CHAPTER FIVE

THE NORTH SASKATCHEWAN RIVER SUB-BASIN

Figure 5.1. *The North Saskatchewan River Sub-basin.*

CHAPTER FIVE

THE NORTH SASKATCHEWAN RIVER SUB-BASIN

The North Saskatchewan River rises on the eastern slopes of the Rocky Mountains. Flowing from the montane cordillera ecozone, it crosses the foothills forest of the boreal plains, then follows the boreal plains-prairie ecotone for the remainder of its course through Alberta and well into Saskatchewan. After a loop through the prairie ecozone it emerges once again into the boreal plains ecozone, joining the South Saskatchewan River east of Prince Albert.

Sub-basin Summary

Characteristics
- high alpine to plains
- river length 1367 km
- gross drainage area 156 420 km^2
- effective drainage area 68 830 km^2

Hydrology
- reliable flow on headwaters tributaries and mainstem
- ephemeral flow on plains tributaries
- mainstem regulated

Water Quality
- excellent to good for headwaters tributaries and the mainstem to Edmonton
- fair to poor for plains tributaries and lakes and fair to good for the mainstem from Edmonton to The Forks

Biodiversity
- headwaters protected
- riparian zones generally healthy
- significant wetland loss

Key Issues
- land use - forestry and agriculture
- municipal and industrial effluents

The mountain headwaters of the basin lie at elevations over 2000 m above sea level. Mount Willingdon in the Clearwater River tributary headwaters, at 3373 m, is the highest point in the Saskatchewan River basin. The North Saskatchewan River itself drops rapidly from 1390 m at Saskatchewan Crossing to about 1000 m at its confluence with the Ram River. In this reach, it changes from a braided river to the channelized river seen at Rocky Mountain House. The river valley is typically 50 to 100 m deep. As it approaches the interprovincial boundary, upstream of its confluence with the Vermilion River, the North Saskatchewan River changes from a gravel bed stream to a sand bed stream.[1] The elevation of the river at the interprovincial boundary is about 500 m and it drops a further 100 m to its confluence with the South Saskatchewan River. The channel gradient, after decreasing gradually from the headwaters, increases slightly about 50 km upstream of Prince Albert.[2]

The alpine and sub-alpine ecosystems of the mountain headwaters are described in Chapter Four. The steeply-sloped mountain ranges have developed soils that support mixed forests of limber pine, white spruce and alpine fir. The major river valleys contain

Douglas fir mixed with trembling aspen and grassland ecosystems.[3] The headwaters of the North Saskatchewan River are in Banff National Park, although some smaller tributaries originate in Jasper National Park. The headwaters streams descend through the foothills – a region of ridges, rolling plateaus and broad valleys. Mixed forests of lodgepole pine, trembling aspen and white spruce dominate the region. Balsam poplar, paper birch, and balsam fir are also common. Black spruce dominates lower elevations wet sites. Conifers are found at the cooler high elevations, while aspen are found in the lower plains. Leaving the foothills, the North Saskatchewan flows though a region consisting of boreal transition forest to the north and aspen parkland to the south of the mainstem. The hummocky to rolling plain is dominated by deciduous forest and farmland. Agricultural lands upstream of Edmonton tend to be rangelands, while the lower basin consists of cropland. There are also many wetlands of all classes. In the boreal plain ecozone, the wetlands tend to be peatlands, while in the prairie ecozone the wetlands are mineral-based. The major plains tributaries of the North Saskatchewan River that enter the river from the south are discussed in Chapter Six.

