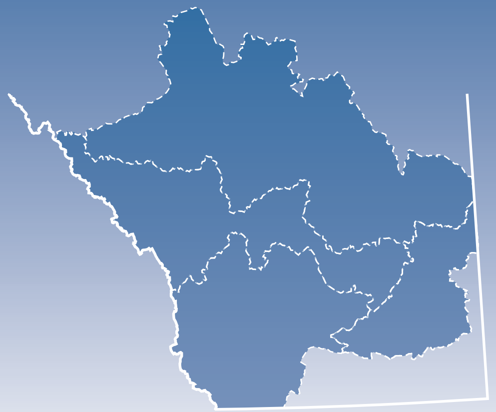
# South Saskatchewan River Basin in Alberta

# WATER SUPPLY STUDY

## *Summary*



SSRB Water Supply Study Steering Committee
Lethbridge, Alberta

January 2010

**Copies of this summary report are available from:**

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This summary report was prepared by Barbara Grinder for Alberta Agriculture and Rural Development. The report summarizes the main report completed by AMEC Earth and Environmental (see attached CD). Appreciation is expressed to Bonnie Hofer in developing the layout and graphics for this summary report.

**The SSRB Water Supply Study Steering Committee:**

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Roger Hohm, Alberta Agriculture and Rural Development
Dave McGee, Alberta Environment
Cathy Ryan, Bow River Basin Council
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Dug Major, Red Deer River Watershed Alliance
Jim Martin, Red Deer River Watershed Alliance
Frank Wetsch, South East Alberta Watershed Alliance

Standard international metric units are used throughout this volume; a table of conversions for the units used herein is provided below. Where abbreviations and acronyms are used, the full name or term is shown at first use and may be repeated from time to time. Definitions of scientific terms are provided in the text at first use and may also appear in the glossary at the end of this volume.

**Volume Units**
1 $dam^3$ = 1,000 $m^3$ = 1 cubic decametre = 1,000 cubic metres
1 cubic metre = 35.31 cubic feet
1 $m^3$ = 1,000 litres
1 $dam^3$ = 0.811 acre feet

**Area**
1 ha = 1 hectare = 2.47 acres
1 $km^2$ = 1 square kilometre = 100 hectares = 247 acres

**Length**
1 mm = 1 millimetre = 0.039 inches
1 metre = 3.28 feet

# South Saskatchewan River Basin in Alberta Water Supply Study Summary

## Contents



The complete study reports are found on the attached CD:

**South Saskatchewan River Basin in Alberta – Water Supply Study**

**Volume 1: Main Report**
**Volume 2: Technical Memoranda**


AMEC Earth & Environmental, Calgary, Alberta
*In Association with:* Marv Anderson & Associates Ltd, Unitech Solutions Inc., Klohn Crippen Berger Ltd., Calgary, Alberta



**Government of Alberta**
Agriculture and Rural Development

# INTRODUCTION

More than 1.6 million people live and work in the South Saskatchewan River Basin in Alberta; almost 90% live in urban areas, including the major cities of Calgary, Lethbridge, Medicine Hat, and Red Deer. To varying degrees, they all depend on the water from the river and its tributaries for household use, for employment, food supply, waste disposal, power, recreation, and life itself.

Not only do the water supplies in the river basin vary considerably from year to year, depending on mountain snow pack conditions and annual precipitation, but climate change has the potential to further impact precipitation and streamflow patterns in the future. Uncertainty about the effects of such changes on temperatures and precipitation makes it even more challenging to predict future water supplies.

As demand for water continues to increase due to economic and population growth, Alberta recognizes that future water use must be considered in light of a limited water supply. Water allocation limits have already been reached or exceeded in the Bow, Oldman and South Saskatchewan River Sub-basins.

Concerns about heightened competition for water, current and future water supply and demand, and constraints on water use led to the commissioning of a science-based report, the *South Saskatchewan River Basin in Alberta: Water Supply Study*. This volume is a summary of that study's final report.

## Scope of the Study

The objectives of the study were to:

- Conduct a detailed assessment of current and projected water demand in the South Saskatchewan River Basin (SSRB) in Alberta;
- Conduct an assessment of historical, current and future water supply, including the possible impacts of climate change;



- Conduct simulation modelling of future water supply and demand to determine magnitude, frequency, and locations of water supply deficits for both instream and consumptive uses; and
- Identify and evaluate structural and non-structural measures to improve water supply security.

**Instream Objectives** (IOs) are minimum flows required for protection of the aquatic environment within a stream.

## Background

In August 2006, the Alberta Government approved a water management plan for the South Saskatchewan River Basin, which includes the watershed or land drained by the South Saskatchewan River and all its tributaries in Alberta. The plan recommended instream flow requirements to be the maximum of either 45% of the natural flow or 10% more than previously established Instream Objectives (IOs) for the Red Deer, Bow, Oldman, and South Saskatchewan River Sub-basins. These new requirements are referred to as Water Conservation Objectives (WCOs). It also closed the latter three sub-basins to any further allocations of water. A year later, a regulation was approved reserving all unallocated water in those three sub-basins for the following purposes only:

- For use by a First Nation;
- To contribute toward meeting a Water Conservation Objective;
- For storage development (if used for protection of the aquatic environment or improving the availability of supply for existing licence holders); and,
- For applications still outstanding on the date the regulation was filed (August 13, 2007).

A **Water Conservation Objective** (WCO) is an instrument under the Water Act that specifies the quantity and quality of water necessary for protection of a water body and its aquatic environment, including the management of fish and wildlife. WCOs are also set for recreational, transportation or waste assimilation needs.

