Partners FOR the Saskatchewan River Basin

# *From the Mountains to the Sea*

2009

## *Summary of the State of the*
## Saskatchewan River Basin


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From the Mountains to the Sea
Summary of The State of The Saskatchewan River Basin
2009

The Partners FOR the Saskatchewan River Basin

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# THE SASKATCHEWAN RIVER BASIN

## SUMMARY

Originating on the eastern slopes of the Rocky Mountains of Alberta and Montana, the Saskatchewan River basin extends from the continental divide through Alberta, Saskatchewan and Manitoba to a vast inland sea – Lake Winnipeg, the 11th largest freshwater lake in the world. The name Saskatchewan is taken from the Cree Indian word, *kisiskâciwanisîpiy*, meaning swift flowing river. The Saskatchewan River system is the fourth longest in North America, and is part of the larger Saskatchewan-Nelson system that flows into Hudson Bay. The river travels about 1940 kilometres from the Rocky Mountains to Lake Winnipeg and drains a surface area of some 405 864 square kilometres – almost the size of France.

*Mountain Waterfalls in Alberta*

Robert Berdan Photography

### LANDFORM AND LAND COVER

Mountain peaks of more than 3000 metres characterize the higher elevations of the Saskatchewan River basin. Dramatic cliffs and rock faces support some low-growing plants on warmer exposures. Somewhat lower elevations contain open stands of alpine fir, while even lower elevations are covered by stands of fir, pine and white spruce. The Alberta foothills, characterized by a series of ridges parallel to the mountain range, form a transition zone to the plains. In the lower river valleys, aspen and poplar forests occur on alluvial fans and terraces, while grasslands dominate the warmest, driest exposures.

The interior plain descends in three steps: the Alberta plain through the Saskatchewan plain to the Manitoba lowland. The only parts of the basin not glaciated in the last ice age are the Cypress Hills in southern Alberta and Saskatchewan, and the Porcupine Hills near Pincher Creek, Alberta.
The undulating, hummocky plain we see today is composed of 50 to 300-metre-thick deposits of glacial drift from earlier ice ages. Brown and dark brown soils are dominant and the natural land cover of the plains is mixed grasses, with limited aspen woodlands in the northern fringe. In the southern parts of the basin, trees and shrubs are found only in the river valleys where there is enough moisture

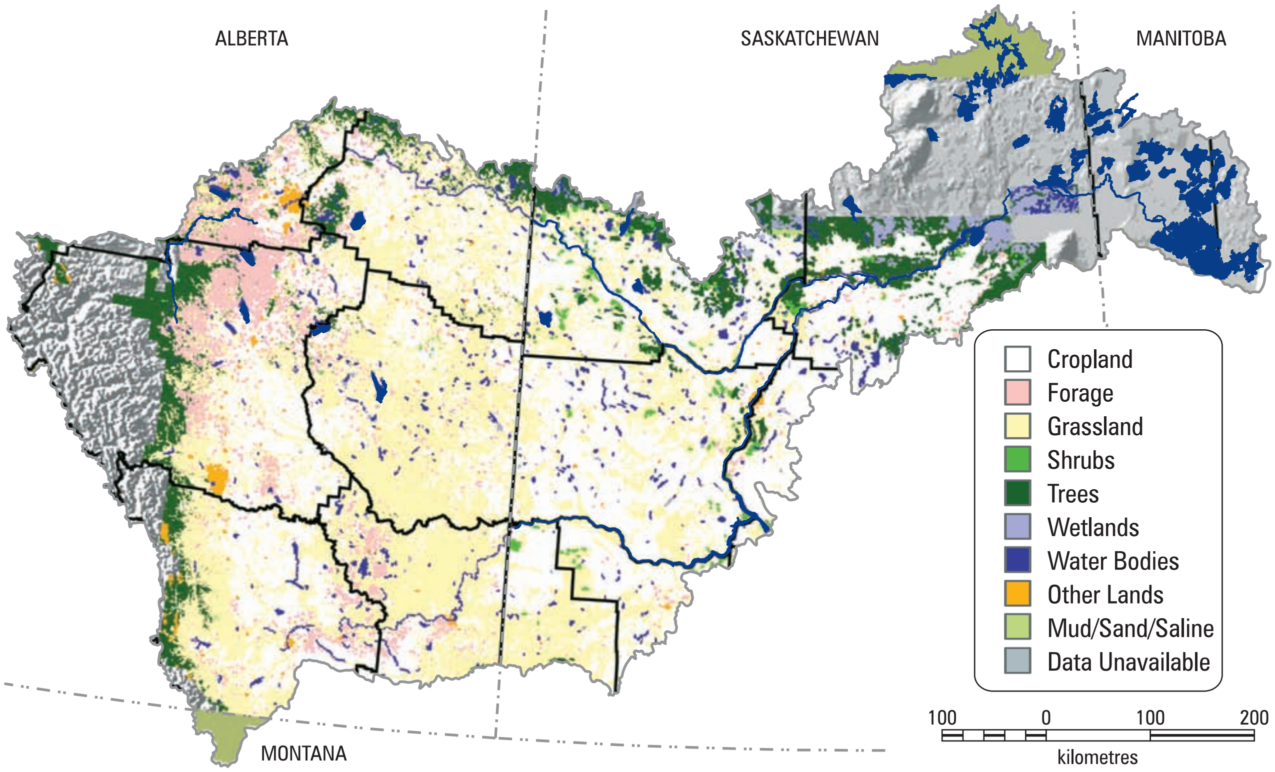



**Figure 1.** Landcover of the Saskatchewan River Basin (source, PFRA)

to support riparian forests. The deciduous and mixed-wood forests of the northern plains give way to coniferous forest in the lower basin.

Short and tall grass prairie covered much of the Saskatchewan River basin prior to European settlement. Deciduous and mixed-wood forest dominated the northern plains, and small potholes and other wetlands dotted the landscape. A review of wetland changes in the Saskatchewan River basin over the last 50 years reveals that 66 percent of the wetland area has been drained or altered to the point where little wetland-ecosystem function remains.

Ecologically distinct areas can be classified based on geology, landform, soils, vegetative cover, climate, hydrology, wildlife, and human factors. The classification hierarchy consists of ecozones, which are further subdivided into ecoregions and ecodistricts. Although dominated by the prairie ecozone, the basin contains portions of three other ecozones: the montane cordillera, the boreal plain and the boreal shield. The montane cordillera is the mountainous portion of the basin. Together with the foothills portion of the boreal plain, this part of the basin is identified as the 'water towers' – the source of much of the water that flows in the basin. The boreal plain ecozone generally forms a transition from prairie to the boreal shield near the Saskatchewan-Manitoba boundary.

