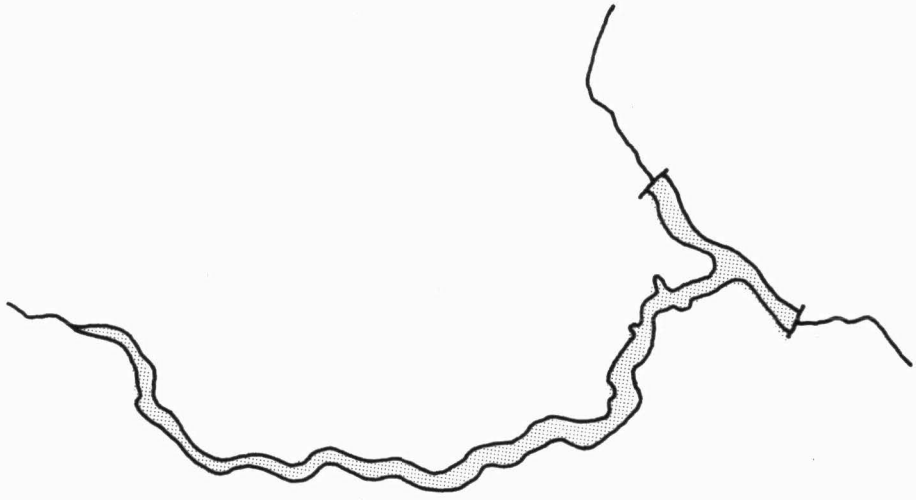
Environment Canada

Saskatchewan Environment and Public Safety

Lake Diefenbaker and Upper South Saskatchewan River

Water Quality Study 1984-85



SUMMARY

December, 1988

LAKE DIEFENBAKER AND UPPER SOUTH SASKATCHEWAN RIVER

WATER QUALITY STUDY

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Water Quality Branch
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WQ 112

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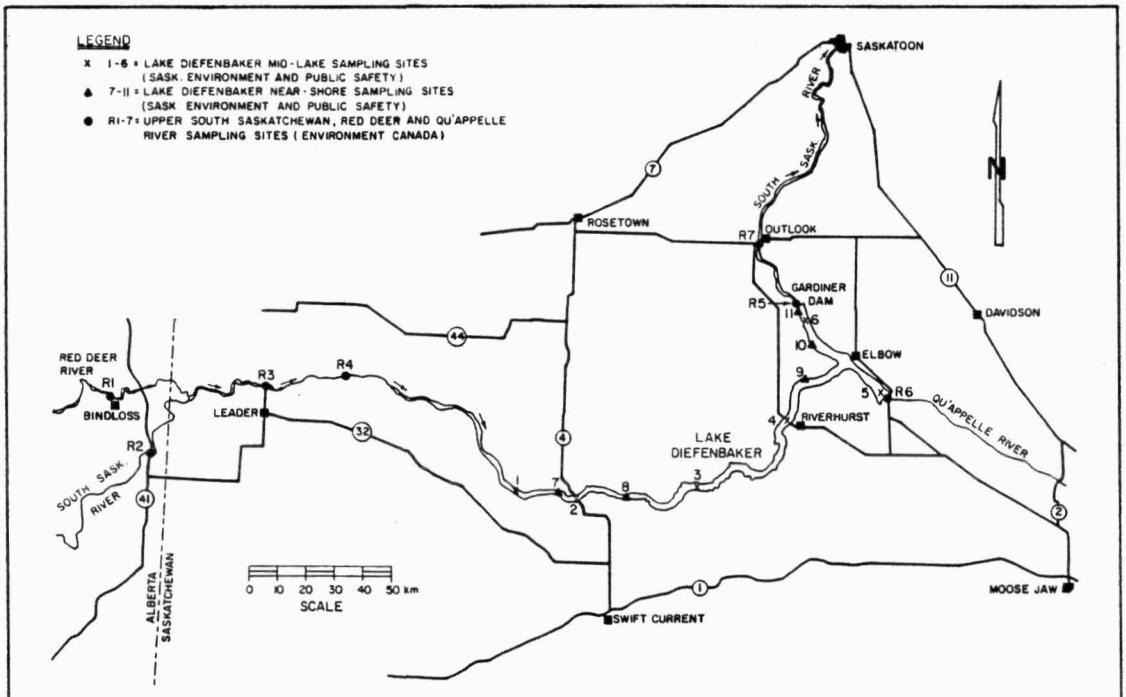
INTRODUCTION

