Atikokan Thermal Generating Station

SUMMARY AND ANALYSIS OF ENVIRONMENTAL MONITORING PROGRAMS

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Foreword

This document is a summary of the Environmental Effects Report prepared for Ontario Hydro in partial fulfilment of the regulatory requirements to construct and operate the Atikokan Thermal Generating Station (ATGS).

The reader should refer to the main ATGS Environmental Effects Report for details.

The ATGS went into service in November, 1985. This summary document describes the natural environment before and after construction and operation of the ATGS began. The scoping process followed by Ontario Hydro to develop the predicted effects of this project and subsequent environmental monitoring program is outlined. This document follows the 12 Hypotheses of effect developed during the scoping process, and summarizes the monitoring results and conclusions associated with each Hypothesis. The final part is an assessment of the effects predictions and comparison with measured effects.

Copies of this summary and the Effects Report are available for viewing at any of Ontario Hydro's offices listed below, or at the Northwestern regional office of the Ministry of the Environment (MOE).

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The careful review of earlier draft reports by staff of the Ontario Ministry of Natural Resources and Ministry of the Environment was beneficial and very much appreciated.

Executive Summary

The Atikokan Thermal Generating Station (ATGS) is located in northwestern Ontario approximately 120 km west of Thunder Bay. Approval for the station was granted in 1977 and the station began operation in 1985.

Government approval of the Ontario Hydro Proposal for ATGS was based in part on predictions of environmental effects. The principal concerns included changes in local air quality, long range transport and deposition of acidic materials, and the health of the sport fishery in Marmion Lake. The Proposal predicted that, for the original 800 MW station concept, effects on lake acidification would be very small, local air quality would be maintained within currently accepted regulatory limits, and the Marmion Lake sport fishery would be protected from effects of thermal stress.

The conclusions drawn from extensive pre- and post-construction monitoring and analyses on these main concerns are presented in this report. Local air quality has notably improved, as a result of reduced emissions elsewhere, a reduction in the size of Atikokan TGS to 200 MW, and good performance of air emission management systems. Acid deposition is small and, as predicted, has not affected lake acidity. The sport fish community in Marmion Lake is very similar to those in other northern Ontario lakes, although it is too early to draw final conclusions on whether the station is having an adverse effect on sport fish reproduction.

The science of "auditing or verifying" environmental impact predictions is relatively new; but is one that can provide tremendous insight into the accuracy of a proponent's predictions, by evaluating the utility of monitoring programs and/or success of their mitigative activities. As such, it can be an extremely useful tool in focusing future large scale monitoring programs.

Two sets of predictions of environmental effects were formulated for the ATGS; one set in the original proposal to build the station in 1977, and a second set from a scoping workshop held in 1984 to design the operational monitoring program. The accuracy of both program and environmental predictions was assessed with data collected during the monitoring programs. Approximately 45% of the effects predictions were considered essentially accurate, while nearly 25% could not be tested. These results compare favourably with the accuracy of environmental impact predictions in the United States and Australia.

The socio-economic impacts of the ATGS on the region must in general be considered positive. The Town of Atikokan was faced with the closure of two mines, the principal sources of employment in the area prior to Ontario Hydro building the generating station. The site selection process to locate the new GS at Atikokan was strongly influenced by the government at the time in consideration of local socio-economic conditions.

The monitoring program at Atikokan was organized around a series of predictions of potential effects of the station on the environment as follows:

Hypothesis 1: Effect of Emissions on Air Quality and Terrestrial Ecosystems

Emissions of SO_x, NO_x, particulate matter and trace elements from the stack will not lead to declines in forest productivity, losses of sensitive vegetation species, undesirable changes in species composition, and consequent losses of wildlife species.

Summary:
No change in local air quality was detected due to stack emissions. Similarly, no significant increase in dry and wet acid deposition was measured. Therefore, changes in soil chemistry, biology and groundwater chemistry are not expected. The impact on vegetation and forest productivity and species composition was not measured but no effects are expected.

Hypothesis No. 2: Effects of Emissions on Water Quality

Emissions of SO_x, NO_x and trace elements from the stack will not result in measurable decreases in fish and amphibian productivity, changes in species composition, losses of fish-eating wildlife, nor lead to increased body burdens of heavy metals in fish, waterfowl or humans.

Summary:
No changes in water quality due to stack emissions were observed. No increase in acidic and trace element deposition was detected and therefore, an increase in trace metals in water is not expected. In fact, water quality improved in nearby lakes since operation of the ATGS began due to cessation of smelting activities in the area.

Hypothesis No. 3: Effects of Construction on Water Use Patterns and Fish and Wildlife Habitat

The construction of weirs and dams in Marmion Lake will lead to:

a) increased risks of flooding;

b) increased demand for water from other sources;

c) reduced hydroelectric generation capacity; and

d) losses of fish and wildlife habitat within the Seine River basin.

Summary:
The construction of weirs and dams in Marmion Lake has decreased the storage capacity within the Seine River system. This could, in turn increase the severity of downstream flooding during an extreme flood event. It appears that the decrease in storage water from Marmion Lake has not affected the downstream supply of water and therefore, has not increased the demand for water from other sources. Changes in water levels most likely reduced fish and wildlife habitat but this assessment was limited due to a lack of monitoring studies. There is no evidence of a reduction of hydro-electric generating capacity downstream from Marmion Lake.

Hypothesis No. 4: Effects of Construction on Fish and Wildlife

The construction of dams, weirs and channels in the cooling circuit lakes will lead to:

a) changes in the species composition, distribution and abundance of fish with consequent changes in fishing effort and the abundance of fish-eating wildlife; and

b) changes in the distribution of waterfowl, shorebirds and furbearers.

Summary:
Construction of dams and channels has affected fish access and distribution between the cooling circuit lakes. Water currents and flowrates in the connecting channels have increased and water levels are more stable in the lakes. The number of walleye spawning areas has been reduced. The abundance of walleye and northern pike appears to be lower than prior to operation of the ATGS, but the causal mechanisms have not been identified. There has been an increased abundance of yellow perch and other forage fish. The increased abundance of these species may be related to decreased predation from fewer walleye and pike. Some terrestrial wildlife habitat loss occurred but the impacts on populations are difficult to ascertain.

Hypothesis No. 5: Effects of Discharge of Heated Cooling Water on Fish

Discharges of heated water from the Atikokan Generating Station will lead to physical changes resulting in:

a) changes in the distribution, composition, abundance, productivity, and harvest of fish

b) changes in fishing effort

c) increases in accidents

d) changes in waterfowl

e) destruction of vegetation

Summary:
The impact of heated cooling water discharge on the lakes' ecology could not be clearly differentiated from the effects of channelization and construction activities. Thermal effects do not extend to Marmion Lake. In the small lakes downstream of the station walleye spawning is now earlier and more protracted due to the heated discharge, however, walleye recruitment is still successful and to date no adverse impact on walleye populations has been observed due to the cooling water. Fishing effort has increased during the winter at Snow and Icy Lakes due to open water as a result of the heated discharge. There are no reports on the effect of fog and rime ice formation on terrestrial vegetation but any impacts would be very localized. No studies were conducted to determine the effect of open water during winter on waterfowl. However, anecdotal observations suggest waterfowl do not overwinter and are not effected by the cooling water discharge.

Hypothesis No. 6: Effects of the Change in Thermocline of Moose Lake

Withdrawal of cooling water from Moose Lake will lead to reductions in Moose Lake fish populations.

Summary:
The depth of the thermocline in Moose Lake has been lowered by the intake of water for the ATGS. It is assumed that the vertical distribution of fish and other aquatic biota in Moose Lake is affected during periods of stratification. The entrainment of plankton and fish does not appear to be significant. There is no evidence to suggest that the fish populations are affected by the lowered thermocline.

Hypothesis No. 7: Effects of Discharges on Fish

Discharges of sewage, liquid waste and cooling water from the station will lead to changes in distribution, species composition, abundance and growth of

plankton, macrophytes and fish within the cooling circuit lakes.

Summary:
Discharges from sewage lagoons resulted in a localized and temporary increase in BOD and phosphorous in Snow Lake, the first receiving water. Phytoplankton biomass has generally increased in the cooling circuit lakes and species diversity has remained constant. There was no measurable change in zooplankton diversity or production but this could be due to large natural variation within a limited amount of survey years. Consequently, there are no impacts on fish populations that can be linked to station discharge.

Hypothesis No. 8: Effects from Boiler Cleaning and Coal Pile Runoff

The delivery, storage and handling of coal at the station will lead to:
a) damage to vegetation, and negative visual impacts in the vicinity of the station; and
b) changes in pH, TDS and TSS in the Lower Basin. Infrequent releases of liquid wastes from boiler cleaning operations will affect pH, TDS and TSS as well as phosphorus in the Lower Basin. These water quality changes in the Lower Basin will affect its current status as waterfowl habitat.

Summary:
No damage to vegetation and no negative visual impacts have been reported due to fugitive coal dust. No significant changes in water quality have been detected due to boiler cleaning activities and therefore, changes in waterfowl habitat are not expected.

Hypothesis No. 9: Effects of the ATGS Ash Pile on Vegetation, Water Quality and Metal Concentrations in Fish and Wildlife

The presence of an ash pile at the station will lead to:
a) damage to vegetation and negative visual impacts in the vicinity of the station; and
b) changes in water quality leading to increased concentrations of metals in fish and wildlife.

Summary:
There is no evidence to suggest that damage to local vegetation has occurred due to the presence of the ash pile at the station. As predicted, leaching of metals and TDS occurred from the ash pile. However, no contamination of groundwater or nearby surface waters could be attributed to the leachate. There was insufficient data to detect changes in the metal body burdens of local fish and wildlife.

Hypothesis No. 10: Effects on Increased Noise Levels

Operation of the station will lead to increases in noise levels in the Atikokan area and, consequently complaints from the public.

Summary:
No complaints of noise were reported and monitoring was not suggested.

Hypothesis No. 11: Effects on Hunting and Fishing Effort

The existence of the station will lead to changes in hunting and fishing effort in the area and consequent accumulations of garbage in localized areas.

Summary:
Waterfowl hunting areas formerly around the GS have been closed. Raft Lake Road has been improved and boat movement between north and south Marmion Lake is more restricted. No information was available about changes in hunting effort. Evidence of increased accumulation of garbage at Anderson Dam promoted the arrangement of garbage pickup.

Hypothesis No. 12: Effects of Stack Presence

The presence of the stack will lead to increased mortality of migrating birds and to negative visual effects.

Summary:
The scoping workshop suggested this was a highly unlikely effect of stack presence and monitoring was not recommended.

Contents

1. Introduction

1.1 PURPOSE AND SCOPE OF STUDY

The Atikokan Thermal Generating Station (ATGS) is approximately 11 km northeast of the Town of Atikokan in northwestern Ontario, off Highway 622 (Figure 1.1). It consists of one 200-megawatt lignite-fired unit, which was placed in service in November, 1985.

Extensive environmental monitoring studies were undertaken from 1981-1988 to measure the environmental impact of the ATGS. This document summarizes the results of those studies and evaluates the environmental impacts that have occurred as a result of the ATGS. Furthermore, this report evaluates the accuracy of the environmental impact predictions originally put forth during the proposal and development phases.

The planning and development of this project was initiated in 1974; therefore the regulations of the Environmental Assessment Act, which was released early in 1976, did not apply. This was agreed to by the Ontario Ministry of the Environment (MOE). In May, 1977, Ontario Hydro submitted a "Proposal for the Atikokan Generating Station" for government and public review (Ontario Hydro, 1977b). Construction of the station began in 1978 (Table 1.1).

During the 1970's the effects of acid rain were receiving considerable attention. Concerns were expressed about the potential effects of atmospheric emissions from operating a lignite-fired generating station on ecologically sensitive areas such as Quetico Provincial Park in Ontario and the Boundary Waters Canoe Area and Voyageur National Park in northern Minnesota. In addition, the Ontario Ministries of Natural Resources (MNR) and Environment (MOE) expressed concerns regarding the impact of discharging heated cooling water into receiving waters, Marmion Lake in particular (Baxter, 1976; Shervill, 1977). The Atikokan TGS would be situated on the acid-sensitive Precambrian Shield. Furthermore, the cooling water would be drawn from a circuit of relatively small inland lakes. This would be a first for Ontario Hydro since all other thermal generating stations in Ontario are situated on the Great Lakes.

1.2 DESCRIPTION OF THE ATIKOKAN THERMAL GENERATING STATION

Central to potential environmental impacts related to any project are the basic physical characteristics of the project. The basic features of the Atikokan TGS are summarized in Table 1.2.

Table 1.1 Sequence of Key Events Related to the Atikokan Thermal Generating Station

Date	Event
1974	planning for the Atikokan GS initiated
1975	environmental inventory conducted by Acres Consulting Ltd.
June, 1976	submission of Draft "Proposal for Atikokan Generating Station"
1976	the ATGS project is exempt from the Environmental Assessment Act
May, 1977	submission of Final "Proposal for Atikokan Generating Station"
1978	construction begins on the ATGS
1981	changes to Atikokan TGS project submitted
1981-1984	pre-operational environmental monitoring studies conducted
1984	workshop held to predict impacts of the ATGS and design post-operational environmental monitoring studies
1984-1985	some environmental monitoring studies conducted during commissioning phase
June-October, 1985	test trials of the ATGS
November, 1985	ATGS goes into production
1986-1988	operational environmental monitoring studies are conducted
May 1990	ATGS Effects Report initiated

The ATGS is a lignite-fired thermal generating station producing 200 MW of electricity. The generating unit includes a steam boiler, a turbine, a generator and a transformer. The boiler is fired with lignite coal and produces superheat steam. The turbine accepts steam and converts the thermal energy into mechanical energy to drive the generator. Exhaust steam from the turbine passes into a condenser where it is condensed by cooling water pumped from Moose Lake.

One of the basic requirements of the station is a once-through cooling water system. Water for condenser cooling and for other purposes is drawn from Moose Lake and transported by means of a 900-m intake tunnel into a

Table 1.2 Atikokan Thermal Generating Station Operating Characteristics			
In-service date	November 14, 1985		
Planned in-service period (yrs.)	30		
Capacity (MW)	200 *		
Fuel	western Canadian lignite		
Sulphur content	0.6% average		
Single chimney (stack) height (m)	145		
Predicted cooling water temperature increase (ΔT) across plant (°C)	Summer: Winter:	11.3 16.6	
Cooling water flow (m^3s^{-1}) (including service water)	Summer: Winter:	6.6 4.0	
Maximum water temperature (°C)		Intake	Discharge
	Summer:	22.0	32-33
	Winter:	2.5	17-21
Depth of intake surface (m below lake surface)	10		
*** Design incorporates expansion capacity to 400 MW**			

forebay located along the north side of the powerhouse. The cooling water pumphouse is located along the south edge of this channel. The pumphouse contains travelling screens, condenser cooling water pumps and service water pumps. Of special note is the nature of the cooling circuit lakes illustrated in Figure 1.2. Through both dam construction and channel modification the five cooling circuit lakes have largely been isolated from neighbouring water systems and essentially constitute a closed circuit system for water circulation. This feature of the plant is unique within Ontario where all other generating stations use cooling water from the larger Great Lakes systems.

The condenser cooling water is drawn from Moose Lake at a depth of approximately 10 m; the discharge is into Snow Lake. From Snow Lake, the discharge flows over a weir into Icy Lake, then to Abie Lake, Marmion Lake, and back to Moose Lake (Figure 1.2). At its far end, Marmion Lake is connected to the Seine River System. Total cooling and station water flow is approximately 6.2 m^3/s at normal full load. Water flow over control weirs and in channels is maintained at 2.4 m^3/s for all operating conditions to maintain moving water for spawning fish and to prevent siltation of spawning beds. The fuel burned by the ATGS is Saskatchewan lignite coal. Saskatchewan lignite burned at this station contains approximately 33-35% moisture and approximately 8-11% ash by weight on an "as received" basis. Normal lignite has a heating value of about 16,400 KJ/kg and a low sulphur content of approximately 0.6%.

The average annual consumption of lignite for the station during the operational period (1986-89) was 614,797 tonnes per year (72 tonnes/hr). At maximum capacity rating, the fuel consumption for the station is about 155 tonnes/hr. Based on the present station capacity of 200 MWh, the maximum quantity of coal stored at the station at any one time is estimated at 186,000 tonnes and requires a total area for coal handling and storage of 5.3 ha. A burrow pit located approximately 2 km east of the powerhouse is used for ash disposal. The estimated maximum annual amount of fly and bottom ash is 92,000 tonnes.

1.3 HISTORICAL PERSPECTIVE

The ATGS is not the first large, man-made project in the area. Large-scale water diversions were first made in the area in the 1920s to develop hydro-electric capacity for pulp and paper mills. Iron ore mining and smelting activities began in the early 1940s. Therefore, it is useful to describe some of the environmental pertubations before construction of the ATGS began.

Marmion Lake, in the District of Rainy River is a relatively large lake forming part of the Seine River system. The Seine River flows through the northern dammed portion of Marmion Lake to Rainy Lake. From there, the water flows into Lake of the Woods, and then via the Winnipeg and Nelson Rivers to Hudson Bay.

Between 1923 and 1927, the water resources of the Seine River were developed by the Ontario-Minnesota Pulp and Paper Company at three hydro-electric stations, namely, Moose Lake, Calm Lake, and Sturgeon Falls. The Marmion Lake system, having a surface area of 9842 ha, was utilized in regulating the flow of the river for optimum power production.

In 1942, Steep Rock Iron Mines Limited de-watered nearby Steep Rock Lake to allow iron-ore mining to take place beneath the bed of the lake. This required creating a new outlet from Marmion Lake to bypass Steep Rock Lake. Through the Steep Rock Iron-Ore Development Act, 1942, it was agreed that the Moose Lake power station be taken out of service to divert the Seine River through Finlayson Lake.

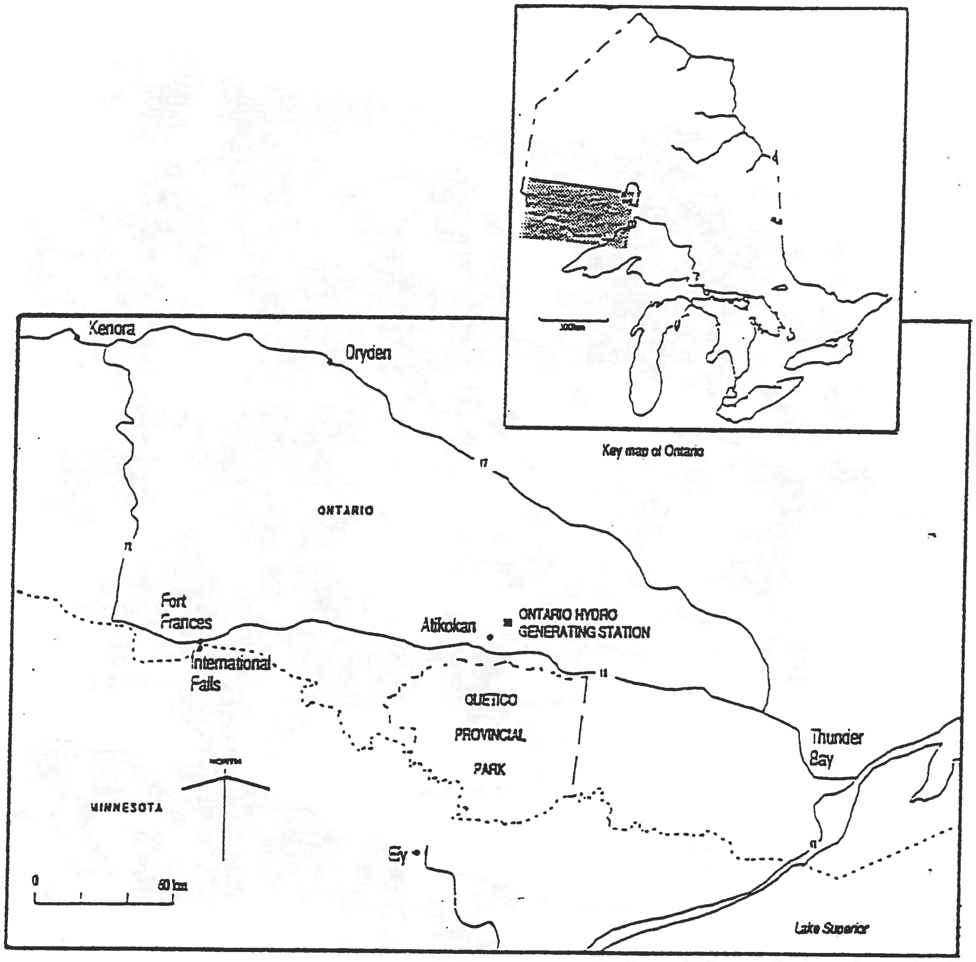

Figure 1.1: Location Map

Spoils disposal by two iron mining developments at Steep Rock Lake has altered the natural environment in the Marmion Lake area considerably. Beginning in 1944, over 76.5 million m^3 of spoil materials (varved clay, silt, sand, and gravel) were removed by dredging operations from Steep Rock Iron Mines Ltd., in order to expose underlying iron ore deposits. These dredged spoils were discharged into the eastern and western arms of Steep Rock Lake. Between 1955 and 1960, similar operations by the Caland Ore Company produced approximately 123,700,000 m^3 of spoil material, 90% of which was disposed of in the south end of Marmion Lake. Approximately 5,400,000 m^3 of material was discharged into the Upper Basin early in the dredging program, and about 6,900,000 m^3 into the Lower Basin towards the end of the dredging project.

By the Seine River Diversion Act, 1952, the flow from Marmion Lake was diverted around Steep Rock Lake, joining the Seine River farther downstream, and thus completing the total diversion scheme as stipulated in the 1942 Act. The right to erect dams and deposit silt in Marmion Lake was given to Steep Rock Iron Mines Ltd. through the 1952 Act. Under the provisions of the 1952 Act, Caland Ore Company was given the right to operate a southern portion of Marmion Lake as a silt basin.

Pre-operational surveys around the Atikokan Generating Station confirmed the presence of historical contamination of surface soils and vegetation by airborne metals (Parsons, 1989). Significantly elevated levels of arsenic and iron, and slightly elevated concentrations of chromium, manganese, nickel, selenium and zinc were found in the terrestrial environment near the station. These were caused by emissions from the former iron-ore mining operations over a 15 year period from the mid 1960's to 1980. The elevated metal levels are expected to persist for many years.

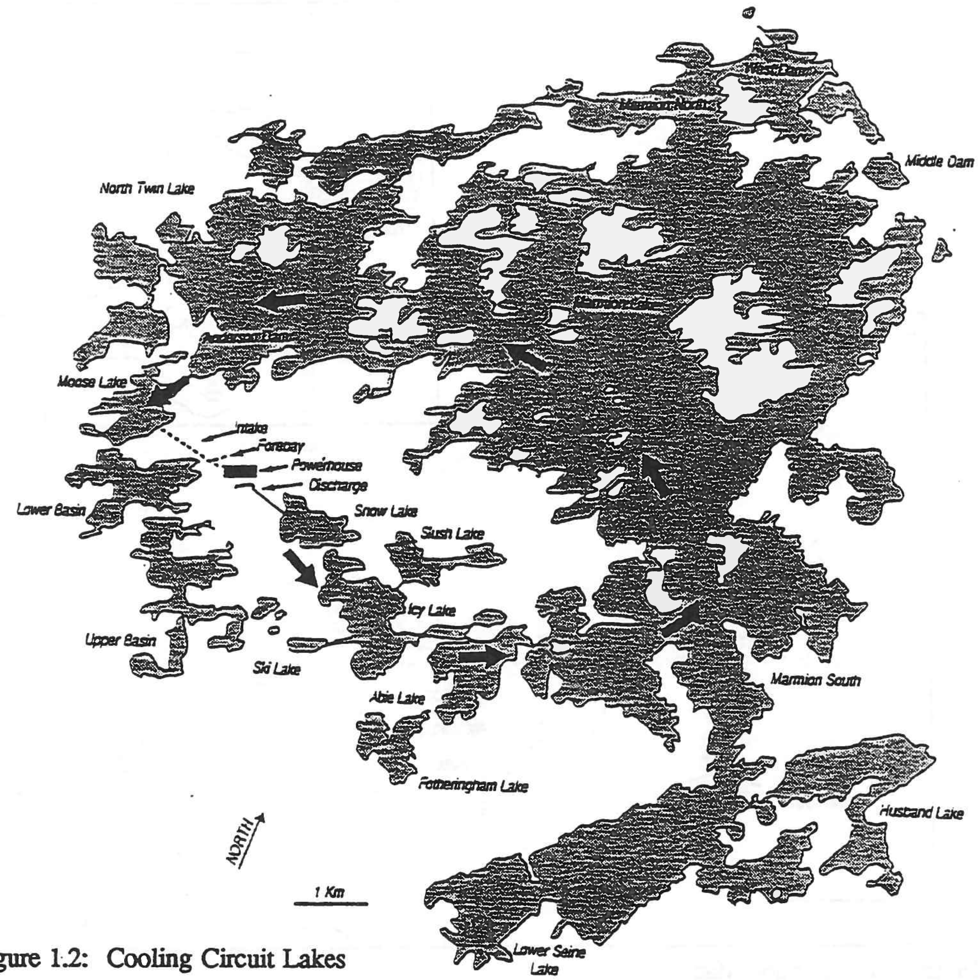

Figure 1.2: Cooling Circuit Lakes

In summary, the construction and operation of the iron-ore operations had three main environmental impacts: 1) changes to water levels and water flow patterns through diversions and dams, 2) changes to water quality from disposal of iron-ore spoils, and 3) contamination of the terrestrial environment due to smelter emissions. These pre-operational impacts significantly altered baseline conditions and make it difficult to later discern environmental impacts attributable to the ATGS.

In 1977, the Ministry of the Environment, with the concurrence of the Ministry of Natural Resources, gave approval to Ontario Hydro to dedicate Snow, Abie and Icy lakes primarily for cooling purposes for the ATGS. In doing so, Ontario Hydro, MOE and MNR recognized that the biological nature of these lakes would be irrevocably changed.

2. Comparison of ATGS EA Requirements to Present Day EA Process

The present day Environmental Assessment Act was not in use when the ATGS was approved. Therefore, the MOE requested that Ontario Hydro follow the Draft EA Guidelines for a Potential Generating Station in the North Channel Area (MOE, 1975) which were then available.

A comparison of the Draft EA Guidelines for the ATGS (MOE, 1975) with today's requirements (MOE, 1989) was carried out to evaluate the present process and to determine if Ontario Hydro's requirement for EA preparation would differ significantly now.

