CHAPTER NINE

THE SOUTH SASKATCHEWAN RIVER SUB-BASIN

Figure 9.1. *The South Saskatchewan River Sub-basin*

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The South Saskatchewan River sub-basin, shown in Figure 9.1, originates in mixed grasslands at the confluence of the Bow and Oldman rivers. The sub-basin comprises the river reach of the South Saskatchewan River and its associated drainage area. The South Saskatchewan River flows east to Medicine Hat then turns northeast to the Saskatchewan boundary. The river receives some tributary flow from small streams rising on the slopes of the Cypress Hills. Shortly after crossing the interprovincial boundary, it is joined by the Red Deer River.

Sub-basin Summary

Characteristics
- plains to boreal transition
- length – 998 km
- gross drainage area – 59 508 km^2
- effective drainage area – 13 277 km^2

Hydrology
- reliable flow on mainstem
- ephemeral flow on plains tributaries
- highly regulated

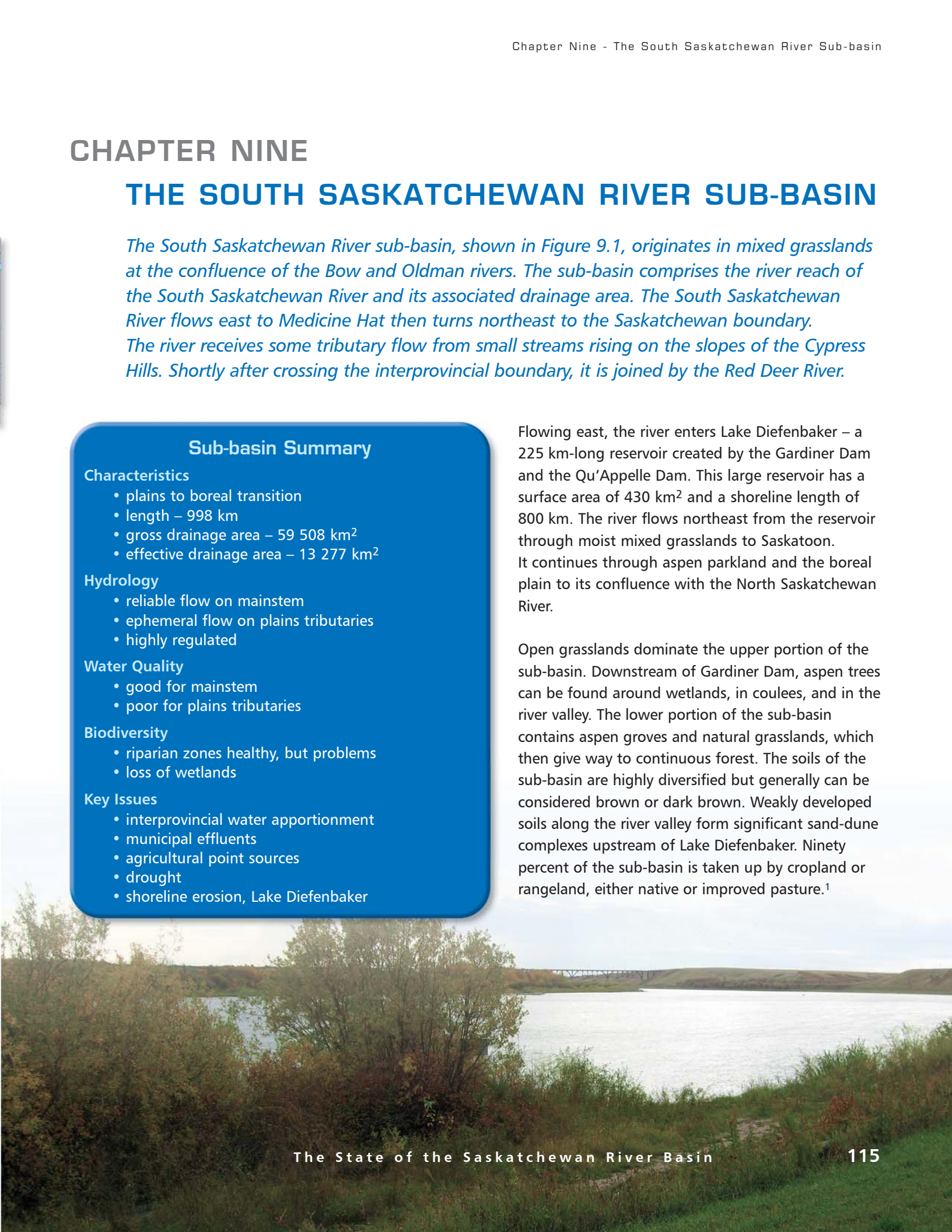
Water Quality
- good for mainstem
- poor for plains tributaries