Lake Diefenbaker and the upper South Saskatchewan River east of the Alberta border form the largest supply of good quality water in southern Saskatchewan. The South Saskatchewan River is a broad, swift-flowing river which derives over 90% of its flow from snowmelt and rainfall in the Rocky Mountains. Lake Diefenbaker, created by the completion of the Gardiner and Qu'Appelle Dams in 1967, is the major storage reservoir on the river. The reservoir measures 225 kilometres in length and has a total storage capacity of 9.4 billion cubic metres. These waterbodies serve as supplies for a wide range of uses including power generation, irrigation, municipal and industrial water supplies, recreation, wildlife habitat, sport and commercial fishing and flood control.



LAKE DIEFENBAKER AND THE UPPER SOUTH SASKATCHEWAN RIVER
STUDY SETTING AND SAMPLING SITES, 1984 - 1985

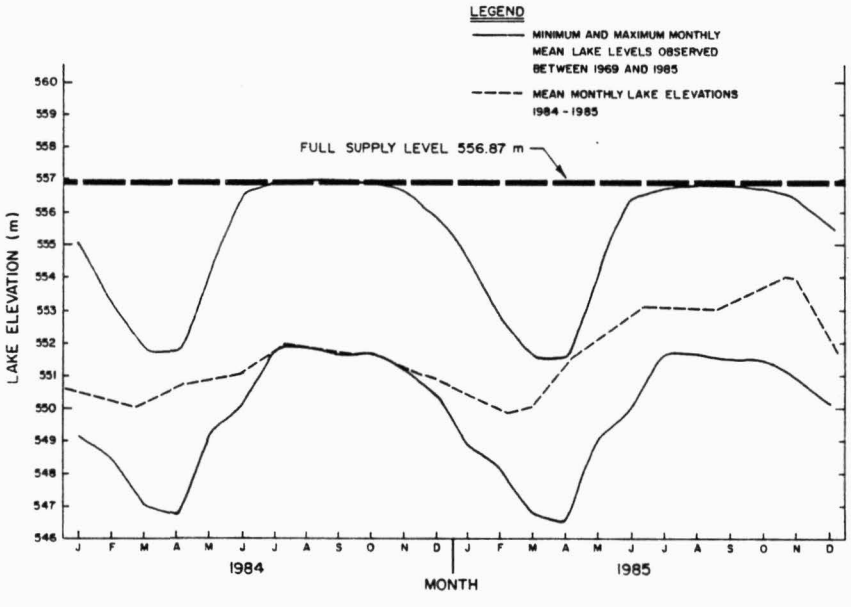
Water entering Saskatchewan from Alberta via the South Saskatchewan River system presently receives point and non-point inputs from municipal, industrial and agricultural sources. Potential problems related to nutrients and salinity are of greatest concern for the Saskatchewan portion of the basin and Lake Diefenbaker, in particular.

In 1984-85 a comprehensive water quality study of the upper South Saskatchewan River and Lake Diefenbaker was conducted jointly by the Water Quality Branch of Saskatchewan Environment and Public Safety and the Water Quality Branch of Inland Waters Directorate, Conservation and Protection, Environment Canada. The goal of the study was to provide a reliable information base for water managers responsible for the long-term protection of these waterbodies. Specific study objectives were:

1. To characterize the physical, chemical and biological properties of these waterbodies.
2. To quantitatively describe the trophic status of Lake Diefenbaker.
3. To assess the acceptability of existing water quality relevant to present and foreseeable uses.