## Overview of the Watershed

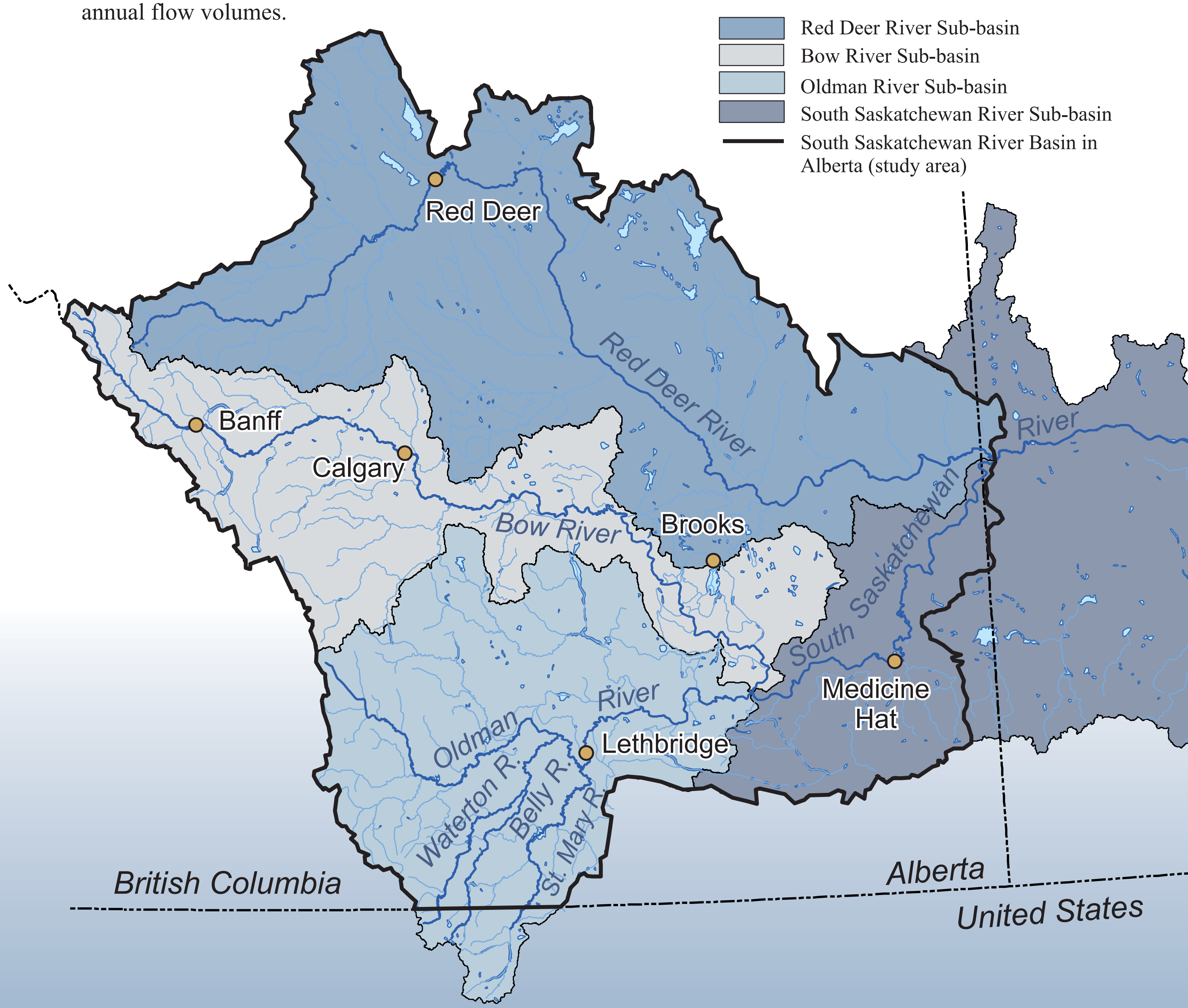
The SSRB extends from the Rocky Mountain Continental Divide in Alberta, into south-central Saskatchewan, where it joins the North Saskatchewan River to form the Saskatchewan River. As such, it is a tributary basin of the Nelson River system, which empties into Hudson Bay in Manitoba. The South Saskatchewan River is considered to start at the confluence of the Bow and Oldman Rivers. The Red Deer River flows directly into the South Saskatchewan, a few miles downstream of Alberta's eastern boundary with the province of Saskatchewan. A small portion of the SSRB watershed rises in Montana.

## Physical Characteristics and Hydrology

In Alberta, the SSRB is comprised of four major sub-basins:

The Red Deer River Sub-basin is the largest in area, but has the lowest mean annual flow volume, primarily because only a small portion of the basin lies in the mountain and foothills regions. Areas of poorly developed drainage contribute to the poor drainage ratio and low runoff yield (*see table page 5*).

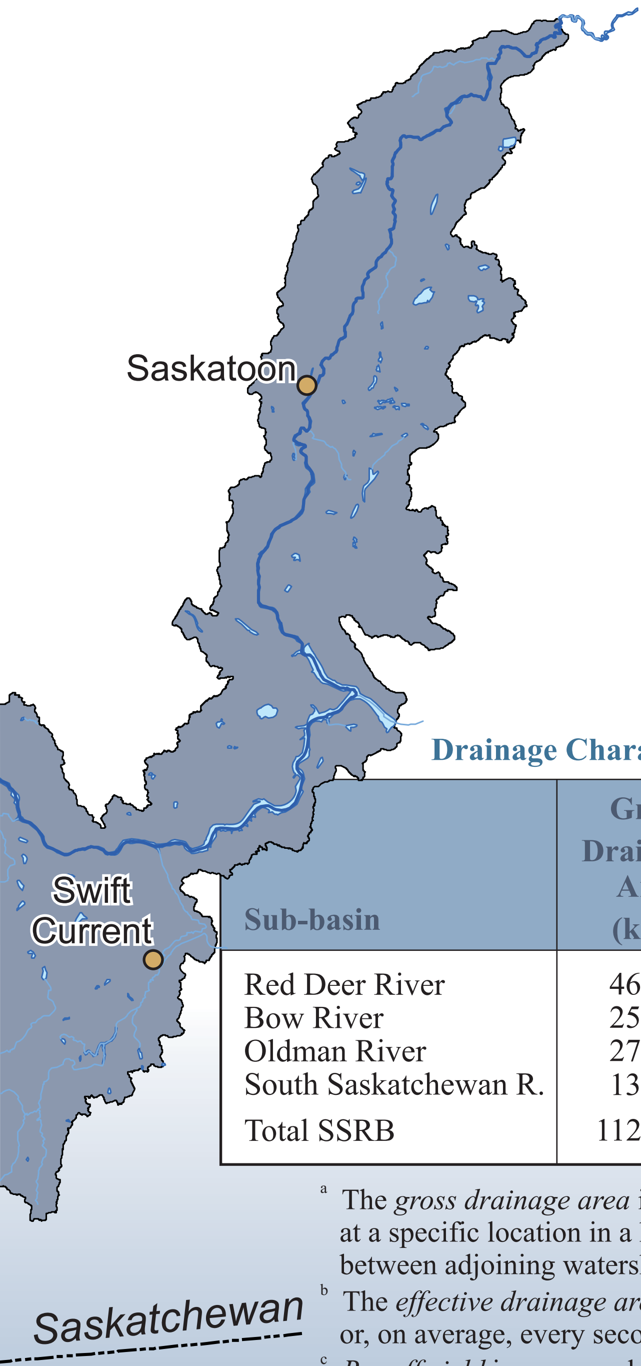
Since 1983, the Dickson Dam (Gleniffer Lake) has regulated flow in the Red Deer River; it is operated primarily to increase low winter flows to improve water quality in the river system. The relatively low level of water use that occurs in the Red Deer River has little impact on annual flow volumes.



