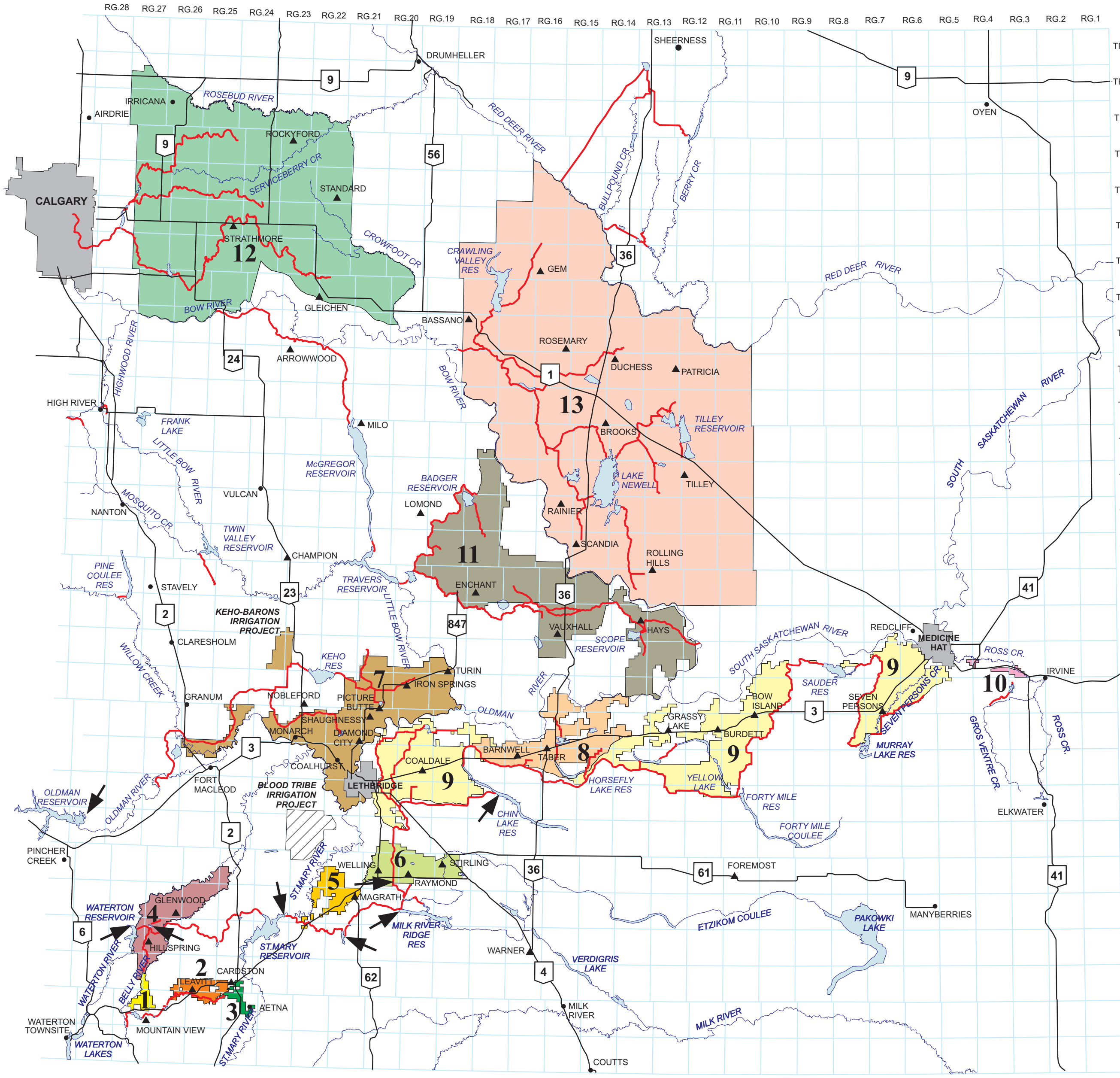
ECONOMIC VALUE
of Irrigation in Alberta



N

1	Mountain View Irrigation District
2	Leavitt Irrigation District
3	Aetna Irrigation District
4	United Irrigation District
5	Magrath Irrigation District
6	Raymond Irrigation District
7	Lethbridge Northern Irrigation District
8	Taber Irrigation District
9	St.Mary River Irrigation District
10	Ross Creek Irrigation District
11	Bow River Irrigation District
12	Western Irrigation District
13	Eastern Irrigation District

Hydroelectric plants associated with water distribution works

Main canals

There are 13 irrigation districts in southern Alberta providing water to 566,000 assessed hectares of farmland. The infrastructure within these irrigation districts is comprised of approximately 8,000 kilometres of conveyance system, of which 339 kilometres are owned and operated by Alberta Environment and Parks.

Alberta's Irrigation Districts

Economic Value of Irrigation in Alberta

Paterson Earth & Water Consulting Ltd.
Lethbridge, Alberta

Prepared for
Alberta Irrigation Projects Association

2015

Prepared as information for the Alberta Irrigation Projects Association; funding for this project was provided through Growing Forward 2, a federal-provincial-territorial initiative. The views and opinions expressed in this report are not necessarily those of Agri-Food Canada or Alberta Agriculture and Forestry.

Economic Value of Irrigation in Alberta

Prepared for — Alberta Irrigation Projects Association

Funding for this study by — Canada-Alberta Growing Forward 2 Program

Prepared by — Paterson Earth & Water Consulting Ltd., Lethbridge, Alberta

Primary Authors
- Brent Paterson, P.Ag., Paterson Earth & Water Consulting Ltd., Lethbridge, Alberta
- Dr. Suren Kulshreshtha, Kulshreshtha Agri-Economics Consultant, Inc., Saskatoon, Saskatchewan
- Dick Hart, P.Eng., Hart Water Management Consulting, Calgary, Alberta

Contributing Author
- Dr. Lorraine Nicol, University of Lethbridge, Lethbridge, Alberta

Technical Contributions
- Allan Florizone, Edmonton, Alberta — Preparation of Economic Impact Analyzer
- Dr. Md Kamar Ali, University of Lethbridge, Lethbridge, Alberta
- Kelechi Nwanekezie, University of Saskatchewan, Saskatoon, Saskatchewan

Report Design and Preparation
- Bonnie Hofer, Bonnie Hofer Design Graphics, Lethbridge, Alberta

Photographs — Unless otherwise referenced, all photographs in this report are provided courtesy of Alberta Agriculture and Forestry, Irrigation and Farm Water Division.

Citation
Paterson Earth & Water Consulting. 2015. Economic Value of Irrigation in Alberta. Prepared for the Alberta Irrigation Projects Association. Lethbridge, Alberta, Canada. 137 pp.

Published by
Alberta Irrigation Projects Association,
Lethbridge, Alberta, Canada

Copies of this report are available from the
Alberta Irrigation Projects Association
2825 – 18 Avenue North
Lethbridge, Alberta T1H 6T5
(403) 328-3063

Printed in Canada

Reproduction of up to 100 copies by non-profit organizations, or photocopying of single copies, is permitted. Please acknowledge the Alberta Irrigation Projects Association. All other reproduction, including storage in electronic data retrieval systems, requires written permission from the Alberta Irrigation Projects Association.

Acknowledgements

Funding for this study was provided to the Alberta Irrigation Projects Association by the Canada-Alberta Growing Forward 2 Program.

Special appreciation is expressed to Dr. Shelley Woods and Ron McMullin for their ongoing advice and support during the preparation of this report. Irrigation district management and staff also provided invaluable information and advice for this study.

The authors wish to thank the Steering Committee for their support and recommendations to improve the report.