KEY STUDY RESULTS

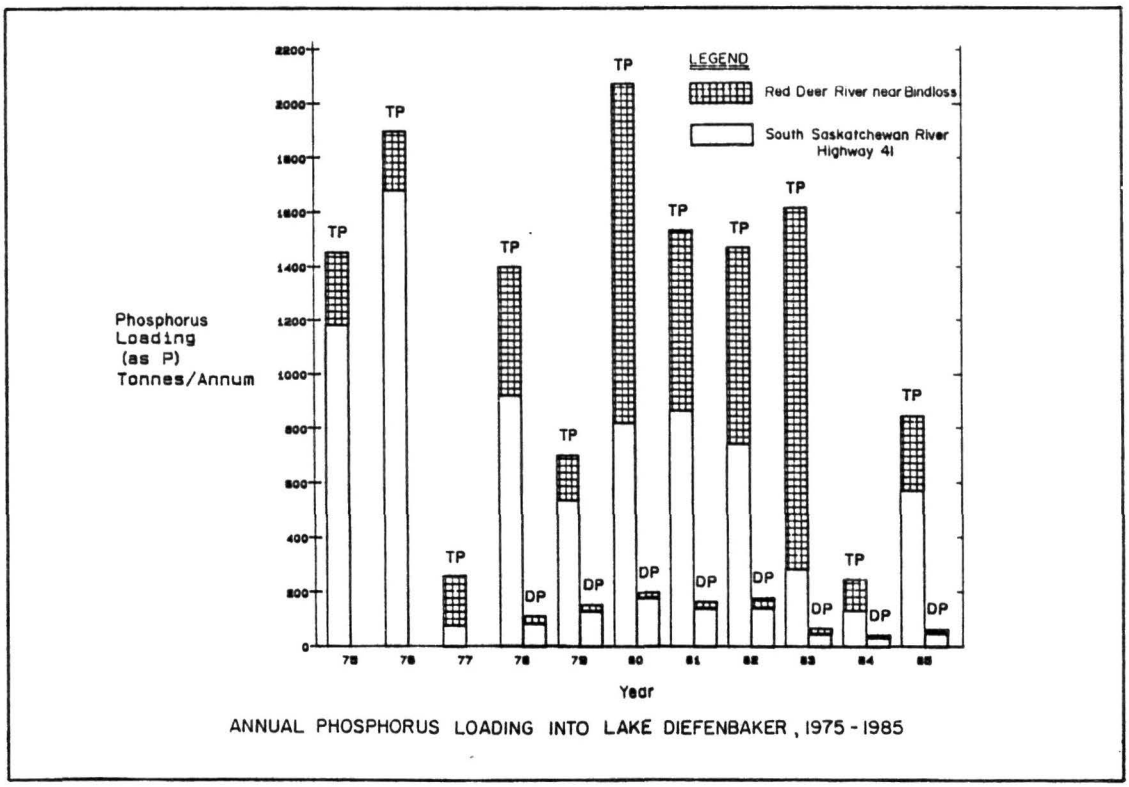
The South Saskatchewan River flow rates during 1984-85 were far below the long-term mean. In 1984, the prairie snowmelt peak was all but absent in the river system. Spring runoff was close to normal in 1985, however, the later mountain snowmelt was well below normal. Lake Diefenbaker water levels in 1984 were the lowest since 1969 for the months of August through November. The lake levels were higher in 1985 for the summer period but remained well below the full supply level of the reservoir.