The North Saskatchewan River basin contains 4 national parks, 10 Alberta provincial parks, 3 Saskatchewan provincial parks, and 35 First Nations reserves. It also has two Alberta wilderness areas and three Alberta ecological reserves. There are numerous crown wildlife areas and private conservation lands

Steamboats on the North Saskatchewan

By the early 1870s Fort Garry (present day Winnipeg) had become the Hudson's Bay Company's dominant centre for shipment of trade goods. The company initiated steamboat service on Lake Winnipeg in 1872 to transport goods between Fort Garry and the mouth of the Saskatchewan River at Grand Rapids. On August 1, 1874 the *S.S. Northcote* – named for a former governor of the Hudson's Bay Company – entered service and travelled upstream to Fort Carleton. Water levels were low and the boat was unable to travel to the head of navigation at Fort Edmonton. The following year the *Northcote* made one run to Fort Edmonton and a second run to Fort Carleton. When river flows permitted, steamboats could transport as much cargo from Winnipeg to Edmonton in a month as 150 to 200 ox carts in an entire summer.

The steamboats on the North Saskatchewan River had to contend with two significant navigational problems. Between The Forks and Prince Albert, La Colle Falls presented a series of rapids that during high flows were difficult to ascend, especially when barges were being towed. From Prince Albert to the confluence with the Vermilion River, the North Saskatchewan River channel was broad, included many islands and had shifting sand bars. It was difficult to navigate in low flows.

The *Northcote* was joined by the *S.S. Lily* in 1877. Following this very profitable year during which the boat made six upstream journeys, the *Northcote* was modified so that it could transport up to 50 passengers. Steamboat activity on the North Saskatchewan River was significant by the early 1880s. The *Northcote* and *Lily* were already steaming the Saskatchewan when in 1882 they were joined by the *Marquis*, the *Manitoba* and the *North West*. The relative speed and reliability of the steamboat service was a boon to settlements along the North Saskatchewan River. The arrival of a steamboat in any community was an event for both the passengers and the community.

By 1888, a combination of changed channel conditions, wrecks, and misadventure had reduced service on the river to one boat, the *North West*. On August 17, 1899, the boat broke loose from its moorings at Edmonton during a flood, struck the submerged piers of the Low Level Bridge, which was then under construction, and sank. This was the end of commercial steamboat traffic on the North Saskatchewan River.[4]

in this sub-basin. The population of the North Saskatchewan River sub-basin was 1.25 million in 2006. The dominant population centre of the sub-basin is the Edmonton metropolitan area, whose population of over one million accounts for more than 80 percent of the sub-basin's population.

HYDROLOGY

The North Saskatchewan River originates at the Saskatchewan Glacier in Banff National Park. It flows generally easterly to Rocky Mountain House. It then loops north through Edmonton and flows generally easterly until it crosses into Saskatchewan, flowing southeasterly through the Battlefords before turning north to Prince Albert and joining the South Saskatchewan River at The Forks. The river is 1367 km long and has a drainage area of 131 000 km^2. The effective drainage area is 68 839 km^2.[5] Headwaters tributaries include the Cline, Brazeau, Ram, and Clearwater rivers and, as explained in Chapter Four, other mountain and foothills streams account for up to 90 percent of the water that flows in the North Saskatchewan River. The North Saskatchewan River channel is relatively straight. From Rocky Mountain House to near Edmonton, and downstream of the interprovincial boundary the channel contains many vegetated islands and unvegetated bars. The plains tributaries that join the river from the south, notably the Vermilion and Battle rivers, contribute relatively little flow; they will be discussed in Chapter Six. The Goose Lake sub-basin rises in Saskatchewan and terminates in Goose Lake adjacent to Eagle Creek. This relatively large sub-basin contributes no flow to the North Saskatchewan River.

The flow of the North Saskatchewan River is regulated by Bighorn Dam, constructed on the mainstem near the mouth of the Bighorn River in 1972, and Brazeau Dam, constructed on the Brazeau River near its confluence with the North Saskatchewan River in 1961. These dams are operated for hydroelectric power generation. As electricity demand is highest in the winter, the effect of the dams is to increase winter flows while decreasing summer flows. The effects of river regulation are made clear in Figure 5.2. Increased winter flows facilitate operation of downstream water intakes and assist waste assimilation. Decreased summer flows mean the flushing flows that sustain some plant, invertebrate and fish species occur less frequently than before regulation.