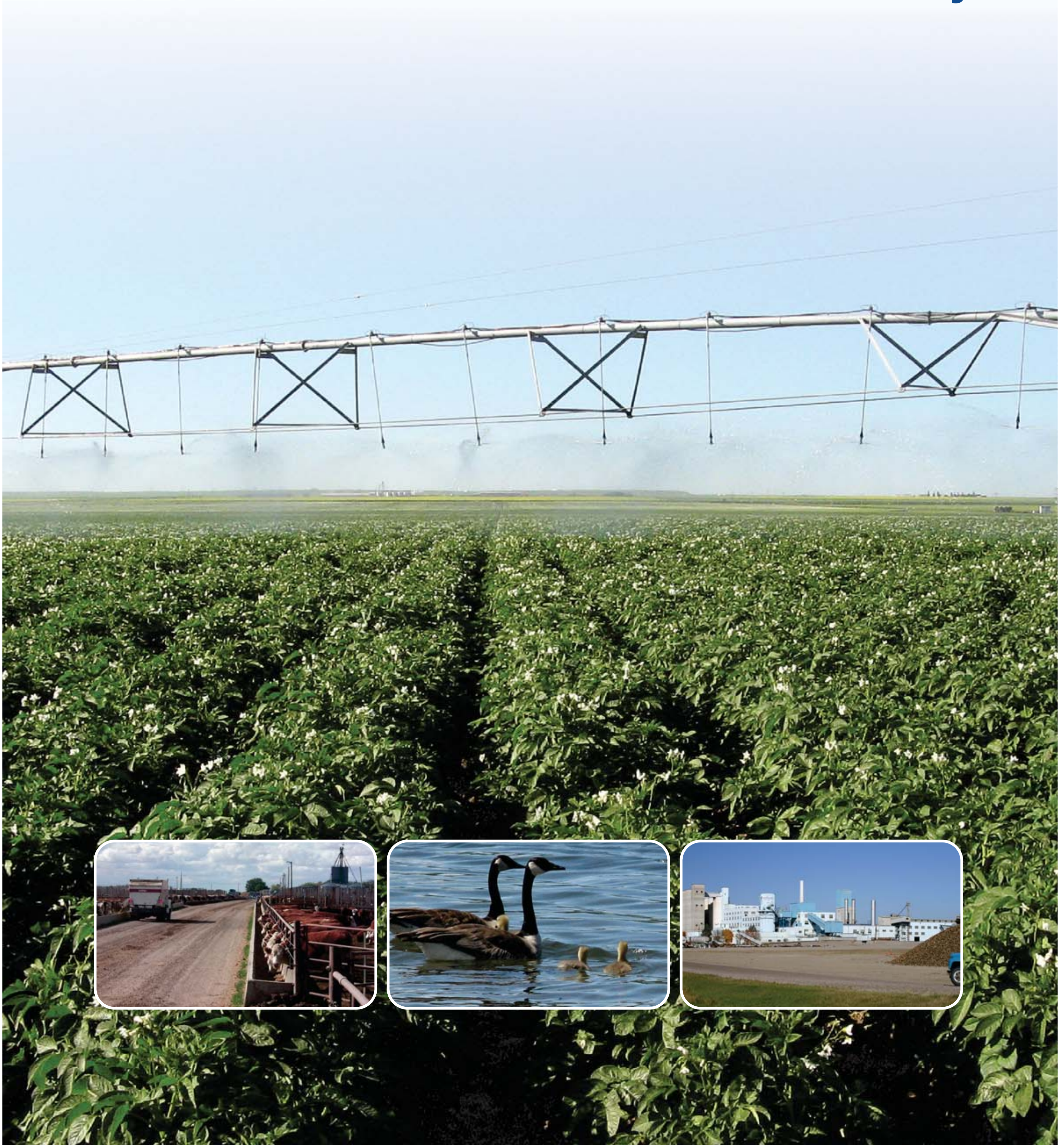
Dr. Shelley Woods (Chair) - Alberta Agriculture and Forestry
Rod Bennett - Alberta Agriculture and Forestry
Rosalie Cunningham - Alberta Agriculture and Forestry
Richard Heikkila - Alberta Agriculture and Forestry
Roger Hohm - Alberta Agriculture and Forestry
Bob Dykstra - Alberta Irrigation Projects Association
Ron McMullin - Alberta Irrigation Projects Association
Olubukola Oyewumi - Alberta Agriculture and Forestry
Richard Phillips - Bow River Irrigation District
Richard Stamp - Alberta Irrigation Council

Thanks also to Dr. Barry Olson for his in-depth review of the draft and final report for this study.

Appreciation is also expressed to the following individuals who took the time to share valuable information in support of this report.

Andrew Llewelyn-Jones
Chris Hustad
Ed Shaw
Jay Bartsch
Jordan Van Hierden
Lukas Matejovsky
Patricia Doherty
Rick Martin
Russ Mellow
Sharon Schentag
Aryal Saroj
Chris Perry
Greg Nikles
Jeff Bronsch
Heidi Eijgel
Marion Henry
Richard Heikkila
Roger Hohm
Sabine Nasse
Surya Acharya
Carolyn Law
David Churchill
Grant Lastiwka
Jennifer Nitschelm
Lisa DeBona
Mary Jean Klima
Richard Stamp
Roy Finzel
Seth Clark

Executive Summary



Executive Summary

Introduction

Alberta's irrigation industry plays a significant role in the province's economic and social well-being. Irrigation development, which began in southern Alberta in the late 1800s, increased steadily throughout the 1900s. In 2013, Alberta's irrigation area totaled about 690,000 hectares, and was located throughout most of Alberta's major drainage basins (Figure 1). Almost 70% of Canada's total irrigated area is in Alberta.

The majority of Alberta's irrigation (566,000 hectares) occurs within the 13 irrigation districts (see map, inside cover), which are in the South Saskatchewan River Basin (SSRB). An additional 124,000 hectares are irrigated throughout the province as private developments (Figure 1).

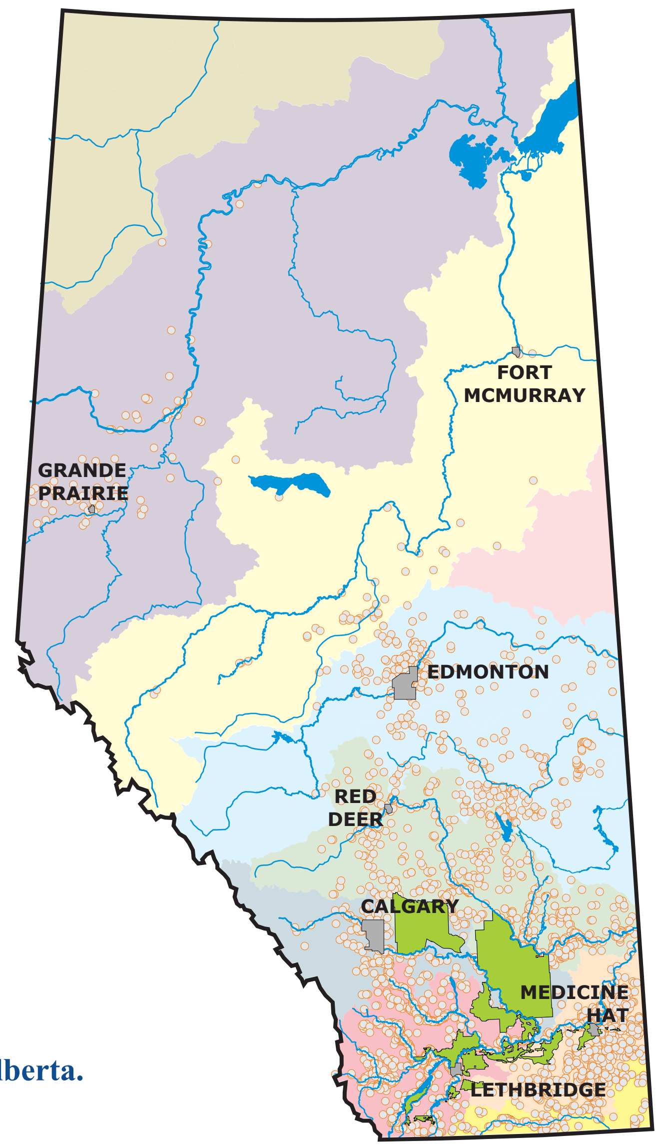


Figure 1. Location of irrigated areas in Alberta.

Irrigation in Alberta has resulted in a diverse array of crops in the province that cannot be grown under dryland conditions, and this allows irrigation producers to take advantage of a wider range of markets. As well, intensive livestock feeding operations in the irrigated areas provide a ready market for calves and feed grains. In times of low precipitation or drought, feed and forages from irrigation farms help supplement dryland producers impacted by feed shortages.

Study Methodology

The *Economic Value of Irrigation in Alberta* study provides the most comprehensive assessment to date of the Alberta irrigation industry's value to the provincial economy, and to all Albertans. The study analyzed the economic effects of primary and value-added irrigation production, including backward and forward linkages related to that production. It also assessed the contribution of irrigation water storage and canal infrastructure on government revenues, and the value of irrigation to non-irrigation water users in southern Alberta. Finally, the study looked at future opportunities and challenges the irrigation industry may face with changing world markets and changing climatic conditions.

The study assessed the economic impact of the irrigation industry on a regional basis as well as on a provincial basis, and included all commercial irrigation systems related to the production of agricultural commodities. The economic assessment was carried out on all lands that were actually irrigated from 2000 to 2011 within the 13 irrigation districts, as well as private irrigation projects throughout Alberta. The actual irrigated area averaged 600,795 hectares from 2000 to 2011. This included 491,017 hectares within the irrigation districts and 109,778 hectares in private projects.

The quantitative analyses in this study included development and use of three interlinked computer models.

- Irrigation Benefits Simulator Model (IBSM) – used to assess the farm-level economic impacts of irrigation.
- Alberta Regional Input-Output Model (ARIOM) – used to assess the secondary economic impacts of irrigated production activities, either related or induced.
- Fiscal Impact Analysis Model (FIAM) – used to assess the fiscal impact on the Government of Alberta (GOA) and Government of Canada (GOC) resulting from irrigation-related activities.

