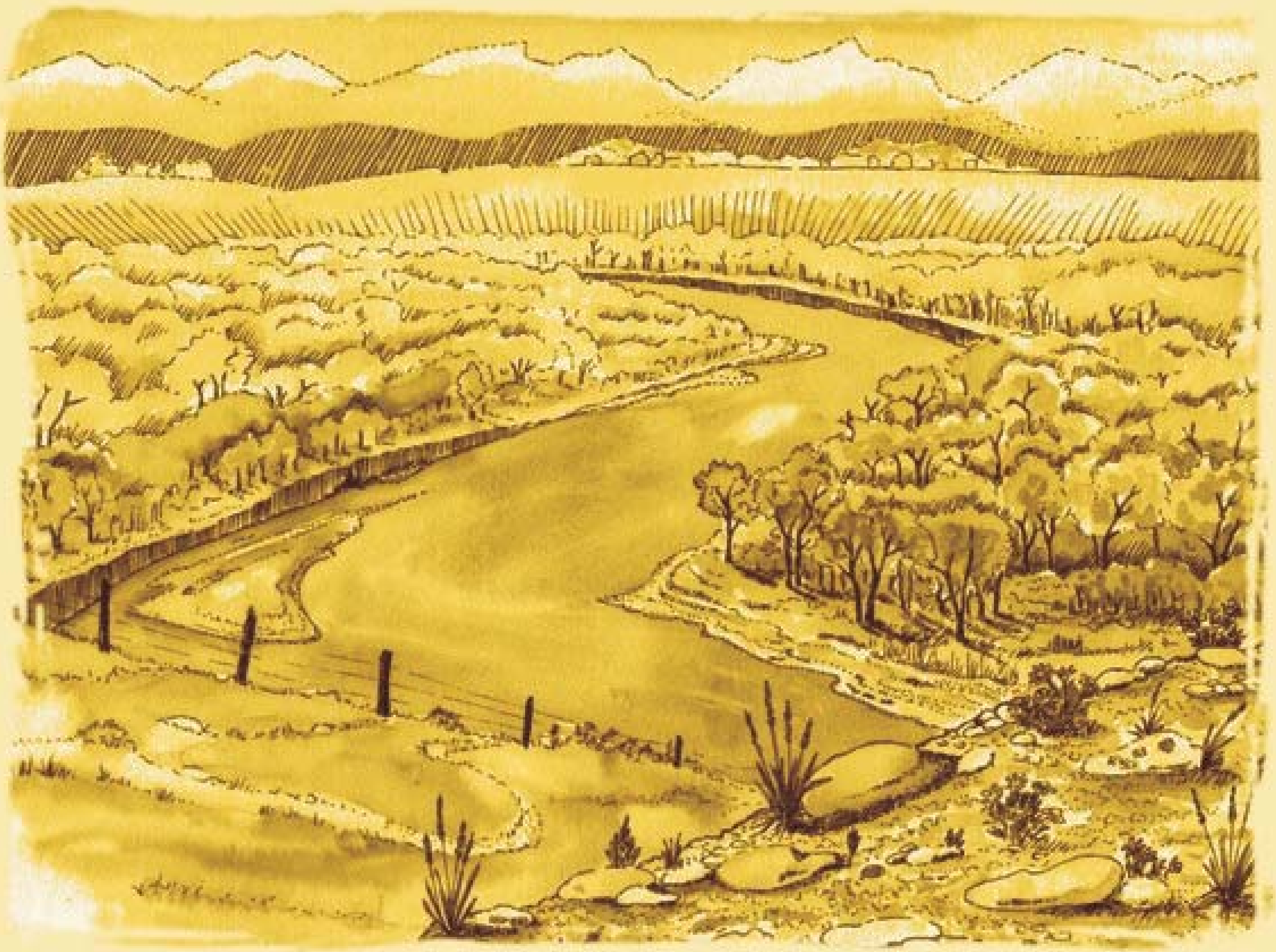
PRAIRIE CONSERVATION FORUM



Southern Alberta's Watersheds: An Overview

Occasional Paper Number 5

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Prairie Conservation Forum

Southern Alberta's Watersheds: An Overview

Kim Lalonde, Bill Corbett
and Cheryl Bradley
August, 2005

Occasional Paper

Number 5

PRAIRIE CONSERVATION FORUM

Foreword

To fulfill its goal to raise public awareness, disseminate educational materials, promote discussion, and challenge our thinking, the Prairie Conservation Forum (PCF) has launched an Occasional Paper series and a Prairie Notes series.

The PCF's **Occasional Paper** series is intended to make a substantive contribution to our perception, understanding, and use of the prairie environment - our home. This series offers an alternative to scholarly journals for those authors who would like to get their message into the hands of a wider audience, including: landholders, industry representatives, environmental advocates, farmers, ranchers, government and non-government resource management professionals, and members of the broader public. Topics covered in this series will contribute to the wise use and conservation of biological diversity in the northern prairies.

We encourage the submission of papers that take a holistic perspective on issues affecting prairie conservation, that synthesize existing knowledge, that offer practical and applied advice on best management practices, that question existing points of view or that open doors to new ways of seeking harmony and promoting the sustainability of our prairie environment.

Interested individuals are encouraged to submit draft essays, articles, and papers to the PCF Steering Committee for review as a future Occasional Paper or Prairie Note. Prospective authors may wish to contact the PCF Secretary to discuss potential ideas and proposals before commencing with a writing project. Manuscripts should be submitted in electronic form to the PCF Secretary: Ian.Dyson@gov.ab.ca. Accepted articles will be posted on the PCF's web site and Occasional Papers may be published.

Disclaimer

The ideas and viewpoints that are contained in this paper are those of the author(s) and do not necessarily represent the opinions or position of the Prairie Conservation Forum.

Preface

The initial idea for this paper came from the Prairie Conservation Forum Steering Committee through discussions about priorities for future Occasional Papers. The opportunity to take action was realized when an international conference "Confronting Water Scarcity: Challenges and Choices" was held in July 2004, in Lethbridge, Alberta. Members of the Conference Organizing Committee: Ian Dyson, Alberta Environment; Brent Paterson, Alberta Agriculture, Food and Rural Development; and Dennis Fitzpatrick, University of Lethbridge agreed on the need to support development of a background paper on *The State of Southern Alberta's Water Resources* to provide participants with a brief overview of the history, the current situation and challenges for the future related to water in southern Alberta. A key audience for the paper was participants visiting the province from other parts of Canada and other countries. Financial support for the project was provided by the University of Lethbridge and the PCF.

Following the conference, the PCF identified an opportunity to expand this original document into an Occasional Paper including a watershed focus and more substantive information about aquatic environments. Additional material has been added to make the report more comprehensive and useful for Albertans, and to support cooperative efforts on watershed planning in southern Alberta. Members of the 2005 PCF Steering Committee reviewed and provided comment on the expanded paper. Participants at this meeting include Linda Cerney, Laura Roberts, Brian Laing, Pam Romanchuk, Rod Bennett, and Cam Lockerbie. Development of the expanded paper was supported financially by Alberta Environment as part of its ongoing support for the PCF partnership.

The original material written by Bill Corbett and Kim Lalonde (Kim Lalonde Environmental Consulting) has been incorporated. Additional material has been written by Kim Lalonde and Cheryl Bradley. Neil Thrussell (Alberta Environment) was responsible for formatting and the publication of the paper. Cheryl Dash (Alberta Environment) organized the PCF Steering Committee review meeting and coordinated final publication. Many of the original graphics and photographs formatted by Bonnie Hofer (Alberta Agriculture, Food and Rural Development) have been used. Rob Wolfe (Alberta Environment) coordinated the development of both reports. Other professionals with the Alberta Government and in the private sector, including Doug Ohrn, Al Sosiak, Wendell Koning, Lorne Fitch, John Mahoney, Sal Figluzzi, Laura Roberts, Gary Kindrat, Terry Clayton, Allan Locke, Liz Saunders, Norine Ambrose, Dennis Fitzpatrick, Brent Paterson, Cyndi Smith, Jan Simonson, Pat Kinnear, Al Violette, Stew Rood, Tom Tang and Richard Quinlan have provided information and materials. A significant source of information for this paper was the background reports prepared in support of the water management planning process for the South Saskatchewan River Basin being led by Alberta Environment. A list of key references and websites is included at the end of the report.

At a time when water is very much on the public agenda, the PCF hopes this paper will be of interest and value to Albertans. In particular, our partnership offers this report as our contribution to those southern Albertans who are offering their time and energies to the watershed partnerships both established (Bow and Oldman) and in the process of being established (Red Deer and Milk) under the provincial *Water for Life* strategy.

About The Authors

Kim Lalonde holds a B.Sc. in Agriculture (Environmental Conservation) and is an independent consultant living in Calgary. After starting her career as a farm management specialist in New Brunswick, she moved to Alberta in the early 1980's. Her extensive and diverse experience with Alberta Environment has included strategic planning, business planning, policy development and analysis, regulatory affairs and managing multi-disciplinary teams responsible for policy analysis and program development, scientific and economic analysis, public consultation and intergovernmental relations. She managed the review process for the Environmental Protection and Enhancement Act and has chaired or directed departmental and interdepartmental committees dealing with a broad range of environmental and resource management issues. Since entering private practice, Kim's projects have included strategic, business and operational planning for Alberta Environment, policy research and analysis, and conference and workshop planning and facilitation.

Bill Corbett is a Calgary freelance writer. He holds a B.A. in Political Science and a Bachelor of Journalism. Before establishing his own company in the 1980s, Bill had experience as a columnist, national reporter and feature writer in the newspaper industry, working for Fort McMurray Today, United Press Canada and the Edmonton Journal. As a freelance writer he has extensive experience as a broadcaster (CBC - The Homestretch and The Eyeopener), a teacher (writing courses at Mount Royal College, Elderhostel and Alexandra Western Centre) and has published articles in numerous publications including Canadian Geographic, Canadian Business, Western Living, Maclean's, and Financial Post. He is also the author of three books: Best of Alberta Outdoor Activities in Alberta's Heartland (Whitecap Books) 1993, Day-Trips From Calgary (Whitecap Books) 1994, and The 11,000ers of the Canadian Rockies (Rocky Mountain Books) 2004.

Cheryl Bradley holds a Master of Science degree in Geography, specializing in Botany and Fluvial Geomorphology, and is an independent environmental and public participation consultant living in Lethbridge. Since the early 1980s she has been involved in research and development of policy regarding aquatic ecosystems. Her original research on the downstream effects of dams and diversions on cottonwood forests along the Milk River informed the work of numerous other researchers. In the early 1990s she coordinated development of a strategy for conservation and management of riparian forests in southern Alberta. She is co-author of a 1996 Prairie Conservation Forum Occasional Paper on prairie ecosystem management. As a volunteer she actively represents the ecosystem protection interest in planning processes for rivers and watersheds within the Oldman River Basin and beyond. Cheryl's volunteer commitment to improving environmental stewardship has been recognized through several awards including an Emerald Award in 2004.

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Tables And Figures

Metric Conversions

1 kilometre (km) = 0.62 miles
1 metre (m) = 3.28 feet
1 centimetre (cm) = 0.39 inches
1 millimetre (mm) = 0.039 inches
1 hectare (ha) = 2.471 acres
1 cubic decametre (dam^3)= 0.81 acre

1.0 Introduction

The purpose of this paper is to provide an overview of the water resources and watersheds found in southern Alberta. After defining what a "watershed" is, the paper looks at the different elements of our watersheds - water supplies available, the kinds of aquatic environments that we find, how we use water and watersheds, and how we govern the management of water and watersheds. The paper looks at the current state of southern Alberta's watersheds, identifies trends and concerns, and introduces ideas for improving our understanding as we face the challenges of the future.

2.0 What is a Watershed and Why are Watersheds Important?

We all understand that water is a fundamental requirement for life. Our key challenge is achieving responsible stewardship of this essential resource. And responsible stewardship must be based on a sound understanding of water in the natural environment.

Work in Alberta to understand, assess and plan for the future of water resources has traditionally used the natural boundaries of river basins and sub-basins (or smaller parts of a basin). A river basin is defined as the total area drained by a river and its tributaries. Another term which is commonly used is a "watershed". A watershed is defined as the area contained within a drainage divide above a specified point on a stream. While the terms are used synonymously, the term watershed is coming into more use to describe either all of a river basin or just a part of it.

When the term watershed is used, it is intended to include both the physical environment and the natural processes at work. Water in a watershed can be found under the surface as groundwater concentrated in aquifers or on the surface concentrated in rivers, streams, lakes, reservoirs, ponds, wetlands, snow packs and glaciers.

Watersheds include a diversity of aquatic environments or ecosystems. Aquatic environments are found in "moving" water flowing in a defined channel, known as lotic environments, and in "standing" water found in basins without a defined channel for flowing water, known as lentic environments. Lotic environments include rivers, streams and canals. Lentic environments include lakes, ponds, man-made reservoirs and dugouts. Riparian areas are the areas found between watercourses or water bodies and the uplands, where water, soil and vegetation interact. Wetlands occur on the edges of some water bodies, in riparian areas and in shallow depressions on the uplands.

Aquatic environments provide a broad range of environmental goods and services. They supply direct human needs for water, food and other products, and are valued for their aesthetic and spiritual qualities and recreational opportunities. Aquatic environments also sustain the natural physical processes of the hydrologic cycle including water filtration and purification, recharge of aquifers, flood control, channel maintenance and mitigation of drought; and they support long term biodiversity by providing habitat and the essentials of life for plants and animals, the cycling and movement of nutrients, and the dispersal of seeds.