## CLIMATE

The Saskatchewan River basin experiences the cold continental climate typical of the North American central plains. Winters are long and cold, but sunny, while summers are short and warm. Precipitation is most significant in the mountains, with average annual precipitation ranging up to 1500 mm. The prairie ecozone is particularly dry, even semi-arid in the south, with precipitation ranging from 300 mm in the rain shadow of the mountains to as much as 500 mm. In the plains portion of the basin, precipitation increases progressively from southwest to northeast. Most of the annual precipitation falls as rain in the spring and summer. These rains replenish soil moisture and sustain crop production. Runoff in the basin is largely dependent on spring snowmelt on the plains and melting of the winter snowpack in the mountains and foothills. Evaporation over much of the basin exceeds precipitation, leading to moisture deficits.

## HYDROLOGY

The North Saskatchewan River originates at the Saskatchewan Glacier in the Columbia Icefields. Headwaters tributaries include the Cline, Brazeau, Ram, and Clearwater rivers. The South Saskatchewan River is fed by three major tributaries: the Red Deer, Bow and Oldman rivers. Tributaries entering the main channels from the plains include the Battle River, which joins the North Saskatchewan River near Battleford, and Swift Current Creek, which joins the South Saskatchewan River near Swift Current. The two principal branches of the Saskatchewan River join at The Forks in central Saskatchewan. There are several lower basin tributaries including the Carrot and Sturgeon-Weir rivers, which join the Saskatchewan River near the Manitoba boundary.

An important natural feature of the Saskatchewan River is the Saskatchewan River Delta – the largest inland freshwater delta in North America – beginning just west of the Saskatchewan-Manitoba boundary. This almost 10 000-km$^2$ delta is a wildlife area of national significance. At the downstream end of the delta, the river flows through Cedar Lake, now regulated for hydropower, and on to Lake Winnipeg.

The streams, lakes and wetlands of the Saskatchewan River basin are sustained by snowmelt. Snow accumulating throughout the winter on the eastern slopes of the Rocky Mountains melts in the spring and summer, providing significant river flows in May, June and July. Although this snowmelt runoff can be augmented by spring rains, the available water supply for the basin largely depends on the accumulated snowpack. Of the precipitation that falls in the

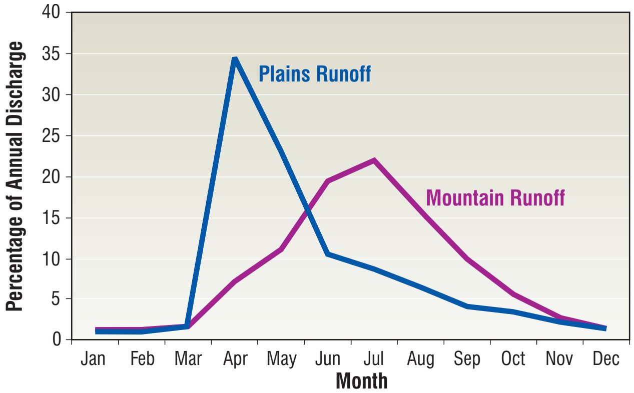



**Figure 2.** Percentage of Annual Runoff by Month for Plains and Mountain Streams.

mountains, a significant portion contributes to groundwater recharge, which in turn discharges to surface water. Most of the water flowing in the North and South Saskatchewan rivers originates in the water towers; however, plains tributaries joining the Saskatchewan River near the Saskatchewan-Manitoba boundary contribute large volumes of runoff.

Runoff in the plains in April and May is also governed by spring snowmelt and early spring rains. In southern Alberta and southwestern Saskatchewan, winter snowpacks can be significantly reduced by chinook winds. The plains runoff replenishes local water supplies, including groundwater and wetlands, but may never join the principal streams. The rain that falls on the plains also replenishes groundwater and some wetlands. Figure 2 shows the timing and percentages of annual runoff by month for typical prairie and mountain streams. The annual volume of runoff from the mountains is much greater, as stated earlier.

Streamflows in the basin show considerable variability, both within years and between years. Mountain-fed streams show a more consistent and much more reliable flow than plains streams.

An aquifer is a water-bearing formation sufficiently porous to yield water to a well. Prairie aquifers can be classed as either bedrock or quaternary aquifers. Bedrock aquifers are either porous or fractured enough to yield water, while quaternary aquifers are near-surface sands and gravels deposited by glacial ice sheets in the last 2.5 million years. These latter aquifers tend to be unconfined and can be recharged from precipitation or surface water. They can also supply water to springs and contribute to streamflow. Although surface water is the source of most of the water used in the basin, groundwater is an important source of rural water supplies.

## HUMAN SETTLEMENT

Aboriginal people have lived in the Saskatchewan River basin for about 11 000 years. By the time English and French fur traders arrived, the use of horses was well established, as was aboriginal use of the waterways.

The 1870s brought many changes to the mid-continent. In 1870, the fledgling Canadian government assumed control of western British North America from the Hudson's Bay Company. Following this assumption of sovereignty, and with increasing pressures of European settlement, a series of numbered treaties was negotiated with First Nations in the 1870s. Treaties 4, 5, 6, and 7 cover parts of the Saskatchewan River basin. They are nuanced and complex but, in essence, are aimed at defining the relationship between First Nations and the Crown, as represented by the Government of Canada.

The late 1800s was a period of burgeoning economic development in western Canada, prompted, in part, by completion of the transcontinental railway in 1885 and the subsequent rush of settlers. Government policies aimed at settling the west led to a population boom in the early part of the 20th century. In succeeding years, this largely rural, agricultural population has been transformed into a highly urbanized industrial and post-industrial society. According to the 2006 census, the total population of the Saskatchewan River basin is about three million. This population is concentrated in Alberta, with 2 412 736 people living in the Edmonton to Calgary corridor. While water demands for irrigation and other agricultural purposes continue, urban residents need water for domestic and industrial purposes. Basin residents and visitors also use the water resources of the basin for many recreational purposes.

The populations of urban centres throughout the basin are steadily increasing. Rural populations in much of the Alberta portion of the basin are increasing, while those in Saskatchewan and Manitoba are decreasing.

