CANADA-SASKATCHEWAN
SOUTH SASKATCHEWAN RIVER BASIN STUDY

TECHNICAL APPENDIX II

RESOURCE ASSESSMENT

B. WATER QUALITY

PREPARED BY:

CANADA-SASKATCHEWAN
SOUTH SASKATCHEWAN
RIVER BASIN STUDY OFFICE

JULY, 1991

ACKNOWLEDGEMENTS

This technical appendix was assembled by the staff of the South Saskatchewan River Basin Study Office. It is based on information from the references cited in the document, the technical reports listed in Appendix A, and extensive consultation with private and government interest groups. The efforts of Diane Blachford, Water Quality Branch, Inland Waters Directorate, Environment Canada in the preparation of this document are appreciated.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

1.1 THE SOUTH SASKATCHEWAN RIVER BASIN STUDY

The results of the Canada-Saskatchewan South Saskatchewan River Basin Study (SSRBS) are documented in a series of reports. The final report provides a summary of the findings in a form suitable for use by the general public. The final report is supported by seven technical appendices: Issues Documentation, Water Quantity, Water Quality, Water Use, Environment, Water Management and The Framework Plan. The technical appendices provide sufficient detail for use by water management professionals. The technical appendices are based on detailed studies reported in more than 60 technical reports prepared for the basin study and various reports on the study area prepared for other purposes. A complete list of the technical reports is included in Appendix A of this report.

The South Saskatchewan River is a high quality source of water for diverse uses in southern Saskatchewan. The high quality of this water is unique in a region that is naturally supplied with erratic quantities of turbid, salty and enriched water which is frequently not suitable for a range of uses.

This technical appendix, "WATER QUALITY", summarizes the water quality knowledge gained over the course of the study as it is related to the water resources of the Saskatchewan portion of the South Saskatchewan River Basin (Figure 1). During the study, work was undertaken to: identify the water quality issues in the basin; evaluate existing water quality data bases; fill information gaps where possible; establish basin-specific water quality objectives for specific uses; and, recommend a monitoring plan for the basin.

In order to provide some context for this report, sections have been included on the background to the study and on the water resources of the study area.

1.2 STUDY BACKGROUND

The South Saskatchewan River is the most reliable supply of good quality water in the southern half of Saskatchewan. It contributes significantly to the social and economic well-being of the people of the region. During the early 1980s, several events led to increasing concern about the ability of the river to meet future needs.

The water resources of the South Saskatchewan River are intensively used by Alberta. Alberta irrigates more than a half million hectares of land in its portion of the basin. During the mid-1980s, Alberta completed a planning study which identified a range of future development options. Several of the options provided for significant expansion of irrigation which would further reduce the amount of water passed to Saskatchewan.

Since its joint development by the federal and provincial governments more than 20 years ago, Lake Diefenbaker has become a focus for development in the Saskatchewan portion of the basin. This multi-purpose reservoir supports irrigation, hydro-electric energy generation, recreation, industrial and municipal water supply. In Saskatchewan, plans were also laid during the 1980s for further development based on the water resources of the South Saskatchewan River, particularly Lake Diefenbaker.

These plans included significant irrigation development. At the same time, proposals were made to further develop the recreation potential of the reservoir. Such developments would place additional demands on the water resources of the South Saskatchewan River.

While further development was being considered for the South Saskatchewan River Basin in both Alberta and Saskatchewan, there were several drought years in the 1980s. The droughts led to increased demand for water while the supply was reduced. In Saskatchewan, this caused problems for most water uses. There was concern regarding the ability of Lake Diefenbaker to support continued development. Weed growth at the upstream end of Lake Diefenbaker also led to concerns that the high quality water in Lake Diefenbaker was at risk.

The possibility of increased development, coupled with a reduced supply, led to greater concern about diverting water from the basin. Prior to the study, there had been a number of options identified for increased diversion of water from the South Saskatchewan River. However, when such diversions were identified, existing users expressed concern about the possible impacts. There was a clear need to determine the importance of the water in the basin to existing and future users.

The Canada-Saskatchewan South Saskatchewan River Basin Study was undertaken to provide information to guide water management. It will help ensure that the water resources of the basin can meet the needs of existing and future users.

1.2.1 The Study Agreement

On May 16, 1986, Federal Environment Minister Tom McMillan and Minister Responsible for SaskWater, Eric Berntson, signed the Canada-Saskatchewan South Saskatchewan River Basin Study Agreement. The agreement set aside 1.6 million dollars for the study with expenses shared equally by SaskWater and Environment Canada. The agreement established policies and procedures for a study of the Saskatchewan portion of the South Saskatchewan River Basin.

The Agreement identified three objectives for the study:

(a) "document the current and emerging water and related issues in the South Saskatchewan River Basin in Saskatchewan;

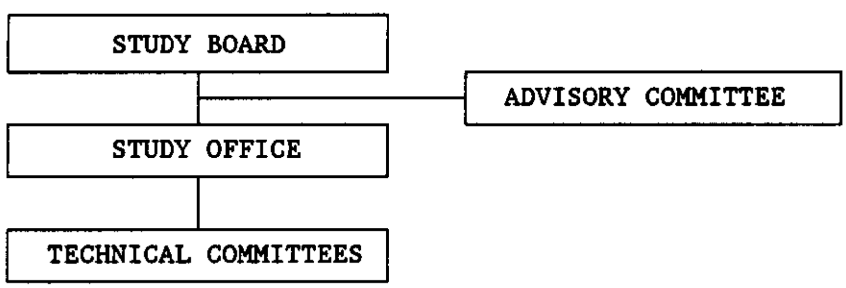
(b) "carry out an assessment of the water and related resources of the South Saskatchewan River Basin, and their current and future use;

(c) "develop a framework plan for the conservation and management of the water in the South Saskatchewan River Basin in Saskatchewan which allows for the evaluation of water resource projects."

1.2.2 Study Organization

The South Saskatchewan River Basin Study Board was responsible for the completion of the study. The board had one representative from each of the two sponsoring agencies: Environment Canada and SaskWater.

STUDY ORGANIZATION



An advisory committee provided policy information to the study board. Senior officials, representing agencies with water management responsibilities or interests in the basin, made up the advisory committee.

The study board set up the South Saskatchewan River Basin Study Office and staffed it with a director, assistant director and secretary. The director was responsible to the study board for the day-to-day administration of the study.

Technical committees assisted the study office. Representatives for the committees were drawn from agencies with responsibilities for water management. The agencies included federal and provincial departments, crown corporations and municipalities. The technical committees provided the study office with expert advice on water quantity, water quality, water use and public involvement. A management strategies technical committee was responsible for drawing together the information produced by the other technical committees and identifying management options.

The technical committees also helped develop terms of reference for work carried out by consultants. More than 20 different consultants participated in the study. The consultants played a role in compiling the basic information needed to carry out the study.

PARTICIPATING AGENCIES

Environment Canada
SaskWater

Agriculture Canada
    Agri-Food Development Branch
    Prairie Farm Rehabilitation Administration
Western Economic Diversification

Saskatchewan Environment and Public Safety
Saskatchewan Parks and Renewable Resources
Saskatchewan Culture, Multiculturalism and Recreation
Saskatchewan Rural Development
Saskatchewan Agriculture and Food

SaskPower
City of Saskatoon
Meewasin Valley Authority

1.2.3 Planning Process

Early in the study, the study board defined the planning process and eight planning principles. These principles guided the study.

THE PLANNING PROCESS

establish goals and objectives

↓

identify issues

↓

assess the resource

↓

identify management strategies

↓

evaluate management strategies

↓

develop recommendations and prepare the framework plan

PLANNING PRINCIPLES

THE WISE AND EFFICIENT MANAGEMENT AND USE OF WATER SHOULD BE PROMOTED THROUGH ALL POSSIBLE MEANS.

THE ECOLOGICAL INTEGRITY OF WATER RESOURCE SYSTEMS SHOULD BE MAINTAINED.

PUBLIC INVOLVEMENT IS ESSENTIAL FOR THE STUDY TO ACHIEVE ITS OBJECTIVES.

ALL WATER USES THAT HAVE SOCIAL, ECONOMIC OR ENVIRONMENTAL VALUE SHOULD BE CONSIDERED.

DOMESTIC WATER USE SHOULD BE THE HIGHEST PRIORITY AMONG ALL USES.

THE WATER RESOURCES OF THE BASIN SHOULD BE MANAGED FOR THE BENEFIT OF ALL PEOPLE IN THE PROVINCE.

WATER RESOURCES SHOULD BE DEVELOPED AND MANAGED CONSISTENT WITH THE CONCEPT OF SUSTAINABLE DEVELOPMENT.

INTERPROVINCIAL SHARING OF WATER IS BASED ON THE MASTER AGREEMENT ON APPORTIONMENT.

The planning process included the use of a base year as the reference point for the analysis of future conditions. The base year for the South Saskatchewan River Basin Study was 1986 -- the year the study began.

There were three separate planning exercises undertaken. They related to three different time horizons. The short-term planning exercise focused on the year 2000 and dealt with water management issues in the basin. The long-term planning exercise looked at the year 2020 and established a range of development options. The third and final planning exercise was the system-limit. It helped put the long-term planning exercise in perspective by identifying the development limits of the basin.

There are three main components to the study area: Mainstem South Saskatchewan River, Saskatoon South East Water Supply (SSEWS) system and Swift Current Creek. Although water management in these components is interrelated, the interrelationships are minor. Therefore most aspects or the study considered each component separately. The Mainstem includes the South Saskatchewan River from the Alberta border to the confluence with the North Saskatchewan at the downstream end of the study area. Lake Diefenbaker is included in the Mainstem component. The effects of actions on this mainstem area on the Saskatchewan River downstream of the study are were also considered in the mainstem section of the report. For this study, the SSEWS system was considered to include all of the works downstream of the East Side Pump Station near Gardiner Dam on Lake Diefenbaker. The Swift Current Creek Basin includes the Rushlake Creek basin.

1.3 SYSTEM DESCRIPTION

The following is a brief introduction to the water resources of the study area. More details are provided in the body of this report and in the other reports of this series.

1.3.1 Mainstem

The South Saskatchewan River rises in southern Alberta where it receives runoff from about 120 000 km^2 of drainage area. A portion of this drainage basin is located on the eastern slopes of the Rocky Mountains and foothills. This portion is a highly productive runoff area, producing virtually all of the flow received at the Alberta - Saskatchewan border where the average annual natural flow is 9 200 000 dam^3. This natural flow has ranged from lows of about 4 800 000 dam^3 in dry years to 16 000 000 dam^3 in wet years. On average, about two-thirds of the runoff occurs in the May to August period and less than 10 percent occurs in the December to March period.

In Alberta the water is used for irrigation, municipal, industrial, hydro-electric, fish, wildlife and recreation uses. On average, the flow is reduced by about 1 900 000 dam^3 per year, with irrigation taking about 95 percent of the water.

In Saskatchewan the river flows through a region of very low runoff. On average, the local runoff augments the natural flow by about 2 percent with half of this local flow originating in Swift Current Creek. Figure 1 shows the drainage area in Saskatchewan.

The largest water uses in Saskatchewan are centred around Lake Diefenbaker and the City of Saskatoon. Total water consumption averages about 500 000 dam^3 per year. Evaporation from Lake Diefenbaker accounts for about half of this total, irrigation is the second largest user and municipal and industrial users take a relatively small portion of the flow. Although less than 10 percent of the water is consumed, the remaining water is used for important instream purposes, including hydro-electric generation, recreation and fish and wildlife.

Downstream of the study area the South Saskatchewan River joins the North Saskatchewan River and their combined flow continues east in the Saskatchewan River. Within Saskatchewan the flow is used to generate electric energy at the Nipawin and E. B. Campbell Power Stations. Downstream of the Saskatchewan - Manitoba border, the Grand Rapids Power Station uses the river before the water discharges to Lake Winnipeg. At Lake Winnipeg the water joins other flows from the south and east as it flows down the Nelson River to Hudson Bay. Along the Nelson River, there are additional power stations. In addition to the power stations the rivers downstream of the study area serve as local transportation routes, provide habitat for fish and wildlife and serve the water supply needs of several communities.

The quality of the water in the mainstem is very good, meeting the requirements of all of the existing and projected users. Upstream of Lake Diefenbaker the quality varies from season to season with the rate of flow but in the lake the seasonal variations are mixed, producing a very uniform quality downstream. Within the study area the greatest pollution threat arises from municipal and industrial effluents in the Saskatoon area where effluent treatment requirements are regularly under review.

1.3.2 SSEWS System

The SSEWS system is a manmade water delivery system which draws water from Lake Diefenbaker and delivers it to an area northeast of the lake as far as Lanigan as shown on Figure 2. The major uses of the water are irrigation, industries, municipalities, recreation and wildlife.

The largest irrigation project is the South Saskatchewan River Irrigation District which serves over 16 000 ha. Potash mines are the main industrial users.

The quality of the water at the upstream end of this system is equal to the mainstem, since it is drawn from Lake Diefenbaker. As the water moves downstream in the system, local surface and ground water inflows of less desirable quality are added and evaporation concentrates impurities resulting in a lower quality of water. The quality is satisfactory for the uses made of it, but is less than ideal.

1.3.3 Swift Current Creek

Swift Current Creek is the largest tributary to the mainstem in Saskatchewan. This creek drains a portion of the Cypress Hills as shown on Figure 3. The average natural flow is about 80 000 dam^3 and the annual flow ranges from about 20 000 dam^3 to 265 000 dam^3.

Swift Current Creek water is used for irrigation and as a source of supply for municipal water at the city of Swift Current and the village of Herbert. The irrigation and municipal systems rely on Duncairn Reservoir for flow regulation to overcome natural periods of low flow. The water supply system from Swift Current Creek extends to areas of the neighbouring Rushlake Creek Basin. In addition to the consumptive water uses, the water of this creek is used for recreation, fish and wildlife. Although the quality of the water in this area is not as good as that in the mainstem, it has been satisfactory for the current uses.