Table 2.0 provides a comparison of the salient features of an Environmental Assessment by current standards with the Draft Guidelines used for the Atikokan project. The definitions of the environment are identical in both cases. Both documents also emphasize the importance of public and agency participation in the process. Although the earlier requirements were less specific and detailed on the role of the public; agency liaison was emphasized. Similarly, although the 1975 Guidelines implied that clear and concise reporting was important, the recent Interim EA Guidelines are much more clear and explicit on this point.

Documentation of the existing, or affected environment, and the expected effects are central to the requirements of both documents. The 1975 Draft Guidelines however, do not specifically require a net effects analysis. Indeed, the earlier guidelines envision the application of mitigation only <u>after</u> the preferred site is chosen, rather than as a means of carrying out the net effects analysis required on all the alternatives to and alternative methods in the current practice.

Some of the observed differences between the Draft Guidelines and current requirements can be attributed to the earlier document's explicit application to the site selection process only. The Draft Guidelines only cover the environmental process up to and including the choice by the proponent of a final site. Other differences relate more to the progressive and significant evolution of the practice of environmental assessment since the passage of the Act and its application over the years.

It appears, for example, that the distinction between alternatives to the undertaking and alternative methods of carrying out the undertaking was somewhat blurred in the 1975 Draft Guidelines. Although the significance of the 'no-go' alternative was noted, the two kinds of alternatives did appear to be confused. There was apparently no requirement to determine and compare advantages and disadvantages in the earlier Draft Guidelines.

The process requirements of the 1975 Guidelines focused primarily on the site selection process, which was presented in what would now be considered a rudimentary or preliminary state. The discipline has advanced considerably in that area since 1975. A related point is the explicit step-wise process now required to carry out the "net effects analysis" of impacts. It, too, was outlined in a rudimentary form in the 1975 document, and as mentioned above, without the important step of consideration of mitigation early in the assessment of effects of the alternatives. Now, of course, site selection is only one of the process activities that are routinely and explicitly documented in most EA's.

It is important to note that the actual selection of the site for the ATGS was heavily influenced by the public and provincial government in response to social and economic conditions around Atikokan at the time. Ontario Hydro had, in fact, undertaken detailed site selection studies, but they comprised a relatively small portion of the proposal submitted to MOE for approval. The proposal was very detailed and thorough on describing the existing environment and predicting effects.

In summary, the requirements to document the existing (affected) environment, the project description, and expected environmental impacts are generally little changed since the 1975 Draft Guidelines. The public participation and conciseness of documentation requirements have changed somewhat more, but in detail rather than substance. The details of net effects analysis -- especially the critical importance of mitigation to the net effects analyses of all of the two types of alternatives now recognized have changed significantly. In addition, the central role now played by comparisons of the advantages and disadvantages of all the alternatives does not appear to have been required in any form in the 1975 Draft Guidelines.

The documentation submitted for the ATGS by Ontario Hydro fulfilled the requirements of the 1975 Draft EA Guidelines. The process Hydro undertook at the time would likely meet many requirements of the existing MOE Interim EA Guidelines. However, documentation of the process would require greater detail.

Table 2.0 Comparison of Present Features of Environmental Assessment[1] with ATGS Draft EA Guidelines[2]

Feature	Description	Requirement(s)	ATGS Guidelines	Comparison(s)
Consult with Affected Parties	Make the planning process a cooperative venture with affected parties. Early consultation with affected parties is essential	The proponent should seek to involve all affected parties as early as possible so that their concerns can be identified and addressed before irreversible decisions and commitments are made	"Meaningful public participation is important to the environmental assessment process in general, and to the search for a site suitable for generation facilities in particular" (p.3)	Present requirements are both more detailed in their particulars and more comprehensive in scope, particularly with respect to the public (vs agency) input.
Consider Reasonable Alternatives	A reasonable range of alternatives must be considered	The planning must consider <u>alternatives to</u> the undertaking which fulfil the purpose of the undertaking in functionally different ways and <u>alternative methods</u> of implementing a particular type of alternative. The <u>do nothing</u> alternative must also be considered.	"Having identified the need, the proponent must consider methods (generally called Alternative Conceptual Plans) of fulfilling this need, including 'no-go'." (p.5) "...it is possible that there may be decisions made <u>external</u> to the environmental assessment process which constrain the alternative conceptual plans studied." (p.5)	Present distinctions between alternatives to and alternative methods are blurred in ATGS. Alternative methods explicitly required in ATGS
Consider All Aspects of the Environment	Identify and consider the effects of each alternative on all aspects of the environment	The planning process must consider not only effects on the natural or biophysical environment, but also effects on "the social, economic and cultural conditions that influence the life of man or a community" and their interrelationships as well as technical considerations	The comprehensive definition of "environment" was adopted explicitly	Identical to present requirements
Systematically Evaluate Net Environmental Effects	Explicitly evaluate alternatives in light of their advantages and disadvantages developed through a net effects analysis	The planning process must include distinct points where alternatives are evaluated and the net environmental effects associated with each alternative are clearly identified.	"Having chosen a series of alternate sites the proponent must evaluate those in sufficient detail to decide upon the best potential site... Having collected the inventory the decisions will result from the <u>Effect Prediction</u> and <u>Evaluation</u> as previously described." (p.8) <u>"[Mitigation]</u> should relate the Inventory and Effect Prediction of the preferred site to the project description." (p.10)	Effects predictions and evaluations of alternative methods are required for ATGS; alternatives to not explicitly considered. See cell immediately below re: net effects analysis <u>ATGS</u> treats mitigation as <u>preferred</u> site requirement (not all other alternatives). In addition, mitigation applied after effects evaluation (e.g. no net effects as now defined). No explicit requirement to assess advantages and disadvantages

Table 2.0 Comparison of Present Features of Environmental Assessment[1] with ATGS Draft EA Guidelines[2]

Feature	Description	Requirement(s)	ATGS Guidelines	Comparison(s)
Provide Clear, Complete Documentation	The EA should strive both to represent accurately the process that was followed in a clear and understandable way and to communicate the results of that process	The approach, the planning process followed and the way in which the principles of environmental assessment were addressed should be clearly explained in the EA. This can be termed traceability. Clarity and simplicity are adjectives as well as completeness and precision	"Inherent [is]...clear identification of all decisions resulting from the evaluations carried out..." (p.3); "...recognition that studies are to be prepared and conducted so that the information obtained provides an accurate qualitative and quantitative description..." (p.4); "...that the environmental assessment document be summarized by the proponent in layman's language." (p.4)	Present requirements are more detailed and explicit; process gets much more attention and emphasis

1. based on "Interim Guidelines on Environmental Assessment Planning and Approvals," Environmental Assessment Branch, Ministry of the Environment, July, 1989.
2. "Draft Environmental Assessment Guidelines for a Potential Generation Station in the North Channel Area," Ministry of the Environment, March 27, 1975.

3. Monitoring Activities and Impact Predictions

Ontario Hydro conducted detailed environmental inventory studies on the site in 1975-1976 (Acres, 1976), for the original ATGS Proposal also referred to here as the Environmental Study Report (ESR).

In 1979, Ontario Hydro, the MOE and MNR developed a comprehensive cooperative environmental monitoring program. Ontario Hydro's studies included air quality and meteorology, onsite aquatic studies and groundwater quality of the ash disposal area. The MOE studies included acid rain and atmospheric deposition, terrestrial, and aquatic studies off site. The MNR studies included assessment of fish communities in several off-site lakes. Unfortunately, the construction phase of the project overlapped with many of the pre-operational environmental surveys, and some construction activities interfered with the accurate description of pre-operational conditions.

Pre-operational environmental studies were conducted from 1981 to 1984. The original ATGS proposal was for a four-unit (800-MW) station. By the beginning of the pre-operational studies, the proposed station capacity had been reduced to two units (400 MW), and finally to one unit (200 MW). The purpose of these three years of study was to establish a baseline description of the physical, chemical, and biotic features of the environment in sufficient detail to permit assessment of significant changes in those features during similar studies conducted during the operational phase of the station, and to identify, where possible, effects of construction activities on the environment.

In 1984, Ontario Hydro adopted the Adaptive Environmental Assessment and Management (AEAM) methodology (Greig *et al.*,1984) to design the operational environmental monitoring programs. Specialists from Ontario Hydro, the MOE, and MNR participated in a scoping workshop to review the results of the pre-operational studies and to develop the operational monitoring programs. Twelve hypotheses of effects were developed and grouped into four broad subjects:

1) Hypotheses related to atmospheric emissions

2) Hypotheses related to the cooling circuit lakes

3) Hypotheses related to the delivery, storage, and handling of coal and ash

4) Hypotheses related to miscellaneous effects of station presence and operation.

Subsequently, the Atikokan operational monitoring program was modified to reflect the results of the AEAM approach. Operational environmental studies were started in 1986, instead of 1985, due to a delay in the start up of the station. However, monitoring studies at the site were continued by Ontario Hydro through the commissioning phase (1984-1985) at a lower level of activity.

The environmental issues identified at the workshop are summarized in Table 3.1. The scoping process established a conceptual framework within which detailed Hypotheses of Effect were subsequently developed.

Each Hypothesis of Effect contains a number of Linkages or specific predictions. Many of the predictions are based on predictions of effect formulated for the Proposal for ATGS (1977). Environmental Effects Monitoring (EEM) was subsequently conducted to test the accuracy of the predictions and to determine actual environmental impacts.

The three general monitoring programs related to the ATGS are:

1) Environmental Effects Monitoring (EEM):
   a) Pre-operational EEM 1981-1984
   b) Operational EEM 1986-1988
   c) Analysis and evaluation of both phases of EEM reported in the Environmental Effects Report (ESP, 1992).

2) Compliance Monitoring: Compliance monitoring of atmospheric and water quality parameters began January 1986, as an MOE requirement of the Certification of Approval (C. of A.) to operate the ATGS.

3) Municipal Strategy for Abatement (MISA): Detailed monitoring of intake and discharge water quality began at ATGS in 1990 as part of the MOE-MISA program. Data from MISA can be used to help determine some of the environmental impacts of the ATGS. However, it should be noted that MISA was never envisioned when the EEM program was designed.

Data from the Compliance Monitoring and MISA programs and a description of those initiatives are included in the ATGS Environmental Effects Report.

Table 3.1 Environmental Issues Related to the Atikokan TGS
Alteration of air quality ◆ effects of emissions on ambient air quality and sensitive vegetation
Acidic precipitation ◆ effects on water quality, biota ◆ metal contamination of biota
Change in water levels and water level stabilization ◆ effects on fish, wildlife, macrophytes in cooling water lakes and Seine River system
Change in water temperature ◆ effects on spawning, furbearers, decomposition, benthos, aquatic macrophytes ◆ changes in extent and thickness of ice; safety concerns
Change in currents ◆ increased turbidity ◆ effects on eggs, erosion, benthos
Change in water quality of cooling water lakes as a result of discharges from the plant ◆ phosphorus, sewage, boiler blowdown
Entrainment of water ◆ entrainment of fish from cooling circuit lakes
Handling of coal pile runoff ◆ treatment of runoff ◆ location of discharge
Groundwater quality ◆ changes due to ash pile leaching
Access ◆ change in recreational use of the area
Presence of the stack ◆ aesthetics ◆ effects on birds
Noise

A series of environmental impact predictions were developed in the original proposal to construct and operate the ATGS in 1977 (Environmental Study Report) and again during the 1984 scoping workshop.

The original Atikokan Environmental Study Report (ESR) contained numerous statements that were implicitly or explicitly predictions of effect. Whereas in current day EA documents, all predicted effects are clearly listed, the predictions in the original ESR were distributed as part of the text and not clearly separate. Approximately 110 statements that can be considered predictions of effect were extracted from the ESR and are summarized in Table 3.2. Program predictions generally refer to actions that will be undertaken as part of the project, and not necessarily as a consequence of it.

The 1984 scoping workshop produced approximately 90 predictions of effect (hypothesis linkages). The predictions from the workshop are also summarized in Table 3.2. The third column of Table 3.2 refers to the program or methodology employed to test a specific prediction. An attempt has been made to match up predictions from 1977 and 1984 that are similar, however, in many cases there is little overlap. The results of the monitoring programs are summarized in subsequent sections of this report and the accuracy of the predictions examined.

3. Monitoring Activities and Impact Predictions

Ontario Hydro conducted detailed environmental inventory studies on the site in 1975-1976 (Acres, 1976), for the original ATGS Proposal also referred to here as the Environmental Study Report (ESR).

In 1979, Ontario Hydro, the MOE and MNR developed a comprehensive cooperative environmental monitoring program. Ontario Hydro's studies included air quality and meteorology, onsite aquatic studies and groundwater quality of the ash disposal area. The MOE studies included acid rain and atmospheric deposition, terrestrial, and aquatic studies off site. The MNR studies included assessment of fish communities in several off-site lakes. Unfortunately, the construction phase of the project overlapped with many of the pre-operational environmental surveys, and some construction activities interfered with the accurate description of pre-operational conditions.

Pre-operational environmental studies were conducted from 1981 to 1984. The original ATGS proposal was for a four-unit (800-MW) station. By the beginning of the pre-operational studies, the proposed station capacity had been reduced to two units (400 MW), and finally to one unit (200 MW). The purpose of these three years of study was to establish a baseline description of the physical, chemical, and biotic features of the environment in sufficient detail to permit assessment of significant changes in those features during similar studies conducted during the operational phase of the station, and to identify, where possible, effects of construction activities on the environment.

In 1984, Ontario Hydro adopted the Adaptive Environmental Assessment and Management (AEAM) methodology (Greig *et al.*,1984) to design the operational environmental monitoring programs. Specialists from Ontario Hydro, the MOE, and MNR participated in a scoping workshop to review the results of the pre-operational studies and to develop the operational monitoring programs. Twelve hypotheses of effects were developed and grouped into four broad subjects:

1) Hypotheses related to atmospheric emissions

2) Hypotheses related to the cooling circuit lakes

3) Hypotheses related to the delivery, storage, and handling of coal and ash

4) Hypotheses related to miscellaneous effects of station presence and operation.

Subsequently, the Atikokan operational monitoring program was modified to reflect the results of the AEAM approach. Operational environmental studies were started in 1986, instead of 1985, due to a delay in the start up of the station. However, monitoring studies at the site were continued by Ontario Hydro through the commissioning phase (1984-1985) at a lower level of activity.

The environmental issues identified at the workshop are summarized in Table 3.1. The scoping process established a conceptual framework within which detailed Hypotheses of Effect were subsequently developed.

Each Hypothesis of Effect contains a number of Linkages or specific predictions. Many of the predictions are based on predictions of effect formulated for the Proposal for ATGS (1977). Environmental Effects Monitoring (EEM) was subsequently conducted to test the accuracy of the predictions and to determine actual environmental impacts.

The three general monitoring programs related to the ATGS are:

1) Environmental Effects Monitoring (EEM):
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Data from the Compliance Monitoring and MISA programs and a description of those initiatives are included in the ATGS Environmental Effects Report.

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The 1984 scoping workshop produced approximately 90 predictions of effect (hypothesis linkages). The predictions from the workshop are also summarized in Table 3.2. The third column of Table 3.2 refers to the program or methodology employed to test a specific prediction. An attempt has been made to match up predictions from 1977 and 1984 that are similar, however, in many cases there is little overlap. The results of the monitoring programs are summarized in subsequent sections of this report and the accuracy of the predictions examined.

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
Program Predictions		
The 1977 load forecast's average growth will be 5.5% per annum in the West System	No prediction	Predictive model based on annual load forecasts for Ontario
Type and Capacity The generating capacity of the station will be 800 MW produced by four 200 MW units (1977).	No prediction	Construction specifications
Station Facilities The area proposed for dry ash disposal is the Lower Basin	No prediction	Visual observation
Utilization of Station The average annual capacity factor for this station will be 70% for the first 10 years, 50% for the second 10 years and 30% thereafter. The economic lifetime of the station is considered to be 30 years		ATGS records
Manpower Requirements The maximum permanent operations staff for the coming thirty years from 1984 will be 120		ATGS records
Fuel The proposed fuel is Saskatchewan lignite coal which has a much lower sulphur content than bituminus coal. The lower ash content results in smaller ash disposal site requirements and reduces particulate emissions.	None, by 1984 factual	Compliance Monitoring Program (CMP)
At maximum capacity rating, the fuel consumption for the station will be about 155 tonnes/hr.	None, by 1984 factual	ATGS records - fuel consumption is monitored continuously
Based on 200 MW, the maximum quantity of coal stored at the station is estimated at 295,000 tonnes	None, by 1984 factual	ATGS records - coal storage and delivery records
Water Quality Monitoring Monitoring of flow, pH, suspended and dissolved solids on a weekly basis will be undertaken at the cooling water intake and outfall as well as for coal pile, ash disposal area and neutralizing sump discharges	No prediction	CMP
Fly Ash It is proposed that a master landscaping plan be prepared which can be implemented progressively as each 2 to 3 acres is filled to final grade		NA

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
Population If both mines remain operational, the total population will rise to about 7,600 by 1983 and drop to just over 7,000 in 1985	No predictions	Municipal records - annual population estimates
If one mine ceases operations in 1981, the total population will peak at about 7,000 in 1980, dropping to slightly more than 5,000 by 1985		Municipal records - mine closing dates - annual population estimates
Housing Assuming both mines remain in operation, a demand for an additional 520 dwelling units, 390 of which may be attributable to the Hydro project, is forecast for 1982	No predictions	Municipal records
Education No strain will be placed upon existing educational facilities	No prediction	Municipal records
Medical The facilities in the town such as the hospital and the medical clinic should not require any further expansion	No predictions	Municipal records
Historical Areas No significant impact is foreseen on historical areas during the construction period	No predictions	Municipal records, ATGS records, MNR records, OMOE records
Municipal and Community Services Municipal and community services may have to be upgraded somewhat in order to handle increased usage No increased industrial activity Upgrades to sewage and water treatment plants required Hydro grants will offset capital requirements for projects	No predictions	Municipal records and Ontario Hydro records
Noise Because of the remote location of the area, with no permanent residences within a 2-mile radius of the site, the overall effect on the public beyond the site boundary will be minimal	Hypothesis 10: Increased noise from station	Municipal records and Ontario Hydro records

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
Biting Fly Control If the need arises, construction staff will be protected against blackflies, mosquitoes and other biting insects by suitable control measures. Such control procedures should ensure that the application of insecticides will have little effect on water quality, wildlife and vegetation in the site area		NA
Population As emissions will not exceed regulatory levels, there should be no adverse health effects upon the resident population of the area	No prediction	Municipal records and Ontario Hydro records
IMPACT OF CONSTRUCTION ACTIVITIES		
Construction Facilities It is expected that almost 200 families of construction workers will require accommodation near or in Atikokan	No prediction	Ontario Hydro records
Traffic A maximum of 200 cars will be on the highway during the morning and evening peak rush hours in 1982. Road improvements may be required	No prediction	Ontario Hydro records
Construction Workforce Distribution The construction workforce for the project will be expected to peak in 1982 when the year's average requirements is estimated at 1260 workers. This will drop to about 70 in 1985 when station construction should be completed		Ontario Hydro records
Control and Restoration Erosion in the form of dust from construction parking areas and access roads will be controlled by water spraying		NA
Environmental Effects During Construction **Air** Atmospheric emissions during the construction stage will be mainly limited to particulate matter	No equivalent predictions for construction phase	NA
Community The particulate matter produced during construction will settle rapidly and should not pose any health problems.		Municipal and Ontario Hydro records CMP - total suspended particulate matter monitoring
Vegetation Premature leaf drop may occur among evergreens. Otherwise, the effects will be mainly visual and of a temporary nature		Ontario Hydro records - visual observations EEM - OMOE vegetation monitoring

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
Wildlife The effect of air emissions on wildlife during construction should be negligible		NA
Cooling Circuit Lake System Site preparation involving clearing, grubbing and grading will result in increased soil erosion and suspended material entering adjacent water bodies		NA
Erosion of sediments will reduce macrophyte development		EEM - Abundance and distribution survey
Cooling water flow per unit will be 4.4 m^3/s at normal full load		ATGS records
The length of the intake tunnel will be 540 m		ATGS records
The flow velocity in the forebay will be limited to less than 0.3 m/s to allow the formation of ice over Moose Lake preventing any intrusion of floating or frazil ice into the intake		EEM- Data records
Channel enlargements between the small lakes will be designed to minimize silt entrainment with flow velocities in the order of 1 to 2 ft/s (0.3 to 0.6 m/s)	No prediction	EEM- Current measurements and flow rate estimations
The purposes of the control weirs are to modify and control the water levels in the lakes and prevent the migration of fish and larvae from Marmion Lake into Abie Lake		EEM - Lake levels monitored
Water Levels and Supply	Hypothesis 3: Decreased water storage in Seine River	EEM - Monthly water level data
	Increase risk of downstream flooding	NA
	Reduced downstream supply of water during low flow	NA
	Reduce water supply will increase demand from other sources	NA
	Changes in water levels will reduce fish and wildlife habitat	NA
	There will be decreased hydro-electric generating capacity downstream of Marmion Lake	NA
During spring freshet the level will be maintained by discharging from Marmion Lake into the Seine River.		EEM - Monthly water level measurements in each lake
The level of Snow Lake will be lowered about 0.3 m		
Icy Lake will increase approximately 0.6m		

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
The level of Abie Lake will be increased approximately 2.2 m		EEM - Lake level monitoring
Moose Lake level will be raised about 2.7 m to the level of Marmion Lake by opening the Anderson Dam		EEM - Lake level monitoring
	Hypothesis 4: Stable water levels in the cooling lakes	EEM - Lake level monitoring
Aquatic Life In general, construction activities are anticipated to have only minimal effects on the existing aquatic biological communities in Moose, Snow, Icy, Abie lakes and the eastern end of Marmion Lake	No equivalent prediction	EEM - Water chemistry data - Changes in populations of the different trophic levels - fish, benthos, plankton
The influx of water from Marmion Lake may result in a slight increase in existing plankton populations	No equivalent prediction	EEM - changes in plankton numerical densities and community structure
Excavation to enlarge existing channels will result in a localized increase in turbidity with a concomitant decrease in plankton activity	No equivalent prediction	EEM - Primary productivity, abundance and diversity data TSS levels
Suspension of sediments in the vicinity of the Moose Lake intake during construction will be confined and cause only a limited loss in plankton activity	No equivalent prediction	
	Hypothesis 4: Construction of dams and channels: Altered current patterns and substrates	EEM - current measurements
	Will change fish distribution	EEM - Fish trapping survey
Destruction of existing benthic communities and fish spawning beds in channels will also occur	Altered the availability of spawning habitat	EEM - Spawning survey
	Increased production of northern pike	EEM - Fish survey (abundance and diversity)
	Increase in the distribution of macrophytes	EEM - Abundance, diversity and distribution survey
	Changes in habitat will cause changes in fish distribution, production and species composition	EEM - Abundance, diversity and distribution data from trapping survey
	Increased macrophytes will increase perch production	EEM - Correlation analysis
	Decreased abundance of forage fish	EEM - Fish survey
	Unknown effects on walleye production	EEM - Fish survey
	Loss of fish and wildlife habitat	EEM - Spawning survey, annual waterfowl observations
	Increased macrophytes will increase fish production	EEM - Correlation analysis
	Increase in numbers of whitefish	EEM - Fish trapping records

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
Terrestrial Life Construction activities will disturb and eliminate wildlife habitat	Hypothesis 4: Change in distribution of waterfowl and furbearers	EEM - Annual waterfowl observations, MNR trapping records
The potential impact of the proposed development on furbearing mammals will be of a local nature only Assuming the Marmion Lake flats and the Upper Basin are left undisturbed the potential impact on waterfowl habitat will be negligible		MNR trapping records, Map of beaver and muskrat lodges, Visual assessment and ATGS records
Stabilized water levels should generally improve waterfowl and resident shore bird nesting		EEM - Water level measurements, No shorebird nesting data
	Hypothesis 4: Stable water levels will increase beaver and muskrat production	MNR trap records
	Hypothesis 4: Changes in angler effort and fish habitat	EEM - Creel census - Fish trapping records
	Changes in fish distribution and abundance will change abundance of fish-eating birds	EEM - Fish survey but no fish-eating bird survey
Providing that clearing is not undertaken during the nesting season (May 15 to July 15), virtually no disturbance to waterfowl will result		NA
Excavation and channelling through Snow, Icy and Abie lakes will disturb or eliminate any beaver dams that exist in these lakes		ATGS records
Recreation and Parkland During construction, increased duck hunting should be anticipated in the populated areas. There will also be increased hunting pressures on the moose population due to the large influx of additional people to the area		MNR records
To overcome elevation difference between the northern portion of Marmion Lake and the Seine River levels upstream of Raft Lake dam, it is proposed that Ontario Hydro install manually-operated facilities capable of handling boats up to 4.9 m in size		Manually-operated facility was installed but rarely operational due to maintenance problems.