## WATER USE

Water use is a broad term that includes any use of water for any activity, economic or otherwise. Water use can include withdrawal or diversion of water from a source, or water used in place. Water uses may be considered consumptive or non-consumptive. For example, water used by livestock is almost entirely consumed, while that used in cooling thermal power stations is almost entirely returned to the water body. Provincial agencies consider the likely consumption of water for a specific use in their licensing processes. A summing-up of the quantities of water allocated by water licences will produce an overestimate of water consumption in a river basin because many licensees do not use their entire entitlement in a given year.

The terminology related to water use varies from one agency or practitioner to another. In this report, the term water allocation is used to identify the quantity of water set aside under provincial law for

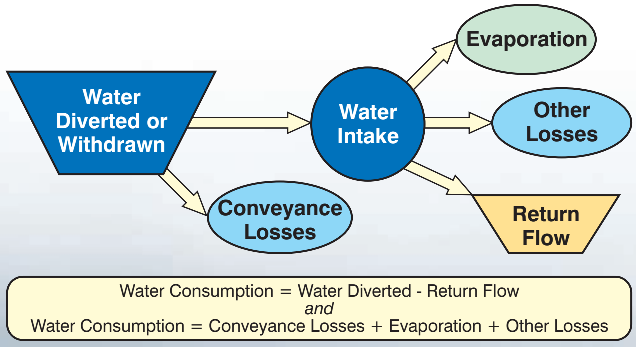



**Figure 3.** A Simplified Schematic of Water Use.

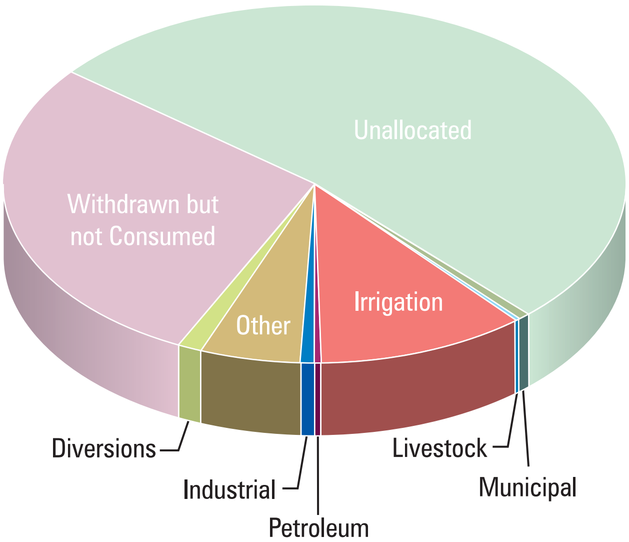



**Figure 4.** Water Withdrawal and Consumption in the Basin in a Median Year.

a particular user. The allocation may include a consumptive use component and a return flow that would be available to downstream users. Water withdrawal or water diversion is the quantity of surface or groundwater a water user removes from the aquatic system. Water consumption is water diverted that does not subsequently return to the aquatic system, and includes losses to seepage or evaporation. Return flow is the difference between water withdrawal and water consumption. These concepts are illustrated in Figure 4.

There are over 20 000 water licences and registered uses in the Saskatchewan River basin, and all but a few hundred of these are in the South Saskatchewan sub-basin in Alberta. Groundwater consumption in the basin represents about 2.5 percent of total consumption. It is evident that irrigated agriculture represents the most significant water use in the basin – most of this occurring in the South Saskatchewan River sub-basin.

## WATER QUALITY

The natural water quality of any stream is influenced by the landscape and geology through which it flows. In the Saskatchewan River basin, the quality of water flowing in streams or contained in lakes and reservoirs is the result of both natural processes and human activity. Water may contain dissolved substances such as calcium, sodium, bicarbonate, or chloride, as a result of natural processes. It may also contain plant nutrients such as nitrogen or phosphorus, as well as trace elements such as selenium, chromium or

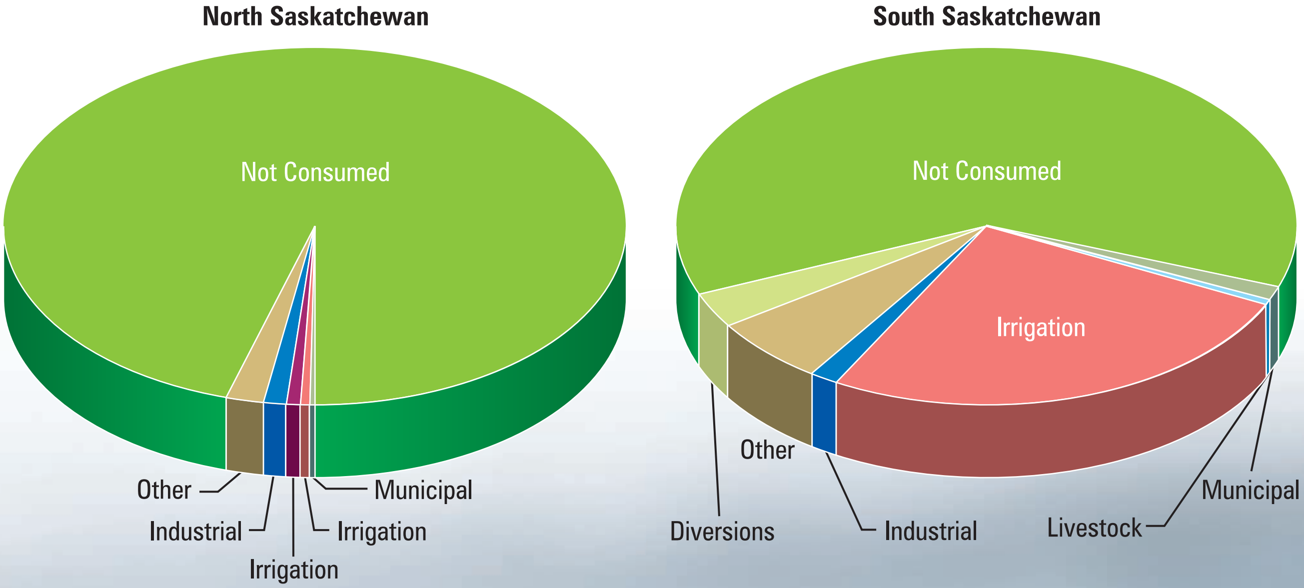



**Figure 5.** Water Consumption in the North and South Saskatchewan Rivers.

arsenic. Naturally occurring substances may only affect the appearance or taste of water, or they may be harmful to human health and aquatic life if found in sufficient concentrations. Water may also contain dissolved gases such as oxygen.