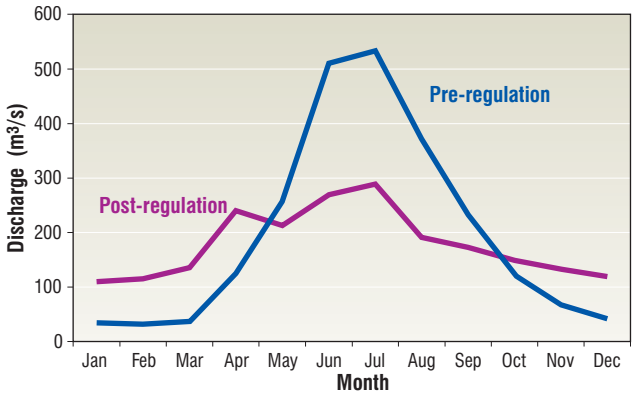

Figure 5.2. Effects of River Regulation on Median Monthly Discharge at Edmonton.

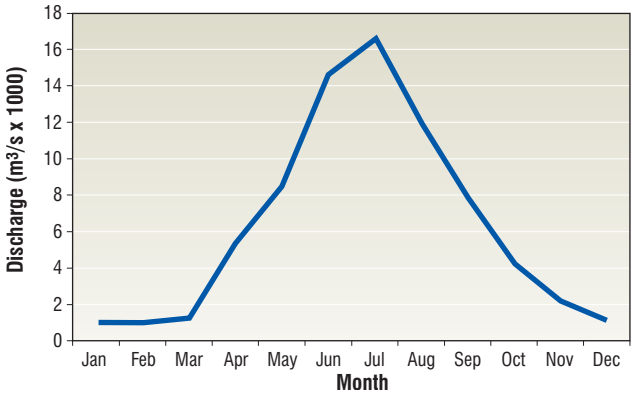

Figure 5.3. Naturalized Median Monthly Discharge at the Interprovincial Boundary.

The annual precipitation in the headwaters valleys of the sub-basin is about 600-800 mm, with about half of that falling as snow. Precipitation at higher elevations is even greater. The annual precipitation decreases with elevation to as little as 373 mm at North Battleford but increases slightly to over 400 mm near The Forks. Annual precipitation in the southern plains portion of the sub-basin near the interprovincial boundary can be as little as 320 mm. Once the sub-basin enters the plains, about three-quarters of the annual precipitation falls as rain.

The Water Survey of Canada, the Saskatchewan Watershed Authority and Alberta Environment operate 21 water level and 78 discharge gauging stations in the North Saskatchewan River sub-basin. The work is carried out under federal provincial cost-sharing agreements.

Annual runoff in the headwaters tributaries can be as great as 900 mm, while runoff in plains tributaries is as little as 10 mm.[6] Figure 5.3 shows the annual naturalized hydrograph for the North Saskatchewan River at the interprovincial boundary. Although there is an increase in runoff in April, due in part to runoff from the plains, most of the runoff in the sub-basin is driven by the melting of the mountain snowpack and the precipitation that falls during this melt period. Usually, peak runoff does not occur until July. Although there are no long-term trends in annual runoff for the North Saskatchewan River itself, there are indications of increased runoff in March and April and decreased runoff later in the year – a consequence of earlier spring snowmelt.[7]

Even without the benefits of flow regulation, the mountain runoff of the North Saskatchewan River is much more reliable than the flow of tributaries originating on the plains. The natural flow range is small in comparison to the median flow. The flow of the North Saskatchewan River is more reliable than that of the South Saskatchewan River.

There are few natural lakes on the main streams of this sub-basin. Abraham Lake was created by Bighorn Dam and Brazeau Reservoir was created by Brazeau Dam. Some plains streams originate at lake outlets and the sub-basin contains myriad small lakes and numerous wetlands. The lakes include both pothole lakes in the hummocky landscape and chain lakes along stream valleys. These features frequently provide opportunities for water-based recreation. Among the most significant are Lake Wabamun and Lac Ste. Anne near Edmonton, Pigeon Lake in the Battle River basin headwaters, and Emma and Christopher lakes adjacent to Prince Albert National Park. The basin also contains terminal lakes such as Manitou and Redberry lakes.