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
Recreation facilities adequate		ATGS and MNR records
	Hypothesis 11: Changes in accessibility of certain areas to hunters and anglers Changes in hunting and fishing due to changes in accessibility	MNR and ATGS records MNR and ATGS records
	Changes in harvest of fish and wildlife in response to changes in effort.	NA
	Localized accumulations of garbage in response to changes in effort.	ATGS records
ENVIRONMENTAL EFFECTS DUE TO OPERATION		
Effects of Atmospheric Emissions: Air Quality **Sulphur Oxides** The stack will produce a maximum ground level concentration of sulphur dioxide of 0.072 ppm approximately 3 miles (4.8 km) downwind of the stack	Hypothesis 1: Atmospheric emissions will not change local air quality	CMP - Atmospheric emissions monitoring data
Total sulphur dioxide emissions for two units (2 x 200 MW), over the lifetime of the station (30 years), would equal approximately 11,820 tonnes		CMP - Atmospheric emissions monitoring data
The reduced stack height (145 m) will not significantly increase the incidence of fumigation relative to that of the 198 m stack	No equivalent predictions	Assumed to be true
Particulate Matter Maximum ground level concentrations of particulate matter will be approximately 5% of the air quality criteria	No equivalent predictions	Dry deposition data, Ontario Hydro CMP - Dry deposition data OMOE
Nitrogen Oxides Maximum ground level concentrations of Nitrogen oxides emissions will be less than 15% of the air quality criteria	No equivalent predictions	CMP - Measured nitrogen oxides at ground level
Other Stack Emissions For most of the elements for which air quality criteria exist, the calculated concentrations will be less than 1% of the regulatory standards. Levels of iron and fluorides are more significant at 1.3% and 7% of the air quality criteria respectively.	No equivalent predictions	CMP - elements in TPS measured directly; MOE terrestrial and depositional data used to infer
Plume Visibility The precipitators will limit particulate emissions to a level that will produce a clear plume under normal operating conditions.	No predictions	CMP - Plume monitoring data, Particulate emissions data

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
The addition of heat to Marmion Lake will affect the stratification period and depth at which the thermocline will form. The extent of alteration to the hypolimnion/epilimnion ratio and dissolved oxygen between these two layers cannot be determined at this time		EEM - Temperature and oxygen profiles
	Temperatures will increase in receiving lakes	EEM - Temperature profiles and measurements
	Increased temperatures will increase macrophytes	Correlation analysis: temperature data, macrophyte distribution and abundance data
	Increased temperatures will increase secondary production	Correlation analysis: temperature data and zooplankton / benthos data
	Increased secondary production will change fish community	Correlation analysis: zooplankton data and fish distribution and abundance data
	Cooling water discharge will increase water currents	CMP - Discharge rates, flow rates, current measurements
	Increased availability of metals to biota hence increased body burdens	EEM - Fish metal body burdens
	Increase nutrients and turbidity due to resuspension of sediments	EEM - Turbidity and water chemistry data
	Sinking plume of O_2 rich water in winter (in Snow, Icy and Abie Lakes)	EEM - Oxygen profiles
	Resuspension of sediments in Snow and Ice Lakes	EEM - Inferred from turbidity and TSS data
	Altered currents will alter spawning habitat	Assumed to be true
	Deposition of sediments will alter walleye spawning habitat	EEM - Current measurements No direct sediment deposition data
	Changing water temperatures will alter spawning habitat in all lakes	EEM - Temperature data, spawning survey data
	Presence of oxygen-rich water in Snow and Icy Lakes will change fish abundance and distribution	EEM - Oxygen profile and fish survey data
	Altered spawning habitat will change species composition and abundance	EEM - Spawning survey (location) and fish survey
	Changes in water temperature will change distribution, composition and abundance of fish	EEM - Temperature profiles and fish survey data

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
i) Effects on Fish Numbers Water temperatures during the summer months in Snow, Icy and Abie lakes will result in mortality of walleye, white sucker and yellow perch which enter and remain in these locations		EEM - Fish survey (distribution, diversity and abundance)
Fish exposed to discharge temperatures in the east arm of Marmion Lake should not be exposed to lethal temperatures during the year		EEM - Temperature data, tolerance thresholds for each species
Mortalities may be anticipated with fish populations resident in the three small lakes, and particular Snow Lake, if exposed to a temperature drop should the generating station be forced to shutdown		NA
ii) Fish Spawning and Growth On the basis of predicted thermal regimes for Snow, Icy and Abie lakes, unlike Marmion Lake, temperatures will never decline sufficiently to induce spawning activity of cisco, white fish or burbot but may induce premature responses of the spring spawners.		EEM - Walleye spawning survey - Temperature profiles
Increases in water temperatures of these lakes during the summer months will result in the death of any juvenile fish which are unable to move away from the heated area		EEM - Temperature profiles, community structure data
Sufficient ice cover will exist in mid-winter to permit normal reproduction of the burbot		NA
iii) Plankton No bluegreen algae blooms are anticipated		EEM - Primary productivity and phytoplankton survey
Enhanced development of phytoplankton populations should stimulate zooplankton responses which will, in turn, provide increased forage for fish residing in the area		EEM - Phytoplankton, zooplankton and fish survey data - correlation analysis
iv) Benthos Increased water movement through the three lakes, Snow, Icy and Abie, will reduce available substrate for benthic organism development. Deposition of these sediments in the east arm of Marmion Lake may enhance benthic responses		EEM - Benthos survey

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
The chironomids, amphipods and gastropods which presently occur in Snow, Icy and Abie lakes will decline in numbers, and the populations of tubificids and sphaeroids will increase in comparison to the existing populations of the east arm of Marmion Lake		NA - Benthos survey data were insufficient
	Hypothesis 6: Intake of water will lower Moose Lake thermocline	EEM - Thermocline measurements and temperature profiles
	Vertical distribution of fish in Moose Lake will be affected	NA - Assumed to be true
	There will be significant entrainment of fish and plankton	EEM - Limited entrainment data
	Entrainment and impingement will reduce fish numbers in Moose Lake	EEM - Limited impingement and/or entrainment data
	Lowered thermocline in Moose Lake will change the fish population	EEM - Fish survey (population structure), thermocline data
b) Entrainment Effects The proposed station may destroy, at worst, 95 to 100% of the entrained young fish and, at best, 15 to 30%		EEM - Limited entrainment data
The low designed approach velocity and the location of the submerged intake is expected to reduce entrainment of adult fish to very small numbers		EEM - Limited entrainment data
Passage of phytoplankton through the cooling system of this station would not appear likely to cause any change in the composition of the population most of the time, but will interfere with photosynthetic responses		EEM - Phytoplankton survey
Submerged intake for the cooling water system is at a depth of 13 m. Entrainment of plankton and larval fish should be very limited		EEM - Limited entrainment data
c) Sewage Discharge All sewage will be collected and transported to either a septic tank and tile bed system or a package sewage treatment plant, depending on site conditions		ATGS records
The design loading for permanent staff during operation is estimated to be 14 kg BOD with a flow of about 9,000 U.S. gallons (34 m^3) per day. Field conditions do not appear to be suitable for sewage lagoon treatment of the sanitary waste		ATGS records

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
Discharge of sewage effluent from the treatment plant will meet regulatory guidelines and should not affect water quality		EEM - Phytoplankton survey, water chemistry data
	Hypothesis 7: Increased BOD and P from sewage Increased BOD and P will alter algae and macrophytes	EEM - Transect survey of water chemistry coupled with phytoplankton and macrophyte survey data
There should be little change in the nutrient content of the water		EEM - Water chemistry survey
	Increased algae and macrophytes will lower oxygen levels in hypolimnion	EEM - Oxygen profiles, phytoplankton and macrophyte surveys
	Lower oxygen will affect fish distribution and abundance	Correlation analysis: oxygen data and fish survey data
TDS levels expected to increase by 0.65 ppm annually	Increased TDS and TSS from discharge of cooling water	EEM - Water chemistry survey in receiving waters
	Increased TDS and TSS will increase algae and macrophyte production	Correlation analysis: water chemistry data with phytoplankton and macrophyte data
OTHER DISCHARGES		
Boiler Blowdown Based on a 400 MW, the anticipated annual quantity of phosphate which would be discharged to the cooling water is 65 kg.		NA
	Hypothesis 8: Increase TDS by 2.5% every 5 y in Lower Basin from boiler cleaning wastes	NA
Condenser Cleaning Shock chlorination is considered the standard process for condenser anti-fouling		ATGS records indicate no chlorine is used for condenser cleaning
Condenser Cleaning Chlorination, if required in the future, would not have a significant toxic effect on the aquatic environment in the Marmion Lake system.		ATGS records indicate no chlorine is used
Prior to proposing chlorination at Atikokan GS for condenser cleaning, Ontario Hydro would review the possible environmental effects of chlorine in relation to the uses of Marmion lake and its associated lakes and potential health effects		NA
Water Treatment Plant Effluent All wastes will be routed to a neutralizing sump with provision for pH control		ATGS records

Table 3.2: Summary of Environmental Predictions and Assessment Methods

EA Predictions (1977)	Workshop Predictions (1984)	Assessment Methods
Accumulation of Chemicals and Dissolved Solids It is expected that the impact of nutrient contribution from water treatment plant wastes such as blowdown and treated sewage will be negligible		EEM - Water chemistry survey
Ash Disposal Area Drainage Studies will be carried out to determine the nature and extent of any treatment required for both coal pile and ash disposal area drainage to meet the Ministry of the Environment discharge guidelines		EEM - Groundwater survey
Coal Pile Drainage The runoff drainage from the coal pile will be collected and routed to a pond. Studies will be carried out to determine the nature and extent of treatment required, prior to discharge to receiving waters	Hypothesis 8: Coal pile runoff of TDS, TSS and pH will increase these parameters in Moose Lake	CMP - MISA ATGS records EEM - Water chemistry survey in the Lower Basin
	Changes in water quality of Lower Basin will make it less desirable for waterfowl	EEM - Water chemistry data
	It is not expected that leaching of heavy metals or other toxic materials will be a problem. However, runoff drainage from the stockpiles will be collected and monitored prior to any discharge to the receiving water	CMP and MISA data
Runoff from disposal areas will be controlled by drainage systems and effluent retention or treatment, so that water quality is not degraded in the adjacent water body		ATGS records EEM - Water chemistry survey

Legend:

NA - no available data
CMP - Compliance monitoring program
ATGS - Atikokan thermal generation station
MISA - Municipal and industrial strategy for abatement
EEM - Ecological effect monitoring program
TSS - Total suspended solids
TDS - Total dissolved solids
SO_2 - sulphur dioxide

4. Environmental Effects Monitoring (EEM) Program

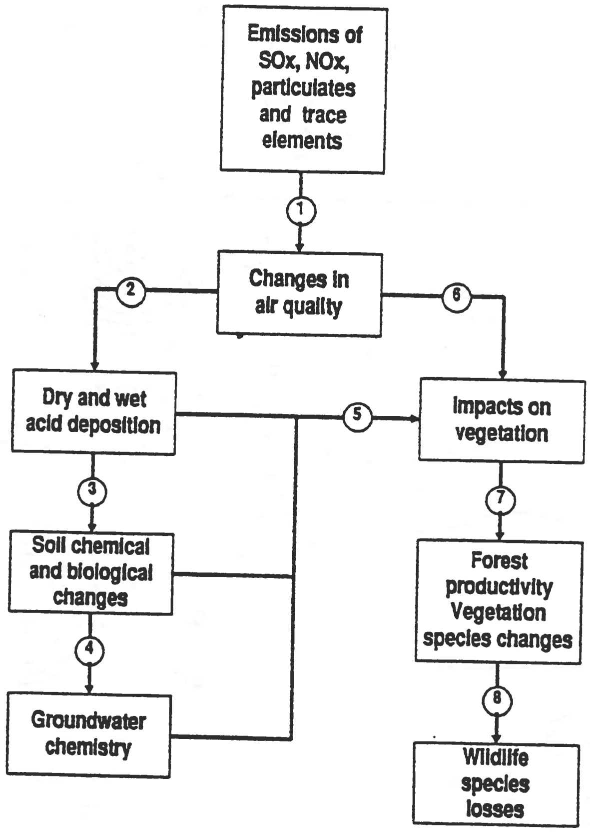
4.1 SUMMARY OF HYPOTHESES OF EFFECTS

A description of baseline environmental conditions at the ATGS site was conducted in 1975 (Acres, 1976). Subsequent to approval to construct and operate the ATGS, pre-operational environmental studies were conducted from 1981 to 1983. The results of the pre-operational studies were reviewed during a scoping workshop in 1984 for the purpose of designing the operational monitoring program (see also section 1.4). Some environmental monitoring was undertaken during the commissioning phase in 1985, and operational monitoring was conducted from 1986 to 1988. The fundamental objective of the pre-operational and operational monitoring programs was to document in sufficient detail features of the environment to permit assessment of significant changes in those features that could be attributed to the ATGS.

The operational monitoring program focused around twelve Hypotheses of Effects (Greig *et al.*, 1984) based on the issues identified in Table 1.4. Each Hypothesis included a number of Linkages that were considered mechanisms, but were generally predictions of effect. A detailed analysis and discussion of the Hypotheses and results of the EEM is provided in the Atikokan TGS Environmental Effects Technical Report (ESP, 1992). The technical report summarizes the results of numerous studies and acts as a guide to various Ontario Hydro, MNR and MOE reports.

This section summarizes the ATGS Environmental Effects Technical Report. A conceptual diagram showing the linkages for each of the original hypotheses is provided as developed from the original scoping workshop (Greig *et al.*, 1984).

Hypothesis No. 1: Effect of Emissions on Air Quality and Terrestrial Ecosystems



Emissions of SO_x, NO_x, particulate matter and trace elements from the stack will not lead to declines in forest productivity, losses of sensitive vegetation species, undesirable changes in species composition, and consequent losses of wildlife species.

2.1 Link 1

<u>Emissions of SO_x, NO_x, particulate matter and trace elements will lead to changes in ambient air quality, including increases in acid forming precursors, ozone and other oxidants, particulate matter and trace elements.</u>

Table 2.1-1 summarizes the annual emission totals for SO_2, NO_x and NO over the operational years (1986-1989) used in this study.

The scoping workshop suggested that increases in ambient SO_2 and NO_x may be detectable, but there should be no detectable increase in other emitted substances or those substances resulting from stack emissions such as ozone.

TABLE 2.1-1
Annual Total Emissions Atikokan TGS

Year	Power Generation		Annual Totals		
	MWh (net)	MWh (gross)	SO_2(Mg)	NO(Mg)	TSP(Mg)
1986	302,889	361,281	1590	500	54
1987	890,828	981,646	4060	1100	140
1988	1,293,955	1408,569	5130	1800	160
1989	1,118,929	1225,974	4430	1600	160

In order to test this link, Ontario Hydro set up a five station monitoring network around the ATGS beginning in 1981. These SO_2 monitoring sites were installed to provide a baseline pre-operational assessment of air quality. The location of these monitoring sites is indicated in Figure 2.1-1.

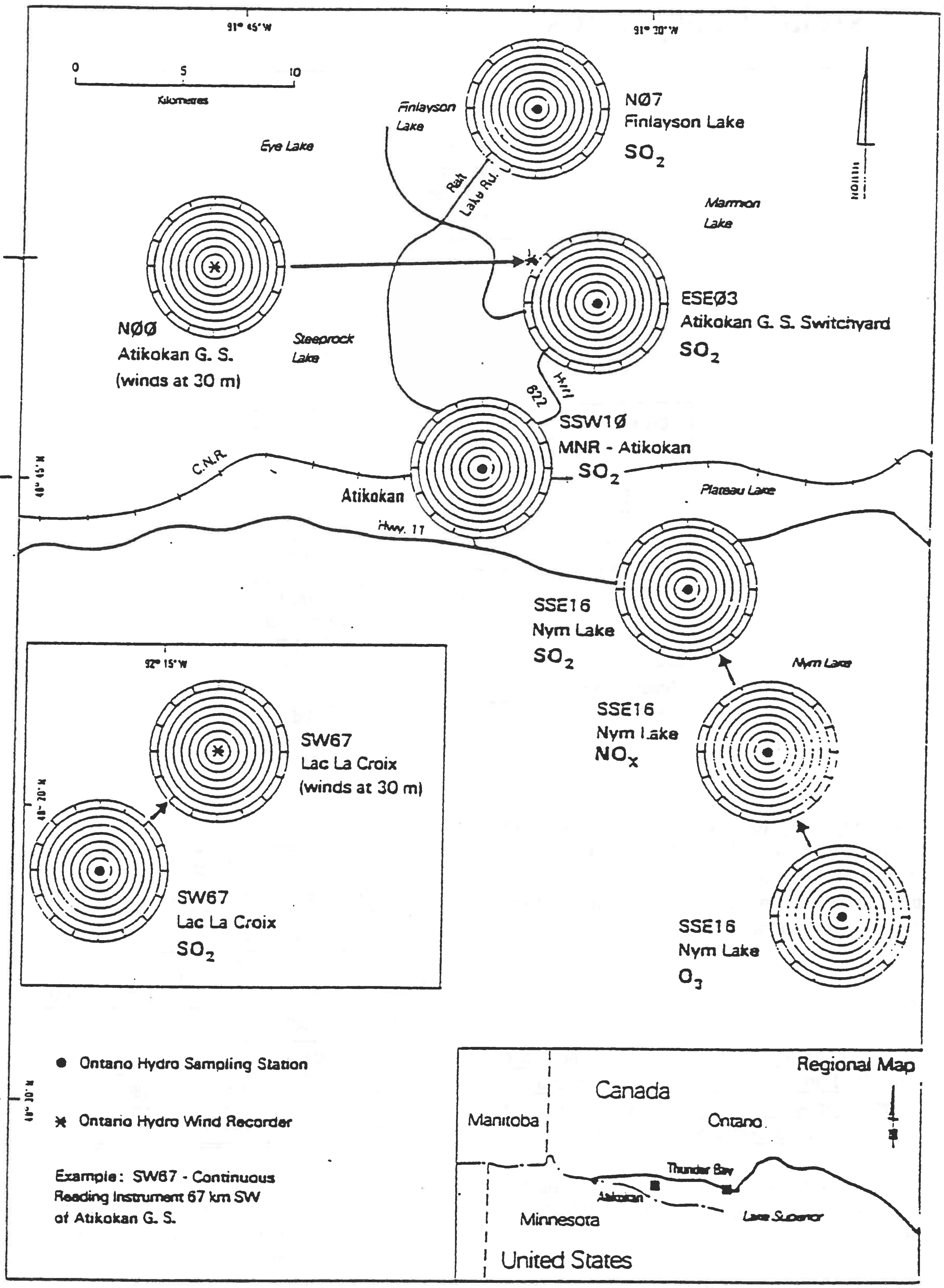


FIGURE 2.1-1
Locations of Air Quality Monitors (Racette and Griffin, 1990 a or b; With Additions)

Despite the fact that some of the changes shown may be statistically significant in the mathematical sense, the magnitude of the annual average concentrations of SO_2 is less than 0.5 ppb. In fact, more than 80% of the hours in which data were measured during the operational period showed concentrations less than the instrument detection limit of 2 ppb. Since other possible sources of SO_2 in the area may contribute concentrations equivalent to those seen at the monitoring sites during the operational period, it is not possible to conclude that changes seen in the annual SO_2 concentrations were the result of emissions from the ATGS.

Similar analyses of the nitrogen oxides gases do not conclusively indicate that changes in concentrations during the operational period are the result of ATGS operations.

Ozone concentrations show a statistically significant difference in period means but the wind sectors which show the highest change are those which may be associated with long-range transport rather than the ATGS. Therefore, it cannot be conclusively determined that the ATGS does or does not cause a change in the ambient ozone concentrations.

Total suspended particulate (TSP) matter was monitored by Ontario Hydro on the National Air Pollution Surveillance (NAPS) 6-day cycle. None of these monitoring data show that increased TSP levels during the operational period were the result of ATGS stack emissions. The only evidence that stack emissions from the ATGS have increased TSP levels is the fact that most of the increase in TSP levels occurred during the winter months when station operation and, consequently, stack particulate emissions were at their peak. These increases, however, could also be attributed to emissions from the coal storage pile, ash disposal area, truck traffic on the access road and/or residential wood burning during the winter months.

The scoping workshop predicted that trace element emissions from the stack of the ATGS would be small. However, environmental monitoring activities were recommended if only to verify this prediction. Trace element concentrations for both the pre- and operational periods were monitored by the MOE (Racette and Griffin, 1983, 1984, 1985, 1986, 1989, 1990a). The monitoring programme included terrestrial and depositional studies in the vicinity of the ATGS. The MOE concluded from these studies that the ATGS has not had a measurable impact on the surrounding environment (Racette and Griffin, 1990a).

In most cases, the interannual variability of annual pollutant concentration averages was greater than the difference between the period means. This fact, coupled with the low concentrations measured at each of the monitors, make it impossible to attribute a degradation in local air quality to operation of the Atikokan Thermal Generating Station.

2.2 Link 2

<u>Changes in air quality, particularly increases in acid forming precursors, will lead to increased dry and wet deposition of acidity.</u>

Link 2, as presented in the scoping workshop, states that increases in acid forming precursors are expected to be so small as to be very difficult to detect above background levels, particularly using the existing monitoring network. When oxides of sulphur and nitrogen emitted to the atmosphere are transported by winds, chemical reactions in the atmosphere convert these oxides to acids, primarily sulphuric acid, nitric acid and nitrates. The acids reach the earth's surface by wet deposition in precipitation, or as dry deposition at other times. Acidic deposition in the Atikokan region was assessed by examining available reports of monitored data for the pre-operational and operational years of the ATGS.

In a continuing review of atmospheric effects in the region near the ATGS, Racette and Griffin (1983, 1984, 1985, 1986, 1989 and 1990a) concluded that wet sulphate deposition rates are unlikely to damage sensitive aquatic ecosystems and that the low acidic deposition in 1987 and 1988 was essentially unchanged from pre-operational levels, which are considered normal for the region.

The annual deposition rate of both sulphates and nitrates was lower in the 1986 to 1988 operational period than those in the 1982 to 1985 pre-operational period. This is due in part to the smaller amount of precipitation during the operating years. The reduction of wet sulphate deposition is also due to the fact that sulphate concentrations decreased at most sites during the operational period. Nitrate concentrations, however, increased during this period, but this was not sufficient to offset the effect of lowered annual precipitation.

It is, nevertheless, interesting that the time-trends of wet sulphate deposition and concentration during this short period are similar to those observed at Hubbard Brook Experimental Forest in New Hampshire over a twenty year period (1964-83) by Hedin *et al.* (1987) and at the Dorset Research Centre in central Ontario over a ten year period (1976-85) by Dillon *et al.* (1988). Both studies attribute the reduction in wet sulphur deposition to decreased sulphur dioxide emissions generally in eastern North America. Dillon *et al.* (1988) found that over the same

TABLE 2.5-2
Mean Concentrations of Elements in Moss and Lichen Samples From 15 Sites Near Atikokan TGS, for Pre-operational and Operational Period.

Element* (µg/g dry weight)			As	Cd	Cr	Cu	F	Fe	Pb	Mn	Hg	Ni	Se	S	Zn
Pleurozium schreberi (moss)	1981-83	Mean	3.8	0.5	5	5	6	2600	15	240	0.09	<2	0.51	0.09	32
	1986	Mean	2.2***	0.3***	5	4***	<1***	2700	10***	300**	0.10	3**	0.5	0.07	35**
	1988	Mean	0.7***	0.2***	1***	3***	<1***	1100***	6***	210***	0.07***	1	0.4***	0.07	28***
Cladina rangiferina (lichen)	1981-83	Mean	1.8	<0.5	<1	2	0.7	1089	5	45	0.04	<2	0.19	0.03	15
	1986	Mean	0.9***	0.2**	<1	<2	<1	1000	4***	50**	0.05**	<1	0.2	0.03	16
	1988	Mean	0.6***	<0.2	<1	<2	<1	840***	2***	57**	0.04	<1	0.2	0.03	16

* *no guidelines available*
** *increased concentration in operational compared with pre-operational period (p = 0.05)*
*** *decreased concentration in operational compared with pre-operational period (p = 0.05)*

None of the concentrations of SO_2 or NO_2 reported near the ATGS are expected to cause acute or chronic damage to plants.

No evidence has been provided to date to suggest that the vegetation in the vicinity of the Atikokan TGS has been adversely affected by the operation of the station. In fact, previous adverse conditions, as evidenced by higher than normal levels of certain elements in soils, lichens and mosses have improved over the past three years. The levels of arsenic and iron (presumably airborne) in the tissues of mosses and lichens have shown a decrease since monitoring began in 1981.

2.7 Link 7

Impacts on vegetation, if sufficient in magnitude, could eventually lead to declines in forest productivity, losses of sensitive vegetation species and undesirable changes in species composition.

There is no evidence to suggest that ATGS emissions affected vegetation (Link 6), therefore declines in forest productivity or other changes are not expected.

2.8 Link 8

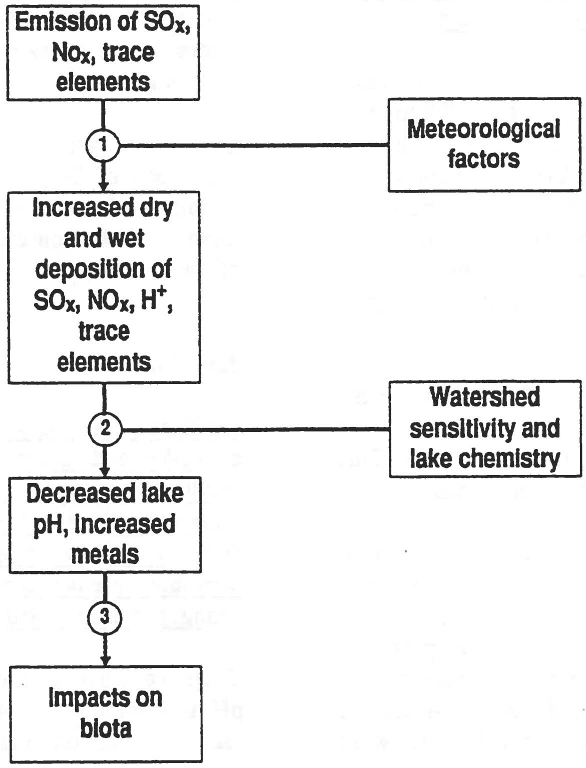
Changes in forest vegetation composition could lead to losses of certain wildlife species.

The participants of the original workshop dismissed this link as being extremely unlikely (Greig *et al.*, 1984). Monitoring activities for the overall Hypothesis were recommended but nothing was advocated specifically for this link. There is no evidence to suggest that changes in the forest vegetation occurred as a result of the ATGS (Link 6,7). Therefore, we would not expect the subsequent indirect effect on wildlife.

Disturbances of insect populations due to forest decline could subsequently affect insectivorous forest birds. DesGranges *et al.* (1987) observed that some species of insectivorous birds were less plentiful in the overstory of a maple forest affected by dieback in Quebec than in healthy stands.

The Hypothesis could have been expanded to include the link that deposition of trace elements from the ATGS to the surrounding environment would lead to increased body burdens of trace elements in some wildlife species. Elevated body burdens of trace elements have been reported in animals grazing near smelters elsewhere (Kucerea 1988; Kramer *et al. 1983).* In these situations, trace element levels were clearly elevated in vegetation and browse surrounding the point source of emissions. Levels of some trace elements are elevated in vegetation near the ATGS but these are due to the previous smelting activities and not operation of the ATGS.

Hypothesis No. 2: Effects of Emissions on Water Quality



Emissions of SO_x, NO_x and trace elements from the stack will not result in measurable decreases in fish and amphibian productivity, changes in species composition, losses of fish-eating wildlife, nor lead to increased body burdens of heavy metals in fish, waterfowl or humans.