Human activities such as urban development, irrigation and other farm activities, industrial development, and resource developments related to petrochemicals, mining, and forestry may degrade the quality of natural waters. Land-use change of itself may also affect water quality. The biological quality of water can be changed by introduction of bacteria normally found in the intestinal tract of humans or animals or by water-borne pathogens such as *Giardia lamblia* or *Cryptosporidium parvum*. In recent years, pharmaceuticals and personal care products in aquatic systems have become a growing cause of concern.

The waters of the Saskatchewan River basin tend to be naturally hard, particularly with calcium and bicarbonate, and that hardness increases as we move downstream. The mountain-fed streams of the basin also tend to be naturally nutrient poor, but treated sewage effluents, storm water runoff, and agricultural runoff significantly increase levels to concentrations greater than natural levels. The waters become turbid during spring runoff and summer rainstorms.

One general descriptor of water quality in a basin is its trophic status. This classification, based on biological productivity, has been applied to lakes for many years, and, more recently, has been applied to streams. Trophic classification represents a continuum of biological production ranging from oligotrophic to mesotrophic to eutrophic to hypereutrophic. Oligotrophic systems exhibit very little biological production; the water tends to be clear and well oxygenated. Mesotrophic waters may be moderately clear, but oxygen may be depleted in the deepest parts of lakes. Eutrophic systems may contain high densities of plants and algae. Lakes may produce algae blooms and be low in oxygen. Hypereutrophic lakes will contain significant persistent algal blooms. Oxygen depletion can lead to fish kills.

## BIODIVERSITY AND ECOSYSTEMS

Biodiversity refers to the variety of all living things and the ecosystems that support them. Biodiversity also includes genetic diversity within a single species and the interactions among species. Although the Saskatchewan River basin has been significantly altered by human activity, considerable landscape diversity and numerous plant communities provide habitat for many large and small mammals and birds. Riparian areas, wetlands, lakes, and streams support a wide array of terrestrial and aquatic species. Natural and cropped uplands adjacent to wetlands also provide habitat for some terrestrial species.

Principal threats to biodiversity include habitat fragmentation and loss of habitat. Habitat fragmentation may occur through construction of dams and weirs that block fish migration, or through linear features such as roads and seismic lines. Draining of wetlands and reduction in old growth forests through fire, disease or harvesting are two examples of habitat loss. Changes in the age structure of forests also affect biodiversity. Suppression of fire and insects lead to an older forest structure, while

Ducks Unlimited Canada

forest harvesting and wildfires lead to a younger. Conversion of the plains to an agricultural landscape also represents a loss of habitat through loss of parkland forest and development of agricultural monocultures. The accompanying wetland loss reduces waterfowl populations.

Riparian zones are important to sustaining both terrestrial and aquatic species. In many tributary sub-basins of the Saskatchewan River basin, riparian zones have been sampled and categorized as healthy, healthy-with-problems, or unhealthy. Riparian zones in the plains portion of the basin tend to be healthy, but with some problems.

The aquatic food web consists of algae, plants, invertebrates, and vertebrates. Algae are single-celled organisms suspended in the stream or attached to rocks or plants as biofilm. They are important energy sources within food webs. The waters of the Saskatchewan River system tend to contain low concentrations of algae, but these concentrations increase greatly downstream of municipal wastewater treatment facilities because of the nutrient content of the effluent. Although some prairie tributaries of the basin and the Saskatchewan Delta contain diverse populations of rooted plants, the mountain-fed mainstem rivers do not. Plant growth increases downstream from municipal wastewater treatment facilities.

Invertebrates are the insects and other animals without backbones that spend at least part of their life cycle in water, or streambed, lakebed or wetland habitat. They live on plants, dead organic matter or other invertebrates. Populations in the principal streams of the Saskatchewan River basin are relatively low, but diverse. This diversity is reduced in river reaches below major urban centres.

Fish are the most evident vertebrates in a stream. The alpine and sub-alpine lakes and streams of the basin, especially those upstream of waterfalls, were almost devoid of fish until the lakes were stocked with rainbow trout, cutthroat trout or brook trout beginning early in the 20th century. Some mountain lakes did contain longnose sucker, mountain whitefish or bull trout. The lower warm-water reaches of the North and South Saskatchewan rivers contain species such as northern pike, walleye, goldeye, yellow perch and sturgeon. In recent years, fish populations have improved because of better water quality. Fish populations downstream of urban centres are sensitive to the nutrient content of the effluent and may decrease when nutrient concentrations are reduced. The greatest diversity of fish species is found in the Saskatchewan River Delta, where 48 species have been identified.

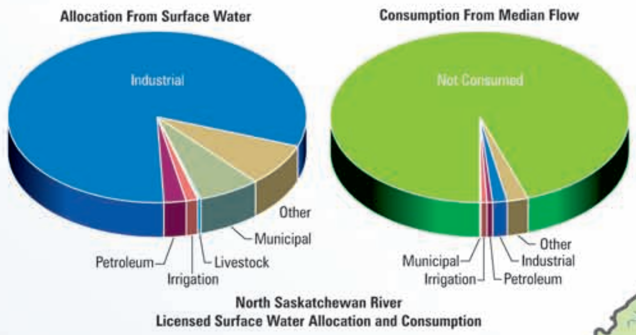
## VULNERABILITIES

The Saskatchewan River basin has been profoundly altered by human activity. The landscape has been modified by agricultural development, drainage, forest harvesting, oil and gas exploration and development, and mining. Natural streamflows have been altered because of this landscape change and through construction of dams and diversions. The basin is also vulnerable to stresses that may originate beyond its boundary. The changes and environmental stresses introduced by human activity will ultimately affect the environmental quality of the basin's receiving water body, Lake Winnipeg.