MEAN MONTHLY LAKE ELEVATIONS FOR LAKE DIEFENBAKER, 1984 AND 1985

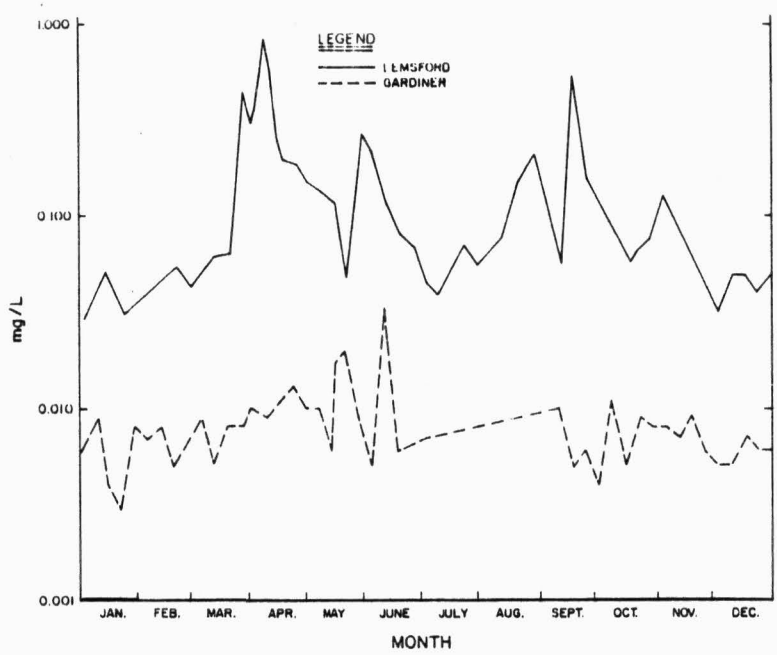
River Chemistry

Seven river sampling locations were established for the 1984-85 study. Monitoring of the four sites upstream of Lake Diefenbaker was designed to examine variability of loading to the lake while the stations at Gardiner Dam, Qu'Appelle River at Highway 19 and South Saskatchewan River at Outlook examined output from the reservoir. Monthly long-term monitoring data from the South Saskatchewan and Red Deer Rivers and more intensive study data acquired at Lemsford Ferry and Gardiner Dam were used to provide nutrient loading information for Lake Diefenbaker. From the historical data the average combined total phosphorus (TP) load to the lake was determined to be 1,229 tonnes per year. The TP load for the study period (1984-85) was determined to be 814 tonnes.



ANNUAL PHOSPHORUS LOADING INTO LAKE DIEFENBAKER, 1975 - 1985

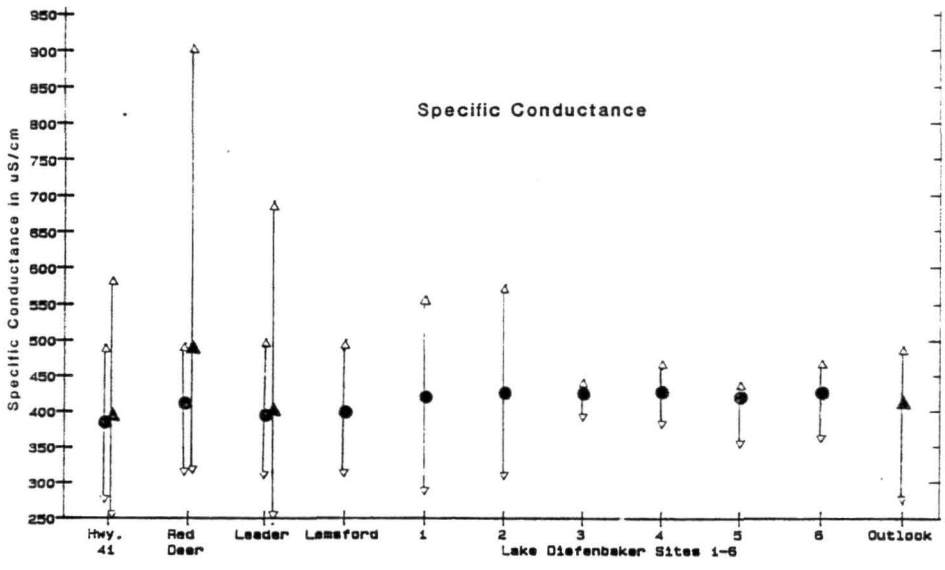
Approximately 89% of the TP load entering Lake Diefenbaker is particulate phosphorus. At Gardiner Dam dissolved phosphorus is the dominant form throughout most of the year. The fact that Lake Diefenbaker is acting as a sink for nutrients flowing in from the South Saskatchewan River is evident by the very low levels of nitrogen and phosphorus measured at the outflow from Gardiner Dam. Total phosphorus concentrations at Gardiner Dam were about ten times less than at Lemsford.



COMPARISON OF TP FOR LEMSFORD AND GARDINER SITES , 1985

Four locations on the Red Deer and South Saskatchewan Rivers were monitored for major ions and physical parameters during the study. Results showed that the Red Deer River tended to be more highly mineralized then the South Saskatchewan. However, little change in

mean concentrations of major ions occurred in the 330 kilometre reach between Leader and Outlook, which includes Lake Diefenbaker. The pattern of dominance of the major ions (calcium, magnesium, sodium, potassium, bicarbonate, sulphate and chloride) also didn't change between these sites.