Biodiversity
- riparian zones healthy, but problems
- loss of wetlands

Key Issues
- interprovincial water apportionment
- municipal effluents
- agricultural point sources
- drought
- shoreline erosion, Lake Diefenbaker

Flowing east, the river enters Lake Diefenbaker – a 225 km-long reservoir created by the Gardiner Dam and the Qu'Appelle Dam. This large reservoir has a surface area of 430 km^2 and a shoreline length of 800 km. The river flows northeast from the reservoir through moist mixed grasslands to Saskatoon. It continues through aspen parkland and the boreal plain to its confluence with the North Saskatchewan River.

Open grasslands dominate the upper portion of the sub-basin. Downstream of Gardiner Dam, aspen trees can be found around wetlands, in coulees, and in the river valley. The lower portion of the sub-basin contains aspen groves and natural grasslands, which then give way to continuous forest. The soils of the sub-basin are highly diversified but generally can be considered brown or dark brown. Weakly developed soils along the river valley form significant sand-dune complexes upstream of Lake Diefenbaker. Ninety percent of the sub-basin is taken up by cropland or rangeland, either native or improved pasture.[1]



The sub-basin has a population of about 300 000, with major centres being Medicine Hat, Swift Current and Saskatoon. Canadian Forces Base Suffield – a 2690 km^2 block of unplowed grassland – is on the west bank of the river in Alberta; some of the base extends into the Red Deer River sub-basin. There are four First Nations reserves downstream of Lake Diefenbaker.

Protected areas in this sub-basin include a portion of Cypress Hills Interprovincial Park, three provincial parks on Lake Diefenbaker, two provincial parks downstream of the Lake, and Batoche National Historic Site. A 458 km^2 portion of Canadian Forces Base Suffield is a National Wildlife Area. The riparian woodland of the South Saskatchewan River from the confluence with the Red Deer River to the Leader area is the largest area of deciduous woodland between the Cypress Hills and the aspen parkland. The sub-basin is dotted with small wetlands. PFRA data reveal 121 452 ha of existing wetlands.[2] The lower sub-basin from Outlook to The Forks contains much of the sub-basin's wetland area. There are also significant waterfowl nesting and staging areas in the sub-basin.

Economic activity includes a broad mix of agricultural activities, with both irrigated and dryland crop production, and livestock. Near Saskatoon, there are several dairy operations, while the upper half of the sub-basin features oil and gas production. There are seven potash mines that depend on the sub-basin's water supply, although one is not in the sub-basin.

HYDROLOGY

The South Saskatchewan River sub-basin extends from the confluence of the Bow and Oldman rivers at an elevation of 740 m to its confluence with the North Saskatchewan River at an elevation of 400 m. As described in Chapter Four, almost 90 percent of the flow in the river originates in the water towers. The river channel serves simply as a conveyance channel. There are no large tributaries in over 1000 km of river channel. Tributary inflow in this sub-basin accounts for only two percent of the annual flow, one-half of that being the flow from Swift Current Creek. Some of the small streams originating on the slopes of the Cypress Hills do not join the South Saskatchewan River. They flow into Many Island Lake – a terminal lake. Of the 59 508 km^2 surface area of this sub-basin, only 13 277 km^2 contribute to flow in a median year. The annual hydrograph is typical of the mountain-fed streams of the Saskatchewan River basin: that is, it rises to a June peak because of snowmelt runoff from the mountains.

The annual precipitation through most of this sub-basin ranges from 300 to 350 mm, although it increases to over 400 mm in the boreal transition zone near the confluence with the North Saskatchewan River. About 75 percent of annual precipitation falls as rain, with most of that occurring in May through August. These spring and summer rains contribute little to runoff on the plains. Spring snowmelt drives the plains runoff. Figure 9.2 shows the typical annual hydrograph for Swift Current Creek. The annual runoff produced by the prairie streams is highly variable and unreliable.

Flows entering the South Saskatchewan River sub-basin have been modified by upstream dams and diversions. Within Saskatchewan, the flow of the South Saskatchewan River is significantly modified by Lake Diefenbaker. This large reservoir, completed in 1967, can store more water than all the reservoirs in Alberta combined. The total storage is 9.4 million cubic decameters of water, more than the median annual flow of the river. The live, or usable, storage of the reservoir is 4.3 million cubic decameters. This storage is greater than the combined live storage of all upstream reservoirs. At the time of construction, Lake Diefenbaker was the largest constructed lake in Canada. Gardiner Dam is one of the largest earth-filled dams in the world.