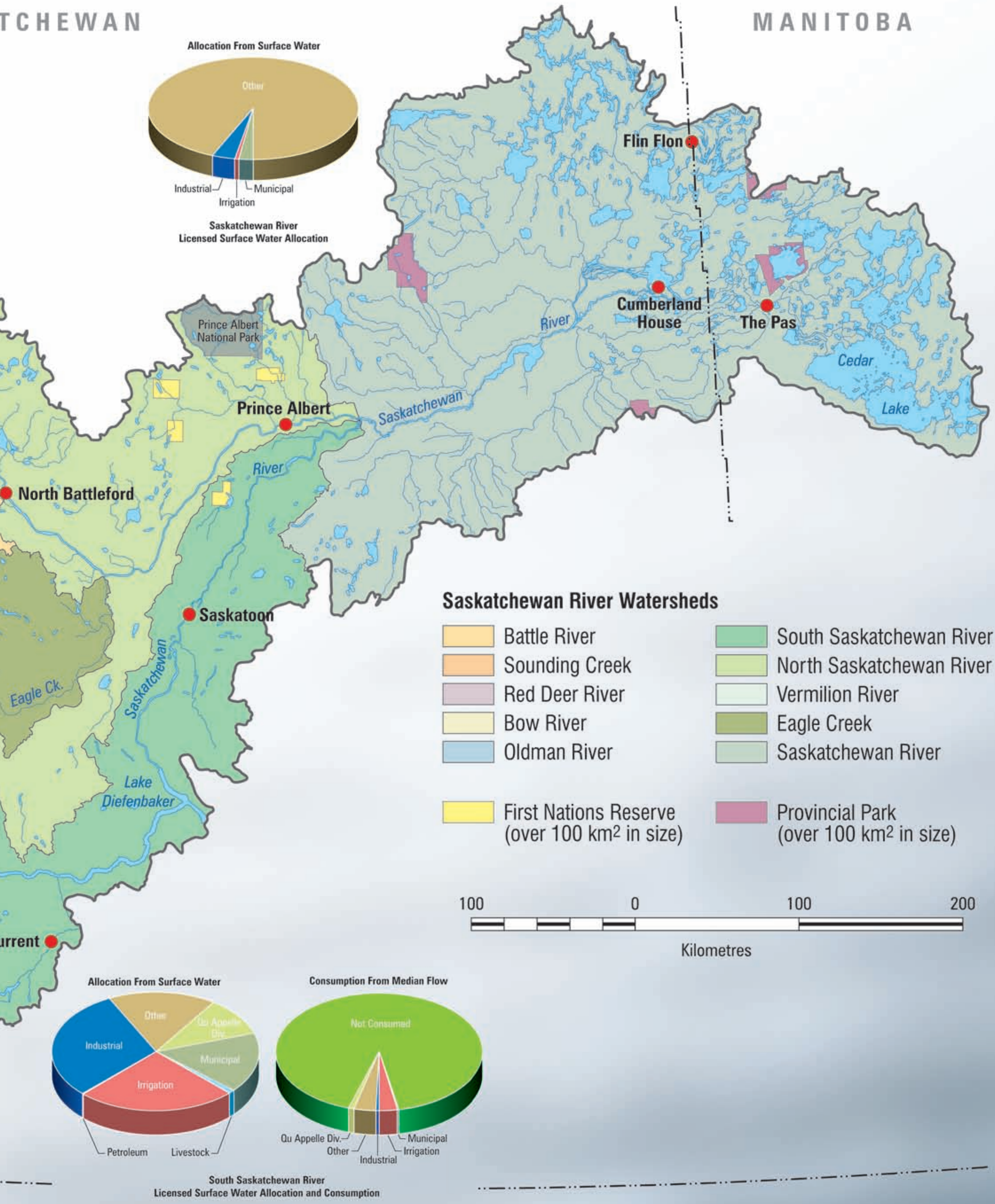
Key vulnerabilities of the basin are related to physical and ecological effects of landscape modification, water supplies to meet human and other needs, effects of urban development on water quality, natural hazards such as floods and droughts, and invasive species.

### Landscape Modification

The plains landscape of the Saskatchewan River basin has completely changed in the last 150 years. Natural grasslands and parkland forests have given way to agricultural development, foothills forests have been disturbed by oil and gas exploration and by timber harvesting, and wetlands have been drained. Expansion of urban centres and growth of


Allocation From Surface Water
Industrial
Other
Municipal
Petroleum
Livestock
Irrigation
Consumption From Median Flow
Not Consumed
Other
Industrial
Municipal
Irrigation
Petroleum
North Saskatchewan River
Licensed Surface Water Allocation and Consumption


ALBERTA
SASKA
BRITISH
COLUMBIA
MONTANA
Edmonton
Elk Island National Park
North
Saskatchewan
Vermilion R.
Vegreville
Vermilion
Lloydminster
River
Jasper National Park
Camrose
Battle R.
Rocky Mountain House
Red Deer
Eyehill Ck.
Banff National Park
Red Deer
Sounding Ck.
Banff
Calgary
Bow
River
South
Brooks
River
Swift C
Medicine Hat
Oldman
River
Lethbridge
Waterton Lakes N.P.
Glacier N.P.


TCHEWAN
MANITOBA
Allocation From Surface Water
Other
Industrial
Irrigation
Municipal
Saskatchewan River
Licensed Surface Water Allocation
Flin Flon
Cumberland House
The Pas
Cedar Lake
River
Saskatchewan
Prince Albert National Park
Prince Albert
River
North Battleford
Saskatoon
Eagle Ck.
Saskatchewan
Lake Diefenbaker
urrent
Saskatchewan River Watersheds
Battle River
Sounding Creek
Red Deer River
Bow River
Oldman River
South Saskatchewan River
North Saskatchewan River
Vermilion River
Eagle Creek
Saskatchewan River
First Nations Reserve (over 100 km2 in size)
Provincial Park (over 100 km2 in size)
100
0
100
200
Kilometres
Allocation From Surface Water
Other
Industrial
Irrigation
Municipal
Petroleum
Livestock
Consumption From Median Flow
Not Consumed
Qu Appelle Div.
Other
Industrial
Municipal
Irrigation
South Saskatchewan River
Licensed Surface Water Allocation and Consumption

transportation networks to support those centres continue to transform the natural landscape. These landscape changes also affect the hydrologic regime of the basin, through changes in storage of surface water and groundwater and through modifications to flow patterns. Physical and hydrological changes lead to biological change through changes in aquatic, riparian and terrestrial habitat.

## Agriculture

Agricultural development has irrevocably altered the natural landscape of prairie Canada, affecting both physical attributes and biological resources. As agriculture became more intensive and farm equipment increased in size, wetlands were drained, trees removed, and grasslands cultivated. As a result, habitat for many plant and animal species has been lost to a grains and forage monoculture. Remaining areas of unaltered wildlife habitat have become progressively more fragmented, more isolated, and often too small to sustain viable populations of once abundant species.

Grazing by cattle and other domestic animals reduces plant cover, decreasing the supply of food and shelter for meadow and grassland species of mammals, birds and invertebrates. On the other hand, some forms of wildlife thrive under conditions arising from agricultural activity. Farm shelterbelts and abandoned farmsteads provide cover for numerous species of birds. Other species have benefited from increased feeding opportunities provided by agricultural crops.