WATER USE

The licensed water allocation from the North Saskatchewan River, including the plains tributaries discussed in the following chapter, is 2 196 481 dam^3 from surface water and 60 716 dam^3 from groundwater. The surface water allocation is about one-third of the median naturalized flow of 6 794 000 dam^3 at the interprovincial boundary. Overall water consumption is only 317 977 dam^3 from surface water and 39 676 dam^3 from groundwater. Figure 5.4 shows the breakdown of licensed allocation and annual water consumption from surface water for the entire basin.[8, 9]

The largest water consumers in the sub-basin are industrial and petrochemical facilities, many of which are near Edmonton. Major industrial users also include thermal power stations, chemical plants and fertilizer plants. Thermal power stations withdraw large quantities of water but most of the water is returned to a lake or river. Other industrial water users include manufacturing and mining. The Highvale Coal Mine near Wabamun Lake is the largest such mine in Canada.[10] The pulp and paper mill near Prince Albert, Saskatchewan was a significant industrial water user prior to its closure in 2006. Gas and petrochemical plants consume relatively high quantities of water, as does water injection for enhanced gas and oil recovery. Water injection in Saskatchewan is almost entirely from groundwater.

The next largest water consumer is the 'other' sector. Much of this use consists of environmental services. This includes lake stabilization for habitat enhancement, primarily for waterfowl. Several of the projects are Ducks Unlimited Canada projects. Projects may also improve habitat for fish and wildlife. Almost all of the water withdrawn to support this use is consumed through evaporation and does not return to the stream. About one-quarter of this water consumption consists of diversions in Saskatchewan to stabilize Jackfish and Emma lakes. These lakes are extensively used for water-based recreation.

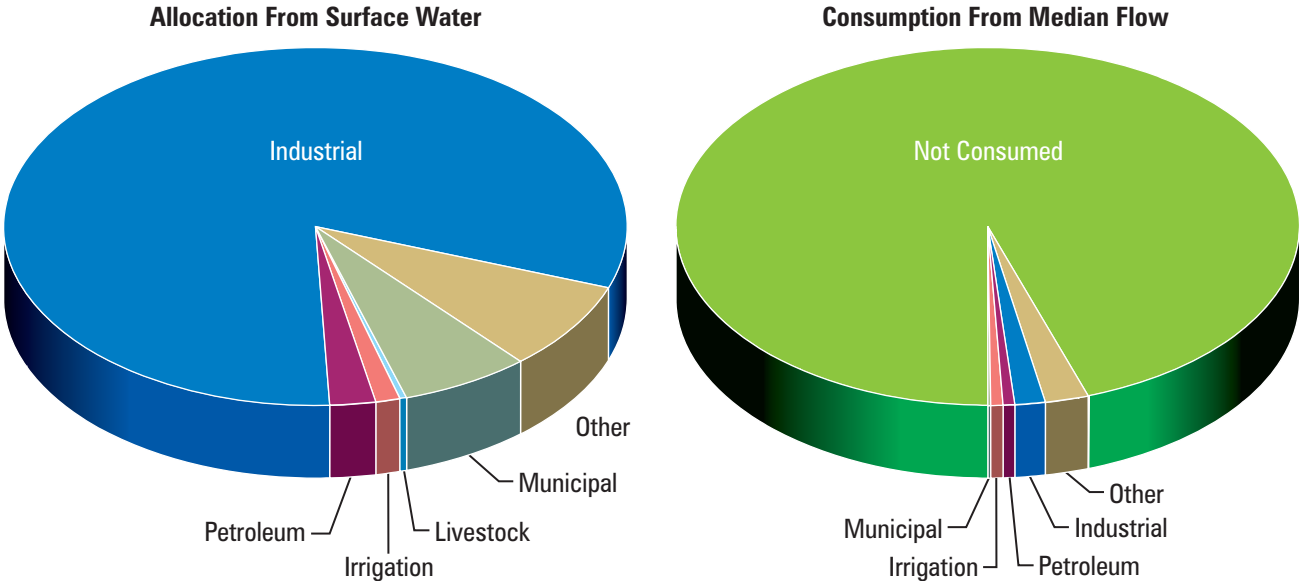

Figure 5.4. Licensed Surface Water Allocation and Consumption.