FIGURE 1 THE STUDY AREA

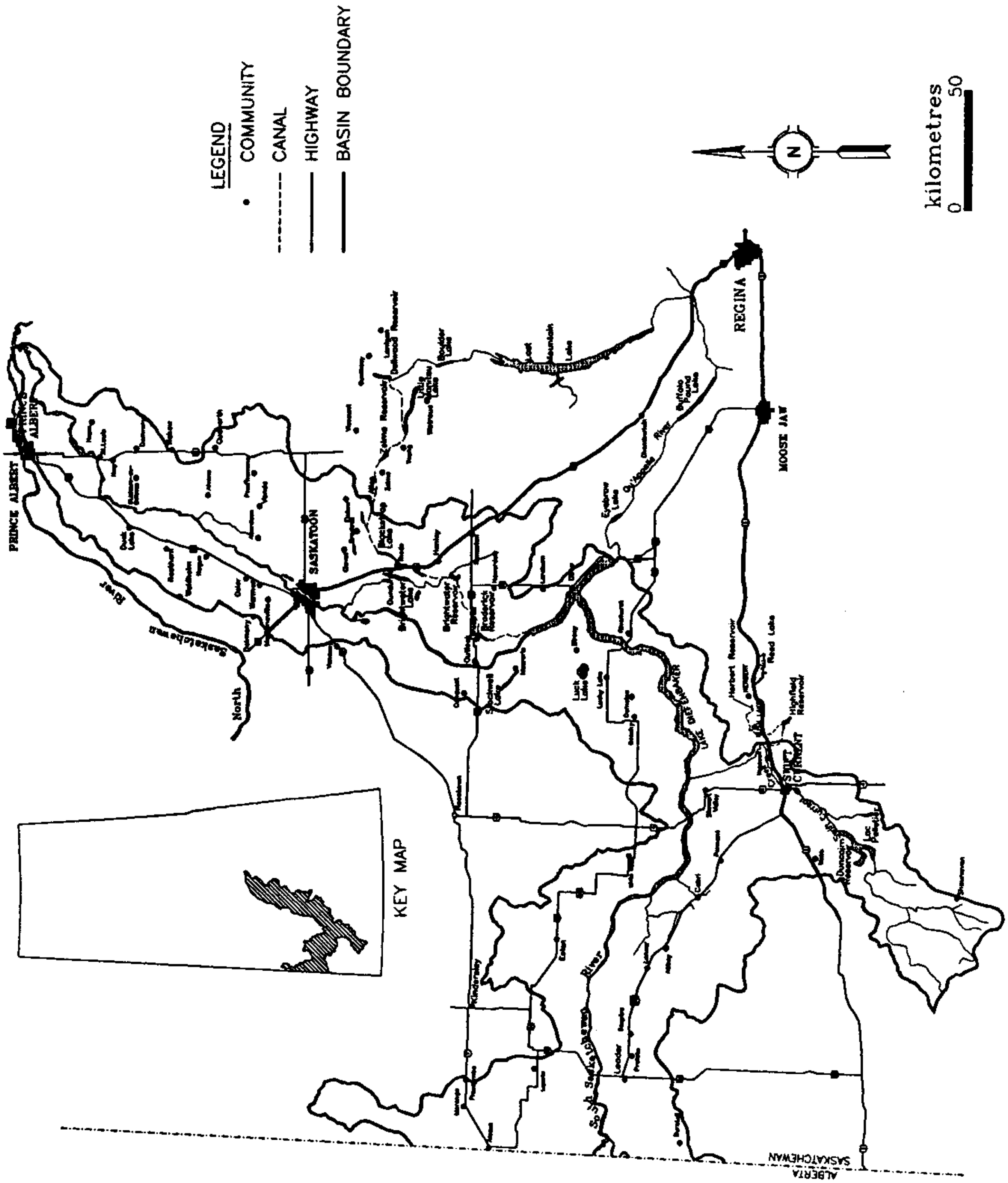


FIGURE 2 SASKATOON SOUTHEAST WATER SUPPLY SYSTEM

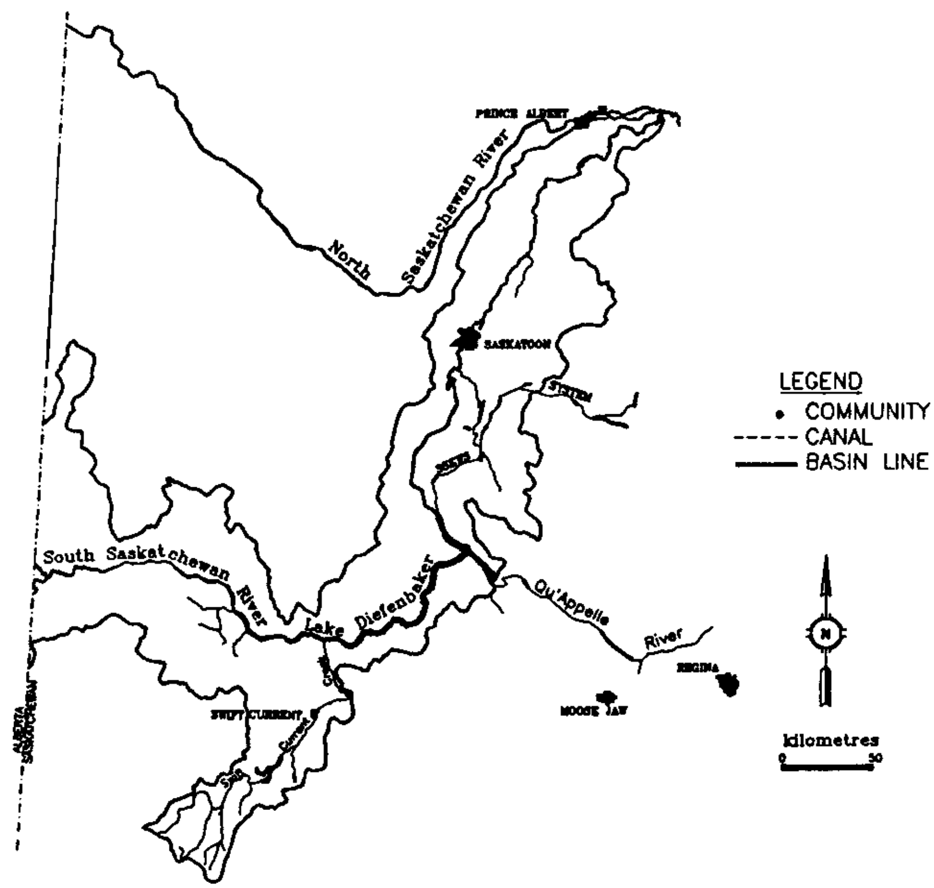
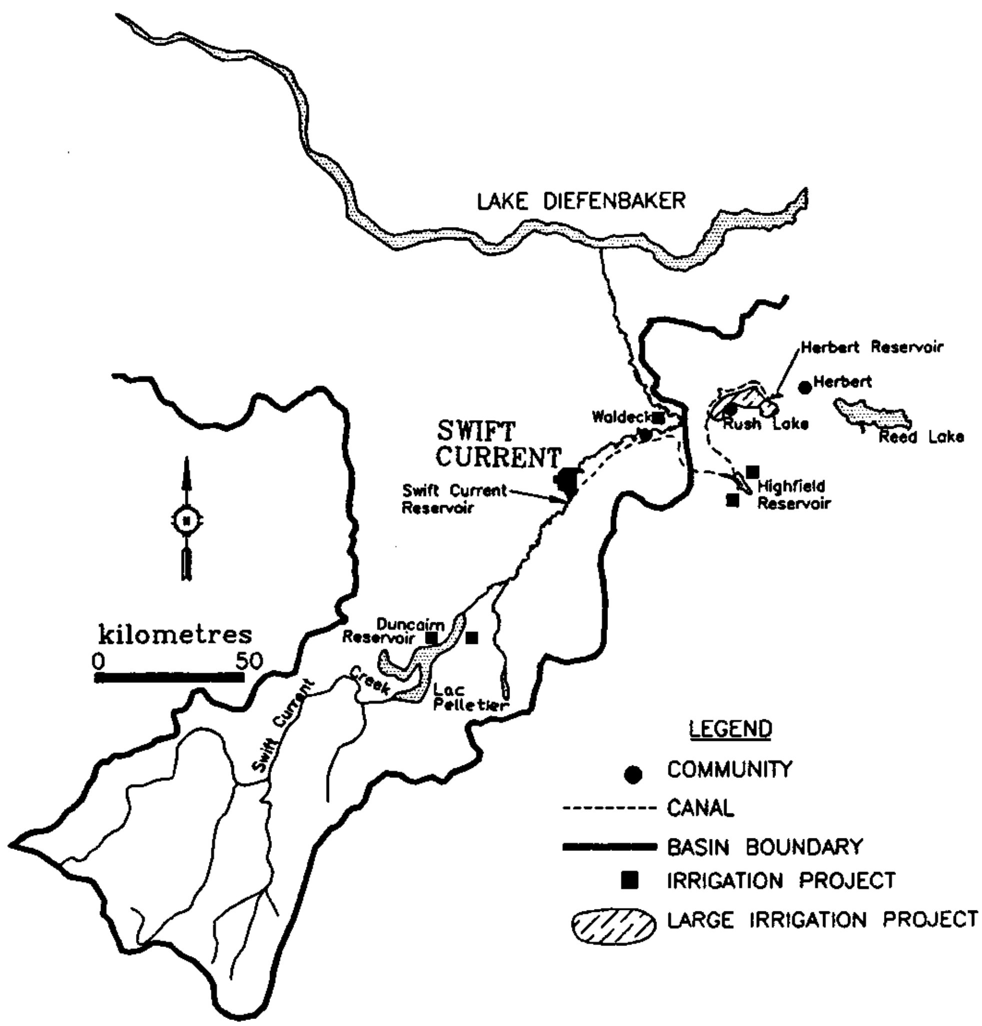


FIGURE 3 SWIFT CURRENT CREEK



2.0 WATER QUALITY ISSUES

The water quality issues in the study area served as the focal point for the studies and deliberations of the Water Quality Technical Committee. The water quality issues were identified by broad consultation with professionals representing diverse agencies active in the basin, with the public and with municipalities. Of concern were the issues relevant to the use, conservation and management of the basin water quality.

Some of the water quality issues were common to all areas of the basin. These were eutrophication, salinity and contaminants. Other issues were specific to a reach or reaches of the basin. The identified water quality issues are discussed here along with a brief explanation of the water quality parameters which relate to the issues, and a brief presentation of the yardsticks against which water quality conditions in the basin are measured.

2.1 BASIN ISSUES

2.1.1 Eutrophication

Eutrophication was identified as a water quality issue throughout the basin. It is the process whereby a body of water becomes rich in plant nutrients. Several portions of the basin are showing signs of becoming eutrophic: the upstream end of Lake Diefenbaker, Swift Current Creek, the Saskatoon Southeast Water Supply (SSEWS) system and the reach downstream of Saskatoon. Enrichment of a water body is a concern due to the potential for promotion of excessive growth of algae and aquatic weeds and for changes in the biological community.

An increase in biological productivity may impair various uses of the water body. Domestic and municipal supplies may be degraded due to the presence of taste and odour-causing organisms, clogging of intakes, a need for increased treatment prior to use, and the potential generation of process-related substances such as chlor-organics. Recreation is affected due to reduced aesthetic appeal and changes in the composition of fish species. Irrigation water supply and distribution may be physically affected by excessive growths, and livestock watering may be impaired by the presence of blue-green algae which are toxic when ingested. Fish can be affected directly by low oxygen levels resulting from excessive growths and indirectly by changes in feeding opportunities due to changes in the aquatic community.

Eutrophication is a natural process, but man has the capability to increase the rate of eutrophication. Nutrients can be introduced from point sources, such as municipal effluents and feedlots and from diffuse sources, including runoff from agricultural areas. Reduction of anthropogenic loadings of nutrients for the purpose of preventing or limiting eutrophication has met with mixed success in the prairies due to the high quantities of nutrients present naturally and a host of other factors which contribute to the proliferation of aquatic weeds.

Species of nitrogen and phosphorus are essential plant nutrients and are therefore used as indicators of the potential for growth of aquatic plants in a water body. Data on the concentration of nutrients is readily obtained, but inferences regarding the amount of resulting plant growth are tentative at best. Site-specific factors, such as water velocity, sediment type, light availability and predation, are as important as nutrient levels in determining plant growth. Work continues in determining nutrient-growth relationships to enable effective action to be taken to control eutrophication where this is feasible.

Phosphorus is the nutrient that commonly limits weed growth in fresh waters. It can occur in numerous organic and inorganic forms, and as dissolved and particulate species. Total phosphorus, total dissolved phosphorus and soluble reactive phosphorus are the species for which data is usually available. Soluble reactive phosphorus is the fraction which is most actively taken up by plants. Particulate phosphorus consists of phosphorus in association with sediment, some of which may be available under oxygenated conditions. The amount of phosphorus in each form is continuously changing due to the process of decomposition and synthesis. Phosphorus from effluents generally contributes to the dissolved phosphorus fraction. Phosphorus from agricultural sources is evident in the dissolved as well as the particulate phosphorus fractions.

Nitrogen also exists in a variety of forms which are continually changing due to chemical and biological transformations. Nitrate, the most oxidized form of nitrogen, is the principal form of nitrogen found in natural waters. A major source of nitrates is human and animal waste. Ammonia is the most reduced form of nitrogen; it results from the decomposition of organic matter and is a constituent of treated sewage. Organic nitrogen results from nitrogenous debris and biological transformations. Total Kjeldahl nitrogen is a measure of ammonia and organic nitrogen and is an indication of nitrogen available for biological activity.

2.1.2 Salinization

Salinization was identified as a water quality issue in Swift Current Creek and in the SSEWS system, and, to a lesser extent in the mainstem. Waters with high concentrations of salt are common in arid areas. High rates of evaporation, low flushing rate, low precipitation and significant ground water discharge contribute to the salt levels in surface waters.

Dissolved salts mainly include sulphate, chloride, and carbonate and bicarbonate salts of calcium, sodium, magnesium and potassium. They can be analyzed individually and can be approximated by measuring total dissolved solids. Specific conductivity is an indirect measure of salt content. Taste problems are common to saline waters, although the salts rarely pose a threat to human health. High salt concentrations can limit the use of water for irrigation of some soils, and, if very high, can eliminate the use of water for irrigation. Saline water may be unsuitable for municipal and industrial uses due to costly treatment requirements.

The effects of salts on aquatic life are poorly understood. The ratio of monovalent to divalent cations (ie. sodium + potassium : calcium + magnesium) may influence the algal composition. Some common diatom species have been shown to require a narrow range of ratios although the actual range of concentrations of the salts can vary considerably. This may be relevant in the South Saskatchewan River because sources of salts such as land drainage and sewage tend to contribute monovalent ions, particularly sodium, rather than divalent ions. An increase in salinity does not appear to cause osmotic effects unless increases are substantial (ie. in the range of thousands of milligrams per litre). Effects of salinity on population and community structure are not known in the study area.

Agricultural practices can contribute to the salt loading of surface waters. Irrigation return flows, particularly from tile drained fields, usually have high concentrations of salts. An increase in irrigated land area is planned in upstream reaches of the basin in Alberta and in the Saskatchewan portion of the basin. There is a possibility that this could lead to higher salt loadings in the South Saskatchewan River.

Reservoirs tend to increase the salt content of a water body through increased evaporation and decreased flow-through. The series of lakes and reservoirs in the Swift Current Creek and in the SSEWS system have a higher salt content than the mainstem. Surface area to volume ratios, ground water influences, irrigation return flows and flushing rates are contributing factors.

The salts are soluble and conservative, meaning they remain dissolved and levels of the individual salts change very little from site to site. The implication of this is that an increase in land drainage or return flow, for example, can be felt at distances far removed from the change.

The sodium adsorption ratio (SAR) is used to evaluate the suitability of water for irrigation. The ratio is an estimate of the degree to which sodium will be adsorbed by soil from water. Specifically, it evaluates the potential base exchange relationships in which calcium and magnesium in soil are replaced by the sodium present in the water. Sodium adversely affects soil structure and permeability and must therefore be closely monitored in irrigation waters.

2.1.3 Contaminants

Contaminants are an issue throughout the basin. Contaminants can generally be divided into two categories: metals and organic substances. Contaminants are a concern because very low levels of organic contaminants can impair water uses, information concerning organic contaminants and their effects in the basin is scant, and some metals exist at elevated levels with uncertain effects.

Metals originate from the weathering of rocks and from industrial and municipal sources. The metals tend to be associated with fine suspended sediments and clays. Their toxicity to aquatic life, the most sensitive use, is dependent, among other factors, upon hardness, presence of organic carbon, acidity, the form of the metal and species tolerance. Other uses, such as drinking water and agriculture, are less sensitive to concentrations of metals.

Iron and manganese affect drinking water more than aquatic life. The metals affect the aesthetics of the drinking water supply ie. taste considerations. High concentrations of these metals occur naturally in suspended sediments. The impact on supplies can be reduced by the removal of the solids in the water treatment process.

Mercury has been a concern in the portion of the basin downstream of Saskatoon. High concentrations of mercury have been detected in fish, crayfish, macrophytes, sediments and water. Mercury is toxic to aquatic life and can bioaccumulate, particularly in bottom feeding organisms.

Unlike metals, the organic contaminants of concern are largely anthropogenic in origin. Natural organic compounds exist in the dissolved, colloidal and suspended phases, but it is the man-made compounds which have the potential to adversely affect water uses. The uses which could be impaired are aquatic life, drinking water, livestock watering and irrigation.

Potentially detrimental organic compounds have several sources. Agricultural and urban pest control chemicals (ie. insecticides, herbicides, fungicides and wood preservatives) may enter surface waters by direct application or by runoff from treated areas. Industrial and manufacturing effluents may contain organic substances such as dyes, surfactants, resins and paints. Sewage treatment plants which receive effluents from commercial establishments or which chlorinate the effluent are also sources. Leachates from landfill sites, storm water runoff and rainfall also contribute organic substances to surface waters.

Pesticides are used throughout the prairies and residues are occasionally detected in surface waters. Measured levels are commonly below what is believed to be harmful to aquatic and human life, but chronic or long-term effects are not known. An increase in the agricultural land area within the study area and upstream in Alberta could dramatically affect pesticide levels in basin surface waters. Changes in agricultural practices, such as a reduction in tilling and an increase in the use of herbicides, are also cause for concern. Recently developed pesticides break down rapidly in the environment and have less toxic by-products, but, in some cases, can be more acutely toxic to aquatic life.

2.2 SUB-BASIN ISSUES

The river in the reach of the study area between the Alberta-Saskatchewan border and Lake Diefenbaker is not intensively used. Water quality issues which may be relevant in the future include Alberta consuming an increasing amount of the natural flow for, amongst other uses, irrigation, and a change in the proportion of South Saskatchewan River and Red Deer River flows entering Saskatchewan. An increase in irrigation would likely increase salt loads throughout the basin. An increase in Red Deer River flows relative to South Saskatchewan River flows would increase the suspended sediment content and associated substances of the river at least as far downstream as Lake Diefenbaker.

Water quality issues in Lake Diefenbaker are varied. The increasing eutrophication at the western (inflowing) end of the lake is a concern due to the potential of the enriched condition to spread to other parts of the lake. Existing and proposed irrigation development in the Lake Diefenbaker drainage raises concern regarding potential impacts of return flows. An increase in the recreational use of the lake could lead to deterioration in water quality due to emissions from yachts and houseboats. Because of the importance of the lake as a drinking water supply for much of southern Saskatchewan, pollution control regulations specific to the lake may be required.

The river reach immediately downstream of Gardiner Dam has the highest water quality in the system due to the filtering effect of the lake. The SSEWS system, originating at Lake Diefenbaker, is within this reach. The system of six reservoirs and canals is heavily used for municipal, industrial (potash mines), agricultural and recreational purposes. Water quality issues in the SSEWS system include high salinity and high nutrient levels, which may impair water uses if levels continue to increase.

The river reach downstream of Saskatoon has the greatest potential for degraded water quality as it has the largest population and most industrial activity in the study area. Enrichment of the reach is manifested in extensive weed beds inspite of recent upgrading of the city sewage treatment plant. Expansion of the population will aggravate the enriched condition. Industrial effluents are also discharged into this reach. Mercury and other contaminants are detectable in sediment, fish and other biota. The point source of mercury has been eliminated and levels are declining.

The basin reach upstream of the confluence of the North and South Saskatchewan rivers has the potential for degradation from municipal and industrial sources in Saskatoon. The presence of methoxychlor in sediment and biota is a concern because of the unknown effects of the levels. Methoxychlor used to be applied to control blackfly populations in order to reduce damage to livestock. The pesticide is being replaced over time by the use of biological control agents.

2.3 WATER QUALITY YARDSTICKS

The suitability of water for a particular use must be judged by some kind of measure. Various measures are currently in use.

Water quality guidelines, or numerical concentrations recommended to support a designated water use, were developed by the Canadian Council of Resource and Environment Ministers (CCREM 1987). The guidelines provide basic scientific information about the effects of water quality parameters on uses. The information is used to assess water quality concerns and to establish water quality objectives for specific sites. Guidelines have been developed for the protection of recreation, freshwater aquatic life, agriculture and industrial supplies. Guidelines essentially provide a "first cut" interpretation of the appropriateness of water for a given use.

Guidelines for drinking water quality were developed by Health and Welfare (1989). Guidelines were established for substances which are known or are suspected to cause adverse effects on human health. They are derived to safeguard health on the basis of lifelong consumption.

Water quality objectives are concentrations which are established to support and protect a designated use at a specific site. Saskatchewan has developed surface water quality objectives based upon the guidelines (CCREM, 1987) and information of the United States Environmental Protection Agency, among other sources. The Saskatchewan objectives are intended for the protection of water quality, the determination of effluent mixing zones, advice to water users on the suitability of a water body and purposes of environmental assessment. The provincial objectives apply throughout the province, but recognize that the natural quality of some rivers and lakes does not meet the objectives. In these cases the objectives do not apply.

Saskatchewan has general and specific surface water quality objectives. The general objectives concern basic water quality characteristics which afford a minimum degree of protection of all uses of water. The specific surface water quality objectives are numeric values for constituents which must be achieved to protect water bodies for aquatic life and wildlife, recreation, irrigation and livestock watering.

Water quality objectives which apply specifically to the waters of the study area were developed over the course of the study. These are presented in Chapter 5.0 of this report. Discussion and evaluation of the existing water quality data make reference to the CCREM (1987) and Health and Welfare (1989) guidelines as well as to the Saskatchewan water quality objectives (1988). These values are presented in Appendix B.

3.0 CURRENT WATER QUALITY

The status of water quality in the South Saskatchewan River Basin is described by basin reach. The descriptions are based upon the historical data of Saskatchewan Environment and Public Safety and Environment Canada, as well as on research projects and special studies carried out in the basin.

Variable amounts of information exist for each parameter group and for each basin region. This reflects changing monitoring and studies emphases as well as shifts in data collection responsibilities of participating agencies over time. Water quality issues were identified for the South Saskatchewan River Basin at the start of the study, and in-depth studies were carried out for issues of specific concern. The latter studies are heavily reported upon below.

Water quality issues in the mainstem of the river include nutrient enrichment (particularly at the upstream end of Lake Diefenbaker and downstream of Saskatoon), salinity and contaminants, as well as localized issues such as industrial effluents, irrigation return flows and recreation. Nutrient (SSRBS Technical Report D.14) and salinity (SSRBS Technical Report D.7) reviews were undertaken for the basin; the issue of organic contaminants was also explored in some detail and is discussed in Chapter 3.5. The river is discussed by reach: South Saskatchewan River upstream of Lake Diefenbaker and South Saskatchewan River downstream of Lake Diefenbaker.

3.1 SOUTH SASKATCHEWAN RIVER UPSTREAM OF LAKE DIEFENBAKER

The upstream reach of the South Saskatchewan River in the study area is dominated by the quantity and quality of flows from Alberta. The Bow, Oldman and Red Deer rivers, arising in the eastern slopes of the Rocky Mountains, drain an area of relatively high total runoff. Fluctuations in the rate of spring snowmelt in this area are the result of variations in elevation. Flows are augmented as the rivers flow east through the foothills, then across the prairie where little runoff is contributed. Ground water contributions sustain a reliable base flow. The Bow and Oldman combine to form the South Saskatchewan River; the Red Deer River flows into it a short distance east of the Alberta-Saskatchewan border. Flows at this point are greatest in May, June and July and recede through the summer, fall and winter.

The reliable source of high quality mountain water makes the development of major water management projects in Alberta possible. These can change the quantity and timing of flow as well as the quality entering Saskatchewan and must therefore be considered in the context of water management in Saskatchewan. Irrigation in Alberta has increased steadily since the 1920s, initially relying upon natural base flow and later using reservoirs to store water from high flow periods. Irrigation development currently consumes 95 percent of annual flow depletions of the river in Alberta and is expected to continue. Hydro-electric generation results in modifying the annual flow regime, with modest fall and winter flow increases as water is released from the reservoirs to meet energy requirements. Municipal and industrial uses have a minor impact on quantity and quality.