3.0 Water in Southern Alberta's Watersheds

3.1 Historical Milestones

Over the Pleistocene period in geological history, from 1.6 million years ago to about 10,000 years ago, major ice sheets scoured the landscape of western Canada as they advanced and retreated over several ice ages. The immense runoff from the last retreat of the glaciers, some 10,000 years ago, shaped southern Alberta's watersheds. It changed the course of some rivers and deepened their valleys, a process that has continued ever since with the continued erosion of the soft sedimentary bedrock.

Erosion has etched each of the main river valleys with numerous coulees and ravines, with badlands forming where the bedrock has been deeply carved. Except for isolated igneous outcrops in the Milk River watershed, exposed valley bedrock throughout southern Alberta is composed of soft sedimentary rocks. Throughout the last 10,000 years of history southern Alberta's rivers and other surface waters have been periodically affected by floods and drought.

Indications from scientific studies show that severe droughts have occurred frequently over the past 2000 years, with an average duration of more than 10 years. During the 20th century at least 20 droughts occurred. The drought of the 1930s, and the subsequent "dust bowl" conditions, is the most notable from the early part of the century. This was the most severe and prolonged drought since the beginning of settlement and its impact on the economy and the settlers of the Prairies was magnified as it coincided with the worldwide economic depression of the time. Another widespread dry period that was to last about 10 years began in 1977 with a major drought in 1988/89. The years 2000-2002 again brought dry conditions to southern Alberta.

> **How are droughts defined?**
> Drought can be defined as a condition of moisture deficit sufficient to have an adverse effect on vegetation, animals and humans over a sizeable area.

Like drought, floods have been a recurring phenomenon in southern Alberta for millennia; but unlike drought, the impacts of floods are localized and mostly confined to river valleys. Flooding occurs when there is more water than stream and river channels, lake basins, and their associated aquifers can hold and the excess water overflows onto adjacent floodplains. Reservoirs exceed capacity and are required to spill excess water downstream. Flooding can occur from rapid snowmelt, heavy rainfall or ice jams. It can be exacerbated by land uses that remove vegetation which intercepts precipitation. Major floods in the South Saskatchewan River and Milk River basins are caused by excessive rainfall events in the headwaters during early summer, usually associated with moist air masses moving up from the Gulf of Mexico. These rainstorms generally occur when mountain snowmelt has already filled headwater stream channels and reservoirs to near capacity. About ten major floods were recorded in all or large parts of southern Alberta river basins over the past century, the most recent ones being in 1995 and 2005. Other major floods have occurred in 1902, 1908, 1916, 1923, 1929, 1932, 1953, 1964 and 1975.

3.2 Current State and Future Trends

Climate And Geography

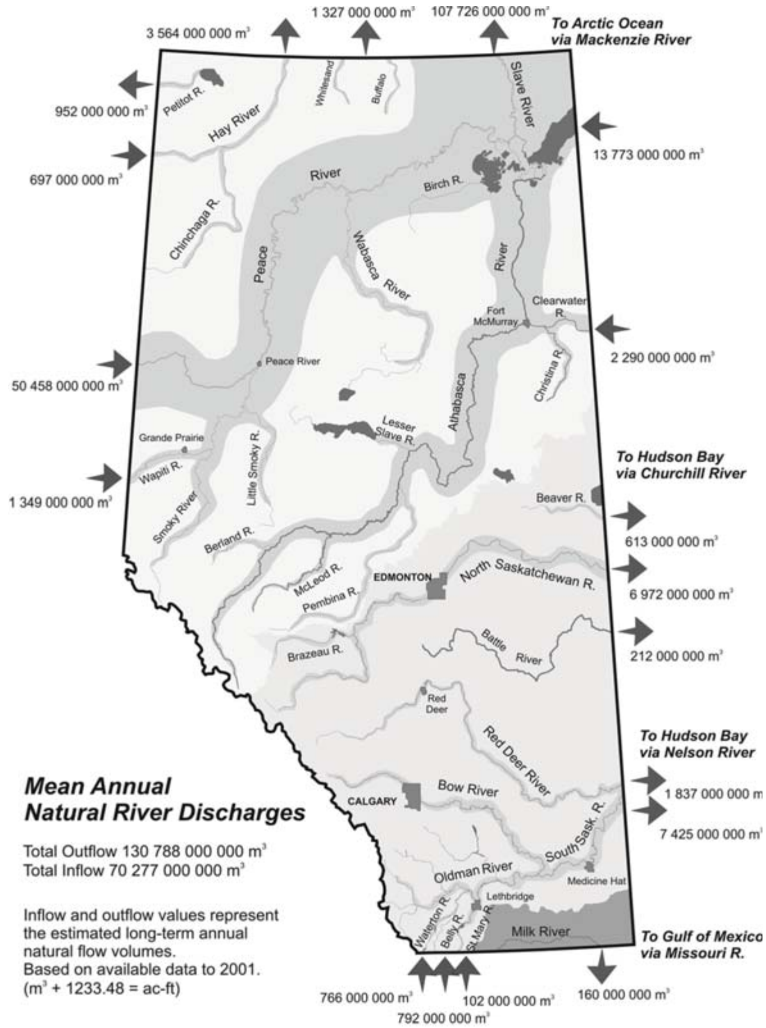
For the purposes of this paper, southern Alberta stretches from Red Deer in the north to the Montana border in the south. Elevations range from 3600 metres atop the region's highest peak to less than 700 metres in the southeast prairie. Other than a narrow swath of aspen parkland in the north, and mountain and foothill landscapes to the west, the area is predominantly a grassland ecosystem, though slightly less than 50% of the native vegetation remains today.

Southern Alberta's precipitation predominantly originates in the Pacific Ocean and falls on the Rocky Mountains and flanking foothills as snow or rain. In these mountain and foothill areas temperatures are low even in the summer, precipitation exceeds evaporation and excess water is available for runoff. To the east the prairie landscape is primarily semi-arid, characterized by abundant sunshine, and strong, dry winds. Here summer temperatures are high and evaporation exceeds precipitation. In fact, the average precipitation in southern Alberta ranges from about 450 millimetres in the northern parkland region to fewer than 300 millimetres in the southeast, with less than half falling during the growing season, which ranges from 160 to 185 days. The gross evaporation rate in the semi- arid southeast is about 700 millimetres, resulting in a net moisture deficit of 400 millimetres in an average year.

In southern Alberta high-elevation headwaters in the mountains mainly funnel into one large river basin, the South Saskatchewan, which drains some 121,000 square kilometres, or 18% of the province. The South Saskatchewan River is fed by three major rivers - the Bow, Oldman, and Red Deer - and flows east from Alberta into Saskatchewan and ultimately into Hudson's Bay. The Milk River Basin, in Alberta's far south, is 6,500 square kilometres in size, about one percent of the provincial land mass. It originates in and returns to Montana, after flowing through Alberta, as part of the Missouri-Mississippi river system that drains to the Gulf of Mexico.

The bulk of the South Saskatchewan River Basin's stream flow originates in the Rocky Mountains' eastern slopes, which accounts for 75% of the volume of the Oldman, Bow and Red Deer rivers. These flows arise as melt water from snow packs and glaciers, augmented by seasonal runoff. Thus, natural river flows are highest in spring and early summer, taper off in the fall and remain low over the winter.

The balance of the stream flow arises as runoff from the parkland and prairie landscape. In the southeast natural lakes are few and small wetlands disappear in dry years. The only significant natural concentrations of trees are along river and stream valleys. The Cypress Hills, arising from the prairie landscape in the southeastern corner of the province, is a unique area made up of a combination of Grassland and Rocky Mountain Natural Regions. The higher terrain here plays an important role as the headwaters for creeks and streams in the area and as a recharge zone for groundwater.



Drought conditions are a fact of life in southern Alberta's semi-arid climate. These conditions intensify the demand for water, affect the natural systems in aquatic environments, and can have major economic impacts on the agricultural sector. Research using lake bottom cores have provided evidence that the droughts encountered in the 20th century were much less severe and shorter in length than droughts that occurred over the last 2000 years.

While historical records can often be used to provide some insight into what to expect in the future, scientific predictions related to climate change have created uncertainty about future climates around the world. In mountain headwaters warmer temperatures mean increase melting of glaciers, snow packs melting faster, and more winter-spring precipitation falling as rain rather than snow. On the prairies higher temperatures may mean more evaporation from rivers, reservoirs and fields. A major research project is underway with scientists from Alberta and Saskatchewan collaborating with the objective of better predicting the implications of climate change in the South Saskatchewan River Basin.

Glaciers

Glaciers are masses of ice that form when annual snowfall exceeds melting and evaporation and becomes compressed, over time, into ice. Most glaciers are found in regions where there is high snowfall in the winter months and cooler conditions in the summer months. Glaciers advance and retreat in response to variations in climate - precipitation, temperature, winds and cloud cover.

The glaciers we see today in the Canadian Rockies are the remnants of the massive ice sheets that last covered North America about 10,000 years ago. The most recent large scale advance of mountain glaciers took place over a cold period known as the "Little Ice Age" which started about 900 years ago and peaked around 1850. Since that time, glaciers around the globe have shrunk in size dramatically as the global climate has warmed.

The glaciers found in the mountainous headwaters of the Bow River can be an important element in the water cycle of the river in dry years. While annual snowmelt and precipitation provides the bulk of stream flow in the spring and early summer, flow from melting glaciers also contributes and becomes more important in the late summer. Studies carried out in the headwaters of the basin have indicated that meltwater from glaciers generally contributes about 2.5% of the annual flow of the Bow River at Banff, but this may be as high as 8 to 9% in dry years. In the late summer, the contribution can be as much as 40% of the flow in extremely dry years.

As in other parts of the world, the glaciers of the southern Canadian Rockies are retreating. In the period since the last cold period, the Little Ice Age, the shrinkage of these glaciers has been in the order of 25% to 75%. This trend has raised concerns about the potential impacts on water supplies in southern Alberta.

Surface Water

Based on records from 1912 to 2001, the average annual natural flow of the South Saskatchewan River, below its confluence with the Red Deer River, is about nine million cubic decametres, representing seven percent of Alberta's total river flow. The average contributions of each of the rivers to the total flow is 43% for the Bow River, 38% for the Oldman River, 18% for the Red Deer River and 1% for the lower South Saskatchewan River (below the confluence of the Bow and Oldman Rivers). The Milk River's annual average flow is about 100,000 cubic decametres entering Alberta and 160,000 leaving the province. The South Saskatchewan River Basin accounts for only seven percent of Alberta's total annual flow yet supports about half the province's population.

What does natural flow mean?

Natural flow is the rate or quantity of water moving past a specified point on a natural stream from a drainage area where there are no effects from stream diversion, storage, import, export, return flow, or change in consumptive use caused by human-controlled modification to land use. Natural flow rarely occurs in a developed country.

Traditionally, water management in southern Alberta has been based on the Milk River Basin and the three main sub-basins of the South Saskatchewan River Basin (SSRB) - the Oldman River Basin, the Bow River Basin, the Red Deer River Basin. The following are brief descriptions of the Milk River Basin and the three sub-basins of the SSRB.

The Milk River Basin

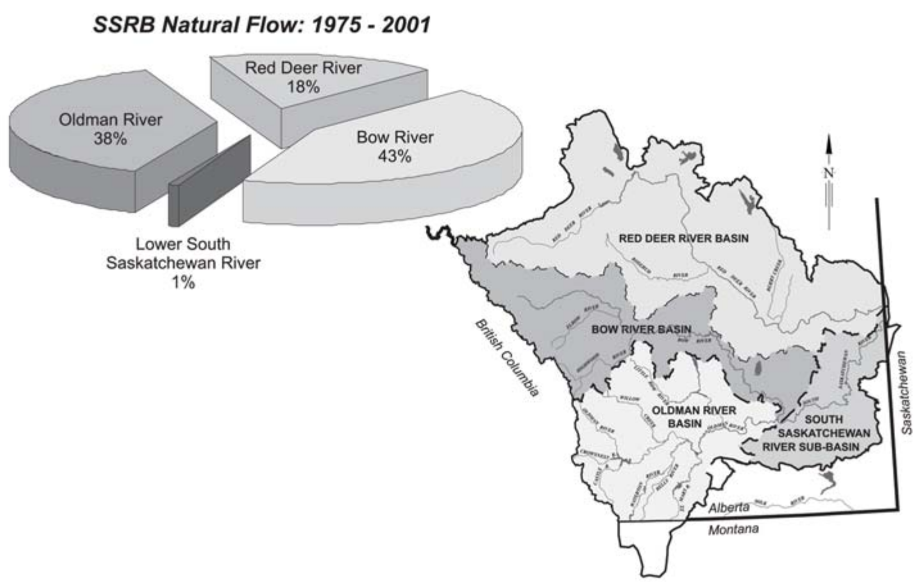
The Milk River Basin is found in the southernmost part of the province. The Milk River originates in the foothills east of the Rocky Mountains in Montana, crosses the border between the United States and Canada, and flows eastward across the prairie landscape for about 170 km before turning south to re-enter the United States. In the lower reaches sediment load increases significantly due to erosion of unstable badland slopes. This gives the lower river its milky colour.