The environmental sustainability of farmed areas of the Saskatchewan River basin cannot be considered without first considering factors that affect the environmental, social and economic aspects of agricultural production. These include protecting quality and productivity of farmed soils; reducing soil erosion and salinity; conserving and restoring soil organic matter; protecting the quality of surface and groundwater; preserving and restoring riparian zones; and maintaining or improving the quality of rangelands. Careful attention to these factors will inevitably lead to a better match of land use to land capability. Enhancing the sustainability of agriculture production can, with care, improve environmental performance.

## Forestry

The forests of the Saskatchewan River basin include foothills forest in Alberta and parkland forests of the North Saskatchewan River sub-basin in Alberta and Saskatchewan, as well as the boreal forest of the lower Saskatchewan River basin in Saskatchewan and Manitoba. The foothills forest of the eastern slopes of the Rocky Mountains is a unique part of the boreal forest. The conifer forest at higher elevations consists of stands of spruce, pine and fir. The mixed-wood forest at lower elevations contains hardwoods and conifers and significant wetlands.

Beyond the boundaries of the national parks and designated wilderness areas, the foothills forest is extensively logged. Harvesting old-growth forests reduces unique habitat. The oil and gas sector also has a major effect on the foothills forest through cutting seismic lines, constructing roads and pipelines, and installing extraction facilities. Construction of access roads and other linear features fragments habit. The old-growth, lodgepole pine stands of this region are particularly threatened by an outbreak of mountain pine beetle. Changes in the composition and age structure of the foothills forest will alter the runoff from these forests.

The parkland forest or boreal transition forest is a mix of trees – largely poplar – shrubs, and wetlands in Alberta and Saskatchewan. It is highly productive habitat for birds, mammals and plants. Over time, agricultural expansion has led to conversion of this transition forest to cropped land. In general, this conversion has led to wetland drainage, loss of habitat, decreased biodiversity and hydrological change. The spruce and pine forests in portions of this forest are also subject to logging pressures.

While forest harvesting has modified the boreal forest of the lower Saskatchewan River basin, the forest of the Precambrian Shield portions of the lower basin in Saskatchewan and Manitoba has been relatively untouched by human activity. The principal disturbances have been road construction and mining, although there is some logging in the Manitoba portion of the shield.

### *Urban Development*

Urban centres in the Saskatchewan River basin are growing rapidly and much of that growth is low-density, automobile-dependent, suburban development. The preference for a suburban life style comes with costs – environmental, social and economic. Loss of wildlife habitat, relatively high water use for lawn watering, and damage to receiving waters from stormwater runoff are some of the environmental costs. Other effects include loss of productive farmland, increased cost of water and transportation infrastructure, and socio-economic fragmentation. Some cities are considering Smart Growth concepts as a means of ensuring more sustainable urban growth patterns.

## Water Supply

Considering the basin as a whole, water supplies are sufficient to meet reasonable needs, if managed wisely. The management challenge differs in different parts of the basin. The quantity of water consumed in the North Saskatchewan River basin in a typical year is small. Under the terms of existing water allocations, that quantity could be double its current size. Even then, this quantity is small compared to the reliable water supply. Water consumption is also very small downstream on the Saskatchewan River.

The South Saskatchewan River basin is a different matter, however. About 35 percent of the naturalized flow is consumed in a median year. The Bow and Oldman sub-basins can be considered as fully allocated. Alberta has placed a cap on water licences for irrigation. The current water-supply situation prompts questions about water supplies under future climate scenarios and raises concerns about environmental effects of existing and proposed dams and diversions.

*Overlooking the South Saskatchewan River as it flows through the city of Saskatoon*

istockphoto.com

Water supplies originating with the mountain-fed principal streams of the basin are much more reliable than those of the plains-fed tributaries. For these latter streams, the reliable flow tends to be small thus many potential investments in water infrastructure are uneconomic. As much of the land surface producing plains runoff is agricultural, land-use change alters the runoff.

## Climate Change

Climate change is a global problem that will affect the Saskatchewan River basin. There is considerable climatic and hydrological variability in the basin, both within years and between years, and basin residents and aquatic ecosystems have adapted to this variability. Water management authorities take variability into account in developing programs and projects. Adaptation to the effects of climate change has to be considered in addition to adaptation to natural variability.

A reasonable climate scenario for the Saskatchewan River basin could be based on the certainty of continued warming and the likelihood of seasonal changes in precipitation, even if annual precipitation remains the same. The relationship between this scenario, or any other, and future water supplies is difficult to determine. Water supplies in the basin are highly dependent on snowmelt. Increased temperatures will inevitably lead to an increased percentage of annual precipitation falling as rain rather than snow.

Projecting runoff under climate change is complicated by the fact that precipitation also recharges groundwater, which, in turn, can sustain streamflow during low-flow periods. Considering the more reliable mountain runoff, there are few current trends suggesting declining annual runoff, although the spring snowmelt is occurring earlier now than in the past. Runoff from the water towers is also affected by the state of the forests on the eastern slopes of the Rockies. In general, younger forest stands yield more runoff than mature stands.

Streams originating on the plains are showing decreases in spring runoff and annual runoff. These reductions could be the effect of changes in land-use practices, such as conservation tillage, as well as a response to changing climate.

Even if future average water-supply conditions are within the ability of basin residents to adapt, climate change could lead to increased likelihood of extreme conditions, such as floods and droughts.

## Dams and Diversions

Dams and weirs constructed in the basin have several important effects. First, they change the portion of the river channel where the project is constructed from a river environment to a lake environment. Reservoirs inevitably change the distribution and abundance of aquatic biota. Nutrients leached from flooded soils may actually increase biological productivity, albeit for species different than the original dominant inhabitants. Even when a project provides little storage, such as a run-of-the-river hydro facility, dams and weirs fragment the natural ecosystem by providing barriers to migration of aquatic species and disrupting riparian habitat.

Reservoirs store water during spring runoff and release it for later use. In the Saskatchewan River basin, hydroelectric stations tend to be used to meet peak load requirements, while thermal generation is used to meet base loads. Although peak power demands occur on a daily basis, hydroelectric stations tend to reverse the high and low cycles of the natural hydrograph. As overall electricity demand is greater in the winter than in the summer, river flows can be higher than natural in the winter and lower in the summer. While hydroelectric projects consume no water other than losses to evaporation, they do significantly alter the flow pattern. Because irrigation water demands are in the summer, the flow conditions downstream may, in some cases, mimic those of the natural hydrograph, when water is released from storage for use downstream. Demands for irrigation, however, are significant enough to reduce downstream flows, thus raising concerns about in-stream flow requirements for aquatic life.