3.1.1 Nutrients

Nutrient concentrations upstream of Lake Diefenbaker are a direct function of loadings from the South Saskatchewan and Red Deer rivers. Total phosphorus and nitrogen levels are higher than elsewhere in the mainstem due to high quantity of suspended material. The nutrient concentrations show distinct seasonality, reflecting the increase in particulates and flow in the late spring and decline through summer and fall. Concentrations do not appear to have changed over time (1975-1987) for total Kjeldahl nitrogen, nitrite-nitrate or total phosphorus. Chlorophyll a and ammonia values tend to be higher in recent years, whereas ortho-phosphorous may be decreasing in concentration.

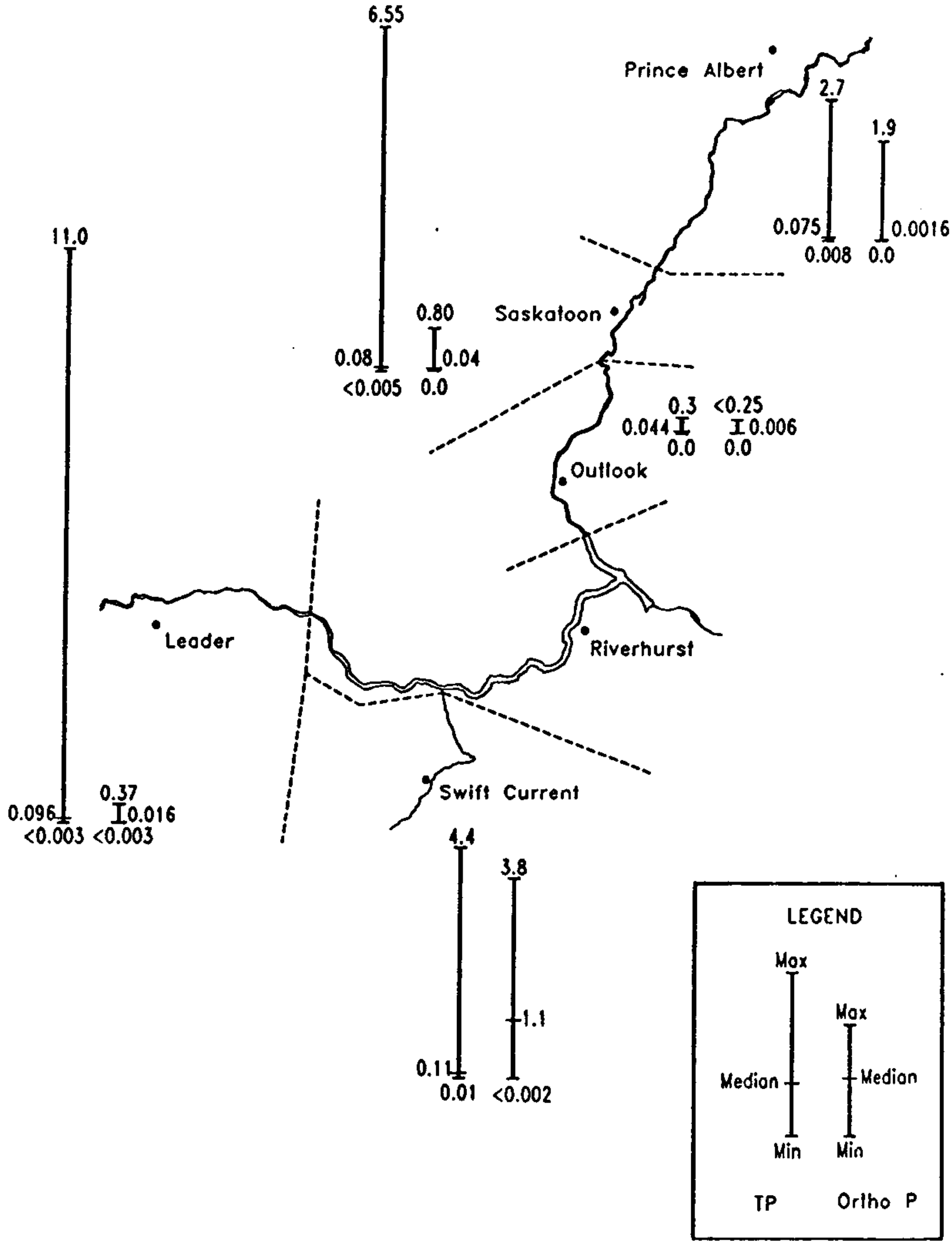
Figure 4 illustrates the downstream changes in total phosphorus and ortho-phosphorus.

3.1.2 Salinity

Chloride concentrations are two orders of magnitude below water quality guidelines. The chloride ion has been increasing at several locations on the mainstem (SSRBS Technical Report D.3), which may indicate an increase in the overall salt content. Salinity increases may reflect increased land drainage, increased irrigation return flow and increased consumption of water. Since salts remain in dissolved form and are relatively conservative, any change in Alberta would potentially be reflected by changes in Saskatchewan.

The concentration of sodium is low, with an average value of 20 mg/L. Sodium is conservative and fluctuates very little. Values of the sodium adsorption ratio (SAR) are <1.0, which are well below the guideline to protect the most sensitive crops. The concentration of sulphate averages 64 mg/L, which is similarly below the guideline for the most sensitive use.

FIGURE 4 TOTAL PHOSPHORUS AND ORTHO-PHOSPHORUS LEVELS IN THE SOUTH SASKATCHEWAN RIVER BASIN



3.1.3 Physical Parameters

Physical parameters for which interpretable data exist are alkalinity, pH, dissolved oxygen and suspended solids. Bacteriological indicators, although they are biological rather than physical parameters, are also discussed here.

Water upstream of the lake is slightly alkaline, with a median value of 146 mg/L and pH above neutral (8.2). The pH values are within the guidelines for all water uses.

Upstream of Lake Diefenbaker, levels of suspended solids (average 287 mg/L) are higher than elsewhere in the mainstem. This is due to the relatively high concentration of solids in the Red Deer (513 mg/L) compared to the South Saskatchewan (66 mg/L) (Tones, 1988). Deposition of solids in Lake Diefenbaker accounts for the low levels of suspended solids in the lake and in downstream reaches.

Dissolved oxygen levels below those recommended to protect aquatic life (5.0 mg/L) are not common, but do occur upstream of the lake. The frequency of low levels is likely to be underestimated since minimum dissolved oxygen conditions usually occur at night. Oxygen values below 5.0 mg/L occur infrequently. Effects on biota are not known.

3.1.4 Metals

Metals are detectable throughout the mainstem waters but their effects on the resident biota are uncertain. Concentrations of cadmium, nickel, selenium and silver are slightly above the detection limit and a few exceeded the guidelines for aquatic life. The risk to biota is considered minimal (SSRBS Technical Report D.6). Every positive value for silver is higher than the guideline (the detection limit is above the guideline). Silver is one of the most toxic metals to invertebrates and fish, but as the mainstem has relatively hard water and the hardness effect was not taken into account when the guideline was determined, biota in the South Saskatchewan River would be less sensitive to silver than is indicated by the guideline.

Concentrations of aluminum, lead and zinc are naturally present in the water and are associated with fine suspended solids. Concentrations often exceed aquatic life guidelines. Levels may be toxic, or marginally toxic, to aquatic life. It is unlikely that much of the lead is available due to the relatively high pH, alkalinity and suspended solids. Similarly, elevated zinc levels are likely due to an increase in suspended solids and are not expected to be toxic.

Chromium and copper levels may be toxic to aquatic life, the most sensitive use, as the guideline is frequently exceeded. The actual toxicity is unknown as it is affected by many site-specific factors. Maximum concentrations of chromium approach, but do not usually exceed the guideline for drinking water quality (the second most sensitive use). Chromium is not likely to be toxic to fish directly, but its toxicity to invertebrates may affect their food supply. Toxicity to invertebrates depends upon the form of chromium and the hardness of water. Copper tends to precipitate as a hydroxide within the pH range found in the river. Its toxicity is reduced by organic matter, and is greatly affected by the tolerance of the organisms.

Iron and manganese exceed the drinking water supply guideline, because of the high concentration of these metals naturally occurring in particulate material. Toxicity is not a problem, although the taste of the water may be adversely affected.

Concentrations of arsenic, barium, beryllium, cobalt, molybdenum and vanadium are below water quality guidelines for aquatic life protection.

Fish and sediments contain low levels of mercury, but mercury levels in water do not exceed the guidelines for the most sensitive use (aquatic life). Aquatic organisms accumulate methyl mercury even though concentrations in water may be extremely low. Known sources of mercury were eliminated in the mainstem over a decade ago.

3.2 LAKE DIEFENBAKER

Lake Diefenbaker is the major storage reservoir on the South Saskatchewan River and the largest supply of good quality water in southern Saskatchewan. Because of its importance to water management in the prairies, the lake was extensively studied by the provincial and federal governments (SSRBS Technical Report D.13). Concern focused upon the nutrient status as enrichment of the lake could be a threat to many of its uses.

3.2.1 Nutrients

The concentration of nutrients in Lake Diefenbaker is low, although the lake does respond to the nutrient loads received from the South Saskatchewan River. Nutrient levels are consistently higher in the shallower upstream locations than in the deep water areas further downstream. Concentrations of phosphorus and chlorophyll a indicate most areas of the lake are mesotrophic. The reach near Gardiner Dam is considered oligotrophic.

Eutrophication is the response of aquatic systems to enrichment by nutrients, particularly phosphorus and nitrogen. An increase in fertility can cause algal blooms, nuisance growths of rooted aquatic plants, low levels of dissolved oxygen and unpleasant taste and odour. Phosphorus is the limiting nutrient in Lake Diefenbaker. The average total phosphorus load to the lake was determined to be 1 229 tonnes per year. Limiting the phosphorus load to the lake will be required to maintain the mesotrophic status and to avoid the undesirable enriched conditions.

Total phosphorus and nitrogen concentrations peak in the spring in association with prairie snowmelt, and peak again later in association with the mountain runoff. In fall and winter, total nitrogen levels gradually rise. Total phosphorus increases in the fall due to increased flow, and accompanying sediment load, from the Red Deer River.

Nutrient levels and variability are greatly reduced at Gardiner Dam relative to upstream of the lake. In addition, the dissolved fraction comprises a much greater portion of the total concentration, reflecting deposition of the particulate fraction along the length of the lake. The lower values at the dam, approximately an order of magnitude less than upstream for total phosphorus, indicate that the lake is acting as a nutrient sink in the South Saskatchewan system (Figure 5).

3.2.2 Salinity

The mean TDS of the lake is 228 mg/L, and alkalinity means range from 143 to 155 mg/L. The Red Deer River contributes a consistently higher concentration of major ions than the South Saskatchewan River. Concentrations remain relatively constant from the upstream end of the lake to Outlook (Figure 6). The pattern of dominance of the major ions (calcium, sodium, potassium, bicarbonate, sulphate and chloride) is also constant over the same reach. The ion concentrations are well below guidelines and objectives for all water uses.

3.2.3 Physical Parameters

Water temperatures in the lake do not appear to vary with depth. During July and August, water temperatures decreased with depth but a distinct thermocline was not observed. Dissolved oxygen concentrations were high and uniform with depth for most of the year, exceeding the Saskatchewan objective of 5.0 mg/L for the protection of fish and aquatic life. Lower dissolved oxygen levels were measured near the lake bottom in late summer when lake temperatures were highest and in the late winter when the lake was ice covered. The low values are not considered a concern for fish populations.

Mean total and fecal coliform densities in the off-shore areas of the lake were low, meeting provincial objectives for contact and non-contact recreation most of the time. Fecal coliform levels exceeded provincial objectives near Saskatchewan Landing and Coteau beaches on an occasional basis, indicating localized contamination possibly due to resuspension of bottom sediments or from livestock or human-related activities.

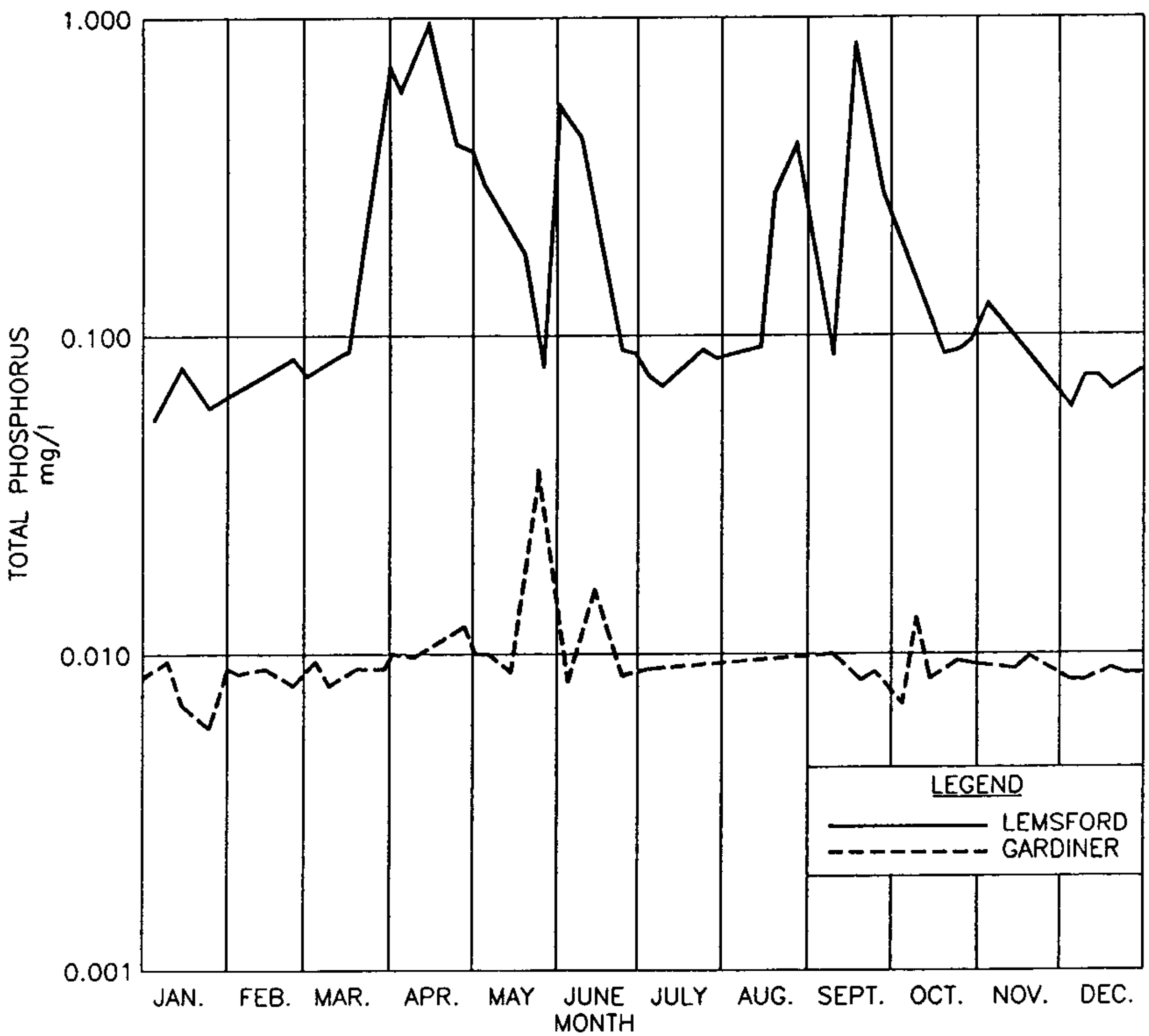
3.2.4 Metals

Data for metals are not available for various regions of the lake. Most metals which enter the lake do so in association with particulate material settling out in the upper reaches of the lake. They are unlikely to threaten any water uses, now or in the future.

3.3 SOUTH SASKATCHEWAN RIVER DOWNSTREAM OF LAKE DIEFENBAKER

Prior to the development of Lake Diefenbaker, the South Saskatchewan River in Saskatchewan was very lightly used. The primary use was for the city of Saskatoon. Irrigation was limited to a few small projects and recreation and fisheries were limited by the wide fluctuations in water flow and level and by the heavy sediment load.

FIGURE 5 **COMPARISON OF TOTAL PHOSPHORUS CONCENTRATIONS UPSTREAM OF LAKE DIEFENBAKER (LEMSFORD) AND AT GARDINER DAM**



After Gardiner Dam and the Qu'Appelle Dam were built, uses were greatly expanded. Lake Diefenbaker was developed as a multipurpose water control project. In addition to supplying water for irrigation, municipal, industrial, recreation and wildlife projects, the lake regulates downstream flows and provide flood control and hydro-electric generation. Annual net evaporation from the lake has been the largest use of water in the basin in recent years.

Whenever the water supply permits, Lake Diefenbaker is full in the fall. This provides the maximum water supply for winter hydro-electric generation. The lake is drawn down through the peak power demand months of December, January and February. By late February, forecasts of spring runoff are available. Releases through March reflect mountain snowpack conditions. The lowest lake levels occur around the beginning of April, then snowmelt results in increased flows and the lake begins to refill. In addition to striving to achieve desirable lake levels, the operations must provide for adequate flows downstream.

3.3.1 Nutrients

Nutrient concentrations downstream of Lake Diefenbaker vary in response to inputs and to the effects of the lake. Optimum nutrient levels are experienced downstream from Lake Diefenbaker, reflecting the high quality of sediment-free water released from the reservoir. Total phosphorus and nitrogen levels are lower than upstream of the lake, due to sedimentation. Nitrate levels are elevated, reflecting reservoir processing. The moderating effect of the lake is shown by the narrower ranges and lower maximums of the nutrient levels downstream of the dam (SSRBS Technical Report D.13).

Nutrient levels are elevated in the Saskatoon reach due to nutrient loading from the city of Saskatoon. Associated with the increase is an enhancement of biological productivity. All forms of phosphorus and nitrogen increase below the municipal sewage treatment plan outfall. Approximately two-thirds of the phosphorus increase is made up of soluble reactive phosphorus. With distance downstream, concentrations decline due to mixing across the river and loss to the aquatic biota and sediments. The downstream attenuation is primarily reflected in the soluble reactive fraction, whereas the particulate and dissolved organic phosphorus concentrations remain relatively uniform along the downstream reach. Nitrogen levels return to background values within about 100 km, whereas phosphorus concentrations did not return to background within the 140 km downstream reach.

3.3.2 Salinity

The salinity downstream of Lake Diefenbaker shows less variation than upstream values due to the dampening effect of the lake (Figure 6). Average values range from 330 to 415 mg/L (SSRBS Technical Report D.6), which are below the guideline for the most sensitive use.

Chloride concentrations are two orders or magnitude below any water quality guidelines. The chloride ion has been increasing immediately downstream of the reservoir, which may indicate an increase in the overall salt content (SSRBS Technical Report D.3). Salinity increases may reflect increased land drainage, increased irrigation return flow and increase consumption of water. The chloride increase does not limit the use of water for the most sensitive use (irrigation).

The concentration of sodium in the mainstem is low, with average values of around 20 mg/L. Sodium is conservative and fluctuates very little. Values of the sodium adsorption ratio (SAR) are <1.0, which are well below the guideline to protect the most sensitive crops. Concentrations of sulphate average 69 mg/L, which are similarly below the guideline for the most sensitive use.

