SOUTH NATION RIVER
CONSERVATION AUTHORITY

SOUTH NATION BASIN STUDY

REPORT 1

PRELIMINARY OPTIMIZATION STUDY

December 1979

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Attention: Mr. G. Burns, P.Eng.
Study Manager

Gentlemen

Re: South Nation Basin Study
Report No. 1 - Draft
Preliminary Optimization Study

We are pleased to submit to you fifteen copies our draft report outlining the findings of our intensive 10 week study of the South Nation Basin. The study has involved the collection, analysis and consolidation of a great deal of information which is available on the Basin and we have endeavoured to include the information of primary importance from each source.

We look forward to discussing your comments early in the new year. Should there be any questions in the interim, please do not hesitate to contact the undersigned.

Yours very truly

MARSHALL MACKLIN MONAGHAN LIMITED

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SOUTH NATION RIVER BASIN STUDY

PRELIMINARY OPTIMIZATION STUDY

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1. SUMMARY AND RECOMMENDATIONS

The South Nation River Basin presently faces a number of serious water management problems. Unless these problems are alleviated and the impact of future resource development and water management strategies are fully evaluated, economic growth in the area may be retarded. The Preliminary Optimization Study has involved the collection, consolidation and analysis of existing information relating to water management and resource development in the basin. This analysis involved a coarse screening of the alternatives proposed for solving the water management problems, and a ranking of the alternatives with regard to economic and technical feasibility, such that greater attention could be placed upon the more attractive alternatives during the main Basin Study.

The study has determined that four basic problems exist within the Basin, namely; flooding in the Plantagenet Area; flooding in the Brinston Area; potential impacts from extensive agricultural drainage improvements; and poor water quality throughout the basin. From the existing information and from previous studies, only the two flooding problems appear to have solutions formulated which seem to be technically and economically feasible. These are the channel improvements at the Plantagenet Springs rock outcrop, and the channel improvements upstream of Chesterville. Dyking is an alternative which appears to have a high potential for success, particularly in the Platagenet Flooding Area; howevever, it has yet to be given any detailed consideration.

The remaining water management alternatives are either economically very unattractive, or there is insufficient quantitative information available on the benefits related to the project. These remaining alternatives should initially be treated with the same priority, although the larger reservoir proposals appear to have slightly more attractive benefit-cost ratios.

Significant findings of this overview study are that there is a [redacted], [redacted] and [redacted] have addressed [redacted] projects with little comprehensive evaluation regarding the effects on

	Location	Comments
35.	South West Headwater Area	Weak deer yard (25-50).
36.	South Nation River (Spencerville Area)	Large muskrat area, extensive trapping.
37.	OsgoodeBog - Middle Branch Castor River	Main source of Castor River natural woodland/marsh area, variety of wildlife.
38.	Mer Bleue - Bear Brook	Tree sphagnum and black spruce, quicking bog, unique habitat, regionally education, and recreational value.

	Location	Comments
16.	South Nation River (Crysler to Cassleman)	Prime pickerel fishing area.
17.	South Nation River (Flood area from Winchester South)	Spring waterfowl staging area.
18.	South Nation River (below Winchester)	Potential pickerel spawning area - rubble bottom.
19.	Payne River	Good muskrat trapping area; spring spawning of pike between Berwick and Finch.
20.	Butternut Creek	Nothing known.
21.	South Nation River (Casselman to Lemieux)	Bullhead fishing.
22.	South Nation River (flooded area below Lemieux)	Excellent muskrat trapping; spring waterfowl staging, potential nesting of waterfowl.
23.	Bear Brook Indian Creek	Muskrat habitat, limited waterfowl nesting. Rock bass, muskrat trapping.
24.	South Nation River (Lemieux to Plantagenet)	Heavy fishing for bass, musky and pickerel, sturgeon fishing at Plantagenet in spring (source Ottawa River).
25.	South Nation River (400 m below and above Plantagenet)	Pickerel spawning.
26.	South Nation River (immediately below dam at Casselman)	Pickerel spawning.
27.	Alfred Bog - Horse Creek	Moose and beaver; unique ecological area; rare orchids.
28.	South Nation River (Pendleton Area to Riceville)	Waterfowl staging area.
29.	Paxton Creek	Nothing known or suspected.
30.	Scotch River - North and South and Beaver Creek	Pike and sucker spawn from St. Isidore to Riceville.
31.	Scotch River South Basin	Trout stream.
32.	Springbrook Creek	Speckled trout.
33.	Moose Creek Bog	Natural area, ecologically sensitive.
34.	Larose Forest	Moose, some deer, beaver trapping waterfowl in marsh lands.

In order to make wise choices on integrated resource management alternatives, the decision makers must be provided with: a more factual representation of the problems and opportunities within the basin; the benefits, costs, and implications of various water management alternatives in quantitative terms; and a master plan for the future development of the Basin. To accomplish such a task, we would endorse the commissioning of a comprehensive basin study as outlined in the Implementation Plan prepared by the Technical Support Team in September 1978. The water management proposals being considered are far too significant to be considered on an ad hoc basis. A framework on a basin scale is needed where in these proposals can be properly addressed and the existing problems of the Basin adequately resolved.

2.0 INTRODUCTION

2.1 The South Nation River Basin

The South Nation is one of Eastern Ontario's major river systems. The river rises in the shield area to the north of Prescott in Grenville County and flows north-eastward to the Ottawa River just north of Plantagenet in Prescott county, draining an area of 381,000 hectares (Figure 1). The tributaries in the south flow at a relatively steep grade but the main branches meander across flat central plains where the bedrock and resistant clays have prevented the erosion of channels sufficiently deep and wide to accommodate flood flows.

Flooding in certain stretches of the South Nation, notably above both Chesterville and Plantagenet is virtually an annual occurrence. (Fig. 2). Once normal spring flooding occurs, excessive areas of prime agricultural land are inundated and runoff is slow, thus reducing the growing season by delaying planting time. Late spring, summer and fall flooding also occur with some regularity and this interferes with cultivation and harvesting operations. Flooding has been a long standing problem in the area and public reaction has increased noticeably. Moreover, there is concern that the frequency and severity of flooding has increased as a result of the land drainage improvements which have taken place in recent years.

Another area of concern is presented by the extremely low flows that are experienced in the river and its tributaries during the summer and/or fall months. The lack of summer flow can further impair water quality to the point where it is unacceptable for domestic, recreational and industrial use, and in addition, the low flows do not accommodate fish and wildlife objectives. A particular problem often exists in the fall when insufficient flows interfere with the discharge of the seasonal retention lagoons upon which the urban and industrial areas of the watershed depend.

There is concern that increasing the extent of land drainage will further reduce low flows and decrease the groundwater reserves upon which the potable water supplies for the area are derived.

It is recognized, however, that land drainage, which reduces local flooding, accelerates increases in spring soil temperatures and provides an aerated root zone. It is a basic management tool in crop production and therefore is necessary in order to maximize the agricultural productivity of the basin.

Based on the available water quality data and observations by Ministry of the Environment staff, it appears evident that the water quality conditions within the South Nation River are closely related to the agricultural activities within the drainage basin. Sheet and bank erosion, the general lack of buffer zones along the river and stream banks, in-stream cattle watering, and the manure handling practices within the basin are considered to be significant factors contributing to the poor water quality condition of the South Nation River.

2.2 The Purpose of the Preliminary Optimization Study

The South Nation River Basin presently faces a number of serious water management problems. Unless these present problems are alleviated and the impact of future resource development and water management strategies are fully evaluated, economic growth in the area may be retarded. Also, the expenditures for remedial water management projects will be higher than might otherwise be necessary.

The goal of the South Nation River Basin Study is as follows:

> "To provide information needed to plan for the enhancement of economic conditions through the integrated management of water and land resources within the South Nation River Basin and to identify the necessary measures to achieve protection against flooding and erosion, effective removal of excess water for the improvement of agricultural production and marketing, acceptable disposal and transport of waste effluents: the provision of adequate supplies of good quality water to meet

water supply, agricultural, fish, wildlife and recreation desires and needs".

Within this context the South Nation River Conservation Authority commissioned a Preliminary Optimization Study as a first phase of the more comprehensive Basin Study. The Preliminary Optimization Study has involved the collection, consolidation and analysis of existing information relating to water management and resource development in the basin. This analysis included a coarse screening of the alternatives proposed for solving the water management problems. The intent was that the alternatives be properly ranked according to economic and technical feasibility such that greater attention may be directed toward the more attractive alternatives and conversely less attention to the least attractive alternatives.

As a result of the analysis of the information currently available, the Preliminary Optimization Study has endeavored to identify the gaps in the information base necessary for the Basin Study, and also to contribute to the technical action plan for the development of the comprehensive watershed model(s) in the Basin Study.

2.3 Methodology

Some 22 reports have been prepared specifically on water management problems associated with the South Nation River Basin. In addition numerous related studies and reports were available from various government and private sources on such subjects as water quality, basin water resources inventory, agricultural drainage design and cost-benefit, basin modelling, etc. The scope of the Preliminary Optimization Study was to utilize existing information, to analyse and consolidate this material and to prepare an assessment of existing and future resource management problems, available water management alternatives,and to make recommendations to enable integrated resource management planning to be undertaken.

Reports were obtained, literature searches carried out and discussions held with representatives of the various provincial government ministries who are active in the South Nation River Basin. The information obtained was then reviewed and consolidated by the study team and extended where necessary on the basis of experience. On the basis of this available background material, the various aspects outlined in Section 2.1 and 2.2 were addressed and summarized in this report.

3-0 HYDROLOGY OF THE SOUTH NATION RIVER BASIN

3.1 Physiography

The South Nation River drains an area of 381,000 ha between the Ottawa and St. Lawrence Rivers southeast of Ottawa (Figure 1). The basin is underlain by nearly horizontal beds of sedimentary rock, chiefly limestone, which produces a very flat topography. The physiography of the basin is dominated by extensive flat areas of clay and sand plains originating from the Lake Champlain marine embayment (Figure 3). These plains are prevalent in the northern half of the river basin and are more sporadic in the upper reaches where sand and clay plains surround areas of shallow till and bevelled limestone surfaces. Local high areas of bedrock and till have provided detritus for sand and gravel beaches and ridges and deltaic deposits along the shoreline of the Champlain Sea. These are most obvious above Inkerman and along the southeast and west water divides.

Drainage tends to be poor throughout the watershed. The South Nation River has a very shallow gradient and the overburden in the central plains is very impervious. Further entrenchment of the river is prevented by resistant bedrock and till. As a result, the channel reaches upstream of Chesterville and Plantagenet are inadequate to carry spring snowmelt discharges and flooding occurs almost annually. Because the overbank areas are very flat, once the river banks are overtopped, widespread flooding occurs and the impervious soils inhibit drainage after the flood waters recede.

With the low relief of the basin and generally high water table, large areas of peat and muck deposits are present which originated as swamps. The most notable of these are the Winchester Bog, Alfred Bog, Newington Bog, Moose Creek Bog, and Mer Bleue. Unnamed areas of peat and muck also exist west of Spencerville and in the west part of Osgoode Township.

The main tributaries of the South Nation River are the Soctch River and the Payne River on the east side of the watershed and Bear Brook and the Castor River on the west side. The arrangement of the tributaries and the locations of principal towns are shown in a simplified schematic form in Figure 4.

3.2 Flow Record Analysis

The South Nation River is characterized by extremes of both high and low flows. Spring flooding occurs on an annual basis in two large areas above Plantagenet and Chesterville, and can be of long duration. For example, in 1934, the spring flow at Plantagenet Springs peaked at 35,700 cfs, well above the estimated channel capacity of 8,000 - 10,000 cfs. The discharge remained above 10,000 cfs for 17 days, and was above 30,000 cfs for 6 days. Similar events occurred in 1976 and 1978. In 1974, there were two snowmelt events a month apart, both of which exceeded the channel capacity.

Snowmelt flows generally peak between mid-March and mid-April, but may be as late as the third week in April. These floods are a general nuisance but are not considered to be seriously detrimental to the agricultural productivity of the watershed. Planting activities get underway in May. Flooding may occur again at this time as a result of a rainfall event superimposed on the high spring water levels. These floods may delay planting and shorten the growing season or they may damage already seeded fields. Since reseeding is still possible at this time crop loss is not likely to be total. The most critical floods are those which occur during the growing and harvesting season from June to October. Replanting is no longer possible and crop damage may be severe.

Low flows in the South Nation River also present problems. It is not uncommon for there to be virtually no flow at Spencerville during the late summer. The low flow extremes at Plantagenet Springs occurred in the early 1930's. There was no flow from August 13, 1930 to March 18, 1931 and after a spring flow that is the second lowest on record, discharge returned to only 10 cfs from mid-July to mid-November during 1931.

Table 1 lists the available Water Survey of Canada discharge records. The periods of record at Plantagenet Springs and Spencerville are adequate for frequency analysis of each of the snowmelt, May rainfall

TABLE 1

Water Survey of Canada

Gauging Stations

Station No.	Station Name	Period of Record Snowmelt	Continuous
02LB005	South Nation River near Plantagenet Springs	1939-1947	1915-1938 1948-1979
02LB006	Castor River at Russell	1948-1967	1968-1979
02LB007	South Nation River at Spencerville	1948	1949-1979
02LB008	Bear Brook near Bourget	1950-1969	1976-1979
02LB009	South Nation River at Chesterville	1949-1971 1975-1979	1972-1974
02LB012	East Branch Scotch R. near St. Isidore de Prescott		1970-1979
02LB013	South Nation River at Casselman		1974-1979
02LB022	Payne River near Berwick		1976-1978
02LB101	Bear Brook at Carlsbad Springs	1975	1976-1979

Chesterville and Russell is also possible. Low flow analysis is restricted to Plantagenet Springs and Spencerville. The period of record at Russell is sufficient for only small return periods.

High Flow Analysis

[redacted] in the South Nation reports of the last thirty years has [redacted]. For example, four different values are given for the 100-year snowmelt flood at Plantagenet Springs:

Source	100-year Flow
1948 Interim Report	42,500 cfs
1966 Acres	53,885 cfs
1976 Lecompte Moller	45,000 cfs
1979 Proctor & Redfern - McNeely	42,040 cfs

There are two possible sources for these discrepancies:

(i) estimates may vary as the period of record increases;

(2) different frequency distributions have been used.

Analysis of the Plantagenet Spring snowmelt series indicates that it is the second source that is most significant. The lognormal, Log Pearson III (LPIII), and Extreme Value I (ECI) frequency distributions were fitted to the data using the method of moments. The following estimates of the 100-year event resulted:

Lognormal	57,300 cfs
Extreme Value I	53,300 cfs
Log Pearson III	40,980 cfs

It was not surprising, then, to find that Acres has used the lognormal distribution, Lecompte Moller the EVI distribution, and

Proctor & Redfern - McNeely the LPIII distribution.

Choice of the appropriate distribution is difficult. The coefficient of skewness was calculated for each flow series and its corresponding logarithmic series. The reliability of sample skewness as an estimate of population skewness is strongly dependent on sample size. It provides a guide in selecting a distribution, but it must be applied with caution. The EVI distribution has a theoretical coefficient skewness of 1.14. On that basis, it should be considered inappropriate for any of the snowmelt flow series.

The lognormal and LPIII distributions become equivalent when the skewness of the logarithms of the flows is zero. This means that for skewness not zero, LPIII will always fit the data better because three parameters are used instead of two. However, the reliability of the skewness should be considered before LPIII is adopted. Of the eight flow series examined, for all but three, the 95% confidence limits on the coefficient of skewness contained zero. This suggests that the lognormal distribution is adequate for most of series.

Of the three remaining, the Plantagenet Springs snowmelt series offers the greatest problem. The log skewness of -1.26 results in a lognormal estimate of the 100-year flood which is 40% greater than the LPIII fit. Visual inspection of the plotted data allows for subjective comparison of the degrees of fit provided by the two distributions (Figure 5). The LPIII line is better. On the other hand, it can be seen that this line is esentially horizontal for higher return periods, which is subjectively difficult to accept as realistic. Siimilar situations result from analysis of the South Nation River at Chesterville and the Castor River at Russell snowmelt series. It is our recommendation that before a distribution is selected for design, the records of other basins in the area should be examined to better establish a regional skewness value. The LPIII flow estimates calculated in this study appear to be too low, but adoption of the lognormal estimates may result in considerable over-design. Summaries of the flow estimates for each series, using different distributions where applicable, are found in Tables 2, 3 and 4 .

Trend Analysis

Improved agricultural drainage in flood hazard areas has allowed the production of more valuable crops, increasing the economic losses associated with flooding. Concern has been expressed that the increasing intensity of agricultural drainage has increased the frequency and severity of flooding. There is a theoretical basis for this concern which is discussed in Section 3.3. There is some question, though, whether flooding has really worsened, or whether the greater economic consequences have resulted in a perception of inceased flooding.

The flow records were examined to identify any trends in flood magnitude. The snowmelt series was chosen for analysis. The best flow records were available for this series and the effects of antecedent moisture conditions, critical to tile drain behaviour, could be neglected. The first problem was to isolate trends due to climatic influences. The cumulative average of the annual snowmelt series for the South Nation River at Spencerville was plotted against time (Figure 6). There has been little drainage activity in this area and the upward trend from 1969 is attributed to increased precipitation. As a check, the cumulative average for the Castor River at Russell was also plotted for comparison (Figure 7). The two gauges are widely separated and the physiographic conditions differ. If the same trend appears, as is the case, it is confirmation of a climatic origin.