The physical, biogeochemical and biological processes within the reservoir will affect the water quality in the reservoir and downstream. The degree to which water quality is affected will depend on factors such as the surface-to-volume ratio and depth of the reservoir, the surficial geology and soils of the catchment, sedimentation rates, magnitude and timing of flows entering the reservoir, and the biological productivity of the reservoir.

## Municipal Water and Wastewater

Continued urban growth and related demand for water services, such as water supply, wastewater treatment, and drainage, pose a considerable challenge. All the urban centres in the basin provide treated water and some level of wastewater treatment to household, industrial, commercial, and institutional users. The cost of providing these services is recovered through water charges and municipal taxes. Providing safe drinking water and reducing effects of wastewater effluents on downstream communities and ecosystems are two of the key challenges for the Saskatchewan River basin.

## *Water Supply*

Almost all of the water used in the cities of the basin is surface water. Groundwater tends to be used only by smaller communities and farmsteads. Although urban water withdrawals are large, household water consumption in the basin is relatively small. The reason for this is that almost all the domestic water used indoors returns to the aquatic system as wastewater; only water used outdoors tends to be consumed. If one includes stormwater runoff as part of the contribution of urban centres to streamflow, most urban centres in the basin return more surface water to the natural system than they withdraw. Urban centres also tend to be net contributors to the groundwater system.

*The Bow River at the City of Calgary, Alberta*

Bob Lee

The main advantage of urban water conservation, therefore, lies not so much in saving water, as in postponing the need for capital investments in water supply and wastewater treatment systems. Reduced water withdrawals also benefit the aquatic health of the streams receiving municipal effluents, by enabling more effective operation of wastewater treatment systems.

Public concerns about safe drinking water can be addressed by source water protection, effective water treatment, a secure distribution system, and robust operating and control systems. Larger centres have the skilled personnel and financial resources to design, build, operate, and maintain a satisfactory water supply system. This is not always the case for smaller centres and First Nations reserves. Difficulties lie not only in the need to secure resources and skills to implement a water supply system, but also in particular problems related to protecting and enhancing local source waters, including meeting the need for innovative small-scale systems.

### *Wastewater*

Municipal wastewater consists of human and other organic waste, suspended solids, nutrients, microorganisms, and various household and industrial chemicals. It may also contain stormwater runoff in centres where combined sewers are still in use. All cities in the basin treat their wastewater before discharging it to the natural system. The treatment process reduces contaminant levels of the effluent, but the sheer volume of effluents discharged annually to the environment make urban wastewater an environmental concern. This effluent suppresses oxygen levels in the stream and may contain suspended solids, nutrients, organic chemicals such as pesticides, and metals. Other contaminants may include pharmaceuticals, personal care products, endocrine disrupting compounds, and brominated flame retardants. These effluents affect the quality of the receiving waters and the quality of sediments in the stream, in turn affecting the plants and animals of the ecosystem. Effluents may also lead to human health and economic effects.

Generally, municipal wastewaters are treated through a progression of processes including preliminary, primary, secondary, tertiary, and quaternary. These processes incrementally remove increasing amounts of suspended solids from the effluent stream and reduce the oxygen demands of the effluent. Sewage lagoons provide a level of treatment similar to that of secondary treatment. Some wastewater treatment systems in the basin also include nutrient reduction. Effluents are disinfected before release to the environment. All municipal effluents in the basin receive at least secondary treatment. Banff, Calgary and Saskatoon carry out advanced nutrient reduction.

### *Stormwater*

Despite construction of wastewater treatment facilities, combined sewers continued to discharge untreated sewage to receiving waters during high-runoff events. These combined sewers still exist in the central cores of some cities in the basin. Cities are modifying infrastructure to reduce overflow incidents.

In recognition of the problems associated with combined sewers, cities developed sewer systems exclusively for stormwater runoff. Stormwater runoff contains much lower levels of contaminants than sewage effluent, but flows of stormwater are much greater than those of sewage effluent and are often confined to pulses of flow during wet weather. These flow pulses contain contaminants from streets and parking lots. As wastewater treatment systems improve, effects of stormwater runoff on receiving waters become more apparent. Treatment of stormwater runoff will become an increasing requirement in the basin.

## Natural Hazards

The Saskatchewan River basin is subject to both floods and droughts. Floods and droughts are primarily natural events, although they can be modified both positively and negatively by human activity. These phenomena affect natural ecosystems and human settlement. Although effects of smaller floods and droughts can be mitigated, there is always the risk of a flood event exceeding the design capacity of the infrastructure, or of a drought exceeding the coping range of aquatic ecosystems, individual water users, or infrastructure.

## Floods

Most urban communities in the basin are in river valleys. During spring runoff and intense summer rainstorms, these communities can be flooded. Although loss of life is rare in Canadian floods, financial and other losses associated with flooding are significant. Entire communities may be disrupted for lengthy periods following a flood.

Rural areas of the Saskatchewan River basin are subject to flooding also, leading to losses in agricultural productivity and other economic losses. Damages can sometimes be reduced through operation of water infrastructure, but often adjustments to help upstream lands lead to flooding of downstream lands and vice versa.

Flood risk areas in the Saskatchewan River basin have been identified, but flood damage reduction measures may be incomplete. Provincial governments produce flood forecasts and warnings so that emergency response personnel and the public can take appropriate action during a flood.

## Drought

Unlike other natural hazards that can affect the basin, drought is a slow-onset phenomenon. In fact, definitions of drought vary considerably and the precise beginning and end of a drought period may be difficult to determine. All droughts begin with a deficiency in precipitation extending over a significant length of time, known as a climatological drought. If this deficiency leads to lack of availability of soil water to support agricultural activities, an agricultural drought exists. With continuing precipitation deficits, streamflows, lakes, reservoirs, and aquifers may become depleted, leading to hydrological drought. Finally, the effects of meteorological, agricultural and hydrological droughts on human activity may be so significant, we can speak of a socioeconomic drought.

The 20th century was climatologically benign compared to other recent centuries. While significant droughts have taken place, for example in the 1930s, they may not have been as severe as those of previous centuries. Nonetheless, the 20th century featured three major prairie drought events. The 2001-02 drought was unusual for its broad spatial coverage and intensity. Farm income on the prairies was negative or zero for the first time in 25 years.