The Bow River Sub-basin median runoff yield is about four times that of the Red Deer Sub-basin. Its median natural flow is the highest of the four sub-basins, because a large percentage of the area lies within the Rockies. Flow regulation and heavy water use have had a significant impact in the Bow River Sub-basin. Winter flows are increased in the Bow River due to releases from hydro-electric reservoirs. Summer flows are significantly decreased due to reservoir storage filling and heavy water use, dominated by diversions for irrigated agriculture.

The Oldman River Sub-basin has historically been more susceptible to drought than the Red Deer and Bow Sub-basins, and its flows have been more variable. The sub-basin's area in the Rocky Mountains is about half that of the Bow River Sub-basin. Its most important tributary rivers are the St. Mary, Belly and Waterton. Almost the entire drainage area of these three streams is effective and runoff yields are very high. The combined flow of these tributaries constitutes 57% of the Oldman River's total median flow. As in the Bow River Sub-basin, summer flows have significantly decreased in the Oldman River Sub-basin due to flow regulation and heavy water use.

The South Saskatchewan River Sub-basin lies mostly in undulating grassland. Flow in the river is essentially the sum of the Bow and Oldman River flows and is heavily impacted by regulation and water use in those sub-basins. Its effective drainage area is 6,600 km$^2$, or 50% of the gross drainage area.




**Drainage Characteristics of the Major Sub-basins in the SSRB**

| Sub-basin | Gross Drainage[a] Area (km$^2$) | Effective to Gross Drainage Ratio[b] (%) | Mean Annual Flow (dam$^3$) | Annual Precipitation (mm) | Runoff Yield[c] (mm) |
|---|---|---|---|---|---|
| Red Deer River | 46,800 | 69 | 1,666,000 | 393 | 51 |
| Bow River | 25,300 | 76 | 3,829,000 | 538 | 199 |
| Oldman River | 27,500 | 76 | 3,343,000 | 488 | 160 |
| South Saskatchewan R. | 13,200 | 50 | 4,000 | 278 | 1 |
| Total SSRB | 112,800 | 70 | 8,842,000 | 435 | 112 |

[a] The *gross drainage area* is the entire area that may be expected to contribute to flow in a stream at a specific location in a high flow year. The area is usually defined by the drainage divide between adjoining watersheds.

[b] The *effective drainage area* is that area expected to contribute to flow during a median-flow year, or, on average, every second year, excluding poorly developed drainage areas.

[c] *Runoff yield* is expressed as a uniform depth of water in mm, over an area of land.

The entire South Saskatchewan River Basin in Alberta (measured just downstream of its confluence with the Red Deer River) drains an area of 112,800 km$^2$ of which 70% is effective drainage area. Median annual discharge is estimated to be 8,842,000 dam$^3$.

The terrain in the SSRB ranges from mountainous to semi-arid plains, with elevations from 3,500 metres above sea level in the west to about 600 metres in the east. Topographic and landscape features influence the hydrologic, meteorologic and historic characteristics of the various ecological regions within the sub-basins, affecting climate, soils, vegetation, settlement patterns, and streamflow.

The variable topography and climate of the SSRB in Alberta makes regulation of the water supply a priority, not only for agriculture, but also for the myriad uses of the resource. Average annual precipitation is highly uneven within the region, due in large part to the influence of the Rocky Mountains on the area's prevailing westerly winds.

Within the mountains, precipitation can exceed 700 mm annually, much of it falling as snow in winter. In the eastern part of the basin, precipitation averages drop to only 270 mm a year and summer temperatures are higher. These factors, combined with generally high winds, give this region the greatest potential for water deficits.

Water storage and flow regulatory structures are needed to assure water supplies throughout the basin, especially in the summer. The illustration below shows the variability of naturalized flow in the Oldman River at the hydrometric station near Lethbridge.

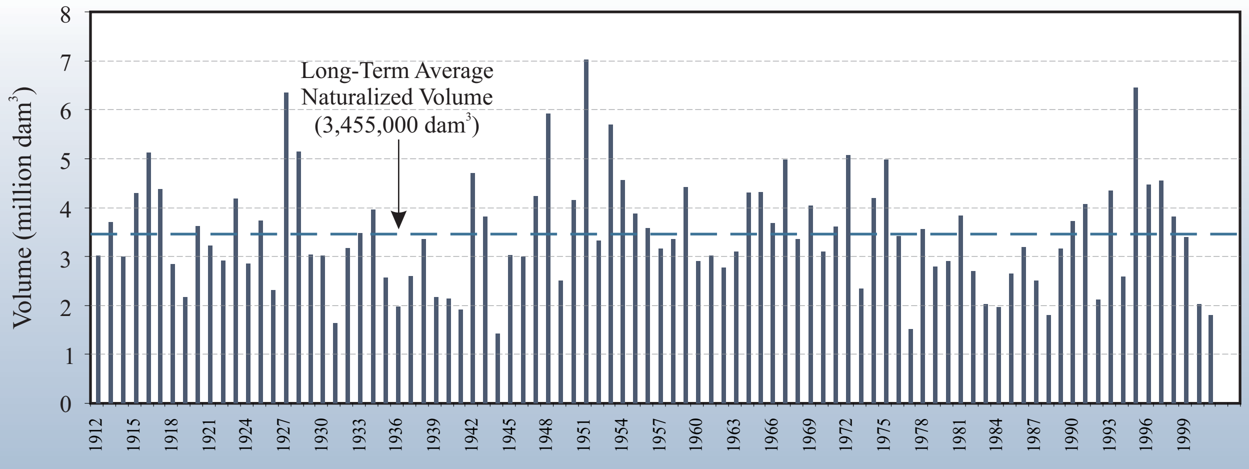
In the SSRB, flow variability has been reduced through the construction of several onstream reservoirs, capable of storing 1,900,000 dam$^3$ of water, as well as some smaller-capacity offstream reservoirs, capable of storing an additional 1,100,000 dam$^3$. Prior to construction of the basin's water management infrastructure, water shortages were common throughout the area. In years when drought conditions prevail, such shortages still occur, but their extent is reduced and their consequences are less severe.

**Naturalized flow** – In a regulated river, natural flow describes the flow that would be in the river in the absence of man-made influences. Naturalized flow is a calculated value based on stream gauge readings, diversions, and other factors.

An **onstream reservoir** is created when a dam is built across the supply stream. Examples include Ghost Reservoir, Oldman Reservoir, and St. Mary Reservoir.

An **offstream reservoir** stores water on a site that is not located on the supply stream.

**Annual Naturalized Flow Volumes of the Oldman River Near Lethbridge**



## History of Water Management in the SSRB

In the early years of Alberta's development, the Dominion Government was responsible for managing water resources and for encouraging irrigation development under the *Northwest Irrigation Act* of 1894. In 1915, the government passed the *Irrigation Districts Act*, authorizing farmer owned and operated irrigation co-operatives. Water use was governed by the principle of prior appropriation or "first-in-time, first-in-right" under both Acts. These actions contributed greatly to the settling of southern Alberta and the establishment of an irrigation infrastructure.