3.3.3 Physical Parameters

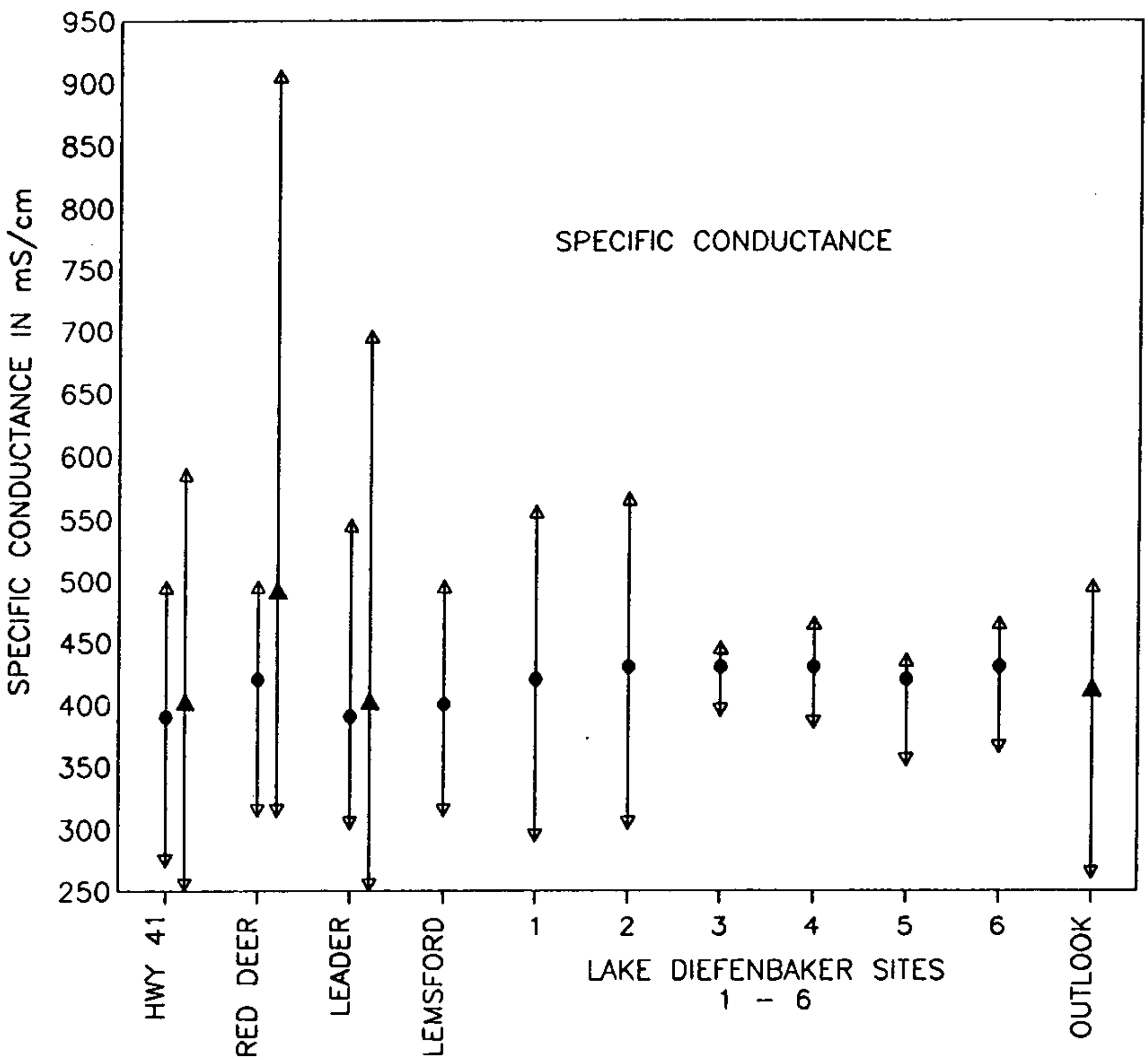
Physical parameters for which interpretable data exist are alkalinity, pH, dissolved oxygen and suspended solids. Bacteriological indicators, although they are biological rather than physical parameters, are also discussed here.

Water in the mainstem is slightly alkaline, with median values in the 130 to 158 mg/L range and pH above neutral (8.1 to 8.5 range). The pH values are within the guidelines for all water uses. Suspended solids levels are low throughout the downstream reach, particularly immediately downstream of the dam due to deposition of solids in the reservoir.

Dissolved oxygen levels below those recommended to protect aquatic life (5.0 mg/L) are not common. The frequency of low levels is likely to be underestimated since minimum dissolved oxygen conditions usually occur at night. Large variations occur downstream of the Saskatoon sewage treatment plant where high plant biomass exists; the variations are characteristic of productive water bodies. Minimum levels occur in the summer when temperatures are highest. This stresses aquatic

FIGURE 6 **TOTAL DISSOLVED SOLIDS IN THE SOUTH SASKATCHEWAN RIVER**

NOTE: SPECIFIC CONDUCTANCE IN uS/cm IS APPROXIMATELY EQUAL TO TOTAL DISSOLVED SOLIDS IN mg/l



SPATIAL PLOT OF STUDY PERIOD (CIRCLES) AND PERIOD OF RECORD (TRIANGLES) MEAN AND RANGE FOR SPECIFIC CONDUCTANCE organisms at a time when their oxygen requirements are greatest. Low dissolved oxygen can be caused by organic waste assimilation and eutrophication. The effect of short summer periods of low oxygen on river biota are unknown. Mobile species with the ability to avoid the zones of low oxygen would be at less risk than sedentary species and non-mobile life stages (SSRBS Technical Report D.6).

Impairment of water quality occurs in the Saskatoon reach where water is unsuitable for irrigation and recreation. Upstream of the City, coliform densities were below the guidelines for all uses. Levels increased within the City, but upstream of the sewage treatment plant. Downstream of the sewage treatment plant discharge, levels increased across the river. Although they declined 22 km downstream at Clarkboro Ferry, the two most sensitive uses, irrigation and recreation, would still be impaired.

3.3.4 Metals

Metals are detectable throughout the mainstem waters but their effects on the resident biota are uncertain. Concentrations of cadmium, nickel, selenium and silver are slightly above the detection limit and a few exceeded the guidelines for aquatic life. The risk to biota is considered minimal (SSRBS Technical Report D.6). Every positive value for silver is higher than the guideline (the detection limit is above the guideline). Silver is one of the most toxic metals to invertebrates and fish, but as the river has relatively hard water and the hardness effect was not taken into account when the guideline was determined, biota in the South Saskatchewan River would be less sensitive to silver than is indicated by the guideline.

Concentrations of aluminum, lead and zinc are naturally present in the water and are associated with fine suspended solids. Concentrations often exceed aquatic life guidelines. Levels may be toxic, or marginally toxic, to aquatic life. It is unlikely that much of the lead is available in the river due to the relatively high pH, alkalinity and suspended solids. Similarly, elevated zinc levels are likely due to an increase in suspended solids and are not expected to be toxic.

Chromium and copper levels may be toxic to aquatic life, the most sensitive use, as the guideline is frequently exceeded. The actual toxicity is unknown as it is affected by many site-specific factors. Maximum concentrations of chromium approach, but do not usually exceed, the guideline for drinking water quality (the second most sensitive use). Chromium is not likely to be toxic to fish directly, but its toxicity to invertebrates may affect their food supply. Toxicity to invertebrates depends upon the form of chromium and the hardness of water. Copper tends to precipitate as a hydroxide within the pH range found in the river. Its toxicity is reduced by organic matter, and is greatly affected by the tolerance of the organisms.

Iron and manganese exceed the drinking water supply guideline, because of the high concentration of these metals naturally occurring in particulate material. Toxicity is not a problem, although the taste of the water may be adversely affected.

Concentrations of arsenic, barium, beryllium, cobalt, molybdenum and vanadium are below water quality guidelines for aquatic life protection.

Fish and sediments contain low levels of mercury, but mercury levels in water do not exceed the guidelines for the most sensitive use (aquatic life). Aquatic organisms accumulate methyl mercury even though concentrations in water may be extremely low. Known sources of mercury were eliminated in the mainstem over a decade ago.

3.4 SASKATOON SOUTHEAST WATER SUPPLY SYSTEM

As construction of Gardiner Dam neared completion and Lake Diefenbaker filled, the Province of Saskatchewan developed works to permit the diversion of water from the lake for uses in an area northeast of the lake. The Saskatoon Southeast Water Supply (SSEWS) system is a man-made supply system designed to carry water to users in an area of limited natural water supplies (Figure 2). The main supply of water is Lake Diefenbaker, but the system is designed to conserve natural inflows to the system reservoirs when they occur. Runoff is an unreliable source that is used when it is available to minimize diversion quantities and to reduce pumping costs. The canals are not intended for winter use.

The SSEWS system is operated to meet a range of uses. The largest use is irrigation, which requires water from May to September. Irrigation occurs along the system, with the greatest concentration near the upstream end. Municipal and industrial uses are concentrated in the downstream end; the uses are year round. Waterfowl projects require water early in the spring to provide nesting habitat. Evaporation from the reservoirs during the summer removes a substantial quantity of water.

Water quality issues in the SSEWS system include salinity and nutrient enrichment. A salinity review (SSRBS Technical Report D.7) provided a substantial amount of information. Considerably less is known about the dynamics of other components of the system.

3.4.1 Nutrients

The nutrient and corresponding chlorophyll a levels in the SSEWS system are a function of nutrient loadings from Lake Diefenbaker, watershed loading, reservoir morphometry and water residence time. The nutrient quality of the SSEWS system reservoirs varies from mesotrophic to eutrophic in reservoirs immediately adjacent to Lake Diefenbaker, to hypereutrophic in the reservoirs further down the system (SSRBS Technical Report D.14).

The nutrient quality of the reservoirs, particularly in the downstream portion, are biologically productive with substantial algal populations and frequent cyanophyte blooms. High levels of chlorophyll have been measured in Bradwell, Zelma and Dellwood reservoirs.

The data suggest an increase in total phosphorus levels during the 1980s in Blackstrap, Brightwater and Dellwood reservoirs. Total Kjeldahl nitrogen and nitrate-nitrite data show no discernable trends.

3.4.2 Salinity

The total dissolved solids (TDS) of reservoirs in the SSEWS system indicate that only Broderick and Brightwater meet all the guidelines and objectives. Water from Blackstrap may be less palatable and affect some crops sensitive to salinity. Bradwell and Zelma reservoirs are more saline; values approach municipal drinking water objectives and have the potential to cause salinity problems on irrigated land since TDS concentrations exceed 1 000 mg/L.

Median chloride levels in the SSEWS system are variable, ranging from 6 to 53 mg/L (SSRBS Technical Report D.6). Maximum levels were 81 and 83 mg/L in Bradwell and Zelma, respectively, which are below the guideline for the most sensitive crops.

Levels of sodium in the SSEWS system are more variable than those in the mainstem. Median levels vary from 24 mg/L at Brightwater Reservoir to 143 mg/L at Zelma Reservoir. Water from Bradwell and Zelma reservoirs could cause foliar damage to sensitive crops when concentrations at the maxima occur. The reservoirs with the highest sodium levels (Bradwell and Zelma) have SAR values of 3.16 and 3.55 respectively, based on maximum values. However, based on median values (more relevant to the long-term effect on soils), all reservoirs have SAR values <3, indicating that under most conditions, the water can be used for the irrigation of all crops (SSRBS Technical Report D.7).

The highest concentration of sulphate occurs at Bradwell Reservoir where the median concentration is 541 mg/L and the maximum is 1 302 mg/L. Bradwell Reservoir does not meet the guideline for drinking water supply. Zelma Reservoir, which also has high sulphate concentrations, is marginal as a drinking water supply.

The reservoir TDS levels gradually increase down the SSEWS system. The best quality is in Broderick and Brightwater reservoirs, where the short residence times create the smallest annual and seasonal variability. Concentrations of TDS increase substantially between the upstream and downstream ends of Blackstrap Reservoir, likely due to a ground water inflow.

Total dissolved solids levels in Broderick Reservoir are identical to those of Lake Diefenbaker, reflecting the relatively rapid flushing rate created by the May to October releases. Evaporative losses are not sufficiently significant, relative to inflows, to create a distinct seasonal variation in TDS quality (SSRBS Technical Report D.7).

Patterns of TDS in Brightwater Reservoir are similar to those of Broderick, but more seasonal variation is evident. The effect of significant watershed runoff in diluting reservoir quality is evident for some years, but is masked within a few months by inflows from Broderick. The formation of ice in winter causes an increase in TDS due to freeze out.

The upstream portion of Blackstrap Reservoir quality reflects the inflows from Brightwater Reservoir, watershed inflows and the concentrating effect of evaporation. The downstream portion experiences a ground water inflow of relatively high TDS water from the Judith River Formation.

Bradwell Reservoir water quality is a function of releases from Blackstrap and winter ice formation. Levels of TDS generally exceed 1 000 mg/L during the open water season due to evaporative concentration and inflows. Freeze out has a substantial impact on salinity levels due to the reservoir's large surface to volume ratio. Zelma Reservoir also experiences a significant freeze out effect.

Dellwood Reservoir exhibits the greatest annual and seasonal variability in TDS, ranging from less than 500 to over 1 500 mg/L. The reservoir appears to be very sensitive to watershed runoff.

Salt levels in Little Manitou Lake, at the end of the system, are very high. This reflects the long-term effect of a small inflow and high evaporative losses. Inflows cause no substantial change in TDS.

Table 1 summarizes salinity data for the SSEWS system; Figure 7 illustrates TDS and SAR variations in the system.

3.4.3 <u>Physical Parameters</u>

The Brightwater, Bradwell, Dellwood and Blackstrap reservoirs were measured for total and fecal coliforms. Geometric means of fecal coliforms were well below the guidelines for irrigation, the most sensitive use.

Dissolved oxygen levels have varied considerably in the reservoirs. Minimum levels of 0.1 and 2.0 mg/L have been reported for Brightwater and Bradwell reservoirs. Levels in other reservoirs were above the 5.0 mg/L required to protect aquatic life.

Alkalinity is slightly higher in the SSEWS system than in the mainstem, with mean values ranging from 122 mg/L in Broderick Reservoir to 210 mg/L in Zelma Reservoir. The median pH values, ranging from 8.1 to 8.4, are similar to the mainstem.

3.4.4 <u>Metals</u>

To date, metals have not been a concern in the SSEWS system, therefore no data are available for the reservoirs.

3.5 SWIFT CURRENT CREEK

From the late 1800s to the present, the water of the Swift Current Creek (Figure 3) has been progressively diverted for human uses. The completion of Duncairn Dam, forming Duncairn Reservoir, lead to the development of a comprehensive system of canals and reservoirs which supply individual and group irrigation projects in the Swift Current Creek Basin and in the adjacent Rushlake Creek Basin. In addition to serving irrigation development, the creek provides municipal water for the city of Swift Current and other smaller communities. Several of the water bodies provide fish, wildlife and recreational opportunities and habitat for fish and wildlife.

Swift Current Creek is the largest tributary to the South Saskatchewan River in the study area, but its average flow of about 1 percent of the total river flow is not considered critical to the management of the river. The flow of the creek is therefore managed as an independent unit. Projects in the basin range from single projects to a complex multipurpose diversion system. The simplest are the many stock watering and small irrigation projects along the headwaters of tributary streams. Duncairn Reservoir, developed to capture the runoff during high flow periods, improves the water supply by capturing spring flows and permitting controlled releases and carrying natural runoff from wet to dry years.

No water quality issues were identified specifically for the Swift Current Creek Basin. However, the system of reservoirs throughout the basin is depended upon for municipal drinking water supplies and for irrigation purposes. Any water quality condition which threatens these uses is therefore of concern.

3.5.1 <u>Nutrients</u>

Swift Current Creek experiences high nutrient concentrations throughout the year, reflecting the low flows, small size and the agricultural nature of the watershed. Benthic algae and aquatic plant densities are substantial in the basin.

Total phosphorus and Total Kjeldahl nitrogen values are comparable to those found in the Saskatoon reach of the mainstem. The highest ortho-phosphorus value in the basin (3.8 mg/L) was identified in the creek.

The median values for total ammonia have approached or exceeded the ammonia objective. Soluble reactive phosphorus concentrations exceed the criteria for public water supply.

TABLE 1

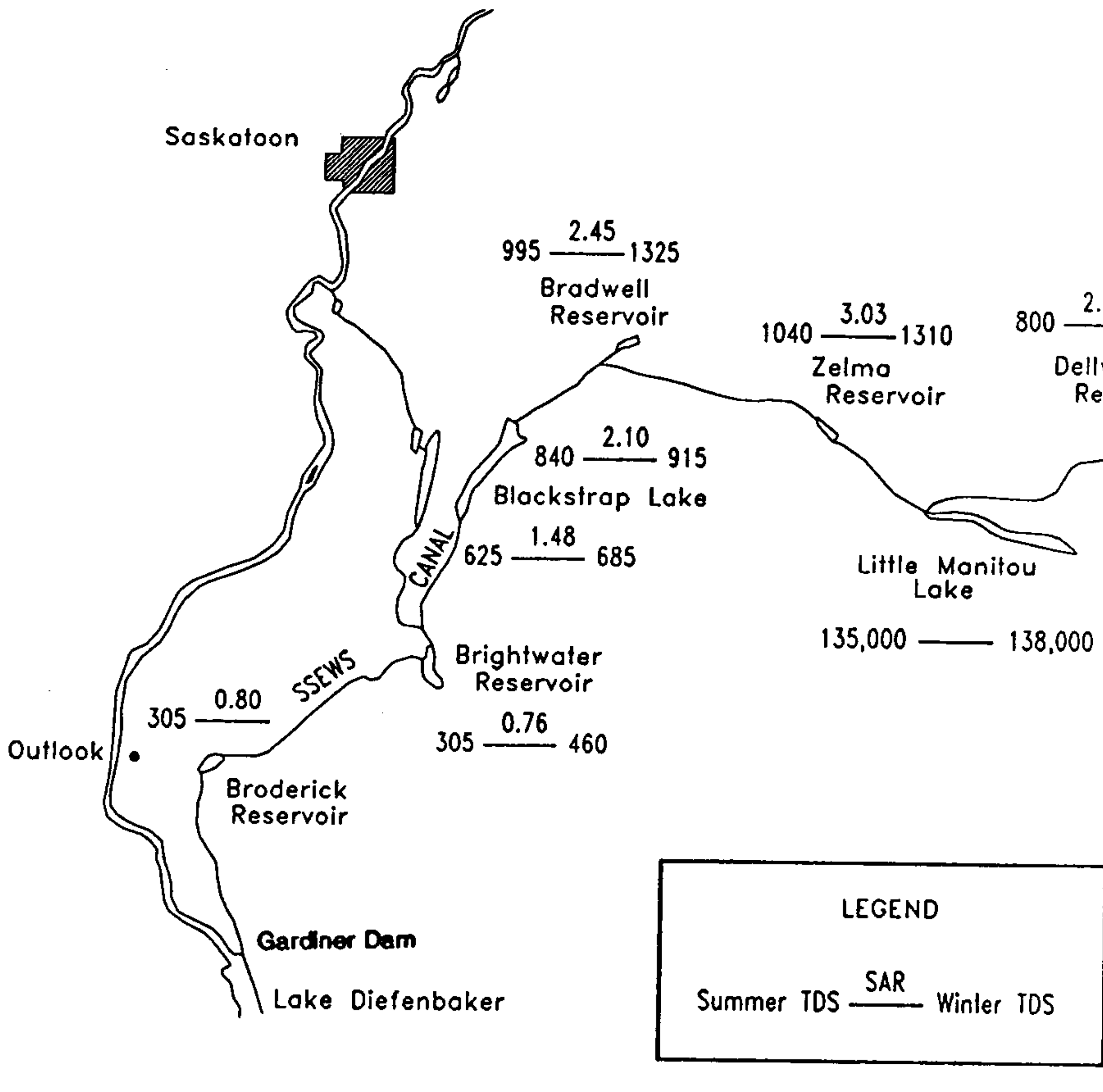
SUMMARY OF SALINITY DATA FOR THE SASKATOON SOUTHEAST WATER SUPPLY SYSTEM

WATER QUALITY

RESERVOIR	PRIMARY USES	MEAN TDS, mg/L Summer	MEAN TDS, mg/L Winter	DOMINANT IONS Anions	DOMINANT IONS Cations	MEAN SUMMER SAR	PRESENT USE CONCERNS
Broderick	Multi-purpose (downstream)	305	—	Bicarbonate Sulphate	Calcium Magnesium	0.80	nil
Brightwater	Irrigation Municipal	305	460	Bicarbonate Sulphate	Calcium Magnesium	0.76	Municipal-aesthetic (TDS)
Blackstrap	Irrigation Municipal Recreation	South Basin					Municipal-aesthetic (TDS)
		625	685	Sulphate Bicarbonate	Magnesium Calcium	1.48	
		North Basin					
		840	915	Sulphate Bicarbonate	Magnesium Sodium	2.10	
Bradwell	Irrigation Industrial	995	1 325	Sulphate Bicarbonate	Sodium Magnesium	2.45	Industrial- TDS Irrigation (soils dependent)
Zelma	Industrial Irrigation Municipal	1 040	1 310	Sulphate Bicarbonate	Sodium Magnesium	3.03	Industrial- TDS Irrigation (Crop, soils dependent) Municipal-TDS, SO_4
Dellwood	Industrial Municipal	800	1 185	Sulphate Bicarbonate	Magnesium Sodium	2.28	Industrial-TDS Irrigation (Crop, soils dependent) Municipal-TDS, SO_4
Little Manitou Lake	Recreation	135 000	138 000	Sulphate Chloride	Sodium Magnesium	—	—

Source: Modified from SSRBS Technical Report D.7

FIGURE 7 **TOTAL DISSOLVED SOLIDS AND SODIUM ADSORPTION RATIO VARIATIONS IN THE SASKATOON SOUTHEAST WATER SUPPLY SYSTEM**



3.5.2 Salinity

The TDS of Swift Current Creek is much higher than that of the mainstem, with means of 532 to 940 mg/L (SSRBS Technical Report D.6). The TDS exceeds the drinking water supply guideline and the guideline to protect irrigation of some plants. It does not exceed the Saskatchewan objective for municipal drinking water.