Lake Diefenbaker is operated on an annual cycle, capturing mountain runoff and releasing it during the remainder of the year. Water stored in the reservoir is used for municipal and industrial water needs, irrigation, recreation, hydroelectric generation, and maintenance of downstream flows. The reservoir also provides some flood control for downstream

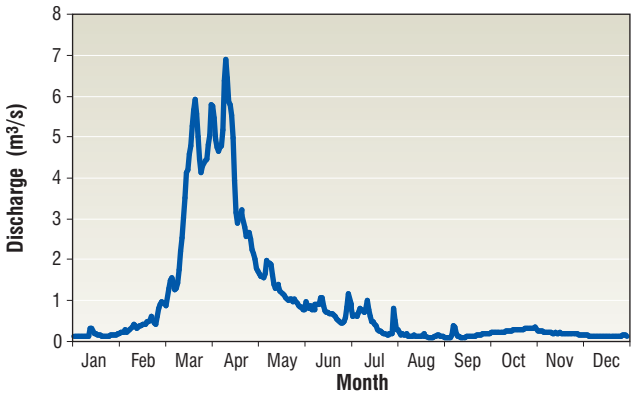


Figure 9.2. Swift Current Creek – Average Daily Flows.

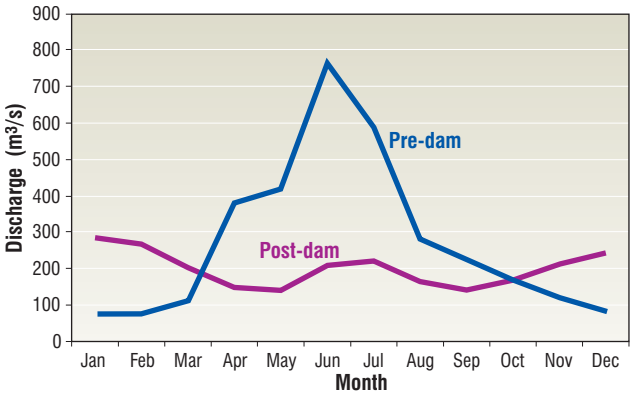


Figure 9.3. Effects of River Regulation Downstream of Gardiner Dam.

communities. Because of hydroelectric installations at Gardiner Dam and downstream on the Saskatchewan River, water is released to meet peak power demands, especially in the winter. The natural hydrograph of the river has therefore been significantly altered as shown in Figure 9.3. Winter flows have increased, which aids assimilation of municipal effluent at Saskatoon. Spring flushing flows are almost entirely absent and overall flow volumes are depleted by upstream diversions. Within this sub-basin, the flows of Swift Current Creek have also been modified by dams and diversions.

Reservoir capacity is affected by sediment inflows, particularly during spring runoff, and by shoreline erosion. These processes may affect the live storage of the reservoir or the unusable storage, known as the dead storage. In the case of Lake Diefenbaker, over a 15-year period following construction, live storage decreased by 1.5 percent. This is made up of a one percent loss from delta formation at the upper end of the reservoir and a half percent loss from shoreline erosion and slumping. Sediments flowing into the reservoir come from the South Saskatchewan River itself; the contribution from Swift Current Creek is negligible.[3]

The effects of climate change on water availability in the South Saskatchewan River have been examined. The climate in 2080 is expected to be warmer and wetter but, for reasons identified in Chapter 12, this does not necessarily lead to increased water supplies. The best estimate of inflow to Lake Diefenbaker for 2080 is for an 8.5 percent reduction in annual inflow. The uncertainty band is wide, however, with the range in inflow values being

"The Greatest Marine Disaster in the History of Saskatoon"

Steamboats rarely used the South Saskatchewan River because the shallow waters made for unreliable service. Not to be deterred, the Medicine Hat hotelier and Scottish nobleman Horatio Ross commissioned a new boat in 1906-07 to connect the newly completed railway at Medicine Hat to points downstream. The sternwheeler, the *S.S. City of Medicine Hat*, was 40 m long and had a draft of only 0.6 m.

On June 7, 1908 the boat proceeded downstream during the high water and tricky currents of the spring flood. It cleared the Grand Trunk Railway Bridge at Saskatoon and was gingerly attempting the passage under the Canadian Northern Railway Bridge when its rudder and sternwheel became entangled in a submerged telegraph line. The captain lost control and the ship drifted downstream striking the pier of the Traffic Bridge. The ship rode up the pier and wrecked. All on board but the ship's engineer clambered on to the bridge. He took to the water and swam to shore downstream. Some remnants of the wreck have been recovered recently.