Key Conclusions

Alberta's irrigation industry annually contributed about $3.6 billion to the provincial gross domestic product (GDP). The irrigation agri-food sector contributed about 20% of the total provincial agri-food sector GDP on 4.7% of the province's cultivated land base. Almost 90% of the GDP generated by irrigation accrued to the region and the province and 10% to irrigation producers. Using labour income as the criteria, 89% of the irrigation-related benefits accrued to the region and province, and 11% to irrigation producers.

Gross domestic product multipliers indicate that for every $1.00 of irrigation sales, the total GDP increased by $2.54 and labour income increased by $1.64. Total employment increased by about 39 jobs for every $1.0 million of irrigation sales.

Every cubic metre of water delivered for irrigation and other related uses generated about $3.00 to the provincial GDP and $2.00 in labour income. Every $1.00 invested by the GOA in irrigation-related activities generated $3.00 in added revenue to Alberta and Canada.

Sales of irrigation crop and livestock products on 4.7% of Alberta's cultivated land base generated 19% of total primary agricultural sales. Irrigation sales equated to about $2,400/ha compared with about $329/ha for dryland production – about seven times greater. Combined annual sales of irrigation crop and livestock products generated about $1.7 billion to the Alberta GDP. Irrigation-related agricultural processing also generated almost $1.7 billion to the Alberta GDP.

Irrigation generated about $1.3 billion in annual revenue for the GOA and the GOC. Government revenues always exceeded expenditures, with the revenue to expenditure ratio of about 3:1.

Benefits from irrigation water and infrastructure used for non-irrigation purposes, such as recreation, hydropower generation, drought mitigation, and commercial fishing, generated an additional $85 million to the provincial GDP and $71 million in labour income. While an economic value was not determined for the 32,000 hectares of habitat development in the irrigation districts, its value in enhancing wildlife populations and biodiversity is considered priceless.

The future will provide opportunities and challenges for Alberta's irrigation industry. Increased frequency, duration, and intensity of droughts may occur as a result of climate change. Long-term water and drought management strategies will allow irrigation districts to better optimize water supply and irrigation production during prolonged droughts.

Climate change may also lead to more diverse and high-value irrigated crop production and encourage establishment of additional processing industries in the region. The message – that water; land; skilled irrigation producers; and diversified, high-quality irrigation products are available to support value-added processing industries – needs to be better communicated to international food processing industries.

The communities and industries supported by Alberta's 13 irrigation districts are an excellent template for what a strong, vibrant rural economy can achieve – because of water. Irrigation districts can continue to play an important role in the expansion of rural development opportunities within the districts and in surrounding dryland regions in southern Alberta.

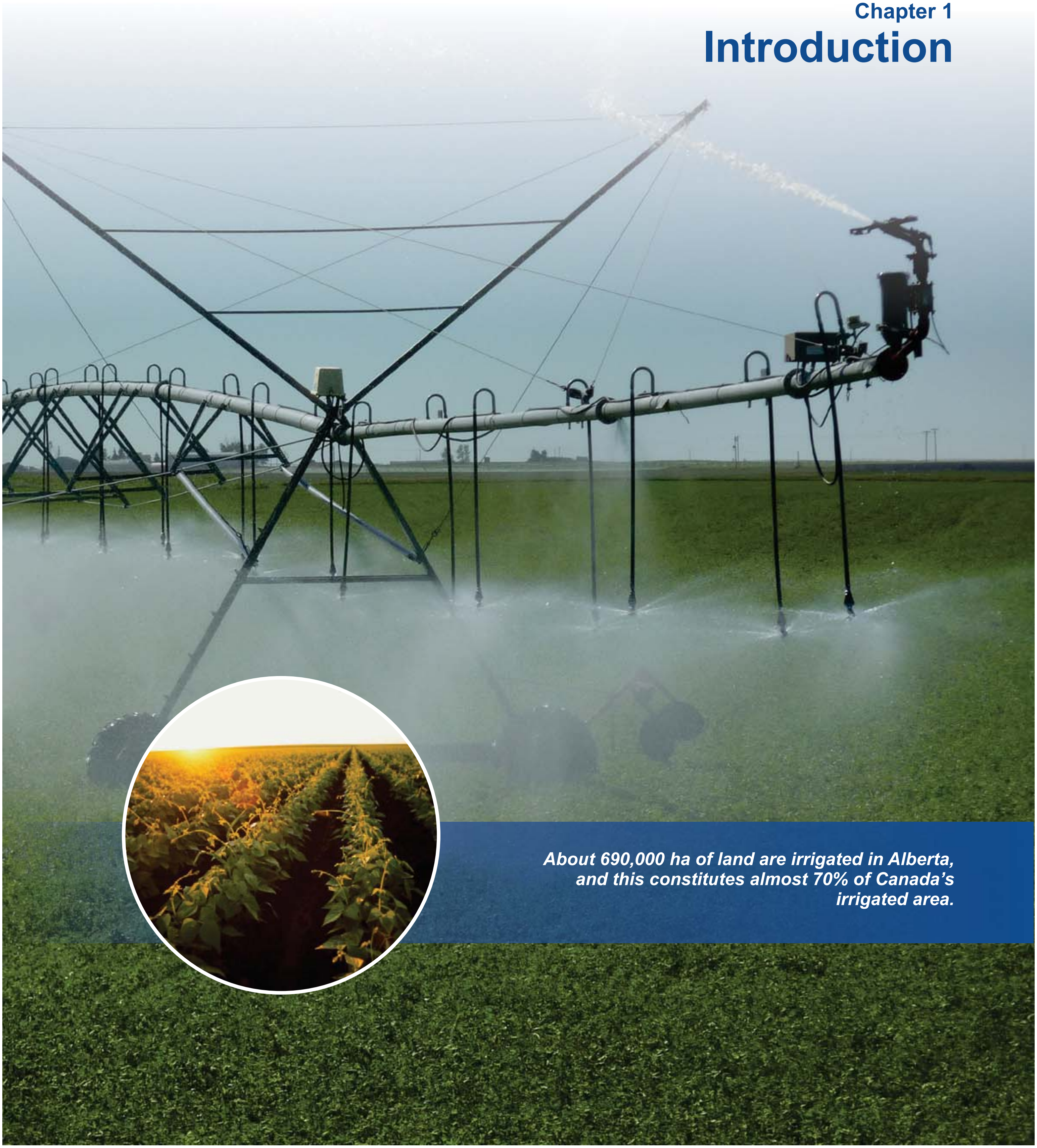
Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction



About 690,000 ha of land are irrigated in Alberta, and this constitutes almost 70% of Canada's irrigated area.

Chapter 1

Introduction

Alberta's irrigation industry plays a significant role in the province's economic and social well-being. As world food demand continues to increase, the province's irrigation industry will play a more prominent global role in feeding the world's population.

About 690,000 hectares of land are irrigated in the province (ARD, 2014b) (Figure 1.1). About 6,000 producers irrigated 566,000 hectares of land within the 13 irrigation districts. An additional 124,000 hectares of irrigation takes place on about 3,000 private projects, ranging in size from a few hectares to several thousand hectares (ARD, 2014b). This constitutes almost 70% of Canada's irrigated area. Almost 98% of Alberta's irrigation takes place in the South Saskatchewan River Basin (SSRB).

Figure 1.1. Location of irrigated areas in Alberta.

1.1 Previous Economic Assessments

Several studies have documented the economic impacts of irrigation in Alberta. It is difficult to directly compare the results of these studies because of differences in methodologies applied. These studies are summarized below.

- **Irrigation Development in Alberta - The Economic Impact (UMA, 1984).**
  - Irrigation activities accounted for approximately $941 million, which was about 2% of the annual GDP in Alberta.
  - Irrigation activities resulted in employment of about 35,000 people. Irrigation-related activities provided gross fiscal revenues to the GOA and GOC of $307 million.
  - The distribution of annual economic benefits resulting from irrigation showed about 15% of the benefits accrue to irrigation water users, 66% to Alberta, and 19% to the rest of Canada.
  - This study confirmed the earlier funding formula established for GOA and irrigation district sharing of infrastructure rehabilitation costs (Appendix A).

- **Irrigation Impact Study. Volume 4 of 7: Economic Input-Output Model Analysis (UMA, 1993).**
  - About 13% of the regional GDP and 19% of the regional production was directly and indirectly linked to irrigated agricultural production.
  - It was estimated that the irrigation sector contributed $2.5 to $3 billion to the regional economy of southern Alberta, and $2.6 to $3.3 billion to the Alberta economy.
  - The irrigation-related activities employed 27,000 to 30,000 people in southern Alberta.
  - At the regional level, the loss of irrigation activity would result in the loss of about 9,600 jobs.