Next, an area of intense outlet and tile drainage was identified between Chesterville and Spencerville. The flow contributions of this area were isolated by subtracting the Spencerville flows from the Chesterville flows. In an attempt to eliminate the influence of climate, the differences were then divided by the Chesterville discharges. The effect is to produce a time series which is the proportion of the Chesterville discharge contributed by the intensively drained area. The cumulative average of the series

TABLE 2

Flow Frequences - Snowmelt Flows

Lognormal Distribution

Estimated Discharge (cfs)

Return Period (years)	South Nation R. Spencerville	South Nation R. Chesterville	Castor R. Russell	South Nation R. Plantagenet Sp.
2	1610	6,060	3670	24,470
10	2910	9,910	6330	39,090
50	4180	13,310	8780	51,850
100	4740	14,780	9860	57,280

Log Pearson III Distribution

Return Period (years)	South Nation R. Spencerville	South Nation R. Chesterville	Castor R. Russell	South Nation R. Plantagenet Sp.
2	1685	6,480	3980	26,380
10	2820	9,290	5840	36,240
50	3610	10,600	6660	40,050
100	3890	10,960	6870	40,980

TABLE 3

Flow Frequences - May Rainfall Flows

Return Period (years)	South Nation River Spencerville Lognormal	South Nation River Spencerville EVI	South Nation River Plantagenet Springs Lognormal	South Nation River Plantagenet Springs EVI
	Estimated Flows (cfs)			
2	200		2,590	3,800
10	490	560	11,160	10,780
50	860	860	26,910	16,900
100	1050	990	36,720	19,480

TABLE 4

Flow Frequency - Summer Flows

Return Period (years)	South Nation River Spencerville Lognormal	South Nation River Spencerville EVI	South Nation River Plantagenet Springs Lognormal	South Nation River Plantagenet Springs EVI
	Estimated Flows (cfs)			
2	120	160	1,830	
10	460	420	7,800	8,410
50	1020	640	18,700	13,420
100	1360	740	25,460	15,530

versus time is given in Figure 8. An increasing trend is apparent beginning in 1960, which is assumed not to be controlled by climate. The statistical significance of this trend was examined by breaking the series into two parts at 1960. The means of the two partial series were compared using a statistical t test. No significant difference was found at the 5% level.

The conclusion is that any increase in flooding, as a result of land drainage, has not been significant or is less significant than the sensitivity of the analysis. It must be kept in mind, however, that it is difficult to reliably identify a small trend of perhaps ten years duration in a flow record of only thirty years. It is also important to note that aggravated flood problems may yet develop as more land is brought into the drainage network.

Minimum Flows

Minimum flows are generally examined through low flow duration analysis. A distribution is selected and frequencies are assigned to flows which persist for a given number of days. The approporiate duration depends on the problems associated with low flows. In the South Nation River, the major concern is water quality. For purposes of sewage lagoon discharge, a duration which corresponds to the discharging time should be used. Longer periods would apply for nonpoint source pollution problems, and shorter periods for water supply problems.

Low flow duration curves for the South Nation River at Spencerville and Plantagenet Springs and the Castor River at Russell are included in the Ministry of the Environment's report on the Water Resources of the South Nation River Basin for durations from one to 90 days. From the draft report, it was found that the 10-year flows at Spencerville are less than 0.1 cfs for durations up to 90 days. At Plantagenet Springs, 10-years low flows vary from 14 to 35 cfs for one and 90 day durations respectively. At Russell they vary from one to 7 cfs. The 2-year flows for various durations are summarized in Table 5.

TABLE 5

Minimum 2-year Flows

Duration (days)	Estimated Flow (cfs)		
	South Nation River Spencerville	South Nation River Plantagenet Sp.	Castor River Russell
1	0.3	35	5
7	0.4	40	6
14	0.5	50	7
30	0.8	60	8
60	1.4	75	10
90	2.3	100	12

(Ministry of the Environment Report 13
Water Resources of the South Nation Basin)

3.3 Modifications to the Natural System

The various proposals which have been made over the past 30 years to alleviate flooding and water supply problems in the South Nation watershed have taken a number of different approaches. Measures considered have included reservoirs, channel improvements, diversions, and dykes. The direct and indirect effects of each type of basin modification are discussed below in general terms. Specific projects may realize all or only some of these impacts. Where several types of remedial works are planned for use together, positive and negative impacts may combine to counteract or reinforce each other. The expected results of the different South Nation proposals are considered in detail in Section 4.3

Land Drainage

The network of improved outlet drains in the basin is already extensive and in Dundas County in particular, a good proportion of the serviced land is tile drained (see Figures 9 and 10) The trend towards increased artificial drainage is expected to continue. So far most of the class 1, 2 and 3 land (see Figure 11) has been provided with outlet drainage, and the intention is to extend this to include class 4 land. Therefore, the influence of drainage on watershed hydrology and its interaction with other watershed management schemes warrants primary consideration.

Land drainage serves two main purposes. Water is removed from the fields earlier in the spring providing a longer growing season. Also, changes in the moisture regime of the soil allow better aeration and the development of a deeper root zone. These two factors make the soil suitable for a wider variety of crops. Crop damage due to waterlogging of the soil during the growing season is also reduced.

A distinction should be made between the effects of outlet drains and tile drains. Outlet drains extend the natural surface drainage network and increase the drainage density. Where natural channels are upgraded to provide outlets, they are enlarged and cleared of obstructions, increasing their flow capacities. Outlets remove surface water more efficiently, but may have little effect on soil moisture. Tile drains remove gravitational soil water from soils of low permeability by creating an artificially high hydraulic gradient. Tile drainage may also lead indirectly to changes in a basin's hydrologic response if there is a change in crops. Drain maintenance is important. An area serviced by a poorly maintained drain may revert, in time, to essentially natural conditions.

The effect of any particular drainage project on downstream channel flows depends on many local conditions including land use, land management, soil properties, ground slope, and the duration and intensity of rainfall. In general, drainage works increase the volume of rapid-response streamflow by reducing surface detention. This increase may be large if previously noncontributing areas are connected to the channel network. Peak discharges also tend to increase because of both increased volumes and improved hydraulic efficiency. As the travel time to the main channel is shortened, the time base of the hydrograph is decreased, raising the peak. For these reasons, agricultural drainage is often perceived as causing or aggravating downstream flooding.

It is also possible, however, for benefits to result downstream. Under natural conditions, a series of frequent, low intensity events may produce a high peak as each successive hydrograph is superimposed on the recession limb of the previous one. Because of faster flow recession rates with improved drainage, a series of distinct and lower peaks may be produced. Also, with the faster recovery of surface and soil detention storage provided by tile drainage, the volume of rapid-response flow from each storm will be reduced. Improved storage recovery also has the potential to delay or reduce ponding and surface runoff, thus reducing the flood peak.

The shape of the flood hydrograph of the main channel of a basin is largely controlled by the volumes and timings of flow contributions from the tributaries. If drainage improvements take place on only part of the watershed, changing the time to peak for some subbasins, a change in the synchronization of tributary contributions results.

The new aggregate runoff may have either a higher or lower peak depending on whether contributing flows become or cease to be coincident.

The effects on basin outflow of small scale drainage improvements are generally small amd may even be insignificant; however, the cumulative effect of many such small projects may be pronounced.

Analysis of streamflow records may indicate whether there has been a change in basin response with time and the degree of drainage, but simulation modelling is required to assess the future impacts of proposed improvements.

Concern has been expressed that land drainage tends to lower low flows. It is argued that by diverting ponded water to outlet drains and intercepting soil water with tile drains, groundwater recharge is reduced. This lowers the water table and reduces summer flows. However, soils which require artificial drainage have low permeability. Under natural conditions the movement of water through these soils is so slow that there is no appreciable percolation to groundwater. The ground dries by evaporation rather than by drainage. Because of the low permeabilities, drawdown around drainage channels is steep and lowering of the water table is local. The performance of nearby shallow wells may be affected, but a general reduction in groundwater discharge is unlikely. Wetlands may be lost inadvertently because of land drainage, but in areas of extensive drainage activity, their loss is more likely attributable to deliberate attempts to bring them into agricultural productivity.

The improved growing conditions resulting from land drainage may make an area suitable for a greater diversity of more valuable crops. In the South Nation watershed, there is the potential for a shift from hay and small grains to corn. This has both water quality and quantity implications. The change to row crops results in more exposed soil of lower infiltration capacity. Surface runoff and soil erosion are increased. (See Figure 12). If there are not adequate buffer zones along the receiving surface drainage network to trap the eroding soil, water quality may be adversely affected. This will be manifested in an increase in suspended sediments and possibly also in nutrients and pesticides. Siltation problems may develop, particularly in outlet drains which are typically of shallow gradient.

Drainage activities may also be connected with silviculture. Proposals to develop pulp poplar resources in the South Nation headwater area of Edwardsburg Township will require well-drained fertile soil. (The relative benefit-cost ratios of committing this land to silviculture versus agriculture bears examination). In this case, the increased ground cover and development of an organic mat associated with reforestation would increase infiltration and reduce surface runoff. Surface soils are protected from erosion. Unless undertaken with proper care, however, harvesting may result in local, intense siltation problems.

The effectiveness of drainage improvements can be influenced by other basin changes. Reservoirs, diversions, and channel improvements which lower water levels during the critical spring period will improve the performance of the outlet drains by increasing the hydraulic gradient. This may also allow more land farther from main channels to be brought into the drainage network. Conversely, anything which causes an increase in water levels will have a negative impact on drainage. Where reservoirs are constructed in drained areas, the loss of hydraulic head in the surrounding outlets may reduce their effectiveness. The problem will be most pronounced in the spring when reservoir levels are high and drainage is most required. Channel improvements which reduce water levels locally may lead to an increase in stage downstream. Depending on the relative intensities of drainage activities, the benefits realizedat one location may be lost at another.

The analysis of the actual impacts of specific land drainage proposals is complex and cannot be done effectively without computer simulation. Simultation is also a useful tool in the evaluation of the impact of the expected changes in land management practices associated with drainage. Unfortunately, reliable modelling is currently hampered by a lack of actual data on drain behavior, particularly for tile drains.

Reservoirs

The degree of flood protection and low flow augmentation provided by a reservoir depends on its location and storage volume. A headwater reservoir will deliver summer discharge to a longer reach of the river. However, if the drainage area behind the reservoir is a small proportion of the total basin area, tributary contributions may continue to cause flooding in downstream parts of the basin. Reservoir storage is controlled by damsite foundation conditions and topography as well as by economic considerations. Flood and low flow concerns may lead to conflicting allocations of potential storage. The extent to which a particular need is satisfied depends on the operational strategy adopted, which in turn is determined by costs and benefits.

The effectiveness of a flood control project is usually evaluated in terms of reducing flooding to some particular return period. A more realistic approach, especially for purposes of cost-benefit analysis, is to consider the effect of the proposal on the actual area flooded. In very flat areas such as those flooded in the South Nation watershed reduction of high water levels by a small amount may be more significant than would be apparent from consideration of flood frequency alone.

Besides the social and economic benefits of flood reduction, there is also a potential for hydraulic improvements. The effect of reduced water levels on drain performance has already been discussed. There may also be a reduction in damage to outlet drains. The heaviest sediment loads in drains and channels usually occur during spring runoff. In areas flooded in the spring, velocities are slow in the outlet drains because of backwater effects. The sediment load cannot be carried and deposition occurs. This may cause serious flow obstruction later in the season. Flood waters may also cause bank erosion at the mouth of the drain and choke it with flood debris. In general, flood control leads to a reduction in drain maintenance requirements.

The sedimentation problem discussed above becomes a potential negative impact on the drainage network in the vicinity of the reservoir. If outlet velocities remain high enough to carry sediments, reservoir siltation may become a problem. The concern is increased if drainage activity is likely to produce a shift to more erosion-susceptible crops. If proposed drainage projects are expected to produce significant increases in flow volumes or rates, the adequacy of the reservoir's storage and spillway capacities should be examined.

Erosion and deposition in general are likely to be reduced as the area flooded is reduced. Floodplain fertility is enhanced by frequent deposition of fine material; however, this small benefit is likely to be overshadowed by the negative impacts of flooding, and will certainly be counterbalanced if the material deposited was eroded by the flood waters from agricultural land upstream.

There is a potential for increased sediment loads in reservoirs. Shoreline erosion may be a problem. If this causes the loss of toe support to slopes, the problem may be increased to a slope stability concern. Reservoir drawdown may contribute to this concern if high pore pressures are left in the side slopes. The severity of these problems is governed by topography and soil types, with the risks increasing with steeper slopes and finer material. If reservoir storage is to provide low flow augmentation, drawdown may be gradual enough to prevent instability problems.

Channel Improvements

There are two approaches to channel improvements. The storage of a reach may be increased by enlarging the channel cross-section. Flood levels are reduced by confining the flow to the channel. Alternatively, the hydraulic efficiency of the channel may be increased by removing obstructions, straightening bends, and steepening slopes. As water is removed from the area faster, water levels are reduced and high flow durations are shortened.

The potential flood reduction benefits derived from reservoirs also apply to channel improvements, including socioeconomic benefits, improvement of agricultural drain performance, and the reduction of overbank erosion and deposition. Channel improvements tend to provide only local relief. The actual extent of the impacts depends on the hydraulic characteristics of the channel and is determined by backwater analysis.

Under natural conditions, overbank flow provides large volumes of storage which delays the arrival of flood waters downstream. The elimination of the damping effect of this storage by channel improvments may cause or aggravate downstream flooding. Local flow velocities will increase, raising the possibility of bed and bank erosion. Scour at piers and abutments may become a problem, and buried faciltiies such as cables and pipelines may become exposed due to bed degradation. Material eroded will be deposited further downstream as velocities are reduced.

As with agricultural drainage, changes in the timing of the hydrograph from an improved reach may lead to a change in the synchronization of flood flows from different tributaries. The impact may be positive or negative, and is best assessed with a simulation model.

Unlike reservoirs, channel improvements offer no relief for low flow problems. In fact, conditions may be aggravated. While discharges remain unchanged, water surface elevations may be reduced. This may adversely affect water supply. Consideration should also be given to slope stability problems if drawdown will increase or occur at a greater rate. On the other hand, if the removal of channel obstructions reduces upstream ponding and lowers winter water levels, a decrease in ice volumes may result, improving the ice jam conditions. However, unless ice jamming is a chronic and severe problem, this should not be considered to be an important benefit.

Diversions

A diversion channel reroutes flood flows either by bypassing a flood hazard area or by directing the excess flows out of the watershed. The effects of bypasses are similar to those of channel improvements and raise the same concerns: flood waters arrive faster downstream and peak flows may be greater. Removing the water from the basin relieves flooding without this complication. The impact of increased flow on the receiving waters must be examined, but the effects should be minor for the two proposed South Nation diversions: the volumes involved would be insignificant contributions to either the Ottawa or St. Lawrence Rivers. Steps must be taken to ensure that low flows are not adversely affected. This may be achieved by the proper selection of the invert elevation of the diversion channel, or by the use of a control gate at the bifurcation.

Dykes

Dykes may be used to protect isolated areas such as towns or farms, or they may be constructed as levees along the river. Local dykes would have little effect on the hydrology of the basin. Levees reduce flooding but without the lowering of water levels associated with channel improvements. If numerous outlet drains enter the channel in the reach of concern, the construction of effective levees may require the use of a pumped drainage system. Levees may lead to the problems of downstream flooding and erosion due to increased velocities, but there will be no reduction of low flow levels.

Urban Development

Urban development has the potential to increase flow levels by reducing the permeable ground surface are and reducing runoff travel times by the use of ditches and storm sewers. Water quality may also be affected. The increased demand for groundwater may overtax that already scarce resource.

While these concerns should be kept in mind, there appears to be little expectation of significant changes in the population of the

South Nation watershed. The exception is the encroachment of urban development from Ottawa into the upper Bear Brook area. Plans have also been discussed for the development of an industrial park in Edwardsburg Township, but it is our understanding that this project is now being questioned and will likely not proceed.

Summary

The main potential positive and negative hydrologic impacts of agricultural drainage and each of the four structural alternatives are outlined below in Table 6 . These will be treated in detailed with respect to specific projects in Section 4.5 . Analysis of these impacts is complex and depends on the degree and location of each improvement. Simulation modelling is the only effective method of weighing the alternatives and assessing their implications.

TABLE 6

Potential Hydrologic Impacts of Structural Alternatives

Potential Impact	STRUCTURAL ALTERNATIVES					
	[redacted]	Reservoirs	Channel Improvements	Diversions	Local Dykes	Levees
Local Flooding	o	+	+	+	+	+
Downstream Flooding	-	o	-	-	o	-
Land Drainage	+	+	+	+	o	-
Soil Erosion	-	o	o	o	o	o
Channel Erosion	o	+	-	o	o	-
Siltation	-	+	-	o	o	-
Low Flows	[redacted]	+	o	o	o	o
Low Water Levels	o	+	-	o	o	o

- negative impact
o no significant impact
\+ positive impact

4.0 WATER MANAGEMENT IN THE BASIN

4.1 Objectives

In a Report on Pre-planning, the Technical Support Committee recommended a set of water management objectives for the South Nation River Basin as follows:

(i) to reduce flood damages to economically practical levels by the implementation of cost effective non-structural and structural measures,

(ii) to develop the means to predict the effect on flooding and low flows of proposed drainage projects,

(iii) to ensure aquatic life is not adversely affected by future channelization, dam construction or flow management practices,

(iv) to evaluate the resources of the basin and promote an integrated management of land, fish and wildlife resources within the basin,

(v) to maintain water quality at a level suitable for all beneficial uses,

(vi) to protect and effectively utilize the groundwater resources of the basin,

(vii) to maintain sufficient low flow levels so that there is no interference with downstream users,

(viii) to develop a drainage plan for the basin which provides for drainage of the soils suitable for agriculture so as to optimize present and future crop production for the whole basin,

(ix) to provide for the improvement and re-establishment of the forest resources within the basin.

These objectives are comprehensive in scope and if achieved should provide sufficient background to enable optimal integrated resource management.

4.2 Problems and Opportunities

Over the years numerous studies have investigated the various aspects of the South Nation River Basin and have identified in general the problems outlined below. In addition various solutions have been offered which are discussed in the following sections.

The frequent flooding of up to 15,000 acres of land in the area upstream of Chesterville in the Brinston Area, and the frequent flooding of up to 19,000 acres of land in the area from Lemieux to Plantagenet Springs are the two most significant problems in the basin. In both cases the problems result from mild gradients, resistant clay plains, extensive flat overbank areas and consequently the inability of the river to erode sufficiently large channels to contain even the mean annual flows. With the mild gradients and consequent low velocities, channel flows do not significantly erode the banks, nor scour the bottom, hence the channel is in a relatively stable condition, certainly not enlarging. When flows in the river increase and exceed bank full capacity, the flows spread across a flat overbank area, velocities drop and hence little erosion has taken place over the life of the river. In addition, with the flatness of the overbank area, the flooded lands are slow to drain, particularly where any depressions exist. Hence, the waterlogging effects of the flooding tend to last for long periods of time.