3.1 Link 1

<u>Emissions of SO_x, NO_x and trace elements will lead to increases in dry and wet deposition of SO_x, NO_x, H^+ and trace elements.</u>

The scoping workshop report predicted that trace element emissions from the TGS would be small, however, environmental monitoring activities were recommended if only to verify this prediction. Monitoring of trace element deposition by MOE in the vicinity of the Atikokan TGS occurred from 1981 to 1989. These studies revealed that levels of all trace elements were generally within normal background ranges through the 9-year study period with the exception of arsenic and iron levels (Racette and Griffin, 1990a). For these parameters, highest concentrations were in the vicinity of the Atikokan TGS.

High arsenic and iron levels have been attributed to the emissions from two iron pelletizing plants which operated in the area from the mid-1960s to approximately 1980. These levels have actually decreased significantly since the generating station began operation, but operational levels still remain high. In fact, the MOE have concluded that historical contamination of surface soils and vegetation, caused by the iron pelletizing plants, will persist for many years.

Mercury levels in the surface soil were also higher than expected during the pre- and operational periods. However, average levels of mercury have decreased during the operational period of the generating station. The cause of the mercury contamination is unknown, but local point sources are not implicated (Racette and Griffin, 1990a).

In conclusion, an examination of the data collected from the MOE's deposition monitoring programme suggests that stack emissions at the Atikokan TGS generally have not caused increased levels of airborne trace elements in the ambient environment.

3.2 Link 2

Increased dry and wet deposition of SO_x, NO_x, H^+ and trace elements will not result in measurable decreases in lake pH or increases in concentration of metals.

The potential for damage to lake water quality is based primarily on wet sulphate deposition. From 1985 to 1987 annual wet sulphate deposition was less than 10 kg/ha at all sites within 100 km of the ATGS, except at the Quetico Centre cumulative monitor in 1983 when it was 11 kg/ha. These values are well below the critical value of 20 kg/ha proposed by the Memorandum of Intent Canada-U.S., and the more stringent value of 14-16 kg/ha proposed by Gorham *et al.* (1984).

At the town of Dorion, approximately 200 km east of the ATGS, annual wet sulphate deposition was 13 kg/ha or less for all years except 1983 when it was 16 kg/ha. This is also within the range of Gorham's critical value.

Precipitation pH has also been used as an indicator of potential for harmful effects. A critical rain pH value of 4.6 to 4.7 was proposed by Henriksen (1979). A comparison of monitored rainfall data with proposed critical pH values shows that pH levels are above critical values of 4.6 to 4.7 for sites within 100 km of Atikokan. At Dorion, 200 km to the east, some annual values were in the range of the critical levels.

Forty lakes in the vicinity of the ATGS were sampled in 1986, 1987 and 1990, analyzed for acid senstivity parameters and results were compared to the pre-operational years of 1980-1983 (Sutton, 1987; Persson and Sutton, 1990). The lakes studied in 1986 and 1987 showed no signs of anthropogenic acidification. The water chemistry and stable sulphur isotopes of the study lakes were similar to "background" lakes in experimental lakes near Kenora, Ontario (Sutton, 1987). Persson and Sutton (1990) found significant lower mean concentrations of sulfate in 1990 as compared to pre-operational years (1982-1983) and significantly higher pH levels for 1990 as compared to 1987 and 1980. Both authors concluded that possible acidifying effects form the ATGS emissions could not be detected and that the results suggested an improvement in lake water chemistry as related to acid deposition.

Since there was no significant increase of dry and wet deposition of SO_x, NO_x, H^+, and trace elements in the vicinity of the ATGS, no decline in pH of lake water nor increase in the concentration of trace metals in the water of the circuit lakes would be expected.

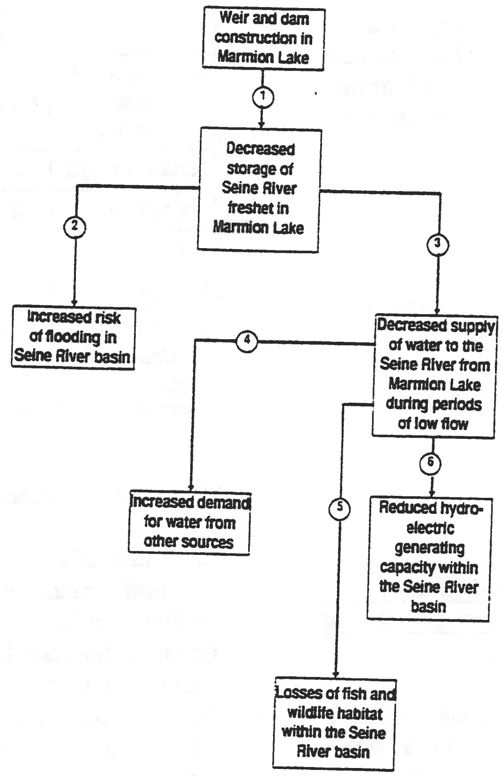
3.3 Link 3

Declines in pH and/or increases in metal concentrations in area lakes and streams are not expected to be sufficient to result in impacts on the aquatic community or wildlife or other consumers utilizing that community. Furthermore, changes in heavy metal body burdens in fish or other consumers are not expected to result from station induced changes in lake or stream chemistry.

There was no immediately demonstrable reduction in lake pH as a result of the ATGS. In fact, a slight increase in lake pH was observed. Similarly, changes in metal concentrations in the water were negligible and could not be attributed to atmospheric deposition. Therefore, no changes in metal body burdens in fish or other consumers could be expected via this link.

Water quality monitoring in the cooling circuit did not detect any change in lake pH or metal concentrations. Furthermore, water quality actually improved in 40 lakes in the vicinity of the ATGS (MOE 1991). The improved water quality was noted by increased lake alkalinity and decreased sulphate levels since operation of the ATGS began.

Hypothesis No. 3: Effects of Construction on Water Use Patterns and Fish and Wildlife Habitat



The construction of weirs and dams in Marmion Lake will lead to:

a) increased risks of flooding;

b) increased demand for water from other sources;

c) reduced hydroelectric generation capacity; and

d) losses of fish and wildlife habitat within the Seine River basin.

4.1 Link 1

The reconstruction of the east, west and middle dams separating the active (Seine R.) and inactive portions of Marmion Lake will lead to decreased storage capacity within the Seine River system.

The reconstruction of the east, west, middle and spillway dams separating the active and inactive portions of Marmion Lake in 1981 and 1982 removed approximately 10,000 ha of storage area from the Seine River system during normal flow. Although flow from the Seine River into Marmion Lake could occur when its level exceeds 415.3 m, comparison of the water levels reveals that the Seine River rarely flows into Marmion Lake. Theoretically, Marmion Lake could act as a storage reservoir for the Seine River system during high flows. However, since the level of Marmion Lake is almost always above that of the Seine River, it is not able to function in this capacity. Thus, reconstruction of the east, west and middle dams has decreased the high water storage potential of Marmion Lake within the Seine River system, supporting this prediction.

4.2 Link 2

The decreased storage capacity of the inactive portion of Marmion Lake will result in an increased risk of flooding downstream from Marmion Lake.

In the event of an extreme flood event, a decrease in the storage of the river system, as has occurred at Marmion Lake, would increase the severity of downstream flooding as suggested in this Link.

4.3 Link 3

The decrease in available storage water from Marmion Lake will decrease the downstream supply of water during periods of low flow.

Rather than decreasing the supply of water to the Seine River, it appears that Marmion Lake is acting as a low flow reservoir, storing water that would otherwise have run its course through the river. Water from Marmion Lake has actually augmented the flow in the Seine River during dry periods.

4.4 Link 4

reduced supply of water will increase the demand for water from other sources within the system.

The water supply was not reduced (Link 3), therefore, this link was not considered further.

4.5 Link 5

Changes in the patterns of water levels and flows arising from the loss of storage will lead to losses of fish and wildlife habitat in the Seine River system.

Although the loss of habitat was expected, the workshop participants concluded change would be difficult to detect and monitoring was **not** recommended (Greig *et al.*, 1984). Despite these recommendations, waterfowl surveys were undertaken by Ontario Hydro as additional studies.

Prior to construction, water levels in Marmion Lake fluctuated about 2.74 m annually. The net result of the construction activities at ATGS was the stabilization of Marmion Lake water levels relative to preconstruction conditions. The water level of Snow and Moose Lakes was raised while that of Icy Lake was lowered (Table 4.5-1).

The impacts of changing water levels and current patterns on fisheries habitat are addressed in Hypothesis 4.

Wildlife that could be affected by changing water levels include waterfowl and furbearers such as beaver, mink and muskrat.

Waterfowl
Waterbirds and shorebirds are well represented in the Atikokan area, both as residents and migrants. Waterfowl surveys were conducted by Ontario Hydro in 1975, 1985, 1986, 1987 and 1988. Species most commonly observed included Ring-necked Duck, Lesser Scaup, Common Merganser and American Coot.

TABLE 4.5-1
Morphometric Characteristics of the Study Lakes (Parameters Based on Original Water Levels)

	Lakes					
	Snow	Icy	Abie	Slush	Marmion	Moose
Water Level (m)						
Original	417.5	416.5	415.5	417	415.5	413.2
Operating	418.6	415.5	415.5	417	415.5	415.5
Surface Area (ha)	41	101	94	28	10516	60
Perimeter (km)	3	9	8	3	455	8
Volume (m^3*10^4)	203	558	452	274	71385	786
Mean Depth (m)	5.0	5.5	4.8	9.7	6.8	13.2
Shoreline Development Factor	1.4	2.5	2.3	1.6	12.5	2.8

The results of the waterfowl surveys suggested that good waterbird habitat was lost by stabilizing water levels over the Marmion Lake Mud Flats, an important stopover point for migratory shorebirds. However, due to the varying level of survey effort between years and among different observers, the resulting data did not lend themselves to statistical analysis that would clearly illustrate temporal trends.

Furbearers
To assess the potential impact of the ATGS on furbearers, the MNR trapping records were examined. Although furbearer harvest is not a direct measure of population numbers, it does provide an indication of the relative abundance of a species if trapping effort remains consistent over time.

The number of beaver trapped near the ATGS fluctuated within natural ranges (85-189 animals per year) and no impact of the ATGS is obvious by examining these data. Similar fluctuations in harvest were reported at a nearby trapline not impacted by water level fluctuations at the ATGS.

The harvest of muskrat declined from 76 in 1980-1981 to only 6 in 1981-1982. Harvest in subsequent years has also remained low. The harvest of mink displays fluctuations but no consistent patterns. Of these three furbearer species, mink would be the least affected by changing water levels.

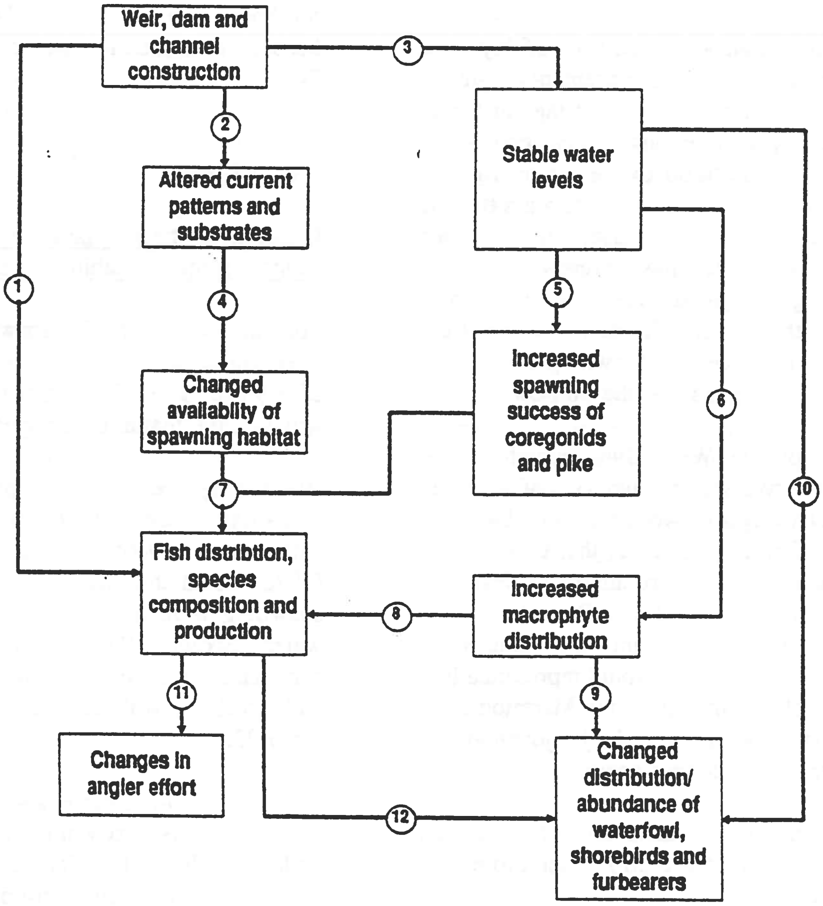
The effect of stabilizing water levels on Marmion Lake should benefit beaver and muskrat compared with the pre-construction period when water levels fluctuated by as much as 2.3 m. The available trapping data do not suggest a net reduction in beaver harvest, although trapping effort may have been shifted to new areas.

4.6 Link 6

The decreased supply of stored water will lead to a reduction in the hydro-electric generating capacity downstream from Marmion Lake.

Flow records from the Sturgeon Falls Dam, located approximately 70 km downstream from the Raft Lake Dam (Environment Canada, 1989), shows no evidence of reduced flow in the years following construction of ATGS. Therefore, the available data do not support this prediction.

Hypothesis No. 4: Effects of Construction on Fish and Wildlife



The construction of dams, weirs and channels in the cooling circuit lakes will lead to:

a) changes in the species composition, distribution and abundance of fish with consequent changes in fishing effort and the abundance of fish-eating wildlife; and

b) changes in the distribution of waterfowl, shorebirds and furbearers.

5.1 Link 1

<u>The construction of dams, weirs and channels has changed the distribution of fish through changes in access between the cooling circuit lakes.</u>

The major changes to fish access involve:

a) construction of the weir at the outflow of Snow Lake which will prohibit movement of fish into Snow Lake from Abie Lake;

b) removal of the beaver dam at the outflow of Icy Lake into Abie Lake which now allows movement of fish into and out of Icy Lake;

c) Moose Lake was dewatered for construction of the station intake, and subsequent breaching of Anderson Dam to refill Moose Lake; and

d) construction of the West Dam which now prohibits fish movement from the Seine River into Marmion Lake, although the reverse is possible.

The changes in fish access all relate to construction activities which had been completed by the time the workshop was held to develop monitoring activities. Unfortunately, very little pre-construction fisheries data were collected. Fisheries surveys by Ontario Hydro were initiated in 1981 while construction activities were occurring. Most of the construction activities related to modifications of the cooling circuit lakes occurred in, or were completed by 1982.

Yellow Perch
The number of larval yellow perch per tow increased threefold from 1986 to 1987. An early spring runoff in 1987 may have enhanced the spawning success of yellow perch that year.

Similarly, the number of perch caught per seine increased in 1986-87, but declined in 1988. This would lend support to Link 5 regarding improved spawning success of perch due to stabilized water levels.

Cisco and Whitefish
There is no evidence from either larval or adult fish studies that spawning success of cisco or whitefish has increased as a result of water stabilization.

Northern Pike
The pike gill net CUE for all locations declined from 1.1 in 1981 to 0.2 in 1988 (Figure 5.5-3). During operational surveys, the 1981 (pre-stabilization) pike year class dominated the pike catch compared with year classes produced after water stabilization.

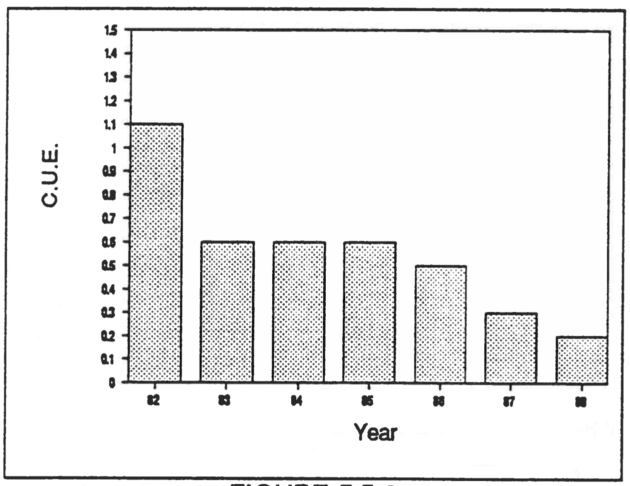


FIGURE 5.5-3
Annual Catch of Northern Pike Per 2-Hour Gill Net Set at All Locations

In summary, there is no evidence to suggest an increase in spawning success of yellow perch, cisco, lake whitefish or northern pike that can be attributed to water level stabilization. The abundance of young perch increased for a 2-3 year period, but not until 3 years after water levels were regulated. The numbers of adult northern pike have declined but the relationship with spawning success or other factors is not established.

5.6 Link 6

Stabilized water levels in Marmion, Moose and Abie Lakes will result in an increase in macrophyte distribution.

The Hypotheses related to macrophytes in the Atikokan TGS cooling circuit lakes were concerned with the effects of water level stabilization due to the construction of dams, weirs and channels as well as discharging of cooling water on the distribution and density of macrophytes. It was hypothesized that stabilization of water levels would lead to an increase in macrophyte distribution, while the thermal effluent would affect the distribution and density of macrophytes due to increased temperature, BOD, nutrients and turbidity.

Abundance and distribution of macrophytes along transects were established by observation from a boat or by snorkelling.

There was no discernable trend in species diversity attributed to the ATGS. Similar numbers and kinds of macrophyte species were found during the pre- and post-operational studies in all lakes.

5.7 Link 7

Changes in fish spawning habitat will result in changes in fish distribution, species composition and production.

The rationale for this particular Link as outlined by Greig *et al.* (1984) is that an increase in pike abundance (Link 5) would increase the predation on forage species such as cyprinids (minnows) and yellow perch and lead to reductions in forage species populations. Changes to walleye populations resulting from their attraction to substrates within the thermal plume were uncertain.

This link has a number of inter-related components that, for the sake of simplicity and clarity, will be addressed separately. The predicted impacts include:

a) increased pike abundance will reduce numbers of forage fish (cyprinids and yellow perch);
b) change to walleye population (unknown direction of effect);
c) abundance of cisco and whitefish will increase; and
d) perch populations might increase in response to changes in macrophyte abundance and distribution.

It was demonstrated in Link 5 of this Hypothesis that the abundance of northern pike has actually decreased in the cooling circuit lakes. If the relationship between predator (pike) abundance and abundance of forage fish is valid, then an increase in numbers of forage species is expected. In other words, the opposite effect of what was predicted would occur.

The abundance of forage fish may be inferred from beach seine catches. There has been a substantial increase in the total average catch of all fish species per beach seine at all locations during the operational period (Figure 5.7-1).

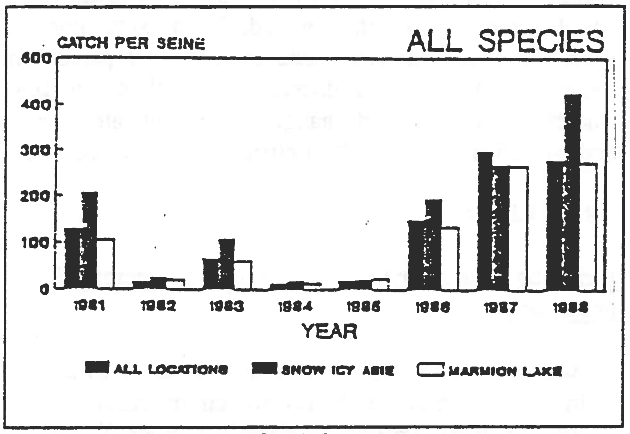


FIGURE 5.7-1
Annual Catch Per Beach Seine

The annual catch in each year was generally accounted for by three or four species. Blacknose shiner, mimic shiner and yellow perch were consistently included among the most abundant species. Additional primary species included spottail shiner, Iowa darter, white sucker and pumpkinseed.

In Marmion Lake, larger mean beach seine catches generally occurred during the operational period. As temperatures in Marmion Lake were not substantially altered due to operation of the station, it is likely that the results reflect an actual increase in the abundance of the most frequently collected juvenile and forage fish.

The available data lend support to part (a) of this Link. That is, an increase in abundance of forage fish coupled with the apparent reduction in the numbers of piscivorous fish (walleye and pike) may be, in part, the result of top down food chain effects (Haymes and Sheehan,1990).

This Link also suggested that the impacts of the ATGS on walleye populations could not be clearly predicted (part b). Similar to northern pike, the abundance of adult walleye decreased substantially after station operation. The gill net CUE for walleye declined from 0.8 in 1983-84 to 0.2 in 1987 (Figure 5.7-2).

The walleye age structure indicates a population experiencing increased mortality of older fish in the operational period. The dominance of younger aged fish increased while the percentage composition of older fish decreased. An increase in angling pressure could account for the age structure alteration.

The abundance of age 1 and 2 year walleye increased in operational surveys (Figure 5.7-3) suggesting good recruitment during this period. Therefore, the response is

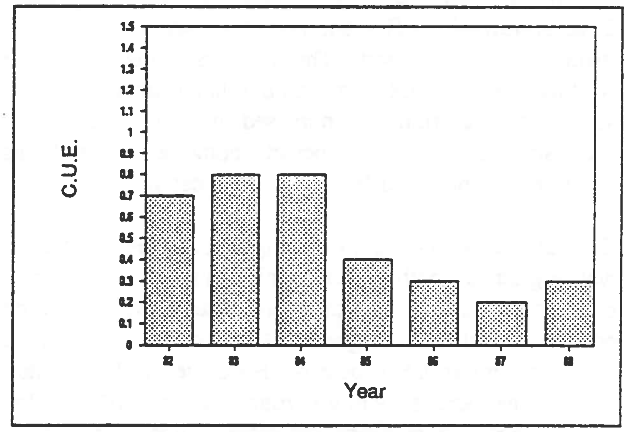


FIGURE 5.7-2
Annual Catch of Walleye Per 2 Hour Gill Net Set at All Locations

not likely due to construction effects on reproduction.

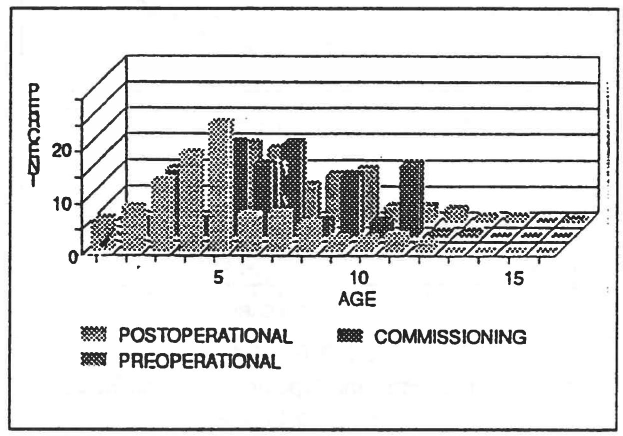


FIGURE 5.7-3
Age Class Composition of Walleye 1981-88

The third component of this Link predicted that the abundance of cisco and whitefish would increase. The relative abundance of cisco and lake whitefish as indicated by gill net CUE fluctuated between pre- and operational surveys. The relative contribution of cisco, and to a lesser extent whitefish to the total gill net catch was substantially higher during the operational period (Table 5.7-1).

The last component of this Link suggested yellow perch might increase in response to increased macrophyte growth. Macrophyte growth has increased since construction and operation of the ATGS began (Link 6) and numbers of yellow perch have increased (Link 5) in beach seine catches. The yellow perch 2-hr. gill net CUE for adult fish has remained between 0.1 and 0.3 from 1981-1988 (Table 5.7-1). The proportion of yellow perch in gill net catches has remained low ranging from 2-7% between 1981-88.

In summary, the accuracy of the predicted effects in this Link is variable. The abundance of northern pike and walleye have decreased. The numbers of cisco and lake whitefish appear stable but their relative contribution to species composition has increased, due to a decrease in other species, and the number of young yellow perch has increased as indicated by beach seine catches.

Growth rate, as illustrated by length at age (Figure 5.7-4), was higher in both northern pike and walleye during operational studies. In fact, growth rate of walleye in the cooling circuit lakes is greater than recorded for walleye in other similar lakes nearby (Baccante, 1990; Freutel, 1990). The increase is more pronounced in northern pike. This observation supports the other trends of decreased abundance of pike and walleye and increased abundance of forage fish. Therefore, the remaining predators have a greater food supply leading to faster growth.

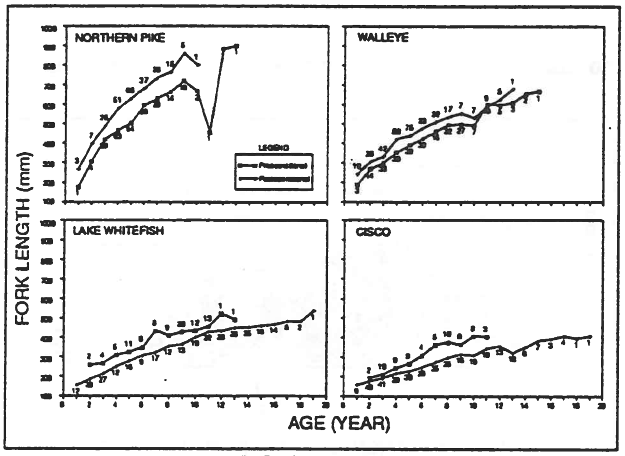


FIGURE 5.7-4
Comparison of Pre- and Operation Growth Rates in Major Fish Species

In contrast, the growth of cisco and lake whitefish was slightly lower during operational surveys (Figure 5.7-4). There have not been noticeable changes in the relative abundance of these species or in the abundance of zooplankton upon which they feed. Zooplankton numbers were lower in Marmion Lake in 1987 compared with those in 1983, but no different from those in 1981. Therefore, the observed changes in growth rate of cisco and whitefish are difficult to attribute to other factors.

5.8 Link 8

Increased macrophytes will result in increased fish production.

It was demonstrated that macrophyte growth and distribution increased in the cooling circuit lakes (Link 6). As demonstrated earlier, the overall number (C.U.E.) of forage fish caught in beach seines increased dramatically in operational surveys.

Therefore, there is no doubt that the abundance of forage species has increased since operation of the ATGS. However, we cannot unequivocally relate the increase to increased macrophyte growth as it might also be due to decreased predation or other environmental factors.