The Oldman River Basin

The Oldman River flows for 450 km from its headwaters in the Rocky Mountains through rangelands in the foothills, and eastward through the semi-arid prairie. It has an area of about 26,500 km^2 making up nearly 22% of the South Saskatchewan River Basin. This area includes the three major tributaries - the St. Mary, Belly and Waterton Rivers. The Oldman River Dam, a major impoundment on the mainstem, is located in the Pincher Creek area, and the water supply diversion for the Lethbridge Northern Irrigation District is found upstream of Fort Macleod. One hundred and ninety kilometres downstream of the Oldman River Dam, the river flows through the City of Lethbridge. Between Lethbridge and the "Grand Forks", the confluence of the Oldman and Bow Rivers, the river is warm and turbid.

The Bow River Basin

The Bow River flows for about 625 km from its headwaters in the Rocky Mountains to its confluence with the Oldman River. It is similar in size to the Oldman River Basin, making up nearly 21% of the total area of the South Saskatchewan River Basin at about 25,500 km^2. Impoundments for hydroelectric generation are located in the upper reaches of the basin. In its middle reaches, the river continues to be fast flowing, moving over a rocky substrate, but it is affected by the development in and around the City of Calgary. Just upstream of Calgary is the last impoundment for hydroelectric generation. In the middle of the urban area, there is the first major diversion for irrigation. This provides a water supply for the Western Irrigation District. The reach of river downstream of the city is highly productive, supporting a world class sport fishery. The river continues to flow across the prairie landscape, with major diversions for irrigation water supplies at the Carseland weir for the Bow River Irrigation District, and at the Bassano Dam for the Eastern Irrigation District. The lowest reaches of the river are warm and shallow.



The Red Deer River Basin

The Red Deer River flows for about 708 km from its headwaters in the Rocky Mountains to the Alberta-Saskatchewan border. Although it is the smallest of the three major rivers of the South Saskatchewan River Basin (SSRB), the Red Deer River Basin has a watershed area of about 49,000 km^2 and makes up over 41% of the total area of the SSRB. There is one major impoundment on the Red Deer River, the Dickson Dam near Innisfail. In the upstream reaches, there is little development in the largely forested watershed. Below the Dickson Dam, the river flows through the City of Red Deer, and is affected by municipal effluents. The river also receives inflows from the Medicine and Blindman Rivers which carry natural organic materials from their headwaters, and runoff from agricultural lands. The lowest reaches are slower moving and subject to high sediment loads from the adjacent badlands areas.

Natural drought cycles, the shrinkage of glaciers and predictions related to climate change have all led to concerns about possible changes in water supplies in the future. Alberta Environment has studied historical flows in the major river basins in southern Alberta in response to these concerns. This analysis indicates that the flows seem to fit within the range observed historically. There has not been a clear or consistent pattern of significant decline in natural streamflow volume over the last 90 years. However, other recent research in the headwaters of the southern Canadian Rockies has found an overall pattern of decline in the average flows of free-flowing headwater streams, with some significant declines, over the 1900s.

Groundwater

Groundwater is the water that is found under the ground surface in the spaces found in rocks, unconsolidated materials such as sands and gravels, and soils. An aquifer is a geologic formation or structure which stores or transmits water. Aquifers receive water, or are recharged, generally in higher areas such as hills or plateaus. Groundwater can come to the surface, or be discharged, through natural discharge areas such as springs, streams, lakes or wetlands. It can also be accessed through water wells drilled into an aquifer.

In southern Alberta, aquifers can be found in unconsolidated material that has filled pre-glacial valleys that existed prior to glaciers carving and reshaping the landscape. There are also aquifers in bedrock foundations made up of sedimentary rock including sandstone, shale and siltstone. A number of efforts over the years have been made to learn more about the groundwater resources of southern Alberta. In the 1970s and 1980s, the Alberta Research Council systematically mapped groundwater resources throughout the province. In the mid-1990s, the federal government began working with municipalities to assess their groundwater resources, producing detailed reports and maps. In addition, the provincial government maintains records on individual water wells.

While there is a range of information available, a comprehensive assessment of groundwater supplies in southern Alberta has not been completed. Some general conclusions have been drawn based on what we do know. One estimate puts the potential sustainable yield of groundwater at 500,000 cubic decametres per year. In general, southern Alberta has a background "lower" groundwater yield level, with areas of higher yield throughout. Groundwater quality shows a trend of decreasing from the west to the east. The overall conclusion has been that while groundwater is very important in some areas, much of it is thought to be of poor quality for potable uses, or expensive to access.

The value of groundwater lies not only in its potential as a source of water but also as a key element in the hydrologic cycle. Scientists are working to increase our understanding of the links between surface water systems and groundwater systems. Once again, mountain headwaters play a critical role in the water cycle in southern Alberta. Potential recharge rates are generally high in mountainous and foothills terrain for both aquifers in bedrock and in unconsolidated materials. This is reflected in studies that have confirmed that groundwater supports the base flow of the Bow River and its tributaries, helping to redistribute precipitation from higher elevations into the groundwater system.

4.0 Aquatic Environments of Southern Alberta

4.1 Historical Milestones

The riverine ecosystems of southern Alberta have responded to cycles of flood and drought throughout the last 10,000 years and have evolved in response to these disturbances. Southern Alberta riparian forests are unique in being dominated by poplar trees, including magnificent stands of plains cottonwood along prairie river reaches. The cottonwoods and associated plants and animal species migrated into southern Alberta along waterways. The plains cottonwood migrated from the east, the narrowleaf cottonwood from the southwest and the black cottonwood (balsam poplar) from the west over the continental divide.

Bison moved across the landscape in great herds, upward of 10,000 head, trampling and fouling the aquatic environments that they came across. Fish and other aquatic life occupied the rivers and lakes, also mostly migrating upstream from the south and east. Beaver became an important agent of floodplain building.

The fur trade, which began in the late 1700s, resulted in a dramatic decline in beaver populations during the 1800s which in turn affected the location and make up of the riparian environment. The first European settlements were established along the rivers, which led to the clearing of riparian forests and cultivation of floodplains. As settlement progressed, the bison were eliminated and cattle replaced bison as the major grazer on the prairies. This meant a shift from an open system where grazing patterns were naturally defined to a closed system where herd management and fencing determined the pattern, timing and intensity of grazing. Increasing human populations put pressures on the fishery resources of some rivers.

The construction of dams for hydroelectric generation and the construction of dams, reservoirs, diversions and canals for irrigation development had the most dramatic impacts on the aquatic environment. This included changing the existing aquatic environments around the construction sites, in some cases creating new man-made aquatic environments and, most importantly, by changing flow patterns and volumes.

4.2 Current State and Future Trends

Scientists describe an ecosystem as the soils, plants, animals, climate, water, topography and all the ecological processes that link them together. All aquatic ecosystems are ever-changing. The natural processes at work include precipitation, runoff from land, streamflow, erosion, deposition, recharge and discharge from aquifers, freeze and thaw cycles, flood, drought, movement of nutrients, evaporation, concentration and movement of other chemicals, salinization, thermal stratification and mixing, uptake of water by vegetation and evapotranspiration by vegetation. In the cycle of life, energy and nutrients flow from plants that capture the sun's energy using photosynthesis, through grazers, predators and decomposers.

The nature of each aquatic ecosystem is largely defined by the geography of the environment in which it occurs, including the climate, landforms, soil and

Definition of "aquatic environment" from the *Water Act*

"aquatic environment" means the components of the earth related to, living in or located in or on water or the beds or shores of a water body, including but not limited to
(i) all organic and inorganic matter, and
(ii) living organisms and their habitat, including fish habitat, and their interacting natural systems

vegetation. As noted earlier, the geography of southern Alberta is remarkably varied from west to east. In the mountains and foothills, common characteristics of aquatic ecosystems are cold water, steep slopes with relatively fast flowing water, rocky or gravelly bottom material and low biological productivity. In contrast, the freshwater aquatic ecosystems found in the prairies have cool to warm water, sandy or clayey bottom materials, gentle slopes with relatively slow flowing water and relatively high production of aquatic vegetation, fish and wildlife.

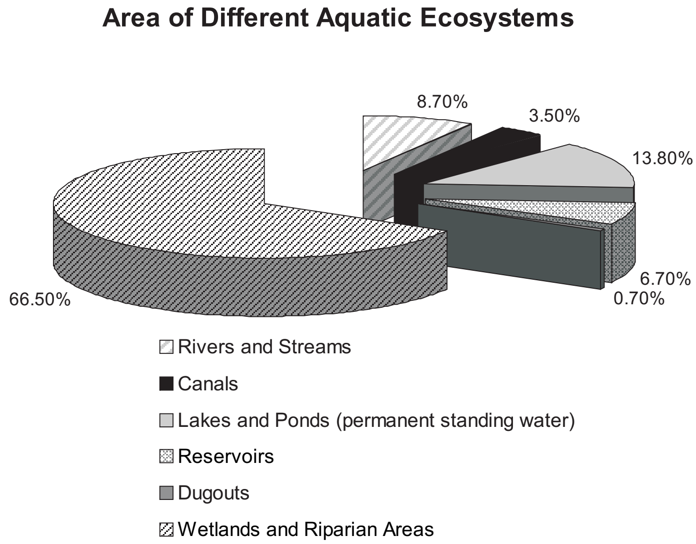
The geography of southern Alberta also changes from the north to the south. This diversity is reflected in the course of the Red Deer River. Arising in an alpine environment, it flows through a gradual transition from coniferous forests to mixed wood forests to a mix of aspen groves and rough fescue grassland before entering the semi-arid grasslands of its lower reaches.

Area of Aquatic Ecosystems in Southern Alberta

Type of Aquatic Ecosystem	Area (ha)	% of S. AB
Rivers and streams	74,000	0.5%
Canals	30,000	0.2%
Lakes and Ponds (permanent standing water)	117,000	0.8%
Reservoirs	57,000	0.4%
Dugouts	6,000	less than 0.1%
Wetlands and riparian areas	565,000	4.1%
Estimated total area of aquatic ecosystems		approx. 6%

This table is intended to provide an indication of how much of the landscape is taken up by aquatic ecosystems in southern Alberta. The areas given are estimated based on information from the landscape database for the Southern Alberta Sustainability Strategy, the Native Prairie Vegetation Inventory (AENV), the Prairie Farm Rehabilitation Administration and Ducks Unlimited.
Note: The total land area for the purposes of the Southern Alberta Sustainability Strategy is 13.8 million ha, including all of the South Saskatchewan River Basin and the Grassland Natural Region.

Rivers



Permanent rivers and streams occupy less than one percent of the total area of southern Alberta (about 74,000 ha). In the mountains and foothills, the beds of rivers and streams are mainly rock and gravel reflecting high energy flows on steeper terrain. In narrow valleys the channels are confined by the bedrock material, while they may wind more across valleys less confined. Braided channels are found where the slope is steep and flows are variable, such as below melting glaciers. The high peak flows of May and June scour the river bed dislodging fine sediments and any aquatic vegetation. Water temperatures are at or near 0 degrees Celsius when the winter ice melts and then follow the air temperature, seldom getting warmer than 20 degrees Celsius. Surface water quality in the western forested portions of southern Alberta watersheds is generally very good. Periodic exceptions to this occur in river reaches immediately below wastewater discharge points for small municipalities. In these upper reaches, coldwater fish thrive, including the native mountain whitefish, bull trout and cutthroat trout in some areas. Rainbow trout, brook trout and brown trout have been introduced. All feed primarily on insects and insect larvae. Bird species closely associated with the mountain and foothill aquatic ecosystems include the American dipper, harlequin duck and common merganser.

In the prairies, the beds of streams and rivers are mainly sand and silt reflecting lower energy flows and the flatter terrain. Channels, varying from just a few metres to tens of metres wide, meander freely across the broad valley bottoms, occasionally confined by bedrock outcrops. The most abundant aquatic vegetation is found in the more shallow reaches with low flow. Fish that are native to prairie streams and rivers are adapted to silty waters and warm water temperatures, often exceeding 20 degrees in the hot summer months. Species that can be found include lake whitefish, walleye, northern pike, sauger, yellow perch, goldeye, and lake sturgeon. There is an abundance of food for these fish including zooplankton, aquatic insects and other aquatic arthropods, clams, snails and smaller bottom-dwelling fish. Crayfish inhabit the channel sediments in some areas. Wildlife species commonly associated with prairie rivers and streams include the Canada goose, great blue heron, common goldeneye, belted kingfisher, bank swallow, rough-winged swallow and the beaver.

The mainstem and major tributaries of the rivers of southern Alberta have experienced a high degree of human intervention. The hydrological regimes of the rivers and tributaries have been altered to provide water supplies for the many demands in the watersheds. Storing water during spring runoff reduces peak flows downstream by varying degrees. The result is reduced channel dynamics including a more stable channel and less bar formation. Onstream reservoirs and diversion structures operated for irrigation purposes on the Oldman River and its southern tributaries and on the Bow River below Calgary have resulted in significant spring and summer flow reductions downstream compared to the natural situation, affecting the habitat of aquatic organisms. The riparian area is also affected by substantially reduced channel dynamics and reductions in riparian water tables.