+8 percent to -22 percent.[4] There is some evidence of declining trends in naturalized flows in the latter half of the 20th Century.[5]

The Water Survey of Canada and the Saskatchewan Watershed Authority monitor streamflows at 24 gauging stations and water levels at 13 stations in this sub-basin. The work is carried out under agreements between Environment Canada and Alberta Environment, and between Environment Canada and the Saskatchewan Watershed Authority.

WATER USE

The licensed water allocation in the South Saskatchewan sub-basin is 1 419 730 dam^3 from surface water and 18 995 dam^3 from groundwater. Most of the licences pertain to the portion of the sub-basin in Saskatchewan. Some 45 percent of that province's population depends on the river for daily needs.[6] For this reach, water consumption in Saskatchewan is ten times greater than consumption in Alberta. Figure 9.4 shows the distribution of water licences from surface water and the actual water consumption, compared to the median annual naturalized flow.

There are some unusual licences that account for the atypical distribution of licences shown in Figure 9.4. The largest single water licence is for the Queen Elizabeth thermal power generating station at Saskatoon. Although the licence is for 427 108 dam^3, the station rarely withdraws more than 75 000 dam^3. Of that, about five percent is consumed. Medicine Hat holds a licence of 162 820 dam^3 for municipal purposes, but much of that water is used as cooling water for a city-owned thermal generating station.[7] As is the case for Saskatoon, consumption is low.

Another large licence in this reach relates to evaporation from Lake Diefenbaker. An annual allotment of 184 143 dam^3 is identified to replace evaporative losses from the reservoir. This reflects the difference between precipitation directly on the lake and evaporation in a typical year, which is about 270 000 dam^3. This annual evaporative loss is similar to the annual consumptive surface water uses in the North Saskatchewan River sub-basin combined.

Water is diverted from Lake Diefenbaker to the Qu'Appelle River at the Qu'Appelle Dam. The licensed diversion, based on the total of individual downstream licences, is about 165 000 dam^3 a year; the average

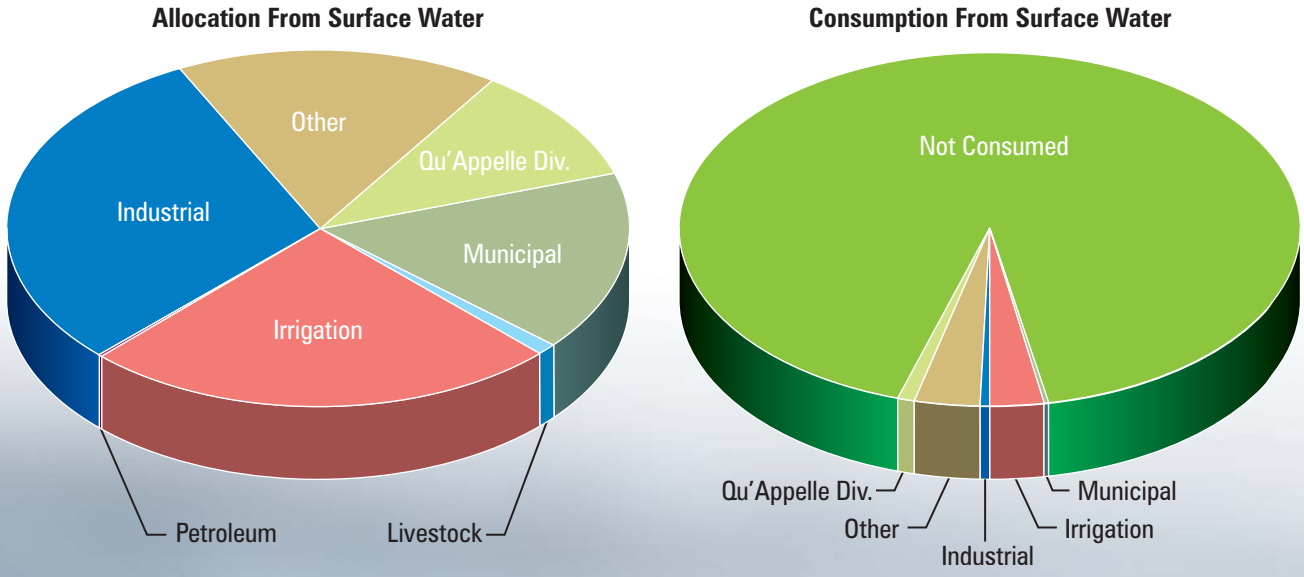


Figure 9.4. Water Allocation and Water Consumption from Surface Water.

quantity diverted annually over the last 20 years is 78 840 dam^3. The annual diversion depends on water needs. The water is used for municipal, industrial, agricultural, and lake stabilization purposes; none of it returns to the Saskatchewan River basin. This diversion represents a loss to the South Saskatchewan sub-basin and is treated as a consumptive use in this chapter. In fact, not all of the water diverted is consumed; some of it reaches Lake Winnipeg by way of the Assiniboine and Red rivers.