The South Nation River Basin has extensive areas of fertile clay soils and is well located with respect to agricultural markets. A large percentage of the soils with high agricultural potential are poorly and imperfectly drained. Hence a significant opportunity exists to increase agricultural productivity and expand the economy of the Basin and Eastern Ontario, through the improvement of drainage for these lands. This opportunity has been long recognized and substantial progress has been made through the encouragement of the of the Ontario Ministry of Agriculture and Food and ARDA. The provision of outlet drains and the channelization and deepening of natural watercourses has been carried out on approximately 60% of the basin with large scale proposals currently pending on the Payne, Middle Castor and South Castor Rivers. As discussed in Section 3.3,these modifications to the natural system have the potential to create or aggravate downstream problems. While the positive benefits of improved agricultural drainage are well recognized and studied, there is a void of information relating to possible negative implications.

Water quality in the South Nation River Basin is generally poor, with respect to the satisfaction of provincial water quality objectives and the ability of the river to support a diversity of water related uses. The river receives high nutrient, bacterial and sediment loadings as it slowly travels northwards to the Ottawa River. The contribution of total phosphorous from various sources cannot be differentiated by existing data. However, based on extensive studies of pollution from various land use activities in southern Ontario watersheds, it is felt that contributions of total phosphorous from municipal and industrial point sources within the South Nation River Basin are much less significant in comparison to contributions from agricultural non-point sources. Indeed the PLUARG studies conducted under the auspices of the International Joint Commission identified a strong relationship between the clay content of soils and the nutrient and pesticide contribution from a drainage area. Sediment survey information for the Basin has indicated that the sediment loads in the South Nation River are among the highest in the province.

Aggravating water quality problems in the South Nation is the frequent occurrence of extremely low flows. As discussed in Section 3.2, the frequency of low flows through the watershed leads to the reduction of dilution for the nutrient and sediment loadings, increased temperatures, decreased dissolved oxygen content and generally reduced water quality during these periods. The river therefore often becomes unable to meet the water supply, irrigation, recreational, fish and wildlife and fire flow requirements.

It would therefore appear that there exists a high potential to improve the water quality in the South Nation River through encouraging remedial measures to reduce the non-point source contributions and through low flow augmentation.

4.3 Analysis of Structural Alternatives

4.3.1 Brinston Flooding Area

The nature of the flooding problem in the Brinston area was described in Section 4.2. In order to alleviate the flooding during spring, late spring and/or summer peak flows either upstream storage, increasing channel capacity or a combination of the two have been proposed. See figures 13 and 14.

The 1948 Interim Report proposal for flood storage and low flow augmentation included reservoirs in the Spencerville area at Spencerville, Spencerville Mill, Domville and Hyndman as well as a diversion of flows to the St. Lawrence. These facilities had the characteristics (shown in Table 7).

In addition, a major reservoir was proposed by Acres above Spencerville just downstream from the original location identified in the 1948 report, which had a storage capacity greater than the combined total of the originally proposed 4 reservoirs and the diversion to the St. Lawrence. These 4 reservoirs have received no further attention since originally proposed and, in fact, would have relatively higher costs per volume of storage. A detailed investigation of the potential of the major Spencerville Dam and Reservoir was carried out by Acres since this single large facility at Spencerville was apparently identified as being the most cost effective and most attractive. The basic design criterion used was the ability to facilitate drainage to 15,000 acres, to reduce flooding and to provide storage for low flow augmentation. It was proposed that the capital cost of the channel improvements required above Chesterville to meet the drainage criterion would be reduced by some 60% if the Spencerville reservoir were constructed. On the contrary, Clough has demonstrated, (as discussed later in this section) that most of the benefits relating to drainage and flood control, can be achieved with the 80 feet channel bottom width Chesterville channelization alternative. Hence, the marginal benefits from expenditures beyond this level (including upstream

TABLE 7

Summary of Proposed reservoir Facilities in Brinston Area

Proposal	Storage $m^3 \times 10^6$ (Ac - ft)	Preliminary Cost Estimate (1979)	Approximate Cost per Volume of Storage $1 x $10^6 m^3$ ($/Ac-ft)
Spencerville (A)	15.8 (12,776)	$2,750,000	$175,050 ($215)
Spencerville Mill	2.2 (1,748)	$ 600,000	$272,700 ($343)
Domville	3.0 (2,449)	$ 650,000	$216,600 ($265)
Hyndman	2.2 (1,760)	$ 525,000	$238,640 ($298)
Proposal Channel Diversion from Spencerville - Domville Reservoirs to St. Lawrence	42.4 (34,402)	$14,000,000	$330,200 ($406)
Spencerville (B) (Acres 1966)	88.5 (72,000)	$20,000,000	$225,988 ($278)

The Spencerville Dam and Reservoir would have a small effect on reducing flows in the Plantagenet area; however, since the relatively large remaining area of the watershed (92.5%) is unregulated, this benefit may be insignificant. This benefit can only be quantified by a comprehensive watershed model.

The release of stored runoff over the 100 day low flow period of the year could augment low flows by in excess of 150 cfs. This would compare to the current low flows at various points in the watershed as discussed in Section 3.2. The Spencerville Dam and reservoir would flood or affect upwards of 11,000 acres of Class 1 to 4 agricultural land including 90 farms, the village of Charlewood, a church and a cemetary at Lord Mills. Justification of the sacrifice of such an area upstream to partially protect 15,000 acres downstream and to provide the low flow augmentation benefits, will require a thorough analysis and very high benefit cost.

In 1968, D.J. Clough carried out a benefit cost analysis of the Spencerville Dam and Reservoir and the Chesterville Channelization. As discussed later in this Section, Clough determined that, in 1966 dollars, in the order of $3,000,000 of benefits could be achieved with a $1,000,000 expenditure on channelization. He identified only $3,500,000 in benefits for the additional expenditure of $5,000,000 for the Dam and Reservoir. Included in the $3,500,000 of benefits related to the Dam and Reservoir are $3,100,000 of benefits for Recreation and Tourism related to storage reservoir. We would question the visitor attraction assumption to a reservoir which decreases in depth at the rate of 3 feet per month, has very shallow depths, and has a shoreline receeding at a rate of 25 to 50 feet per day. Areas of any proximity to the water's edge would be waterlogged during the demand period, extremely muddy, and would have access and maintenance problems. It is felt that this aspect of the benefit analysis should be particularly reviewed.

Channelization to alleviate flooding in the Brinston area was considered by several consultants. To achieve an objective of preventing May flooding for 9 out of 10 years, would require a channel capable of passing 3600 cfs at a slope of 0.015% at a water surface elevation of less than elevation 230 feet at Salter's Bridge. Several studies addressed the channelization requirements to accomplish this objective. It would appear that a channel bottom width of 105 feet or greater is required to meet this objective. A secondary objective would be to further minimize the water surface elevation in the river to enable concurrent drainage of the adjacent lands. To also meet this secondary objective requires a channel bottom width of approximately 160 feet. At the present time, a channelization scheme is underway based upon an 80 feet bottom width channel. This design would pass approximately 2800 cfs at elevation 230' and 1700 cfs at elevation 227' at Salter's Bridge. This results in an improvement to the frequency of flooding from annually to something between 5 years and 10 years for the May events, and improves the summer flooding risk from almost annually to about once every 15 to 20 years.

In terms of frequency of flooding an improvement over the existing situation is being made. However in terms of economic benefit comparison with project costs and downstream implications virtually no analysis has been done to date.

Clough, in 1968, has made the only attempt to evaluate the economic benefits of the proposals to alleviate the flooding. In this study a basic assumption was made that if the channelization were carried out, the 15,000 acres susceptible to flooding, could then be drained and improved such that higher value crops could be grown. This implies zero potential from drainage improvement under "existing" conditions, which we do not believe is rigorously correct. The approach of comparing additional revenues to additional input costs is appropriate; however, the assumption that municipal ditches can be taken as a single capital cost for a life of 50 years is very optimistic. Current Ontario experience suggests a lcak of maintenance requiring a wholesale reconstruction every 10 - 15 years.

Data relating stage - discharge versus area flooded for the various design scenarios was not developed or apparently used in the determination of benefiting acreage on an average annual basis for the alternatives considered. Alternatively, fairly gross assumptions appear to have been made about the benefit derived due to a channelization scenario.

On the basis of the information available to this study, primarily the Acres and Clough reports, the recent decision to proceed with the channelization upstream from Chesterville, with an 80 foot channel bottom width, appears to have been economically well justified, (even when drainage benefits are discounted) upon a 1966 base. However, construction costs have increased significantly faster than the values of agricultural produce and it would appear appropriate to re-evaluate the cost-benefit of this program on a 1980 dollar base. [redacted]

4.3.2 Plantagenet Flooding Area

A rock outcrop at Plantagenet Springs restricts the channel and controls upstream water levels, especially during low flows. The upstream channel is extremely flat for about 20 miles, and as a result the carrying capacity of the river is low. In addition, the riverbank and adjacent land elevations are in fact lower along this upstream channel than at Plantagenet Springs. The 1979 Proctor and Redfern - McNeely study determined that throughout this low lying area, the main channel has a bank full capacity of only about 8,000 to 10,000 cfs, significantly less than the average annual snowmelt flood of about 25,000 cfs. From analyses of aerial photographs of the 1978 and 1979 spring floods, the Proctor and Redfern - McNeeley report estimated flooded areas of 18,500 acres and 7,000 acres for flows of 37,500 and 14,000 cfs respectively. In addition, their examination of the recent flooding indicated that some of the flooding occurs due to overtopping of the local tributaries rather than solely due to flooding from the main South Nation River.

Similar in nature to the Brinston flooding area, the Plantagenet flooding area suffers from low channel capacity, flat overbank areas and constricted downstream capacity. Four types of solutions have potential for alleviating the flooding in this area: upstream storage, dykes, channel improvements and diversion to the Ottawa River. (See figures 13 & 14)

Of the six various reservoir sites which have been given serious consideration, only the Spencerville, North Castor and Bear Brook sites have been given any detailed analysis. Acres concluded that the Spencerville and North Castor reservoirs would have positive but relatively small effects on the Plantagenet flooding. The Bear Brook site has significant foundation problems, which limit dam height and consequently storage volume. This consequently reduces the viability of the site for flood control purposes. An alternative site on the Scotch River, at Riceville has been identified with a potential storage of some 37,00 acre-feet. Little analysis has been done on this alternative, or on sites on the Payne River and Middle and South Branches of the Castor. However, it is doubtful from the volumes of storage potentially available, that these sites, all combined, would significantly reduce the annual flooding situation at Plantagenet. The comprehensive watershed modelling component of the Basin Study should, however, evaluate their effects before these proposals are abandoned.

Dyking is a technique for containing the flood flows within a defined channel, which has been given little consideration to date. Proctor & Redfern - McNeely (1979) identified frequent overbank flooding in the lower reaches of the Scotch River, Bear Brook, Cobbs Lake Creek and Caledonia Creek tributaries before they discharge to the main South Nation. The creation of artificially deeper channels by construction levees would appear to have a high potential for success on the lower parts of the tributaries to protect some lands, and is worth evaluating for technical and economic feasibility along parts of the main South Nation as well. Pumping of local surface funoff entrapped behind the dykes would have to be evaluated versus the benefit of a reduction in frequency of flooding. This technique would likely proceed in conjunction with the removal of the downstream construction.

Several studies have been carried out to determine exactly how to minimize the obstruction to flow created by the rock outcrop at Plantagenet Springs. In the early 1970's, two rock cuts, about five feet deep and 44 feet wide were made in the rock outcrop in an effort to provide additional capacity and reduce flood levels. Flooding has continued to be a problem; however; under low flow conditions the upstream water levels have been considerably reduced. These works did, however, decrease upstream water supply under low flow conditions and concerns have been expressed that recent severe bank slipping and sloughing were related to the reduced water levels.

The 1979 study by Proctor & Redfern - McNeely has recommended further removal of the rock outcrop to reduce the head loss through the area and the installation of a simple sharpcrested weir to maintain water levels above elevation 142 feet. Based upon an analysis of economic factors only, the benefit cost ratio for the proposal works was found to be 0.6, although we feel the calculation of the secondary benefits may be over-stated. However, based upon the intangible social, inconvenience and indirect flood impacts which cannot be measured on monetary terms, the project was recommended to the Authority as the preferred alternative for mitigating the problems caused by the rock outcrop. It was determined, through the hydraulic analyses carried out by Proctor & Redfern - McNeely, that the recommended improvements at the rock outcrop will only partially relieve upstream flooding. This is why the benefits are not commensurate with the costs.

If the Plantagenet Springs rock outcrop were to be removed, a two mile downstream reach containing a secondary till and rock outcrop would then constitute the main outlet control for the South Nation River influencing water levels in the Plantagenet flood area, particularily under higher flows. The hydraulic analysis of the rather expensive improvements required to reduce the control influence of this reach (as carried out by Proctor & Redfern - McNeeley) revealed that the flood level reduction, additional to the proposed Plantagenet Springs improvements, would only be 0.6 to 1.4 feet, which is relatively minimal in comparison with the costs involved.

The potential for improving the flooding situation further would appear to lie with the ability of a dyking program to contain the flood flows of the main river and its tributaries.

4.3.3 Drainage Improvements

As outlined in preceeding sections, the potential to effect significant benefits to the agriculturally based economy of the basin by the provision of improved drainage facilities is high.

The benefits to be derived from the construction of outlet drains and the installation of tile drainage is well recognized and supported by recent comprehensive studies. Figures 8 and 9 illustrate the present (1978) extent of agricultural outlet drainage and tile drainage in the South Nation Basin. Figure 11 outlines the soils which according to the Ontario Ministry of Agriculture and Food have the potential for being drained. By comparing these three figures, one can see the large extent of the area remaining to be drained.

In a report dated December 13, 1979 the Ministry of Agriculture and Food has summarized the outlet drains which are currently under construction, are designed but awaiting approvals, and drains which are in the proposal stage. There are some 83 drains drains with a capital cost in an excess of $7,000,000 under active consideration in the South Nation River Basin.

In Section 3.3, the implications of modifications to the hydrologic and hydraulic response of the basin were discussed. To date, no attempt has been made to comprehensively assess the future of the agricultural drainage program in the Basin with regard to its total benefit or its aggregate effect on the water resources of the Basin. The channel improvements upstream of Chesterville and at Plantagenet Springs are, in almost every way, similar in nature to the hydraulic improvements being proposed as outlet drains. From the discussions in Section 3.3 one would anticipate downstream effects of a negative nature due to these improvements however, the necessary hydrologic and hydraulic modelling has yet to be done to identify the magnitude of these downstream effects. Consequently, until the downstream effects are quantified, it prevents a comprehensive benefit-cost analysis from being carried out on the proposed drainage improvements. It may be necessary to include consideration for upstream storage or downstream channel improvements in the benefit-cost calculation to ensure that upstream proponents are not benefiting to some degree at the expense of the downstream landowners.

It is anticipated that the economic benefits of the proposed agricultural drainage improvements program will continue to outweigh the costs, however, the drainage improvement program in the Basin is too substantial to continue without some comprehensive analysis and planning on a basin scale, as opposed to an individual works basis.

In addition, works proposed on the Payne, Bear Brook, South Castor, North Castor, Middle Castor and the upstream South Nation river systems may be mutually exclusive with many of the upstream storage proposals. While the potential for justifying some of the upstream storage facilities may not appear high, we now have available, powerful simulation models which can aid the decision making with regard to these proposals, in the context of the overall basin. As drainage and development continue in these areas, the options available to a water management plan for the basin tend to reduce.

4.3.4 Water Quality

The status of water quality in the South Nation Basin, as outlined in Section 4.2, is to a major degree non-point source related and to a minor degree created by point sources of pollution. In general, as discussed in detail in Appendix B, the pollution loading from the point sources within the Basin (Casselman, Plantagenet, Russell, St. Isidore, Chesterville, Winchester, Embrun and the industrial soucres of Nestle at Chesterville and Ault Foods at Winchester) are well in hand with the Ministry of the Environmental coordinating individual programs to optimize the operation of the current treatment facilities. Little consideration has been given to advanced treatment of these point-sources since they are already achieving good levels of treatment and the combined contribution of the point sources is relatively small in comparison with non-point loadings.

Non-point sources of surface and groundwater pollution include sediment from water and wind erosion, fertilizers, pesticides and plant residues and animal manures from cropland, grazing areas and animal confinement areas.

Erosion occurs as a natural geological process, but may be accelerated by man's activities. Soils are protected naturally by vegetation and vegetation residues. If moisture or fertility is too low, the land is more vulnerable to erosion. Tilling the soil, over grazing, crop harvesting, and burning of vegetation remove or bury portions of the organic material which protects soils from erosion and may expose more vulnerable, erodable conditions.

Factors influencing nutrient losses are precipitation and excess irrigation, temperature, kind of soil, type of crop, nutrient mineralization, denitrificiation, fertilizer type, application method and rates, tillage practices and soil erosion rates.

Pesticides enter the aquatic environment by wind drift, runoff and erosion, and seepage to subsurface drains or groundwater. Factors influencing pesticide loss include precipitation, type and persistance of chemical, temperature, tillage practices and soil erosion rates, livestock types, housing types, etc.

Disposal of plant residues and animal manures on land is also a potential source of non-point water pollution. Animal manure is particularly high in nutrient and organic content. Proper application to the land can provide benefits for crop production and assist in reducing surface runoff. Inadequate practices can lead to highly contaminated runoff.

Remedial measures for the control of non-point sources of water pollution range in sophistication from well defined structural methods, such as sedimentation ponds or treatment processes, to the intangible aspects such as the use of common sense or adherance to manufacturers' specifications for pesticide application. A catalogue of a large number of remedial measures, both structural and non-structural where there was sufficient tangible information on the measure to fully describe and evaluate it was prepared by Marshall Macklin Monaghan Limited for the International Joint Commission through the PLUARG program. Table 8 illustrates the available remedial measures, the land use activity to which it applies, and the pollutant for which it is effective.