The water quality of the rivers tends to deteriorate downstream of the mountains as a result of both natural changes and increased human activity. Natural changes include higher summer temperatures, waterfowl gathering sites and materials that can be easily eroded such as in the badlands areas. Human activity results in contaminants from both point sources and non-point sources. Large and increasing withdrawals of water from rivers and streams contribute to deteriorating water quality downstream. There is less flow to assimilate pollutants and temperatures can be higher as a result of reduced flows.

Canals

While irrigation canals occupy about 30,000 hectares of southern Alberta - an area equal to about half the area occupied by rivers and streams - this is declining. Lateral and smaller feeder canals are being replaced by underground pipelines in efforts to reduce evaporation losses and improve irrigation efficiency.

The canals are confined by steep banks lined with gravel and cobbles, and are lined with clay to prevent losses of water through seepage. The main canals are generally about 10 metres in width while the smaller lateral canals average about

3 metres in width. River flows are diverted into irrigation canals over the growing season, from early May until late October, with flows fluctuating depending on changing demands for water. Between October and May, canals are dry except for natural rainfall and snowmelt. The canals are managed to ensure efficient water conveyance, including flushing of sediments and control of aquatic vegetation. As a result, they provide only marginal habitat for wildlife. Fish that are regularly swept through the diversion structures and into canals generally do not survive, although each fall Trout Unlimited rescues many fish in their annual Fish Rescue program.

Lakes and Reservoirs

Lakes are scattered throughout southern Alberta, ranging in surface area from a high of tens of square kilometres to a low of just a few hectares. The natural permanent lakes of southern Alberta formed in large depressions and blocked waterways left by the retreating ice sheets. They include Buffalo Lake, Pine Lake, Sylvan Lake, Bow Lake, Lake Louise, Crowsnest Lake and Waterton Lake. Man-made weirs maintain the water levels of some lakes including Little Fish Lake, Beauvais Lake and Elkwater Lake in the Cypress Hills; and man-made diversions have raised water levels in others including Gull Lake, Namaka Lake and Reesor Lake.

Onstream reservoirs are created when the flow of a major stream or river is blocked by the construction of a dam creating a water storage area. Off-stream reservoirs are created when a structure is built across a minor stream or coulee to create a storage area for water diverted from outside the natural drainage basin. There are 14 onstream reservoirs in southern Alberta including the Oldman Dam reservoir, the Ghost reservoir, Glennifer Lake (formed by the Dickson Dam) and Twin Valley reservoir; and 32 offstream reservoirs include Lake McGregor, Lake Newell, Keho Reservoir, Travers Reservoir and the Chain Lakes.

While they are small in total area, freshwater lakes and ponds are very productive ecosystems, supporting a variety of aquatic organisms. Fish species that are found include lake trout, white sucker, walleye, northern pike, perch and lake whitefish as well as smaller fish such as minnow, shiner, chub and dace. Birds commonly associated with lakes are common loon, osprey, bald eagle, white pelican, double-breasted cormorant, red-necked grebe, western grebe, bufflehead, lesser scaup, canvasback, gulls and terns. Shorelines of exposed mudflats or sand and gravel provide feeding, resting, and in some cases nesting habitat for more than two dozen species of shorebirds. Tiger salamander, leopard frog, boreal chorus frog and western toad frequent the shores of small lakes and ponds. The aquatic ecosystem of a reservoir varies significantly from that of a natural lake. A first major difference occurs at the base of the food chain. Reservoirs have relatively high water exchange rates compared to lakes and nutrients do not linger long enough to be exploited by phytoplankton, a key primary producer. Water level fluctuations are substantially greater in reservoirs than in lakes and occur less gradually and with greater frequency. This has a major impact on the growth of aquatic vegetation at the shoreline and in the shallow areas around the shore. In addition, erosion can take place when shorelines are exposed. Fine materials in the water lead to higher turbidity and can settle, increasing the sedimentation on the bottom of the reservoir. These factors combine to create conditions where the habitat requirements of many species of aquatic invertebrates and fish are not met. While the range of biological diversity is affected, there are a number of species that are commonly found. Fish species include lake whitefish, northern pike, walleye, rainbow trout, burbot, suckers and smaller fish such as shiners and chub. Islands in some reservoirs provide important nesting habitat for colonies of white pelicans, cormorants, gulls and terns. Muskrat and beaver are seldom found as drops in water level during the winter cause serious freezing problems for these animals.

Reservoirs create large surface areas of water that are exposed to evaporation by the sun and wind. In arid regions, this increased evaporation can be significant, affecting the water supply gained from new reservoir storage. This is an important consideration in water management planning.

Water quality monitoring for many southern Alberta lakes and reservoirs began in the mid-1970s and early 1980s. This monitoring is used to evaluate the general lake quality as well as the level of primary production (growth of algae and plants). Periodic water quality monitoring of lakes in the national parks is done by Environment Canada. Mountain and foothill lakes and reservoirs are naturally poor in nutrients. Human activities in the watersheds of these waterbodies are sporadic and localized and appear to have little effect on water quality. A key factor in maintaining good quality water is preventing any increases in the supply of nutrients to a lake.

Prairie lakes and off-stream reservoirs have ample supplies of nutrients to support high production of algae and plants during the late summer. Human activities in prairie watersheds are more persistent and widespread. Nutrients from the runoff from agricultural lands or leakage from septic systems often stimulates growth and diversity of aquatic plants, invertebrates and fish. Excessive addition of nutrients, however, can result in excessive algal or plant growth leading to a depletion of dissolved oxygen which can result in fish kills. Periodically there are blooms of toxic algae which can cause death to domestic animals, waterfowl and other wildlife. Management practices for agriculture and for other nutrient sources including sewage disposal, cottage developments and golf courses, are important factors in controlling nutrient additions to water bodies.

Elevated levels of mercury can be a concern in fish such as walleye and pike in the South Saskatchewan River Basin. The mercury originates in natural sources but it is believed that more mercury comes into the aquatic environment where reservoirs flood substantial areas. Microorganisms ingest mercury naturally found in the sediments and the mercury becomes concentrated up through the food chain. The levels of Provincial sport fishing regulations include an advisory about the amount of fish considered safe to eat.

Altogether the total area occupied by lakes and ponds is somewhat higher than the area occupied by rivers, but it is still less than one percent of the total area of southern Alberta (about 117,000 ha); reservoirs occupy about half the area occupied by lakes (about 57,000 ha).

Ponds and Dugouts

Ponds are found in smaller depressions than lakes and are usually encircled by wetland vegetation. Natural ponds are most common in areas of rolling moraine in the foothills and central parkland. In order to secure a reliable source of water for human and livestock use, many generations of farmers have developed small reservoirs known as dugouts, filled by natural runoff or by pumping from a nearby watercourse. Generally dugouts are similar in size to small ponds. As nutrients and sediment wash in with runoff, newly constructed dugouts are quickly colonized by algae, zooplankton, aquatic plants, insects, amphibians and other organisms that are also characteristic of small ponds. Most dugouts are too shallow to sustain fish over the winter.

Wetlands

Wetlands can be found in areas where runoff collects, where groundwater is close to the surface, including springs, and close to surface water bodies in riparian areas which are subject to periodic flooding. It has been estimated that there are a few hundred thousand wetlands in southern Alberta, commonly referred to as swamps, marshes, wet meadows, potholes and sloughs, covering several hundred thousand hectares. Natural wetlands are most common in the moister northern and western areas of the region. Most of these are seasonal and small - less than two hectares in area. Further south, large, permanent wetlands have been created by man-made diversions and small dams. As the irrigation districts were developed in the region, wetlands were inadvertently created by seepage along the edges of off-stream reservoirs and from canals and drainage ditches. Rehabilitation of canals, initiated in the 1970s, resulted in a significant decline in wetlands associated with seepage. Nevertheless, there has been an overall increase in wetland area within districts partly facilitated by wetland construction projects of Ducks Unlimited in partnership with irrigation districts. These man-made wetland areas depend on continued diversions of water or management of structures to sustain them.

Wetlands perform an important function, acting like sponges throughout a watershed, filling with runoff and groundwater discharge during high precipitation events. In this way they help to store water, reduce overland flow, and alleviate flooding. The stored water can then slowly infiltrate into nearby groundwater aquifers. Wetland vegetation also serves a role in filtering out sediment and nutrients, purifying water as it moves through the watershed.
Since the late 1800s, Alberta has lost about 64% of its slough and marsh wetlands in the settled areas and continues to lose wetlands at an average rate of about 0.5% per year - with a loss of the functions that support the water cycle. There is little information currently available on water quality in wetlands in southern Alberta. One area of concern is chronic, low levels of multiple pesticide residues moving into wetlands.

Riparian Areas

Riparian areas are the parts of the landscape strongly influenced by water and are characterized by water-loving vegetation. Riparian areas perform many important functions as part of aquatic ecosystems including mitigating flood flows, storing water, recharging groundwater, stabilizing banks, trapping sediment, influencing water quality, providing habitat and maintaining biodiversity. Vegetation found in riparian areas in southern Alberta includes more than 50 plant community types. Coniferous forests dominated by white spruce occur on floodplains in the mountains and foothills and in the Cypress Hills. Three species of poplars, including cottonwoods, are the dominant trees of deciduous riparian forests. Balsam poplar, including black cottonwood, is dominant or co-dominant with spruce in riparian forests in montane and parkland regions. Narrowleaf cottonwood is found only in the valley bottoms of the Waterton, Belly and St. Mary rivers as well as along the Oldman River upstream of Lethbridge. Plains cottonwood occurs along rivers through the mixed grass region, being most abundant in reaches where the river channel meanders freely across a broad floodplain. Other riparian vegetation communities are dominated by shrubs including willows, water birch, red-osier dogwood, chokecherry, thorny buffaloberry or greasewood. Riparian herbaceous communities are dominated by moisture-loving sedges or grasses.

While riparian areas cover a very small portion of southern Alberta, they are a critical component of healthy watersheds and are among the most productive wildlife habitats, benefiting the greatest number of species. For example, in the prairies of southern Alberta, about 80% of wildlife species use riparian areas for all or part of their life cycle. Bird species nesting in riparian forests include great blue heron, common merganser, merlin, great-horned owl, northern flicker, grey catbird, loggerhead shrike, yellow-breasted chat, and spotted towhee. Riparian areas are especially critical to the conservation of neotropical songbirds, the majority of which rely on riparian forests and shrublands for breeding or as stop-over sites while migrating. Deer rely on riparian areas for critical winter and breeding habitat. High forage production in riparian areas makes them preferred range for livestock.

As with wetlands, there has been a loss of riparian areas as a result of human activity. In order to maintain long term health, riparian areas need to be able to sustain trees, shrubs and herbaceous vegetation with few invasive plants, have little unnatural bare ground or altered banks and have flow conditions close to the natural condition. These indicators are key components of a user-friendly approach to riparian health assessment that has been developed by the Alberta Riparian Habitat Management Society ("Cows and Fish Program").

A general overview of riparian health has been completed for the Red Deer, Bow and South Saskatchewan rivers under the Alberta Riparian Habitat Management Program (Cows and Fish Program). This overview resulted in ratings for the 48 sites examined: 33% healthy; 46% healthy but with problems, and; 21% unhealthy. Similar work on the Oldman River and its tributaries has found that less than 15% of 46 sites are healthy, about 30% are unhealthy, with the largest portion in the category of healthy but with problems. Management to restore riparian health will need to include changing flow regimes, improving grazing management, minimizing disturbances and controlling invasive plants. The Cows and Fish Program is working to foster better understanding and management among livestock producers and communities.

RIPARIAN HEALTH STATUS

Riparian health is described in the following categories:

Healthy	All riparian functions are being performed.
Healthy but with problems	Many functions are being performed but signs of stress are apparent.
Unhealthy	Most functions are severely impaired or have been lost.

From: Riparian Areas: A User's Guide to Health, Cows and Fish Program

Water Quality

Water quality is critical for both the health of aquatic ecosystems and for human, livestock and irrigated crop consumption. Key indicators of water quality are levels of waterborne pathogens, pesticides, nutrients, and metals and ions. Some of these contaminants occur naturally in waterbodies. For example, mercury occurs naturally in sediments, nitrogen and phosphorus enter aquatic ecosystems through natural biological and chemical processes, coliform bacteria are present naturally in soil, and fecal coliforms are in the systems of many warm-blooded animals including wildlife. As noted earlier, water quality is affected by human activity through point and non-point sources of contaminants and by alterations to natural flows. Fundamental to understanding how human activities are affecting water quality is sound knowledge of natural levels of contaminants and of potential sources of human-caused pollution.

Municipal effluents from the region's cities and towns have a significant impact on water quality, as their wastewaters are assimilated by the watersheds' rivers. Wastewater treatment facilities in Alberta must use secondary treatment or better (this results in 90% removal of organics and solids), and the region's cities must disinfect and remove nutrients to reduce effluent loadings. All cities in southern Alberta have invested in improved sewage treatment in recent years. All the major communities that discharge into the Bow River now have tertiary treatment, with Calgary's tertiary treatment rated the best of all major cities in

Canada. The focus of attention and resources to upgrade treatment facilities is now shifting to smaller municipalities.

Untreated runoff from urban streets, yards and green spaces can be a significant source of contaminants. Periodic high levels of phosphorus, fecal coliforms and some metals have been found in Chestermere Lake and were attributed to contaminated stormwater from the City of Calgary. Very high concentrations of nutrients, bacteria and pesticides were measured in Lethbridge storm drains during the years 2000 to 2002. Although the volume of individual storm drain flow is small in comparison with the volume of water in rivers, they have local impacts and when combined can contribute to overall contaminant loading. Increasingly municipal land use plans are including stormwater ponds to store and treat runoff. Urban residents in some municipalities are being encouraged to reduce their use of fertilizers and pesticides.