Responsibility for managing natural resources was transferred from the federal government to Alberta in 1930 and the province's *Water Resources Act* was passed the following year. In 1999, that legislation was replaced by the *Water Act*, which provided greater flexibility and new approaches to managing water where demand was high and supply limited.

Like its predecessors, the *Water Act* is based on four principles:

- Crown ownership of water and suppression of individual riparian rights;
- Government control of the allocation and use of water;
- An allocation process designed to promote development; and
- A first-in-time, first-in-right priority system designed to protect existing development.

These principles and an improved understanding of water supply and demand issues have shaped the management of the basin in the 21st century. In 2002, the Waterton, Belly and St. Mary River tributaries of the Oldman River were closed to further allocations, and the entire Oldman, Bow and South Saskatchewan Sub-basins were closed in 2006. The unprecedented decision in August 2007 to reserve all unallocated water in these sub-basins will have far-reaching implications for the future.

## Current Water Management Legislation and Water Use

In Alberta, the right to divert and use water is granted by a licence or registration under the *Water Act*. The *Act* requires that a licence be obtained before diverting and using surface water or groundwater, except for household or domestic use, traditional (non-irrigated) agriculture, fire suppression, and other small-quantity uses by riparian landholders. Licences identify water sources, points of diversion, maximum allocations, the purpose of the projects, rates and conditions of diversion or withdrawal, and the priorities of the water right.

The licensee is given an annual allocation, which is the maximum amount of water the user is allowed to divert each year. The licence also provides an estimate of consumptive use, losses and return flow. Though these estimates are not enforceable, they provide sufficient information on which to base the annual licensed use (the annual allocation less the return flow) for the project at the time the application was made.

Many licensees don't use all the water their licence entitles them to, thus actual use is usually less than licensed use. For example, actual use for irrigation licences varies from year to year, depending on such factors as weather, economic conditions and crop rotations.

Licence applications are reviewed for impacts on the source water, the aquatic environment, public safety, and on other users. Under the *Alberta Environmental Protection and Enhancement Act*, approvals are required for activities with a high potential to impair or damage the environment, personal property, human health, and safety.

Environmental Impact Assessments are mandatory for dams more than 15.0 m high, for diversion structures and canals with flow capacities greater than 15.0 cubic metres per second and for reservoirs with a storage capacity greater than 30,000 $dam^3$.

All licences are given a priority number, based on the date a completed application is received by Alberta Environment. Higher priority (earlier) projects are entitled to their full water requirements before projects with lower priorities can divert water. When streamflow and demand data indicate a trend toward deficits, the operations and management of provincially owned storage projects are reviewed as alternatives to imposing diversion restrictions. Licensees, in accordance with their priority dates, may be directed to stop diverting water until minimum streamflow has been restored and the needs of all higher priority licences can be met.

An **allocation** specifies a volume, rate and timing of a diversion of surface water or groundwater that the licensee is entitled to divert.

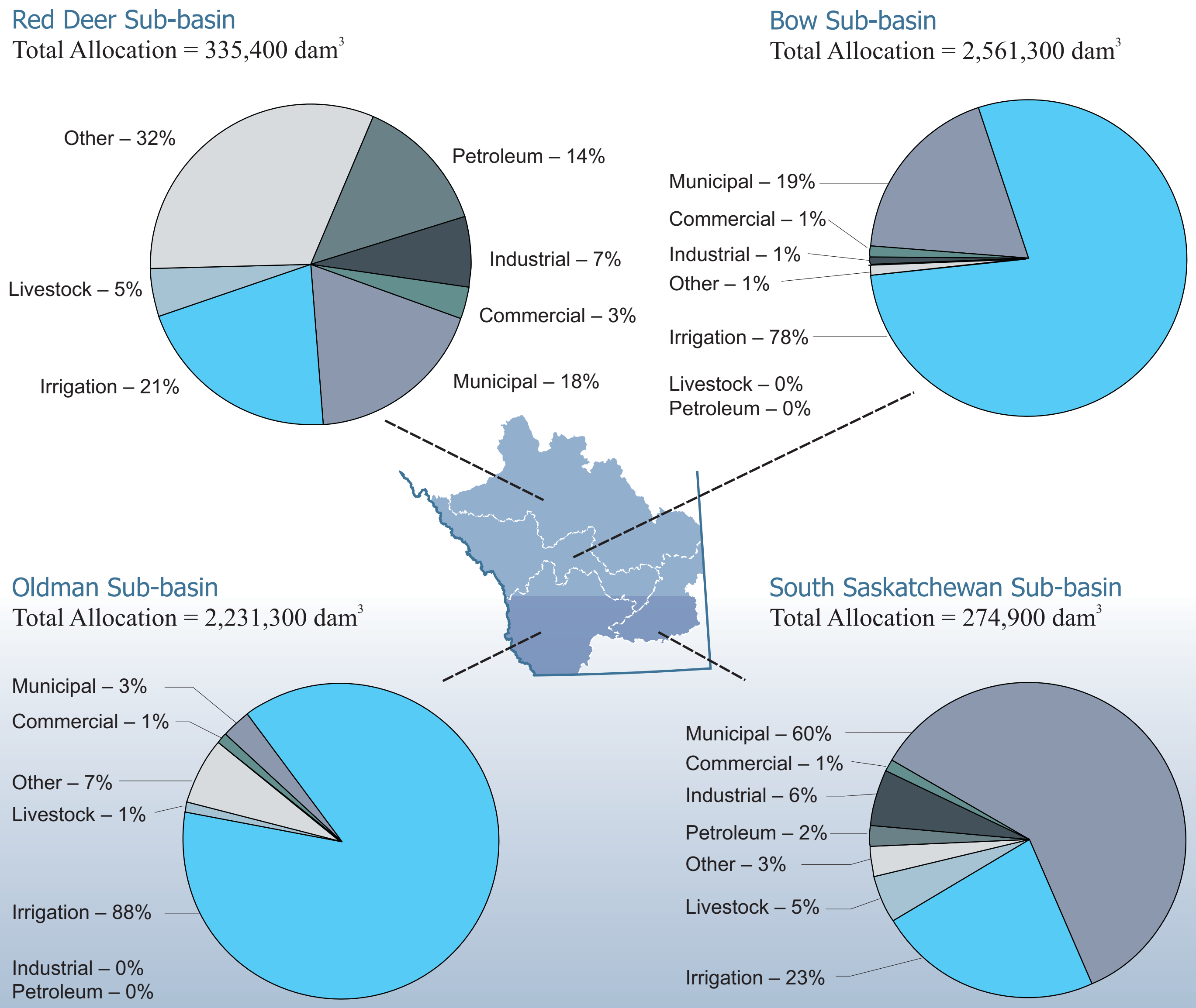
**Actual use, or consumptive use** is the amount of water that a licence holder is entitled to divert, that is not directly or entirely returned to that source.