Remedial Measures Application Matrix TABLE 8

	Land Use Remedial Techniques	Urban	Agriculture	Recreation	Forest	Extractive	Transportation	Liquid Waste Disposal	Deepwell Disposal	Solid Waste Disposal	Lakeshore & Riverbank Erosion	Shoreline Landfilling
1	Chemical Soil Stabilizers	S n	S n				S n				S	
2	Roof Top Ponding	s n										
3	Dutch Drain (Gravel filled ditches with option drainage pipe in base)	s n										
4	Porous Asphalt Paving	s c		S n			s c					
5	Precast Concrete Lattice Blocks and Bricks	s n c					s n c				S n	
6	Seepage Basin or Recharge Basin (Single Use)	s n c										
7	Recharge - Detention Storage Basins (Multi-Use)	s n c	s n									
8	Seepage Pits or Dry Wells	s n c										
9	Pits, Gravity Shafts, Trenches and Tile Fields	s n c										
10	Recharge of Excess Runoff by a Pressure Injection Well	s n c										
11	Conservation Construction Practices	S			S	S	S				S	
12	Temporary Mulching and Seeding of Stripped Areas	S			S	S	S					
13	Conservation Cultivation Practices on Steep Slopes	S	S		S		S					
14	Temporary Diversions on Steeply Sloping Sites & Temporary Chutes	S	S		S	S	S				S	
15	Temporary Check Dams on Small Swales and Watercourses	S	S			S	S				S	

Significantly Effective in Reducing Magnitude of Pollutant

C - chemicals
N - nutrients
P - pesticides
S - sediments

Moderately Effective in Reducing Magnitude of Pollutant

c - chemicals
n - nutrients
p - pesticides
s - sediments

Table 8 cont'd

	Land Use **Remedial Techiques**	Urban	Agriculture	Recreation	Forest	Extractive	Transportation	Liquid Waste Disposal	Deepwell Disposal	Solid Waste Disposal	Lakeshore & Riverbank Erosion	Shoreline Landfilling
16	Seeded Areas Protected with Organic Mulch	S	S		S	S	S				S	
17	Seeding Areas protected by Netting or Matting	S			S	S	S				S	
18	Single Family Aerobic Treatment Systems	N c	N c	N c								
19	Contour Listing		S									
20	Disposal of Treated Sewage Effluent by Spray Irrigation	s N c	s N c	s N c				s N c	s N c			
21	Surface Water Diversion	S	S		S	S	S					
22	Terraces (Diversion Terraces)	S	S		S	S	S					
23	No-Tillage Cultivation (Shot Planting, Zero Tillage)		S									
24	Pesticide Application Methods	P	P	P	P		P					
25	Alternatives to Chemical Pesticides	P	P	P	P		P					
26	Slow Release Fertilizers		N c		N c							
27	Placement of Fertilizer		N c		N c							
28	Timing of Fertilizer Application		N c		N c							
29	Roughening of the Land Surface		S									
30	Promotion of Soil Clods or Aggregates		S									
31	Stripcropping		S		S	S						
32	Miscellaneous Tillage Alternatives		S									
33	Conservation Tillage		S									
34	Sod-Based Crop Rotation		S									
35	Winter Cover Crops		S									

Table 8 cont'd

	Land Use Remedial Techiques	Urban	Agriculture	Recreation	Forest	Extractive	Transportation	Liquid Waste Disposal	Deepwell Disposal	Solid Waste Disposal	Lakeshore & Riverbank Erosion	Shoreline Landfilling
36	Improved Soil Fertility		S									
37	Timing of Field Operations		S									
38	Contouring or Contour Cultivation		S									
39	Grassed Outlets	S	S				S				S	
40	Direct Dosing of Alum to a Septic Tank	N	N	N								
41	Swirl Concentrator for Runoff Treatment	S n	S n									
42	Retention Basins for the Treatment of Wet-Weather Sewage Flows	S n										
43	Stationary Screens	S n										
44	Horizontal Shaft Rotary Screen	S n										
45	Vertical Shaft Rotary Fine Screen	S n										
46	Treatment Lagoons *	s N	s N	s N								
47	Rotating Biological Contactors *	N	N	N								
48	Trickling Filters *	N	N	N								
49	Contact Stabilization	N		N								
50	Air Flotation	S n										
51	Physical-Chemical Systems	s N										
52	Reverse Osmosis of Mine Tailings Effluent					C						
53	Chemical Adsorption onto Clays in Experimental Environment		P		P							
54	Surface Water Diversion		S n c		S n c	S n c				S n c		
55	Reducing Ground or Mine Water Influx					n C				n C		

Table 8 cont'd

	Land Use Remedial Techiques	Urban	Agriculture	Recreation	Forest	Extractive	Transportation	Liquid Waste Disposal	Deepwell Disposal	Solid Waste Disposal	Lakeshore & Riverbank Erosion	Shoreline Landfilling
56	Underdrains for Mineral Stockpiles or Tailings					n C						
57	Evaporation Ponds					n c						
58	Street Cleaning	Snc					Snc					
59	Interception of Aquifers		n c	n c		n c				n c		
60	Neutralization of Mine Acid Waste					c						
61	Stream Neutralization					n c						
62	Improved Methods of Sludge Disposal on Land	n c	n c					n c				
63	Annual Storage and Land Application of Livestock Wastes		N									
64	Sewer Flushing	S n c										
65	Combined Sewer Overflow Regulators	S N c										
66	Overburden Segregation	S n				S n	S n					
67	Mineral Barriers or Low Wall Barriers					S n c						
68	Longwall Strip Mining					S n c						
69	Modified Block Cut or Pit Storage					S n c						
70	Head-of-Hollow-Fill					S n c						
71	Box Cut Mining					S n c						
72	Area Mining					S n c						
73	Auger Mining					s n c						
74	Reducing Surface Water Infiltration					n c				n c		
75	Road Planning & Design				S		S					

Table 8 cont'd

Land Use Remedial Techiques		Urban	Agriculture	Recreation	Forest	Extractive	Transportation	Liquid Waste Disposal	Deepwell Disposal	Solid Waste Disposal	Lakeshore & Riverbank Erosion	Shoreline Landfilling
76	Blocking					C						
77	Check Dams	S	S				S				S	
78	Retaining Walls for Road Construction for Steeper Slopes				S		S					
79	Revegetation -Reforestation Cut Areas and Bare Slopes	S			S	S	S				S	
80	Vegetative Buffer Strips	S	S			S	S	S n				
81	Sediment Basin	S	S		S	S	S			S		
82	Rip Rap Bank Protection	S	S				S				S	S
83	Protection of Culvert Outlet, Chute Outlets, etc.	S	S				S				S	
84	Dolos (Offset assymetric tetrapods)											S
85	Engineering Design & Management For Shoreline Landfilling											S n c
86	Revegetation of Mine Tailings: Stabilization					S						
87	Slope Lowering of Spoil and Tailings Stockpiles					S						
88	Package Sewage Treatment Plants (Multi-Family Use)	s N c	s N c	s N c								
89	Waste Exchange for Resource Recovery									C		
90	Head Gradient Control									s n C		
91	Biological Treatment									S N C		
92	Streambank Protection with Vegetation	S	S								S	
93	Grass Channels or Waterways	S n	S n				S n				S	
94	Permanent Diversions	S n	S n		S n		S n				S n	
95	Bank Protection By Jetties, Deflectors	S	S				S				S	S

Table 8 cont'd

Land Use Remedial Techiques		Urban	Agriculture	Recreation	Forest	Extractive	Transportation	Liquid Waste Disposal	Deepwell Disposal	Solid Waste Disposal	Lakeshore & Riverbank Erosion	Shoreline Landfilling
96	Reduction and Elimination of Highway Deicing Salts	C					C					
97	Septic Tank/Tile Bed Sewage Disposal	N	N	N								
98	Miscellaneous Methods to Reduce Storm Runoff	S n					S n					
99	Exclusion of Livestock From Watercourses		S n									
100	Land Smoothing		S									
101	Gabion Baskets	S	S								S	S
102	Miscellaneous Erosion Control Fabrics and Materials	S	S								S	S
103	Miscellaneous Individual Wastewater Treatment Systems	N	N	N								
104	Clivus Multrum	N	N	N								
105	Controlling Feedlot Runoff		N									
106	Landfill Liners									C		
107	Hydroseeding	S			S	S	S				S	
108	Catch Basin Cleaning	Snc					Snc					
109	Plant Materials For Bank and Slope Stabilization	S	S	S	S	S	S				S	S

By no means is the importance of such intangible techniques as the use of common sense, the application of modern methods, the use of additional control, increased pre-construction study and design effort, etc., to be discounted. It is,perhaps, from these philosophies that the initiative to implement the more physical remedial measures will be derived.

In addition to the structural and non-structural distinction between remedial measures is the aspect of source control versus treatment of pollutants already in the transport system. It is generally recognized that prevention measures to abate the generation of contaminants before they become mobile, is a preferable approach, particularily in the agricultural sector.

The need for eduction of the public or persons concerned is probably the first step in a remedial measures implementation program in order to inform those affected of the nature of the problems and the measures available for their control. However, each and every public education program design would be specific to the area involved and the target population.

Although it is difficult to quantitatively assess the economic benefits to be attained from a public education program within the Basin to reduce non-point source pollution, it is anticipated that such a program would potentially be very cost effective.

The alternate consideration to reducing the pollutant loadings is,in many cases, to provide low flow augmentation from upstream reservoirs to ensure adequate dilution of the contaminant load. Studies to date have addressed low flow augmentation as a secondary consideration to flood control benefit but it is apparent that some improvement of water quality would result downstream, primarily under the more extreme low flow conditions. The only benefit cost analysis prepared to date was undertaken by Clough for the Spencerville Reservoir. Unfortunately, at that time, the Clough study considered only the benefits to be derived from dilution to permit point source waste treatment operations to operate less efficiently and thereby reduce their capital and operating cost. No water quality modelling has been carried out to evaluate the effectiveness of low flow augmentation as a part of the system and therefore, no sound information exists to establish the physical requirements to achieve the water quality objectives of the Basin.

Control and reduction of the non-point sources of pollutants appears to have a much higher potential for cost effective water quality improvement; however, the low flow augmentation concept may have some degree of optimum utility.

4.4 Analysis of Non-Structural Alternatives

Alternative measures forthe reduction of damages due to flooding can generally be grouped under three classifications:

i) Measures to Modify the Flood
ii) Measures to Modify the Damage
iii) Measures to Modify the Loss Burden

Non-structural measures to modify the flood include extensive reforestation of marginal agricultural lands in the uplands areas, and other land management techniques to encourage infiltration and reduce or retard runoff. Secondary benefits of sediment and nutrient load restriction and potential silviculture revenue are also associated with these alternatives. Extensive tracts of land would be required to have any significant effect on the downstream flooding or on ground water availability on other than a local basis, due to the clayey nature of the soils. It is anticipated that the benefit-cost of any formal program would be economically unacceptable except where silvicultural practice has a strong influence. These practices should, however, be encouraged since their benefits are entirely positive with respect to water management.

Measures to modify damage relate to the protection of property from flooding. They may reduce, but not entirely eliminate economic losses associated with inundation of the area. The main technique is flood proofing individual buildings. Flood damage reduction analyses, where a benefit analysis was carried out, have tended to ignore components other than crop loss, loss of cropping opportunity and increased operational costs. This would therefore imply that the component of flood damages associated with the damages to buildings and equipment is negligible in comparison to the other damage components. From an aerial and ground reconaissance of the major areas susceptible to flooding, it is apparent that most farm buildings are outside or in the marginal areas of the flood susceptible areas, or are on the higher ground. The major population centres in the basin have a low flooding vulnerability. Considering the high frequencey of flooding, one would expect a relatively low flood plain occupancy of dwellings and buildings. It is probable that site specific cases exist which would benefit from flood proofing measures and it could be a service program which the Authority could easily implement, however we feel that on a basin scale the impact of such a program will be relatively insignificant.

Non-structural techniques used to modify damage are associated with the regulation of floodplain lands through methods such as floodplain mapping, restrictive zoning and acquisition. Studies have shown that benefits accrue slowly in areas of existing development, but that these measures are effective in rural areas in preventing damages and management problems. The implementation of flood prediction and warning systems is another non-structural measure which, in the South Nation Basin, would not have major benefits during the sping floods. However, some preparatory work for a late spring or summer flood may result in some reductions in flood damages to buildings and equipment. Upon completion of the Basin Study, it is anticipated that the comprehensive watershed model would be able to operate in a forecasting mode and with the support of the Hydrometeorological Section of the Conservation Authorities Branch of the Ministry of Natural Resources, a flood forecasting and warning system could be economically established.

Options which modify the loss burden are, by their nature, neither preventative nor truly corrective. If such measures are implemented, flood damages would continue to occur but losses to individuals would be modified. "Insurance" programs wither as government relief or as a flood insurance characterize this method. Due to the high frequency of flooding in the major flood susceptible areas, the cost or premiums from such a program would likely be unattractive for all but the peripheral areas where low frequency flooding takes place. Should the hydrologic and hydraulic analysis of the proposed upstream channelization and drainage improvements conclusively demonstrate an aggravation of downstream flooding, flood insurance in the downstream areas could be a vehicle for an adjustment from upstream proponents. Such an adjustment could be in the form of a contribution toward the flood insurance premium as opposed to carrying out uneconomic structural improvements to offset the change in the Basin response.

The various non-structural remedial measures described above are not mutually exclusive. On the contrary, most of the measures are compatible and can contribute a degree of cost effectiveness to a water management plan consisting of several interrelated components. Alternative combinations of measures should be analysed with due care being taken not to double count their associated effectiveness.

4.5 Impacts of Structural Alternatives

The expected impacts of the structural improvements proposed for the watershed are summarized in the matrices which follow. Table 9 presents the potential impacts of general catagories of improvements with respect to the South Nation Basin. A distinction is made between local and regional impacts. Local impacts are those realized at the improvement, such as the reduction in flooding at the Chesterville channelization. If the channel improvement cause flooding downstream, a regional negative impact results.

The impacts of specific projects may deviate from these generalized potentials. Selected proposals are addressed specifically in Table 10.

TABLE 9

Potential Impacts of Structural Alternatives in the South Nation Basin

LOCAL IMPACT

REGIONAL IMPACT

++	MAJOR POSITIVE
+	MINOR POSITIVE
o	INSIGNIFICANT
-	MINOR NEGATIVE
--	MAJOR NEGATIVE

		LAND DRAINAGE	RESERVOIRS	CHANNEL IMPROVEMENTS	DIVERSIONS	DYKES
ENVIRONMENTAL	TERRESTRIAL SPECIES & HABITATS	- o	+ o	o o	o o	o o
	AQUATIC SPECIES AND HABITATS	-- -	++ +	- -	o o	o o
	SOIL EROSION	-- o	+ o	+ o	+ o	+ o
	CHANNEL EROSION	-- -	+ +	-- -	o +	- o
	SEDIMENTATION	-- -	+ +	-- -	o +	- o
	CHANNEL HYDRAULIC EFFICIENCY	o o	o o	++ o	o o	++ o
	LOW FLOW WATER LEVELS	o o	++ ++	- o	o o	o o
	MINIMUM DISCHARGE	o o	++ ++	o o	o o	o o
	WATER QUALITY	-- -	+ +	o o	o o	o o
	FLOODING	-- --	+ +	++ -	++ ++	++ -
	AGRICULTURE - SILVICULTURE	++ o	-- ++	++ -	++ o	++ -
AESTHETICS	LAND	+ o	+ o	+ -	+ +	+ -
	WATER	-- o	+ +	-- o	+ +	o o
	BIOTA	- o	+ +	- -	o o	o o

Table 10

Project Impact Matrix

LOCAL IMPACT

REGIONAL IMPACT

++ MAJOR POSITIVE
+ MINOR POSITIVE
o INSIGNIFICANT
– MINOR NEGATIVE
-- MAJOR NEGATIVE

		SPENCERVILLE RESERVOIR	CHESTERVILLE CHANNELIZATION	PAYNE R. CHANNEL IMPROVEMENT	PLANTAGENET SPRINGS ROCK CUT	PLANTAGENET CHANNELIZATION	PLANTAGENET DYKING
ENVIRONMENTAL CONCERNS	TERRESTRIAL SPECIES AND HABITATS	-- o	-- o	-- o	o o	-- o	-- o
	AQUATIC SPECIES AND HABITATS	+ +	– –	– –	-- o	– –	o o
	SOIL EROSION	+ +	– –	– –	– o	+ o	o –
	CHANNEL EROSION	+ +	– –	– –	– o	+ o	o –
	SEDIMENTATION	++ +	+ –	+ –	o o	+ o	o o
	CHANNEL HYDRAULIC EFFICIENCY	o o	++ o	++ o	++ o	+ o	++ o
	LOW FLOW WATER LEVELS	++ +	– –	– –	– –	– –	o o
	MINIMUM FLOWS	++ +	o o	o o	o o	o o	o o
	WATER QUALITY	– ++	o o	o –	o o	o o	o o
	FLOODING	+ +	++ --	+ –	++ –	+ o	++ –
	AGRICULTURE-SILVICULTURE	-- +	++ --	++ –	++ o	+ o	++ –

4.6 Evaluation of Existing Proposals

Although numerous studies have been carried out since 1948 only two projects appear to be sufficiently justified in their technical basis and economic benefit to be considered high priority projects. These are the Chesterville Channelization Scheme and the improvements proposed in the most recent study for the Plantagenet Springs rock outcrop. These projects effectively improve the flooding problems in their respective locations in a cost effective manner. All of the remaining proposals are either ineffective, uneconomic or there is insufficient information available to develop an opinion about the feasibility of the proposal. In general, all of the dam and reservoir proposals do not appear to be economically justified and even under the most cost effective senario; the effects on downstream flooding would not substantially alter the total average annual costs. Some potential exists for the reservoir operations on the basis of improving water quality via low flow augumentation; however, analysis of the water quality of the river is needed to quantify that potential.

4.7 Satisfaction of Water Management Objectives

The water management objectives in the basin, as outlined in Section 4.1, have only partially been addressed by the studies to date, and none of the nine objectives has been fully satisfied. To date the studies have addressed site sepcific proposals and in only the 1948 Watershed Report and in the 1966 Acres report was any analysis done on a basin scale. [redacted]

With the two priority alternatives recommended in the previous section, the channelization upstream of Chesterville and the Plantagenet Springs rock outcrop improvements, there will be a reduction in the depth and frequency of summer and late spring flooding the Brinston and Plantagenet-Lemieux flood areas respectively. It is important to recognize, however, that flooding will continue to exist in these areas, certainly in the spring and to a lesser extent in the late spring and summer. The flooding situation will be improved but not eliminated.