Studies have indicated that non-point source runoff from agricultural lands containing nutrients from fertilizers and livestock manure, herbicides and pesticides are contributing to the degradation of water quality in some rivers. Also, as agriculture becomes more intense, concerns about contamination of shallow groundwater sources are increasing. Efforts are underway to control agricultural runoff and improve manure management, especially from intensive livestock operations. Water quality is closely linked to the health of riparian areas. Riparian health assessments are being conducted in various South Saskatchewan River Basin reaches. These assessments will be a tool that can be used to help improve land-use practices, such as grazing, to reduce their impact on riparian areas. Irrigation also produces runoff. Some of the highest phosphorus, nitrogen and bacteria concentrations in the Oldman River watershed during 1998 to 2003 were measured in irrigation return flows during dry periods.

The importance of non-point source contributions of contaminants is strengthened by the observation that water quality in wet years is worse than in dry years in the Oldman River and its tributaries. When there is more precipitation, substantially more material stored on the land moves into waterways through runoff. In dry years irrigation of lawns and crops still provides a pathway for the movement of non-point contributions from the land to rivers and streams through storm drains and return flows.

The public is increasingly concerned about the quality of drinking water, primarily drawn from the rivers of the South Saskatchewan River Basin. The region's four largest cities account for 90% of municipal withdrawals of surface water. Sixty-seven smaller centres also rely on surface waters, while 100 rural communities depend on groundwater. As noted above, with increasing population there will be continued demand to assure the safety of drinking water quality.

Biodiversity

About 130 animal and plant species that depend on aquatic ecosystems in southern Alberta for their survival have been assessed by the Alberta Species at Risk Program as requiring special attention or protection to ensure they do not become extinct or extirpated from the province.

About three-quarters of 63 species of fish in Alberta are found in southern Alberta. Eight fish species are deemed to be "At Risk", "May Be At Risk", or "Sensitive". Diversions of streamflow for irrigation have probably reduced fish populations downstream on the lower Bow, St. Mary, Waterton and Belly Rivers. On the other hand, significant non-native populations of rainbow trout and brown trout have been established below the Bearspaw Dam on the Bow River and attempts are being made to establish brown trout below the Dickson Dam and the Oldman Dam.

About one third of the 402 known species of birds in Alberta are reliant on aquatic ecosystems of southern Alberta for all or part of their life cycles. Twenty-one of these bird species are assessed as "At Risk", "May Be At Risk" and "Sensitive". Southern Alberta has some of the most productive waterfowl habitat in North America. Since waterfowl counts began in 1970, the Alberta spring breeding duck population has fluctuated from a high of ten million in 1975 to a low of five million in 1985 and appears to be related to the number of May ponds each year. Efforts are underway through the North American Waterfowl Management Plan to secure and enhance waterfowl habitat.

Almost all of Alberta's 95 species of mammals rely on aquatic ecosystems for their daily requirement of water. Three species of mammals living in riparian areas have been assessed "May Be At Risk" or "Sensitive".

All ten amphibian species in Alberta can be found in the aquatic ecosystems of southern Alberta. Seven are assessed as "At Risk, "May Be At Risk" or "Sensitive". This is not surprising as amphibian populations have been declining dramatically around the globe. Of eight reptile species known in Alberta, four are found in the southern region of the province. All are assessed as “Sensitive”. As with amphibians, reptiles worldwide are going through a decline. While molluscs play an important role in aquatic ecosystems, few studies have focused on them. Their sensitivity to changes in flow, oxygen levels, temperature and nutrient levels, and their ability to concentrate toxic substances make them excellent bio-indicators of the health of aquatic ecosystems.

Alberta's 2,040 species of vascular plants are a significant component of the province's biological diversity. Eighty-six plant species found in aquatic ecosystems in southern Alberta have been assessed as “At Risk” or “May Be At Risk”. In addition, 37 plant communities found in aquatic ecosystems are on the Alberta Natural Heritage Information Center tracking list because they are rare or threatened. These include forest, shrubland and herbaceous communities.

Evaluation and Monitoring of the Health of Aquatic Ecosystems

The complexity of aquatic ecosystems creates significant challenges in assessing their current status, changes over time, and patterns or trends that can send important signals about the health and sustainability of the ecosystems. Work is progressing on a number of initiatives to help improve our understanding and knowledge.

Instream Flow Needs

Instream flow needs (IFN) determinations have been carried out on various river reaches in southern Alberta as part of water resource planning. The most recent IFN investigations focused on the major rivers in the South Saskatchewan River Basin (SSRB) downstream of major dams and reservoirs as part of the water management planning process underway. The approach used in the SSRB was based on the latest understanding of river ecosystems - it sought to identify the flows necessary to sustain the natural ecological processes and diversity that maintain aquatic habitats over the long term. Four ecosystem components were used to represent the full extent of the aquatic ecosystem - water quality, fish habitat, riparian vegetation and channel maintenance. These four IFN components are integrated to produce an aquatic ecosystem IFN defined for each week of the year for each river reach. This approach relies on data collection and analysis, computer modeling and professional judgment. The results provide an indication of how much the natural flow regime can be drawn down in each river reach without compromising the functioning of the natural system.

INSTREAM FLOW NEEDS IN THE SSRB

In determining instream flows for the SSRB, the following four ecosystem components were used to represent the full extent of the aquatic ecosystem:

Water Quality

- based primarily on flows needed to protect against high instream temperatures and high ammonia levels; and on maintaining minimum dissolved oxygen concentrations for protection of fish species

Fish Habitat

- based on flows needed to protect physical fish habitat

Riparian Vegatation

- based on flows needed to provide adequate seedling establishment opportunities for riparian poplar forests and to promote tree growth

Channel Structure

- based on flows required to maintain natural channel processes

Adapted from: Instream Flow Needs Determinations for the South Saskatchewan River Basin, Alberta, Canada

Using computer modeling, the IFN values were compared to natural flows for the period from 1928 to 1995. Based on this analysis, the IFN values tend to be about 80% of the natural flow during times of moderate to high flow. During times of low flow, the IFN values are equivalent to or higher than the natural flow due to the need to assimilate wastewater from treatment plants. In an average year, the IFN values are less than natural flow during at least some part of spring and summer, while during the fall and winter the IFN value is the same as or less than natural flow. When the IFN values are compared to the actual river flows under current allocations and commitments, the conclusion is that in the Bow, Oldman, St. Mary, Belly and Waterton Rivers, the IFN values are generally much greater than existing flows, and restoring flows to IFN values would be impossible with the present degree of allocation. In these rivers, the aquatic environment is believed to be in a state of long term declining health. Some other instream flow needs work has been carried out in southern Alberta as part of water resource planning efforts.

<u>Ecosystem Assessment</u>

An expert panel was recently convened to assess the ecological status of river reaches within the South Saskatchewan River Basin (SSRB). The approach taken was based on first identifying environmental themes important for aquatic ecosystem functioning. The ratings of a “Best Judgement Panel” based on those themes were then compiled. This approach tapped into the knowledge and experience of scientists and managers most familiar with the SSRB.

The study rated 2 reaches as relatively unchanged or recovered, 22 moderately impacted, 6 moderately to heavily impacted and 3 degraded. The panel concluded that reaches of the Red Deer River are in generally better ecological condition than those of the Bow and Oldman Rivers. The reach of the Bow River downstream of the Bassano Dam and the reaches of the St. Mary River below the dam were considered degraded due to high nutrient load and low flows caused by large diversions. Heavily impacted reaches include the middle Red Deer River with inflows from the city wastewater treatment plant, the Medicine and Blindman Rivers, the Bow River through Calgary to the Highwood confluence, and the lower Waterton and Belly Rivers. Upper reaches above dams and with a lower density of land use in the watersheds were rated as in the best ecological condition.

Grading System Used for the Overview of Ecosystem Conditions in the SSRB

Unchanged/ recovered (0) –
most factors have either remained unchanged over time or recovered from any disturbance

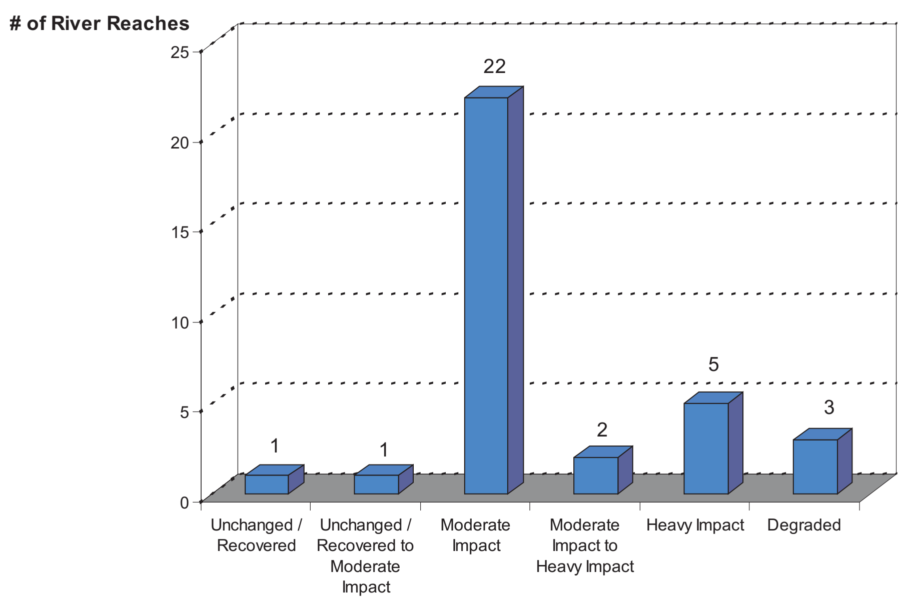
Moderately Impacted (-1) –
most factors have changed measurably over time and some are near or approaching ecologically unacceptable values

Heavily Impacted (-2) –
many factors have degraded over time and are below or forecasted to be below ecologically acceptable values

Degraded (-3) –
most factors are now below ecologically acceptable values

From: Strategic Overview of Riparian and Aquatic Condition of the South Saskatchewan River Basin

Existing Condition: Overview



Other Approaches

While the information from the ecosystem assessment approach and the instream flow needs determination have provided valuable information and knowledge, more work is needed to develop other science-based methods of assessing and evaluating the status of aquatic ecosystems. In the South Saskatchewan River Basin (SSRB), the Aquatic and Riparian Condition Assessment study is examining the three main human influences affecting aquatic conditions - changes to the natural hydrology, riparian area management and changes to water quality. The intent is to use a set of indices to quantify the current condition of 42 river reaches within the SSRB, and to describe the ecological services provided by each reach. Options for improved management for each reach and for the basin as a whole will be identified.

Environmental Indicators for Aquatic Health

As it is impossible to fully understand and monitor all of the natural processes taking place in ever changing ecosystems, a useful approach is the identification of some key indicators. Indicators are measurements that can be used to monitor, describe and interpret change over time. Indicators can be chosen to provide direct information on key elements of a watershed such as water supply available. Others can be chosen to provide scientific information that provides both direct information as well as insight into the status of processes in aquatic ecosystems. For example, water quality indicators may provide direct information on the level of nutrients, but may also provide information on the level of productivity in a lake or pond. A carefully chosen set of indicators can be used to monitor the health and long term sustainability of aquatic ecosystems. Some possible indicators include changes in the hydrological regime, status of water quality, impaired functioning of riparian areas, and loss of biodiversity.

5.0 Human Uses of Water and Watersheds

5.1 Historic Milestones

Aboriginal peoples reached southern Alberta some 10,000 years ago and followed a fairly nomadic existence in search of game thereafter. They, along with beavers and bison, undoubtedly had some impact on water resources and riparian areas, though these were likely short lived.

The fur trade brought European traders and explorers to Alberta in the 1770s, but their activities were concentrated in the beaver-rich northern half of the province. In the late 1850s, Captain John Palliser explored the southern Canadian prairies and warned that an arid area - now known as the Palliser Triangle and extending into southeast Alberta - was desert-like and unsuitable for farming. He was followed by John Macoun in the 1880s. Mr. Macoun, exploring during a wet period in the natural cycle, found lush vegetation and conditions that could readily support agriculture.

Despite the concerns expressed by Captain Palliser, the new Canadian government was keen to encourage settlement. The Canadian Pacific Railway (CPR), completed in 1885, facilitated the large-scale influx of mostly European settlers into southern Alberta, often selling homesteaders land it received for building the railway.

The search for water in this dry landscape spurred these pioneering farmers to dig wells, build small dams and divert water for small-scale irrigation, beginning with Alberta's first irrigation project in 1879 near Calgary. As such diversions multiplied, the federal government in 1894 passed the *Northwest Irrigation Act*, which set two important precedents - government ownership of and control over water resources and allocation of water licences on a first-in-time, first-in-right basis.