A return to the more extreme climates of previous centuries may raise the prospect of decadal droughts. Planning for a decadal drought in the entire Saskatchewan River basin is very conservative.

## Invasive Species

Invasive species are animals, plants or microorganisms originating in other countries, or from other ecosystems outside the basin. They are characterized by an ability to reproduce and spread rapidly, as well as having negative attributes that affect natural systems, crops and people. They often have no natural enemies to limit their reproduction, and spread where they are introduced. Invasive species threaten the environment by causing habitat loss for native species or by out-competing them. They threaten the economy through pest control costs and economic losses. As well, they threaten social values by altering the natural landscape, decreasing property values, or affecting our health. Some introductions, the European starling and the house sparrow, have been deliberate, while others, such as the Norwegian rat, were accidental. (Alberta has a program aimed at keeping rats out of the province.) Recent examples of invasive species in the basin include the mountain pine beetle and purple loosestrife.

## INSTITUTIONAL DEVELOPMENT

Governments at all levels have developed a sophisticated web of legislation and programs that applies to various aspects of water management in the Saskatchewan River basin. The *Water for Life Strategy* in Alberta, *Long-term Safe Drinking Water Strategy* in Saskatchewan and *The Manitoba Water Strategy* are examples. Municipal governments, agricultural producers, industries and other organizations have developed, over time, their own programs in response to legislation, regulation and other perceived needs. Contemporary water management seeks to engage basin interests and the general public in meeting the needs of society, without degrading the natural environment. There is an underlying concept of shared governance, at least as it pertains to water planning.

Traditional water management emphasized problem solving, but the solution to one problem was often accompanied by unintended consequences. There is every expectation that water management will grow more complex as the ever-increasing population of the Saskatchewan River basin faces the vulnerabilities and threats identified earlier in this summary. The water resources of the basin are finite. Meeting future challenges will depend not only on better scientific understanding and technological improvements, but also on institutional development that encourages integrated and adaptive approaches to water management. These approaches require legislative and policy support, appropriate science, monitoring and data, and a basin-scale or sub-basin-scale institutional framework that accommodates various interests.

Integrated water resources management cannot be achieved quickly or without difficulty. There is certainly no operations manual for engaging in IWRM. Drawing a circle around water-related activity in a basin will inevitably result in a series of intersecting circles around water and other activities, such as land management, energy, wildlife, fisheries and so on. Natural resources agencies and

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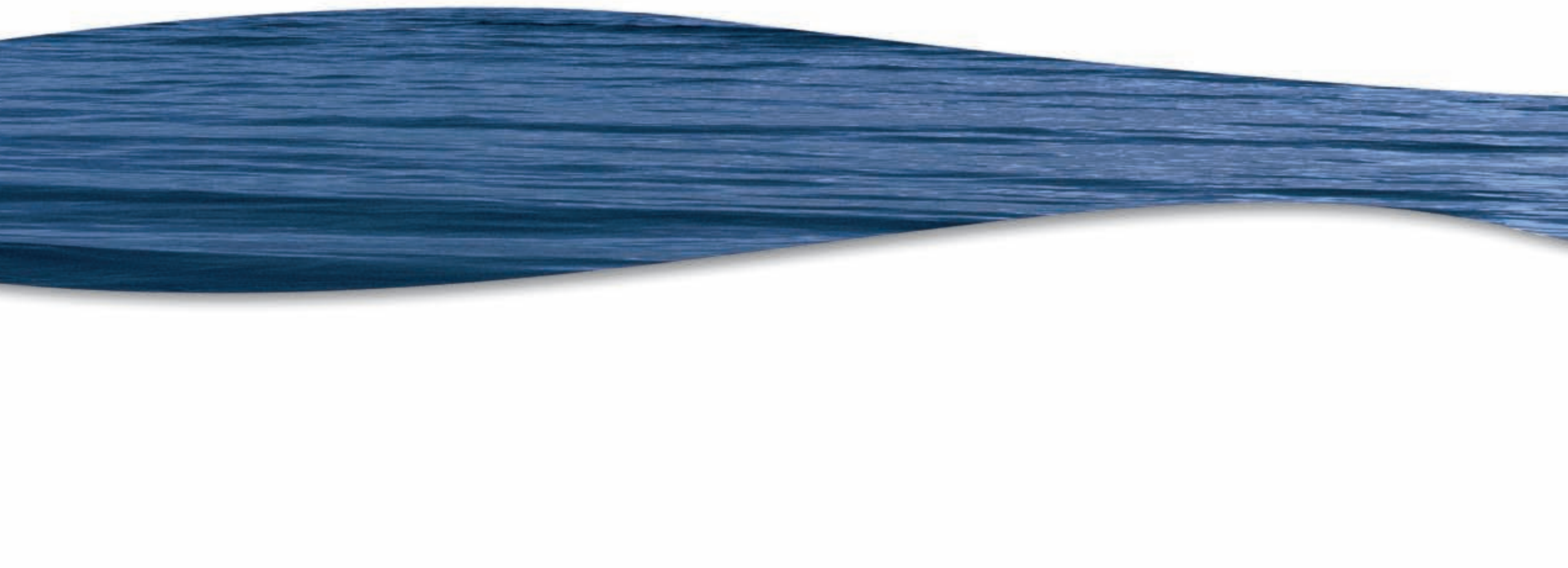
*The Oldman River*

organizations tend to be organized along sectoral lines; thus, the challenge lies in integrating water resources activity across those sectors.

Turning to the Saskatchewan River basin, there is a significant body of legislation and policy relating to water management. Chapter Three of this report considers these matters in some depth.

As regards science, monitoring and data, while there are significant programs in operation in the basin, there are also many knowledge gaps related to matters such as climate change effects on hydrology, hydrological processes, sources and pathways of contaminants, aquatic and riparian habitat, and water conservation. Data gaps are also evident. Although excellent data are available on water allocation, there are little on actual water diversion or consumption, or on groundwater quantity or quality. Even when data are collected, they are sometimes difficult to obtain. The Alberta Water Portal is a recent example of water data made more accessible to the public. There is also a need to continue to build capacity in the various regional planning organizations in Saskatchewan River basin. The Water Planning and Advisory Councils (Alberta), Water Advisory Committees (Saskatchewan) or Conservation Districts (Manitoba) of the basin should be nurtured and supported so they can reach a common understanding of key vulnerabilities and threats, and explore possibilities for effective measures to meet those challenges.



Saskatchewan Watershed Authority

The Calgary Foundation

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alberta ecotrust
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Manitoba