TABLE 5.7-1
Comparison of Gill Net Catches 1982-1988

Species	1982	1983	1984	1985	1986	1987	1988
Cisco	20(1.2)	31(1.6)	19(0.6)	33(1.3)	29(1.1)	42(1.5)	46(1.9)
White Sucker	26(1.6)	23(1.2)	21(0.7)	20(0.8)	18(0.7)	17(0.6)	21(0.9)
Northern Pike	18(1.1)	12(0.6)	19(0.6)	16(0.6)	13(0.5)	8(0.3)	4(0.2)
Lake Whitefish	17(1.1)	16(0.8)	13(0.4)	14(0.5)	26(1.0)	22(0.8)	15(0.6)
Walleye	12(0.7)	15(0.8)	23(0.8)	10(0.4)	8(0.3)	6(0.2)	8(0.3)
Yellow Perch	6(0.1)	2(0.1)	4(0.1)	7(0.3)	5(0.2)	6(0.2)	2(0.1)
Burbot	-1(0.1)	-1(0.1)	0(0.0)	0(0.0)	-1(0.0)	-1(0.0)	2(0.1)
Pumpkinseed	0(0.0)	0(0.0)	0(0.0)	-1(0.1)	0(0.0)	0(0.0)	-1(0.0)
Total Catch	344	644	98	184	1861	2020	888
Catch per 2 hr Set	6.2	5.2	3.2	4.0	3.8	3.6	4.1
(May, Aug and Oct)	(6.2)	(4.6)	(3.2)	(4.0)	(3.2)	(3.6)	(3.9)

Notes: percent composition and (catch per 2 hr set) are presented.

5.9 Link 9

Increased macrophyte abundance will result in changes in the distribution of waterfowl, shorebirds, and muskrats.

Link 9 is probable. There is some evidence to suggest that increased vegetation in the Lower Basin increased the abundance of waterfowl and shorebirds at this site. This may represent more a change in distribution rather than an overall increase in abundance since other sites were much less utilized by birds after construction. There were no data to examine the effect of macrophyte growth on muskrat numbers or distribution.

5.10 Link 10

Stabilized water levels will result in increased production of beavers and muskrats.

A similar effect was discussed in Hypothesis 3, Link 5. The harvest of beaver in the study area has fluctuated but, overall it has remained at a level similar to that in the pre-operation period. The harvest of muskrats in this area substantially declined since operation of the ATGS began. This decline cannot be attributed to operation of the ATGS without detailed examination of the trapping effort and location of trapping.

5.11 Link 11

Changes in fish distribution, species or production will result in changes in angler effort and catch.

The workshop participants (Greig *et al.*, 1984) identified the potential effects of construction and operation of the generating station on angler effort and harvest in the cooling circuit lakes under Hypotheses 4, 5, and 11. The instrument recommended to monitor these impacts was a creel survey, which was undertaken in 1986 and 1987 (Kristmanson and Wismer, 1990). These creel surveys focused on Marmion Lake.

Given the number, variety, and significance of the changes made to Marmion Lake over the last century, and the potentially enduring impacts of all of these changes on the lake's fishery, it is difficult to accept without contrary evidence that the fishery impacts of the changes resulting from the generating station can be isolated from the fishery impacts of all the earlier changes.

The monitoring program did not address the question of how a creel survey would be able to discriminate among the effects of Hypotheses 4, 5, 7, 9, and 11. Nor did it address the possibility that the effects could operate in opposite directions, and cancel each other out to the point that any cumulative effect might be unmeasurable.

Construction and operation of the generating station involves a long succession of hypothesized impacts on angler effort and harvest. Therefore, the 1986-87 creel survey provides a pre-operational benchmark for Hypotheses 5, 7, and 9. It is operational for Hypothesis 11, and it should reflect the beginnings of any impacts of Hypothesis 4. No pre-operational benchmark exists for the two latter Hypotheses.

The results of the 1986-87 creel survey suggest sport fish harvests are well below productivity, in the order of a quarter of sustainable yields. It is most unusual for a productive warmwater lake in road-accessible northwestern Ontario to exhibit such low harvests relative to productivity, unless angler success is also unusually low.

It was concluded that the 1986-87 creel survey very substantially underestimated angler effort and harvests on both south and north Marmion Lake.

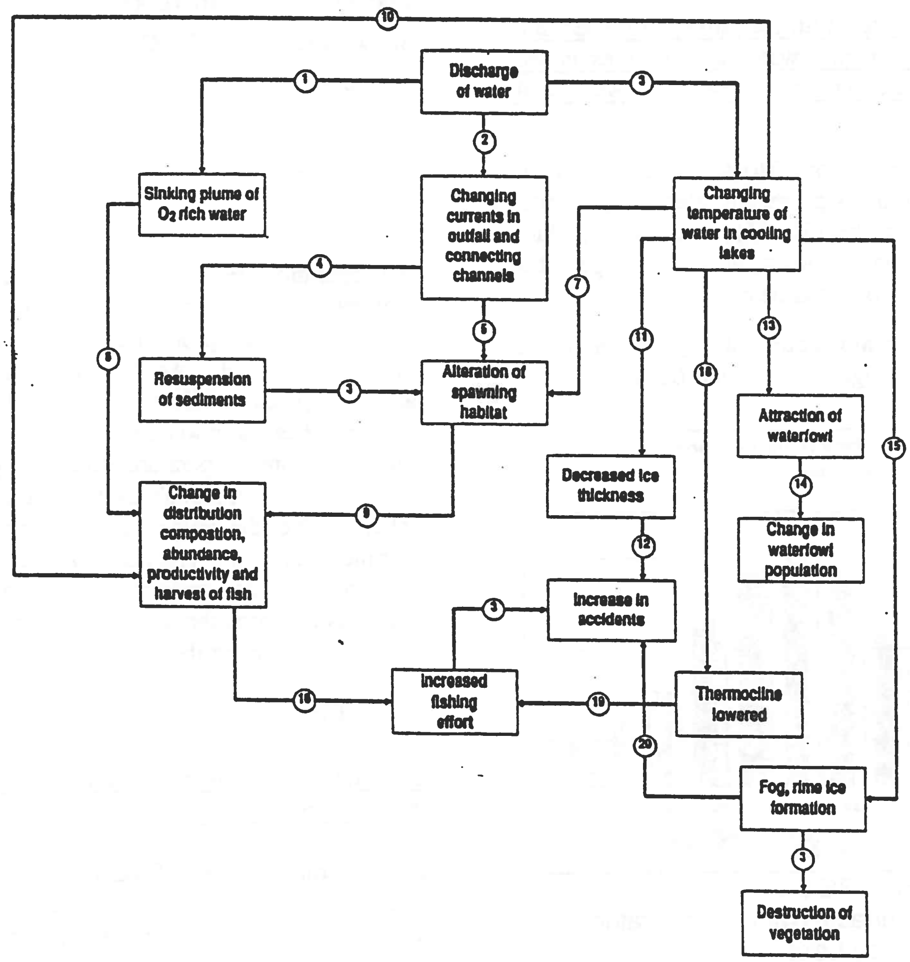
In light of the preceeding discussion, a series of Marmion Lake creel surveys beginning with the 1986-87 survey is unlikely to demonstrate any construction or operations impacts of the Atikokan generating station unless there is a complete collapse of the fishery that cannot be attributed to other causes in the future.

5.12 Link 12

Changes in fish distribution and abundance will result in changes in distribution and production of fish-eating birds and furbearers.

Although monitoring was recommended to document changes in the abundance and distribution of these species (Greig *et al.*, 1984), no data were collected to examine this link.

Hypothesis No. 5: Effects of Discharge of Heated Cooling Water on Fish



Discharges of heated water from the Atikokan Generating Station will lead to physical changes resulting in:

a) changes in the distribution, composition, abundance, productivity, and harvest of fish
b) changes in fishing effort
c) increases in accidents
d) changes in waterfowl
e) destruction of vegetation.

6.1 Link 1

Discharge of water from the Atikokan Generating Station will lead to a sinking plume of oxygen-rich water in Snow, Icy, and Abie Lakes in the winter when water temperatures are less than 4°C.

Operational winter measurements showed well oxygenated water at all depths of Snow and Icy Lakes. These oxygen profiles differ greatly from those taken before the station began operations. This difference is attributed to the combined mixing effects of the water from the station circuit pumps and increased wind action. Mixing due to wind action has increased since both Snow and Icy Lakes remain ice free for most of the winter.

Since the entire lake profile was well-oxygenated, it can be inferred that mixing is occurring throughout the winter and a sinking plume of oxygen rich water did not develop as predicted.

6.2 Link 2

Discharge of water from the Atikokan Generating Station will lead to changing water currents at the outfall, and in the connecting channels at the outlets of Snow, Icy, and Abie Lakes.

As reported in Hypothesis 4, currents in the connecting channels have increased and are now more constant.

6.3 Link 3

Discharge of heated water from the Atikokan Generating Station will lead to changing water temperatures in the first four cooling water lakes: Snow, Icy, Abie, and Marmion.

The ATGS pumps water from Moose Lake into Snow Lake whether the station is producing electricity or not. During station operations heat is added to the water, while during periods of station shutdown, water is pumped at a reduced flowrate with no added heat.

The monthly average temperatures of Icy and Marmion Lakes are presented in Figures 6.3-1 and 6.3-2.

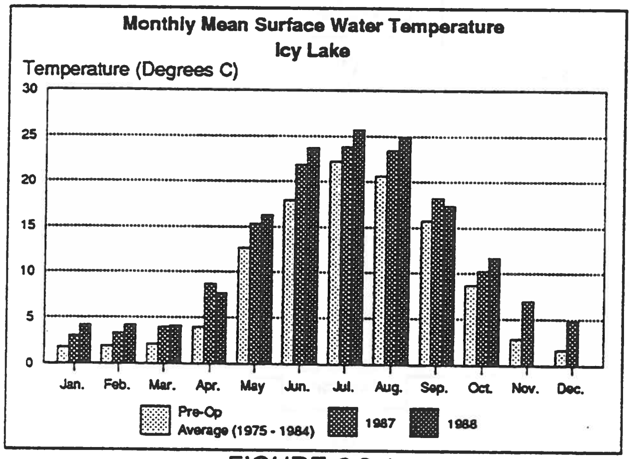


FIGURE 6.3-1
Monthly Mean Surface Water Temperature
Icy Lake

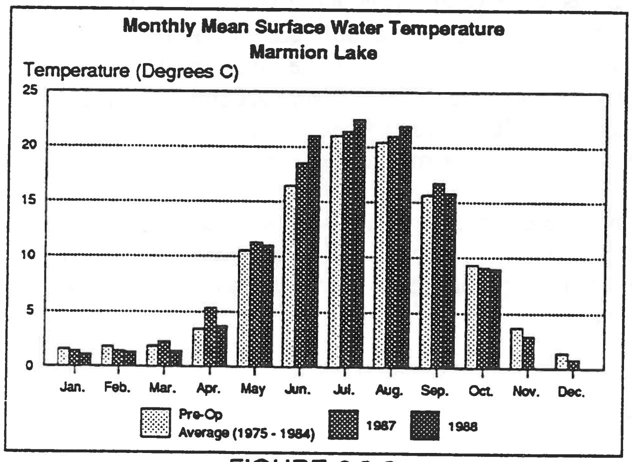


FIGURE 6.3-2
Monthly Mean Surface Water Temperature
Marmion Lake

The maximum monthly mean temperature increases for the first four cooling circuit lakes are:

Location	Average Increase	Range of Maximum Monthly Mean Increases
Snow Lake	5.0°C	2.6-8.4°C
Icy Lake	3.5°C	2.0-5.8°C
Abie Lake	2.7°C	1.1-6.0°C
Marmion Lake	1.0°C	0-4.6°C

The operation of the ATGS has caused the surface temperatures of the cooling circuit lakes to increase. The effects are most pronounced in Snow Lake and the Snow/Icy Channel. As the water flows into the other lakes, temperature effects are reduced. By the time the water reaches Marmion Lake, effects on temperature are minor. Bottom temperature effects are primarily confined to Snow Lake, although at times they extend to Abie Lake. Neither the surface nor the bottom temperatures of Marmion Lake are affected by the ATGS discharges. Pumping of water through the system when the station shuts down causes the temperatures in the cooling circuit lakes to become similar.

6.4 Link 4

Currents in the connecting channels and outfall will cause the resuspension of sediments in Snow and Icy Lakes.

Comparison of monthly Secchi depth measurements from 1981, 1983 and 1988 indicated reduced water transparency in most of the small cooling lakes since the ATGS began operating. However, the reason(s) for reduced transparency may not be simply due to resuspension of sediments.

6.5 Link 5

Changing currents in the outfall and connecting channels will lead to alteration of spawning habitat.

There was concern that walleye might be impacted in the connecting channels if the station stopped discharging water after spawning. This would potentially cause silt to smother the incubating eggs. It was arranged, however, that the station would continue to discharge water and maintain water flows irrespective of station operation.

6.6 Link 6

Deposition of sediments will cause alteration of walleye spawning habitat.

Resuspension of sediments should not be a problem after construction was completed. The establishment of currents in the connecting channels as a result of station operation would tend to keep walleye spawning beds clear of silt.

6.7 Link 7

Changing water temperatures in the cooling water lakes will lead to the alteration of spawning habitat in Snow, Icy, Abie, and Marmion Lakes.

Significant changes in the thermal regimes as a result of station operation occurred only in Snow, Icy and Abie Lakes. Marmion Lake was not affected. Consequently, the only major spawning bed to be influenced by elevated water temperatures was the Snow Lake outlet.

Post-operation spawning observations began in April of 1986. Two observations of interest were noted during this survey: a) ripe walleye and white suckers were present simultaneously at the Ski Lake outlet (normally suckers begin to spawn after walleye have completed spawning), and b) the capture of walleye larvae simultaneously with large numbers of undeveloped walleye eggs on April 29. The walleye larvae must have been spawned one month earlier. This suggests that spawning occurred over a protracted time period or there were two or more spawning runs.

The theory for two or more spawning runs is based on the presence of separate populations coming to the same area to spawn. The resident walleye population in Icy Lake would be exposed to elevated water temperatures due to thermal discharges. Consequently they would be ready to spawn earlier than normal. Walleye resident in Marmion or Abie Lake may also come into the Ski Lake outlet to spawn at the regular time in April, rather than early in March.

In later operational years (1987 and 1988), spawning appeared to start as much as two weeks earlier in Snow Lake compared with the other sites. This is due to the thermal effects of the generating station. The thermal impact could have been much greater, but the ATGS shut down in March during both years which would have slowed maturation of walleye exposed to the thermal discharge. As a result, spawning was more protracted at Snow Lake than at other sites.

Therefore, the discharge of heated cooling water has affected the timing of the walleye spawning run at the Snow Lake outlet. The impact of fluctuating water temperatures due to sporadic station operation is unknown, although, successful reproduction to date is indicated by the presence of larval walleye in drift nets and strong catches of young walleye in the gill nets.

6.8 Link 8

The presence of oxygen-rich water in the hypolimnion of Snow and Icy Lakes during the winter will lead to changes in the distribution, composition, abundance, productivity and harvest of fish.

Although 1987-88 gill net catches of walleye and pike were better in the winter than in the summer, no pre-operational winter gill net data exists for comparison. Subsequently, this link could not be examined in the Environmental Effects Report.

6.9 Link 9

Alteration of spawning habitat will lead to changes in the distribution, composition, abundance, productivity and harvest of fish.

Changes to spawning habitat were discussed in previous Links. There was no clear relation between spawning habitat impacts as a result of the ATGS and fish distribution or abundance.

6.10 Link 10

Changing water temperatures in the cooling water lakes will lead to changes in the distribution, composition, abundance, productivity and harvest of fish.

The observed changes in the fish community cannot be attributed to any one factor. However, one possible effect that can be attributed directly to temperature is the apparent reduction in fish catches in gillnets in the small lakes during the summer. In addition, the presence of open water during the winter has led to angling in the small lakes of the circuit throughout the winter.

6.11 Link 11

Changing water temperatures in the cooling water lakes will lead to decreased ice thickness.

Ice thickness has generally decreased as predicted.

6.12 Link 12

Decreased ice thickness will lead to increased winter accidents.

No data were collected to verify or disprove this suggested Link, however, there have been no winter accidents reported to the Atikokan OPP since the ATGS began operating in 1985.

6.13 Link 13

Open water in the cooling water lakes will lead to the attraction of waterfowl during the winter.

This link was not considered worth monitoring and, subsequently, no studies were initiated. Other researchers have noted significant overwintering of waterfowl in open waters as a result of heated water discharge. Protracted periods of station shutdown in midwinter and subsequent freezing of the lakes could result in mortality of over wintering birds; however, the practice of continuing to operate one pump at all times should mitigate this risk.

6.14 Link 14

Attraction of waterfowl during the winter will lead to changes in the waterfowl population.

No data were gathered to examine this link.

6.15 Link 15

Changing water temperatures in the cooling water lakes will lead to fog and rime ice formation.

No data were collected to examine this effect but anecdotal information suggests that rime ice was more visible on the vegetation around Snow Lake during the operational period. There was no noticeable effect on fog formation.

6.16 Link 16

Changes in the distribution, composition, abundance, productivity and harvest of fish will lead to changes in fishing effort.

There is now winter sport fishing occurring in Snow and Icy Lakes. This may be attributed to change in fish distribution or to increased access through the open water.

6.17 Link 17

Increased fishing effort will lead to increased accidents.

There were no data collected to examine this Link, however no boating accidents on any of the ATGS circuit lakes have been reported to the Atikokan OPP.

6.18 Link 18

Changing water temperatures will result in a lower thermocline in the cooling water lakes.

Results of temperature profile surveys taken during the months of July and August (when maximum stratification usually occurs) indicated that the average thermocline depth in Snow, Icy and Abie Lakes was 1-1.5 metres lower than the normal thermocline depth for those months during the pre-operational years.

The lowering of the thermocline of Snow, Icy and Abie Lakes may be linked to the ATGS operations, but natural variation from year to year could also have an effect.

6.19 Link 19

A lowered thermocline will cause changes in the distribution, composition, abundance, productivity and harvest of fish.

There were no studies available to assess the vertical distribution of fish in relation to the thermocline. However, cold water species such as cisco continue to survive in Snow Lake.

6.20 Link 20

Fog and rime ice formation will lead to an increase in road accidents.

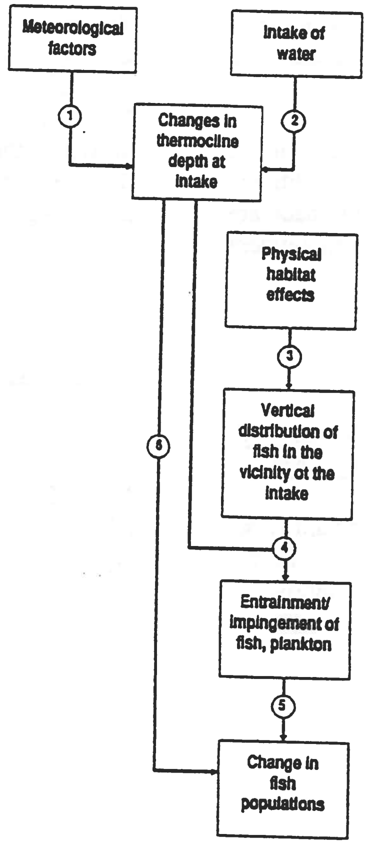
No data were collected to examine this Link.

6.21 Link 21

Fog and rime ice formation will lead to the destruction of terrestrial vegetation.

The scoping workshop report stated that this link was unimportant, since the effects would be "very local".
No data were available concerning the effects on vegetation related to the formation of fog or rime ice resulting from the operation of the Atikokan Generating Station.

Hypothesis No. 6: Effects of the Change in Thermocline of Moose Lake



Withdrawal of cooling water from Moose Lake will lead to reductions in Moose Lake fish populations.

7.1 Link 1

<u>Meteorological factors influence the depth of the thermocline.</u>

Assumed to be true.

7.2 Link 2

<u>The intake of water for the Atikokan TGS will lower the depth of the thermocline in Moose Lake.</u>

The thermocline depth in Moose Lake prior to ATGS operations was 3 to 6 m. During operational summer months, the Moose Lake thermocline has increased in depth approximately 12 m. Therefore, the predicted effect is true.

7.3 Link 3

<u>The distribution of fish habitat in Moose Lake will influence the vertical distribution of fish in the vicinity of the intake.</u>

This Link may be correct although no studies examined the vertical distribution of fish after station operation. Acoustic surveys conducted in 1981 showed that the majority of fish in open water were associated with the thermocline. With the drawdown of the thermocline it must be assumed that the vertical distribution of fish would change.

7.4 Link 4

The vertical distribution of biota in the vicinity of the intake, in combination with the lowered thermocline, will result in the entrainment of significant numbers of fish and plankton.

The vertical distribution of biota would only be affected during periods of stratification, which seasonally at Atikokan is only about one quarter of the year.

The available data suggest very little entrainment of ichthyoplankton is occurring at the ATGS. Additional studies may be warranted since the existing data are limited and this is the only example of TGS entrainment on an inland lake in Ontario.

7.5 Link 5

Entrainment/impingement of biota at the ATGS intake will lead to reductions of fish populations in Moose Lake.

Fish impinged on screens were recorded during pump tests in 1984. A total of 20 fish were impinged during a 15 day period. Sixteen (80%) of the specimens were yellow perch. No walleye, pike or whitefish were reported. Fish impingement during 1986 was reported to be negligible and no data were subsequently reported (Kozopas and Krishnamurthy, 1986). Fish impingement is generally less than 10 fish per month with cyprinids and perch being the most frequent species observed.

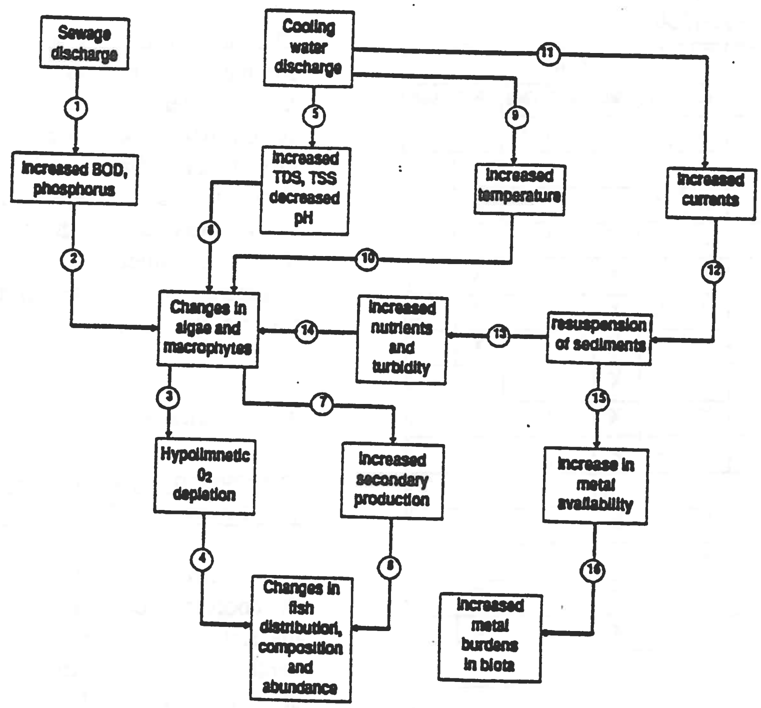
The rate of entrainment and the apparently low rate of impingement would be inadequate to cause a measurable reduction in the abundance of fish in Moose Lake. However, sampling for entrainment at ATGS and potential impact on the local fisheries is generally inadequate given the level of attention these effects have been given at other generating stations.

7.6 Link 6

The lowered thermocline depth will result in a change in the fish population of Moose Lake.

There is no evidence to suggest that fish populations in Moose Lake are affected by the thermocline. Fish surveys taken during the operational period show a community typical of northwestern Ontario lakes.

Hypothesis No. 7: Effects of Discharges on Fish



Discharges of sewage, liquid waste and cooling water from the station will lead to changes in distribution, species composition, abundance and growth of plankton, macrophytes and fish within the cooling circuit lakes.

The rationale for the Hypothesis was that additional nutrients along with the increase in water temperature and stabilization of water levels would change the macrophyte and phytoplankton communities, and increase secondary production. This, in turn, would result in changes in fish distribution, composition and abundance (Greig *et al.*, 1984).

A list of the chemical properties of lake water collected from the circuit lakes is outlined in Table 8.0-1. Several of the surface water parameters including hardness, conductivity, alkalinity, calcium, sodium, magnesium, potassium, chloride, soluble silica, dissolved solids and total organic and inorganic carbon, either increased or decreased in Snow, Icy and Abie Lakes during 1987 to more closely resemble levels in Marmion Lake where levels were relatively constant throughout the study. These changes were attributed to the mass water movements from Moose and Marmion Lakes into the chain of small lakes (Snow, Icy and Abie) via the ATGS cooling water system.

8.1 Link 1

<u>Discharges from sewage lagoons will result in increased BOD and phosphorus.</u>

Relatively large discharges of sewage into Snow Lake occurred when the construction camp was active (1983-1984). Sewage discharges and seepage resulted in increases in total phosphorus, total Kjeldahl nitrogen and BOD in the area adjacent to the discharge stream but they had minimal impact on open water concentrations.

All of the microbiological parameters exceeded acceptable levels (MOE, 1978) at the discharge site (Haymes, 1985b). However, only the total coliforms were considered unacceptable at all three sites. The construction camp was removed in 1984 and production of sewage was reduced.

TABLE 8.0-1
A List of the Chemical Properties of Lake Water Collected from the ATGS Circuit Lakes in The Years 1981-1988.

Parameter	YEAR						
	1981	1982	1983	1985	1986	1987	1988
pH	X	X	X	X	X	X	X
Conductivity	X	X	X			X	
Alkalinity	X	X	X			X	
Hardness	X	X	X			X	
Chloride	X	X	X			X	
Sulphate	X	X	X			X	
Calcium	X	X	X			X	
Magnesium	X	X	X			X	
Sodium	X	X	X			X	
Potassium	X	X	X			X	
Aluminum	X	X	X			X	
Manganese	X	X	X			X	
Zinc	X	X	X			X	
Copper	X	X	X			X	
Nickel	X	X	X			X	
Arsenic	X	X	X			X	
Selenium	X	X	X			X	
Suspended Iron	X	X	X			X	
Dissolved Iron	X	X	X			X	
Mercury	X	X	X			X	
Turbidity	X	X	X			X	
Total Suspended Solids @ 105	X	X	X			X	
Total Suspended Solids @ 550	X	X	X			X	
Total Dissolved Solids @105	X	X	X			X	
Total Dissolved Solids @ 550	X	X	X			X	
Total Phosphorus	X	X	X	X	X	X	X
Soluble Phosphorus	X	X	X	X	X	X	X
Particulate Phosphorus	X						
Total Kjeldahl Nitrogen	X	X	X	X	X	X	X
Nitrate	X	X	X	X	X	X	X
Nitrite	X					X	
Ammonia	X	X	X				
Particulate Nitrogen	X						
Soluble Nitrogen	X						
Total Silica	X	X	X			X	
Soluble Silica	X	X	X			X	
Total Inorganic Carbon	X	X	X			X	
Total Organic Carbon	X	X	X			X	

8.2 Link 2

<u>Increased BOD and phosphorus will result in changes in algae and macrophytes.</u>

The increase in BOD and P in Snow Lake could account for the rapid growth of *Elodea canadensis* and *Najas flexilis* observed in this lake during the operational study period, but it does not explain the increase in macrophyte growth seen elsewhere in the cooling circuit lakes or in the control lake. The fact that an increase in macrophyte growth was seen in the control lake would also suggest that factors other than an increase in nutrient loadings are responsible for changes in macrophyte populations in the cooling circuit lakes.