SPATIAL PLOT OF STUDY PERIOD (CIRCLES) AND PERIOD OF RECORD (TRIANGLES) MEAN AND RANGE FOR SPECIFIC CONDUCTANCE.

Specific conductance is an indicator of the total amount of dissolved substances in the water.

Lake Chemistry and Biology

Six sampling stations were established at approximately equal distances along the length of Lake Diefenbaker. For most of the year, water temperatures did not vary with depth at each station. During July and August, water temperatures decreased with depth but distinct thermoclines (layer of water where temperatures decline rapidly) were not observed. Dissolved oxygen concentrations were high and quite uniform with depth for

most of the year. Lower dissolved oxygen levels were measured near the lake bottom in late summer when lake temperatures were highest and in late winter when the lake was ice-covered.

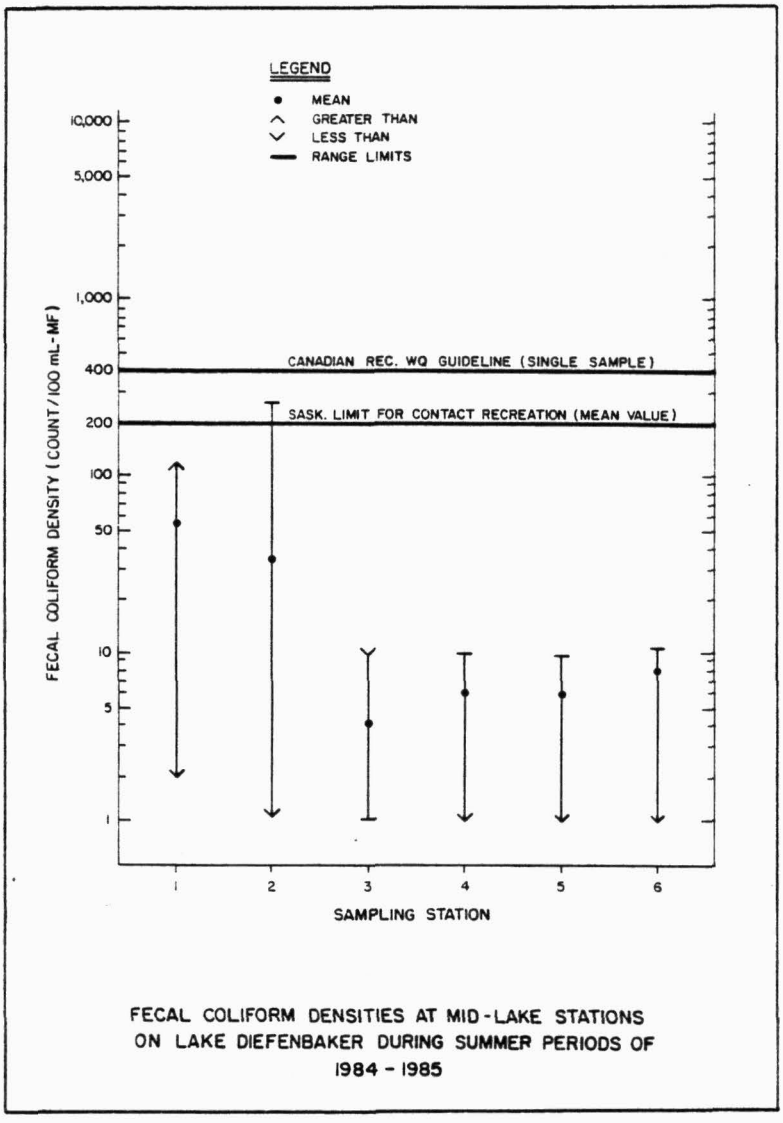
Eutrophication is the response of aquatic ecosystems to enrichment by nutrients, particularly phosphorus and nitrogen. The increase in lake fertility can cause symptoms such as algae blooms, nuisance growths of rooted aquatic plants, low dissolved oxygen levels and unpleasant taste and odour of the water. In Lake Diefenbaker, phosphorous was determined to be the nutrient limiting algae growth. The trophic response of Lake Diefenbaker to river phosphorus loadings was evaluated using the OECD (1982)[1] eutrophication model.