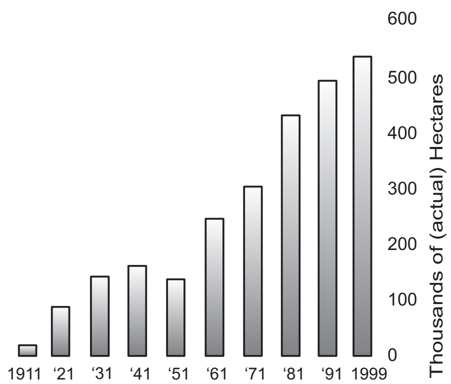
MAJOR HISTORICAL MILESTONES

1879 The first recorded irrigation project in southern Alberta - a hay field south of present-day Calgary.
1894 The Canadian government passes the *Northwest Irrigation Act*, giving government control of water resources and the ability to issue water-use licences.
1900-04 The first large-scale commercial irrigation systems in Southern Alberta are built.
1909 The Boundary Waters Treaty is signed, governing the flow of rivers between Montana and Alberta.
1915 The *Alberta Irrigation Districts Act* is passed, allowing the creation of farmer-controlled irrigation districts.
1930 The federal government transfers control over resources, including water, to the province.
1935 In the midst of the Great Depression, the federal Prairie Farm Rehabilitation Administration is established and becomes a major builder of irrigation works in Alberta.
1969 Alberta signs an interprovincial agreement assuring 50 per cent of natural river flows are passed on to Saskatchewan.
1991 Limits are set on the allocation of irrigation water.
1992 The Oldman River Dam and Reservoir, with a capacity of nearly 500,000 cubic decameters, is completed, providing irrigation water, flood control and steady water supplies to the City of Lethbridge.
1999 Alberta's *Water Act* is passed, protecting existing water-use licences, allowing transfers of water allocations and calling for water management plans to be developed.
2001 The Alberta government launches Water for Life, a strategy for sustainable water management in the province.

The first large-scale irrigation systems were corporate investments, beginning with a 1900 canal project southwest of Lethbridge, followed by CPR diversions downstream of Calgary that brought water to 240,000 hectares of land. Though such projects stimulated land sales and rail shipments, they soon failed financially.

In 1915, the Alberta government passed the *Irrigation Districts Act*, allowing landowners to organize themselves into local cooperatives for building and managing large irrigation projects. This concept of farmer-owned irrigation districts was unique to Alberta and eventually led to the formation of 13 such districts, which today covers more than 500,000 hectares of irrigated land. But the irrigation districts, like the corporate efforts before them, soon ran into financial problems. Both federal and provincial governments stepped in, agreeing to fund all major capital works and assume some district debts. The Great Depression of the 1930s reinforced the need for continued irrigation funding from both levels of government, which constructed water storage and delivery systems and later rebuilt and expanded aging infrastructure.

Subsequent investments by the province allowed irrigation acreage to increase by 50% between 1970 and 1980, a trend that continued with the construction of a large dam and reservoir on the Oldman River in the late 1980s and early 1990s. Rapid expansion was aided by centre pivot sprinklers, allowing larger farm areas to be watered with less manpower, and by infrastructure repairs that reduced evaporation and seepage losses.



Growth of Alberta's irrigation districts

Larger municipalities have also been major water users in southern Alberta. The Bow and Oldman Rivers supplied North-West Mounted Police forts in Calgary and Fort McLeod in the 1870s and later settlers who flocked to the new urban centres. The fledgling city of Calgary began drawing water from the Bow River in the 1890s and has since relied on river waters to feed its continued rapid growth.

Beginning in the 1890s, some eleven hydroelectric dams have been built on the upper Bow River system, providing important peak electricity to the regional power grid. Small hydro plants have been installed at other dams in the basin.

Alberta's primary industry, the petroleum sector, has long used water to extract and process oil and natural gas in southern Alberta. As conventional reserves have diminished, water injections have increased to enhance recovery rates. Southern Alberta's other growing industries, including food processing and manufacturing plants, and several large petrochemical complexes have also been fuelled by water withdrawals from the area's major rivers.

5.2 Current State and Future Trends

Population and Economic Development

More than 1.5 million people live in southern Alberta. Some 80% reside in urban centres, nearly all situated along its major rivers and two principal highways. Canada's fourth-largest city, Calgary, is the area's dominant centre, with about one million residents in its greater metropolitan area. The other cities are Lethbridge (about 71,000 people), Red Deer (68,000 people), and Medicine Hat (51,000 people). All these urban centres have experienced considerable growth during the past decade, especially Calgary's satellite communities. By contrast, large rural stretches of southern Alberta, such as the semi-arid southeast, are sparsely populated. Many of these small rural towns and villages have suffered population declines in recent years.

Despite occupying less than 20% of Alberta's total area, southern Alberta is responsible for about half of the province's economic activity. Petroleum, agriculture and manufacturing are major drivers in this economy, each accounting for about 10% of southern Alberta's sales; the service sector is responsible for 65% of the region's production. While primary production of resources has long been the driving force of the southern Alberta economy, a long term diversification strategy has spurred the growth of knowledge-based and value-added processing industries, particularly in the larger cities.

The demand for water has been increasing and is expected to continue rising to feed the rapid expansion of southern Alberta's population and economy. The population in the South Saskatchewan River Basin, for example, is expected to grow from about 1.5 million today to more than three million people by 2046. The provincial government will be continuing with its long term strategy to make a transition from a resource based economy to a more market-focused, knowledge intensive, value-added economy across all of the province's economic sectors.

The increased demand for water will put pressure on the aquatic environments of southern Alberta in both direct and indirect ways. While the amount and timing of water withdrawals have direct effects on aquatic environments, other factors need to be considered. Increases in population and development of the tourism sector will increase the demand for access to aquatic environments. As the various economic sectors develop, this can lead to increased conflicts on the landscape including possible impacts on aquatic environments.

Interprovincial Obligations

Not all the water that flows in southern Alberta's rivers is available for local use or instream needs. The province of Alberta has international and interprovincial agreements related to the sharing of water in the rivers of southern Alberta which must be met before any other uses are considered.

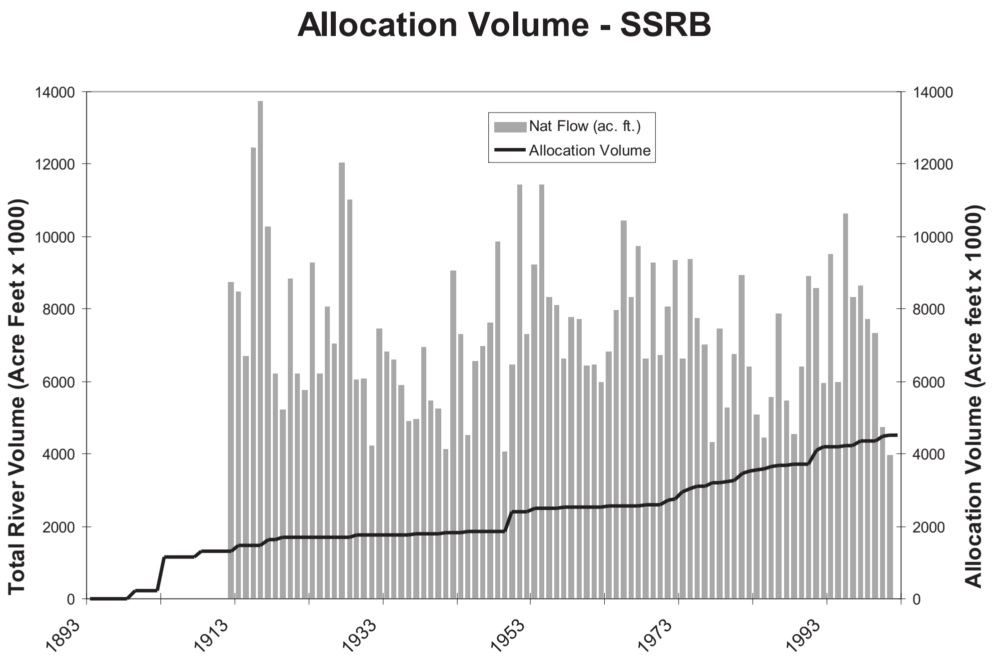
Under a 1969 interprovincial agreement, Alberta is required to pass, on an annual basis, 50% of the natural flow of the South Saskatchewan River Basin to Saskatchewan. The departing waters must also meet certain water quality guidelines. On average, Alberta passes approximately 75%, but in 2001, one of the driest years on record, this amount fell to slightly more than 50%.

Similarly, the 1909 Boundary Waters Treaty sets flow requirements for rivers that cross the Alberta-Montana border. Under a complex formula, Alberta is entitled to a considerable portion of the natural flows of the Milk and St. Mary Rivers, the latter emptying into the Oldman River. On average, Montana has been using about 60% of its entitlement to the St. Mary's flows, an amount that could increase with planned improvements to irrigation infrastructure, thus potentially reducing the river's flow entering Alberta.

Surface Water Allocations

Once international and interprovincial agreements are met, the remaining water in southern Alberta's rivers is available for instream flow needs and for allocation. As noted previously, a system to allocate water was established in the early days of the province's settlement. Under the *Water Act*, the Government of Alberta owns the rights to all waters within its borders and allows it to be diverted and used by licence holders. It allocates these licences on a first-in-time, first-in-right basis, which means that in times of shortage, the older the licence, the higher its priority, regardless of the purpose the water was allocated for. Some of these licences date back to 1894, when the federal government controlled water resources.

There are approximately 20,000 licences and registrations in the South Saskatchewan River Basin (SSRB), accounting for 61% of all the water allocated in Alberta. In the SSRB, irrigation accounts for 75% of the allocation volume (or more than 3.8 million cubic decametres of water), followed by municipalities (13%), industry (3.7%) and other agriculture (1.7%). In the Milk River Basin, about 3,300 hectares of land are irrigated.



Allocations show the different purposes that water is being used for in southern Alberta. It should be noted, however, that allocations refer to the maximum amount of water a licence holder can withdraw - in most cases, not all the allocated water is actually used. For example, irrigation demand is highly variable, depending on the amount of precipitation received during the growing season. There is also a difference between how much water is withdrawn and how much is consumed, or not returned to the watershed. It is estimated that about 80% of water withdrawn for municipal purposes is returned to rivers following sewage treatment, compared to less than 30% for irrigation.

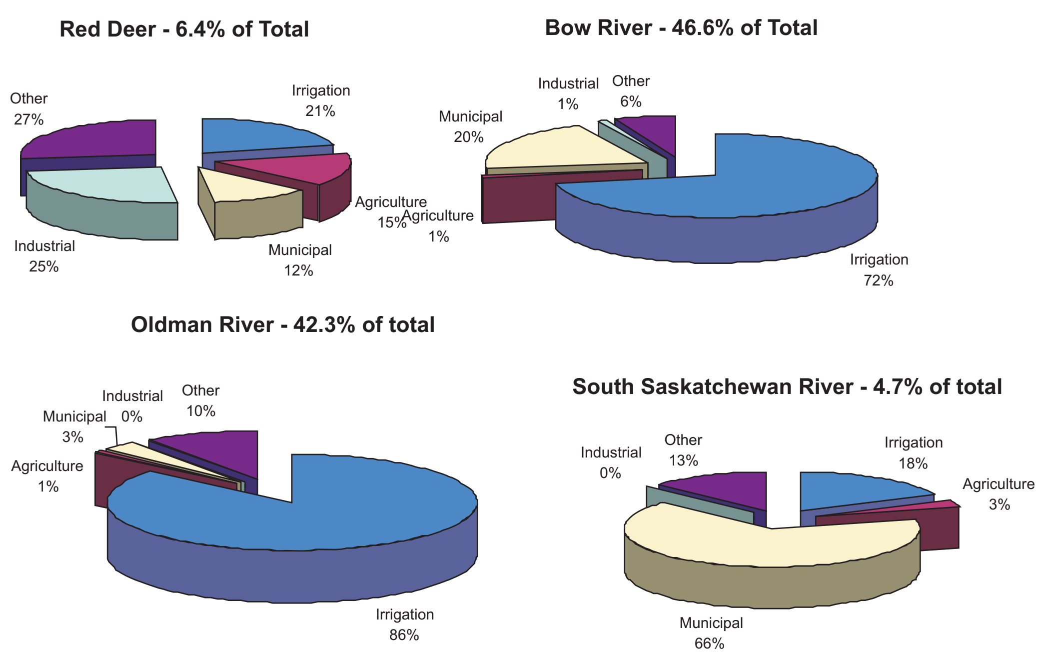
When allocating water, a general benchmark that has been used is that when allocations reach 50% of the median natural flow, limits to allocation should be evaluated. A number of other important factors need to be considered including flow patterns, storage, apportionment and the frequency that water shortages occur. Alberta Environment recently completed a detailed investigation of the current state of water availability in the South Saskatchewan River Basin using computer simulations. These computer simulations have produced firm evidence that the overall demand for water in the basin is rapidly reaching, and in some cases already exceeding, the water supply.

> **What does median flow mean?**
>
> Median flow is comparable to an arithmetic average but differs in that the median has an equal number of values higher than it and lower than it.

The Bow and Oldman Rivers currently have a significant degree of allocation at 68% and 70% of median flow respectively. Any new licences issued in the Bow and Oldman Basins would have significant risk of not getting water in drier years. The Oldman River's southern tributaries have a high degree of allocation, with the Belly at 80%, the Waterton at 75% and the St. Mary River at 118% of median flow. The Red Deer River has a relatively low degree of allocation compared to its natural flow, 18.4%. The development of water management infrastructure has supported the high degree of water allocation, allowing for water to be stored for later use.