The largest conventional water consumption in the sub-basin is irrigated agriculture, with needs met almost exclusively from surface water. The Ross Creek Irrigation District is the only irrigation district in Alberta supplied by the South Saskatchewan River. The St. Mary Irrigation District upstream of Medicine Hat is supplied from headworks in the Bow-Oldman sub-basin. In Saskatchewan, 12 irrigation districts depend on water from Lake Diefenbaker, as listed in Table 9.1. One of these is the 1427 km^2 South Saskatchewan Irrigation District near Outlook. Three are outside the sub-basin but are supplied by the Qu'Appelle Diversion. Two districts draw water directly from the South Saskatchewan River.[8] There are also private irrigators in the sub-basin. The irrigated areas in the South Saskatchewan sub-basin and the Bow and Oldman sub-basins together comprise almost three-quarters of the irrigated area in Canada.[9]

The water needs of the South Saskatchewan Irrigation District are met by the Saskatoon Southeast Water Supply System (SSEWS). This diversion from Lake Diefenbaker consists of a lift station, five reservoirs, and connecting channels. The system also supplies private irrigators, stabilizes the level of Blackstrap Lake for recreation, supports waterfowl habitat, and meets municipal and industrial needs. Although some of the diverted water reaches Last Mountain Lake in the Qu'Appelle River system, most of the water is used within the South Saskatchewan sub-basin.

Table 9.1. Irrigation Districts Supplied by the South Saskatchewan River.

Source	Name	Irrigated Land (km^2)
South Saskatchewan River	Ross Creek	4
South Saskatchewan River	Chesterfield	–
Lake Diefenbaker	South Saskatchewan River	1427
Lake Diefenbaker	Riverhurst	40
Lake Diefenbaker	Lucky Lake	37
Lake Diefenbaker	Macrorie	10
Lake Diefenbaker	Grainland	9
Lake Diefenbaker	Miry Creek	6
Lake Diefenbaker	River Lake	4
Lake Diefenbaker	Thunder Creek	6
Lake Diefenbaker	Saskatoon Southeast Water Supply	71
Qu'Appelle Diversion	Brownlee	8
Qu'Appelle Diversion	Disley South and West	4
Qu'Appelle Diversion	Rocky Lake	9
South Saskatchewan River	Moon Lake	6

Industrial users in the sub-basin consist primarily of fertilizer plants in Alberta and potash mines and a fertilizer plant in Saskatchewan. These facilities use surface water and consume much of the water they withdraw. The most significant consumptive use of groundwater in the sub-basin is in petroleum-related operations in Saskatchewan. Overall, water use by the petroleum sector is relatively small.

As in other parts of the Saskatchewan River basin, water allocations for municipal purposes are large but since most of the water withdrawn is returned to the river, consumption is small. Allocations for municipal purposes tend to be from surface water, although there are some Saskatchewan communities such as Kindersley that depend on groundwater. The town of Bow Island draws its water from the Oldman River.

Other water allocations include water management and habitat enhancement. The previously-mentioned allocation for Lake Diefenbaker evaporation dominates this use. All of the water allocated is consumed.

The breakdowns of water licences and water consumption in the South Saskatchewan River sub-basin discussed previously are for the sub-basin from the confluence of the Bow and Oldman rivers to The Forks. Figure 9.5 shows the licensed allocation and water consumption for the larger sub-basin including the Bow and Oldman river sub-basins. The dominant role of irrigated agriculture is evident. Surface water consumption represents a significant portion of the naturalized median annual flow of the river.

The flows in the South Saskatchewan River are subject to the PPWB *Master Agreement on Apportionment*. Because of relatively high water use in the Bow and Oldman sub-basins, the apportionment of the South Saskatchewan River at the interprovincial boundary is more complex than for other streams subject to the Master Agreement.