Other less significant water consumers in the sub-basin include irrigated agriculture, livestock, and municipal use. Private irrigators use water primarily for forage production. Water use is small in comparison to that of district irrigators in the South Saskatchewan sub-basin. Similarly, water for livestock does not represent a major water use. Municipal water consumption is also small, as much of the water withdrawn, including groundwater, is returned to surface water.

The flows in the North Saskatchewan River and its eastward flowing tributaries, such as the Battle River at the interprovincial boundary, are subject to the PPWB *Master Agreement on Apportionment*. Under the agreement, for its own use Alberta is entitled to 50 percent of the naturalized annual flow of the North Saskatchewan River and each of the tributaries crossing the interprovincial boundary. Consumptive water uses in the basin in the Alberta portion of the sub-basin are small in comparison to the natural flow. This relatively low water use, combined with the reliable flow of the North Saskatchewan, means that administering apportionment of the river is quite straightforward. Water uses on the transboundary tributaries are also relatively small in comparison to the median flow. The highly variable flows of these streams, however, mean that apportionment concerns can be raised during low flow years.

WATER QUALITY

Water quality of the streams and lakes of the North Saskatchewan River sub-basin is influenced by the landscape through which the streams flow, as well as by human factors. As the North Saskatchewan River and its headwater tributaries originate in the Rocky Mountains and most of the water flowing in the river constitutes mountain runoff, the quality of the mainstem and upper sub-basin tributaries is good to excellent. The water tends to be naturally hard and nutrient poor. During high flows, the water contains elevated levels of particulate phosphorus. This phosphorus tends not to be biologically available and has little effect on eutrophication or on river biota. On the other hand, the tributaries and small lakes of the plains tend to have water that is naturally highly mineralized and nutrient rich. The natural quality of the sub-basin's waters is influenced by municipal and industrial effluents, and by runoff from urban and agricultural lands.[11]

Water quality is monitored at several locations on the mainstem of the North Saskatchewan River, its important tributaries, and some lakes, particularly those used for water-based recreation. Table 5.1 and Figure 5.1 display key locations at which water quality is routinely monitored. Environment Canada monitors water quality in Banff National Park on behalf of Parks Canada and at the interprovincial boundary on behalf of the Prairie Provinces Water Board, while Alberta Environment and the Saskatchewan Environment monitor water quality at other locations within their respective provinces. The provincial agencies also conduct periodic water quality assessments on other provincial streams and lakes. In Alberta, these assessments have been conducted on the Brazeau, Clearwater, Sturgeon and Vermilion rivers.

There is a natural increase in nutrient levels as mountain-fed rivers move downstream. This is the cumulative effect of sediment processes such as erosion and scouring. The mountain headwaters of the North Saskatchewan River are oligotrophic, as is the river reach upstream of Edmonton. The river is mesotrophic downstream of Edmonton to The Forks. The plains tributaries of the North Saskatchewan River tend to be eutrophic. Alberta monitors 37 small lakes and two reservoirs in the sub-basin. The lakes are in areas that are predominantly agricultural rangeland. The lakes tend to be hypereutrophic or eutrophic based on one or more criteria. Larger lakes such as Wabamun Lake and Pigeon Lake in the Battle River sub-basin are eutrophic, while Lac Ste. Anne is hypereutrophic. The wetlands in the sub-basin tend to be rich in total phosphorous but relatively low in algal mass. Most have elevated salinity levels.[12] The nutrient levels of the waters of the plains tributaries can be attributed to both natural levels and human additions from municipal effluents and agricultural use.

Monitored data are used to calculate a water quality index for several locations on the mainstem of the North Saskatchewan River and its important

Table 5.1. Long Term Water Quality Monitoring Locations.