- **Western Irrigation District (WID) Regional Impact Analysis (Russell Consulting, 1998).**
  - The WID generated a total crop production value of $13.4 million and a livestock production value of $130 million.
  - The WID irrigation producers contributed $18.7 million to Alberta's GDP.
  - The regional net economic benefit from irrigation was estimated to be nearly $7 million. Without the WID, the regional agricultural returns would be reduced by approximately 20%.

- **South Saskatchewan River Basin: Irrigation in the 21 Century. Economic Benefits and Opportunities**

Agri-Food: The sum of agricultural production and food processing in a region.

Gross Domestic Product (GDP): A measure of the value of goods and services that becomes available from economic activities. This is estimated using an income approach, which occurs from the gross sale of products minus related expenditures.

Net Economic Benefit: A measure of the gain to an irrigation producer compared to the same conditions as a dryland producer.

(Hart Water Management Consulting, 2001) and Volume 5: Economic Opportunities and Impacts (Irrigation Water Management Study Committee, 2002).

- Irrigation contributed nearly $832 million (18.4%) to Alberta's agri-food GDP, taking into account increases in primary production and forward and backward linkages.
- The value-added incremental contribution of irrigation to Alberta's agri-food GDP was estimated at $927 million annually.
- The irrigation sector was directly or indirectly responsible for the full-time employment of more than 11,000 individuals in 1999.
- Additional benefits included:
  - Supply of potable water for municipal and industrial uses;
  - Recreation and tourism opportunities;
  - Wildlife habitat; and
  - Support for rural business enterprises.
- This study highlighted the need for the GOA to consider more opportunities for irrigation-related investments in the agri-food industry to enhance the economic value of irrigated agriculture in the region.

- **Irrigation Development in Alberta: Water Use and Impact on Regional Development, St. Mary River and "Southern Tributaries" Watersheds (AFRD, 2004).**
  - Irrigation development in southern Alberta brought about agricultural production stability for the region, and increased land productivity by nearly 300% compared with dryland production.
  - The regional population would have been reduced by approximately 65 to 75% in the absence of irrigation activities.
  - The total agricultural benefits generated from irrigation in southern Alberta were more than $5 billion.
  - Irrigation was responsible for more than 13,000 full-time jobs.
  - It estimated that 13% or more of the regional GDP, 19% of regional production, and 30% of regional employment opportunities in southern Alberta were directly or indirectly associated with irrigated agriculture.

- **Enhancing Value Added Food & Agriculture on Irrigated Lands (Bouma, 2007).**
  - Although Alberta has about 82% of the irrigated land in the Prairie region, the province is still faced with obstacles to enhancing the value of agriculture on irrigated lands, particularly from a water-management perspective.
  - The economic contribution of irrigated land to total agricultural production in the province is also still poorly understood, particularly among irrigation water users.

- **Economic Impact of Agriculture in Lethbridge County (Serecon Services Inc., 2014).**
  - The Lethbridge Northern Irrigation District (LNID) is located mainly in Lethbridge County, and includes the most intensive livestock feeding area in Canada.
  - In 2011, Lethbridge County's agricultural sector made a contribution of $1.1 billion to Alberta's economy, with a

corresponding contribution to the provincial GDP of $419 million.

- The major agricultural sub-sectors that had the largest impact on the Alberta economy were the livestock and major field crop sectors.
  - Livestock was responsible for 67% ($758 million annually) of the total economic impact, while crops contributed 33% ($371.4 million annually) to the provincial economy.
  - More than 1,500 workers were added to Alberta's agricultural industry.

1.2 Study Objectives

Much has changed in Alberta's agriculture and irrigation industry since the last comprehensive economic analyses were carried out. It was recognized that an up-to-date assessment of the value of Alberta's irrigation industry is needed to better understand its current and future role in Alberta's economic landscape. The *Economic Value of Irrigation in Alberta* study was implemented to update the economic assessment of the impacts of irrigation on the economy and social well-being of Albertans.

1.3 Study Components

The vision of Alberta Irrigation Projects Association (AIPA) is as follows.

> *"The Irrigation industry will increase its economic contribution to Alberta through the wise and sustainable use of allocated water, to produce food, stimulate economic growth and rural development, and supply water for multi-purpose use, mindful of its need to support aquatic systems restoration, wherever feasible".*

This study recognizes AIPA's vision and the valuable contribution of the irrigation industry to the Alberta economy and well-being of Albertans. The study assessed the economic impact of the irrigation industry on a regional basis as well as on a provincial basis. The following were the key components of the study.

- Evaluation of the economic, environmental, and social impacts that Alberta's irrigation industry has on the Southern Irrigation Region and the province.
- Specific economic objectives assessed the value of irrigation and related infrastructure for:
  - Primary agricultural production (Chapter 5);
  - Backward linkages (Chapter 6);
  - Forward linkages (Chapter 6); and
  - Government revenues (Chapter 7).
- Other agricultural and non-agricultural benefits of irrigation were also assessed (Chapter 8).
- Overall cumulative economic impacts of irrigation in Alberta were developed (Chapter 9).
- Opportunities to strengthen the future value of Alberta's irrigation industry, and challenges related to climate change and the growing demand for water in the province (Chapter 10).

This study included all commercial irrigation systems related to the production of agricultural commodities, except for production in greenhouses. It did not include operations such as golf courses. The economic assessment was carried out on all lands that were actually irrigated from 2000 to 2011 within the 13 irrigation districts, as well as private irrigation projects throughout Alberta.

The actual irrigated area averaged 600,795 hectares from 2000 to 2011, and this area amounted to 4.7% of Alberta's cultivated land base (ARD, 2012a). This included 491,017 hectares within the irrigation districts and 109,778 hectares in private projects. Since nearly all of Alberta's irrigation development occurred within the SSRB, most of this study was focussed on that basin.

Chapter 2

Setting the Stage

It is projected that the world's population will increase to more than 9 billion people by 2050.

Chapter 2

Setting The Stage

2.1 Demand for Food

The world's population is projected to grow from the current seven billion people to about 9.2 billion by 2050 (Figure 2.1). Agricultural production will need to increase by 70 to 100% to meet the resultant growing demand for food (FAO, 2011). This translates to an additional one billion tonnes of cereal grains and 200 million tonnes of livestock products that will need to be produced each year (Bruinsma, 2009).

While part of this increased demand is related to population growth, other key factors include a rise in global per capita food consumption (Figure 2.2) and changing diets in many developing countries related to economic improvement and rising incomes. Per capita consumption of cereals continues to decline, while consumption of meat and dairy products are growing. It is projected that world meat consumption will expand from 24.2 kg/capita/year (1964-1966) to 45.3 kg/capita/year by 2030 (FAO, 2003), an increase of almost 90%. Most of this change will take place in developing countries. Cereal production for animal feed accounts for about 50% of the projected 70% increase in demand for cereals in developing countries from 1997/99 to 2030 (FAO, 2004).

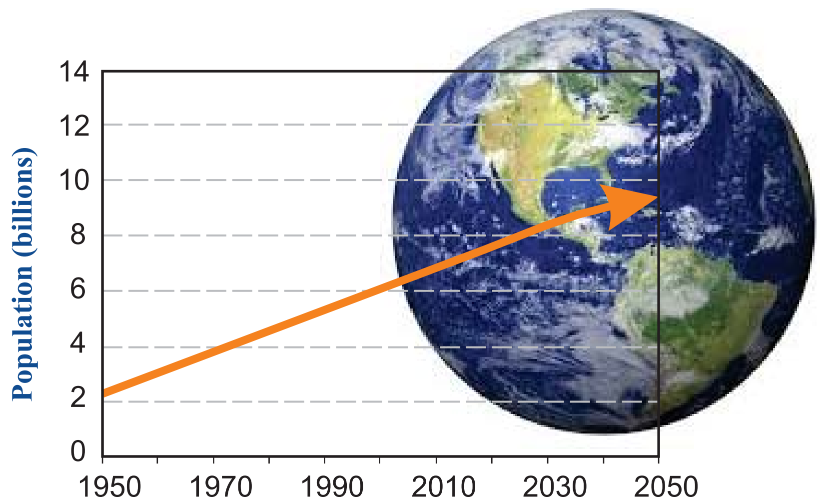


Figure 2.1. Projected world population growth (United Nations, 2009).

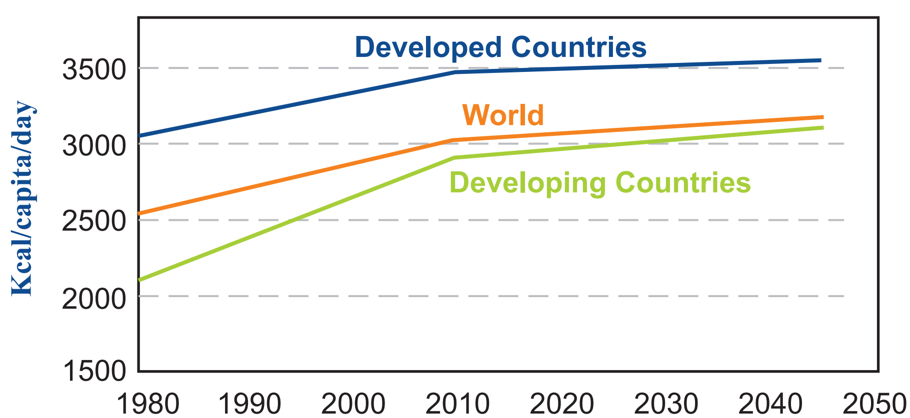


Figure 2.2. Global food consumption (1980 to 2050) (FAO, 2003).