In general, the Master Agreement requires that Alberta pass on 50 percent of the natural flow originating in the province to Saskatchewan. In the case of the South Saskatchewan River, however, Alberta has the right to divert or store 2 589 000 dam^3, irrespective of the natural flow in the river. This is in recognition of the extensive water developments, primarily irrigation, that had taken place in Alberta prior to the signing of the Master Agreement in 1969. In doing so, Alberta cannot

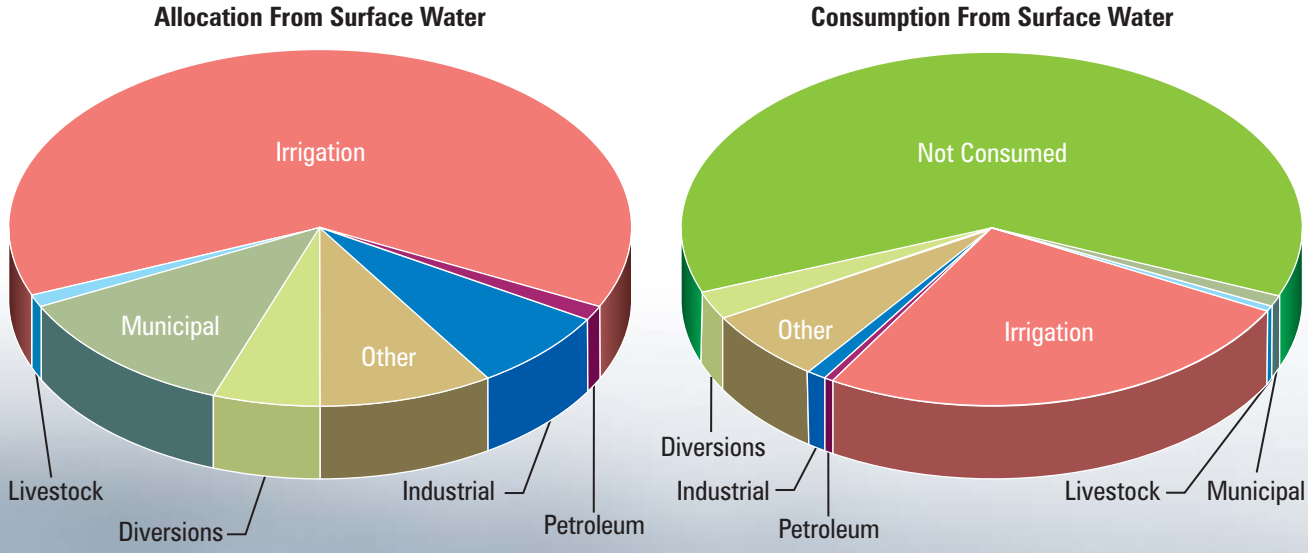


Figure 9.5. Surface Water Allocation and Consumption for the South Saskatchewan River Sub-basin plus the Bow and Oldman River Sub-basins.

reduce the flow in the South Saskatchewan River upstream of its confluence with the Red Deer River below 42.5 m^3/s, except when one-half the naturalized flow would be less than this. If the annual flow is distributed evenly enough that the 42.5 m^3/s flow criterion is met, Alberta and Saskatchewan would share the annual volume equally up to 2 680 000 dam^3. Once the naturalized flow has exceeded that amount, Alberta could use its prior allocation of 2 589 000 dam^3. When the natural flow exceeds 5 180 000 dam^3, any additional flow would be divided equally between the two provinces. The median annual flow in the South Saskatchewan River below the junction with the Red Deer River is 8 661 000 dam^3.

Despite the complexity of these arrangements, there are only four years since 1912 when Alberta's prior allocation provision would have been triggered. In all other years, Saskatchewan would have received at least 50 percent of the natural flow.[10] On average Alberta delivers 78 percent of the combined natural flow of the South Saskatchewan and Red Deer rivers to Saskatchewan.[11]

WATER QUALITY

The quality of the South Saskatchewan River upstream of the confluence with the Red Deer River is governed almost exclusively by the quantity and quality of the waters received from the Bow and Oldman sub-basins. Overall reductions in flow caused by upstream regulation and diversion, combined with the effects of land management practices, influence water quality. Water quality in the South Saskatchewan River reflects the cumulative impacts on the upper sub-basin. The quality is generally good, as is the water quality from the confluence with the Red Deer River to Lake Diefenbaker. Effluents from Medicine Hat do not influence overall water quality. Long-term monitoring at the PPWB site near the Saskatchewan boundary does not indicate any trends in water quality.[12]

Water quality in Lake Diefenbaker is considered good, as is water quality downstream to the confluence with the North Saskatchewan River. Water quality trends are few, although there is some decrease in nutrient loadings. In the channels carrying irrigation return flows, water quality is typically degraded by

A Naval Battle on the South Saskatchewan River

In 1885, the sternwheeler *S.S. Northcote*, a veteran of North Saskatchewan River shipping, was called into service during the Battle of Batoche. The boat had overwintered in Medicine Hat. In mid-April it left Saskatchewan Landing with troops, a field hospital, munitions, provisions and forage. The boat towed two supply barges. Water levels were low and the boat ran aground several times before reaching Major-General Middleton's camp upstream of Batoche village on May 5.