Median chloride levels in the basin are low, ranging from 3.8 to 14 mg/L. Levels are higher at some locations than in the mainstem, but are still much lower than guidelines for the most sensitive use. Median concentrations of sodium range from 30 to 108 mg/L. The SAR values calculated from the medians are all <3, therefore water from the basin is suitable for irrigation (the most sensitive use). Median sulphate levels are higher than those of the mainstem. They range from 85 to 325 mg/L, and are below the municipal drinking water objective and the drinking water supply guideline of 500 mg/L.

Duncairn Reservoir is the largest reservoir in the Swift Current Creek system, and is the primary source for the other system reservoirs. Quality is affected by contributions from rangeland and cultivated land and by evaporation. Bicarbonate and calcium are the predominant anion and cation. No water uses are impaired. All drinking water objectives and guidelines are met, and the quality falls well within guidelines for the irrigation of most crops. Mean summer TDS values indicate the water may be unsuitable for the irrigation of non-tolerant crops.

Swift Current Reservoir quality is governed by Duncairn Reservoir outflows and watershed runoff. Values of TDS increase substantially in the winter. Spring, fall and winter averages all exceed the drinking water guideline of 500 mg/L; however, the Saskatchewan maximum of 1 500 mg/L is not exceeded. The aesthetic objective of 150 mg/L for sulphate is exceeded throughout the year. Irrigation concerns relate mainly to the spring and summer months. Values of TDS for the spring indicate unacceptable levels for the irrigation of non-tolerant crops. Conclusions cannot be drawn for summer quality due to insufficient data. Values of SAR for spring and summer (1.09, 1.30 respectively) indicate suitability for irrigation of all crop types.

The quality of Highfield Reservoir is a function of releases from Swift Current Reservoir and flow from Rushlake Creek. Magnesium and sodium are the primary cations and bicarbonate and sulphate are the dominant anions. Highfield Reservoir water is within drinking water guidelines and objectives for the spring and summer. Maximum TDS values occasionally exceed the aesthetic objective of 500 mg/L. Values for SAR for spring (1.65) and summer (1.62) indicate acceptability of the water for irrigation of all crops.

Inflows to Herbert Reservoir consist of releases from Highfield Reservoir and minor contributions from area runoff. Sulphate is the major anion while magnesium, closely followed by sodium, is the dominant cation. Drinking water guidelines and objectives are met most of the time. Guidelines for the commonly grown forage crops are met, while those for only slightly tolerant crops may be at risk in spring. SAR values for spring and summer (1.67, 1.70 respectively) indicate the water is acceptable for the irrigation of sensitive crops.

Reed Lake is a shallow, internally drained lake that acts as a sink for the entire delivery system. No water quality data are available for the lake, but it is expected that the major ion quality would fluctuate considerably with the water level and would tend to have high concentrations.

Table 2 summarizes salinity data for Swift Current Creek.

3.5.3 Physical Parameters

Alkalinity is slightly higher in the Swift Current Creek than in the mainstem. Mean values range from 199 to 288 mg/L. Mean pH values, 8.0 to 8.7, are in the same range as those of the mainstem.

Minimum values of dissolved oxygen fall below the guideline to protect aquatic life. Values have reached as low as 1.0 mg/L.

The geometric mean range of fecal coliforms is 10 to 61/100 mL, which is below the guideline for the most sensitive use (irrigation).

TABLE 2

SUMMARY OF SALINITY DATA FOR THE SWIFT CURRENT CREEK SUPPLY SYSTEM

WATER QUALITY

RESERVOIR	PRIMARY USES	MEAN TDS, mg/L		DOMINANT IONS		MEAN SUMMER SAR	PRESENT USE CONCERNS
		Summer	Winter	Anions	Cations		
Reid Lake	Multi-purpose Irrigation	520	—	Bicarbonate Sulphate	Calcium Magnesium	1.25	nil
Swift Current	Municipal Irrigation	465	800	Bicarbonate Sulphate	Calcium Magnesium	1.37	Municipal-aesthetic (TDS, SO_4)
Highfield	Irrigation	470	—	Bicarbonate Sulphate	Magnesium Sodium	1.62	nil
Herbert	Irrigation Municipal	510	530	Sulphate Bicarbonate	Magnesium Sodium	1.70	Municipal-aesthetic (TDS, SO_4)
Reed Lake	Waterfowl	—	—	—	—	—	nil

Source: Modified from SSRBS Technical Report D.7

3.5.4 Metals

Data for metals are very limited. The concentration of aluminum in Swift Current Creek exceeds the guideline for the protection of aquatic life in 10 to 50 percent of the samples. Levels of cadmium infrequently exceed the guideline and occur at concentrations close to the detection limit. Concentrations of chromium frequently exceed the guideline for the protection of aquatic life, but are below the guideline to protect fish. Copper and lead levels in the creek rarely exceed the aquatic life guideline (SSRBS Technical Report D.6).

3.6 STATE OF AQUATIC HEALTH

The true indication of the condition of any water body is the health of the biological organisms which inhabit it. Plants and animals respond to the cumulative consequence of all entities in their environment. Quantification of the entities, as has been done in this chapter, is limited in its ability to predict its consequence to individual biota and to the entire aquatic community.

Three approaches were taken in the study to address the question of aquatic health in the South Saskatchewan River Basin. Firstly, a review of all the organic contaminants in the basin was undertaken, from the view of identifying those of potential concern. Secondly, the effect of all entities (organic and inorganic) in the water on selected test biota was investigated as an estimate of possible biological responses in the real system. Thirdly, fish and invertebrates living in the system were identified to serve as an additional indication of the health of the aquatic community in the study area.

3.6.1 Organic Contaminants

The organic contaminant review (SSRBS Technical Report D.4) identified all the anthropogenic organic contaminants potentially present in the basin. This was done by examining permits issued for the use of pest control substances, contacting pesticide distributors and reviewing the results of water quality monitoring programs and studies.

Many of the identified compounds did not appear to pose a threat to aquatic life. Thirty-seven compounds are potentially present in the basin, of which only 20 are routinely monitored. As a result of a special study, only one (bromoxynil) of the remaining 17 was found to be present. Some compounds had maximum values which were observed in the basin below the Saskatchewan surface water quality objectives: atrazine, alpha-BHC, carbofuran, dicamba, 2,4-D, picloram and 2,4,5-TP. Other compounds had no detectable levels in the basin: chlorpyriphos, DDT and metabolites, diallate, methoxychlor and trifluralin (Table 3).

The maximum concentration of lindane (0.8 ug/L) exceeds the Manitoba objective and USEPA chronic exposure level (0.08 ug/L) and the Ontario objective (0.01 ug/L), but is below the USEPA acute exposure level (2.0 ug/L). Similarly, the maximum concentration of PCBs (0.03 ug/L) was also above the Manitoba objective and USEPA chronic exposure level (0.014 ug/L) and the Ontario objective (0.001 ug/L), but is below the acute exposure level (2.0 ug/L). Based upon these reported maximum values, lindane and PCBs may, over the long-term, pose a threat to aquatic life.

Although routine water quality monitoring data suggest that methoxychlor does not pose a threat to aquatic life, special studies have identified low levels in sediments, plants, invertebrates and fish. Over the long-term, methoxychlor can be desorbed from sediments and vascular plants. Low level contamination of organisms could therefore persist for some time. The long-term effects to the organisms are not known. Methoxychlor is currently used in much lesser quantities than in previous years.

Many compounds are thought to be present in the basin, but for which no monitoring or study information is available (Table 3). The levels and their consequent effects on the basin biota, therefore, cannot be estimated.

A final group of compounds are present in basin waters, but no objectives exist with which to judge the safety to aquatic life.

Data for individual organic contaminants from industrial and manufacturing effluents, municipal sewage treatment plant effluents, landfill leachates and storm water runoff were not available. The lack of publicized acute reactions by aquatic organisms (ie. fish kills) or complaints by water users downstream from the inputs (ie. taste and odour in water or in fish) implies that if these sources did contribute detrimental compounds, their concentrations in surface waters are either sufficiently small so that no threat exists for either water quality or aquatic organisms, or their effects on the aquatic environment can only be demonstrated over long periods of time and may be manifested as sublethal reactions in aquatic organisms.

TABLE 3	ANTHROPOGENIC ORGANIC COMPOUNDS PRESENT OR POTENTIALLY PRESENT IN THE BASIN
Compounds below detectable levels	chlorpyrifos DDT and metabolites diallate dimethoate methoxychlor trifluralin
Compounds with maximum values below Saskatchewan water quality objectives	atrazine alpha-BHC carbofuran dicamba 2,4-D picloram 2,4,5-TP
Compounds which exceed some limits for aquatic life	lindane PCBs
Compounds which are potentially present but are not routinely monitored	acrolein bromoxynil carbaryl dalapon deltamethrin diquat difenzoquat flamprop-methyl malathion mecoprop methoprene paraquat propanil pyrethrins sethoxydim temephos
Compounds present above detectable limits with unknown effects	diclofop MCPA triallate 2,4,5-T 2,4-DP

Municipal and industrial point sources in the basin are few, but could add significantly to the organic contaminant burden of the river. The point sources discharge continuously throughout the year or, in the case of the smaller sources, only one or two times per year. Agricultural and urban pest control products are added only seasonally. Inspite of this, and the fact that there may be a high incidence of organics in effluent discharged by Armak Chemicals, considerably less is known about the presence of the point source contaminants than about the pest control compounds. The lack of public feedback and the fact that such information has not been collected to date does not in any way imply that long-term chronic reactions in the aquatic biota are not occurring.

3.6.2 Toxicity Studies

Various water quality data evaluations have indicated values of some water quality parameters which exceed aquatic life protection limits (ie. metals in turbid waters, lindane), values of others which are of concern but which are currently below aquatic life limits (ie. salts) and values which cannot be interpreted (ie. diclofop, MCPA). Are any of these levels a problem for aquatic organisms living in the basin? In an attempt to answer this question, basin water was screened for its effects on biota, using a range of organisms representing major categories of aquatic life: bacteria, algae, invertebrates and fish (Melville et al., 1989)

A selection of test procedures were employed to approximate the biological response throughout the basin. 1) The Microtox test is a bioassay which is based upon the reduction of light emitted by a luminescent marine bacterium, after the bacteria have been exposed to a toxic sample. The test determines the concentration of sample that reduces the light emitted by 50 percent after a predetermined period of exposure. 2) The algal bioassay used in the study measures the degree of inhibition of growth of algal cultures (cell divisions/day) relative to controls. 3) Chronic toxicity tests were done with Ceriodaphnia dubia as the test organism. The measure of chronic toxicity is the failure to produce at least ten young within the first seven days of life. 4) A static renewal 96 hour test was run using rainbow trout fingerlings. Observations were made over a 96 hour period and the fish were noted as normal, stressed, moribund or dead.

Responses to the Microtox test showed that the St. Louis reach of the river was the most inhibitory, the Saskatoon and Clarkboro reaches were less inhibitory than at St. Louis but more so than the majority of reaches, and that the reaches upstream of Lake Diefenbaker, downstream of Gardiner Dam and outflow to the Qu'Appelle River were consistently less inhibitory than other reaches.

Results of the algal test were inconclusive. Inhibited growth rates in some reaches may or may not have been related to turbidity of the samples. Algal growth rates increased downstream, likely in response to the availability of nutrients.

None of the invertebrates were adversely affected by the basin water, based on survival and reproduction results. Reproduction equalled or exceeded the required number of young per female, and the variation in number of young could be partly explained by turbidity. The suspended particulates appeared to interfere with the ability of the organisms to obtain food.

All of the fish were in good condition at the end of the test. It would appear that no toxicants were present in sufficient quantities in any of the reaches to cause distress to rainbow trout over a four day period.

The individual toxicity tests, evaluated together, indicate that there do not appear to be any substances in the river at levels which adversely affect biota, in spite of the exceedance of some aquatic life guidelines.

3.6.3 Fisheries Review

The diversity and abundance of aquatic life is an indication of the condition of a water body. The fisheries and invertebrates were therefore investigated (SSRBS Technical Report D.8) to provide insight to the health of the river basin and to aid in the development of objectives for aquatic life protection.

Twenty-seven species of fish were collected from the mainstem of the river and from the Swift Current Creek and the SSEWS system (Table 4). The highest yields of fish were obtained from the reservoirs of the SSEWS system. An average of 12 fish/net set were caught in the mainstem of the river, 59.7 fish/net were caught in the SSEWS system and 43.6 fish/net were caught in Swift Current Creek. The greatest diversity of species was found downstream of the Gardiner Dam. This included species typical of lakes (lake whitefish and ciscoes) and introduced species (rainbow and brook trout) in the unique habitat created by the cold, clean water discharged from Lake Diefenbaker.

TABLE 4 FISH SPECIES COLLECTED BY GILLNETTING AND SEINING IN THE SOUTH SASKATCHEWAN RIVER SYSTEM IN 1988 (SSRBS TECHNICAL REPORT D.8)	
COMMON NAME	**SCIENTIFIC NAME**
Lake sturgeon	*Acipenser fulvescens*
Quillback	*Carpiodes cyprinus*
Longnose sucker	*Catostomus catostomus*
Common white sucker	*Catostomus commersoni*
Cisco, tullibee	*Coregonus artedii*
Lake whitefish	*Coregonus clupeaformis*
Spoonhead sculpin	*Cottus ricei*
Lake chub	*Couesius plumbeus*
Northern pike	*Esox lucius*
Iowa darter	*Etheostoma exile*
Brook stickleback	*Eucalia inconstans*
Goldeye	*Hiodon alosoides*
Mooneye	*Hiodon tergisus*
Flathead chub	*Hybopsis gracilis*
Burbot, ling, freshwater cod	*Lota lota*
Shorthead redhorse	*Moxostoma macrolepidotum*
Emerald shiner	*Notropis atherinoides*
River shiner	*Notropis blennius*
Spottail shiner	*Notropis hudsonius*
Yellow perch	*Perca flavescens*
Trout-perch	*Percopsis omiscomaycus*
Fathead minnow	*Pimephales promelas*
Longnose dace	*Rhinichthys cataractae*
Rainbow trout	*Oncorhynchus mykiss*
Brook trout	*Salvelinus fontinalis*
Sauger	*Stizostedion canadense*
Walleye	*Stizostedion vitreum*

The least suitable habitat for fish is the reach from Lake Diefenbaker to Saskatoon. The habitat downstream of Saskatoon provides vegetation and organic substrate suitable for pike, walleye and several species of suckers. Goldeye, sauger, walleye and sturgeon predominate upstream of Lake Diefenbaker where conditions are typical of those which existed prior to the creation of Lake Diefenbaker.

A reduction in goldeye and sturgeon and an increase in walleye downstream of the lake appears to be linked to flow modifications and physical barriers which affect migration and river spawning. Walleye populations in the river may be replenished by strong reproducing stocks in the lake.

Sport fish populations in the reservoirs of the SSEWS system are being maintained through a stocking program of Saskatchewan Parks and Renewable Resources. Suckers, whitefish and forage fish species have been introduced from Lake Diefenbaker by way of the water supply canal system.

The most numerous species in the mainstem were common suckers, lake whitefish and longnose suckers. Other species included walleye, shorthead redhorse, cisco, goldeye, northern pike, sauger, flathead chub and quillback. Species abundant in the SSEWS system were white suckers, walleye, lake whitefish and yellow perch; northern pike and shorthead redhorse were also present. Swift Current Creek supported white sucker, walleye, northern pike, shorthead redhorse and yellow perch. Smaller species, such as minnows and sticklebacks, were present in all areas.

Potential spawning areas for walleye, sauger and suckers were available throughout the river. Goldeye spawning sites were limited to the upper reaches of the river. No potential spawning areas for northern pike were identified.

The diversity and abundance of invertebrate fauna was found to be related to the type and stability of the sediments. Sandy substrates produced the smallest quantity and diversity of invertebrates. Organic ooze provided the most productive habitat. Average standing crop of bottom fauna was determined to be 16.22 kg/ha in the mainstem, 30.98 to 211.85 kg/ha in the SSEWS system and 182.65 kg/ha in the Swift Current Creek system. Changes in the use of the river or reservoir systems which affect the quantity and type of substrate will affect the invertebrate fauna, which in turn provide food for a variety of fish species.

A more detailed evaluation of fisheries and aquatic habitats appears in the South Saskatchewan River Basin Study Environment Technical Appendix.

4.0 GROUND WATER

The physical behaviour of ground water is considerably different from that of surface water, and it therefore requires different management practices. Ground water originates as surface water percolates through the soil; some of the water may be absorbed by plant roots and transpired to the atmosphere, while the remaining water which infiltrates beyond the root zone becomes part of the ground water resource. Aquifers are zones of coarse-grained sands and gravels in which ground water has accumulated. Aquifers provide usable supplies of ground water.