2.2 Food Production

Cereal production in many developing countries is not expected to keep up with demand, and net cereal deficits in these countries could rise to 265 million tonnes by 2030 (FAO, 2003).

1.0 km^3 = 1.0 billion m^3

Many countries with rapidly growing populations will have to increase their imports of cereals to meet the rising demand.

Global agricultural food production is practised on about 1.6 billion hectares, which is about 11% of the world's total land area. About 20% (300 million hectares) of the agricultural land base is under some form of irrigation, while the remaining 1.3 billion hectares is under dryland agriculture. The dryland agricultural areas provide about 60% of the global crop output, while the irrigated regions provide almost 40% (FAO, 2011).

2.3 Water Supply

During the last 50 years, world agricultural production grew by 2.5 to 3 times, with more than 40% of that increase attributed to irrigated agriculture. While irrigation agriculture accounts for 70% of all water withdrawn from rivers, lakes, and groundwater aquifers, it is expected to play a dominant role in the future growth in crop production to meet projected food demands, particularly in many of the developing countries (United Nations Water Assessment Programme, 2015). Achieving this will require an increase in water use for irrigation by about 10% by 2050. Future global water withdrawal for irrigated agriculture is expected to increase from 2,743 cubic kilometres in 2008 to 3,858 cubic kilometres in 2050 (United Nations, 2012). Much of the increase in irrigation water consumption will be in regions already suffering from water scarcity.

In many areas that utilize groundwater for irrigation, declining aquifer levels will present an ever-increasing risk to regional food production. Competition for water from non-irrigation sectors is taxing already limited supplies, and will likely result in water being transferred from the irrigation sector to meet these needs.

Water scarcity is a current reality for up to 25% of the world's population, and up to 67% will face moderate to severe water scarcity by 2025 (Figure 2.3). As demand for water grows, more countries may be unable to feed themselves with the amount of water they have available, and will thus have to make trade-offs in their economic, agriculture, and trade policies.

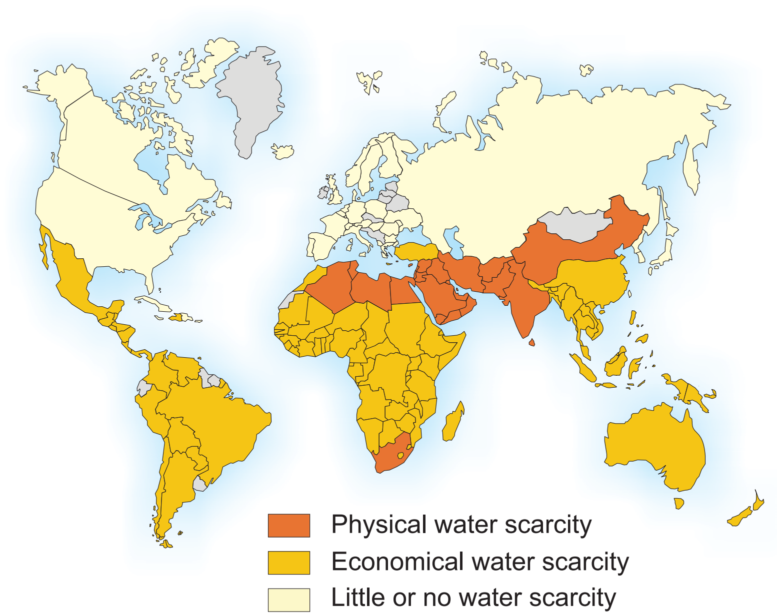


Figure 2.3. Projected global water scarcity by 2025 (Seckler et al., 1998).

Movement of water among countries as "virtual water" will become an increasingly important requirement for water-short countries to sustain their food supply. Countries trade virtual water through food and other products rather than physically transporting water itself. This makes limited water supplies available for other uses and saves money needed to transport water.

2.4 Future Food Production

Global food sales are worth about $1.3 trillion per year, and are expected to grow significantly in the future. Nine of the world's 193 countries (Argentina, Australia, Brazil, Canada, France, Russia, Thailand, United States, and Vietnam) exported about 67% of the key global food products (Figure 2.4). In the future, only five countries will have the ability to significantly increase food production for export: Argentina, Brazil, Canada, Russia, and the United States (Schreier and Wood, 2013).

Canada, with a large arable land base, small population, ample precipitation, skilled agricultural producers, resource-rich environment, and reliable infrastructure, is well-positioned to take advantage of the growing world markets in grains and meat products. Alberta is unique in having a strong dryland agricultural industry and a world-class irrigation industry. This combination provides opportunities for crop and livestock diversification that many other regions of Canada do not possess.

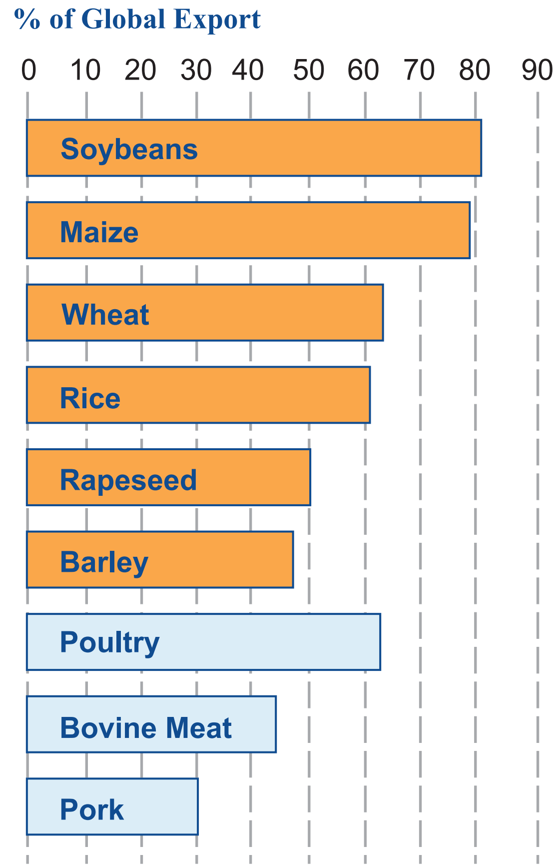
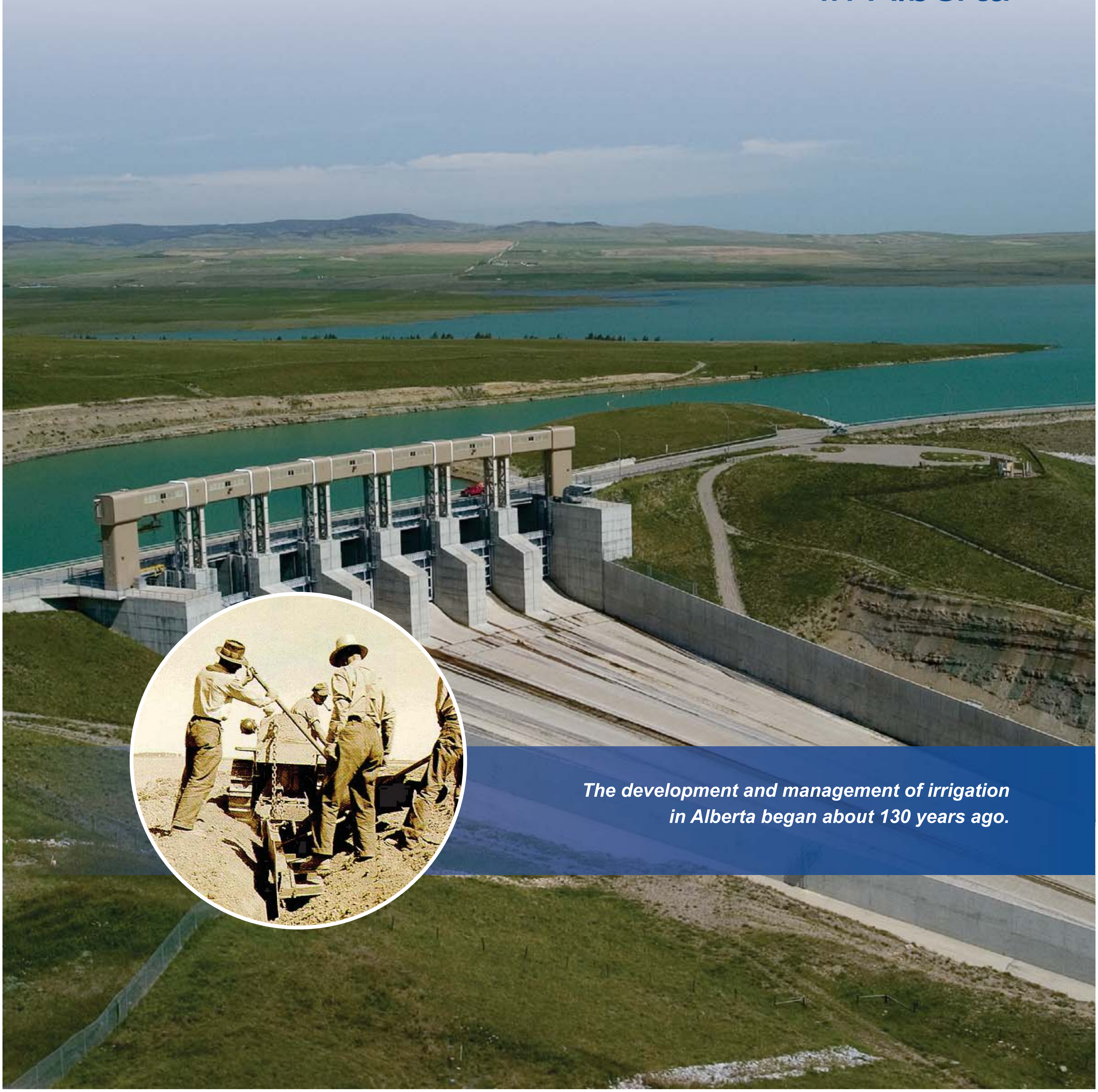