8.3 Link 3

<u>Increases in algae and macrophyte production will bring about increased O_2 depletion in the hypolimnion.</u>

As outlined in Hypothesis 5, Link 18, the thermocline of the cooling circuit lakes has lowered by 1 to 1.5 m since the station began operating. Along with the increased depth to the thermocline and the hypolimnion, the depth at which oxygen depletion occurs has also increased (Haymes, 1989a). This effect on hypolimnion oxygen levels is directly attributable to station operations, and would likely outweigh any effects due to a change in algae and macrophyte production and subsequent plant decay.

8.4 Link 4

<u>Increased hypolimnetic O_2 depletion will lead to changes in fish distribution, composition and abundance.</u>

A larger portion of the hypolimnion of the small lakes in the circuit was oxygen poor during the summer during operation of the station (Haymes, 1989a). Gill net catches during the summer when oxygen depletion was most severe were very low in the small lakes. It is suggested that many fish may leave the small lakes when oxygen and temperature limitations are greatest. However, lake whitefish and walleye are now present in Snow, Icy and Abie Lakes during the winter months.

8.5 Link 5

<u>Cooling water discharges will result in increased TDS, TSS and altered pH.</u>

TDS levels were significantly lower in 1987 than in the pre-operational period in both surface and bottom samples from Icy and Abie lakes which is the opposite to what was predicted by Greig *et al.* (1984). The workshop participants did not account for increased flushing rates. Marmion Lake water which is characterized by lower TDS levels has simply replaced the water in the smaller circuit lakes. This effect, i.e. decrease in TDS levels, may however, gradually change with time. It is conceivable that, after several years of plant operations, a gradual increase in TDS levels in the system will occur.

The Atikokan cooling circuit lakes are better buffered than most Precambrian Shield lakes due to the dumping of iron ore spoils which contained dolomite which is high in calcium and bicarbonate. The average pH values for the circuit lakes in the preconstruction year of 1975 with the exception of Abie Lake, were comparable to the range of mean values for the other years (Table 8.5-1). Consequently, Link 5 was not validated and the cooling water discharges neither increased levels of suspended and dissolved solids nor decreased pH of the water in the circuit lakes.

TABLE 8.5-1
Significant Differences Among Years for Lakes Where Differences in Mean pH Occurred as Delineated by Duncan's Multiple Range Procedures. Years joined by lines are not significantly different at P<0.05

	1981	1982	1988	1983	1987	1986
AD-S	6.6	7.2	7.2	7.4	7.6	8.1

	1981	1988	1982	1983	1987	1986
Slush-S	6.2	7.0	7.0	7.2	7.5	7.6
MS-S	6.6	7.3	7.2	7.4	7.4	7.9

	1983	1982	1987	1986	1988
Snow-S	7.0	7.1	7.5	7.6	7.7

Hypothesis No. 7 did not address the impact of the change in flushing rates on the water quality of the three small lakes (Snow, Icy, Abie). Assuming a maximum discharge of 6.6 m^3/s in the summer (Greig *et al.*, 1984), the maximum flushing rates were calculated to be 3.6, 9.8, 7.9, 1,252 and 13.8 d for Snow, Icy, Abie, Marmion and Moose lakes, respectively. This represents a substantial increase from those in the pre-operational period. The operation of the Atikokan TGS has resulted in the replacement of harder water in Snow, Icy and Abie Lakes with softer water from Marmion and Moose lakes.

In summary, the primary effect of the operation of the ATGS on water quality was to allow the water in the circuit lakes to become more homogeneous.

8.6 Link 6

Increases in TDS and TSS will lead to increases in algae and macrophytes.

This section discusses phytoplankton (algae) in the circuit lakes with respect to changes in species diversity, species composition, relative abundance and biomass, community structure and primary production.

Species Diversity

Phytoplankton diversity was measured by two methods: 1) the presence/absence of taxa and 2) the calculation of a Shannon-Weaver diversity index which takes into account both species richness and evenness (Poole, 1974).

No effect of the ATGS on phytoplankton diversity could be distinguished from natural interseasonal and intraseasonal variation (Table 8.6-1). The Shannon-Weaver indices of diversity also did not differ significantly among years for each lake (Figure 8.6-1).

TABLE 8.6-1
The Mean (SE) Number of Phytoplankton Taxa Identified on Each Sampling Date in the Circuit Lakes During 1981, 1983, 1987

	1981	1983	1987
Slush	14.6 (3.1)	11 (2.8)	12 (0.9)
Snow	14.8 (2.1)	9.5 (3.1)	13 (2.4)
Icy	12.7 (2.8)	11.7 (2.5)	14.5 (1.4)
Abie	14.2(4.3)	12.0 (1.1)	14.5 (1.2)
Marmion South	16.8 (5.6)	12.0 (1.8)	14.2 (1.2)
Marmion North	16.0 (3.5)	12.2 (2.2)	14.0 (1.8)
Anderson Dam	11.0 (2.1)	11.2 (2.4)	11.3 (1.9)

Species Composition

In the preconstruction, pre-operational years of 1975-76, the most common phytoplankton in the study lakes were the blue-greens (Cyanophyta) and diatoms. However, the Bacillariophyceae (diatoms) and Pyrrophyta (flagellates) were the most common phytoplankton in the study lakes in 1981, 1983 and 1987.

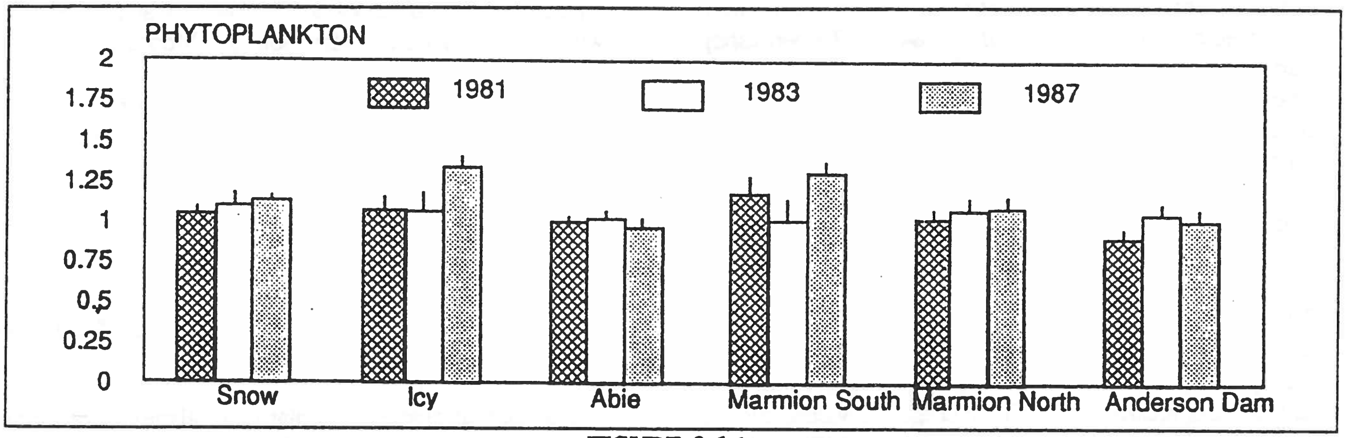


FIGURE 8.6-1
Annual Mean Shannon-Weaver Diversity Indices for Phytoplankton in the ATGS Circuit Lakes in 1981, 1983 and 1987. Bars Represent One Standard Error

Common and widespread (occurring at all locations) taxa included the blue-green algae *Anabaena* sp., *Aphanizomenon flos-aquae*, and *Microcystis* sp., and the chlorophytes (green algae) *Elekatothrix gelatinosa*, *Oocystis* sp., *Stephanodiscus binderanus* and *Tetraedon* sp.. The flagellate *Rhodomonas minuta*, the chrysophyte (golden alga) *Dinobryon* sp. and the diatoms *Asterionella gracillima*, *Rhizosolenia* sp., *Stephanodiscus* sp., *Tabellaria fenestrata*, and a group of unidentified pennates were also among the more common and widespread taxa present in the study area. *Microcystis* sp., *F. crotonensis*, *T. fenestrata* and *Stephanodiscus* spp. were not as widespread in 1981.

Phytoplankton Biomass and Community Structure
The mean phytoplankton biomass increased significantly in the circuit lakes from 1981 to 1983 and from 1981 to 1987 (Table 8.6-2). The increase in 1983 was limited to Snow, Icy and Abie Lakes and was thought to be associated with sewage discharges and seepage to Snow Lake. However, nutrient levels in these lakes did not show a concomitant increase. In 1987 the elevated phytoplankton biomass was not restricted to Snow, Icy and Abie Lakes, but occurred at the three locations in Marmion Lake as well. The measurable increase in phytoplankton biomass throughout the circuit lakes in 1987 was thought to be attributable to changes in nutrient status of the lakes because of the mixing of water from the operation of the ATGS (Haymes, 1989b).

The transfer of water from Moose and Marmion to Snow, Icy and Abie lakes would also result in the transfer of plankton and ultimately in greater similarity in the structure of the phytoplankton communities among these circuit lakes.

TABLE 8.6-2
The Mean (SE) Phytoplankton Biomass (mg/m^3) in Each Circuit Lake For 1981, 1983 and 1987

	1981	1983	1987
Snow	371 (62)	1856 (63)	810 (219)
Icy	348 (74)	963 (179)	1035 (154)
Abie	567 (131)	1430 (565)	1406 (406)
Marmion South	874 (236)	784 (237)	1961 (943)
Marmion North	804 (254)	536 (85)	951 (450)
Anderson Dam	417 (70)	463 (93)	724 (262)
Average % C.V.	56	61	83

Primary Production
The Atikokan TGS has had only a minimal influence on the primary production of Marmion Lake with the trophic status of this lake remaining unchanged. Perhaps the most significant change has been in Snow, Icy and Abie Lakes where production levels have decreased, suggesting that a change in the trophic status of these lakes has occurred. This is not too surprising given that the lakes have probably changed from phytoplankton dominated lakes into macrophytic dominated "rivers" because of the increased flushing rates of the smaller circuit lakes.

8.7 Link 7

Increased algae will lead to increased secondary production

Species Diversity
Zooplankton diversity was measured by two methods: a) the presence/absence of taxa and b) the calculation of a Shannon-Weaver index of diversity which takes into account both species richness and evenness (Poole, 1974).

Species diversity, as reflected by total number of taxa, for both groups of zooplankton varied greatly among lakes and among years and showed no consistent pattern in seasonal succession of species. Variability was attributed to infrequent sampling and changes in the level of identification (Kwik and Dunstall, 1989). The Shannon-Weaver indices of diversity for total zooplankton (combined rotifers, cladocerans and copepods) did not vary significantly among the three years (Figure 8.7-1). Mean annual diversity values ranged from 1.3 to 2.42. Values greater than three are typical of unpolluted waters with diverse plankton communities, whereas values less than one are considered "stressed" (Wilhms and Dorris, 1968).

Species Composition
The zooplankton communities in the lakes included species of microzooplankton or rotifers and macrozooplankton (Cladocera and Copepoda) typical of north-temperate lakes (Schindler and Noven, 1971). The most abundant species of rotifers were *Keratella cochlearis*, *Kellicottia longispina*, *Polyarthra spp.* and *Asplanchna spp.*.

The most abundant species of macrozooplankton included the cladocerans *Daphnia retrocurva*, *Bosmina longirostris*, *Chydorus sphaericus*, *Daphnia longiremis* and *Daphnia galeata mendotae*, the calanoid copepod, *Diaptomus oregonensis* and the cyclopoid copepod *Cyclops bicuspidatus thomasi*. These species typify northern-temperate lakes (Acres, 1976; Schindler and Noven, 1971).

It is interesting to note that *Ceriodaphnia spp.* was not prevalent among the cladocerans and that there was a decline in numbers of *Daphnia galeata mendotae* from 1981 to 1987. *Ceriodaphnia* sp. was a dominant cladoceran species in 1975 in these lakes (Acres, 1976).

Zooplankton Community Structure and Density
Average annual numerical densities of the major zooplankton groups and total zooplankton for 1981, 1983 and 1987 are presented in Table 8.7-1. In summary, the data were too variable and sparse to permit an adequate evaluation of the effects of the ATGS on secondary production in the circuit lakes. Generally, the only effect of the ATGS on zooplankton in the circuit lakes is the apparent increased homogeneity of community structure.

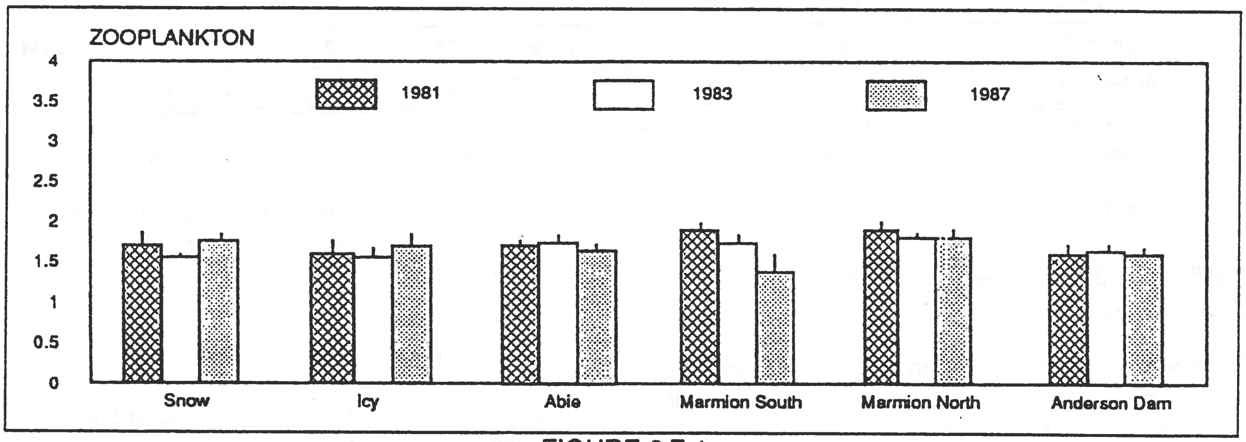


FIGURE 8.7-1
Annual Mean Shannon-Weaver Diversity Indices for Zooplankton at the ATGS Circuit Lakes in 1981, 1983 and 1987. Bars Represent One Standard Error

TABLE 8.7-1
Mean densities (no./m³) of rotifers, crustacean zooplankton and total zooplankton for each lake in 1981, 1983 and 1987 for the months of June to October.

	Pre-Operational						Operational		
Rotifers	1981			1983			1987		
Slush Lake	[a]2,458	[b](424)	[c]30	33,052	(6,811)	46	12,946	(9,745)	168
Snow Lake	32,252	(20,073)	139	241,022	(75,375)	69	50,871	(43,944)	193
Icy Lake	93,445	(40,356)	97	292,637	(84,661)	65	61,551	(31,805)	115
Abie Lake	124,574	(73,130)	131	104,455	(24,750)	53	60,778	(51,247)	189
Marmion South	61,598	(49,391)	179	62,975	(5,659)	20	38,177	(32,609)	171
Marmion North	34,503	(22,429)	145	68,773	(10,848)	35	12,374	(8,636)	156
Anderson Dam	85,646	(30,912)	81	111,102	(15,420)	31	22,691	(15,296)	151
Crustacean Zooplankton									
Slush Lake	4,261	(1,408)	57	28,877	(7,399)	57	11,445	(9,092)	177
Snow Lake	18,306	(3,529)	43	83,934	(21,044)	56	26,785	(23,308)	194
Icy Lake	22,236	(6,558)	66	71,401	(13,253)	42	48,657	(28,582)	131
Abie Lake	33,024	(13,432)	91	77,694	(11,324)	33	18,192	(14,351)	176
Marmion South	22,890	(14,579)	142	42,968	(7,481)	39	27,199	(23,621)	174
Marmion North	14,883	(8,542)	128	49,211	(8,351)	38	9,995	(7,718)	173
Anderson Dam	38,457	(16,967)	98	71,102	(7,148)	23	18,066	(14,589)	181
Total Zooplankton									
Slush Lake	6,719	(1,056)	27	61,930	(12,414)	45	24,391	(18,821)	175
Snow Lake	50,558	(17,856)	79	324,956	(71,992)	50	77,656	(67,248)	194
Icy Lake	115,682	(45,005)	87	364,039	(97,113)	60	110,208	(60,169)	122
Abie Lake	157,599	(76,818)	109	182,149	(22,583)	28	78,971	(65,592)	186
Marmion South	84,489	(63,952)	169	105,944	(3,004)	6	65,377	(56,226)	172
Marmion North	49,387	(30,908)	140	117,984	(15,783)	30	22,369	(16,351)	164
Anderson Dam	124,104	(40,889)	85	249,677	(205,259)	82	40,750	(29,870)	50

a = Mean b = (SE) c = % C.V.

8.8 Link 8

Increased secondary production will lead to changes in the fish community.

There was insufficient data to suggest that secondary production had increased as a result of station operation. Therefore, this Link was not validated.

8.9 Link 9

Cooling water discharges will lead to increased temperatures in cooling water lakes

The average operational temperature increase in Snow, Icy and Abie Lakes was 5.0, 3.5 and 2.7 °C, respectively. Effects on the cooling circuit lakes diminished with increasing distance from the station discharge channel and were minimal by the time water flow reached Marmion Lake.

8.10 Link 10

Increased temperatures in cooling water lakes will increase aquatic macrophytes

The increase in abundance of macrophytes, particularly in some areas of Snow, Icy and Abie Lakes, may be related to thermal discharge. However, the increase may also be due to natural factors since increases in macrophyte populations also occurred in the control lake (Slush Lake). Slush Lake was not influenced by the ATGS thermal discharge.

8.11 Link 11

Cooling water discharges will lead to increased currents

Flow rates in the connecting channels have increased and become more consistent.

8.12 Link 12

Increased currents will result in resuspension and transport of sediments

This was discussed in Hypothesis 5, Link 4. Only casual observations have been recorded since the ATGS began operations.

8.13 Link 13

Resuspension of sediments will increase nutrients and turbidity.

The link between resuspended sediments and increased turbidity was not established. Link 13 was invalid with respect to nutrients since significant increases in nutrient levels (P, TKN, NO_3-NO_2) did not occur in the operational years.

8.14 Link 14

Increased nutrients and turbidity will bring about changes in macrophytes.

Links 2 and 6 indicated that nutrient levels did not increase during the pre-operational study period, making the first part of this link irrelevant. Transparency measurements taken in 1988, showed an increase in turbidity in Snow, Icy and Abie Lakes. An extreme reduction in clarity would reduce photosynthesis and ultimately would result in a decrease in macrophyte populations. The macrophyte data, however, show an increase in the distribution of macrophytes over the study period, indicating that light is not a limiting factor for the growth of macrophytes in the study area.

8.15 Link 15

Resuspension of sediments will increase the availability of metals for uptake by biota.

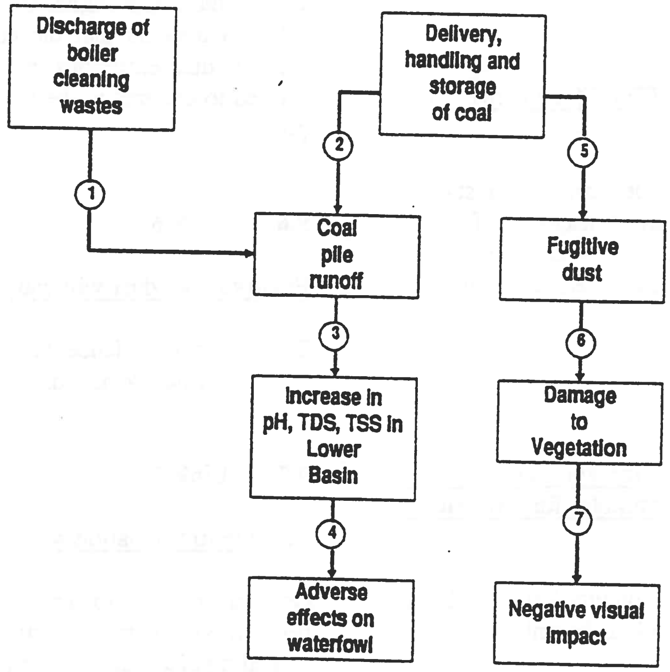
There is no evidence to suggest resuspension of sediments occurred (Link 13). Therefore, increased metal availability by this route would not be expected.

8.16 Link 16

Increased availability of metals will lead to increased body burdens.

Since increased metal availability by this route cannot be supported (Link 15), metal burdens in fish are irrelevant with respect to this mode of action.

Hypothesis No. 8: Effects from Boiler Cleaning and Coal Pile Runoff



The delivery, storage and handling of coal at the station will lead to:

a) damage to vegetation, and negative visual impacts in the vicinity of the station; and

b) changes in pH, TDS and TSS in the Lower Basin. Infrequent releases of liquid wastes from boiler cleaning operations will affect pH, TDS, TSS and phosphorus in the Lower Basin. These water quality changes in the Lower Basin will affect its current status as waterfowl habitat.

9.1 Link 1

Discharges of boiler cleaning wastes will lead to increases in pH, TDS, TSS and phosphorus in the Lower Basin.

All of the chemical parameters, except iron, measured in the Lower Basin in October were comparable to those measured in the circuit lakes in the operational year of 1987. Iron levels were higher in the Lower Basin than those in the circuit lakes prior to and after discharge of the commissioning fluids which suggests that the discharges may not be solely responsible for the high iron levels.

The predictions from this Link of Hypothesis 8 were not validated. There was no significant change in pH values of the water in the Lower Basin and only a temporary measured increase in TSS at the discharge point. Several chemical parameters measured in the Lower Basin after discharge were highest at the point of discharge with levels dissipating rapidly with distance from the source. Away from the point of discharge, the measurements generally were comparable to or below the pre-discharge levels. The only significant effect of the commissioning fluids was an increase in the concentration of copper immediately after discharge.

9.2 Link 2

Precipitation will cause coal pile runoff containing elevated levels of TDS, TSS and pH.

The ATGS lignite is stored in an exposed pile southwest of the generating station and is subject to weathering, i.e. precipitation, resulting in rainwater interaction with the lignite. The lignite pile drainage is directed into a ditch and discharged into the Lower Basin of Moose Lake.

The chemical composition of the coal pile runoff at the ATGS was never characterized, therefore, this prediction was not verified. However, a survey of existing data on coal pile drainage suggests that it is highly unlikely that acid drainage would result from the storage of Bienfait lignite at Atikokan.

9.3 Link 3

Coal pile runoff will increase the TDS, TSS and pH of the Lower Basin.

The pH in the Lower Basin did not change after startup and the increase in TSS at the point of discharge of boiler cleaning fluids was temporary. No change in these chemical parameters in the Lower Basin could be attributed to coal pile runoff.

9.4 Link 4

Significant changes in water quality will result in the Lower Basin becoming less desirable for waterfowl habitat.

Since significant changes in water quality have not been observed we would expect this Link to be unlikely.

9.5 Link 5

Wind action on the lignite in the storage pile may produce fugitive dust emissions.

The Ontario Ministry of the Environment (MOE) conducted a snow sampling survey and moss exposure tests during 1989 to determine if the coal storage area was a source of airborne emissions of substances which might be of environmental concern (Racette and Griffin, 1990b). Elevated concentrations of aluminum, carbon, suspended solids, iron and titanium were observed. The elevated concentrations of most contaminants generally extend no farther than approximately 500 m from the coal storage pile. It appears that the coal storage pile is producing fugitive dust emissions, however, the impact tends to be limited to the area in the immediate vicinity of the storage pile.

9.6 Link 6

Fugitive coal dust will cause damage to vegetation.

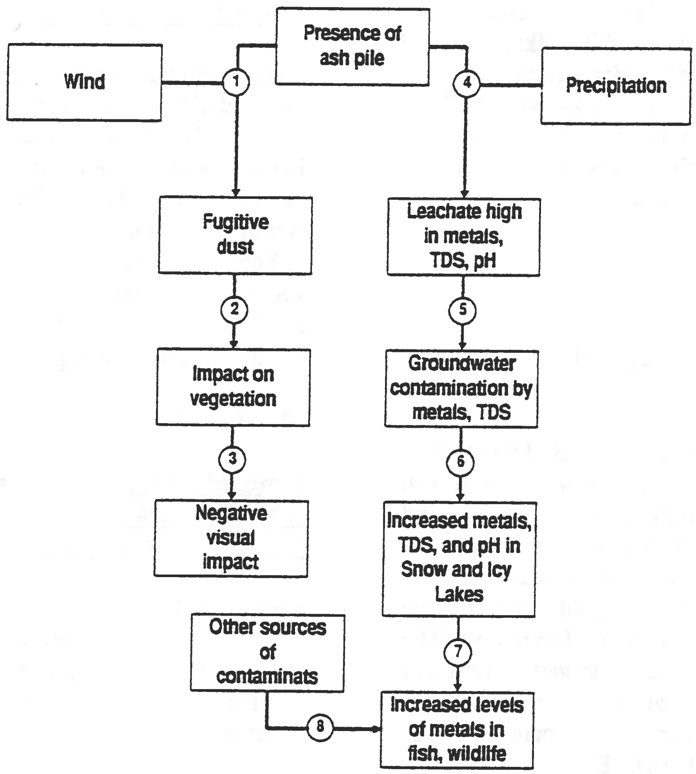
There is no evidence to conclude that any damage to vegetation has occurred, or will occur.

9.7 Link 7

Damage to vegetation will cause a negative visual impact.

No visual damage to vegetation surrounding the ATGS has been reported from casual observations. Given the preceding discussions no impact to terrestrial vegetation as a result of fugitive dust would be expected.