The slow movement of ground water is responsible for its reliability and its quality. Aquifers act as storage reservoirs representing many years of relatively small flows. They are not susceptible to short term variability in surface moisture conditions or to evaporative losses. As water creeps through the soil, it is affected by biological and chemical processes. Organic material, bacteria and other substances are removed, while dissolved minerals are acquired. In some cases, the mineral content of ground water is so high that uses are restricted.

Because of the slow movement of ground water and its distribution, any change in quantity or quality can take many years to recover. Overuse of an aquifer, meaning water is removed more quickly than it is replaced, can leave it unusable until the aquifer naturally recharges. Degradation of quality, due to human interference for example, can be virtually impossible to treat within a reasonable time span.

Ground water is an important, but a relatively lightly used resource in the study area. The main uses are for municipal water supply for towns and villages, and domestic water for households and stock watering in rural areas.

5.0 WATER QUALITY OBJECTIVES

Water quality objectives were developed over the course of the study specifically to protect the uses of the water in the study area. Guidelines and objectives currently in place are general. That is, they are revelant in a Canadian context, for drinking water anywhere or for the entire province of Saskatchewan (see section 2.3). These existing values are not satisfactory for the purposes of the current study.

Many stages were involved in the development of basin-specific water quality objectives. The first stage served as the focal point for the objectives development process: the identification of water quality issues. Water uses were then identified, and objectives were targeted for the most sensitive use. Water quality parameters and the appropriate media were then selected which could act as indicators of potential impairment to the specific water uses. Available water quality data were evaluated and information gaps were filled. Criteria and guideline information were compiled and their relevance to the study was determined. Objectives development methodologies were selected individually for each parameter. The proposed objectives were reviewed by the Water Quality Technical Committee, and monitoring plans were developed.

Once the objectives and monitoring plans are in place, it is essential that they both be reviewed on a routine basis, in order to incorporate new scientific information as it becomes available and to ensure that the objectives are protecting the intended water uses. Of most importance, the responsible agencies must be committed to working towards the achievement or maintenance of the water quality objectives (SSRBS Technical Report D.9).

The principles for the development of objectives and the technical rationale for the development of objectives for selected parameters is presented here. The monitoring plan is discussed in section 6.0.

5.1 PRINCIPLES

Several principles were adopted by the Committee and used as guidelines during the development of objectives unique to the study area:

1. Objectives established co-operatively between jurisdictions for transboundary locations respect the sovereignty of each jurisdiction to manage water resources within each portion of the basin as it sees fit.

2. Objectives are established to protect the most sensitive agreed-upon designated downstream use.

3. Present and reasonably foreseeable water uses should be designated so that objectives will be consistent with the evolution of social and economic needs.

4. Objectives should be specific for each basin, river or river reach and should be developed for interjurisdictional crossing points or basin management units.

5. Objectives should be developed for all parameters deemed to be significant by all parties.

6. Whenever possible, water quality should endorse the ecosystem concept and consider the antagonistic, synergistic and additive effects of substances.

7. Objectives should be subjected to ongoing review.

8. Water quality objectives are not legally binding numbers, but should be used to develop standards or effluent regulations by jurisdiction.

5.2 TECHNICAL RATIONALE

The technical rationale for the development of use and basin specific objectives is presented for nutrients, salinity, bacteria, metals and organic contaminants. A complete rationale is documented in SSRBS Technical Report D.12. Water quality objectives developed for the study area are presented in Table 5.

TABLE 5 — **SUMMARY OF WATER QUALITY OBJECTIVES FOR THE SOUTH SASKATCHEWAN RIVER BASIN**

PARAMETER		PROPOSED USE - SPECIFIC OBJECTIVES			
		Irrigation	Livestock Watering	Contact Recreation	Aquatic Life
SALINITY	TDS	500 mg/L	1000 mg/L		
	SAR	< 3			
BACTERIA	Total Coliform	1000/100 ml			
	Fecal Coliform	100/100 ml		200/100 ml	
METALS	Aluminium				
	Arsenic				
	Barium				
	Beryllium	0.1 mg/L	0.1 mg/L		
	Boron	0.5 mg/L	5.0 mg/L		
	Cadmium				0.001 mg/L
	Chromium				0.01 mg/L
	Cobalt	0.05 mg/L	1.0 mg/L		
	Copper				0.01 mg/L
	Cyanide				0.01 mg/L (total)
	Iron				1.0 mg/L
	Lead				0.02 mg/L
	Manganese	0.2 mg/L			
	Mercury				0.0001 mg/L, [1]
	Molybdenum	0.01 mg/L	0.5 mg/L		
	Nickel				0.025 mg/L
	Selenium				0.002 mg/L
	Silver				
	Vanadium	0.1 mg/L	0.1 mg/L		
	Zinc				0.05 mg/L
ORGANIC CONTAMINANTS	2,4-D				2 ug/L
	Lindane				0.01 ug/L
	Carbofuran				1.7 ug/L

NUTRIENTS	Soluble Reactive Phosphorus	Total Phosphorus	Total Ammonia
Lake Diefenbaker			
at Saskatchewan Landing		0.061 mg/L	
at Herbert		0.059 mg/L	
at Riverhurst		0.058 mg/L	
at Douglas		0.058 mg/L	
at Danielson		0.058 mg/L	
Mainstem South Saskatchewan River		[2]	
upstream of Lake Diefenbaker			CCREM[3]
downstream of Lake Diefenbaker	<0.005 mg/L		CCREM
Swift Current Creek	<0.005 mg/L		
SSEWS System Reservoirs		<0.03 mg/L	CCREM
Broderick		<0.03 mg/L	CCREM
Brightwater		<0.03 mg/L	CCREM
Blackstrap		<0.05 mg/L	CCREM
Bradwell		<0.03 mg/L	CCREM
Zelma		<0.03 mg/L	CCREM
Dellwood		<0.05 mg/L	CCREM
Little Manitou			

[1] See provincial guidelines for fish consumption.
[2] Maintain oxygenated conditions at sediment-water interface.
[3] CCREM, 1987. Chapter 3-19. Maintain total ammonia at guideline levels.

5.2.1 Nutrients

Nutrient quality is of concern due to the potential for growth of excessive quantities of algae and aquatic macrophytes. Enrichment impairs domestic and municipal supplies by affecting taste and odour, recreation by reducing clarity and aesthetics, agriculture by impairing livestock watering supplies and by disrupting irrigation supply and distribution, and aquatic life by reducing dissolved oxygen levels.

Objectives are developed independently for Lake Diefenbaker, the mainstem, and for Swift Current Creek and the SSEWS system reservoirs. Objectives are developed for soluble reactive phosphorus for the mainstem, total phosphorus for the lake and reservoirs, and total ammonia for all areas.

Soluble reactive phosphorus (SRP) is considered the readily bioavailable form of phosphorus. Algae and macrophytes respond to nutrients available in the water column, thus SRP is the phosphorus species of most importance in a flowing system. The longer residence time in lakes and reservoirs permits time for non-available forms to be biologically and chemically converted; therefore, a total phosphorus objective for lakes and reservoirs was developed.

Ammonia can be toxic to aquatic organisms. An objective for total ammonia was established to protect aquatic life from ammonia toxicity.

Nutrient objectives for the basin are presented in Table 5. They are discussed by basin reach.

LAKE DIEFENBAKER

The trophic status of Lake Diefenbaker ranges from mesotrophic in the upper reaches to oligotrophic in the lower reaches, 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 would ensure avoidance of problems such as algal blooms, deoxygenation and unpleasant taste and odour. Considerable effort has been spent on deriving phosphorus objectives for Lake Diefenbaker to maintain the mesotrophic status and for the South Saskatchewan River to control inputs to the lake. A trophic state model was developed (SSRBS Technical Report D.5) to examine the response of the lake to various nutrient inputs, thereby contributing to the development of water quality objectives.

The trophic model is based upon the concepts in OECD (1982): when the productivity of a water body is controlled by a limited supply of a single nutrient, it is directly related to the addition of that nutrient. Given that the limiting nutrient is phosphorus, (SSRBS Technical Report D.13), a model was developed that related phosphorus supply to the concentration of chlorophyll a in the photic zone. Modifications to the OECD model were made so that the model was specific to Lake Diefenbaker. Relationships between variables in each lake area were determined and incorporated in the model. Chlorophyll a was found to be the most accurate for prediction of phosphorus levels (high chlorophyll a - phosphorus correlation coefficient), and was, therefore, chosen as a trophic indicator for the lake. The following boundary levels were selected:

Eutrophic	chlorophyll a	> 0.008 mg/L	
Mesotrophic	0.003 mg/L	> chlorophyll a	< 0.008 mg/L
Oligotrophic	chlorophyll a	< 0.003 mg/L	

Maintenance of mesotrophic or less productive conditions in all lake areas is identified by chlorophyll a concentrations less than 0.008 mg/L. A relationship was developed to achieve these conditions based upon phosphorus, nonfilterable residue and chlorophyll a levels. The relationship was used to calculate the water quality objectives for each of the five lake areas for total phosphorus (Saskatchewan Environment and Public Safety, 1988).

MAINSTEM SOUTH SASKATCHEWAN RIVER

The challenge of developing water quality objectives for nutrients in the mainstem upstream of Lake Diefenbaker is determining what inflowing nutrient concentrations would limit or maintain the proposed Lake Diefenbaker nutrient objectives.

Total phosphorus in the lake originates from atmospheric, terrestrial, riverine and internal sources. Aquatic loadings dominate in all lake areas except Douglas, contributing from 73 to 94 percent of the total phosphorus loading (Saskatchewan Environment and Public Safety, 1988). Land loadings varied from 6 to 27 percent (except for Douglas) and atmospheric loadings from 0 to 6 percent of the total phosphorus loading. The Douglas area differs from other lake areas, having a much greater contribution of land loadings, due to its unique morphology and hydrology. Aquatic loadings are therefore the primary external phosphorus source that can cause changes in the trophic state of the lake.

Internal phosphorus loadings could result from regeneration of phosphorus from the sediments. The lake is a sink for phosphorus, with annual loads entering the lake exceeding those leaving the lake by a factor of 26:1 (SSRBS Technical Report D.13). The particulate portion of the phosphorus load is rapidly deposited, particularly in the upper reaches of the lake. Non-apatite inorganic phosphorus and organic phosphorus comprise about 55 percent of all sediment phosphorus entering the lake, and are the fractions which could be biologically available if phosphorus were released due to oxygen depletion at the sediment water interface. Lake Diefenbaker rarely experiences hypolimnetic oxygen depletion, so phosphorus release from the sediments would be minimal.

It is doubtful whether an objective for phosphorus upstream of Lake Diefenbaker would be an effective strategy for attaining lake nutrient objectives. Most of the phosphorus entering the lake is sediment-bound from natural sources and is not bioavailable under prevailing conditions. In place of an objective for total phosphorus for the mainstem upstream of the lake, it is recommended that every effort be made to limit development upstream of the lake and on the lake which may adversely affect the oxygen regime of Lake Diefenbaker.

Concentrations of total ammonia should not exceed those of CCREM (1987). Historic records for the tributaries (South Saskatchewan River at Highway #41, Red Deer River at Bindloss) show that to date toxic levels have been rare.

From Gardiner Dam to the confluence with the North Saskatchewan River, the soluble reactive phosphorus objective is set at <0.005 mg/L to protect the public water supply. Compliance with the objective will limit plant and algal densities, thus minimizing taste and odour problems.

Total ammonia levels should not exceed those of CCREM (1987) for the protection of aquatic life. The levels of total ammonia are based upon the variation of the toxic (unionized) component with pH and temperature. Historic records downstream of Saskatoon indicate a moderate level of concern for toxic levels.

SWIFT CURRENT CREEK AND THE SSEWS SYSTEM RESERVOIRS

Nutrient data for each reservoir are not sufficiently abundant to enable the development of specific water quality objectives as was carried out for Lake Diefenbaker. Objectives for the reservoirs, therefore, are based upon criteria for the protection of the public water supply, and for the protection of aquatic life in the case of Bradwell and Little Manitou.

The objective of <0.005 mg/L soluble reactive phosphorus (SSRBS Technical Report D.14) is recommended for Swift Current Creek. Concentrations below this level will limit plant and algal densities, thus minimizing taste and odour problems.

A total phosphorus objective of <0.05 mg/L for Bradwell and Little Manitou would limit biological growth such that aquatic life would be protected. A more stringent objective of <0.03 mg/L total phosphorus is required for the remaining reservoirs to protect the public water supply.

The objectives are intended for the open water season, when plant growth most impairs water uses. They should be applied as average seasonal concentrations as the plant community responds to prevailing conditions over the growth period.

The phosphorus objectives for Lake Diefenbaker are greater than those for the SSEWS system reservoirs (Table 5), which are supplied by Lake Diefenbaker. This apparent anomaly reflects the difference in the way in which the objectives are derived. When more data are available for the reservoirs, specific objectives based upon ambient levels, as opposed to on water use protection criteria, will be developed and the discrepancy between the lake and reservoir objectives will be reduced or eliminated.

Total ammonia values should not exceed those of CCREM (1987) for the creek and all reservoirs.

5.2.2 Salinity

The salinity, or total dissolved solids (TDS) concentration, is of great importance because the basin's waters are used to irrigate large areas of land. An increase in salinity causes an increase in the osmotic pressure of the soil solution, resulting in a reduced availability of water for plant consumption.

Water quality-soil compatibility guidelines (Saskatchewan Agriculture, 1986) are recommended for application in the study area. They are based upon a combination of salinity (as measured by electrical conductivity) and the adjusted sodium adsorption ratio (SAR), soil characteristics and leaching fractions to control the build-up of salts within a soil profile. The guidelines are approximate, and are shown in Figure 8.

The SAR in the basin should be maintained at <3. Values of SAR of 3 to 9 in irrigation water create slight to moderate restrictions on use; values above 9 create severe restrictions. Mainstem SAR values are all <1.

A value of 500 mg/L for TDS is the recommended objective for the protection of irrigation. Average values in the basin are below this level. A salinity problem would not be expected if the TDS in irrigation water did not exceed 1 000 mg/L, but sensitive crops would not be protected.

A TDS value of 1 000 mg/L is the recommended objective for the protection of the livestock watering use. Waters containing up to 3 000 mg/L TDS are satisfactory for all classes of livestock and poultry, but some loss of productivity should be anticipated. Mainstem values are considerably lower than the proposed 1 000 mg/L objective.

5.2.3 Bacteria

Bacteriological contamination of water occurs from the discharge of inadequately treated wastewaters and from farm runoff, feedlots and contaminated soils. Contamination of water primarily affects agricultural use, recreational use and drinking water. The most sensitive uses are irrigation and contact recreation.

The microbial content of water is measured indirectly by the use of indicator organisms. The indicators show the presence of fecal contamination, suggesting that pathogens may also be present. Coliforms and fecal streptococci are the most commonly used indicators. Coliforms are associated with the feces of warm-blooded animals and with soil. The use of fecal coliforms is more indicative of sanitary pollution than the use of total coliforms, because the fecal bacteria are restricted to the intestinal tract of warm-blooded animals. Fecal streptococci give a better estimate of the viral content of water than coliforms and may be the only indication of fecal pollution at points distant from the source.

For the protection of consumers of vegetables irrigated with surface waters, an objective of 100/100 mL for fecal coliforms is recommended. An objective of 1 000/100 mL is recommended for total coliforms.

The geometric mean density of 200/100 mL is the objective for protection of contact recreation. The mean value should be based on at least five samples obtained over a 30 day period. A fecal coliform density of more than 400/100 mL should be followed up immediately by repeat analysis. Contact recreation includes such activities as swimming, water skiing, bathing and wading.

An objective for fecal streptococci is not proposed at this time due to a lack of sufficient scientific information. An objective should be developed for the protection of human health when sufficient information is available.

5.2.4 Metals

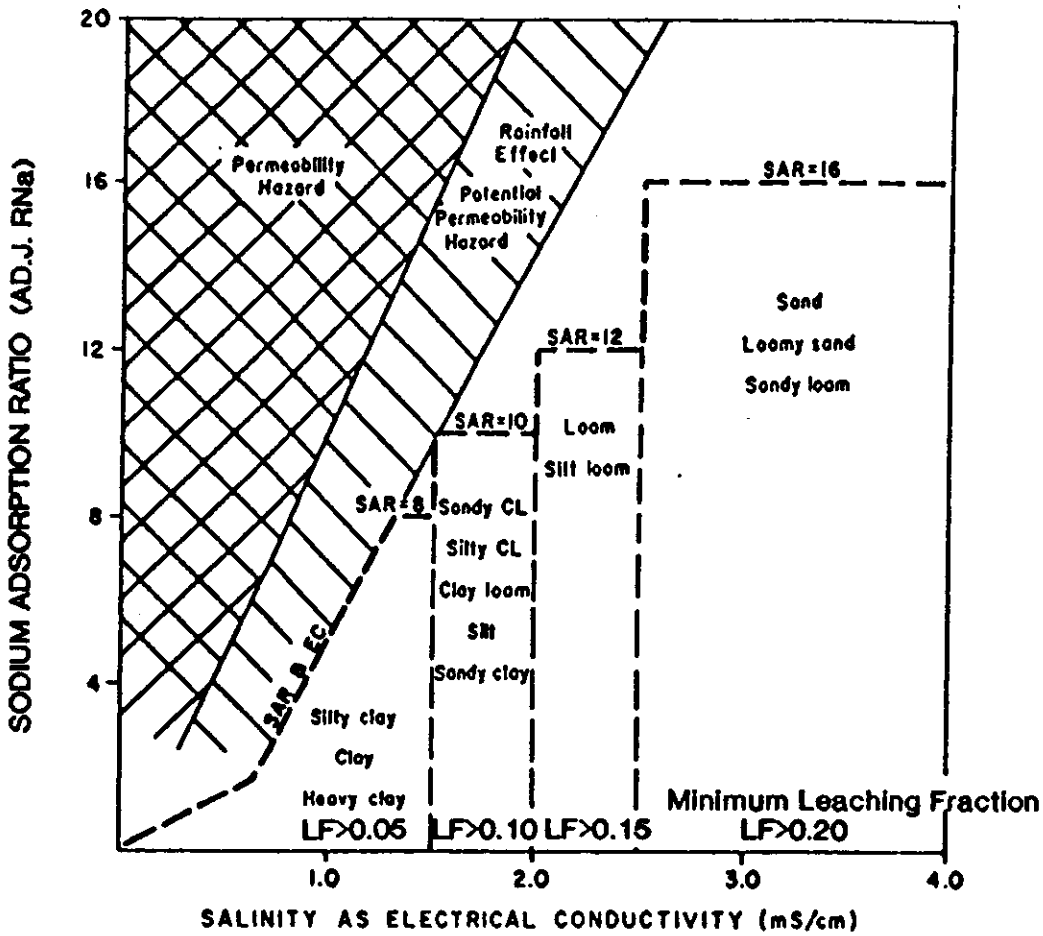
Metals existing in the surface waters of the South Saskatchewan River originate from natural and human (municipal and industrial effluents, urban runoff, agricultural inputs) sources. Metals affect most water uses, with aquatic life being the most sensitive use.

Aquatic life objectives were developed for cadmium, chromium, copper, cyanide, iron, lead, mercury, nickel, selenium and zinc (Table 5). The objectives take into consideration local water quality conditions such as pH, hardness and turbidity. The objectives were developed for total metals. Filterable levels provide a better estimate of bioavailability, but not of the total amount available. The objectives based on the total metal levels are therefore conservative values.