Figure 2.4. Percent of global exports by nine countries in 2010 (Argentina, Australia, Brazil, Canada, France, Russia, Thailand, United States, and Vietnam) (Schreier and Wood, 2013).

Chapter 3

Water Management and Irrigation in Alberta



The development and management of irrigation in Alberta began about 130 years ago.

Chapter 3

Water Management and Irrigation in Alberta

3.1 Water Management

The development and management of irrigation in Alberta began about 130 years ago. Decisions made in those formative years continue to play an important role in today's management of water resources and irrigation. More detail on the subject is in Appendix A.

As settlement began on the Prairies, farmers were quick to realize the need for and benefits of irrigation in increasing and stabilizing crop yields. William Pearce, a federal government resource management official located in the Canada's Northwest Territories in the late 1800s, saw irrigated agriculture as a key factor in stimulating settlement on the arid Canadian Prairies.

Using great foresight, Dominion resource managers developed water management legislation to control the orderly use and distribution of water that would encourage investment in irrigation infrastructure, protect the investment of corporate enterprise and individual developers, and result in the greatest public good. Key elements of the *Northwest Irrigation Act* (1894) were as follows.

- Changes to British Common Law riparian rights.
- Declaration that water was the property of the Crown.
- Provision for individuals or corporations to obtain the right to use water upon compliance with provisions of the *Act* and approval of government.
- A priority system based on the principal of prior allocation, often referred to as "first-in-time, first-in-right".

These basic principles of the 1894 *Act* remain and are still in force today.

Early irrigation in Alberta.

In 1915, the province passed the *Irrigation Districts Act,* providing the mechanism for co-operative farmer-owned, -financed, and -operated irrigation districts. Irrigation districts proved to be the most effective administrative bodies for day-to-day management of irrigation projects.

Governments' active involvement in irrigation and water management increased producer confidence in irrigation and stimulated growth. Following are key actions taken by the GOA and GOC.

- The GOC and GOA participated in operation, rehabilitation, and expansion of irrigation district infrastructure from 1950 to 1970.
- In 1968, the GOA announced a cost share program for ongoing rehabilitation and maintenance of district irrigation infrastructure. The cost sharing arrangement recognized that the benefits of irrigation extended beyond the farm gate to other members of society.
- In 1973, the GOA assumed responsibility for ownership, rehabilitation, operation, and maintenance of irrigation headworks (works required to divert water from source-rivers and convey it to the districts). This helped stimulate growth of irrigation districts and provided for multi-purpose use and operational flexibility.
- In 1980, the GOA made the decision to construct the Oldman River Dam and Reservoir, which increased water supply security for irrigation districts and many other water users.

The *Water Act* (GOA, 1999) shifted the focus from supply management to protection of the aquatic and riparian ecosystems, and sustainable resource development. Key provisions of the *Act* are as follows:

- Provisions for establishing Water Conservation Objectives (WCOs) for protection of aquatic and riparian ecosystems;
- Provisions for reserving unallocated water for specific uses or for instream protection. This resulted in Alberta Regulation 171/2007 (GOA, 2007b), which reserved all unallocated water in the Bow, Oldman, and South Saskatchewan Sub-basins, and stipulated that reserved water may be allocated only for:
    - Use by First Nations,
    - Contributing toward meeting WCOs,
    - Meeting existing and outstanding water licences, and
    - Storage to mitigate impacts on the aquatic environment and to support existing water licences;
- The ability to manage water, recognizing specific characteristics of a river basin or aquifer, and local and regional issues;
- Provision for water allocation transfers to allow new or alternative uses of water; and
- The ability to share available water supplies in water-short years through assignment provisions of the *Act*.

The *Irrigation Districts Act* (GOA, 2000b) provided updated legislation for the formation and governance of Alberta's 13 irrigation districts and provided for the efficient management and delivery of water to meet the needs of all users.

3.2 Hydrology

Annual average precipitation in the South Saskatchewan River Basin (SSRB) is highly variable, ranging from a high of up to 900 millimetres in sub-alpine regions of the Rocky Mountains to a low of 300 millimetres in the mixed grassland regions of the eastern part of the basin (AMEC, 2009). The stream flow characteristics of the main rivers in the SSRB are largely influenced by the extent of the respective watersheds that are located in the high mountainous and foothills regions.

3.3 Irrigation in Alberta

Irrigation is currently practiced on about 690,000 hectares throughout Alberta, and this represents about 5% of Alberta's cultivated land base (ARD, 2014b). This includes about 566,000 hectares within the 13 irrigation districts in the SSRB and about 124,000 hectares in private projects throughout Alberta. The private irrigation includes 2,893 projects developed and operated by individual producers or enterprises, each with their own irrigation works and water licences (Table 3.1).

The Blood Tribe Irrigation Project (BTAP), located on the Kainai Reserve in southern Alberta, is the largest private irrigation project in North America. The 10,000-hectare project was incorporated on June 25, 1991, to “promote, encourage, and enhance agricultural investment in the Blood Tribe, and to create incentives for job creation” (Aboriginal Affairs and Northern Development Canada, 2013).

Three other private irrigation projects made possible by provincial water storage development are:

1. Willow Creek project, supported by Pine Coulee Reservoir (5,263 hectares);
2. Highwood/Little Bow Project, supported by Twin Valley Reservoir and a diversion from the Highwood River (8,000 hectares); and
3. Sheerness/Deadfish Diversion Project, supported by Berry Creek and Forster Reservoirs, and two diversions from the Red Deer River (potential for 6,500 hectares).

The assessed area in irrigation districts increased from 526,000 hectares in 2000 to about 555,000 hectares in 2011, an increase of 5.4% (ARD, 2012a). The private irrigation area increased from about 113,000 hectares in 2000 to 126,000 hectares in 2011, an increase of about 11%.

Snow is the lifeblood of irrigation in Alberta, particularly for the 13 irrigation districts. Spring snowmelt is stored in five on-stream and about 45 off-stream reservoirs, owned and operated by the GOA or the irrigation districts. These on-stream and off-stream reservoirs have a total water storage capacity of about 3 billion m^3, and supply irrigation water through almost 8,000 km of canals and pipelines. The entire storage and distribution system is worth about $3.6 billion (ARD, 2014b).