In recognition of the high demand for water, some restrictions on further water allocations have been put in place. The Alberta government established irrigation expansion guidelines in 1991 that put a cap on the amount of water allocated for irrigation purposes throughout the South Saskatchewan River Basin. In addition, more specific restrictions have been implemented in some areas. Applications for any new allocation licenses, for any purpose, are not being

Allocation by Basin



accepted on the Belly, Waterton and St. Mary Rivers. On the Highwood River, Ross Creek and Willow Creek, applications for municipal use and small stockwatering use are the only ones being accepted.

Groundwater Use

Groundwater is not a major source of water throughout the basin, but is an important source in some local areas, especially where access to surface water is limited. Currently there are approximately 500,000 domestic wells in the province. Although some smaller communities and industries also rely on groundwater, it is believed that the quantity and quality available in southern Alberta would not be enough for major developments in most areas. In 1996, total withdrawals were about 23,000 cubic decametres of water a year.

A significant bedrock aquifer system is found in the Milk River geologic formation in the southernmost part of the region. This aquifer is the primary source of water for over 800 farms and ranches, a number of Hutterite Colonies and several small communities. Increasing demands and decreases in flow led to an evaluation of the state of the aquifer in 1997. This review found that the total water usage had approximately doubled during the period of 1960 to 1992, primarily due to a substantial increase in the number of livestock in the area. It was also confirmed that there was a large area where groundwater levels had declined by more than 30 metres. An aquifer management plan has been put in place to address the concerns that have been identified.

Major Water Users

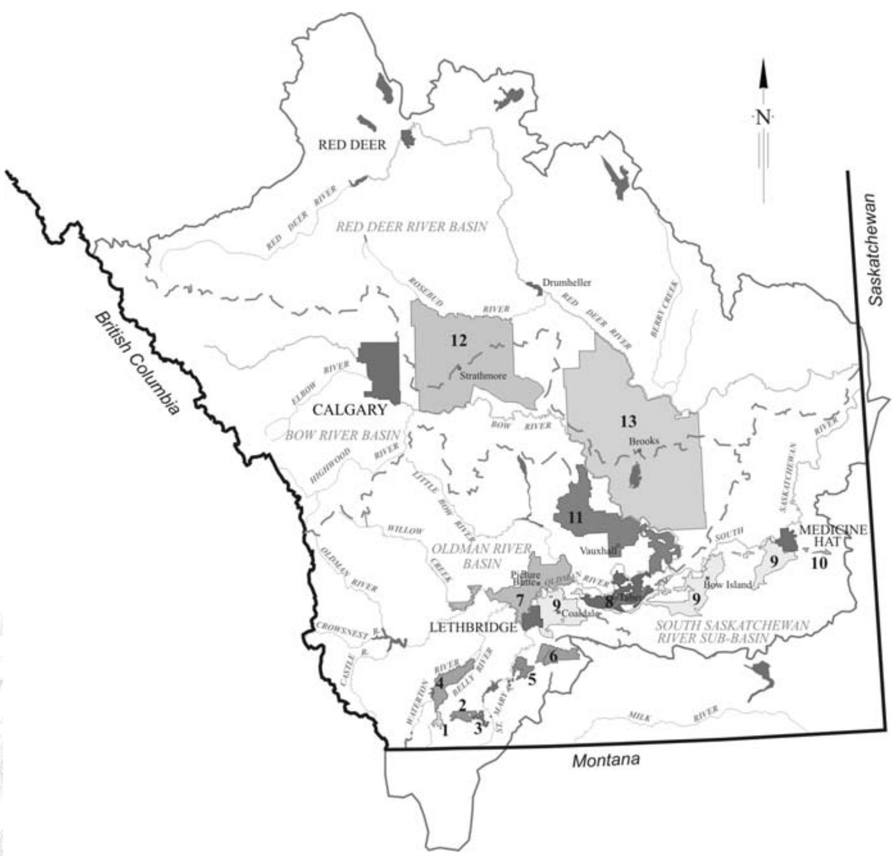
Agriculture

Southern Alberta's irrigation agriculture, which accounts for more than 70% of the irrigated farm acreage in Canada, is a major economic force in the province. Irrigation allows four percent of Alberta's total arable land to reliably produce some 20% of the province's agricultural output, on lands otherwise exposed to considerable periods of drought. Overall, irrigation allows fertile but dry lands to be reliably productive, increasing their economic productivity by three-to ten-fold compared to adjacent dryland areas. These irrigated lands rely almost exclusively on surface waters, unlike the U.S. Midwest, which depends heavily on groundwater.

Directly and indirectly, irrigation adds about 35,000 jobs and nearly $1 billion a year to the provincial economy. Although much of the water is devoted to crops - principally cereals and forages, along with some specialty crops, vegetables and oilseeds - millions of irrigation litres also support Alberta's rapidly-growing livestock and food processing industries.

Alberta's irrigation systems have helped create 40% of Canada's beef cattle industry and have fed the rapid growth of Alberta's pork, poultry, speciality meat and dairy industries by assuring a reliable supply of pasture, feed and water. Alberta's livestock industry, centred in the irrigated south, has more than doubled in size over the past decade.

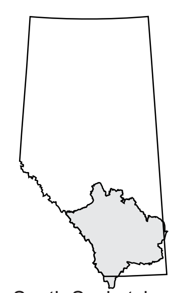
Southern Alberta's irrigation infrastructure has also been the source of domestic and municipal water for about 50 rural communities, thousands of farms and small rural industries. Over the years, irrigation lakes and reservoirs - often the only sizable bodies of water on the dry southern prairies - have provided recreational opportunities.



Irrigation Districts 2003 Assessed Area

	District	(ha)
1	Mountain View (MVID)	1,502
2	Leavitt (LID)	1,928
3	Aetna (AID)	1,461
4	United(UID)	13,930
5	Magrath (MID)	7,414
6	Raymond (RID)	18,739
7	Lethbridge Northern (LNID)	66,486
8	Taber (TID)	33,412
9	St.Mary River (SMRID)	150,592
10	Ross Creek (RCID)	465
11	Bow River (BRID)	86,481
12	Western (WID)	39,112
13	Eastern (EID)	114,513

Total Assessed = 536,397



South Saskatchewan River Basin

Agriculture will continue to be a major economic driver throughout the province and in the region. The Alberta Government has developed an Agriculture Growth Strategy to support sustainable growth of the agriculture sector. Key areas with growth potential in both primary production and value-added production have been identified. The overall target is to achieve $10 billion primary and $20 billion value-added agricultural food and non-food products by the year 2010.
Although the Alberta government set limits in 1991 on the allocation of irrigation water in the South Saskatchewan River Basin, irrigation farming still has room to grow, largely through more efficient use of water. Continued development of drought-resistant crops and improvements to irrigation infrastructure, sprinkler systems and water management mean less water will be lost or wasted. Simulation modeling indicates irrigation water-use efficiencies could improve from 54 to 64% in the Oldman Basin and from 40 to 55% in the Bow Basin. As a result, irrigation acreage could expand beyond the 1991 limits by up to 20% in the Bow and 10% in the Oldman Basins. The downside of improved irrigation efficiency is less water returns to rivers for other uses, and the quality of the returned water may be adversely affected.

<u>Municipal Use</u>

The other major users of water in southern Alberta are cities and towns, drawing water for their people and industries from rivers, storage reservoirs and, to a lesser extent, groundwater supplies. In the 1890s, the young City of Calgary, with a population of a few thousand, began taking water from the Bow River. The river has since fed the city's growth, which doubled in population between 1974 and 2001 and now stands at more than 900,000.

Albertans have placed a priority on a continued safe and secure drinking water supply. The growing population of southern Alberta will continue to be concentrated in urban areas, and will result in increasing pressure for municipalities to provide safe and secure drinking water supplies. The *Water for Life* strategy proposes a comprehensive plan for protecting that supply and upgrading water treatment facilities in Alberta.

<u>Energy</u>

Alberta's extensive oil and gas reserves have long fueled the economy of the province. As a result of the nature of oil and gas reserves in Alberta, innovative methods to ensure the most efficient recovery of this valuable resource have been developed over time. These methods have included the use of "enhanced recovery" where water is forced into a well to increase the pressure and force out some of the remaining oil that can no longer be pumped. As conventional reserves have diminished, water injections have increased to enhance recovery rates. Still, the surface and groundwater used for enhanced recovery decreased from 88.7 million cubic metres in 1973 to 47.5 million in 2001, of which 37 million was fresh water and the rest saline or brackish water.

With increasing public concerns about the long term loss of water when it is injected underground, a comprehensive review of this use was undertaken. Key results of this review include a focus on conservation initiatives and a call for research into alternative technologies. In general, innovation in the energy sector will continue to be driven by continuing efforts to enhance the recovery of conventional oil and gas reserves, to develop non-conventional reserves, to develop alternative energy sources, and to promote conservation.

<u>Other Industries</u>

Other industries currently include food processing, other manufacturing, and a petrochemical complex near Red Deer. Though such uses still pale in comparison to agriculture, their consumption is expected to continue to grow, and to compete more with agriculture for limited water supplies, as Alberta's economy diversifies. In fact, industrial use is expected to show the greatest increase in water demand. Overall, demand in the South Saskatchewan River Basin for non-irrigation consumptive use, including losses, is predicted to increase between 63 and 132% by 2046.

<u>Tourism and Recreation</u>

The natural beauty and diversity of the landscapes of southern Alberta and our high quality of life will continue to attract people to live, work and visit. Southern Alberta attracts local, national and international tourists and currently accounts for almost half of the total provincial sales for tourist services. The tourism sector is seen as a key economic driver for the province and strategic plans have been put in place to increase total tourism revenue from $5.4 billion now to $5.9 billion by the end of 2006.

Recreational activities use a fraction of southern Alberta's surface waters but play a vital social role; water quality and quantity are an important part of the experience. About 25% of visitors, including Albertans, partake in water-based recreation activities such as boating, swimming and fishing in the South Saskatchewan River Basin. In the dry south, irrigation reservoirs are often the only sizable water bodies available for recreation. In cities, rivers have been transformed in recent decades from industrial backyards to aesthetically-pleasing parkways. The Bow River immediately downstream of Calgary and the Oldman River and its tributaries support world-class trout fisheries. The upper Bow and Red Deer rivers and their tributaries are also highly prized fishing locations. As the population in the region continues to increase, the demand for recreational opportunities and access to recreational facilities will continue to grow.

Water Management Infrastructure

Irrigation development was the initial driving force behind the development of man-made structures built to increase the reliability of access to water supplies. Over the years, other demands for water came into play as the water management infrastructure in southern Alberta developed. Various water uses have been integrated into the management and operations of irrigation districts including wildlife conservation, recreation, hydro power and water supplies to communities, industries, livestock and domestic users. Alberta Environment is responsible for managing provincial assets in southern Alberta that are currently valued at about $4.8 billion.

In the Oldman River Basin, this infrastructure includes the Oldman River Dam and reservoir, the Lethbridge Northern headworks system, the Waterton-St.Mary headworks system, the Mountain View-Aetna headworks system, and the Cavan Lake headworks system. In the Bow River Basin, this infrastructure includes the Western headworks system, the Carseland Bow River headworks system, two Highwood River diversions, the Chain Lakes reservoirs, the Pine Coulee reservoir, the Twin Valley dam and reservoir and the Sheerness-Deadfish water supply system. The Dickson Dam and reservoir are the major water management works found in the Red Deer River Basin.

One possible solution to the water supply challenge is to build more onstream storage reservoirs in southern Alberta, though there are few remaining undeveloped sites and any such development would have significant environmental impacts and be highly contentious. Off-stream storage may provide regional water supply solutions with less environmental concerns. Under the *Water for Life* strategy, evaluation of potential storage options will be done as part of the local water and watershed management planning process. Where gaps between supply and demand are identified, the costs and impacts of storage will be compared to other mechanisms such as water conservation and better management of demand.

There has been a significant investment in improving the efficiency of the existing water management infrastructure in southern Alberta. An ongoing challenge is ensuring that the infrastructure continues to be maintained to ensure that it serves Albertans well into the future.

Water Conservation

Water conservation is a high priority for making southern Alberta's water resources go further. Calgary's per capita water use, for example, has fallen from nearly 800 litres per day in the 1980s to around 500 today, largely through the installation of more water meters and more efficient use of water. Still, the city's water consumption remains high when compared to many North American and European cities, and much greater savings are possible, largely through existing technologies and changing habits.

Similarly, further improvements in industrial water use are possible through better water management practices and new technologies, such as automated control systems. The *Water for Life* strategy calls for the overall efficiency and productivity of water use in Alberta to improve 30% by 2015. This will partly offset the increased demand for water from such industries as food processing and petroleum, which may need more water for enhanced oil recovery and perhaps coalbed methane extraction.

Because most municipal and industrial water withdrawals eventually return to the watershed, conservation initiatives in these areas will not measurably increase the amount of water available for other users and instream needs. Continued investments in enhanced wastewater treatment, however, will improve the quality of water downstream of municipalities and industrial sites.

Major investments in rehabilitating and upgrading water management infrastructure have been made by the federal government, the provincial government and the Irrigation Districts to improve water use efficiencies in the delivery and distribution of water for irrigated agriculture. Significant improvements have also been made to on-farm water use efficiency during the last 40 years as a result of efforts in a number of areas including improvements to irrigation methods, the type of irrigation equipment used, and on-farm management practices. While major gains have been made, it is expected that overall irrigation water use efficiencies can still improve, as noted earlier.