Water quality objectives were not developed for some metals for which data are available. When existing levels of the metals are well below any level which could be considered to be harmful to aquatic life, objectives were not considered to be necessary.

Levels of mercury in basin waters are well below guideline levels, however mercury bioaccumulates in fish even though concentrations in water are very low. Mercury is likely to continue to persist in the basin for some time, although sources of mercury have been eliminated. The consumption of mercury-containing fish guidelines, published by Saskatchewan Parks and Renewable Resources (1989), must remain in effect in the basin. The guidelines indicate the number of meals of fish of various length and given mercury content which can safely be consumed from the basin.

FIGURE 8 WATER QUALITY - SOIL COMPATIBILITY GUIDELINES



Water quality objectives for the protection of agricultural uses were developed for beryllium, boron, cobalt, manganese, molybdenum and vanadium (Table 5). The objectives take into consideration existing water quality conditions, guidelines and objectives.

5.2.5 Organic Contaminants

The surface waters receive inputs of organic contaminants from agricultural, industrial and municipal sources. Pesticides (herbicides and insecticides) constitute the vast majority of the organic contaminants for which water quality data are available. Pesticides can adversely affect man, wildlife and aquatic life. By far the most sensitive use, for which pesticide objectives are developed, is aquatic life.

It is not necessary, nor is it possible, to develop objectives for all the pesticides present in the basin. Pesticides of most importance are those which are used in the greatest quantities and those which are most toxic. Based upon this information, development of objectives were considered for 2,4-D, trifluralin, triallate, MCPA, diclofop-methyl, bromoxynil, malathion, lindane, carbofuran and chlorpyrifos (SSRBS Technical Report D.12). There is insufficient aquatic life guideline information from which to develop objectives for all these compounds except 2,4-D, lindane and carbofuran. Basin values exist for eight of the ten pesticides, but are very limited in time, location and representation. Even criteria information, the most basic scientific level of information required to develop objectives, is missing for seven of the ten pesticides.

The aquatic life guideline for 2,4-D is 4 ug/L. Ambient values vary from 0.004 to 0.71 ug/L, while single values of 7 ug/L and 9.4 ug/L have been recorded in unique situations. The objective for aquatic life protection in the basin is 2 ug/L.

The aquatic life guideline for lindane is 0.01 ug/L. Ambient values vary below this level, from 0.001 to 0.009 ug/L. An isolated value of 0.03 ug/L was observed in a unique situation. The value 0.01 ug/L is the objective for protection of aquatic life in the basin.

The aquatic life guideline for carbofuran is 1.7 ug/L. Only a single value of 0.0033 ug/L was observed in Swift Current Creek. Until more data are available on carbofuran levels in the basin, the guideline will serve as the objective for the protection of aquatic life (CCME, 1989).

An interim objective of "below accepted detection limits" should apply for the remaining seven pesticides until sufficient information becomes available with which to develop pesticide objectives.

6.0 WATER QUALITY MONITORING

Our knowledge of the water resource and the strategies developed to improve and to protect it depend upon the availability of a strong water quality data base. As approaches to water quality management evolve over time, data needs change and so, therefore, must our data collection methodologies.

This chapter reviews the current and historic data collection activities and presents the changes to the activities recommended on the basis of work conducted over the course of the study.

6.1 EXISTING ACTIVITIES

Water quality has been monitored on a regular basis since 1974. Saskatchewan Environment and Public Safety and Environment Canada, on behalf of the Prairie Provinces Water Board, both have responsibilities to monitor in the basin.

Data have been collected by Saskatchewan Environment and Public Safety for various periods of time from a total of 45 stations. The stations with the most comprehensive data sets are on the mainstem at Leader, Outlook, Saskatoon and Birch Hills. These stations were sampled monthly for various nutrient and bacterial parameters and major ions, quarterly for metals and three times a year for pesticides. The purpose of the data collection was to assess suitability for water uses, to provide long-term assessment information, to provide trend assessment data, to provide information for impact assessments and to provide in-depth, problem-oriented information as required.

Environment Canada has been collecting data for the Prairie Provinces Water Board since the 1960s at the two tributaries to the study area: the Red Deer River and the South Saskatchewan River on the Alberta side of the Alberta/Saskatchewan boundary. Monthly sampling has taken place for an extensive suite of nutrients, physicals, metals and pesticides (Blachford and Weagle, 1990). The purpose of the data collection has been to assess the quality of interprovincial waters and to identify potential concerns.

The sites currently monitored in the basin by Saskatchewan Environment and Public Safety and Environment Canada and the parameters which are analyzed are presented in Table 6.

6.2 WATER QUALITY DATA DEFICIENCIES

Evaluation of the historic and current monitoring programs of the two agencies (SSRBS Technical Report D.11), recommendations of each of the water quality studies carried out over the course of the study and new requirements for information for management point to the need to fill some information gaps and to complement routine monitoring with specific studies. These are summarized below.

Modifications to Monitoring

- It must be recognized that one data base cannot serve all purposes. Water quality data should be collected for a specific purpose.
- Sampling frequency and sample representativity must be carefully determined if trend analysis is the purpose of data collection.
- Parameters collected and analyzed at each station should be based on the prevailing water use.
- Basin waters should be monitored for trends in salinity, particularly chloride (SSRBS Technical Report D.3).
- Little Manitou Lake should be monitored for salinity every two years.
- The nutrient data base for Swift Current Creek should be updated, and that for SSEWS system should be expanded.
- The biological status of primary producers should be incorporated into monitoring programs (SSRBS Technical Report D.14).
- The trophic relationship between nutrient levels and algal growth in the SSEWS system should be investigated.
- Samples should be collected weekly from April to July and monthly from August to March in order to accurately estimate phosphorus loads to Lake Diefenbaker (SSRBS Technical Report D.13).
- The water quality monitoring programs in the basin should be redesigned to include trend assessment, wastewater audit and special study stations.
- All sampling sites should be subjected to tests for spacial variation (SSRBS Technical Report D.11).

TABLE 6 CURRENT MONITORING STATIONS AND PARAMETERS IN THE SOUTH SASKATCHEWAN RIVER BASIN

STATION/NAQUADAT CODE	PARAMETERS		
	GENERAL	PESTICIDES	METALS
RED DEER RIVER AT BINDLOSS /00AL05CK0001 SOUTH SASKATCHEWAN RIVER AT HIGHWAY #41 /00AL05AK0001	Alkanes Aromatic Hydrocarbons Boron Calcium Chlorophyll a Colour Specific Conductance Floride Magnesium Odour (TON) Dissolved Oxygen pH Phosphorus Potassium Sodium Sulphate Surfactants Turbidity Alkalinity Carbon Chloride Coliforms Hardness Nitrogen Oil & Grease Phenolics Residues Silica Sulfide Temperature	Aldrin Barban BHC (alpha) Chlordane DDD, DDE, DDT Dicamba Endosulfans Hexachloro - benzene MCPA Mirex 2,4,-D BHC (gamma) Dieldrin Endrin Heptachlor MCPB Methoxychlor PCB's (arochlors) Picloram Silvex Trifluralin 2,4,5,-T	Cobalt Mercury Selenium Silver Zinc Aluminum Arsenic Barium Cadmium Lead Manganese Nickel Chromium Cyanide Copper Vanadium Iron
LEADER BRIDGE /00SK06100001 OUTLOOK BRIDGE /00SK06220002 OPPOSITE QUEEN ELIZABETH GENERATING STATION /00SK06220003 ABOVE SASKATOON STP /00SK06230001 CLARKBORO FERRY (WEST) /00SK06230004 CLARKBORO FERRY (EAST) /00SK06230011	pH Specific Conductance Temperature Carbon Organic Dissolved Nitrogen Total Kjeldahl Nitrogen Dissolved (NO_3 & NO_2) Nitrogen Total Ammonia Phosphorus Sol. Ortho Phosphorus Total Oxygen Dissolved Oxygen Biochem. Demand-BOD Residue Nonfiltr. Residue Fixed Nonfiltr.	2,4,5-T 2,4-D 2,4-DB 2,4,-DP Aldrin Alpha-BHC Alpha-Endo-Sulphan Alpha-Chlordane Arochlors Total (PCB's) Atrazine Barban Beta-Endo-Sulphan Diallate Diclofop Dieldrin Endaven Endrin Gamma-BHC (Lindane)	Aluminum Arsenic Barium Cadmium Chromium Cobalt Copper Iron Lead Manganese Mercury Molybdenum Nickel Selenium Silver Titanium Tungstun Vanadium Zinc

TABLE 6 CURRENT MONITORING STATIONS AND PARAMETERS IN THE SOUTH SASKATCHEWAN RIVER BASIN (continued)

STATION/NAQUADAT CODE	PARAMETERS		
	GENERAL	PESTICIDES	METALS
MUSKADAY BRIDGE (NORTH) /00SK06230027	Residue Volatile Total Total Dissolved Solids Hydroxide (Calcd.) Alkalinity Phenolphthalein Alkalinity Total $CaCO_3$ Bicarbont. (Calcd.) Carbonate (Calcd.) Magnesium hardness Calcium hardness (as $CaCO_3$) Hardness Total (as $CaCO_3$) Hardness Non-Carb. (Calcd. as $CaCO_3$) Sodium Magnesium Boron Sulphate Chloride Potassium Calcium Coliforms Total MF Coliforms Fecal MF Strep. Fecal MF Cyanide Beryllium Silicon	Gamma-Chlordane Heptachlor Heptachlor Epoxide Hexachloro-Benzene MCPA Mirex o,p-DDT" p,p-Methoxy-Chlor" p,p-DDD" p,p-DDE" p,p-DDT" Silvex Tri-Fluralin Tri-allate	

New Information Requirements

- It should be determined whether the following compounds are used in sufficient quantities in the basin to warrant their inclusion in routine monitoring programs:

acrolein	malathion
Bromoxynil	mecoprop
Carbaryl	methoprene
chlorsulfuron	paraquat
dalapon	propanil
deltamethin	pyrethrins
diquat	sethoxydim
difenzoquat	temephos
flamprop-methyl	

- It should be determined whether the following compounds are present at levels which may be detrimental to aquatic life and other water uses:

diclofop	2,4,5-T
MCPA	2,4-DP
triallate	

- Effort should be made to identify, quantify and evaluate the impact on basin surface waters of organic contaminants from industrial and municipal effluents, landfill leachates and storm water runoff (SSRBS Technical Report D.4).
- An intensive study program should be designed and implemented over a one year period to provide inflow and seasonal salinity data for the Swift Current Creek system.
- In order to better define anthropogenic impacts, a one year study should be designed and implemented to obtain information on SSEWS system canal inflow/outflows, surface water inflow and seasonal quality.
- The morphometrical characteristics, longitudinal quality variations, ground water inflow quality and quantity of Blackstrap Reservoir should be investigated (SSRBS Technical Report D.7).

6.3 RECOMMENDED MONITORING FOR THE BASIN

Following the recommendations of SSRBS Technical Report D.11, it is proposed that the surface Water Quality Monitoring Plan for the South Saskatchewan River Basin include three types of monitoring:

1. Trend Assessment
2. Wastewater Audits
3. Special Studies

The monitoring sites and reaches are shown in Figure 9.

TREND ASSESSMENT

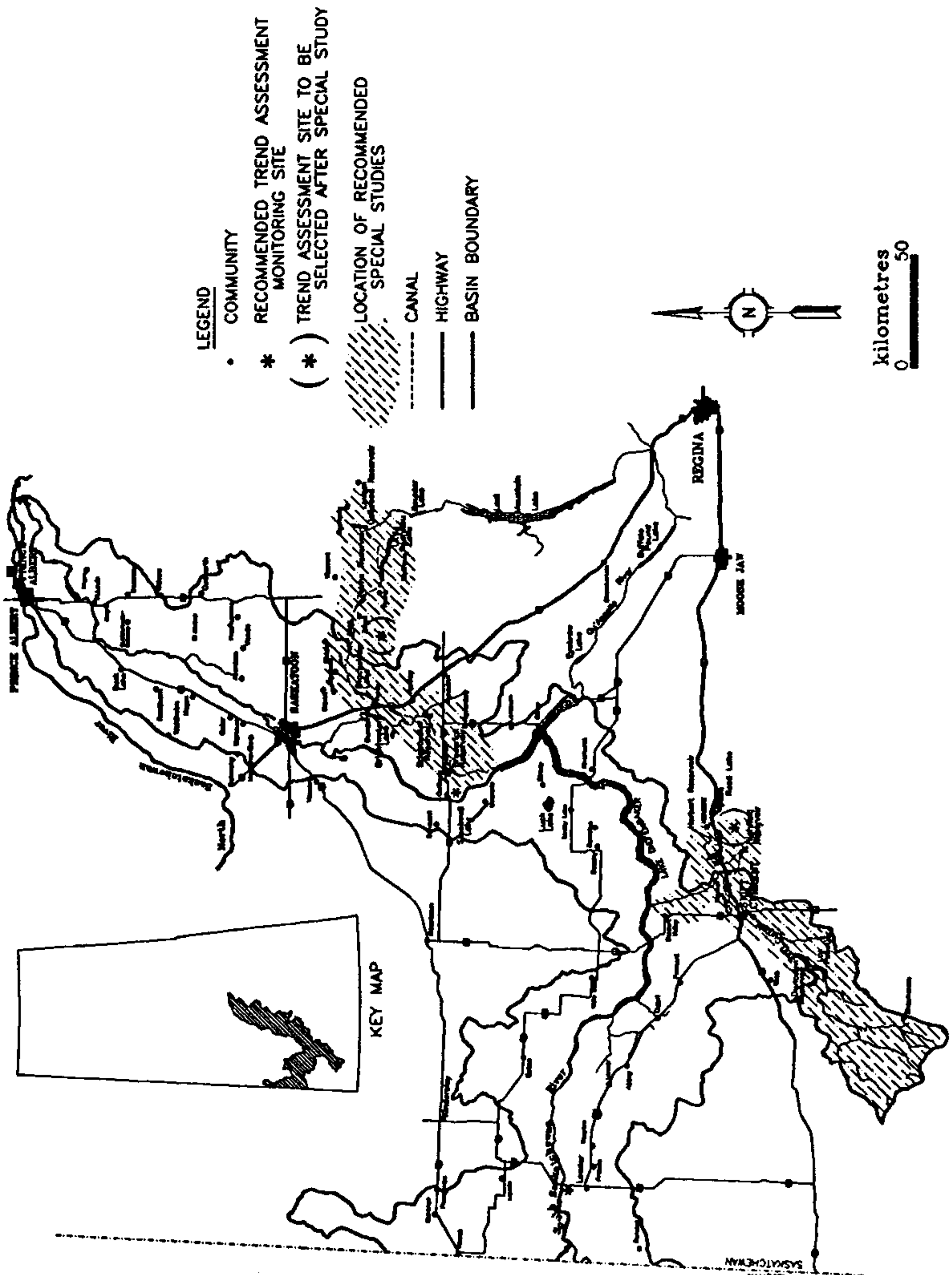
The detection of trends in water quality is an aim of both the federal and provincial water quality monitoring programs. The detection of trends in water quality, or a statistically significant change in a water quality parameter over time, is essential for water management purposes to aid in identification of areas of concern, to characterize baseline conditions and to provide use/compliance data. Stations for trend assessment are the backbone of a monitoring program.

The monitoring stations selected are representative of the hydrology and water uses of each reach. The trend detection methodology selected should be consistent for the basin. Parameters must reflect primary water uses, and frequencies must be chosen consistent with the trend detection methodology.

The following stations are recommended for Trend Assessment monitoring in the study area:

1. South Saskatchewan River at Highway #41, Alberta
2. Red Deer River at Bindloss, Alberta
3. South Saskatchewan River, Leader Bridge
4. South Saskatchewan River, Outlook Bridge
5. South Saskatchewan River, Muskoday Bridge
6. SSEWS system station(s) to be selected after a one year special study.
7. Swift Current Creek station(s) to be selected after a one year special study.

FIGURE 9 RECOMMENDED MONITORING SITES AND REACHES IN THE STUDY AREA



Sites (1) through (6) would continue the present monitoring programs of Saskatchewan Environment and Public Safety and the Prairie Provinces Water Board. Site 6 is a new station established by Saskatchewan Environment and Public Safety to replace (improved accessibility) the Birch Hills site. Sites 7 and 8 are new sites established to fill the data gaps identified by SSRBS Technical Report D.7, SSRBS Technical Report D.6 and SSRBS Technical Report D.14.

The seven sites should be monitored for the present suites of parameters used by Saskatchewan Environment and Public Safety and by the Prairie Provinces Water Board. The adequacy and need for the entire parameter lists should be reviewed on a regular basis, i.e., not longer than every three years. New monitoring and analytical techniques should be considered during the same review process.

Saskatchewan Environment and Public Safety and the Prairie Provinces Water Board should each select a trend assessment methodology which would be applied to all monitoring data on an annual basis. The methodologies could be the same, but would likely differ due to differing frequencies of data collection and a greater number of data gaps in the provincial data base.

The frequency of sampling at the Trend Assessment stations will depend upon the chosen methodology. Until the selection has taken place, monthly sampling should be continued.

Each of the Trend Assessment stations should be evaluated for cross-sectional and vertical variability. Stations should be sampled on a longitudinal and vertical grid during low flow and high flow conditions. Samples should be analyzed for selected parameters. The results should be statistically evaluated for cross-sectional and vertical variability and a sampling point representing the mean chosen. A rotating schedule of profiles could be designed to provide the information for all sites.

Monitoring for total phosphorus at South Saskatchewan River at Highway #41 and Red Deer River at Bindloss should be modified to reflect the recommendations of SSRBS Technical Report D.13. Accurate characterization of phosphorus loadings to Lake Diefenbaker requires weekly sample collection from April to July and monthly collection from August to March.

WASTEWATER AUDITS

The purpose of wastewater audits is to accurately monitor the impact of point source discharges on the receiving environment. The monitoring design at each site reflects the particular problem of the discharge, and may vary from mixing zone delineation to toxic profiles. Data from wastewater audits are used to evaluate the general health of the aquatic environment downstream of the discharge, to provide quality information to permittees, and to evaluate compliance with provincial water quality objectives.

It is recommended that the present Use/Compliance monitoring stations sampled by the provincial government be changed to Wastewater Audit sites. The sites would be located by discharges of point sources of pollution. A fixed number of sites and a parameter list cannot be identified at this time. It is envisioned that parameters would include not only physical and chemical analyses but also biological evaluations (e.g. macroinvertebrates, fish, periphyton, toxicity testing).

The frequency of sampling at Wastewater Audit sites would depend upon the threat presented by the discharge to the aquatic environment. At a minimum, the sites should be sampled for purposes of compliance every 3-5 years.

SPECIAL STUDIES

Special studies serve a variety of purposes, such as data collection for environmental impact assessments, modelling studies, or filling information gaps. Studies are time-limited and have a focused purpose.

The two studies recommended by SSRBS Technical Report D.7 should be carried out as soon as possible. The studies are required to provide mass balance and seasonal water quality information in the Swift Current Creek system and in the SSEWS system. Sites in each system should be identified for long-term monitoring.

The provincial program to monitor for mercury levels in fish, and to inform the public about consumption guidelines, should continue.

6.4 IMPLEMENTATION

The water quality studies carried out for the South Saskatchewan River Basin Study identified knowledge deficiencies and the need for follow-up investigations which are required as part of the information base for the management and conservation of water quality in the basin. A distillation of the necessary undertakings and a time frame for their implementation is presented in Table 7.