At 06:00 am on May 7, the *Northcote*, carrying 50 riflemen and still towing two barges, pulled anchor and turned downstream as part of a coordinated attack. She tooted her whistle at 07:40 as a signal to Middleton and continued downstream. Coming abreast of Batoche, the boat came under heavy fire and was unable to anchor because of the strong current produced by now rising water levels.

Seizing the moment, the Métis commander, Gabriel Dumont, ordered the ferry cables lowered. The cables caught the *Northcote's* smokestacks, at the same time taking out the boat's signalling whistle. The boat was unable to set its anchor until it had drifted some distance downstream. The civilian crew declined to rejoin the battle. The boat continued further downstream to take on supplies. It finally returned to Batoche on May 12 to find that Middleton had seized the village earlier that day. The *Northcote's* engagement in the only naval battle on the prairies had lasted a little over an hour. The boat was beached at Cumberland House towards the end of 1886 and never sailed again.

Table 9.2. Long Term Water Quality Monitoring Locations.

Stream	Location	Agency	Remarks
South Saskatchewan River	Medicine Hat	Alberta Environment	Upstream of Medicine Hat
South Saskatchewan River	at Highway 41	Environment Canada	PPWB site near Saskatchewan boundary
South Saskatchewan River	at Leader	Saskatchewan Environment	Upstream of Lake Diefenbaker
South Saskatchewan River	Clarkboro East	Saskatchewan Environment	Downstream of Saskatoon
South Saskatchewan River	Clarkboro West	Saskatchewan Environment	Downstream of Saskatoon
South Saskatchewan River	at Muskoday	Saskatchewan Environment	near confluence with North Saskatchewan River

nutrients, sediments and pesticides. Saskatoon treats its municipal effluent to tertiary standards, including nutrient reduction; nonetheless, the city increases nutrient levels downstream.

Under the PPWB Master Agreement, except in drought conditions, Alberta is required to maintain a flow of at least 42.5 m^3/s in the Saskatchewan River channel. Alberta has a water conservation flow objective of 42.5 m^3/s on the South Saskatchewan River and one of 10 m^3/s on the Red Deer River. Saskatchewan, in turn, is committed to releasing at least 42.5 m^3/s from Gardiner Dam. The normal summer target flow is 60 to 150 m^3/s.[13] Minimum flow in the South Saskatchewan River means the water is generally well-oxygenated and the overall good water quality is maintained.

Water quality is routinely monitored at several locations in this sub-basin, as listed in Table 9.2.

The mainstem of the South Saskatchewan River is mesotrophic. Elkwater Lake and Spruce Coulee Reservoir near the Cypress Hills are eutrophic and mesotrophic, respectively.

Monitoring data have been used to calculate water quality indices for the South Saskatchewan River, shown in Figure 9.6. PPWB maintains water quality objectives at the interprovincial boundary. These objectives are aimed at protecting all downstream water uses including aquatic life. Monitoring results are compared with the objectives quarterly. If the objectives are exceeded, a report and recommended course of action is prepared for the PPWB. The PPWB then makes a recommendation on how to resolve the problem to member agencies.

Saskatoon is the largest city in this sub-basin and can be expected to have some effect on downstream water quality. Upgraded effluent treatment has led to improved nutrient reduction in recent years. Figure 9.7 shows the water quality index upstream and downstream of the city. The effect of nutrient reduction measures since 2000 is apparent.

BIODIVERSITY AND ECOSYSTEMS

Algal biomass increases in the South Saskatchewan River moving downstream because of increased availability of plant nutrients. The dominant form is filamentous green algae, which tends to peak in the summer. Rooted aquatic plants, macrophytes, tend to increase sharply below municipal effluent outfalls.[14]

Midges and mayflies dominate invertebrate populations of the South Saskatchewan River. Populations tend to be related to food resources and the temperature regime. Benthic invertebrate populations tend to be low and vary considerably from year to year, depending on river flow.