Currently, 61% of the median natural flow in the South Saskatchewan River Basin in Alberta is allocated, though actual net use is only 22% of the median natural flow. The Bow and Oldman Sub-basins are most heavily allocated, because water is used extensively for irrigated agriculture, as well as for industry, municipalities and other purposes.

Groundwater use accounts for about 2.5% of total water use in the SSRB.

As has been noted, irrigation is by far the largest water use sector in the SSRB as a whole, though distribution by purpose (*i.e.,* irrigation, municipal, commercial, industrial, petroleum, livestock watering) varies greatly in the four sub-basins, as shown below.

## Sub-basin Distribution of Surface Water Allocations in the SSRB



## Water Management Infrastructure

Significant water storage reservoirs and diversion works exist within the SSRB in Alberta. They are owned and operated by Alberta Environment (AENV), the irrigation districts, and private entities. Most have multiple-purpose uses, including the maintenance of instream flows for protection or enhancement of the aquatic ecosystem and water quality, as well as for irrigation, flood control, hydropower, recreation, and municipal water supply. For example, 47 communities receive their municipal water through the irrigation headworks and conveyance systems operated by AENV and the irrigation districts.

Many rural and urban municipalities outside the major cities receive water supplies from regional water supply projects. There are 65 water co-operatives that supply surface water to rural families and communities in the SSRB.

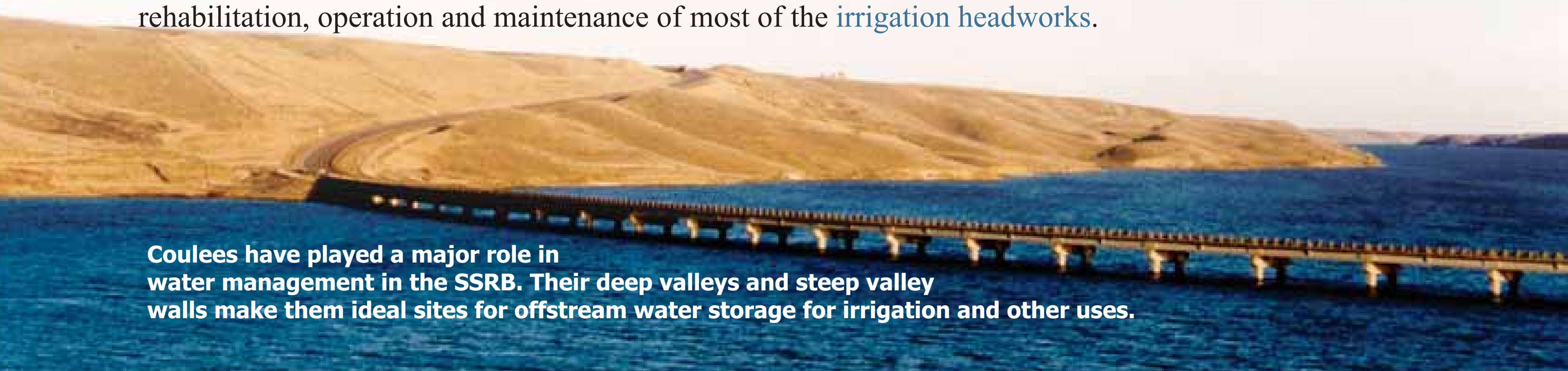
The water management infrastructure also serves recreational, industrial and commercial needs, enhances or makes possible fish and wildlife habitat projects, helps create electricity, and enables flow regulation and flood control. In the Bow River Sub-basin, almost a dozen hydroelectric plants produce power for homes, industries and businesses in Calgary and elsewhere. More than 35,000 hectares of wetlands have been created or enhanced by the water management infrastructure in the SSRB.

While most of the water management infrastructure in the SSRB is government owned, there are also major non-government projects including:

- Hydropower reservoirs and diversion works owned and operated by TransAlta;
- Offstream irrigation storage and conveyance works, owned and operated by the irrigation districts;
- The Bassano Dam onstream diversion works, owned and operated by the Eastern Irrigation District; and
- Numerous large and small wetland complexes owned and operated by Ducks Unlimited.

By 1950, most of the early irrigation works had deteriorated to the extent that major rehabilitation was required to bring them up to standard and, where feasible, to enlarge the system. In 1969, the provincial and federal governments, in conjunction with the irrigation districts, initiated the Irrigation Rehabilitation Program (IRP). The IRP continues today to provide cost-share funding to improve the efficiency and effectiveness of the water distribution system. This program has helped modernize the water storage and distribution infrastructure, especially in regard to water conservation and supply stabilization. Alberta Environment has assumed responsibility for rehabilitation, operation and maintenance of most of the irrigation headworks.

**Irrigation headworks** are those structures required to divert water from mainstem source streams and convey it to the irrigation districts.