Stream	Location	Agency	Remarks
North Saskatchewan River	Whirlpool Point	Environment Canada	Banff National Park
North Saskatchewan River	Abraham Lake	Environment Canada	Downstream of dam
North Saskatchewan River	Rocky Mountain House	Alberta Environment	
North Saskatchewan River	Devon	Alberta Environment	Upstream of Edmonton
North Saskatchewan River	Pakan Bridge	Alberta Environment	Downstream of Edmonton
North Saskatchewan River	Hwy. 17 (Lea Park)	Environment Canada	PPWB site at interprovincial boundary
North Saskatchewan River	North Battleford	Saskatchewan Environment	
North Saskatchewan River	Borden Bridge	Saskatchewan Environment	
North Saskatchewan River	Prince Albert	Saskatchewan Environment	Upstream of Prince Albert
North Saskatchewan River	Cecil Ferry	Saskatchewan Environment	Downstream of Prince Albert
North Saskatchewan River	Codette Reservoir	Saskatchewan Environment	
Battle River	Ponoka	Alberta Environment	Upstream of Ponoka
Battle River	Driedmeat Lake	Alberta Environment	Upstream end of Driedmeat Lake
Battle River	Unwin	PPWB	At interprovincial boundary

tributaries. In general, the water quality in the mainstem is rated as good to excellent from the headwaters to Edmonton, then fair to good from Edmonton to the interprovincial boundary. Figure 5.5 shows the index for the North Saskatchewan River upstream and downstream of Edmonton. Mountain tributaries are also rated as good to excellent, while plains tributaries may be rated as fair or even poor because of high nutrient content.

Water quality throughout the North Saskatchewan River sub-basin is affected by non-point sources varying from atmospheric deposition to agricultural runoff. Much of the sub-basin from the vicinity of Edmonton downstream is also affected by point source pollutants such as municipal and industrial discharges. Wabamun Lake receives effluent from a wastewater treatment plant and cooling water and ash lagoon discharges from the Wabamun generating station.

Municipal discharges from the Edmonton metropolitan area have a significant impact on the quality of the North Saskatchewan River. These discharges include 238 storm water outfalls, 19 combined sewer outflows, 2 water treatment plants, and 2 wastewater treatment plants. In addition there are some 26 petrochemical plants in the vicinity of Fort Saskatchewan.[13] The degraded water quality downstream of Edmonton is the result of many point and non-point sources of pollution. In general, nutrients and bacteria are the primary concern. Rainstorms, in particular, tend to raise concentrations through both natural processes and urban runoff. The City of Edmonton is planning to reduce the impacts of combined sewers by providing additional primary level treatment to combined sewer overflows. Figure 5.5 shows the effect of improvements in 1998 to municipal wastewater treatment on downstream water quality. The recent decrease in the index relates to increased bacteria levels. The cause is under investigation.

Saskatchewan has examined trends in seven water quality parameters at several locations from the interprovincial boundary to The Forks for the period 1986 to 2002. The results showed a long-term, generally decreasing trend in total phosphorous, chloride, sodium, and ammonia. There tends to be no trend in nitrate/nitrite, total dissolved solids and pH.[14] The overall water quality of the North Saskatchewan River in Saskatchewan is rated as fair.[15] Figure 5.6 shows the water quality index at the interprovincial boundary. The index values are based on different water quality analyses than those for Alberta sites and therefore are not directly comparable to those in Figure 5.5.

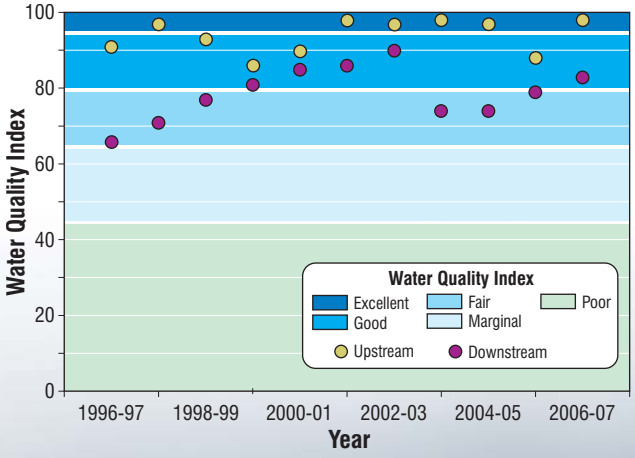

Figure 5.5. Water Quality Index Upstream and Downstream of Edmonton.

