construction off project Simple to construct	Adequate spreader length may not be available Sodding of overflow berm is usually required Must be a part of the permanent erosion control effort Maintenance forces must maintain spreader until no longer required
PROTECTION OF STREAM		
Construction Dike 	Permits work to continue during normal stream stages Controlled flooding can be accomplished during periods of inactivity	Usually requires pumping of work site water into sediment pond Subject to erosion from stream and from direct rainfall on dike
Cofferdam 	Work can be continued during most anticipated stream conditions Clear water can be pumped directly back into stream No material deposited in stream	Expensive
Temporary Stream Channel Change	Prepared channel keeps normal flows away from construction	New channel usually will require protection Stream must be returned to old channel and temporary channel refilled
Riprap	Sacked sand with cement or stone easy to stockpile and place Can be installed in increments as needed	Expensive
Temporary Culverts for Haul Roads 	Eliminate stream turbulence and turbidity Provide unobstructed passage for fish and other water life Capacity for normal flow can be provided with storm water flowing over the roadway	Space not always available without conflicting with permanent structure work May be expensive, especially for larger sizes of pipe Subject to washout
Rock-lined Low-Level Crossing 	Minimizes stream turbidity Inexpensive May also serve as ditch check or sediment trap	May not be fordable during rainstorms During periods of low flow passage of fish may be blocked

Treatment Practice	Advantages	Problems
BORROW AREAS		
Selective Grading and Shaping	Water can be directed to minimize off-site damage Flatter slopes enable mulch to be cut into soil	May not be most economical work method for contractor
Stripping and Replacing of Topsoil	Provides better seed bed Conventional equipment can be used to stockpile and spread topsoil	May restrict volume of material that can be obtained for a site Topsoil stockpiles must be located to minimize sediment damage Cost of rehandling material
Dikes, Berms Diversion Ditches Settling Basins Sediment Traps Seeding & Mulch	See other practices	See other practices

APPENDIX C

Construction Practices and Environmental Criteria for the Construction of Power Lines.

Source: Ontario Hydro.

CONSTRUCTION PRACTICES

ENVIRONMENTAL CRITERIA FOR THE CONSTRUCTION OF POWER LINES

The activities of the Lines and Stations Construction Department can significantly affect the success of Ontario Hydro's effort to meet the environmental concerns of society. The following criteria are to be used in the planning and execution of our field operations in a manner that will preserve and enhance the natural environment.

P1.0 General

P1.1 All personnel working on a particular project shall be advised of the following general environmental constraints as well as the specific constraints, as made known through engineering instructions associated with that particular program.

P1.2 An individual shall be designated on each project as the field contact for all matters concerning the environment. This may be a general foreman or other delegated individual.

P1.3 Among other factors, equipment for a particular project shall be chosen with the maintenance of the environment in mind.

P1.4 Construction activities shall be planned for those seasons of the year resulting in a minimum of environmental damage.

P1.5 Natural water courses shall not be crossed except where absolutely necessary and then only with the approval of the Zone Superintendent.

P1.6 Housekeeping and removal of surplus material and debris shall be continuous and integral with each construction activity. Disposal shall be either by burial (minimum of 2 feet cover) or by removal from R/W to an approved disposal area.

P1.7 Construction forces shall not cut or destroy any trees without the prior consent of the Forestry Department.

P1.8 Clearing and grading of construction areas will be minimal and done in such a manner as to prevent erosion and conform to the natural topography.

P1.9 Grubbing shall be limited to that which is absolutely necessary and preferably removed to an inconspicuous area on the right-of-way, alternatively it shall be hauled to an approved disposal area.

P1.10 Oil, gasoline and other pollutants shall not be discharged or buried on the right-of-way or other areas, but shall be removed to an approved disposal facility.

P1.11 Burning of material shall be in accordance with Government and Hydro regulations and shall be minimized.

P1.12 Dust, smoke, fumes etc. shall be controlled in sensitive areas. Vehicles shall not be left idling.

P1.13 Work shall be planned to minimize the vehicle trips over access roads.

P1.14 Noise nuisance shall be considered and kept to a minimum.

P1.15 Blasting shall not be done in or near streams.

P1.16 Borrow pits shall not be opened without permission. Consideration shall be given to the use of established commercial pits and quarries.

P1.17 Fences and gates shall be maintained in a state equal to or better than the condition in which they were found.

P1.18 An effort shall be made to identify the location of tile drains before construction commences, using aerial photography, local knowledge etc.

P2.0 <u>Material Yards and Camps</u>

P2.1 Sites shall be so chosen that they are as inconspicuous as possible and compatible with the surrounding area.

P2.2 They shall be maintained in a neat, tidy and respectable condition.