[redacted] The technical analysis must be carried out comprehensively on a basin scale to identify not only the local benefits, but also the downstream implications. Similarly, the evaluation of basin water management alternatives must be carried out on a basin scale to ensure optimal management of the basin resources.

agricultural practices. The Basin Study should give some consideration to the land management trends that might be expected to continue into the future and should evaluate what the future implications of these trends might be. Urban development in the upper reaches of the Bear Brook watershed might be expected to intensify. As the development of faster maturing varieties of corn proceeds, one mightexpect that the gradual shift from pasture hay and small grains to row crops would continue or accelerate. Research and development into the hybrid poplar potential to supply the pulp and paper market from a silviculture operation are currently active. Each of these possible changes in land management or land use would have it's respective implications to the hydrology and hydraulics of the Basin. We would suggest that the comprehensive basin modelling exercise carry out some preliminary evaluation of the sensitivity of the Basin to these possible changes. This would help delay the obsolesene of the Basin Plan when it is prepared.

5.0 COMPREHENSIVE BASIN PLAN

5.1 Objectives

The objectives for Water Management in the Basin developed by the Technical Support Committee, as outlined in Section 4.1, describe an integrated approach to resource management which should optimize resource development within the basin with the conscious knowledge of the benefits, costs and implications of the decisions being taken. These objectives are well founded, clearly defined and should enable the study team to develop the information necessary for decision to be formulated in the light of these objectives.

In addition to the previously stated nine objectives, it is suggested that consideration be given to the development of the administrative infrastructure necessary to guide the implementation of immediate action plans and the evaluation and management of future resource development proposals. The administrative infrastructure guiding the Basin Study was constituted on a short term basis, but the requirements for the long term achievement of the water management objectives for the basin should be evaluated and considered a part of the implementation and future phases.

5.2 Overview

To develop a comprehensive basin plan to satisfy the above described objectives, will require six basic components: problem identification, data collection, problem definition, opportunity evaluation, comprehensive opportunity analysis and selection of attractive opportunities.

The initial phase of any comprehensive basin study must be clearly identify the problems of the basin and to develop an understanding of these problems such that an efficient program can be developed for attacking the problem. In Section 4.2, there were four basic problems outlined for the basin: the Brinston Flooding Area; the Plantagenet Flooding Area; the potential implication of large scale agricultural drainage programs; and the poor water quality of the South Nation River and its tributaries.

From problem identification, the previous studies have jumped to the elevation and selection of attractive opportunities, without having the problems more fully defined in quantitative terms. [redacted] Hydraulic modelling studies need to be undertaken of the flood susceptible areas to define the extent of flooding and the sensitivity of flood areas to flow. Unfortunately, minimal information is available to date on the variation of water quality in the basin in recent years. Some basic water quality modelling will be required to develop an understanding of the nature and sensitivity of water quality in the system and to establish quantitatively the magnitudes and sources of the problems. With regard to assessing the potential impact of the extensive agricultural drainage practices, while theory, as outlined in Section 3.3 , suggests that downstream peak flows would generally be increased, and the perception of the downstream property owners is that this is happening, there has been little research carried out to quantify such a senario, either in the South Nation River Basin, or elsewhere in Southern Ontario. Professor Watt at Queen's University has recently been commissioned by the South Nation River Conservation Authority to carry out some field instrumentation and analysis to determine the effects that tile drainage has on the runoff hydrograph. We understand that only one event has been recorded to date, so it is likely that insufficient data will continue to exist in the near future. Hence we would recommend an extensive literature search to locate the data and results of research in this field outside of Ontario.

The identification of opportunities to mitigate any of the four problem areas should be a relatively straight forward exercise if undertaken by persons experienced in the respective fields. Many of the possible solutions have been outlined in Section 4.0. However, it is anticipated that additional alternatives would result from the basin modelling exercise, supporting the problems definition component. The most important study component will be the comprehensive evaluation of the opportunities under consideration.

In the past, studies have not considered proposal solutions on a basin scale, the assessment of downstream implications were non-existant, and there has been only very limited eveluation of the actual benefits to be derived from the proposed works. It is essential that sufficient comprehensive analysis of any proposed improvements be carried out to allow the responsible decision makers to make informed decisions.

5.3 Hydrologic and Hydraulic Modelling

In order to prepare a quantifiable comparison of the relative costs and benefits of various resource use options in the South Nation basin, it is necessary to select a set of hydrologic and hydraulic models which are capable of providing a reasonable approximation of the behaviour of the basin under varying hydrologic inputs. The models chosen must have certain general characteristics to justify their application to this particular project. As an example, it must be recognized that the opportunities to calibrate the models are severely restricted by the available data base. Application of the more sophisticated models is particularly limited since the coarse assumptions required to provide estimates of the relatively large number of governing parameters in the larger models tends to negate the better approximation of the physical system being studied and cloud the behaviour of the primary hydrologic processes.

Further, it is necessary to select a set of models whose capabilities are closely matched to the phase of the study being undertaken. A number of alternative reservoir sites for flood control must be analysed - in a general case it would appear advisable to apply a model capable of simulating the behaviour of a system of reservoirs controlled by varying sets of operational strategies and subject to a series of downstream objective constraints. A careful consideration of the specific problems and likely solutions on the South Nation basin as described in this Report tends, however, to nullify the need for the generalized abilities of a model like HEC-5c which is capable of performing this type of analysis. Factors relating to the choice of appropriate models are detailed on the following pages, grouped by the function of the models.

Flooding

The nature and extent of the flooding problem experienced by the residents of the South Nation basin has been described in Section 4.2 of this report. The models used to simulate the basin's response to flood events must be capable of providing an accurate representation of both the current conditions of the watershed and the effects of potential future modifications which may be imposed. Ideally, the changes in basin response resulting from both past and present alterations should be clearly illustrated by the models. These alterations must include the effects of tile drainage, the channelization of small watercourses, the creation of open channel drains, the channelization and diversion of major watersources and the construction of dams and other water control structures.

The conceptual and empirical representations of the physical watershed must also be chosen so as to reflect the characteristics of the South Nation basin. Particular attention must be focussed on the routing of flood flows in this watershed because of the flat slopes encountered on most of the main stem and many of the tributaries.

It is recommended that the hydrologic and hydraulic processes be segmented in order to assess the impact of modification to the individual components of the hydrologic regime of the basin. This is of special significance in the South Nation study since the proper assessment of proposed water management alternatives, both structural and nonstructural, requires that defensible, quantified assessments be made of the impacts of these proposed alternatives and strategies on other groups and interests in the basin.

Event Analysis

The initial consideration with respect to the estimation of a probability density function of flood discharges is the spatial and temporal distribution of liquid water, which comprises surface runoff. It has been widely recognized for some time that the probability density of outputs from a hydrologic system is not identical to that of the system inputs. Because of this consideration, and in recognition of the nature of flood events in the basin, it would be advisable to carry out an event analysis study component in order to select a series of events which represent the interrelationships between rainfall, antecedent moisture, snow depth, snowpack history and condition and other meteorological variables which determine snowmelt.

This analysis would include an infiltration model which could be adjusted to include the effects of tile drainge and changed land use on the availability of liquid water for runoff. While precise calibration of such a model is not achievable because of the lack of good data on the effects of tile drainage, it is a justifiable approach and will allow the assumption concerning these effects to be made clear, rather than being hidden as in a more lumped model. It should also be kept in mind that the understanding of the behaviour of tile drains in the basin will be significantly advanced during the course of the study.

The Atmospheric Environment Service of the Federal Department of Fisheries and the Environment are strongly interested in performing event analysis as a service to Consultants under their Cost Recovery Program. Since this agency has the necessary data, expertise and computer softward required to perfrom this sort of analysis, it is recommended that they be involved in the Study.

The results of their investigations would certainly be of use in other studies carried out in Eastern Ontario. Since the damages associated with early spring, late spring, summer and fall floods are significantly different from one-another, the need to retain event seasonality in the hydrologic modelling is of special impor~~a~~tance, further supporting the desirability of rigorous examination of input events.

The set of events generated by AES (or a Consultant) will be passed through a roughly calibrated coarse screen model of the basin to adjust the frequency of the system outputs and enable selection of detailed events for simulation by a more highly calibrated model. The coarse screen could be a simple hydrologic tool such as Hymo provided the Consultant is familiar with the limitations and peculiarities of the model.

For the purpose of analysing alternative flood reduction schemes, relatively coarse models are adequate and certainly desirable from a cost and time point of view. This will enable the early identification of undesirable and ineffective alternatives and provide a quantitative, 'hard', and economical means of eliminating those alternatives which appear unattractive.

For purposes of this type of coarse screening there is no need to carry out a detailed event analysis program and it is recommended that several representative events for the 2 year, 10 year, 25 year and 100 year occurrences be selected based on those runoff events which caused the flows with these return periods, as determined by analysis of flow gauging records.

System Response

Several alternate models and approaches are available to determine the response of the basin to runoff inputs. All of these models are capable of including the effects of channelization, flow obstructions, reservoirs and other structural flood-modification schemes.

The HYDRO-1 model recently developed by the Conservation Authorities Branch of the Ministry of Natural Resources, contains a non-linear response function which may be of considerable use in calibrating the behaviour of the basin to runoff events. It is recommended that the non-linear variable unit hydrograph approach be used, at least for model calibration purposes.

It may be necessary to consider the use of data from other basins and studies to supplement the calibration work because the usefullness of the data base for calibration is relatively limited. The application of a non-linear model for calibration could reduce the biases created by the use of a wide range of runoff intensities. Should effects of the range of intensities considered in the calibration and subsequent modelling be relative minor it may be possible to later apply a non-linear model, which would allow the use of more commonly applied tools such as HYMO and other unit-hydrograph methods. By applying Hydro-1 for calibration, however, the province-wide data base for hydrogic calibration could be expanded on a common basis. The benefits of this type of approach becomes progressively more important as future work is carried out both on the South Nation Basin and other watersheds.

The flood routing capabilities and characteristics of the applied model must be well understood by the Consultant and must be suited to the nature of the South Nation basin. Flood routing in this watershed is characterized by long travel times, flat slopes and very large, often shallow, flood storage areas. The capabilities of any proposed flood routing technique should be satisfactorily demonstrated before application in the Study.

There is no reliable data for separate calibration of a routing model for this watershed, so the use of the Muskingum model, for example, must rely on empirical equations for estimation of the weighting factor x, with K computed on the basis of travel times. For any proposed routing model, travel times should be predicted through the use of HEC-2 to estimate flood wave velocities. A coarse HEC-2 model of large portions of the basin is recommended using very widely spaced cross-sections. Care must be taken in any calibration exercises to ensure that the elements which are being calibrated are not mixed. It is not logical, for example, to calibrate unit hydrograph response using a downstream g~~ua~~auge, and later make adjustments to the routing portion of the model.

Flood Forecasting

The co-ordination of flood forecasts for all areas of Ontario is carried out by the Consercation Authorities Branch (C.A.B.) of the Ministry of Natural Resources. This group is continually updating and improving its flood forecast capabilities and should be closely involved in the preparation and calibration of a flood forecast tool for the South Nation basin.

It appears likely that the National Weather Service Model will be set up for the most large watersheds in Southern Ontario. Interim approaches are available until this model has been successfully employed on other watersheds by the C.A.B. and tied into a centralized flood warning facility using radar to track storm events. Continual liaison with the C.A.B. should be maintained by the South Nation River Conservation Authority and any Consultants working on this aspect of water mangement.

At present it is felt that a cursory treatment of flood forecasting is sufficient pending later discussion with the C.A.B. concerning their plans for bringing the NWS model on line for Authorities. Work on the central flood warning capability is progressing steadily and an interim system is probably not economically justifiable.

Low Flow Modelling

The analysis of low flows is important in order to model water quality within the watershed. Extensive work in stochastic hydrology has been carried out at the University of Waterloo which is directly applicable to the low flow modelling component. The development of ARIMA (Auto-regressive Integrated Moving Average) models provides a powerful method of preparing series of simulated flows for input into the water quality phase.

The ARIMA models are available in 'canned' form and have been extensively tested. They offer major advantages over earlier MARKOV methods in that the whiteness, or randomness, of residuals can be tested in order to determine how good an approximation of the behaviour of the basin is achieved by the model. The generated low flows may be distributed across the basin and used to model both baseline water quality and the effects of constructing low-flow augmentation reservoirs.

There are,of course, disadvantages ot the stochastic models which must be carefully considered before they are applied. The gradual hydrologic intervention created by agricultural activities through changed land use, tile drainage and the construction or improvement of outlet drains may reduce ~~the reduce~~ the effectiveness of the stochastic approach by decreasing the stationarity of the process. In addition, it may be necessary to study the behaviour of flood and low flow events jointly because of their interdependence. That is, there may be a greater likelihood of flood events in years are "wetter" in terms of low flow. This interdependence becomes important when analysing the operation of a multipurpose reservoir, since trade-offs must be made between storage requirements for low flow augmentation and flood control.

Although the stationarity of flow cannot be precisely determined through analysis of the downstream flow records, it would seem unlikely that the drains would have a significant effect because of the generally localized drawdown characteristics they exhibit. Through a more detailed consideration of the effect of the drains on flows, it may be possible to assume that their effect is negligible and this course of action is recommended.

The problem of considering joint low flow/high flow operational situations can quickly become a complex one. It is recommended that the problem be approached by creating a series of milestones in the study at which problems regarding the level of detail necessary to provide answers to the central questions in the study can be discussed and approaches confirmed.

One scenario, for example, could be that none of the flood control reservoir options passes the initial screening and that only the incremental flood contol benefit on constructing a low flow augmentation reservoir need be evaluated. In this event a relatively coarse method of evaluating the incremental benefit would be sufficient because of its low relative importance. It would be advisable to make some assumptions concerning the likely method of reservoir operation and initial pool level, and carry out the analysis with the watershed response model, e.g. HYMO or HYDRO-1. If flood control assumes a higher priority and hence a more detailed level of investigation is warranted, a more sophisticated approach would be justified.

In such a situation a set of synthetically generated (ARIMA) reservoir inflows could be used as a base on which to test operational strategies for both low and high flow events. Since the minimum achievable time step will likely be at best in the order of 1 week, this may present difficulties in simulating the flood events. This difficulty may be overcome by correlating peak flows with weekly averages and deriving hydrograph shapes based on analysis of similar magnitude events.

An alternate approach is to group events on the basis of seasonal occurrence, separate base flow and flood flow and reconstitute a synthetic set of events by superimposing two synthetically derived series.

Water Quality Modelling

The water quality models applied to the South Nation basin must be capable of accurately assessing the import of non-point pollution loadings, of the predicting the changes in water quality or a function of discharge and of modelling water quality within any proposed reservoirs. The range of available models is very wide, including as in the hydrologic component, both deterministic and stochastic procedures, each with differing sensitivities, error terms, data requirements and computer time requirements.

Potential candidates include models such as SWMM, DOSAG-1 a modified version of the Thames River model prepared by the Ministry of the Environment and more recent non-linear stochastic solutions to the governing differential equations.

It is recommended that a thorough review of applicable models be conducted before work is undertaken on this particular component-modelling of water quality is still in its infancy and there are wide variations in approaches and costs. A review of this nature will be undertaken for the Glengowan Dam Environmental Assessment in the near future. The results of their review will yield inforamtion directly applicable to the South Nation Study and it is further recommended that full advantage be taken of their work.

Hydraulic Modelling

The computer program HEC-2 has become the standard method for computing water surface profiles for gradually varied flow conditions and will certainly be used on this study. The model should not be used without due consideration of input requirements particularly at hydraulic structures. Since the backwater from bridge losses may extend for large distrances upstream, it is recommended that special attention be focussed on each significant bridge crossing or structure to ensure that the correct coding procedure has been followed and that the procedure reflects the hydraulics of the structure adequately.

It would be advisable to require the consultant to demonstrate or state his knowledge of bridge hydraulics beyond the minimal capabilities required to run the HEC-2 program.

As previously discussed, HEC-2 may also be used to derive travel time and estimates of the storage delay constant for use in routing.

The reservoir operation model HEC-5C has been mentioned as being of use in modelling potential reservoirs and related operation or managemtn strategies. At present, it does not appear likely that enough of the potential storage facilities will pass the pre-screening stage to warrant the use of HEC-5C, which is best applied to the optimization of multi reservoir systems. Should the complexity of the problem be relatively low as is presently envisaged, it is recommended that a more simple model, probably the routing component of HYMO or HYDRO-1 be used. Alternately, it would not be difficult to create a specialized routing routine to study specific problems on tihs basin. Such a routing could function outboard to the hydrologic response model or could become a subroutine.

Action Plans

The present discussion of hydrologic and hydraulic models is by no means exhaustive. Different consultants have preferences as to model use and application based on their experience, personal biases and awareness of the primary study objectives. Many alternative modelling technology uses are available, and indeed, may be suitable for the study depending on the direction which the work takes as th alternatives pass successive levels of screening. The important factor is to ensure the flexibility is maintained in the modelling approach so that the project does not become locked-in to unsuitable modelling techniques, whether they be unnecessarily complex and costly or overly simplistic and inadequate.

The situation may be avoided through the establishment of an effective project control and liaison system characterized by milestone events which allow for regular discussion, feedback and confirmation concerning critical study approaches.

This approach places responsibility on both the Consultant and the Steering Committee to ensure that the milestone meetings are productive and efficient. In numerous recent studies, however, this approach has proven effective, with a few additional meetings required and serving to maximize the Consultants' efforts in meeting client objectives.

Throughout the study it is encumbent upon the consultant to see that objectives of the Authority are sufficiently sensitive to the detail of the work being undertaken to justify the approach. With these factors in mine, and in light of the previous discussion, it is clear that any action plan for hydrologic and hydraulic modelling must be strongly dependent on the continual evolution of study objectives.

The specifics of an Action Plan for hydrologic and hydraulic model selection lie in the implementation of a effective study approach.

Possible Pre-Screening Tools

Hymo
Hydro 1
HEC-1
TR-20
STORM

Of these models, Hymo is the most commonly used and work adequately provided the user is aware of the limitations of the model in routing on flat slopes and applies the most recent guidelines concerning the estimations of the hydrograph shape and scale parameters. Hydro-1 is a new model, relatively untested but capable of non-linear analysis and likely to become a commonly used method because of its capabilities and support from the C.A.B. The advantage of a common model for many applications is that calibration data may be transferred from study to study.

Hec-1 and TR-20 are SCS unit hydrograph techniques which are now less commonly used, but may still be adequate for prescreening.