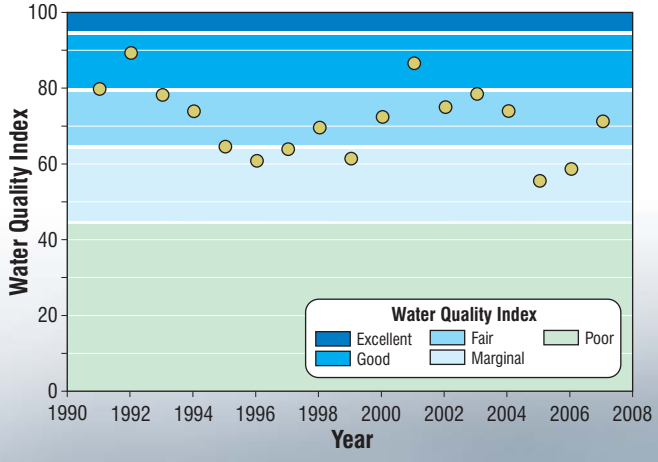

Figure 5.6. Water Quality Index for the North Saskatchewan River at the Interprovincial Boundary.

In the Saskatchewan portion of the sub-basin, North Battleford, Battleford and Prince Albert operate secondary sewage treatment facilities that discharge continuously to the North Saskatchewan River. Lloydminster obtains its drinking water from an Alberta facility but municipal effluents are treated by a lagoon system in Saskatchewan that discharges continuously. About 60 percent of the effluent is diverted for irrigation; the remainder is discharged to the river. There are some 60 other lagoon systems in the Saskatchewan portion of the sub-basin. Some discharge continuously, while others discharge in the spring or in spring and fall. The receiving bodies could be the North Saskatchewan River, smaller streams, lakes or groundwater.[16] Saskatchewan calculates a water quality index based on monitoring data upstream and downstream of Prince Albert. There is considerable scatter in the values, with downstream indices usually being lower than the upstream indices.

BIODIVERSITY AND ECOSYSTEMS

The headwaters of the North Saskatchewan River sub-basin and major headwaters tributaries including the Brazeau, Ram and Clearwater rivers lie in a relatively undisturbed landscape. As indicated earlier, two major dams modify the flows of the river itself. The headwaters areas of the sub-basin are unmodified by human activity as the area is protected by Banff and Jasper national parks. Much of the remainder of the upper sub-basin lies within the Rocky Mountain Forest Reserve where some protection is provided by wilderness areas, ecological reserves and provincial parks. Unprotected areas within the reserve are subject to forest management agreements. About one percent of the area is cut each year. Other industrial activity includes oil and gas exploration and development. Less than two percent of the upper sub-basin is disrupted by linear features, primarily cutlines, rights of way and roads. There are few wetlands in the upper sub-basin. The lower Clearwater sub-basin near Rocky Mountain House contains significant agricultural forage land.

Table 5.2. Fish species of the North Saskatchewan Sub-basin[17, 18]

Species Type	Common Name
Coldwater Species * *Introduced Species*[19]	Arctic Grayling* Brook Trout* Brown Trout* Bull Trout Cutthroat Trout* Golden Trout Lake Trout Mountain Whitefish Rainbow Trout*
Coolwater Species	Burbot Goldeye Lake Sturgeon Lake Whitefish Mooneye Northern Pike Sauger Walleye Yellow Perch Walleye Yellow Perch
Non-game Species	Brook Stickleback Emerald Shiner Fathead Minnow Flathead Chub Finescale Dace Iowa Darter Lake Chub Longnose Dace Longnose Sucker Mountain Sucker Northern Redbelly Dace Shorthead Redhorse Pearl Dace Quillback River Shiner Silver Redhorse Spoonhead Sculpin Spottail Shiner Trout-Perch White Sucker