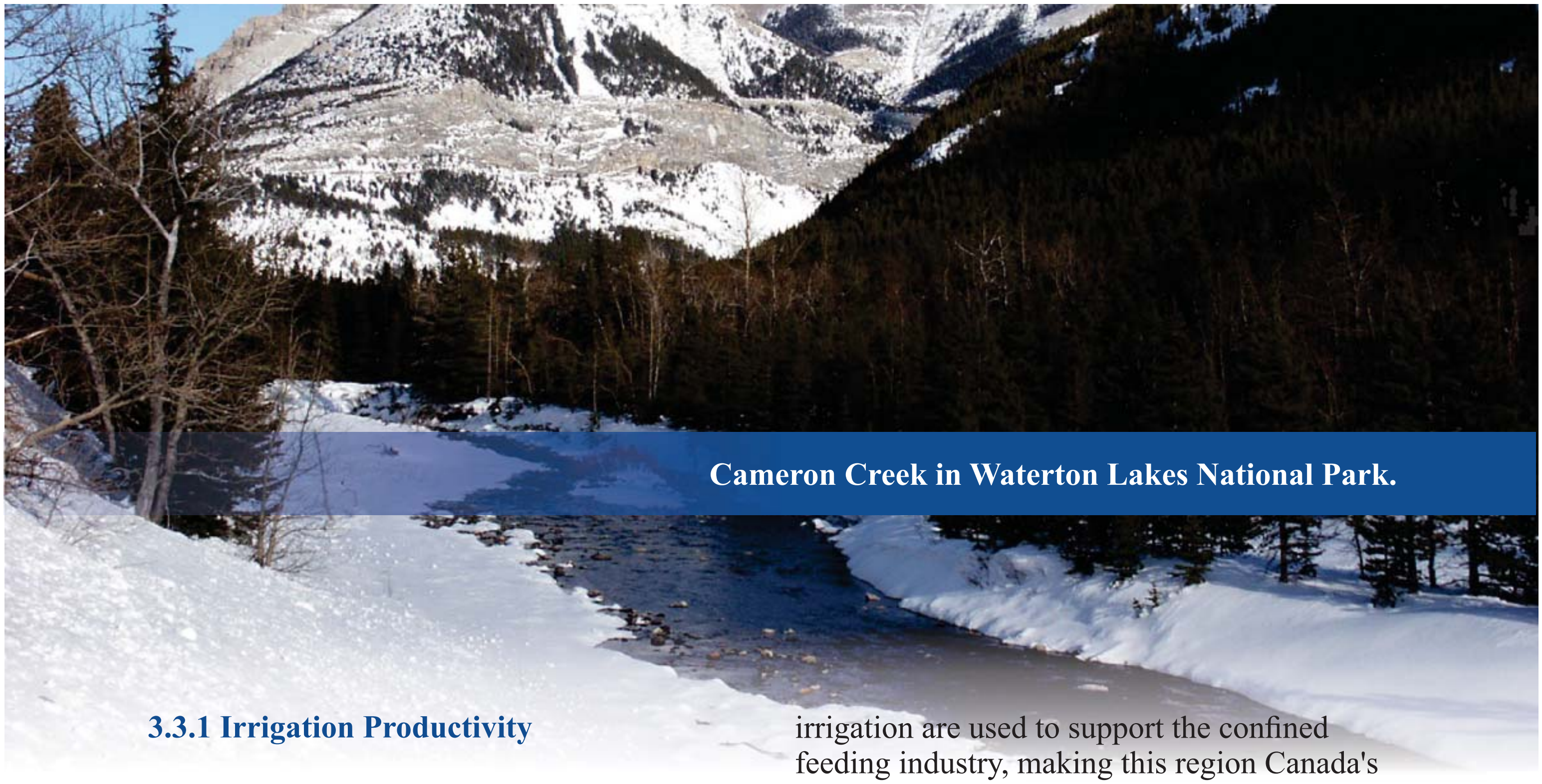
Assessed Area: land within one of the 13 irrigation districts for which a water rate has been assessed.

Irrigated Area: area actually irrigated in any given year - often 10% lower than the assessed area because of crop rotations, weather conditions, or economic circumstances.

Private Licensed Area: is the area defined in private water licence applications.

Table 3.1. Private irrigated area by river basin and size (2013) (ARD, 2014a).

River Basin	Total Licensed Area (ha)	Licences for 1 to 40 ha	Licences for 40 to 120 ha	Licences for >120 ha	Total Licences
Athabasca River	794	43	6	0	49
Milk River	7,520	97	43	14	154
North Sask. River	10,826	314	55	15	384
Peace River	1,345	67	9	0	76
South Sask. River	103,615	1,598	493	139	2,230
Total	124,100	2,119	606	168	2,893



Cameron Creek in Waterton Lakes National Park.

3.3.1 Irrigation Productivity

Alberta's irrigated land base has a number of significant impacts on farm production in Alberta.

Crop Diversification. More than 60 crop varieties are grown under irrigation in Alberta, including 28 specialty crops. These high-value crops are grown mainly in the irrigation districts, and include potatoes, hybrid canola seed, dry beans, sugar beets, and a variety of fresh vegetable crops. Irrigated crops grown in Alberta are shown, by area, in Figure 3.1 (ARD, 2012a).

Many of these irrigated crops are processed into value-added products that are consumed nationally and exported for international use. Processing facilities provide employment and economic opportunities for the region. Major potato processing plants such as Lamb-Weston, McCain, Cavendish Farms, Frito-Lay, and Old Dutch rely on potatoes grown under irrigation.

The irrigated area has also made southern Alberta the world capital for seed canola production. Forage and silage produced under irrigation are used to support the confined feeding industry, making this region Canada's leader in cattle feeding and processing.

In comparison, crops grown under dryland are mainly cereals and oilseeds, with cereals comprising more than 50% of the total cropped area (ARD, 2011c). Wheat (spring and durum) is grown on about 26% of the total dryland area, while barley and other cereals make up slightly more than 26% of the total area. Canola makes up about 18%.

During the past 30 years, increased average temperatures combined with improved crop genetics and irrigation management technologies have been factors in increasing the variety of irrigated crops being grown. For

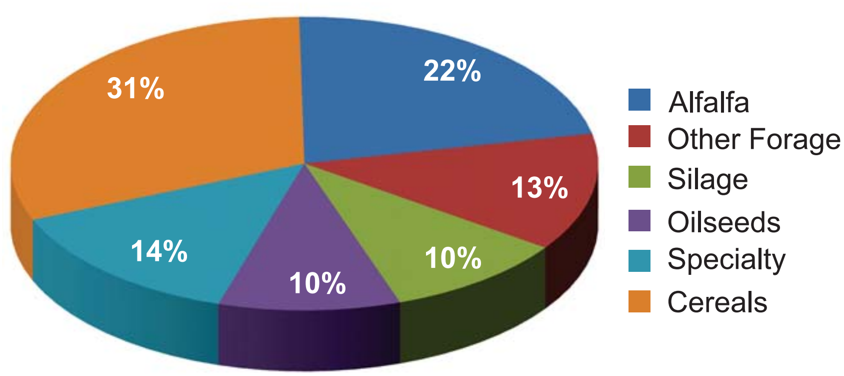


Figure 3.1. Distribution of irrigated crop varieties in Alberta (ARD, 2012a).

example, almost 26,000 hectares of irrigated corn silage are now being grown in southern Alberta in place of barley silage for the intensive livestock feeding industry, compared to about 12,000 hectares of corn silage in 2000 (ARD, 2001; 2014b). Corn silage has greater energy levels as a feed supply than barley silage, and further increases are likely in the future (Gabruch and Gietz, 2014).

Crop Yields. From 2000 to 2011, average irrigated crop yields were significantly greater than provincial dryland yields (AFSC, 2012; 2015). For the drier regions of southern Alberta, the difference between irrigation and dryland crop yields are much greater. In addition to yield advantages, crops grown under irrigation also provide increased production stability compared with dryland production, and this provides greater on-farm stability and confidence in meeting production contracts with food processors.

Improvements in water management, crop protection, agronomic practices, and crop breeding have led to an increase in irrigated cereal crop yield of approximately 30% during the past 30 years (Ross McKenzie, ARD, personal communication, 2011 – in Woods, 2012). From 1980 to 2013, the irrigation productivity index has increased from about four kilograms of dry matter per cubic metre of water to 12 kilograms of dry matter per cubic metre of water (Figure 3.2). This index was developed using historical yields of sugar beets (Alberta Sugar Beet Growers), potatoes (Potato Growers of Alberta), and soft white spring wheat (Alberta Soft Wheat Growers) (ARD, 2014c).

Advances in hybrid canola breeding have led to a 50% increase in the yield of this irrigated crop in the past decade (Ross McKenzie, ARD, personal communication, 2011 – in Woods, 2012). Woods (2012) assessed current and potential crop yields for 13 irrigated crops that made up about 80% of Alberta's irrigation districts in 2010 (Table 3.2).

While increases in crop yields are important, increasing emphasis is being placed on improving crop quality. Food processors are demanding a higher quality product from producers for their food processing plants throughout Alberta. For example, Lantic Inc. (Taber, Alberta), which processes irrigated sugar beets, began paying producers on the basis of sugar content, rather than yield. This provided the incentive for producers to pay closer attention to management of irrigation water and agronomic inputs. This resulted in an increase in yield and sugar content of the sugar beets. In 2011, the sugar beet crop was rated as the highest quality crop in Alberta's history (ARD, 2013d).