Under the *Water for Life* strategy, the merits of using economic instruments as an incentive to conserve water will be explored. While the strategy does not specify what form such instruments might take, it should be noted that residential, industrial and agricultural users now pay relatively little for the water they actually use.

5.3 Governance

The Government of Alberta owns the rights to all water within its borders and, through legislation, regulates activities that might impact rivers, lakes and groundwater. The federal government, which ceded control of water resources to Alberta in 1931, has jurisdiction for such things as interprovincial and international water agreements, fish habitat protection, navigable waters and rivers within national parks. Municipalities too, have some ability to regulate their water use. But the provincial government is the lead player in responding to the increasing pressures being placed on southern Alberta's water supplies.

The Water Act

The province's 100-year-old water resources legislation was reviewed and revised in the 1990s to better manage and protect this vital resource. The new legislation confirmed the principles that the Crown owns all of the water in Alberta, and continued the province's allocation system. New provisions in the *Water Act* permit the transfer of water allocations under existing licences. This allows flexible water management in areas where water is already fully allocated and thus accommodates new or alternative users, such as new food processing facilities. There is no physical transfer of water, just a transfer of the right to divert a volume of water at a new location and for a different use. The government is entitled to withhold up to 10% of the transferred water to help meet aquatic needs in the affected watercourse. The new legislation also permits the establishment of Water Conservation Objectives to maintain flows for a number of purposes including the protection of the aquatic environment and other instream flow needs. The *Water Act* specifically prohibits the export of water to the United States and inter-basin transfers of water between Alberta's major river basins.

Water Conservation Objectives

Historically, limits to the allocation of water centred on the need to meet international and interprovincial commitments and to provide assurance of secure supplies for water licences. Through earlier water basin planning initiatives, instream flow objectives were established for parts of all of the rivers of the South Saskatchewan River Basin. The establishment of these objectives was primarily driven by concerns about possible extremely low flows in rivers and the need to meet allocation commitments. When flows decline to the instream flow objective levels, Alberta Environment curtails withdrawals in accordance with licence conditions and priorities. Some of these instream flow objectives offer limited protection for the aquatic environment.

The provisions of the *Water Act* have strengthened the government's ability to protect all or part of the aquatic environment and to recognize the flows required for instream needs through the establishment of Water Conservation Objectives. Economic, social and ecological factors must be considered when these Objectives are set. More scientific work is needed to improve our understanding of the flows needed to sustain aquatic and riparian ecosystems in river basins throughout the province. This work is underway through watershed management planning initiatives as described below. In the future, Water Conservation Objectives may be considered for other aquatic ecosystems including lakes and wetlands.

Watershed Management Planning

A comprehensive water resource planning program was first initiated in the South Saskatchewan River Basin in the 1980s. This planning program resulted in policies to guide water management in the basin, and led to the 1991 South Saskatchewan Basin Allocation Regulation, which set limits on water allocations for irrigation.

More recently, new water management planning initiatives have been undertaken to address issues in the basin. Phase One of the South Saskatchewan River Basin water management plan, completed in 2002, confirmed that water supplies in the basin are approaching their limits. The use of water allocation transfers has been authorized in the basin as provided for in the *Water Act*, subject to Alberta Environment approval. Phase One also resulted in a moratorium on new water allocations from the St. Mary, Belly and Waterton Rivers, pending the recommendations of Phase Two. Phase Two of the water management plan, currently underway and scheduled for completion in 2005, is seeking to find the best balance between water consumption and environmental protection and to recommend Water Conservation Objectives. It will also determine how much water, if any, remains available for allocation. The need for additional phases and other water management planning priorities will be identified in Phase 2.

Computer models are important tools used to increase our understanding of water demand, water supply and management options. The Water Resources Management Model is a large computer model which was originally developed in 1981 by Alberta Environment. It has been used as a planning tool to understand surface water use and to provide assessments of long term water use alternatives. The model has undergone considerable technical improvement and computer enhancement and has evolved to be a major water management decision tool. Work is continuing on building and improving computer models. A key objective is to expand the use of modeling related to water quality, and to better integrate water quantity and water quality. Work is also proceeding on a landscape cumulative effects simulator, which explores how land-use practices interact with natural processes to change the landscape and impact all natural resources.

Water for Life Strategy

In 2001, the Alberta Government launched *Water for Life,* a strategy for developing a new and sustainable water management approach for the entire province. The strategy is based on three goals:

- a safe and secure drinking water supply,
- healthy aquatic ecosystems, and
- reliable, quality water supplies for a sustainable economy.

Water for Life is calling for the establishment of three types of partnerships, allowing Albertans to be involved in the planning process and to take a stewardship role in maintaining provincial water resources. These are:

- **Provincial Water Advisory Council** - A multi-stakeholder body to oversee the implementation of *Water for Life* and provide policy advice to the Alberta government;
- **Watershed Planning and Advisory Councils** - Multi-stakeholder groups that will lead in watershed planning, develop best management practices, report on the state of the watershed and educate water users; and

- **Watershed Stewardship Groups** - Community-based groups that will share information and take action to protect and enhance their local watersheds.

Management of Land and Natural Resources

The purpose of this section is to provide an overview of the governance of water in the province of Alberta. In order to look at watersheds in a comprehensive way, it is also necessary to consider how land and other resources are managed. A full review of all resource and environmental management policy and legislation is beyond the scope of this paper.

6.0 Challenges for the Future

Although it focuses on the whole province, the Alberta government's *Water for Life* strategy aptly summarizes the dilemma facing southern Alberta:

Population growth, droughts and agricultural and industrial development are increasing demand and pressure on the province's water supplies, and the risk to the health and well-being of Albertans, our economy and our aquatic ecosystems. In the past, Alberta has been able to manage our water supply while maintaining a healthy aquatic environment because there has been a relatively abundant, clean supply to *meet the needs of communities and the economy. However, fluctuating and unpredictable water supply in recent years has stressed the need to make some major shifts in our approach to managing this renewable, but finite, resource.*

6.1 Sustainable Resource and Environmental Management

A sustainable resource and environmental management approach will be needed to continue to build our understanding and to manage our activities into the future. This means an approach that takes a comprehensive and integrated view. Outcomes and goals are set considering the long term health of the environment and our economic and social needs. Progress in meeting those outcomes and goals is measured, and adjustments are made where necessary.

This will be a shared responsibility, with all affected and interested parties involved in identifying issues, gathering information, developing and implementing action plans, and monitoring progress toward sustainability. The Provincial Water Advisory Council, Watershed Planning and Advisory Councils and Watershed Stewardship Groups form a foundation for this.

This paper has included information on the governance of water in the province of Alberta. A sustainable resource and environmental management approach will move us to management of watersheds in a comprehensive way, considering all of the elements of the environment in the landscapes we live in.

6.2 Improving Our Knowledge and Understanding

Human activity has made its mark across the landscapes of southern Alberta. Human decisions now play a key role in determining the distribution of water, both in time and space. But our understanding of the implications of these decisions is incomplete. When looking at watersheds in southern Alberta, there are some key areas where we need to improve our knowledge and understanding to support sustainable resource and environmental management.

Water in Southern Alberta's Watersheds

While there is extensive information on the historical and current status of surface water supplies, there is uncertainty about potential impacts on water supplies in the future. The information available on groundwater and its importance in southern Alberta is less comprehensive. A starting point is improving our knowledge and understanding of the anticipated effects of global climate change on the climate in southern Alberta and, in turn, on the hydrologic cycle. Research and analysis are needed on the precipitation patterns and temperature regimes that we can expect; on the intensity, duration and frequency of drought cycles; on the rate of recession of mountain glaciers and the contribution of glacial meltwaters to surface and groundwater; recharge patterns for groundwater; and the relationship between groundwater and surface water in the region.

In looking toward the future, it is imperative to recognize and manage uncertainty - raised by factors such as climate change, global events and technological advances. In addition to adding to our knowledge base, there is also a need to increase both the capacity to respond to short term changes and to develop adaptation strategies intended to improve the province's capability to respond to longer term changes.

Aquatic Environments of Southern Alberta

A key focus for the future is to improve our understanding of aquatic and riparian ecosystems and their response to human impacts, developing science-based methods to assess their health, and building systems to monitor and sustain the ecosystems over time. One of the more immediate challenges that needs to be addressed is developing scientific approaches that can support planning and decision making in the shorter term.

Human Uses of Water and Watersheds

As the pressures on water supplies increase, the need to use the supply that is available in the most efficient and effective way also becomes more important. Work will continue to encourage water conservation - this will include investigating economic instruments and incentives that encourage efficient use of water, the development of best management practices for agriculture and other economic sectors, and research and development to support innovation and new technologies.

Partnerships for Research

Identifying research priorities and developing a research agenda will be a shared responsibility. Opportunities for collaboration and partnerships are being explored. Important work is already underway through such initiatives as the Water Institute for Semi-Arid Ecosystems, the Prairie Adaptation Research Collaborative, the Climate Change Impact and Adaptation Program and Alberta Ingenuity Research Partnerships. These research programs will be enhanced by plans to develop a provincial, multi-disciplinary water research centre and a provincial water research plan by 2007.

6.3 Conclusion

The province of Alberta has been blessed with an amazing diversity of landscapes and abundant natural resources. Albertans have built a vibrant economy and a high quality of life based on those natural resources. Every day important plans are being developed and decisions are being made that will shape the future. All Albertans share responsibility for what that future will look like - to ensure wise stewardship of our economy, environment and communities. It is hoped that this paper provides some information, creates some insights, and stimulates discussion and debate, in support of shared stewardship.

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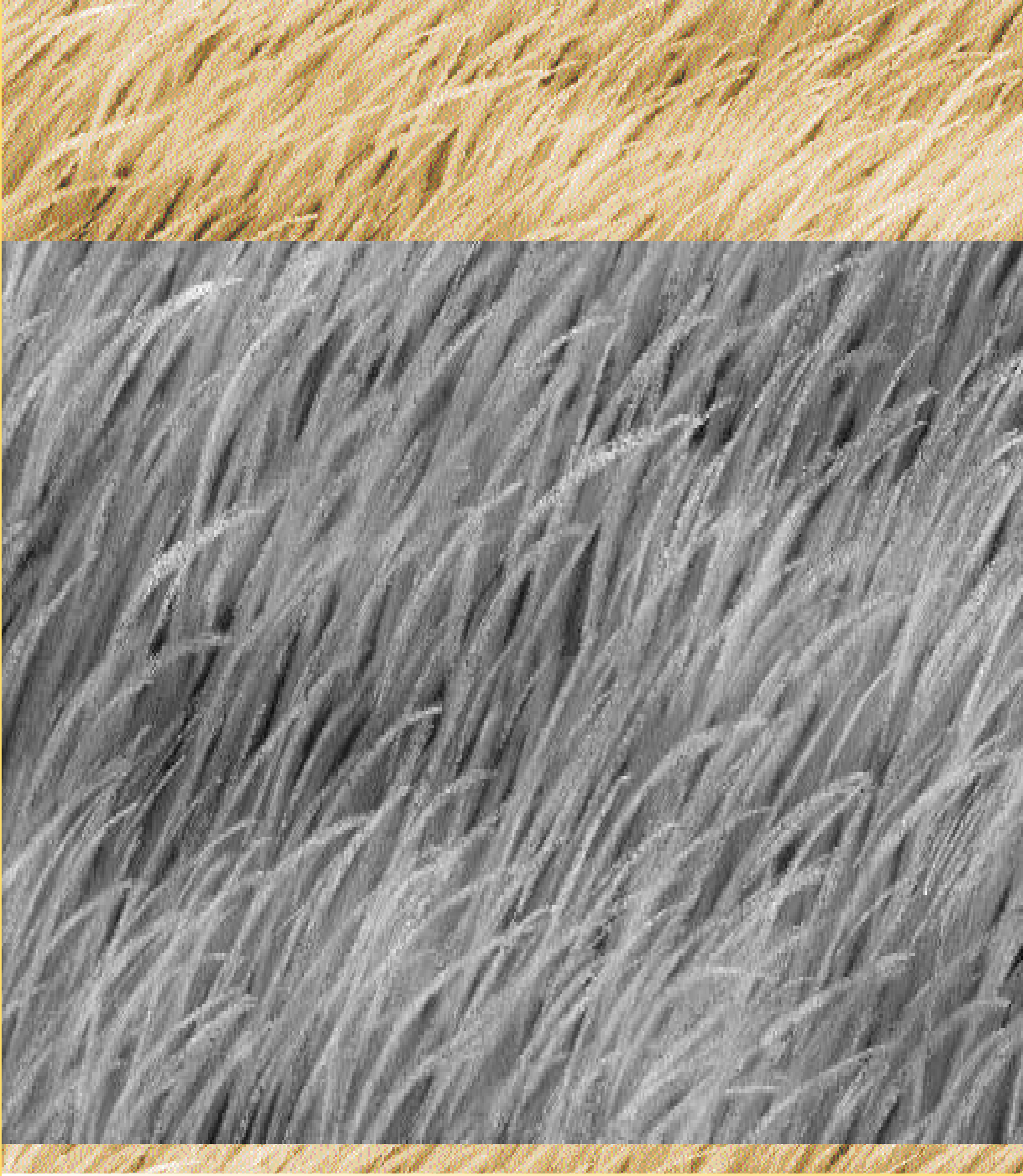

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