STORM is a very simple model which produces peaks and volumes for flood events. It may be roughly calibrated and used as a very coarse screening tool at an early stage in a study.

Detailed Hydrologic/Hydraulic Modelling

Hymo
Hydro-1
Stanford Watershed Model
HEC-5C
HEC-2
ARIMA Models

Hydro-1 is recommended for watershed calibration because of its non-linear capability. If the effect of non-linearity is small enough, a calibrated version of Hymo could be applied to the basin.

The Stanford Watershed Model is on extremely powerful tool for the simulation of large watersheds, able to produce long term simulations of both low and high flow events. Unfortunately the costs of operating this model offset its usefullness. The difficulting in achieving an acceptable calibration of its many parameters also tends to limit its use in an area with limited data.

Hec-5c is generally applied for the analysis of multi reservoir system operating under sets of objective constraints. It could be used if more than one major reservoir emerges as a strong alternative, a somewhat unlikely situation.

Hec-2 is the standard backwater model and will definitely be used throughout the study.

An ARIMA model may be applied for the generation of synthetic reservoir inflows should a detailed analysis of a reservoir be required. The inputs provided by ARIMA would be linked to a calibrated basin model to optimize the operation and sizing of a reservoir and provide a sound basis for assessing its benefits.

5.4 Data Acquisition Program

Based upon our understanding of the objectives of the Basin Plan, and our knowledge of what data is currently available, it is recommended that the following Data Acquisition Programs be either established or continued.

(i) Water Quantity

Calibration is the process of adjusting the model construction and parameters so that the simulation results correspond to actual observations.

The Water Survey of Canada currently operates a number of flow recorders in the basin. The results from these recordings will form the basis for calibration of the hydrologic model and development of frequency relationships which are then related to economic risk factors in the damage areas. We would expect this data collection to continue.

In recent years, the South Nation River Conservation Authority and the Water Survey of Canada have been measuring flood stage and relating it to flows at several points along the Plantagenet reaches of the river. We would recommend that this program be expanded to include the Brinston flood areas as well, and some points on the tributaries. Once a full range of stage discharge data has been collected for normal events, this program could be reduced to consider the effects of ice hamming and to monitor the success of the improvements proposed for immediate action.

The availability of this data for calibration reduces the error and increases the confidence in simulation models being used and improves the overall results of the analysis.

(ii) Water Quality

The Ministry of the Environment has six provincial water quality network stations in the South Nation basin that have been monitored for up to 10 years. In addition, the Ministry has carried a "one time only" sampling program at 176 locations within the Basin during the preparation of Water Resouces Report 13 for the South Nation River Basin. This information will allow preliminary analysis to be carried out to determine the conformance of the water quality to the water quality objectives of the basin and the singnifance of the non-conformity with the objectives. To some degree, this data will also enable as assessment of the main sources of pollutants to the watercourses.

Should the significance of the non-conformance be identified as major, then a water modelling program will be required to further define the existing conditions and to allow predictions to be made regarding the effectiveness of remedial works. This modelling program would require more extensive water quality data of a more continuous nature in order to allow reasonable calibration of the model. We would suggest that regular water quality monitoring should be carried out at Spencerville, Russell, Finch and Bourget as a minimum in addition to the five existing provincial stations in order to provide reasonable distribution of information throughout the Basin.

(iii) Flood Damage Inventory

The foremost problem within the basin is the economic loss to agriculture due to the inundation of low lying lands by floods at various times of the year. The expenditure of many millions of dollars has been proposed based upon the calculation of benefits determined by very indirect methods. Certainly it would be excessively burdensome to collect actual data for all flood susceptible areas; however, there are very large sums of money being considered on the basis of relatively gross assumptions. To date, only limited work has been carried out in the Plantagenet and Brinston flood areas in the form of hydraulic to identify the extent of flooding in various areas. What is needed is the depth and area of flooding expressed as frequencies through all the flood susceptible lands, information that is provided by a flood plain mapping program using a range of flows from high to low in frequency. This would then enable quantitative definition of the flooding problem and would allow basin identification of benefits resulting from any proposed improvements.

In addition to the flooding frequency-depth information it is felt that a more accurate assessment should be made of the acutal resultant damages and alternatively, the value of the opportunity to produce higher value crops or to increase production. Out of some 25,000 to 30,000 acres of land which are affected we would suggest a detailed analysis of approximately 1,500 acres to ascertain the real economic benefit to be gained from the improvement of flooding conditions. Such an analysis should include on-site interviews with the land owners to establish input costs, losses suffered under various conditions, the changes in management and cropping practices that would result from a reduction of the flooding, and the farmer's attitudes toward the flood frequency at which he would consider making the change to his management and cropping practices.

(iv) Environmentally Significant Areas

There are no existing fish and wildlife inventories for the purposes of indentifying significant or sensitive areas within the South Nation Basin. In Appendix D, we have prepared a listing of areas within the Basin, identified by the Ministry of Natural Resources - Cornwall, Ottawa and Brockville Districts, as having fish and wildlife resource values. There is a need to evaluate these areas in at least an overview assessment particularly where they are directly to be affected by any proposed works.

(v) Hydrometeorological Data

For the purposes of hydrologic modelling of both flood flows and low flows, extensive hydroleteorological data is required. Adequate data is, however, available from the Atmospheric Environment Service of

Environment Canada in many forms. Access to this data should be readily possible to anyone working on the Basin Study.

(vi) Geotechnical Data

From our discussion with Mr. Klugman of the Ministry of Natural Resources and Mr. N. Gadd of the Department of Energy, Mines and Resources, a great deal of general information is known about the surficial geology of the area, particularly the problematic marine clay deposits. The acquisition of additional site specific geologic information would be pre-mature at this time. Should, during the course of the Basin Study, alternatives develop of high potential and economic justification, it would then be appropriate to invest in site specific exploratory work to ensure foundation stability.

(vii) Attitudes

An important part of the formulation of the program to satisfy the water management objectives of the basin will be the relative emphasis placed upon various aspects by the residents and land owners within the basin. It is often difficult to speculate what levels of inconvenience are tolerable, what the preferential uses of the river are, and hence what level of quality is needed and in general in what priority the landowners would prefer their tax dollars to be invested.

We understand that an attitude study has recently been commissioned which would address many of these areas. We would encourage the Authority to give priority to this program since it will help guide many future programs within the Basin Study. Since there is and will be a competition for the use of various resources within the watershed it would be advantageous to have some factual basis upon which to make the various compromises, trade-offs and decisions that are required in an integrated resource management plan.

5.4 Land Management Considerations

The South Nation Basin has undergone significant changes in the recent past. Additional lands are being cleared, swamps and wetlands are being drained, and there has been a gradual intensification of

SOUTH NATION RIVER CONSERVATION AUTHORITY

PRELIMINARY OPTIMIZATION STUDY

APPENDIX ~~7~~ A

IMPACT OF MUNICIPAL AND INDUSTRIAL WASTES

TABLE OF CONTENTS

1. INTRODUCTION

Several towns and villages in the South Nation River Basin are provided with piped water and sewage facilities. All of the municipal sewage systems use waste stabilization ponds (lagoons) for treatment of raw sewage prior to discharge to the river system.

The use of mechanical treatment plants with continuous discharge of effluent is not acceptable for most locations because of seasonally low river flows and thus poor assimilation of effluent. Mechanical plants with seasonal discharge provide no significant technical advantages over the cheaper lagoon systems.

Six communities each have their own lagoon system - Casselman, Plantaganet, Russell, St. Isadore, Chesterville and Winchester. A seventh community, Embrun, is presently in the process of designing a lagoon system. With the exception of Embrun, all of the municipal lagoon systems are operated by the Ministry of the Environment.

The only significant industrial contributors of sewage are the Nestle plant at Chesterville and Ault Foods at Winchester; the former having a mechanical plant and the latter an abated lagoon system.

Base data on the quality and quantity of municipal and industrial sewage is fairly limited with effluent flow measuring equipment presently being installed at some of the lagoons.

River flow measuring devices are numerous and well placed in relation to the lagoon discharge points so that flow proportional discharge will soon be possible at most of the lagoons.

Water supply is generally from groundwater with only Casselman and Plantaganet (proposed) treating water directly from the river.

Water quality in the rivers is poor and adequate dilution of effluents is difficult to achieve particularly in the upper reaches of the river system.

2. MUNICIPAL SEWAGE DISPOSAL

2.1 Casselman

The Village of Casselman has a population in the order of 1,600 persons and is served by piped water and sewage systems. Sixteen hectares (40 acres) of lagoons discharge effluent on a semi-annual basis to the South Nation River.

The Ministry of the Environment does not envisage any imminent problems with this system and would permit some expansion of the lagoons.

The lagoons have a flume on the effluent system to facilitate flow measurement and thus manual flow proportional discharge. The Ministry have recently recommended suitable lagoon discharge rates for different river flows for the Casselman lagoons and thus flow proportional discharge is anticipated to commence in the near future.

2.2 Plantaganet

The Village has a 6.9 ha (17 acre) lagoon facility discharging into the lower reaches of the South Nation River on a semi-annual basis. The lagoons are not provided with an effluent flow measuring device.

The Ministry of the Environment does not have any problems with this system at present and dilution factors in the lower reaches of the river are fairly good.

2.3 Russell

The Village of Russell has a 16.9 ha (42 acre) lagoon facility discharging into the Castor River. The designed detention period is 235 days but with recent increases in flows to the system discharge will soon be on a semi-annual basis.

The lagoons have been installed with an effluent flume and so manual flow proportional control can be achieved. As with Casselman, the Ministry of the Environment have set acceptable discharge rates for given river flows to achieve acceptable dilutions.

The Ministry feels that no further lagoon expansions can be permitted at Russell, although there is no pressure at present for such expansion.

2.4 St. Isidore

The St. Isidore lagoons have been in operation for about 2 1/2 years and so far there has been no need for discharge of effluent. There are 15.7 ha (39 acres) of lagoons designed for discharge to the Scotch River on an annual basis. However, the system is nowhere near design capacity.

Effluent flume measurement is not provided. The Ministry of the Environment would not favour future expansion of this facility.

2.5 Chesterville

The existing Chesterville lagoons cover some 5.8 ha (14.5 acres) discharging into the South Nation River on a semi-annual basis. The lagoons are currently overloaded and a design is underway for an additional 6 ha (15 acres). However, increased water usage and new development will account for most of this new capacity with the result that semi-annual discharge will still be required. A flume will be installed in the new expansion to allow flow measurement of all of the lagoon's discharge.

2.6 Winchester

The water supply and waste disposal for Winchester are currently presenting local authorities with the greatest problems. The present lagoon system has 6.7 ha (16.5 acres) and besides being overloaded is discharging semi-annually into a watercourse with insufficient flows to provide suitable dilution.

These problems, together with water supply problems (See Chapter 4 of this Appendix) have prompted the initiation of an environmental assessment. A preliminary report on this environmental assessment is currently being reviewed by the Ministry of the Environment.

2.7 Embrun

The Embrun water and sewage systems design was underway by the Ministry of the Environment when the policies regarding responsibility for municipal projects were revised and the municipality undertook to carry out the project and operate the systems. Thus, with some delays, the systems are now at the final design phase. It is understood that approximately 40 ha (100 acres) of lagoons to discharge to the Castor River on an annual basis were originally proposed by the Ministry. However, the municipality is now questioning the need for annual discharge and incorporating an effluent flume to enable flow proportional discharge. If such is the case, then the Ministry will be specifying acceptable discharge rates for given river flows.

3. INDUSTRIAL WASTE DISPOSAL

3.1 Chesterville - Nestle

The Nestle plant is provided with a mechanical secondary treatment plant which discharges continuously to the South Nation River at Chesterville. Effluent quality from the plant is generally good with BOD and phosphorous occasionally exceeding the permissible levels of 15 and 1 mg/l respectively. However, the Ministry of the Environment is satisfied with the plant's performance and sees no immediate problems. The plant and the Ministry are continually monitoring its performance and data effluent quality and quantity is readily available. However, it is noted that the plant operating reports from January 1978 until June 1979 show maximum average monthly levels of BOD and Suspended Solids as 52 and 201, respectively.

3.2 Winchester - Ault Foods

This plant is provided with a lagoon system consisting of three aerated and two polishing lagoons which discharge 3 to 4 times per year to a small tributary of the Castor River. BOD, Suspended Solids and Phosphorous readings are high and the receiving watercourse has inadequate flow to facilitate anywhere close to acceptable dilution ratios. The receiving watercourse has considerable algae blooms. Ministry of the Environment laboratory analysis of the effluent from the lagoons for April 1978 - June 1979 show BOD up to 65 mg/l, Suspended Solids up to 85 mg/l and Total Phosphorous to 64 mg/l.

4. WATER SUPPLY

Water supply in the South Nation River watershed is primarily from groundwater sources. Only Casselman presently draws water from a surface supply (South Nation River) and a proposed treatment plant at Plataganet will draw also from the South Nation River.

The Casselman plant has a capacity for 3,200 m^3 /day (0.7MGD). The Ministry of the Environment operate the plant and report that raw water quality is poor with noticeably high faecal coliform counts.

The Plantaganet plant is presently under design and will have a capacity of 1,600 m^3/day (0.35 MGD). It too will be operated by the Ministry and it is expected that raw water quality problems will also be experienced.

Bedrock in the area is generally close to the surface and problems are being experienced in some areas with well capacity and groundwater quality. Winchester and Chesterville are currently experiencing capacity and quality problems. At Winchester, existing municipal wells are thought to be mining the aquifer and the problem is being addressed in the current environmental assessment of services.

Piped water supply systems are presently operated in Chesterville, Winchester (both MOE), Bourget (part MOE), St. Isidore (Private), Clarence Creek, St. Pascal and Embrun (all municipally operated).
A study is presently underway on the St. Isidore system. The Village of Finch presently has a water supply system under construction. However, the discovery of hydrogen sulphide during test pumping has necessitated the design of an aeration tower.

Farms in the area generally use wells for water supply which, through providing adequate capacity for such relatively small demand points, are costly to construct as most are into bedrock.

5. CONCLUSIONS AND RECOMMENDATIONS

The municipal and industrial sewage disposal systems on the South Nation River system are undoubtedly causing a degradation of water quality, although the extent to which these systems contribute as compared to contributions from non-point sources has not been analyzed in this Appendix.

Because of the erratic and predominantly low flows experienced in most of the river system, sewage treatment systems with some sort of controlled discharge are necessary. Thus, the waste stabilization, or lagoon, system had been adopted over other available treatment methods for the municipal sewage systems. The industrial plants which produce stronger wastes have needed to provide more sophisticated treatment such as the activated sludge process.

However, with many of the plants the discharge facilities still require modifications to ensure flow proportional discharge. In the case of the two plants at Winchester, it is unlikely that even controlled discharge would result in adequate assimilation of effluent in the watercourse because of low flows all year round. For this and other reasons the Ministry of the Environment have identified Winchester as a particular problem area with regard to municipal and industrial wastes.

Data on flow into and out of the municipal lagoons is sparse and has not been gathered in an organized program in the past. A serious effort is currently underway by the Ministry of the Environment to rectify this and it is understood that good water quality data is now available for some facilities for 1978 and 1979.

It is recommended that further studies into pollution of the South Nation River system include the following with regard to point source pollution:

1. Evaluation of available 1978 and 1979 influent and effluent quality data on municipal lagoon systems.

2. Sampling and analysis of all municipal and industrial influent and effluent over a one year period in an organized sampling program including analysis of river quality upstream and downstream of

discharge points.

3. Installation of flow measuring devices on the remaining treatment facilities and record flows for all systems over the same 1 year period.

4. Evaluation of operations of present treatment methods and recommend improvements where needed.

5. Evaluation of alternative methods of sewage treatment and disposal in areas where river flows are inadequate for present treatment facilities.

6. Determine current contributing populations, water consumption and estimate per capita sewage contributions in order to forecast future sewage loads.

7. Recommend controls on future plant expansions as required.

Appendix ~~'C~~ b

Marine Clays within the area under consideration were deposited under saline marine or brackish water conditions. The structure of the sediments deposited in such an environment differ from those deposited in fresh water or glacial meltwaters exhibited elsewhere in the strata in southern Ontario. Changing salinity conditions within the groundwater regime since the drainage of Champlain marine phase some 13 thousand years ago have exchanged typical marine electrolytes for others and has in some instances caused precipitation of minerals resulting in weak cementation of particles.

Groundwater regimes in clay stratigraphy existing in South Nation River Basin fluctuate widely with 5 M rises in phreatic levels being noted, Mitchell R.J. Klugman MA Mass Instabilities in Densitive Canadian Soils Eng. Geology 14(1979) 109-134 Elsevier Publishing Company, (Mitchell & Klugman 1979). Coarser seams and beds within the clay stratigraphy account for transmissivity anisotropy within these sediments so that internal drainage of groundwater to valleys may be poor.

Loadings of banks by groundwater and undercutting by streams are frequent causes of bank failure anywhere. With the added problem of high liquidity clays and silts that have the ability of reorganization into a less dense, highly fluid state make the problem of landslips or landflows an almost common annual occurrence. Many papers dot the literature on the subject of sensitive marine clays in the Ottawa Valley and an adequate bibliography exists in the recent paper ibid situ.

Slope management data are being generated and published by the Geological Survey of Canada and by the Ministry of Natural Resources of the Ontario Government. This effort is aimed at providing guidelines of evaluation criteria for sensitive areas. In no sense are these documents, Klugman M.A. & Chung P. Slope stability Study of the Regional Municipality of Ottawa Carleton Ontario Canada. Ontario Ministry Natural Resources O.G.S. Misc. Paper 68, and Klassan K.E. Poshman A.S. Klugman MA IN PRESS Slope Stability of the South Nation River Basin Banks MNR Eastern Region.

in Press definite engineering studies for specific sites or projects.