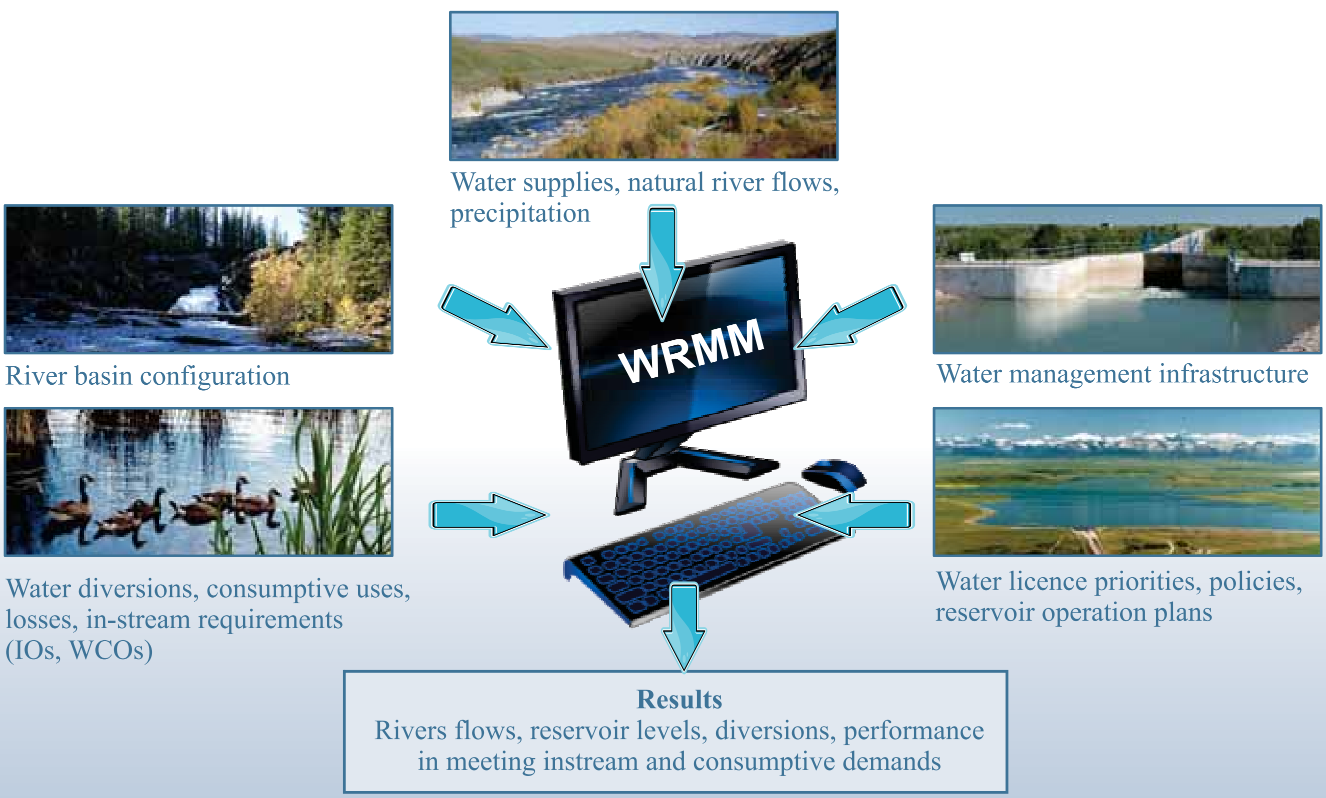
**Coulees have played a major role in water management in the SSRB. Their deep valleys and steep valley walls make them ideal sites for offstream water storage for irrigation and other uses.**

# STUDY METHODOLOGY

Simulation modelling was the key analytical tool used in this study to explore the relationship between current and future water supply and demand in the SSRB. Modelling gives a view of how well the water supply and existing infrastructure meet current and projected water needs. It also helps identify and understand the issues involved and provides a basis for a rational discussion of alternative remedial measures. The Water Resource Management Model (WRMM) has been used for simulating water management in the SSRB for almost 30 years and has been calibrated using recorded and naturalized flows. At this time, it is the best available tool for modelling water management in the SSRB.

Inputs to the model include the physical system, the configuration of streams, canals and water management infrastructure, water supplies, consumptive and instream demands, licence priorities, water management policies, and operating plans.

### Input Data Required for Simulation Modelling in this Study



The WRMM model was used for SSRB water management planning, but its use in this study differs in the following respects:

- Actual current uses and projected uses to year 2030 were used as demand data, rather than licensed demands. Since actual demands are often less than water entitlements under existing licenses, this study assesses actual supply/demand relationships and impacts on source streams, rather than the relationships and impacts if licensees had used their full legal entitlements.
- The IOs and WCOs, specified in the approved SSRB Management Plan were used for all scenarios modelled.
- A climate change scenario was tested, using a recent projection of climatic impacts on water supply in the SSRB.

The simulation modelling of weather and streamflow conditions for this study was based on the historical period 1928 to 1995.

Four scenarios were formulated and modelled to identify water supply and demand issues. All four assume existing WCOs and IOs, with the priorities established in the SSRB management plan, and respect the existing water licence priorities.

**Scenario 1.** Current water supply and current demand

**Scenario 2.** Current water supply and increased future demand

**Scenario 3.** Current water supply and additional increased future demand

**Scenario 4.** Future water supply and Scenario 3 demands adjusted for climate change

**Scenario 1** simulates the current relationship between water supply and demand and is used as a basis of comparison for Scenarios 2 through 4, which project changes from current conditions. It does not include proposed projects that have not yet been issued a licence, such as the Special Areas Water Supply Project, nor does it include committed projects for the Piikani and Siksika First Nations. In keeping with licences issued to date, it includes full development of the Highwood / Little Bow Project, and only partial development of the Pine Coulee Project.

Irrigation demands for this scenario assume current levels of on-farm and irrigation district efficiencies and irrigation water applications. Current on-farm management is about 80% of optimal crop water use. (The other three scenarios assume this value increases to 90%.) The average of 2004-2007 irrigated areas, gross diversions and return flows are used to derive the current level of demand for the irrigation districts. Municipal demands are non-varying from year to year and are based on current populations and levels of per capita use. Total current net use in Scenario 1 is 1,981,100 dam$^3$ as detailed in the table below.

**Scenario 2** simulates a projected future level of water demand to the year 2030, using a minimal level of irrigation district expansion; that is, a 10% increase in the Bow River Sub-basin and 8.5% in the Oldman. Water demand would also be increased by private irrigation projects that have been applied for and committed to by the Province. Related infrastructure projects, such as the Bruce Lake and Langdon Reservoirs, are included and assumed to be in operation. This scenario also projects a demand level for private irrigation, municipalities and other non-irrigation uses based on population projections for 2030, using current levels of per capita water use. Total projected net use modeled in Scenario 2 is 2,758,600 dam$^3$.

**Scenario 3** simulates a higher level of irrigation expansion within the irrigation districts, but one that was thought to be sustainable by the 2002 Irrigation Water Management Study Committee. (Sustainability would be dependent on improved efficiencies, reduced return flows, and higher (closer to optimal) on-farm crop water applications.) Irrigation district demands were based on 32% expansion of the irrigated area assumed for Scenario 1 for the

### Net Water Use of Surface Water – Scenario 1 and Scenario 3

| | Red Deer | Bow | Oldman | South Saskatchewan | Total in SSRB | SSRB Allocation[2] |
|---|---|---|---|---|---|---|
| **Scenario 1 – current estimated net water use[1] in the sub-basins (dam$^3$)** | | | | | | |
| Municipal | 12,100 | 43,700 | 8,800 | 3,500 | 68,100 | 776,400 |
| Irrigation | 48,900 | 748,200 | 826,200 | 42,600 | 1,665,900 | 3,688,100 |
| Livestock | 18,000 | 8,000 | 16,000 | 8,000 | 50,000 | 62,000 |
| Commercial | 1,000 | 7,300 | 5,000 | 700 | 14,000 | 18,500 |
| Petroleum | 18,100 | 1,200 | 800 | 4,100 | 24,200 | 66,800 |
| Industrial | 13,900 | 20,100 | 0 | 17,200 | 51,200 | 71,400 |
| Other | 55,600 | 8,500 | 43,600 | 0 | 107,700 | 304,500 |
| **Total – Net Use** | **167,600** | **837,000** | **900,400** | **76,100** | **1,981,100** | **4,987,700** |
| **Scenario 3 – modelled net water use for 2030 in the sub-basins (dam$^3$)** | | | | | | |
| Municipal | 26,700 | 68,900 | 12,800 | 4,300 | 112,800 | |
| Irrigation | 112,900 | 1,256,600 | 1,214,700 | 43,900 | 2,628,100 | |
| Livestock | 33,800 | 15,100 | 30,000 | 11,300 | 90,200 | |
| Commercial | 1,700 | 12,300 | 8,400 | 1,300 | 23,700 | |
| Petroleum | 18,000 | 700 | 700 | 4,100 | 23,400 | |
| Industrial | 13,900 | 20,100 | 0 | 17,200 | 51,200 | |
| Other | 55,600 | 8,500 | 43,600 | 0 | 107,700 | |
| **Total – Net Use** | **262,600** | **1,382,200** | **1,310,200** | **82,100** | **3,037,100** | |