The grassy slopes and forests of the sub-alpine portion of the upper sub-basin provide habitat for many mammals, large and small. The forests support migratory songbirds and non-migratory birds such as owls and woodpeckers. Several species are

threatened by habitat fragmentation and the loss of old-growth forest. The ecological resources of the upper sub-basin provide extensive outdoor recreation and ecotourism opportunities. Terrestrial animals and birds are often dependent on the riparian zone of streams and wetlands for their sustenance. The streams of the upper sub-basin provide a significant coldwater fishery (Table 5.2).

In general, the riparian areas of major streams in the North Saskatchewan River sub-basin are largely undeveloped. This encourages abundant plant and animal species and promotes biodiversity. Extensive studies of the North Saskatchewan River upstream of Edmonton find that the riparian and aquatic communities at that location are generally healthy.[20] The City of Edmonton is developing its riparian areas and ravines as open spaces that conserve the natural environment and provide recreational opportunities.

The mid-basin landscape from the confluence with the Brazeau River to the interprovincial boundary is much more open than the headwaters. Overall, only about 13 percent of the mid-basin is tree-covered and most of that lies in provincial forest north of the North Saskatchewan River. Agricultural forage cover is about 16 percent, much of that upstream of Edmonton, while agricultural cropland and grasslands each represent about 31 percent of the land cover. Cattle densities are moderate. About three percent of the mid-basin is affected by linear features.[21] Most of these features consist of roads, but there are oil and gas-related features as well.

Elk Island National Park near Edmonton is entirely within the sub-basin. The park lies in the Cooking Lake Moraine and contains grassland, woodland and wetland habitat. Nearby Beaverhill Lake is a designated wetland of international importance. Provincial parks in the mid-basin provide some ecological protection as well. The North Saskatchewan River transitions from a coldwater to coolwater fishery in the reach from the confluence with the Brazeau River to Edmonton. One effect of the altered thermal regime produced by the Brazeau Dam was to move that transition zone closer to Edmonton. Coolwater fish species (Table 5.2) become more abundant and dominant downstream of the city.

The effect of the Edmonton metropolitan area on aquatic ecosystems in the North Saskatchewan River has been monitored for many years. In general, the health of aquatic ecosystems is good upstream of metropolitan Edmonton. Ecosystems degrade through the city then recover further downstream. Benthic invertebrate communities increase as the river moves through the Edmonton region – an effect of increased nutrients from municipal and industrial effluents. The community structure also changes to more pollution-tolerant species. The extent of these effects changes seasonally, depending on streamflow. Aquatic biomass as measured by chlorophyll *a* tends to be low upstream of Edmonton and increases through the city. Benthic, algal and invertebrate communities tend to recover from nutrient enrichment by the interprovincial boundary. The aquatic condition of the lakes and semi-permanent wetlands in the mid-basin tends to be consistent with their trophic state.[22]

About 40 percent of the lower sub-basin in Saskatchewan is cultivated, 17 percent is native grassland, and an additional 3 percent is in forage or pasture. Some 23 percent of the landscape is treed. An arc of provincial forest lies to the west and north of Prince Albert. Waterbodies and wetlands account for the remaining six percent of the surface area. Despite significant alterations to the sub-basin by human activity, there are good populations of large mammals such as moose, elk and deer. Populations of the threatened woodland caribou also exist. The Sturgeon and Spruce river tributaries originate in Prince Albert National Park. Provincial parks also provide some ecological protection and recreational opportunities.[23]

Few systematic surveys have been conducted in this portion of the sub-basin to assess riparian and aquatic ecosystem health.

ENDNOTES

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[19] North Saskatchewan Watershed Alliance 2005. *supra.*

[20] Alberta Environment 2007b. *supra.*

[21] North Saskatchewan Watershed Alliance 2005. *supra.*

[22] Alberta Environment 2007b. *supra.*

[23] Saskatchewan Watershed Authority 2007. *supra.*