Monitoring for nutrients in Lake Diefenbaker revealed that the concentrations were quite low, although the lake does respond to the nutrient loads received from the South Saskatchewan River system. Nutrient levels were consistently higher in the shallower upstream locations than in the deep water areas further downstream. The concentrations of phosphorus and chlorophyll "a" indicated most areas of the lake were mesotrophic (moderately productive). The Danielson reach near Gardiner Dam is considered oligotrophic (low in nutrients and productivity).

1. OECD (1982) Eutrophication of waters: Monitoring, Assessment and Control. Organization for Economic Co-operation and Development. Paris, France.

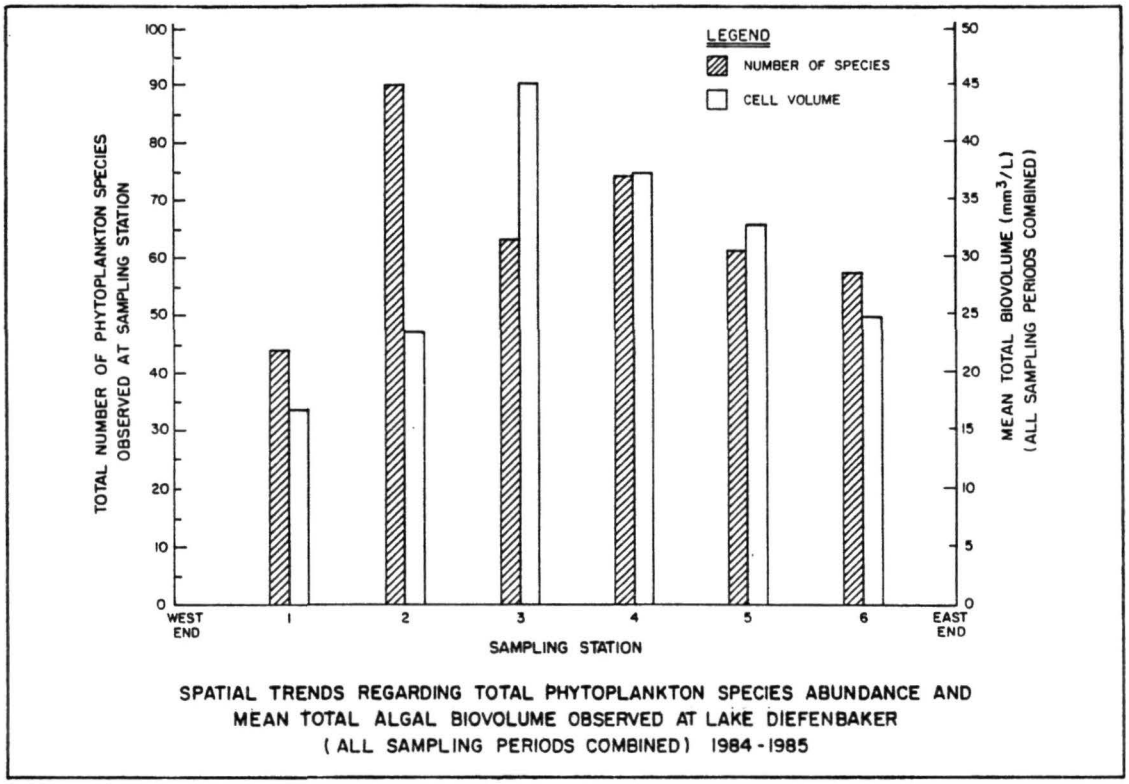
The OECD (1982) model was used to estimate phosphorus loadings necessary to maintain a mesotrophic status in the upstream portion of the lake near Saskatchewan Landing Provincial Park. Based on average annual flows in the South Saskatchewan and Red Deer Rivers, the critical phosphorus loading at the Alberta-Saskatchewan border was estimated to be 130 tonnes per year. The Prairie Provinces Water Board is considering a draft Water Quality Indicator for total phosphorus loading at the border of 285 tonnes per year to prevent excessive phosphorus loading to the whole lake. The present database is not sufficient to make a final recommendation on a phosphorus loading limit for Lake Diefenbaker at this time.