Agencies are identified in the implementation plan with each activity. Each agency may be responsible for, have interest in, or have particular expertise for carrying out a certain activity. Activities may be undertaken with other agencies. For example, the intensive studies may be done federal-provincially on a cost-shared and/or time-shared basis.

The implementation plan must be overseen by a new or existing committee with water quality expertise. Existing committees which may be appropriate for taking on the necessary responsibilities include those of the Canada-Saskatchewan Water Quality Monitoring Agreement and the South Saskatchewan River Basin Implementation Committee. Responsibilities of the committee would include on-going review of collected data, site evaluation pending variability studies, parameter assessment (for example, the need to add or delete pesticides from the parameter list), observation of potential trends and evaluation of exceedance of water quality objectives.

TABLE 7	Implementation Plan for Water Quality Activities. Possible implementing agencies are Environment Canada (EC), Saskatchewan Environment and Public Safety (SE & PS), Prairie Provinces Water Board (PPWB) and Saskatchewan Parks and Renewable Resources (SPRR).		
PHASE 1	**PHASE 2**	**PHASE 3**	**PHASE 4**
Intensive 1-year study of nutrients and salinity in Swift Current Creek. (EC, SE & PS)	Intensive 1-year study of nutrients and salinity in the SSEWS system. (EC, SE & PS)		
Enhance monitoring frequency for calculation of phosphorus load to Lake Diefenbaker. (PPWB)	------------------->	------------------->	------------------->
Spacial variability studies at Hwy. #41 and Bindloss. (PPWB)	Spacial variability studies at Leader and Outlook. (SE & PS)	Spacial variability studies at Clarkboro and Muskday. (SE & PS)	Spacial variability studies at Swift Current Creek and SSEWS system sites. (SE & PS)
Continue monitoring six Trend Assessment sites. (SE & PS, PPWB)	------------------->	------------------->	------------------->
Evaluation of data for exceedances and on-going review of water quality objectives. (EC, SE & PS)	------------------->	------------------->	------------------->
	Start trend monitoring at one site in Swift Current Creek basin. (SE & PS)	Start trend monitoring at one site in SSEWS system. (SE & PS)	
		Review parameter list for trend assessment sites. (SE & PS, PPWB)	
	Begin sampling of Wastewater Audit sites. (SE & PS)		
Continue monitoring for mercury in fish. (SPRR)	------------------->	------------------->	------------------->

7.0 REFERENCES

Canadian Council of Resource and Environment Ministers. 1987. Canadian Water Quality Guidelines.

Canadian Council of Ministers of the Environment. 1989. Canadian Water Quality Guidelines for Carbofuran. Appendix V. Update (September, 1989).

Health and Welfare Canada. 1987. Guidelines for Canadian Drinking Water Quality. Prepared by the Federal-Provincial Subcommittee on Drinking Water of the Federal-Provincial Advisory Committee on Environmental and Occupational Health, Canada.

Melville et al. 1989. Bioassessment for the South Saskatchewan River Study. Saskatchewan Research Council. SRC Publication No. E-901-3-E-89.

Saskatchewan Environment and Public Safety. 1988. Surface Water Quality Objectives. Regina, Saskatchewan.

Saskatchewan Environment and Public Safety and Inland Waters Directorate. 1988. Lake Diefenbaker and Upper South Saskatchewan Water Quality Study. 1984-85. Report No. WQ-111. Regina, Saskatchewan.

Saskatchewan Agriculture. 1986. Water Quality Guidelines for Irrigation in Saskatchewan. Irrigation Branch, Saskatchewan Agriculture, Outlook, Saskatchewan.

APPENDIX A

SOUTH SASKATCHEWAN RIVER BASIN STUDY
LIST OF TECHNCIAL REPORTS

SOUTH SASKATCHEWAN RIVER BASIN STUDY TECHNICAL REPORTS		
TITLE	SSRB TECHNICAL REPORT	DATE
Annual Report to December 31, 1986	A.3	11.87
Annual Report to December 31, 1987	A.4	07.88
Annual Report to December 31, 1988	A.5	05.89
Annual Report to December 31, 1989	A.6	03.90
Compendium of Water Quality Objectives Development Methodologies	D.9	06.88
Contaminant Organic Compounds in the Surface Waters of the South Saskatchewan River Basin	D.4	12.87
Crop Damage and Associated Economic Impact of Flooding, South Saskatchewan River Downstream of Lake Diefenbaker	E.13	12.89
Data Collection and Date Base Development: South Saskatchewan River Basin Recreation Survey	E.1	11.86
The Delphi Report	B.3	08.90
Demand for Water-Based Recreation in the South Saskatchewan River Basin	E.17	08.90
Economic Profile and Trends 1951-1986	E.9	06.88
Erosion and Sedimentation in the South Saskatchewan River Basin	C.9	12.89
Farm-Level Drought Analysis Model	E.15	08.90
Fishery Survey of the South Saskatchewan River and Its Tributaries in Saskatchewan	D.8	11.88
Flood Frequencies in the South Saskatchewan River Basin	C.5	08.88
Flooding Gardiner Dam to the Forks	C.8	10.89
Framework Plan Working Definition	B.1	09.87
Frequency Analysis of Meterological Drought in the Saskatchewan Portion of the South Saskatchewan River Basin	C.4	07.88
Ground Water and the South Saskatchewan River Basin: Recommendations to the Study Board	C.2	03.88
Ground Water Study: South Saskatchewan River Basin	C.2	03.88
Heritage Resources	E.16	08.90
A Hydraulic Study of the South Saskatchewan River	E.12	05.89
Hydro System Simulation (HYDSIM) Model Study Report	C.7	05.89
Hydrologic Drought Analysis of Simulated Flows - South Saskatchewan River Basin	C.6	02.89
Information Base: Surface Water Hydrology and Water Use	E.2	03.87
Instream Water Use: South Saskatchewan River Basin	E.7	12.87
Irrigation Water Use Pilot Study	E.8	04.88
Irrigation Water Use Survey (South Saskatchewan River Basin Study)	E.11	12.88
Lake Diefenbaker Trophic State Model	D.5	01.88
Land Use in the Effective Drainage Area of the South Saskatchewan River Basin	D.2	10.87

SOUTH SASKATCHEWAN RIVER BASIN STUDY TECHNICAL REPORTS		
TITLE	SSRB TECHNICAL REPORT	DATE
Legal and Administrative Analysis Interim Report	B.2	03.88
Legal and Administrative Summary	B.4	02.91
Low Flow Frequency Analysis for the South Saskatchewan River	C.10	05.91
Major Industrial Water Users in the South Saskatchewan River Basin	E.10	10.88
Mass Loading of Phosphorus to Lake Diefenbaker	D.13	09.89
Municipal and Residential Water Use Study	E.5	08.87
Municipal Water Use Survey	E.3	07.87
Nutrient Quality Review and Objectives Development for the South Saskatchewan River Basin	D.14	01.90
Phosphorus Loading from Non-Point Sources Relevant to the Lake Diefenbaker Basin	D.1	09.87
Proposed Water Quality Objectives for the South Saskatchewan River Basin	D.12	08.89
Public Involvement Program Position Paper	F.1	10.86
Public Opinion Survey, 1988 Survey Design	F.2	03.88
Recreational Data Analysis Report South Saskatchewan River Basin	E.4	07.87
Reservoir Salinity Model: Application to the Saskatoon Southeast Water Supply System	D.16	05.90
Reservoir Salinity Study Phase 1	D.7	10.88
Short-term Water Use Forecast South Saskatchewan River Basin Study	E.14	12.89
Study Plan and Annual Work Plans - 1987	A.2	02.87
Study Proposal for the South Saskatchewan River Basin	A.1	04.86
Style Guides for Reports	A.7	03.90
Summary and Evaluation of the Public Information and Awareness Strategy	F.3	09.89
Summary and Evaluation of the Public Information and Awareness Strategy, April 1990	F.4	04.90
Summary and Evaluation of the Public Information and Awareness Strategy, November 1990	F.5	12.90
Water Demand Management: An Application to the South Saskatchewan River Basin	E.18	08.90
Water Intake and Outfall Survey South Saskatchewan River Basin	E.6	12.87
Water Management Model Study South Saskatchewan River Basin	C.1	01.88
Water Quality Data Review	D.6	03.88
Water Quality Modelling South Saskatchewan River	D.10	04.89
Water Quality Monitoring Plan for the South Saskatchewan River Basin	D.15	04.90
Water Quality Monitoring Review South Saskatchewan River Basin	D.11	06.89
Water Quality Trend Analysis and Data Base Summary	D.3	11.87
Water Use Analysis Model Study: South Saskatchewan River Basin Study	D.19	05.91

APPENDIX B
WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN									
PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
INORGANIC PARAMETERS									
Aluminum			0.005-0.1 mg/L	5.0-20.0 mg/L	5.0 mg/L			5.0 mg/L	5.0 mg/L
Arsenic	0.05 mg/L		0.05 mg/L	0.1-2.0 mg/L	0.5-5.0 mg/L		0.05 mg/L	0.1 mg/L	0.5 mg/L
Barium	1.0 mg/L				0.1 mg/L		1.0 mg/L		
Beryllium				0.1-0.5 mg/L				0.1 mg/L	0.1 mg/L
Boron	5.0 mg/L			0.5-6.0 mg/L	5.0 mg/L			0.5 mg/L	95.0 mg/L
Cadmium	5.0 ug/L		0.2-1.8 ug/L	0.01 mg/L	0.02 mg/L		0.001 mg/L	0.01 mg/L	0.02 mg/L
Chloride	≤ 250 mg/L			100-700 mg/L				100 mg/L	
Chlorine			2.0 ug/L		1.0 mg/L		0.002 mg/L		
Chromium	0.05 mg/L		0.02-2.0 ug/L	0.1 mg/L			0.02 mg/L	0.1 mg/L	1.0 mg/L
Cobalt				0.05-5.0 mg/L	1.0 mg/L			0.05 mg/L	1.0 mg/L
Copper	≤ 1.0 mg/L		2.0-4.0 ug/L	0.2-5.0 mg/L	0.5-5.0 mg/L		0.01 mg/L	0.2 mg/L	< 1 mg/L
Cyanide	0.2 mg/L		5.0 ug/L				0.01 mg/L		
Dissolved Oxygen			5.0-9.5 mg/L				5-9.5		
Fluoride	1.5 mg/L			1.0-15.0 mg/L	1.0-2.0 mg/L			1.0 mg/L	2.0 mg/L
Iron	≤ 0.3 mg.L		0.3 mg/L	5.0-20.0 mg/L			1.0 mg/L	5.0 mg/L	
Lead	0.01 mg/L		1.0-7.0 ug/L	0.2-2.0 mg/L	0.1 mg/L		0.02 mg/L	0.2 mg/L	0.1 mg/L
Lithium				2.5 mg/L				2.5 mg/L	

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN									
PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
INORGANIC PARAMETERS (Continued)									
Manganese	≤ 0.05 mg/L			0.2-10.0 mg/L				0.2 mg/L	
Mercury	1.0 ug/L		0.1 ug/L		0.003 mg/L		0.1 ug/L		0.003 mg/L
Metolachlor	0.05 mg/L								
Molybdenum				0.01-0.05 mg/L	0.5 mg/L			0.01 mg/L	0.5 mg/L
Nickel			25-150 ug/L	0.2-2.0 mg/L	1.0 mg/L		0.025-0.100 mg/L	0.2 mg/L	1.0 mg/L
NITROGEN Ammonia			2.2-1.37 mg/L				0.06-2.06 mg/L		
Nitrite Nitrate	45 mg/L		0.06 mg/L Concentrations that stimulate prolific weed growth should be avoided.		10.0 mg/L				
Nitrate plus Nitrite	10 mg/L				100 mg/L				100 mg/L
pH	6.5-8.5	5.0-9.0	6.5-9.0						
Selenium	0.01 mg/L		1.0 ug/L	0.02-0.05 mg/	0.05 mg/L		0.01 mg/L	0.02 mg/L	0.05 mg/L
Silver	0.05 mg/L		0.1 ug/L				0.01 mg/L		

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN									
PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
INORGANIC PARAMETERS (Continued)									
Sodium	< 200 mg/L			Soils: Determine SAR Crops: SAR: 2-102				100 mg/L	
Sulphate	≤ 500 mg/L				1000 mg/L				1000 mg/L
Sulphide	0.05 mg/L								
Total Dissolved Solids	500 mg/L			5000-3500 mg/L	3000 mg/L			700 mg/L	<1000 mg/L
Uranium	0.1 mg/L			0.01-0.1 mg/L	0.2 mg/L			0.01 mg/L	0.2 mg/L
Vanadium				0.1-1.0 mg/L	0.1 mg/L			0.1 mg/L	0.1 mg/L
Zinc	≤ 5.0 mg/L		0.03 mg/L	1.0-5.0 mg/L	50.0 mg/L		0.05 mg/L	1.0 mg/L	
ORGANIC PARAMETERS									
Acrolein				1.5 mg/L					
Aldicarb	0.009 mg/L								
Aldrin & dieldrin	0.7 ug/L		4.0 ng/L		0.7 ug/L				
Benzene	0.005 mg/L		0.3 mg/L						
Bromoxynil	0.005 mg/L								
Carbaryl	0.09 mg/L				70 ug/L				
Carbofuran	0.09 mg/L		1.7 ug/L						

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN

PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
ORGANIC PARAMETERS (Continued)									
Carbon Tetrachloride	0.005 mg/L								
Chlordane	7.0 ug/L		6 ng/L		7.0 ug/L				
Chlorinated ethylenes tetra-chloroethylene			260 ug/L						
Chlorinated phenols Mono-			7.0 ug/L						
Di-			0.2 ug/L						
Tri-			18 ug/L						
Tetra-			1.0 ug/L						
Penta-			0.5 ug/L				0.5 ug/L		
Chlorofenac				traces					
Dalapon				< 0.2 mg/L					
DDT	0.03 mg/L		1.0 ng/L		0.03 mg/L				
Diazinon	0.02 mg/L				14 ug/L				
Dicamba	0.12 mg/L								
Diclofop-methyl	0.009 mg/L								
2,4-D	0.1 mg/L		4.0 ug/l						
Diquat	0.07 mg/L			L 0.1 mg/L					

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN

PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
ORGANIC PARAMETERS (Continued)									
Diuron	0.15 mg/L			0.2 & 0.8 mg/L					
Endosulfan			0.02 ug/L						
Endrin	0.2 ug/L		2.3 ng/L		0.2 ug/L				
Ethylbenzene			0.7 mg/L						
Glyphosate	0.28 mg/L								
Heptachlor + Heptachlor epoxide	3.0 ug/L		0.01 ug/L		3.0 ug/L				
Hexachloro-butadiene			0.1 ug/L						
Hexachloro-cyclohexane			0.01 ug/L						
Lindane	4.0 ug/L						0.1 ug/L		
Malathion	0.19 mg/L								
Methoxychlor	0.9 mg/L								
Methyl parathion	7.0 ug/L								
Nitrilotriacetic acid (NTA)	0.05 mg/L								
Paraquat	0.01 mg/L								

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN									
PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
ORGANIC PARAMETERS (Continued)									
Parathion	0.05 mg/L				35 ug/L				
2,4-D	0.1 mg/L		4.0 ug/L		0.1 mg/L		0.004 mg/L		
2,4-D amine				0.10 mg/L					
PCB (total)			1.0 ng/L				0.001 ug/L		
Pesticides (total)	0.1 mg/L				0.1 mg/L				
Phenols	2.0 ug/L		1.0 ug/L		2.0 ug/L		1.0 ug/L		
Phthalate esters DBP			4.0 ug/L						
DEHP			0.6 ug/L						
Others			0.2 ug/L						
Picloram	0.19 mg/L								
Simazine				0.25 & 0.7 mg/L					
Temephos	0.28 mg/L								
Toluene	≤ 0.024 mg/L			0.3 mg/L					
Toxaphene	5.0 ug/L		8.0 ng/L		5.0 ug/L				
2,4,5 - T	0.28 mg/L				0.01 mg/L				
Trihalomethanes	0.35 mg/L				0.35 mg/L				
Trifluralin	0.045 mg/L								

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN

PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
PHYSICAL PARAMETERS									
Aesthetics		All water should be free from: - materials that will settle to form objectionable deposits; - floating debris, oil scum and other matter; - substances producing objectional colour, odour, taste or turbidity; and - substances and conditions or combinations thereof in concentrations which produce undesirable aquatic life.							
Aquatic Plants		Rooted or floating plants which could entangle bathers should be absent; very dense growths could affect other activities such as boating and fishing.							
Clarity		The water should be sufficiently clear that a Secchi disc is visible at a minimum of 1.2 m.				Secchi disc visible at 1.2 m.			

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN									
PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
PHYSICAL PARAMETERS (Continued)									
Colour	≤ 15 TCU								
Odour	Inoffensive								
Oil and Grease		Oil or petrochemicals should not be present in concentrations that: - can be detected as a visible film, sheen or discolouration on the surface; - can be detected by odour; or - can form deposits on shorelines and bottom deposits that are detectable by sight and odour.							
Taste	Inoffensive								

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN

PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
PHYSICAL PARAMETERS (Continued)									
Temperature	≤ 15°C		Thermal additions should not alter thermal stratification or turn-over dates, exceed maximum weekly average temperatures, and exceed maximum short-term temperatures.				Not to be altered by more than 3°C from ambient water temperature		
Total Suspended Solids			Increase of 10.0 mg/L or increase of 10% above background depending upon background concentration						
Turbidity	1 NTU	The turbidity of water should not be increased more than 5.0 NTU over natural turbidity when this is low (<50 NTU).							

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN									
PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
RADIOLOGICAL PARAMETERS									
Cs^{137}	50 Bq/L								
I^{131}	10 Bq/L								
Ra^{226}	1 Bq/L								
Sr^{90}	10 Bq/L								
H^{3}	40,000 Bq/L								
MICROBIOLOGICAL PARAMETERS									
Bacteria Fecal Coliforms		The geometric mean of not less than 5 samples taken over a 30-d period should be less than 200 fecal coliforms per 100 mL. Resampling should be performed when any sample exceeds 400 fecal coliforms per 100 ml.		100/100 ml.		Contact use: Not to exceed geometric mean density of 200/100 mL. Not to exceed a density of 200/100 m/L in more than 20% of samples. Non-contact use: not to exceed a density of 1000/100 mL		100/100 mL	
Total Coliforms				1000/100 ml.		Non-contact use: not to exceed a density of 5000/100 mL		1000/100 mL	

WATER QUALITY GUIDELINES AND OBJECTIVES RELEVANT TO THE BASIN									
PARAMETER	HEALTH AND WELFARE GUIDELINES	CANADIAN WATER QUALITY GUIDELINES				SASKATCHEWAN SURFACE WATER QUALITY OBJECTIVES			
	Drinking Water	Recreation and Aesthetics	Aquatic Life	Irrigation	Livestock Watering	Recreation	Aquatic Life & Wildlife	Irrigation	Livestock Watering
MICROBIOLOGICAL PARAMETERS (Continued)									
Blue-green Algae					Avoid heavy growth				
Microorganisms	a. No sample should contain more than 10 total coliform organisms per 100 mL; and b. not more than 10% of the samples taken in a 30-d period should show the presence of coliform organisms; and c. not more than two consecutive samples from the same site should show the presence of coliform organisms; and d. none of the coliform organisms detected should be fecal coliforms.								
Pathogens		Must be sufficiently absent to protect health of the user.			Water of high quality should be used.				

Technical appendix II - resource assessment
: B. Water quality
SSRBS no.72 1991