1 Net use does not include return flow water

2 Total current allocation in the SSRB basin is 5,403,000 dam$^3$. The simulation modeling excluded uses that do not affect flows in the mainstem rivers.

three Bow River Sub-basin districts, and 19% expansion above the Scenario 1 area for the nine Oldman River Sub-basin districts. Private irrigation and non-irrigation demands for Scenario 3 are the same as for Scenario 2. Total projected net use modeled in Scenario 3 is 3,037,100 $dam^3$, as shown below.

It should be noted that the modelled expansions in Scenarios 2 and 3 are both within the existing allocations of the irrigation districts.

**Scenario 4** uses estimates of the impacts of climate change on streamflow in the SSRB, based on Global Climate Model (GCM) projections and several economic and environmental scenarios. This scenario was a first attempt to use the WRMM to define impacts of projected changes in temperature, precipitation and streamflow on the water supply and demand balance in the SSRB. Due to availability, data input was limited to the 30-year period 1961 to 1990.

The estimates yield a broad range of possible outcomes. Evidence suggests temperatures are increasing, but there is less certainty about future precipitation, particularly on a regional level.

Findings of a study conducted by the National Water Research Institute suggest a wide range of potential impacts on streamflow in the SSRB. Generally, streamflows in the fall and winter months are projected to increase in all sub-basins, with a less significant impact in the Red Deer Sub-basin. In the summer months, reduced flows would likely be experienced in all sub-basins.

Thus, Scenario 4 natural flows are 4% to 13% lower than Scenario 3 natural flows. Irrigation areas assumed for Scenario 3 were adopted for Scenario 4, and irrigation demands were increased by 10% to 16% to reflect increases in average annual temperatures of 3° to 5°C and decreases in the growing season precipitation of 3% to 12% projected for the SSRB. Return flows were projected to increase by 2% to 5%.

# KEY FINDINGS

## Current and Future Water Supply

**Alberta has consistently met its commitments under the Prairie Provinces Master Agreement on Apportionment.**

- Surplus water has been delivered to Saskatchewan even in dry years.
- Surplus deliveries from 1970 to 2006 have averaged 2,573,000 $dam^3$, varying from 350,000 $dam^3$ in 2001 to 5,498,000 $dam^3$ in 2005.
- On average, Alberta has passed 81% of the apportionable flow to Saskatchewan, considerably higher than the 50% required. This suggests water may be available for additional use in Alberta.

**The Master Agreement on Apportionment**, signed in 1969, is the formula agreed to by the governments of Alberta, Saskatchewan, Manitoba and Canada for the equitable distribution of water flowing eastward from the Rocky Mountains into the Prairie Provinces. The formula states that Alberta and Saskatchewan may each take up to one half of the natural flow of water originating within their boundaries and one half of the flow entering the province. The remainder is left to flow into Manitoba.

**Future reductions in natural streamflow volumes are more likely than increases for all streams in the SSRB.**

- Researchers have concluded streamflows were relatively high on the Canadian Prairies during the 20th century, compared with earlier centuries.
- Streamflow variability may be somewhat higher in the future than experienced during the past century.
- Climate change studies indicate a wide range of potential impacts, both positive and negative, on natural streamflow in the SSRB. However, future flow reductions are more likely than increases in all the sub-basins.
- The reduction in the area of glaciers and the resultant decline of their contribution to streamflow in the Bow River give rise to concerns about the sustainability of flows in the late summer and fall.

## Current and Future Water Demands

**Current actual surface water consumed by all sectors in the SSRB in Alberta is estimated to be about 1,981,000 dam$^3$, which is approximately 40% of the total volume of water (4,987,700 dam$^3$) allocated for use.**

- The total allocation of 4,987,700 dam$^3$ excludes projects that do not impact mainstem flows. These projects were not included in the study.
- Irrigation is the largest water-use sector in the SSRB, representing 84% of actual current surface water use.
- Surface water use currently represents about 22% of the median natural flow of the South Saskatchewan River downstream of the Red Deer River confluence, and about 46% of Alberta's entitlement under the apportionment agreement.

**In most of the basin, there is a high frequency of deficits to current junior water users and to the Water Conservation Objectives (WCOs).**

- Junior water users are those subject to recently established WCOs in the Red Deer River Sub-basin and those subject to IOs established since the mid-1990s in the Bow and Oldman Sub-basins.
- Junior projects not supported by dedicated storage are particularly vulnerable to deficits.
- Impacts of deficits to irrigation districts and other senior water users are minor for the current level of demand.
- Deficit tolerance thresholds for water-use sectors other than irrigation are largely unknown.

**By 2030, water use could increase from the current 1,981,000 dam$^3$ to about 3,040,000 dam$^3$. This magnitude of increase would occur if irrigation districts were to implement, under their existing licence allocations, the maximum level of expansion modelled in this study. The maximum expansion assumed a 32% increase of the irrigation district area in the Bow Sub-basin and 19% in the Oldman Sub-basin.**

- The potential for expansion of irrigation districts is significant within the Bow River Sub-basin, but more limited in the Oldman Sub-basin.
- If southern Alberta's climate becomes warmer and drier, water demand per unit of irrigated area would increase and the irrigation districts desire to expand would likely decrease.
- Climate change could affect all water-use sectors. Changes in demand for non-irrigation water use would likely be small compared to changes in demand for irrigation use.

**Potential increases in future water use, primarily within the irrigation districts, would increase deficits to WCOs and junior users.**

- Irrigation districts in the Bow and Oldman Sub-basins could perform adequately with existing water allocations (including two pending applications) for the expansion options considered in this study, except for the climate change scenario.
- Generally, the impact of future water demand on the WCOs would be a modest increase in deficits throughout the SSRB. The impact on junior water users in the Red Deer Sub-basin would also be a modest increase in deficits. The increase in deficits to junior users in some parts of the Bow, Oldman and South Saskatchewan Sub-basins would be substantial.