P2.3 They shall be restored to their original or natural condition.

P2.4 Disturbance of permanent vegetation shall be kept to a minimum.

P3.0 Right-of-way Access

P3.1 Where access has been specified as a result of an environmental study, deviation will not be permitted without the consent of the Project Engineer.

P3.2 Established access facilities including local roads shall be utilized to the grestest extent possible.

P3.3 Access roads, where possible, shall be confined to the R/W. However, where such would result in severe environmental damage, consideration shall be given to alternative access routes.

P3.4 The routing of access roads shall take into consideration access to all future lines on the same right-of-way.

P3.5 Where possible, access roads shall avoid steep slopes and wetlands.

P3.6 In general, the width of access roads shall be a minimum and limited to 15 feet; however, on curves, widths may be increased to accommodate the longest component to be transported.

P3.7 Rutting and the mixing of sub-soil and topsoil shall be minimized.

P3.8 Where an access road is established it shall be used for all transport involved. Diversions shall be permitted on cultivated fields within the confines of the right-of-way to minimize rutting and crop damage.

P3.9 When it becomes apparent that excessive marring, scarring or erosion damage is being initiated, immediate steps shall be taken to curtail such damage.

P3.10 Sizing of ditch culverts shall have the approval of local control authorities.

P4.0 Clearings for Tower Sites

P4.1 Clearing of tower sites shall normally be carried out by the Forestry Department and shall be of minimum size as mutually agreed to by Construction and Forestry personnel.

P4.2 Trees which are to remain in the work area shall be identified and protected.

P5.0 Foundations

P5.1 Trees in the vicinity of the tower that were not removed as a result of the clearing operation shall be preserved.

P5.2 Disturbance of the vegetation and top soil shall be kept to a minimum.

P5.3 All excavated top soil and sub soil shall be segregated for the purpose of restoring the site subsequent to the operation.

P5.4 Care shall be taken to ensure that excavated material or other foreign matter will not enter natural water courses.

P5.5 Surplus excavated material shall be spread to enhance the tower site except where specified to be removed from the site.

P5.6 Surplus concrete, bentonite and other construction material shall be buried, hauled away or otherwise disposed of to minimize environmental impact.

P5.7 The discharge from any pumping operation shall be arranged so that sediment will not enter any nearby streams.

P6.0 Tower Assembly and Erection

P6.1 Selection of methods and equipment shall recognize the environmental concerns of the project.

P6.2 Care shall be exercised during the assembly and erection operations to ensure that disturbance to existing trees, shrubs, vegetation, etc. is kept to a minimum.

P7.0 Stringing

P7.1 Tension stringing techniques shall be used to avoid damage to trees and vegetation along the right-of-way. Conventional stringing methods may be employed where it is established that minimum damage will occur to the environment.

P7.2 Vehicular travel along the right-of-way shall be minimized and limited to the access road where possible.

P7.3 The location selected for stringing set-ups shall be carefully chosen by utilizing, where possible, existing cleared areas adjacent to established roads. The area required shall be kept to a minimum by the optimum arrangement of machines, conductor tie-downs and conductor reel storage.

P7.4 The area of the set-up shall not be bladed or graded unless absolutely necessary.

P7.5 Where possible, trenching for temporary anchors shall be avoided by utilizing screw-type, inclined logs or steel beam tie-downs etc.

P7.6 Cable and wire clippings and other debris associated with the stringing operation shall be collected and removed to designated disposal areas each day.

P7.7 Upon completion of the work at each set-up location, the area shall be cleaned up and left in a respectable condition.

P8.0 Counterpoise

P8.1 In sensitive areas such as natural water courses, consideration shall be given to the hand placement of counterpoise conductor.

P8.2 Where selective cutting has been carried out, consideration shall be given to the use of light, narrow trenching and laying machines.

P8.3 Care shall be taken to avoid the initiation of erosion channels by diversion of run-off onto undisturbed soil and/or by switch-back installation on steep slopes.

P9.0 Clean-up

P9.1 At the end of construction activities the right-of-way and all associated access roads shall be patrolled to ensure that all litter, hardware, and waste material including concrete has been disposed of and that all fences and gates have been left in a secure condition.

P9.2 All temporary culverts shall be removed and the drainage courses, including embankments, restored to an acceptable condition.

P9.3 All land which has been disturbed shall be restored to a reasonable state and shall include:

(a) The elimination of deep ruts and holes by filling or grading.

(b) Grading around tower sites and pole footings.

(c) Restoration of access roads to an acceptable condition consistent with final seeding and rehabilitation by the Forestry Department.

P9.4 Upon the completion of all construction activities in an area, for example, between township limits, complete restoration shall be carried out as soon as possible.