Hypothesis No. 9: Effects of the ATGS Ash Pile on Vegetation, Water Quality and Metal Concentrations in Fish and Wildlife



The presence of an ash pile at the station will lead to:

a) damage to vegetation and negative visual impacts in the vicinity of the station; and

b) changes in water quality leading to increased concentrations of metals in fish and wildlife.

The combustion of lignite coal at the Atikokan TGS produces fly ash and bottom ash. Fly ash was hauled off-site until 1987-1988 to Kidd Creek Mines for use as backfill, however, the bottom ash (and fly ash after 1988) was subsequently disposed onsite.

10.1 Link 1

Strong winds will cause fugitive dust emissions from the ash pile.

The MOE conducted a snow sampling survey and moss exposure tests during 1989. The purpose of this study was to determine if the ash disposal site was a source of airborne emissions of substances which might be of environmental concern (Racette and Griffin, 1990b). This study suggests that fugitive dust is being emitted from the ash disposal site, however, the impact of dust emissions is limited to the area in the immediate vicinity of the disposal site.

10.2 Link 2

Fugitive dust will have an impact on vegetation.

Casual observations did not reveal damage to vegetation in the vicinity of the ATGS. Since fugitive dust emissions are very localized, no damage is expected.

10.3 Link 3

Vegetation damage may be significant enough to create a visual vegetative impact.

There is no evidence to support this assertion. Experience at Thunder Bay TGS suggests that it is unlikely that such an impact will occur.

10.4 Link 4

Precipitation will enhance leaching of metals and TDS.

The composition of bottom ash sluice water effluent was determined experimentally as highly alkaline, well mineralized (calcium, sodium and sulphate), and enriched in aluminum, strontium, barium, boron and silver. Since leachate from the ash pile would in all likelihood have similar characteristics, the decision was made to monitor groundwater for leachate contamination.

10.5 Link 5

Leachate may enter the groundwater resulting in increased metals, TDS and pH.

In the operational period, the concentrations of most major and secondary parameters in groundwater remained unchanged. Calcium, potassium, sodium, chloride and bicarbonate alkalinity levels increased in both the up-gradient and down-gradient wells. The increases in these constituents was attributed to mineralization of the surrounding bed-rock of chloride schist formation. The elevated concentrations of the water parameters were not considered fly ash related since boron and strontium concentrations remained unchanged compared to pre-operational levels (Quarshie, 1988). Boron is one of the most abundant trace elements in fossil fuel waste including fly and bottom ash. Because it is highly leachable in water it is considered a good indicator of leachate movement in soils.

Therefore, there is no apparent contamination of ground water yet that can be attributed to leachate from the ash pile.

10.6 Link 6

Groundwater contaminated by leachate may seep into Snow and Icy Lakes leading to increased metal and TDS concentrations as well as increased pH.

There were no data to suggest that seepage from the ash pile had elevated metal and TDS levels in Snow and Icy Lakes. TDS values in the circuit lakes (Icy and Abie Lakes) were actually lower in the operational years. Although the pH of Snow and Icy Lakes was not significantly higher in all of the operational years, the pH of Snow Lake increased from 1986-1988. Therefore, there was no discernable impact on water quality of Snow and Icy Lakes that could be attributed directly to runoff or leachate from the ash pile.

10.7 Link 7

Increased levels of metals in the cooling lakes (in particular Snow and Icy Lakes) may lead to increased body burdens of metals in fish and wildlife.

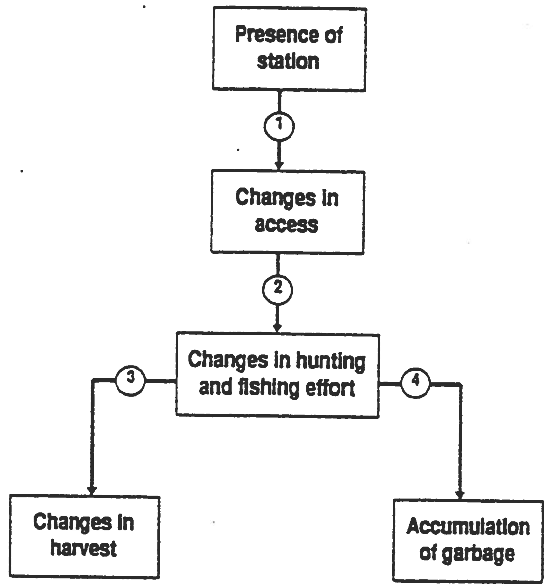
Metal levels in the cooling lakes did not increase significantly in the operational period. This linkage was considered uncertain and difficult to document (Greig *et al.*, 1984) and monitoring of fish and wildlife was **not** recommended.

Hypothesis No. 10: Effects on Increased Noise Levels

Operation of the station will lead to increases in noise levels in the Atikokan area and, consequently complaints from the public.

The workshop participants and Ontario Hydro decided this Hypothesis was highly unlikely and no further action was taken. Therefore, Hypothesis 10 was not addressed in the Environmental Effects Report.

Hypothesis No. 11: Effects on Hunting and Fishing Effort



The existence of the station will lead to changes in hunting and fishing effort in the area and consequent accumulations of garbage in localized areas.

12.1 Link 1

The presence of the station and activities associated with its construction and operation will lead to changes in accessibility of certain areas to hunters and anglers.

The effects hypothesized in the scoping workshop report have incontestably happened. Areas around the generating station formerly available for waterfowl hunting have been closed. The Raft Lake Road has been improved and boat movement between south and north Marmion Lake is more restricted.

12.2 Link 2

Changes in the accessibility of certain areas in the general vicinity of the station will lead to changes in hunting and fishing.

The Ministry of Natural Resources has no information on changes in the spatial distribution of waterfowl hunting effort.

According to the Ministry of Natural Resources, the improvements to the Raft Lake Road did result in increased utilization of the West Dam access to Marmion Lake, however, the increase was not considerable.

12.3 Link 3

Change in hunting and fishing effort will lead to changes in harvests of fish and wildlife.

Regarding waterfowl hunting, there is no evidence of any change in effort. The linkage between angler effort and angler harvest is discussed under Hypothesis 4.

12.4 Link 4

Changes in hunting and fishing effort will lead to localized accumulations of garbage.

According to the Ministry of Natural Resources, any increase in angler use of the West Dam access has not resulted in discernible changes in garbage problems at that site. Impacts were not expected to be substantial, so monitoring was neither recommended nor conducted.

Hypothesis No. 12: Effects of Stack Presence

The presence of the stack will lead to increased mortality of migrating birds and to negative visual effects.

The workshop participants and Ontario Hydro decided this Hypothesis was highly unlikely and no further action was taken. Therefore, Hypothesis 12 is not addressed in the Environmental Effects Report.

4.2 STATISTICAL POWER ANALYSIS OF EEM

Another objective of reviewing the ATGS environmental assessment was to critically review the statistical analysis and design of the environmental monitoring program. This analysis concentrates on the fisheries surveys conducted to examine impacts of the ATGS on whitefish and walleye populations in the cooling circuit lakes.

First, it should be borne in mind that walleye and whitefish were cited in over 20 of the original linkages or predictions of effects (Section 4.1). The linkages were isolated during the scoping process to give some insight into the mechanisms of impacts on the fish populations. However, the intricately related links were all measured by the same parameter, namely abundance of fish. Since many of the expected directions of effect in the predictions were in opposite directions, or had no direction of change, it was immediately impossible to attribute change in fish abundance to any specific link.

Secondly, the original Hypotheses as stated in the scoping workshop were simply not testable. They were more like predictions than true Hypotheses. Therefore, the first program design change would be to restate the starting null hypothesis H_0 to: The ATGS will not change whitefish or walleye fish populations in the cooling circuit lakes.

To statistically examine the available fisheries data it is necessary to account for two aspects of the monitoring design, a) pseudoreplication, and b) power of the test.

Pseudoreplication applies to monitoring programs that attempt to determine an impact by measuring a specific parameter before and after the potential disturbance. There is no spatial component to the measurements. The implication is that repeated measurements of the same parameter at the same place taken after a proposed disturbance (ie. start-up of the ATGS) are not truly independent and, therefore, cannot be treated as replicates (Hubert 1984; Madenjaian *et al.* 1986). To avoid this pitfall the monitoring design must incorporate an Impact and a Control site where both sites are sampled simultaneously (Allen Stewart-Oaten and Murdoch, 1986).

For the Atikokan environmental effects monitoring program no such Control site exists with respect to fisheries (or any other biological component for that matter). It should be noted that in this context Allen Stewart-Oaten and Murdoch, (1986) use the term Control site, whereas the term Reference site is probably more appropriate. There are other similar lakes in northwestern Ontario where the fisheries populations were monitored by the Ontario Ministry of Natural Resources (MNR). The resulting data are useful for a qualitative comparison and some inferences can be made with regard to natural variability and general fisheries trends, but the data were not collected simultaneously or by the same staff or same methods.

Thus, there is no Reference or Control site with which the Atikokan fisheries data can be statistically compared. The available data should be re-examined to account for autocorrelated observations.

The available fisheries data can also be examined with regard to the statistical power of the data used to test the null hypothesis. Statistical power is defined as 1-Beta, where Beta is the probability of failing to reject the H_0 when in fact H_0 is false (Peterman 1990). This is also referred to as a Type II error. Power thus reflects the probability of correctly rejecting Ho. Biological scientists are generally most familiar, and preoccupied with, a Type I error, that is rejecting H_0 when in fact H_0 is actually true.

In the ATGS situation, a Type II error would occur if the H_0 was accepted, that there was no impact on fisheries due to the ATGS, when in fact there has been an impact. The implications of not testing the power of a test by fisheries scientists and managers and accepting the H_0 are outlined by Peterman (1990).

The power is a function of alpha, effect size, sample size and sample variability. Statistical power analysis can be done before the start of data collection (*a priori* analysis) or after their completion (*a posteri* analysis). Since the ATGS monitoring program is complete, an *a posteri* analysis of the ATGS fisheries data was conducted for this review. The *a posteri* analysis is <u>only</u> relevant in examining statistical analysis of data that has already failed to reject Ho. Statistical comparison of the fisheries gill net CUE data for the pre-operational (1982-85) with the operational (1986-88) gill net data reveals a significant increase in whitefish numbers after the ATGS began operating (Haymes and Sheehan 1990; data reanalyzed by ESP, 1992). Therefore, power analysis of the whitefish data is not required.

Statistical analysis revealed no significant change in the abundance of walleye between the pre-operation and operational periods. The lack of statistical difference is likely due in large to the data variability and change in gill net methods between the two sample periods. Power analysis of the data suggests that a seven-fold difference in walleye abundance would have to occur to be detected by the sampling regime conducted at the ATGS. Conversely, to detect a significant change (at $p = 0.05$), a sample size of approximately 600 net sets would have been required for the pre-operation and operation periods (compared with 214 and 275 net sets actually conducted).

Similar studies in the U.S. indicated that impingement of white perch in power plants along the Hudson River reduced population abundance by 10-20% (Brinkhouse *et al.* 1983). However, power analysis showed that given the variability in the baseline data due to natural year class fluctuations at least 20 years of data collection would be required to detect an actual 50% reduction in year class strength (Vaughan and Van Winkle, 1982).

5. Summary and Evaluation of Monitoring Results

5.1 EA RATING METHODOLOGY

The environmental assessment process and environmental effects monitoring programs have been in place for a sufficient period of time that it is now possible to review or audit individual case histories to critically evaluate the efficacy of such programs. An integral part of the EA process is to "predict" environmental effects as a result of the undertaking. The present day process is used to predict the "net effect" of a project after mitigation has been taken into account. However for the ATGS, "effects" were generally considered prior to mitigation, although this was not always obvious in the documentation.

Culhane (1987) developed a series of criteria with which to compare the accuracy of EA "predicted effects" with "observed effects" of various undertakings. The methodology developed by Culhane is followed here as modified by Ontario Hydro (Wismer 1991). The accuracy of the prediction is scored according to five basic categories: 1) Inauditable, due to weaknesses in the predictions or subsequent monitoring programs; 2) Clearly inaccurate; 3) Mostly inaccurate; 4) Mostly accurate; and 5) Accurate. Within each category there are several subcriteria (Table 5.1). For example, if a predicted effect is considered inaccurate, it is informative to know if the actual effect is greater than predicted (criteria 3.2) or less than forecast (criteria 3.3).

The scoring of predicted versus observed effects is in many cases subjective and open to interpretation. This is often due to the vagueness of the original prediction. However, where the original prediction is specific, and subsequent monitoring data sufficient to evaluate the prediction, the judgement should be quite clear.

The predicted effects cited in the original Atikokan Environmental Study Report and Environmental Effects Monitoring program were ranked by five different researchers familiar with the Atikokan study according to the criteria listed in Table 5.1. The results are summarized in Section 5.2. Comparisons of the predicted with observed effects are presented in Table 5.2.

Table 5.1 Observed/Predicted Match Criteria (from Culhane, 1987)

5.	Good Fit (Accurate) 5.1 Close 5.2 Complex, but arguably accurate
4.	Fit Due To Vagueness (Mostly Accurate) 4.1 Within RANGE of VAGUE Forecast ("accurate enough") 4.2 NO clear impact, NONE forecast 4.3 Accuracy INTUITIVELY OBVIOUS 4.4 Impact has NOT YET occurred (see 3.9) ("accurate so far") (time-dependent) (B&T 1988) 4.5 Limited observations indicate support for prediction, but not proof due to survey design weakness
3.	Variance Uncertainty of Fit (Mostly Inaccurate) 3.1 COMPLEX, essentially inaccurate 3.2 Impact EXCEEDS forecast 3.3 Impact LESS than forecast 3.4 Impact DISPUTED 3.5 Impact wholly SPURIOUS (i.e. false, phony, artificial) 3.6 UNANTICIPATED, but beneficial (see 2.2) 3.7 UNDERANTICIPATED, beneficial (see 2.3) 3.8 No CLEAR IMPACT, some impact forecast 3.9 INACCURATE so far (see 4.4)
2.	(clearly) INACCURATE, (it is with no doubt a) COMPLETE MISS 2.1 INCONSISTENT (opposite) match pred/obs 2.2 UNANTICIPATED, adverse (see 3.6) 2.3 UNDERANTICIPATED, adverse (see 3.7)
1.	CANNOT BE SCORED 1.1 Prediction not auditable in practice (no obs., project design change, altered events & conditions assumed to apply in 1982) 1.2 Observation inadequate

Definition of Terms

"Close"
This classification, the most accurate, indicates that either quantified or verbal data show the actual impact to be the same as the forecast; a quantified impact need not be exactly the same as forecast, just so close that the difference is neither materially nor statistically significant.

"Inconsistent"
Impacts are basically opposite from the predicted outcome, with none of the qualifiers below; quantitative indicators of such outcomes should be in the "wrong" direction.

"Exceeds" and "Less"
An impact's indicator is numerically higher or lower than the value predicated, but is in the general direction forecast.

"No Clear Impact, No Impact Forecast" and "No Clear Impact, Some Change Forecast"
In cases of "No impact" forecasts and forecasts of some change, no project-related impact is clearly discernible, usually because of data limitation (e.g. an "excessive variance" data series).

"Not Yet"
A predicted outcome had not occurred by the time of the fieldwork, but field information suggests the outcome is still scheduled or possible.

"Complex, Basically Accurate" and "Complex, Basically Inaccurate"
In these two classifications auditors could not make a clearcut conclusion because of a definitional problem about an impact, but in their best professional informed judgement the forecast is arguably correct or incorrect.

"Impact Within the Range of a Vague Forecast"
This important classification covers cases where the impact is relatively clear but the forecast is too vague to be rated accurate; that is, the actual impact falls within the range of possible impacts allowed by the vague forecast.

"Unanticipated, Adverse" and "Unanticipated, Beneficial"
EIS writers failed to forecast these actual impacts, with serendipity distinguished from adverse unanticipated impacts because the EIS process is designed to prevent the latter.

"Underanticipated, Adverse" and "Underanticipated, Beneficial"
These codes cover passages that are so evasive that a reasonable coder might not even recognize them as forecasts.

"Dispute"
An inherently subjective impact or outcome is disputed by informants.

"Accuracy Intuitively Obvious"
These impacts must logically occur if the proposed project is implemented; such "incidental impact" forecasts were audited only in the absence of good forecasts within a category during fieldwork.

"Spurious"
In several cases an apparent impact proved to be caused by something wholly unrelated to the project.

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
Program Predictions		
The 1977 load forecast is average growth will be 5.5% per annum in the West System	No prediction	Actual load demand from 1975-1986 in the west system increased by an average 2.7% per annum (3.2% for all Ontario)
Type and Capacity The generating capacity of the station will be 800 MW produced by four 200 MW units (1977).	No prediction	The original design was modified to use only one 200 MW unit in 1981
Station Facilities The area proposed for dry ash disposal is the Lower Basin	No prediction	Ash disposed of in a burrow pit not Lower Basin
Utilization of Station The average annual capacity factor for this station will be 70% for the first 10 years, 50% for the second 10 years and 30% thereafter. The economic lifetime of the station is considered to be 30 years		Average annual load from 1986-1989 varied between 20.3-75.0%
Manpower Requirements The maximum permanent operations staff for the coming thirty years from 1984 will be 120		
Fuel The proposed fuel is Saskatchewan lignite coal which has a much lower sulphur content than bituminus coal. The lower ash content results in smaller ash disposal site requirements and reduces particulate emissions.	None, by 1984 factual	Saskatchewan lignite coal is used. Ash quantities are measured and emissions monitored, but no quantified comparison of ash or emissions with any other types of coal.
At maximum capacity rating, the fuel consumption for the station will be about 155 tonnes/hr.	None, by 1984 factual	Fuel consumption estimates modified and are now as predicted
Based on 200 MW, the maximum quantity of coal stored at the station is estimated at 295,000 tonnes	None, by 1984 factual	Station is 200 MW. Maximum coal storage (1986-89 was 185,737 tonnes.
Water Quality Monitoring Monitoring of flow, pH, suspended and dissolved solids on a weekly basis will be undertaken at the cooling water intake and outfall as well as for coal pile, ash disposal area and neutralizing sump discharges	No prediction	These parameters were monitored at intake and outfall only for Compliance Monitoring Program. Data actually reported only 43% of the time
Fly Ash It is proposed that a master landscaping plan be prepared which can be implemented progressively as each 2 to 3 acres is filled to final grade		A master landscaping plan for the ash disposal site was prepared.

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
Population If both mines remain operational, the total population will rise to about 7,600 by 1983 and drop to just over 7,000 in 1985	No predictions	Two mines closed, overall population decreased about 988 in 1985
If one mines ceases operations in 1981, the total population will peak at about 7,000 in 1980, dropping to slightly more than 5,000 by 1985		
Housing Assuming both mines remain in operation, a demand for an additional 520 dwelling units, 390 of which may be attributable to the Hydro project, is forecast for 1982	No predictions	Housing shortage did not develop due to mine closures
Education No strain will be placed upon existing educational facilities	No prediction	As predicted
Medical The facilities in the town such as the hospital and the medical clinic should not require any further expansion	No predictions	Facilities were adequate. Hydro contributed $60,000 toward new clinic
Historical Areas No significant impact is foreseen on historical areas during the construction period	No predictions	No impacts reported
Municipal and Community Services Municipal and community services may have to be upgraded somewhat in order to handle increased usage No increased industrial activity Upgrades to sewage and water treatment plants required Hydro grants will offset capital requirements for projects	No predictions	Fire and Police service adequate but Hydro contributed for new Police radar No observed changes Hydro contributed to upgrade although they were needed before ATGS
Noise Because of the remote location of the area, with no permanent residences within a 2-mile radius of the site, the overall effect on the public beyond the site boundary will be minimal	Hypothesis 10: Increased noise from station	No complaints of noise reported but monitoring not recommended at Workshop

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
Biting Fly Control If the need arises, construction staff will be protected against blackflies, mosquitoes and other biting insects by suitable control measures. Such control procedures should ensure that the application of insecticides will have little effect on water quality, wildlife and vegetation in the site area		No data
Population As emissions will not exceed regulatory levels, there should be no adverse health effects upon the resident population of the area	No prediction	No adverse health effects reported
IMPACT OF CONSTRUCTION ACTIVITIES		
Construction Facilities It is expected that almost 200 families of construction workers will require accommodation near or in Atikokan	No prediction	Increase did not occur due to closure of mines
Traffic A maximum of 200 cars will be on the highway during the morning and evening peak rush hours in 1982. Road improvements may be required	No prediction	Road improvements undertaken
Construction Workforce Distribution The construction workforce for the project will be expected to peak in 1982 when the year's average requirements is estimated at 1260 workers. This will drop to about 70 in 1985 when station construction should be completed		Pattern of change occurred but numbers not accurate
Control and Restoration Erosion in the form of dust from construction parking areas and access roads will be controlled by water spraying		Unknown if implemented
Environmental Effects During Construction **Air** Atmospheric emissions during the construction stage will be mainly limited to particulate matter	No equivalent predictions for construction phase	Assumed to be true
Community The particulate matter produced during construction will settle rapidly and should not pose any health problems.		No health problems were observed
Vegetation Premature leaf drop may occur among evergreens. Otherwise, the effects will be mainly visual and of a temporary nature		Only casual observations of vegetation were noted and no effects reported

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
Wildlife The effect of air emissions on wildlife during construction should be negligible		No specific program implemented to monitor this prediction but assumed to be true
Cooling Circuit Lake System Site preparation involving clearing, grubbing and grading will result in increased soil erosion and suspended material entering adjacent water bodies		Assumed to be true. There were no reports of visible turbidity.
Erosion of sediments will reduce macrophyte development		Macrophytes have increased but change not linked to ATGS
Cooling water flow per unit will be 4.4 m^3/s at normal full load		Water flow maintained at 6.2 m^3/s at normal full load
The length of the intake tunnel will be 540 m		Tunnel length is 900 m
The flow velocity in the forebay will be limited to less than 0.3 m/s to allow the formation of ice over Moose Lake preventing any intrusion of floating or frazil ice into the intake		Solid ice cover forms on Moose Lake
Channel enlargements between the small lakes will be designed to minimize silt entrainment with flow velocities in the order of 1 to 2 ft/s (0.3 to 0.6 m/s)	No prediction	Water flow velocities in channels ranged from 0.2 - 0.8 m/s
The purposes of the control weirs are to modify and control the water levels in the lakes and prevent the migration of fish and larvae from Marmion Lake into Abie Lake		Water levels are maintained but there is movement of fish into Abie Lake because there is no weir between Abie and Marmion.
Water Levels and Supply	Hypothesis 3: Decreased water storage in Seine River	As predicted
	Increase risk of downstream flooding	No assessment
	Reduced downstream supply of water during low flow	No assessment
	Reduce water supply will increase demand from other sources	No assessment and difficult to measure
	Changes in water levels will reduce fish and wildlife habitat	Loss of habitat likely occurred but monitoring not recommended
	There will be decreased hydro-electric generating capacity downstream of Marmion Lake	No evidence of such an impact
During spring freshet the level will be maintained by discharging from Marmion Lake into the Seine River.		Water is discharged in the Seine River
The level of Snow Lake will be lowered about 0.3 m		Snow Lake level raised 1.1 m
Icy Lake will increase approximately 0.6m		Icy Lake level lowered 1.0 m

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
The level of Abie Lake will be increased approximately 2.2 m		Abie Lake level not changed
Moose Lake level will be raised about 2.7 m to the level of Marmion Lake by opening the Anderson Dam		Moose Lake level raised 2.7 m
	Hypothesis 4: Stable water levels in the cooling lakes	Water levels have become more stable
Aquatic Life In general, construction activities are anticipated to have only minimal effects on the existing aquatic biological communities in Moose, Snow, Icy, Abie lakes and the eastern end of Marmion Lake	No equivalent prediction	Overall changes related to construction activities probably had more significant impact than operations
The influx of water from Marmion Lake may result in a slight increase in existing plankton populations	No equivalent prediction	Primary production decreased in Snow, Icy and Abie lakes but increased in Marmion Lake
Excavation to enlarge existing channels will result in a localized increase in turbidity with a concomitant decrease in plankton activity	No equivalent prediction	Increased turbidity not reported but assumed to be true. Overall production in small circuit lakes decreased but probably due to dilution effect
Suspension of sediments in the vicinity of the Moose Lake intake during construction will be confined and cause only a limited loss in plankton activity	No equivalent prediction	No observed change in plankton activity
	Hypothesis 4: Construction of dams and channels: Altered current patterns and substrates	Currents have increased and become more constant when station is operational. Impact on substrates has not been documented
	Will change fish distribution	This has occurred but not quantified
Destruction of existing benthic communities and fish spawning beds in channels will also occur	Altered the availability of spawning habitat	Number of walleye spawning areas reduced
	Increased production of northern pike	Decreased abundance
	Increase in the distribution of macrophytes	Increase in distrubution and development but change not linked to ATGS
	Changes in habitat will cause changes in fish distribution, production and species composition	These changes have occurred but cannot be attributed to any one factor
	Increased macrophytes will increase perch production	Number of perch has increased but likely due to several factors
	Decreased abundance of forage fish	Increased abundance
	Unknown effects on walleye production	Relative abundance appears to have decreased

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
	Loss of fish and wildlife habitat	Some loss of walleye spawning areas and waterfowl staging areas
	Increased macrophytes will increase fish production	No demonstrated relation between these two variables
	Increase in numbers of whitefish	Populations not changed or slight increase
Terrestrial Life Construction activities will disturb and eliminate wildlife habitat	Hypothesis 4: Change in distribution of waterfowl and furbearers	Insufficient data to determine effects on distribution but habitat lost
The potential impact of the proposed development on furbearing mammals will be of a local nature only Assuming the Marmion Lake flats and the Upper Basin are left undisturbed the potential impact on waterfowl habitat will be negligible		Impacts difficult to ascertain but are certainly "local" in nature Marmion Lake flats were flooded, destroying waterfowl habitat
Stabilized water levels should generally improve waterfowl and resident shore bird nesting		Not assessed
	Hypothesis 4: Stable water levels will increase beaver and muskrat production	Beaver harvest has fluctuated while muskrat harvest has declined, but actual production not directly measured
	Hypothesis 4: Changes in angler effort and fish habitat	Data inconclusive
	Changes in fish distribution and abundance will change abundance of fish-eating birds	No assessment
Providing that clearing is not undertaken during the nesting season (May 15 to July 15), virtually no disturbance to waterfowl will result		No monitoring implemented. Unknown if clearing ceased during nesting season
Excavation and channelling through Snowy, Icy and Abie lakes, will disturb or eliminate any beaver dams that exist in these lakes		Beaver dams removed
Recreation and Parkland During construction, increased duck hunting should be anticipated in the populated areas. There will also be increased hunting pressures on the moose population due to the large influx of additional people to the area		Increased hunting but no measure of impact
To overcome elevation difference between the northern portion of Marmion Lake and the Seine River levels upstream of Raft Lake dam, it is proposed that Ontario Hydro install manually-operated facilities capable of handling boats up to 4.9 m in size		There is an operational marine railway.
Recreation facilities adequate		As predicted