Some of the effects of flood control works can be outlined in point form in the following manner:

1. Lowering of annual flood levels can increase the loading on banks stable or unstable by increasing ~~poor~~ water pressures and increasing the moment promoting failure.
2. Remedial measures for erosion along the rivers and creeks must be given sufficient attention to design so as to not aggrevate any of the slope instabilities that exist.
3. Channelization of any nature should encompass the need to lower slopes to 1:4 or less to reduce the moment inciting instability and failure.
4. Dyking must have detailed grotechnical engineering reports accompanying the design because of the necessity of considering consolidation and failure of the founding soils. Dyking may also impede drainage of groundwater and increase poor pressures to the point where safety factors are lowered and failure can occur.
5. Channel deepening and modifications that lower the stream bed elevation are also detrimental to bank stability because of the increased bank height (and therefore instability) produced and because of greater flow velocities and erosion capabilities of the stream. This effect will have a tendency to move upstream with time and will affect areas that previously had no associated problems.
6. Stream bed lowering may also effectively uncover strata of soft clay that have the ability to extrude or flow plastically causing "retrogressive" mass wastage Mitchell & Klugman 1979, Klasser, K.E., Poshman A.S. of a slide such as this inevitably creates an ongoing long term failure of ever increasing areal extent.
7. Embankments associated with buildings, roads, bridges hydroline towers, and railway embankments are also susceptible to failure by excessive rapid flood water drawdown and other factors listed above that reduce safety factors. In one case a railway embankment had to be bermed to maintain stability after floodwater drawdown (pers. comm. Chief Geotechnical Engineer C.N.R.)

The report and contained maps rank the sensitivity of the river banks to failure using the accepted terminology of Saftey factor. Each safety factor grouping outlines the level of investigation required for any development in the area of the valleys.

Four major remedial works have been proposed and the level of geotechnical environmental investigation is commented on below:

1. Chesterville Channelization:

   From the data in press in the article ibid situ. three areas totalling 2.0 km have a safety factor of 1.2-1.5 and it is recommended that detailed geotechnical investigations be carried out. The type of remedial measures required must increase the safety factor (from 1.2-1.5 which is marginal). Such remedial measures would consider but not be confined to lowering of valley slopes to 1:4 or less, erosion protection of the toe of slope only, and measures to drain land surface more effectively in the spring months.

   Most of the remainder of the length of channelization is through areas where valley banks have safety factors of 1.5 to 2.5 that require routine geotechnical investigation to visual inspection only. It must be emphasized that remedial measures should not reduce the safety factor in any way without nitigative offsetting measures.

2. Plantagenet Rock Cut

   The hydrologically supportive bedrock high at Plantagenet was lowered a matter of feet with concommitant increase in the slide incidences upstream. The realization whether real or not was mitigated by construction of a weir to prevent low water from dropping too low. On the Maps of the Slope Stability above the railway bridge the safety factor varies between 1.2 and 1.5 - marginal, requiring detail geotechnical investigation of the banks with suggestive controlling measures for stability. A relatively innocuous concept of lowering the low flow at Plantagenet necessitates investigation and remedial measures for 10 km and upstream with the likelihood of temporally progressive aggravation of stabilities as the nick-paint moves upstream. Two areas totalling approximately 11KM require extensive remedial stability measures dictated by exhaustive geotechnical investigations (these zones are at the north end of South Plantagenet Twp).

Any consideration of channel improvement at this point must of necessity have geotechnical investigations carried out and remedial measures must be integrated with those at Plantagent. The importance of decisions are wide reaching because of the sensitivity of the river banks and valley walls for large distances upstream.

3. Dyking to confine flows in Plantagenet Flood Area:
   While no detailed engineering considerations have been given to the effects of dyking in the Plantagent Area, it is really obvious from the foregoing comments that the stability of banks will be in jeopardy.

   Foundation problems of placing dylus on sensitive marine clay is one that requires detailed field investigations and careful design; not the least of which is the consideration of water movement from the marine clays into the valley being impeded.

4. Plantagenet Channelization downstream of Rock Cut:
   Hydrologic considerations of improving flood flows through Plantagenet might necessitate channel improvements to the S.N.R. below the town of Plantagenet. It has already been demonstrated that this will result in increased velocities and in turn increase toe erosion along the river banks.

   Below P. are numerous zones with safety factors from 0.8 to 1.2 requiring extensive remedial measures dictated by detailed geotechnical studies. Other zones that are from 1.2 - 2.5 in Safety Factor would worsen if not considered within the total framework of mitigative measures.

(1) Klugman M.A. & Chung P.
Slope stability Study of the Regional Municipality
of Ottawa Carleton Ontario Canada
Ont. Min. Nat. Resources.
O.G.S. Misc. Paper 68

(2) Klassen K.E. Poshman A.S. Klugman MA IN PRESS
Slope Stability of the South Nation River Basin Banks
MNR Eastern Region

(3) Mitchell R.J. Klugman MA
Mass Instabilities in Sensitive Canadian Soils
Eng. Geology 14(1979) 109-134
Elsevier Publishing Company.

APPENDIX D

Environmental Considerations in the Basin

The environmental aspects of the various water management alternatives must be given due consideration. As a component of this study, a biologist reviewed the proposed alternatives and assessed the available information in the basin on forestry, fish and wildlife. The following Tables and map illustrate the areas identified by the Ministry of Natural Resources - Cornwall, Ottawa and Brockville Districts, as having forest, fish and wildlife resource values.

None to the Districts represented within the Authority boundaries have actually conducted a detailed fish and wildlife inventory for the purposes of identifying significant or sensitive areas. As a result, the information presented herein is specific in some cases, but quite general for the most part. Further, information of a quantitative and/or qualitative nature is also lacking. This is not to imply that the resources are not present or important, but rather it indicates the need for such studies. In all instances, the wildlife supervisors were well aware of the hydrology studies which have been undertaken and that are now underway. All expressed concerns regarding flooding and water level fluctuations. Major concerns relate to (1) the effects of water fluctuations on fish migration and muskrat habitat, and (2) the effects of bank slumpage and flooding on stream sediment loading and, hence, the degradation of existing and potential water-related fish and wildlife resources and habitats.

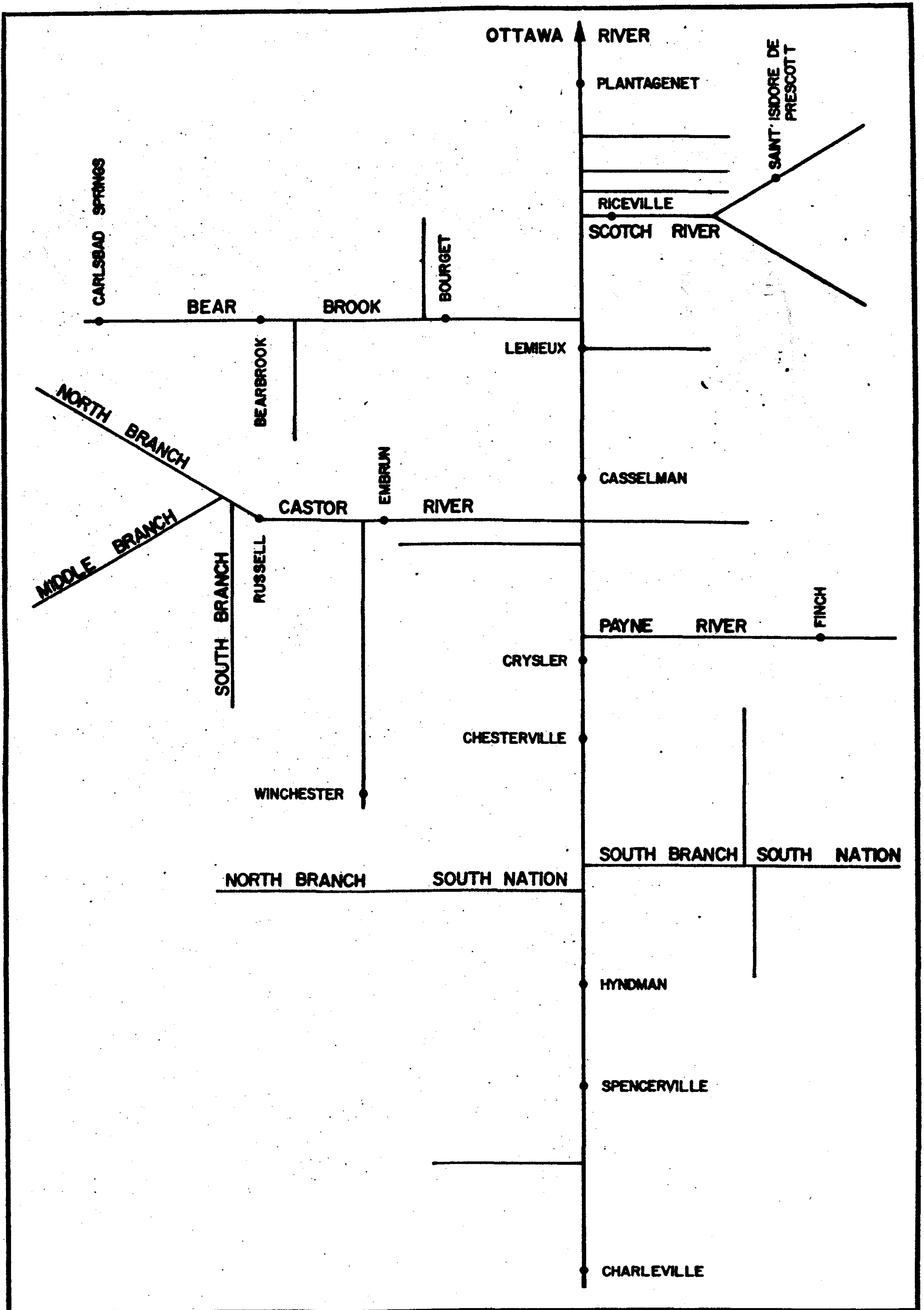
Simultaneously with any formal proposals regarding hydrologic improvements, i.e. reservoirs and channelization, a detailed investigation of fish and wildlife resources should be undertaken to identify any site specific concerns. Such an investigation should not only be site specific, but should also consider both the upstream and downstream implications.

MAP KEY

	Location	Comments
1.	Provincial Wildlife Area	Deer yard, spring nesting of waterfowl, limited trapping, hunting, coyotes, no fishing.
2.	Allen Creek	Brook trout
3.	Castor River	
	North Branch	Stocked with speckled and rainbow trout, muskrat at village of Greely.
	Middle & South Branch	Pickerel and pike, not an intensive fishery but important to locals; suspected spawning in south branch from Hwy. 31 through Metcalfe and from east of Vernon to Kenmore on the south branch.
4.	Castor River (above Russell to Outfall)	Limited pickerel, sucker, bass and pike.
5.	Castor River	Pike spawning in spring.
6.	Castor River (below dam at Russell)	Pickerel spawning.
7.	Little and East Castor	Spring trapping of muskrat.
8.	Black Creek	Nothing known.
9.	South Branch of South Nation	No known spawning, low flow in summer. Occurrence of bullhead, pike and pumpkinseed.
10.	Sandy Creek	No known fish or wildlife areas.
11.	South Nation River (west of Cass Bridge to Outlet)	Pickerel spawning west of Cass Bridge, occurrence of pike.
12.	South Nation River (150 m below Chesterville Dam)	Artificial spawning bed for pickerel.
13.	South Nation River (Wheelers Rapids below RR tracks at Finch/Winchester Twp. boundary)	Pickerel spawning
14.	South Nation River (below Chesterville Dump)	Pickerel spawning.
15.	South Nation River (425 m below dam at Crysler)	Pickerel spawning

	Location	Comments
16.	South Nation River (Crysler to Cassleman)	Prime pickerel fishing area.
17.	South Nation River (Flood area from Winchester South)	Spring waterfowl staging area.
18.	South Nation River (below Winchester)	Potential pickerel spawning area - rubble bottom.
19.	Payne River	Good muskrat trapping area; spring spawning of pike between Berwick and Finch.
20.	Butternut Creek	Nothing known.
21.	South Nation River (Casselman to Lemieux)	Bullhead fishing.
22.	South Nation River (flooded area below Lemieux)	Excellent muskrat trapping; spring waterfowl staging, potential nesting of waterfowl.
23.	Bear Brook Indian Creek	Muskrat habitat, limited waterfowl nesting. Rock bass, muskrat trapping.
24.	South Nation River (Lemieux to Plantagenet)	Heavy fishing for bass, musky and pickerel, sturgeon fishing at Plantagenet in spring (source Ottawa River).
25.	South Nation River (400 m below and above Plantagenet)	Pickerel spawning.
26.	South Nation River (immediately below dam at Casselman)	Pickerel spawning.
27.	Alfred Bog - Horse Creek	Moose and beaver; unique ecological area; rare orchids.
28.	South Nation River (Pendleton Area to Riceville)	Waterfowl staging area.
29.	Paxton Creek	Nothing known or suspected.
30.	Scotch River - North and South and Beaver Creek	Pike and sucker spawn from St. Isidore to Riceville.
31.	Scotch River South Basin	Trout stream.
32.	Springbrook Creek	Speckled trout.
33.	Moose Creek Bog	Natural area, ecologically sensitive.
34.	Larose Forest	Moose, some deer, beaver trapping waterfowl in marsh lands.

	Location	Comments
35.	South West Headwater Area	Weak deer yard (25-50).
36.	South Nation River (Spencerville Area)	Large muskrat area, extensive trapping.
37.	Osgoode Bog - Middle Branch Castor River	Main source of Castor River natural woodland/marsh area, variety of wildlife.
38.	Mer Bleue - Bear Brook	Tree sphagnum and black spruce, quicking bog, unique habitat, regionally education, and recreational value.



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SCHEMATIC REPRESENTATION OF
THE SOUTH NATION WATERSHED

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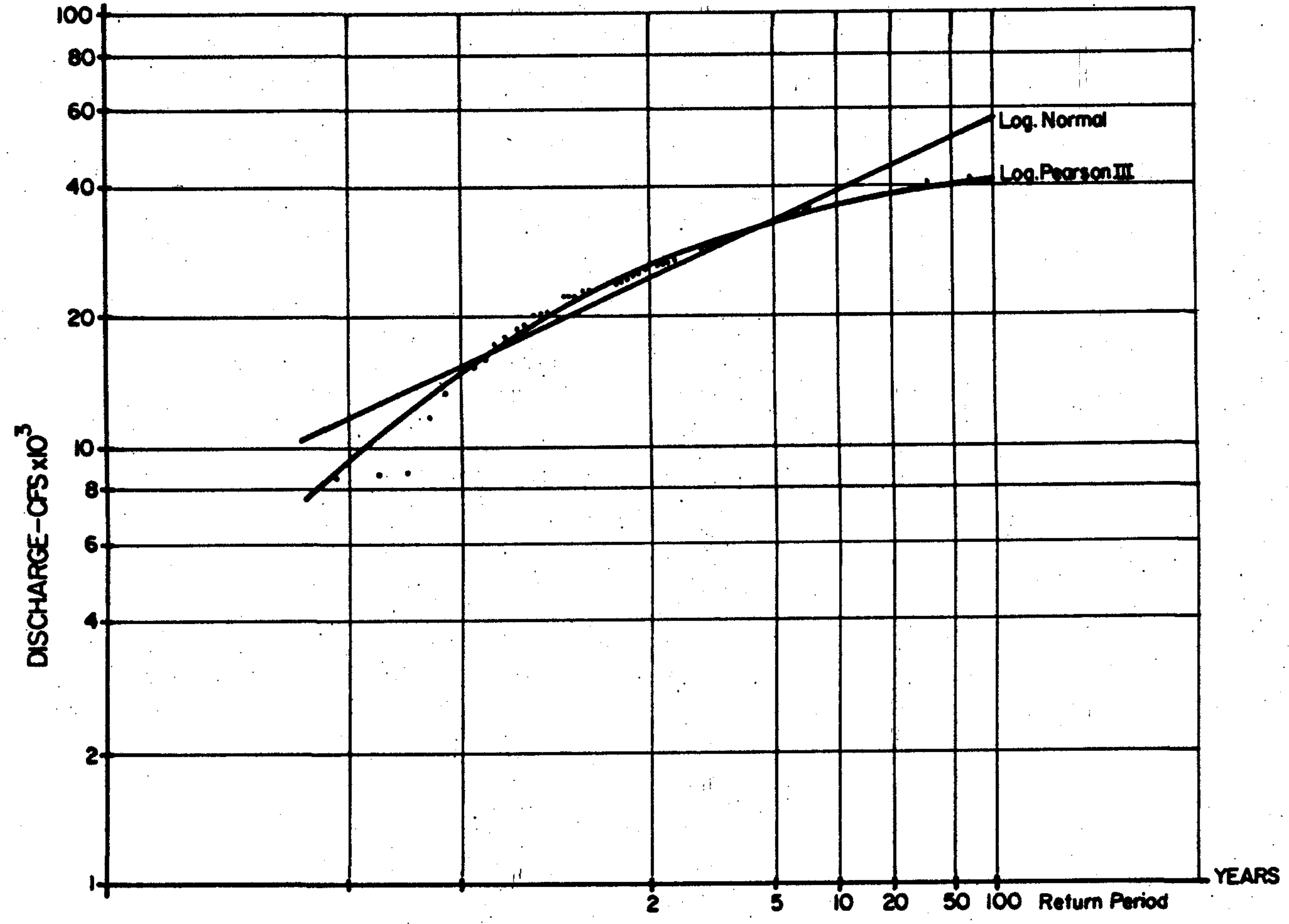