The coliform group of bacteria were monitored in Lake Diefenbaker to evaluate the sanitary status of the lake for recreational use. Mean total and fecal coliform densities in the off-shore portion of the lake were low and indicative of water with little fecal contamination. Five near-shore beach areas were monitored on one day in the summer. Fecal coliform levels in some samples collected near Saskatchewan Landing and Coteau beaches exceeded the provincial water quality objectives for contact recreation, indicating potential localized contamination caused by suspended bottom materials (due to wave action) or from livestock or human-related activities. Bacteria densities at other beach areas were low. There are no large scale sources of fecal contamination (e.g. sewage) in any portion of the basin studied.



FECAL COLIFORM DENSITIES AT MID-LAKE STATIONS ON LAKE DIEFENBAKER DURING SUMMER PERIODS OF 1984 - 1985

Phytoplankton (algae) are the major primary producers in the lake ecosystem and can be used as an indicator of lake trophic status. Over 100 algal species were observed in the lake during the study. The greatest diversity of species occurred within the green algae group. Blue-green algae accounted for the majority of the algal biovolume measured, however the overall algal abundance indicated mesotrophic to oligotrophic conditions in the lake.



SPATIAL TRENDS REGARDING TOTAL PHYTOPLANKTON SPECIES ABUNDANCE AND MEAN TOTAL ALGAL BIOVOLUME OBSERVED AT LAKE DIEFENBAKER (ALL SAMPLING PERIODS COMBINED) 1984-1985

Water Quality and Water Use

The results of the 1984-85 Lake Diefenbaker and upper South Saskatchewan River study were assessed in terms of the Saskatchewan Surface Water Quality Objectives and the Canadian Water Quality Guidelines published by the Canadian Council of Resource and Environment Ministers. Overall, the results showed the quality of these waterbodies is satisfactory for present and foreseeable uses.

The concentrations of major ions did not exceed the Canadian or Saskatchewan guidelines and objectives for most sensitive uses including drinking water supply, irrigation and livestock watering.

Dissolved oxygen levels in Lake Diefenbaker generally exceeded the Saskatchewan objective of 5.0 mg/L for protection of fish and aquatic life. Low oxygen levels measured near the lake bottom on some occasions are not considered a concern for fish populations.

The densities of total and fecal coliform bacteria measured at all off-shore and most near-shore sites on Lake Diefenbaker met the Saskatchewan objectives for contact and non-contact recreational use.

The trophic status of Lake Diefenbaker ranged from mesotrophic to oligotrophic, based on in-lake measurements of total phosphorus, chlorophyll a and phytoplankton. Maintenance of at least mesotrophic or better conditions in all areas of the lake will ensure avoidance of problems such as nuisance algal blooms, deoxygenation and unpleasant taste and odour in the long-term.

Recommendations

1. It is recommended that any new or modified developments in the basin upstream not be undertaken in a manner that would result in a net increase in phosphorus loading to Lake Diefenbaker.
2. Research to determine the proportion of the particulate phosphorus load in the South Saskatchewan River which is biologically available should be undertaken. This would help evaluate the significance of the total phosphorous loading to eutrophication in Lake Diefenbaker.
3. It is evident that total phosphorus loading to Lake Diefenbaker is already high. Negotiations should be held with Canada, Alberta and Saskatchewan to prevent further increases in TP loading and to examine feasible options for protecting the long-term quality of Lake Diefenbaker.
4. Future refinement of the OECD (1982) eutrophication model should include phosphorus loadings from all major sources, including runoff from surrounding land and atmospheric deposition.
5. Additional bacteriological monitoring of selected beach areas on Lake Diefenbaker should be undertaken during the recreation season to determine if objectives for contact recreational use are being achieved.
6. The present nutrient-related database for Lake Diefenbaker and the South Saskatchewan River should be augmented by three more years of data collection and targeted at more typical hydrological conditions.

Lake Diefenbaker and upper South Saskatchewan River : water quality study, 1984-85 : summary.

DATE	ISSUED TO

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