**Climate change is likely to reduce streamflows in the SSRB. Reduced streamflows would have significant impact on irrigation district expansion in the Oldman Sub-basin.**

- If streamflows decrease, deficits to irrigation district demands in the Bow River Sub-basin would increase, but performance would still be acceptable for all expansion scenarios considered in this study. Deficits to district irrigators in the Oldman Sub-basin would be beyond the tolerable limits of the highest level of expansion in this study.
- If streamflows decrease, the WCOs indexed to streamflow would also decrease. The ability to meet these reduced WCOs would improve throughout the SSRB.
- If streamflows decrease, deficits to junior water users throughout the SSRB would significantly increase.

## Non-structural and Structural Water Management Options

**Refining or modifying the operations of existing storage reservoirs in the Red Deer and Bow Sub-basins would potentially reduce or eliminate deficits to the WCOs and junior consumptive users in those basins.**

- In the Red Deer Sub-basin, deficits are infrequent, low in volume, and occur primarily in the winter months. Refining the operation of the Dickson Dam would probably reduce or eliminate both current and future deficits.
- In the Bow Sub-basin, studies indicate significantly improved performance in meeting demands could be achieved through shared use of existing hydroelectric water storage facilities.

**Other non-structural measures include improved irrigation efficiencies, reduced return flows, market-based water allocation transfers, and deficit sharing. While all have a role to play in improving water management in the SSRB, the collective benefits of these measures would likely not completely address current and future issues identified in this study.**

- Irrigation district efficiencies have increased substantially during the past four decades. Reduced return flows from the irrigation districts have been a major result of these improvements. Further improvements beyond the current 53% efficiency, to 63% efficiency in the next 10 to 15 years, would conserve an average of about 326,000 $dam^3$ per year. Under the Water for Life program, the Government of Alberta has set increased efficiency and productivity targets for all water use sectors.
- Research in Alberta and elsewhere indicates market-based allocation transfers will gradually shift water use to higher value purposes, more efficient uses, and to help meet instream requirements. However, the contribution of these transfers and associated environmental holdbacks in the reduction of basin-wide deficits is likely to be small. A large volume of transfers would be required for this to have a significant impact on the issues identified.
- In water-short years, voluntary deficit sharing among licensees, through allocation assignments or by other means, is a valuable tool for reducing the impacts of periodic droughts.

**A preliminary review of the hydrology of the Red Deer, Bow and Oldman River Sub-basins indicates there is unused flow available at various locations in each sub-basin. Additional storage and flow regulation can assist in reducing deficits to instream requirements (WCOs and IOs), and junior consumptive users.**

- Onstream storage at strategic upstream locations in the SSRB would enable capture and release of water for downstream users and instream flow needs. Additional onstream storage of more than 1,000,000 dam$^3$ may be possible in the Red Deer, Oldman and Bow River Sub-basins.
- Climate change research suggests mountain runoff in the future may occur during winter and early-spring seasons, before offstream diversion canals can operate. Onstream storage will be more effective than offstream storage in capturing these snowmelt events.
- Offstream storage has made a significant contribution to water management in the SSRB and should be considered to address specific issues in the future. Historically, offstream storage has not been optimally located or utilized for the purpose of diverting water from a main river system and later releasing it back to the source stream for flow regulation. While improved placement and use is possible, it is unlikely to be as effective as onstream storage for this purpose.

The full report, South Saskatchewan River Basin in Alberta – Water Supply Study, which provided the basis for this summary document, can be found on the attached CD.

# GLOSSARY

**Allocation, Licensed Allocation** – Specifies a volume, rate and timing of a diversion of surface water or groundwater the licensee is entitled to divert.

**Basin** – The area of land drained by a stream and all its tributaries. Also called the watershed, catchbasin or drainage basin. A **Sub-basin** is the part of a stream's watershed drained by a specific tributary.

**Consumptive Use** – The amount of water a licence holder is permitted to divert that is not entirely or directly returned to the water body; also, the difference between the amount of water diverted and the amount of return flow to the system.

**Diversion** – The withdrawal of water from a stream, impoundment, canal or other source. Water diversions are typically less than water allocations because the full licensed amount is often not diverted.

**Effective Drainage Area** – The area expected to contribute to flow during a median-flow year, or, on average, every second year, excluding areas with poorly developed drainage. The **Gross Drainage Area** is the entire area that may be expected to contribute to flow in a stream in a high flow year. It is delineated from adjoining drainage areas by the divide between adjoining watersheds. The **Drainage Ratio** is that portion of the gross drainage area that is considered effective, expressed as a percentage.

**Hydrology** – The study of the Earth's water resources, especially water quantity.

**Hydrometric Station –** An on-site station containing electronic monitoring devices that continuously record streamflows and water levels of a stream.

**Instream Objectives** (IOs) – Minimum flows required for protection of the aquatic environment within a stream.

**Irrigation District** – In Alberta, a farmer-owned and operated corporation, with an elected board of directors responsible for its management. The roles of each of the 13 districts in Alberta include delivering water through the irrigation works in accordance with licence conditions, and to construct, operate and maintain the district works.

**Irrigation Headworks** – Those structures required to divert water from mainstem source streams and convey it to the irrigation districts. Most of these works are owned and operated by Alberta Environment. Irrigation districts own and operate the structures within their boundaries required to distribute water to individual users.

**Mainstem** – The primary channel of a river or the primary river in a drainage basin.

**Naturalized Flow** – In a regulated river, natural flow describes the flow that would be in the river in the absence of man-made influences. Naturalized flow is a calculated value based on stream gauge readings, diversions, and other factors.

**Return Flow** – Water that has been withdrawn from a river, then returned un-used or after use. Examples would be treated wastewater discharges or water that has passed through the canals of an irrigation district but not used on crops. Sometimes water can be withdrawn from one river and returned to another. Return flows may also include drainage water from shallow groundwater discharge or from surface runoff following major precipitation events.

**Runoff** – That portion of precipitation, snowmelt or applied irrigation that flows off the land into streams or other surface water bodies, rather than moving through the soil. Runoff yield is the volume of runoff from a given area of land, expressed as a uniform depth of water, in mm.

**Stream** – Any flowing body of water, such as a river, brook or creek.

**Sub-basin** – The part of a stream's watershed drained by a specific tributary.

**Water Conservation Objectives** (WCOs) – Specifications of the amount and quality of water necessary for protection of a water body and its aquatic environment, including the management of fish and wildlife. WCOs are also set for recreational, transportation or waste assimilation needs or to maintain a specified rate of flow.

**Watershed** – The area of land drained by a stream and all its tributaries. Also called the basin, catchbasin or drainage basin.