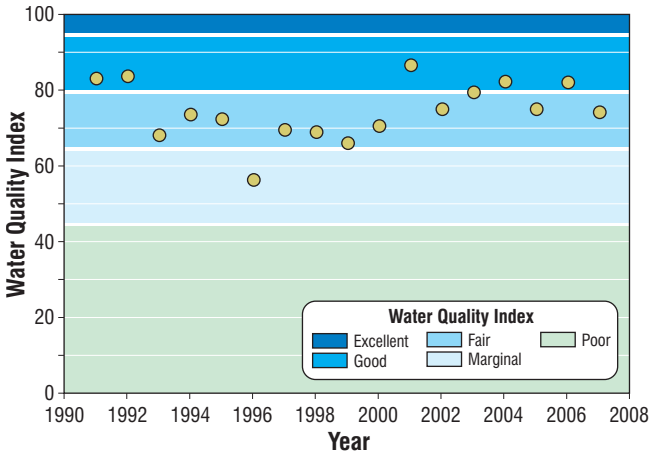


Figure 9.6. Water Quality Index at Interprovincial Boundary.

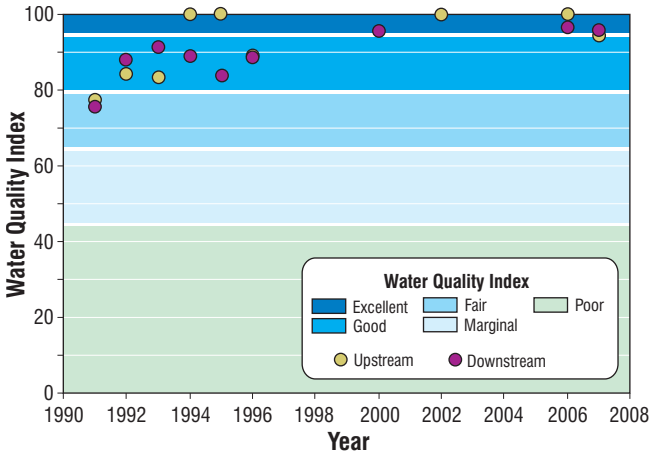


Figure 9.7. Water Quality Index Upstream and Downstream of Saskatoon.

The fish species found in the South Saskatchewan River and its tributaries are shown in Table 9.3. Upstream of Lake Diefenbaker goldeye, sauger, walleye, and lake sturgeon are common.[15] Well-developed riffle, run and pool sequences provide habitat.[16] The bed of the South Saskatchewan River tends to be composed of gravel, sand and silt. The development of Lake Diefenbaker destroyed the riverine fishery but a highly productive reservoir fishery has evolved. Fish species in the reservoir include walleye, northern pike, sauger, burbot, goldeye, whitefish, rainbow trout, and lake sturgeon. There is also a rainbow trout farm on the lake. The reach from Gardiner Dam to Saskatoon is not particularly good fish habitat, in part because of effects of the dam. The river's thermal regime has been altered and nutrient content is low. Riffle habitat is rare. From Saskatoon to the confluence with the North Saskatchewan River, pike, walleye, and several species of sucker dominate.

Table 9.3. Fish Species of the South Saskatchewan River.

Species Type	Common Name
Coldwater Species **** Introduced Species***	Brown Trout* Mountain Whitefish
Coolwater Species	Goldeye Mooneye Lake Whitefish Northern Pike Sauger Walleye Yellow Perch Burbot Lake Sturgeon
Non-game Species	Emerald Shiner Fathead Minnow Flathead Chub Lake Chub Longnose Dace River Shiner Spottail Shiner Longnose Sucker Quillback Shorthead Redhorse Silver Redhorse Spoonhead Sculpin Trout-Perch White Sucker

There is no longer a commercial fishery on Lake Diefenbaker. An aquaculture operation produces almost one million kilograms of rainbow trout annually.

Alberta's conservation flows and riparian flows downstream from Lake Diefenbaker help sustain ecosystems on the main stem of the South Saskatchewan River: that is, water quality, fish habitat, and riparian vegetation are supported. Elsewhere in the sub-basin riparian zones tend to be

healthy, but with problems. Invasive species such as purple loosestrife are a concern. These riparian zones provide important habitat for nesting and staging of waterfowl. Galloway Bay on Lake Diefenbaker is an internationally recognized staging area on the mid-continent flyway.

Shoreline erosion around Lake Diefenbaker has led to broad sand and gravel beaches that provide nesting habitat for the endangered piping plover – a medium-sized shorebird, similar in appearance to the common killdeer. Lake Diefenbaker has frequently supported the largest single-site population of piping plover in the world. The lake is considered a globally significant Important Bird Area, and may be designated a Western Hemisphere Shorebird Reserve Network site. The piping plover is very susceptible to water level increases during the critical nesting and brooding season. Rapid increases can flood nests and reduce brooding habitat. Reservoir operations have been modified to the extent possible to accommodate the piping plover.[17, 18] During high flows in 2005, when rapid reservoir rises were forecast, eggs were taken from nests and hatched, and the young birds were later released to the lake. This practice has been repeated, when required, in subsequent years.

ENDNOTES

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