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SOUTH NATION RIVER AT
PLANTAGENET SPRINGS.
-SNOWMELT FLOODS-

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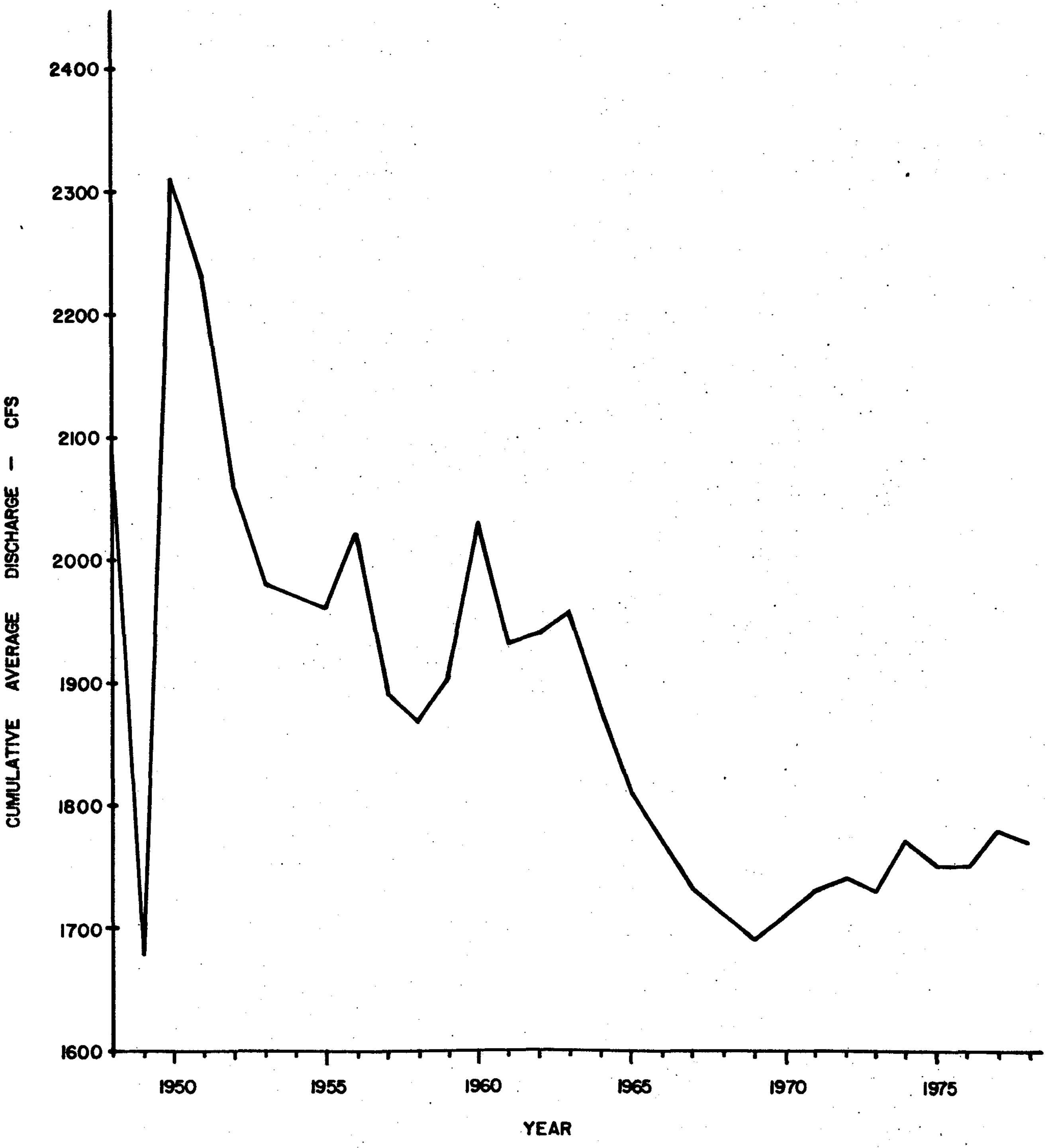
Checked S.L.	Date DEC. 1979	Job No. 11-79126
Drawn J.L.P.	Scale ----	Figure No. 5

TRANSLAR 100-7-79



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TREND OF SNOWMELT FLOWS FOR

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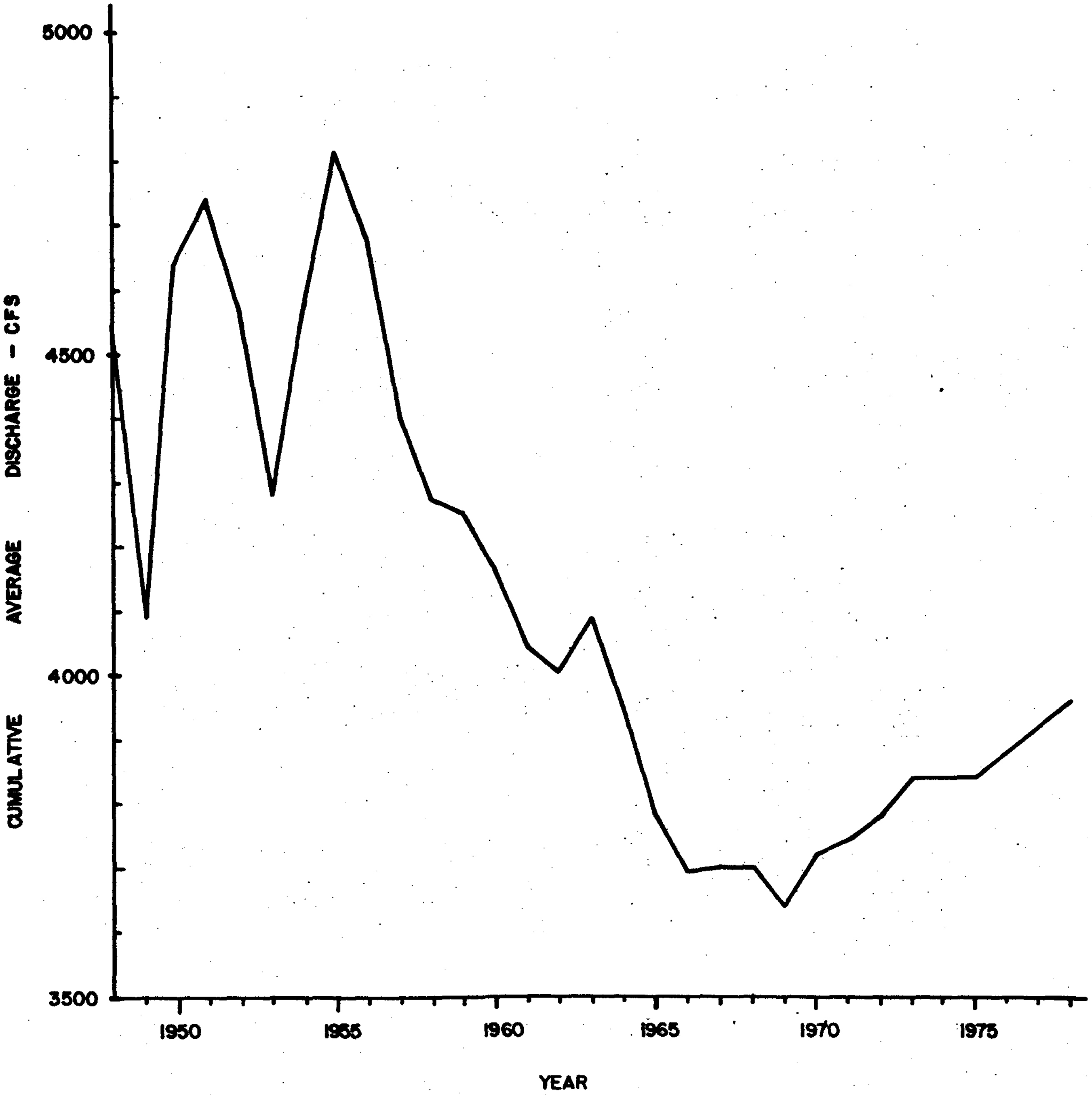
Consulting Engineers, Planners
275 Duncan Mill Road, Don Mills, Ont. 449-2500



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TREND OF SNOWMELT FLOWS
FOR THE CASTOR RIVER AT

Marshall Macklin Monaghan Limited
Consulting Engineers, Planners
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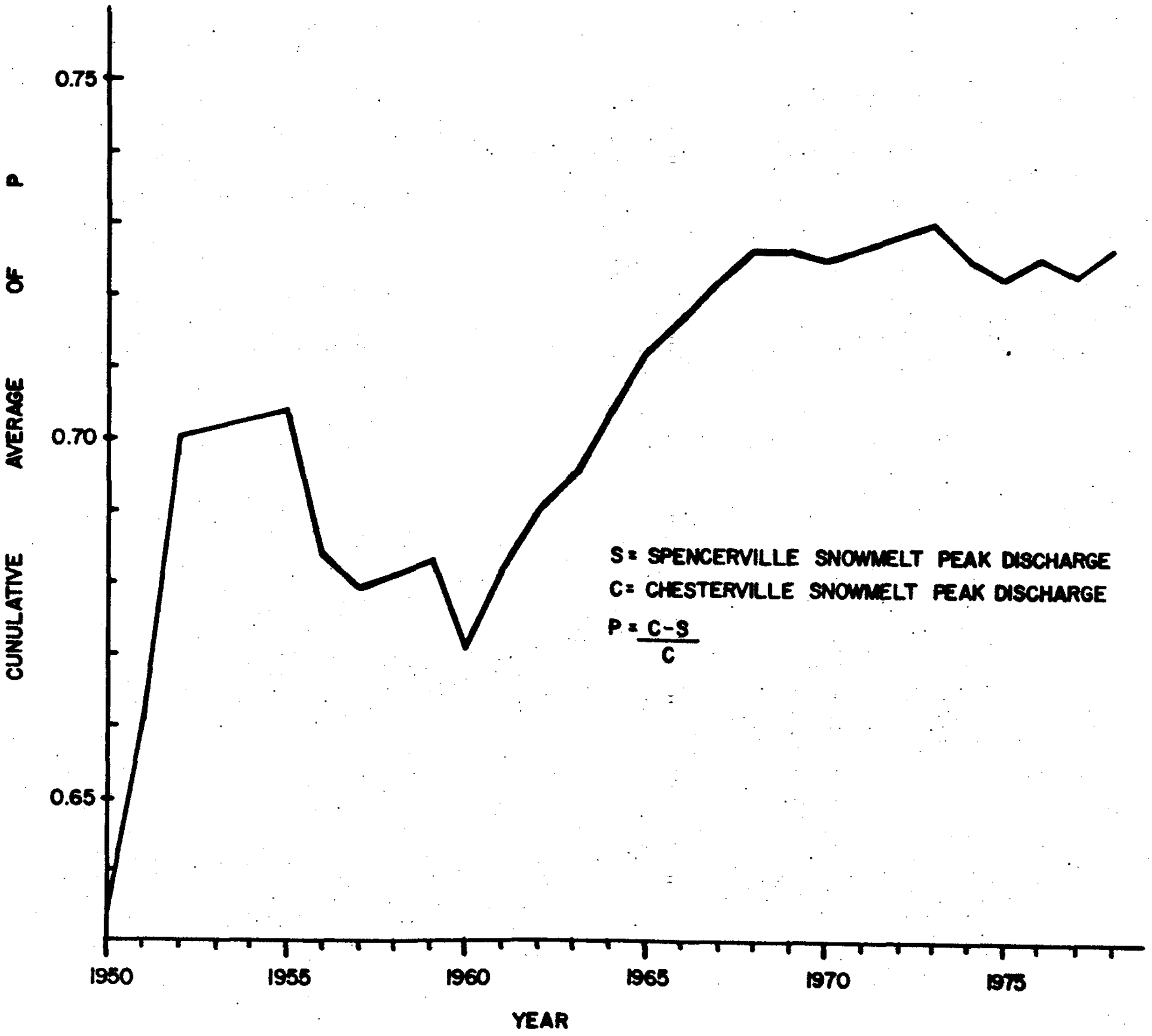

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TREND OF FLOW CONTRIBUTIONS
FROM AREA BETWEEN

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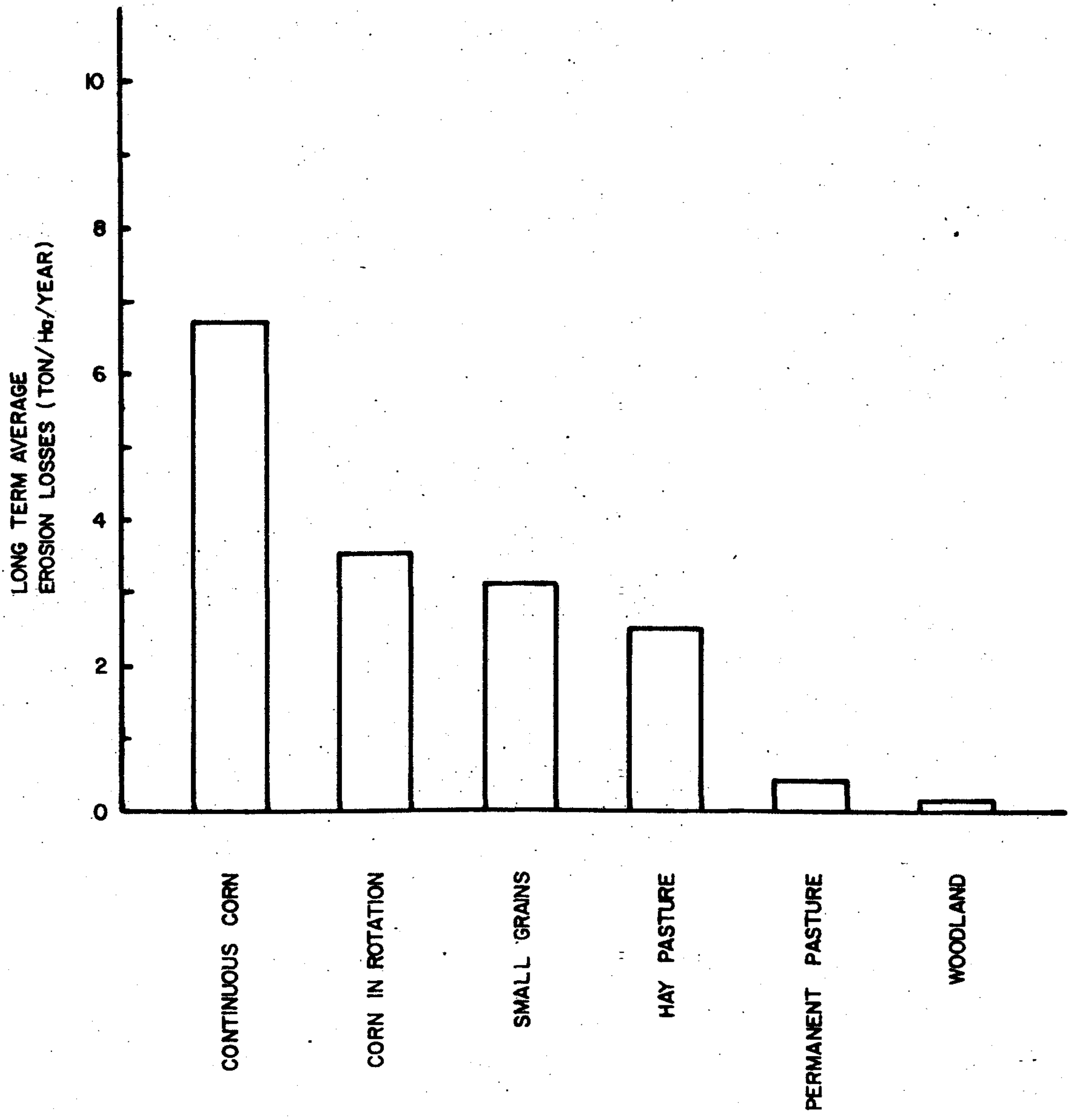
449-2500



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PREDICTED SHEET & RILL

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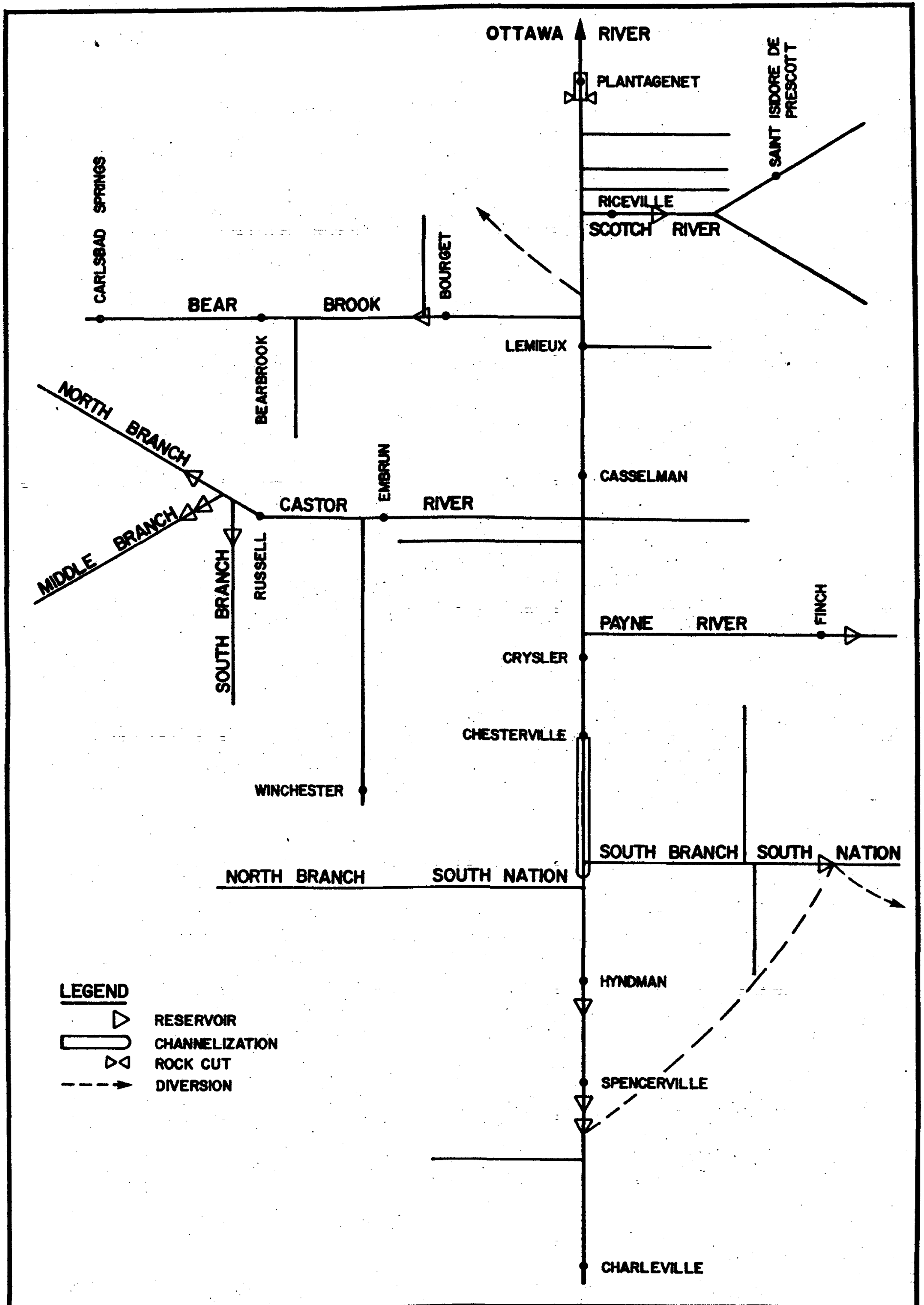

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SCHEMATIC REPRESENTATION

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