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
	Hypothesis 11: Changes in accessibility of certain areas to hunters and anglers Changes in hunting and fishing due to changes in accessibility	Waterfowl hunting areas have been closed, Raft Lake Road has been improved and movement between north and south Marmion Lake is more restricted. No information on changes in hunting effort, slight increase in use of the West Dam access to Marmion Lake reported.
	Changes in harvest of fish and wildlife in response to changes in effort.	Monitoring not recommended.
	Localized accumulations of garbage in response to changes in effort.	There was evidence of increased garbage accumulations at Anderson Dam so garbage pickup at this site was arranged.
ENVIRONMENTAL EFFECTS DUE TO OPERATION		
Effects of Atmospheric Emissions: Air Quality **Sulphur Oxides** The stack will produce a maximum ground level concentration of sulphur dioxide of 0.072 ppm approximately 3 miles (4.8 km) downwind of the stack	Hypothesis 1: Atmospheric emissions will not change local air quality	No changes have been detected Maximum measured SO_2 concentration was only 0.050 ppm
Total sulphur dioxide emissions for two units (2 x 200 MW), over the lifetime of the station (30 years), would equal approximately 11,820 tonnes		Sulphur dioxide emissions underestimated. Emissions of SO_2 in 1988 were 5130 Mg (15,200 Tonnes for the first four years).
The reduced stack height (145 m) will not significantly increase the incidence of fumigation relative to that of the 198 m stack	No equivalent predictions	Assumed to be true
Particulate Matter Maximum ground level concentrations of particulate matter will be approximately 5% of the air quality criteria	No equivalent predictions	Maximum particulate levels exceeded 5% of criteria (120 ug/m^3) but levels attributed to sources other than ATGS
Nitrogen Oxides Maximum ground level concentrations of Nitrogen oxides emissions will be less than 15% of the air quality criteria	No equivalent predictions	Measured nitrogen levels verified this prediction
Other Stack Emissions For most of the elements for which air quality criteria exist, the calculated concentrations will be less than 1% of the regulatory standards. Levels of iron and fluorides are more significant at 1.3% and 7% of the air quality criteria respectively.	No equivalent predictions	Air concentrations of elements not measured directly, but MOE terrestrial and depositional studies show decreased levels of elements, particularly iron and arsenic since start of ATGS
Plume Visibility The precipitators will limit particulate emissions to a level that will produce a clear plume under normal operating conditions.	No predictions	As predicted

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
The flue emissions will contain water vapour which condenses particularly during cold weather, to produce a visible water vapour plume		As predicted
Under conditions when emissions are temporarily confined within a stable atmosphere, the reddish-brown colour of nitrogen dioxide may be visible. This colour will disappear on subsequent break up of the stable atmosphere		As predicted
Acid Precipitation There will be no measurable increase in precipitation acidity due to the generating station		No measurable increase has occurred
	Hypothesis 2: Emissions will increase acidic and trace element deposition	No measurable increase has occurred
	No effects on water quality due to emissions	No water quality changes attributed to emissions
	No effects on aquatic biota due to emissions	No detectable impacts on aquatic biota due to emissions
	Hypothesis 1: Emissions will impact ambient air quality near the ATGS	No changes in air quality measured.
Assuming dry deposition accounts for 70% of total wet plus dry deposition of a substance, and applying a deposition velocity of 1 cm/s total annual deposition at Quetico Provincial Park is equivalent to 0.076 g SO_4/m^2/yr. or a total of 2.280 g/m^2 after 30 years	No prediction	Annual wet deposition of SO_4 at Quetico during operational period from SO_2 was ~ 0.07 g/m^2/yr. Therefore, annual total was 0.23 g/m^2/yr.
Water Quality Existing concentrations of sulphate in the lakes of the area are about 5 mg/L. Sulphate increases to these lakes as a result of station operations over a period of 30 years would be less than 1 mg/L.		No water quality changes attributed to emissions
No reduction in the water quality of lakes of the area, particularly those within Quetico Provincial Park, is anticipated as a result of sulphur dioxide emissions from the generating station	Hypothesis 2: No effects on water quality due to emissions	No reduction in water quality was measured
	No effects on aquatic biota due to emissions	No detectable impacts on aquatic biota due to emissions
Vegetation There is expected to be no vegetation damage resulting from sulphur dioxide emissions during plant operations	Hypothesis 1: No impacts of emissions on terrestrial vegetation	No detectable change
	Increased deposition will change soil chemistry	Deposition did not increase so soil chemistry not affected

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
	Changes in soil chemistry will change ground water chemistry	No impact on groundwater chemistry expected
	Impacts on vegetation will change forest species composition	No measurements but effect not expected
	Changes in forest species could lead to loss of some wildlife species	No measurements but effect not likely
Other On-Site Emissions Dust is produced at the fuel storage pile primarily by vehicular movement and wind eddies.	Hypothesis 8: Increase in fugitive dust due to handling delivery and storage of coal	Effects from fugitive dust are very localized
	Fugitive coal dust will cause damage to vegetation	No evidence of damage to vegetation
	Damage to vegetation will have a negative visual impact	No evidence of damage to vegetation
Similar dust sources will be present at the dry ash disposal area. Wet spraying control methods, layering of wet bottom ash over dry fly ash and vegetation on completed portions of the storage area will be adopted to reduce emissions	Hypothesis 9 Wind will cause fugitive dust from ash pile	Effects from fugitive dust are localized
	Increased damage to vegetation from fugitive dust from ash pile	Damage to vegetation could not be attributed to fugitive dust from the ATGS ash pile
	Vegetation damage may have a negative visual impact	No evidence to suggest this has occurred
	Precipitation will leach metals and TDS from ash	As predicted (MISA data)
	Increased metal body burdens in fish and wildlife from ash pile presence	Insufficient data
	Groundwater contamination by ash pile leachate	No groundwater contamination could be attributed to ash pile leachate
Regulatory Implications An operational control program, including a monitoring system, will be incorporated to ensure the air quality criteria are not exceeded during station operation	No predictions, factual by 1984	Air monitoring system was implemented, but there was no indication of an operational control program.
Wildlife A potential effect on wildlife associated with the control of atmospheric emission is impingement of migrating birds against the 650-ft stack	Hypothesis 12: Increased mortality of migrating birds and negative visual effects due to presence of stack	Monitoring not recommended at 1984 Workshop

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
Industry Operation of the proposed generating station is not expected to have any detrimental effect on any of the industries in the area	No prediction	No effects reported
Climate This proposed generating station is not expected to have any measurable effect on the local climate	No prediction	No impact reported, assumed to be true
Recreation The area affected by stack emissions will extend into Quetico Provincial Park and the air quality in this area will be very slightly degraded as a result of the emissions from the station. However, the resulting air quality should not have a detrimental affect on the recreational use of the park		No impact on air quality. No effect on park use reported or expected
	Hypothesis 2: There will be changes in fishing effort	Now a winter fishery in Snow Lake
	Increased fishing effort will lead to increased accidents	No evidence to support this
a) Direct Thermal Effects **Fog and Rime Ice** It can be assumed that there will not be more than one or two days of fog per month from the warmer lakes in the chain, with the exception of late March and November when conditions are favourable for fog formation	Hypothesis 5: Increased fog and rime ice formation	Fog is reported particularly around Snow Lake but occurrence not quantified
Rime ice is formed when water vapour condenses and freezes on cool surfaces. It is concluded that ice deposition should not pose any hazard to structures or roads near the warm water discharge		No hazards reported due to rime ice
	Hypopthesis 5: Increased vegetation destruction from rime ice	No assessment
	Decreased ice thickness will lead to increased winter accidents	No accidents have occurred
	Thermocline lowered in the cooling circuit lakes	The average operational thermocline depth in Snow, Icy and Abie Lakes is 1-1.5 metres lower than it was during the pre-operational years. Operational Moose Lake thermocline depth was 8-10 metres deeper than in the 1975-1980 period
	Lowered thermocline will change distribution and abundance of fish	May have reduced presence in small lakes but not directly assessed

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
Water **Thermal Discharges** Most of the cooling of the heated discharge water takes place well before the end of the lake circuit. The maximum down-lake excess temperature is less than 1°C for the last 3 or 4 km from the end of the cooling water circuit	Hypothesis 5: Change in temperature of water in cooling lakes (eg. up to 14°C in Snow Lake and 2°C in Marmion Lake)	All excess heat dissipated in small circuit lakes before reaching Marmion Lake Temperatures have increased less than expected in Snow Lake
At full load the temperature of the station discharge into Snow Lake will be in the range of 32-33°C in summer to 17-21°C in winter		Discharge temperatures close to predicted
Modifications to the Current Regime The once-through cooling water flow will be approximately 336,000 USGPM (21.2 m^3/s) which will result in velocities of 1 to 2 ft/s (0.3 to 0.6 m/s) in the channels between the small lakes	Water discharge from ATGS will change water currents in connecting channels	Cooling water volume approximately 6.2 m^3/s with velocities ranging from 0.2 - 0.8 m/s.
Ice At the entrance to Marmion Lake there will be some open water throughout the whole year. Therefore, final freeze-up will never occur for the cooling water system under full load conditions	Decreased ice thickness on the cooling circuit lakes Open water in winter will attract waterfowl Attraction of waterfowl will change waterfowl production	True: Snow and Icy Lakes remain relatively ice free when the station is operating No monitoring recommended or carried out No assessment
Water Quality The intake and discharge flow pattern will change the existing hydraulic regime which will tend to eliminate any differences in concentration of the various chemical parameters		Water quality in the circuit lakes has become similar
There will be a slight increase in dissolved solids and alkalinity at the discharge. Given the size of the cooling water system, the increase in dissolved solids concentration may not be measurable		No overall change in TDS has been detected
The heated discharge may increase the rate of biological decomposition of organic matter in turn, increase the oxygen demand. The exact balance of oxygen demand and supply is currently too difficult and complicated to predict		Not assessed
The addition of heat to Marmion Lake will affect the stratification period and depth at which the thermocline will form. The extent of alteration to the hypolimnion/epilimnion ratio and dissolved oxygen between these two layers cannot be determined at this time		Thermocline in Marmion Lake not affected

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
	Temperatures will increase in receiving lakes	Temperatures increased 2-5°C in Snow, Icy and Abie Lake but not affected in Marmion Lake
	Increased temperatures will increase macrophytes	Increased macrophytes observed but change was not temperature related
	Increased temperatures will increase secondary production	No increase in secondary production but data were considered insufficient
	Increased secondary production will change fish community	Changes in fish community cannot be linked to secondary productivity
	Cooling water discharge will increase water currents	This has occurred
	Increased availability of metals to biota hence increased body burdens	Some indication of higher metal levels but more analysis required
	Increase nutrients and turbidity due to resuspension of sediments	Turbidity did not increase significantly and significant increases in nutrients (P,TKN,NO_3,NO_2) did not occur in the operational year
	Sinking plume of O_2 rich water in winter (in Snow, Icy and Abie Lakes)	Well oxygenated water at all depths of Snow and Icy Lakes due to circulation
	Resuspension of sediments in Snow and Ice Lakes	No data to support any conclusions about sediment resuspension
	Altered currents will alter spawning habitat	Presumed to be true
	Deposition of sediments will alter walleye spawning habitat	Increased currents have likely decreased sediment deposition in channels
	Changing water temperatures will alter spawning habitat in all lakes	Walleye spawning at outlet of Snow Lake affected
	Presence of oxygen-rich water in Snow and Icy Lakes will change fish abundance and distribution	No comparable pre-operational studies
	Altered spawning habitat will change species composition and abundance	No clear link between habitat changes and changes in fish populations
	Changes in water temperature will change distribution, composition and abundance of fish	Decreased numbers of fish in small cooling circuit lakes likely due to elevated temperatures (especially in the summer).
i) Effects on Fish Numbers Water temperatures during the summer months in Snow, Icy and Abie lakes will result in the mortality of walleye, white sucker and yellow perch which enter and remain in these locations		Mortality or avoidance resulted in fewer fish in these lakes during summer

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
Fish exposed to discharge temperatures in the east arm of Marmion Lake should not be exposed to lethal temperatures during the year		This is true
Mortalities may be anticipated with fish populations resident in the three small lakes, particularly Snow Lake, if exposed to a temperature drop should the generating station be forced to shutdown		Not assessed
ii) Fish Spawning and Growth On the basis of predicted thermal regimes for Snow, Icy and Abie lakes, unlike Marmion Lake, temperatures will never decline sufficiently to induce spawning activity of cisco, whitefish or burbot, but may induce premature responses of the spring spawners.		Walleye spawning at Snow Lake advanced but no assessment of other species
Increases in water temperatures of these lakes during the summer months will result in the death of any juvenile fish which are unable to move away from the heated area		Seine surveys in Snow Lake were conducted but data were inconclusive
Sufficient ice cover will exist in mid-winter to permit normal reproduction of the burbot		No ice cover on Snow or Icy Lake
iii) Plankton No bluegreen algae blooms are anticipated		Some blooms occurred due to sewage lagoon seepage
Enhanced development of phytoplankton populations should stimulate zooplankton responses which will, in turn, provide increased forage for fish residing in the area		Primary productivity increased in Marmion Lake but decreased in other lakes. No measurable change in zooplankton. Forage fish increased but likely due to reduced predation
iv) Benthos Increased water movement through the three lakes, Snow, Icy and Abie, will reduce available substrate for benthic organism development. Deposition of these sediments in the east arm of Marmion Lake may enhance benthic responses		No sufficient assessment Theoretically incorrect
The chironomids, amphipods and gastropods which presently occur in Snow, Icy and Abie lakes will decline in numbers, and the populations of tubificids and sphaeroids will increase in comparison to the existing populations of the east arm of Marmion Lake		Not assessed
	Hypothesis 6: Intake of water will lower Moose Lake thermocline	Thermocline depth lowered 8-10 m

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
	Vertical distribution of fish in Moose Lake will be affected	Assumed to be true but not assessed
	There will be significant entrainment of fish and plankton	Impact appears small but data inadequate
	Entrainment and impingement will reduce fish numbers in Moose Lake	Inadequate data to assess prediction
	Lowered thermocline in Moose Lake will change the fish population	Adult fish numbers not changed. Larval fish have increased but probably linked to construction effects
b) Entrainment Effects The proposed station may destroy, at worst, 95 to 100% of the entrained young fish and, at best, 15 to 30%		Not accurately measured
The low designed approach velocity and the location of the submerged intake is expected to reduce entrainment of adult fish to very small numbers		Entrainment of adult fish is low
Passage of phytoplankton through the cooling system of this station would not appear likely to cause any change in the composition of the population most of the time, but will interfere with photosynthetic responses		Not assessed
Submerged intake for the cooling water system is at a depth of 13 m. Entrainment of plankton and larval fish should be very limited		Entrainment appears low but not adequately measured
c) Sewage Discharge All sewage will be collected and transported to either a septic tank and tile bed system or a package sewage treatment plant, depending on site conditions		Sewage is directed to a sewage lagoon
The design loading for permanent staff during operation is estimated to be 14 kg BOD with a flow of about 9,000 U.S. gallons (34 m^3) per day. Field conditions do not appear to be suitable for sewage lagoon treatment of the sanitary waste		A sewage lagoon was utilized for sewage treatment
Discharge of sewage effluent from the treatment plant will meet regulatory guidelines and should not affect water quality		Sewage effluent did result in local algal blooms
	Hypothesis 7: Increased BOD and P from sewage	Localized increase which quickly dissipated with distance from source of input
	Increased BOD and P will alter algae and macrophytes	Changes to macrophytes not linked to ATGS

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
There should be little change in the nutrient content of the water		No changes measured
	Increased algae and macrophytes will lower oxygen levels in hypolimnion	Lower oxygen levels occurred but not related to plant activity
	Lower oxygen will affect fish distribution and abundance	Low summer catches of fish in small lakes may be partially attributed to this
TDS levels expected to increase by 0.65 ppm annually	Increased TDS and TSS from discharge of cooling water	TDS did not increase and TSS data were insufficient
	Increased TDS and TSS will increase algae and macrophyte production	Significant increase in 1983 and 1987 relative to 1981; primary productivity increased in Marmion Lake and decreased in Snowy, Icy and Abie Lakes. These changes could not be linked to TDS and TSS levels.
OTHER DISCHARGES		
Boiler Blowdown Based on a 400 MW, the anticipated annual quantity of phosphate which would be discharged to the cooling water is 65 kg.		
	Hypothesis 8: Increase TDS by 2.5% every 5 y in Lower Basin from boiler cleaning wastes	There was no documentation of an increase in TDS in the Lower Basin of Moose Lake
Condenser Cleaning Shock chlorination is considered the standard process for condenser anti-fouling		Chlorine and other chemicals are not used to clean condensers
Condenser Cleaning Chlorination, if required in the future, would not have a significant toxic effect on the aquatic environment in the Marmion Lake system.		Water is not chlorinated.
Prior to proposing chlorination at Atikokan TGS for condenser cleaning, Ontario Hydro would review the possible environmental effects of chlorine in relation to the uses of Marmion Lake and its associated lakes and potential health effects		No assessment conducted
Water Treatment Plant Effluent All wastes will be routed to a neutralizing sump with provision for pH control		Effluent is neutralized

Table 5.2: Summary of Environmental Predictions and Observed Effects

EA Predictions (1977)	Workshop Predictions (1984)	Observed Effects
Accumulation of Chemicals and Dissolved Solids It is expected that the impact of nutrient contribution from water treatment plant wastes such as blowdown and treated sewage will be negligible		No measurable change in water quality
Ash Disposal Area Drainage Studies will be carried out to determine the nature and extent of any treatment required for both coal pile and ash disposal area drainage to meet the Ministry of the Environment discharge guidelines		No effects detected so drainage not treated
Coal Pile Drainage The runoff drainage from the coal pile will be collected and routed to a pond. Studies will be carried out to determine the nature and extent of treatment required, prior to discharge to receiving waters	Hypothesis 8: Coal pile runoff of TDS, TSS and pH will increase these parameters in the Lower Basin	Runoff from coal pile goes directly to Lower Basin via an open ditch. Monitoring of runoff initiated in 1990 as part of MISA program No change in water quality of the Lower Basin could be attributed to the presence of the coal pile
	Changes in water quality of Lower Basin will make it less desirable for waterfowl	Water quality not changed
	It is not expected that leaching of heavy metals or other toxic materials will be a problem. However, runoff drainage from the stockpiles will be collected and monitored prior to any discharge to the receiving water	Coal pile runoff monitored as part of MISA program starting 1990. Runoff contains significant levels of some trace elements
Runoff from disposal areas will be controlled by drainage systems and effluent retention or treatment, so that water quality is not degraded in the adjacent water body		No reports but water quality in the circuit cooling lakes was not significantly degraded.

5.2 COMPARISON OF ESR AND EEM PREDICTIONS AND ACCURACY

The frequencies (expressed as a percent of the total) of a prediction:observation comparison falling into a particular criteria category are summarized in Figure 5.1.

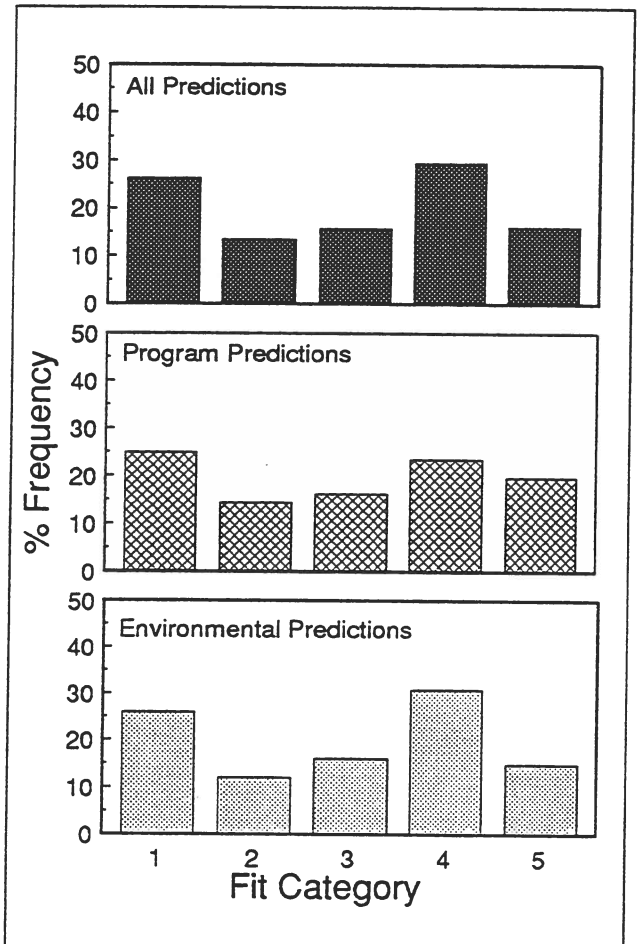


FIGURE 5.1 Comparison of ESR and EEM Predictions and Accuracy

The predictions of effect for both the original 1977 predictions and the 1984 workshop predictions were grouped for evaluation.

It should be noted that the 1977 document included a number of program predictions and predictions related to social and economic effects. These predictions should be more accurate by their nature, since social or economic impact predictions are often verified by deliberate actions taken by Ontario Hydro. For example, the prediction that "roads may need upgrading" was accompanied by a grant from Hydro to upgrade local roads. The uncertainty associated with such predictions is much less than predictions associated with potential environmental impacts.

In contrast, the 1984 EEM predictions dealt primarily with biological effects as related to changes in air or water quality. These latter predictions were more detailed than the rather vague predictions in the ESR document. For example, an estimated 28 separate predictions or links from the scoping workshop related to changes in fisheries, in comparison with only one or two from the earlier document. Unfortunately, in several instances no direction of effect (ie. increase or decrease in fish population) was given to the prediction, therefore, it was difficult to either support or disprove.

The accuracy of predictions was grouped for the total predictions, program predictions and environmental predictions (Figure 5.1). The results for each group are very similar despite what we felt were inherent strengths in the program predictions. For example, approximately 43% of the program predictions were considered either mostly accurate (Category 4), or very accurate (Category 5), while 45% of the environmental predictions were considered accurate (Category 4 & 5). The number of predictions considered very accurate ranged from 15-20%.

Approximately 28.6% of all predictions were considered either mostly inaccurate (Category 3) or clearly inaccurate (Category 2). The proportion of predictions that could not be scored (Category 1) was about 25% (25-26.6%) for all three groups (Figure 5.1). Predictions could not be scored for a variety of reasons, including predictions that simply could not be tested, predictions that were not tested or for reasons of insufficient data. Closer scrutiny of the reasons why predictions could not be scored may help reduce the numbers in this category for future environmental assessments.

Culhane (1987) reviewed the accuracy of impact forecasts in 29 U.S. environmental impact statements. In general, he observed that 30% of the impacts were close to the forecasts. In this study we considered that 15-20% of the predictions were very accurate. Impact forecasts (predictions) were grouped into four categories: physiographic, economic, biological or social. The author noted that quantitative data on biological impacts were the most difficult to obtain. It should be noted that 25% of the scores for the ATGS were considered inauditable but this category was not used in the U.S. study.

In a review of environmental impact predictions in Australia, Buckley (1991) estimated that 44% of testable predictions were accurate. This compares very closely with the 45% of all predictions considered accurate in this study. Significantly however, Buckley (1991) states that of almost 1,000 Environmental Impact Statements examined, only 3% contained adequate monitoring data to test the predictions.

In comparison to the two audits conducted in the U.S.A. and Australia, the results of the ATGS audit of predictions are favourable. Clearly, there is a need to develop and ensure consistency of methodology for scoring or testing predictions between programs, and as Buckley (1991) points out "not all ... predictions ... are of equal significance". To our knowledge, Ontario Hydro is the first proponent in Canada to review (publicly) the accuracy of environmental predictions associated with a major project. The practice of auditing the accuracy of environmental predictions should be an integral component of the EA process if we are to improve our ability to predict the environmental consequences of various undertakings.

6. Conclusions

Original concerns of operating the lignite-fired Atikokan Thermal Generating Station (ATGS) in the ecologically-sensitive area of northwestern Ontario have largely proven unfounded. Atmospheric emissions from the 200 MW station at Atikokan have not impacted either local or long-range air quality. In fact, air quality around Atikokan has improved since the station began operation due to the closure of two iron ore mining and smelting operations previously located there. Water quality in poorly-buffered lakes surrounding the ATGS has actually improved since the station began operation, again in response to cessation of the smelting activities. This provides further evidence that deposition of acidic material from the station has not been environmentally significant.

The principal effects of the ATGS on water quality and lake biology are due to physically joining the cooling circuit lakes and pumping lake water through the station. This has substantially reduced the flushing time of the lakes, and lead to homogenous water quality, phytoplankton and zooplankton populations between the lakes. Spawning of walleye in the outflow of one of the circuit lakes has been advanced by about two weeks due to the discharge of heated cooling water from the station. However, the actual impact of this phenomenon on the walleye population, if any, is not yet apparent. Entrainment of larval and juvenile fish and impingement of adult fish does not appear to be a problem.

Other effects on biota are less clear or not yet apparent. Index netting studies suggest that the numbers of predatory fish including walleye and northern pike have decreased since the station began operation, while the numbers of forage fish have increased. However, the data are equivocable, and the possible mechanisms are not clear. Although detailed fisheries surveys were conducted for three years after the station began operation, this may be insufficient time to expect impacts on the fisheries to manifest themselves. Furthermore, many of the biological studies are hampered by a lack of adequate baseline data prior to construction of the station, as well as changes in methodology during the operational monitoring phase.

The scoping process followed by Ontario Hydro was beneficial for identifying potential environmental impacts and defining links between station activities and ecosystem values. However, more attention should be given to the purpose and details of study design. The information gathered from the ATGS program will be useful for helping design monitoring studies for future developments of all types, not just those for electricity generation.

The socio-economic impacts of the ATGS on the region must in general be considered positive. The town of Atikokan was faced with the closure of two mines, the principal sources of employment in the area, prior to Ontario Hydro building the generating station. The site selection process to locate the new GS at Atikokan was strongly influenced by the government at the time in consideration of local socio-economic conditions.

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