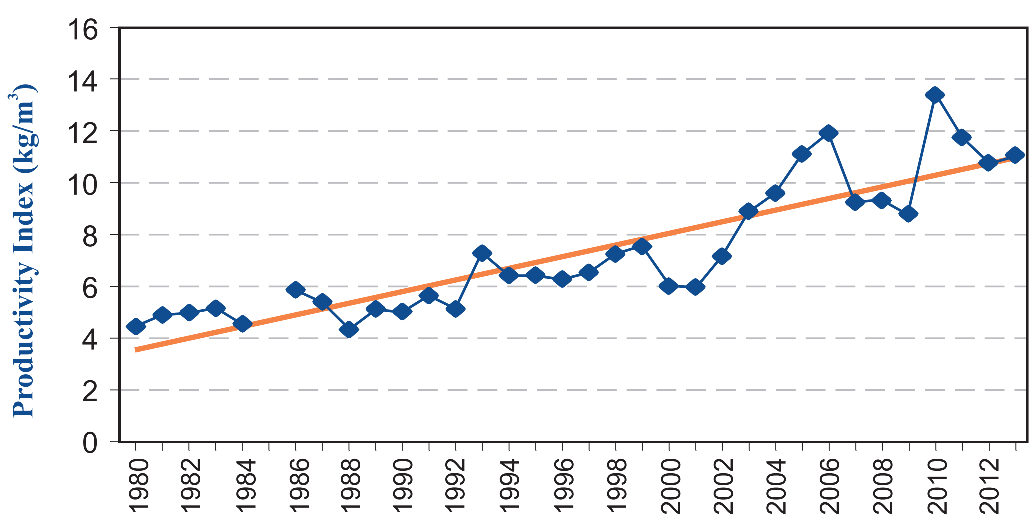


Figure 3.2. Irrigation district water-use productivity index (1980 to 2013) (ARD, 2014c).

Table 3.2. Maximum typical and potential irrigated crop yields in southern Alberta.

Irrigated Crop	Area Seeded in 2010 (ha)	Current Yield (t/ha)	Potential Yield (t/ha)	Ratio of Current to Potential Yield (%)
Hard Spring Wheat	73,436	6.3[z]	7.8[y]	80
Canola	68,842	3.3[z]	3.9[y]	83
Alfalfa Hay	66,219	13.4[z]	18.0[y]	74
Tame Pasture	44,152	4.5[x]	7.8[x]	58
Barley Grain	41,031	6.0[z]	7.3[y]	83
Barley Silage	30,149	20.0[z]	31.4[z,y]	63.5
Corn Silage	23,911	33.7[z]	44.8[z,y]	75
Dry Bean	19,077	2.8[z]	3.6[y]	78
Potato	14,718	51.5[z]	67.2[y]	76.5
Sugar Beet	12,888	51.1[w]	81.5[w]	75
Durum Wheat	12,663	6.7[z]	8.1[z]	83
Alfalfa Silage	12,105	10.0[v]	12.0[v]	83
Grass Hay	11,833	10.1[z]	13.4[y]	75.5
Total Area	431,024			

[z] Source: Ross McKenzie, ARD, personal communication (2011); Woods (2012).
[y] Source: Bennett and Harms (2011); Woods (2012).
[x] Source: Lynn Fitzpatrick, ESRD, personal communication (2011); Woods (2012).
[w] Source: Five-year (2006 to 2010) means of average annual yield and top grower yield, Alberta Sugar Beet Growers (2006; 2007; 2008; 2009; and 2010) in Woods (2012).
[v] Source: Surya Acharya, Agriculture and Agri-Food Canada, personal communication. (2011); Woods (2012).

Other specialty crop processors in Alberta are also demanding that producers grow a higher quality product for processing. Environmental sustainability will also be a significant factor in crop production. Consumers are placing increasing pressure on food processors and irrigation producers to ensure that the quality of irrigation water used to grow crops meets acceptable guidelines. Irrigation districts are taking a leadership role in assessing the quality of water distributed and supplied to irrigation producers.

Livestock. Irrigated agriculture supports a significant livestock industry, particularly intensive livestock feeding operations. Irrigation ensures a consistent supply of irrigated forage, silage, and water for the livestock operations. Many of the livestock feeding operations support ranchers and dryland farmers through purchase of calves and feed grains.

The beef feedlot industry is the most intensive component of the beef production chain, where a significant portion of value is added (ACFA, 2014). The value-added chain is extended through meat packers and processors. In 2013, there were about 970,000 cattle on feed in Alberta, and this is about 69% of Canada's fed cattle production (ACFA, 2014). About 60% of the province's feeder cattle are associated with irrigated farms (IWMSC, 2002; ACFA, 2014).

Value-added Food Processing. Irrigation reduces risks to value-added companies through a relatively assured water supply and the production of high-quality crops and livestock. This promoted the establishment of food processing companies in Alberta seeking to serve local, national, and international markets. These industries in return provided ready market access for irrigation producers, and provided additional income and job opportunities for Alberta citizens.

Major processing plants are associated with irrigated areas, ensuring ready and dependable availability of speciality crop inputs central to their operations. Following are examples of major processing plants that utilize irrigated produce from Alberta.

- **Lantic Inc.** About 11,000 hectares of sugar beets are grown on irrigated fields as the primary input into sugar production. Lantic Inc. (Rogers Sugar) is in Taber and is entirely dependent on local sugar beet production. About 200 production contracts are arranged with 150 growers each year. In addition to irrigated sugar beets, the company uses approximately 600,000 m^3 of water per year, delivered by the Taber Irrigation District infrastructure, for plant operations. The company employs 100 people full time, another 150 people at harvest, and an additional 50 to 70 people when processing is in operation.
- **Lamb-Weston Inc.** About 17,000 hectares of potatoes are grown on irrigated fields in support of potato processing. Lamb-Weston processes irrigated potatoes into frozen potato products. The plant also depends on water supplied through the Taber Irrigation District for its operation (ARD, 2013c). The Lamb-Weston plant employs approximately 200 people.
- **McCain Foods Ltd.** McCain Foods is the world's largest manufacturer of frozen potato products. One of their processing facilities is located east of Coaldale, and is similar in size to the Lamb-Weston facility.
- **Cavendish Farms.** Cavendish Farms is also a producer of frozen potato products and supplies clients throughout the world. In 2012, Cavendish Farms acquired Maple Leaf Foods Inc.'s potato processing facility in Lethbridge. It employs 135 staff at the Lethbridge facility.
- **Old Dutch Foods Ltd.** The company operates plants in Calgary and Airdrie, specializing in the potato chip and associated snack market.
- **Viterra Inc.** Viterra Inc. is located in Bow Island and processes 18,000 hectares of irrigated dry beans and 5,000 hectares of dry peas. The company also processes chickpeas and lentils.
- **Spitz Canada.** This company was originally started by Tom Droog in Bow Island to process and market sunflower seeds grown under irrigation in southeastern Alberta. The company moved to a larger processing facility near Medicine Hat, and was sold to PepsiCo in 2008. It has captured more than 75% of the Canadian sunflower confection seed market, and is the number three selling brand in the United States (Alberta Treasury Branch, 2013).

Irrigated sugar beets.

3.3.2 Irrigation Conservation and Efficiency

The irrigation districts and irrigation producers began to focus significant attention on improving water-use efficiency during the 1990s. Their initiatives were accentuated when the *Water for Life Strategy* (GOA, 2003b) called for improvements to overall water conservation, efficiency, and productivity by 30% from 2005 levels, by 2015. The irrigation districts commissioned a conservation, efficiency, and productivity assessment report for the irrigation sector (AECOM Canada Ltd., 2009).

Irrigation districts have been very successful in improving irrigation district conveyance efficiencies. A key initiative was the replacement of earth canals with buried pipelines. Of the approximately 8,000 kilometres of distribution canals, about 50% are now in buried pipelines (ARD, 2014b). This reduced water losses due to seepage and evaporation, returned valuable irrigation land back to agricultural productivity, and played a role in irrigation producers investing in more efficient on-farm irrigation systems. Soil salinity and waterlogging problems have essentially been eliminated in the irrigation districts (ARD, 2014a).

Current improvements to irrigation infrastructure resulted in annual water savings of about 47 million m^3/year through reduced canal seepage and 2.4 million m^3/year through reduced canal evaporation (ARD, 2014a).

The efficiency of on-farm irrigation systems in Alberta has improved significantly since irrigation development began. Most producers have switched to state-of-the-art low pressure, drop-tube pivot irrigation systems. These systems are more efficient and use significantly less energy than other sprinkler systems. In 2013, about 70% of the irrigated area in the irrigation districts used these irrigation systems (ARD, 2014b) (Figure 3.3). On-farm irrigation improvements have increased efficiency in Alberta from about 35% in 1965 to almost 75% in 2010, and this is considerably greater than the world average efficiency of about 44% (FAO, 2011).

From 1999 to 2012, Alberta's irrigation producers invested about $375 million in improvements to on-farm irrigation infrastructure, with most investments going to purchase the most efficient low-pressure, drop-tube pivot systems (Bennett et al., 2013). It is projected that on-farm irrigation efficiency could increase to at least 85% by 2025 as new higher efficiency sprinkler nozzles and improved irrigation management technologies are adopted by producers (ARD, 2014a).

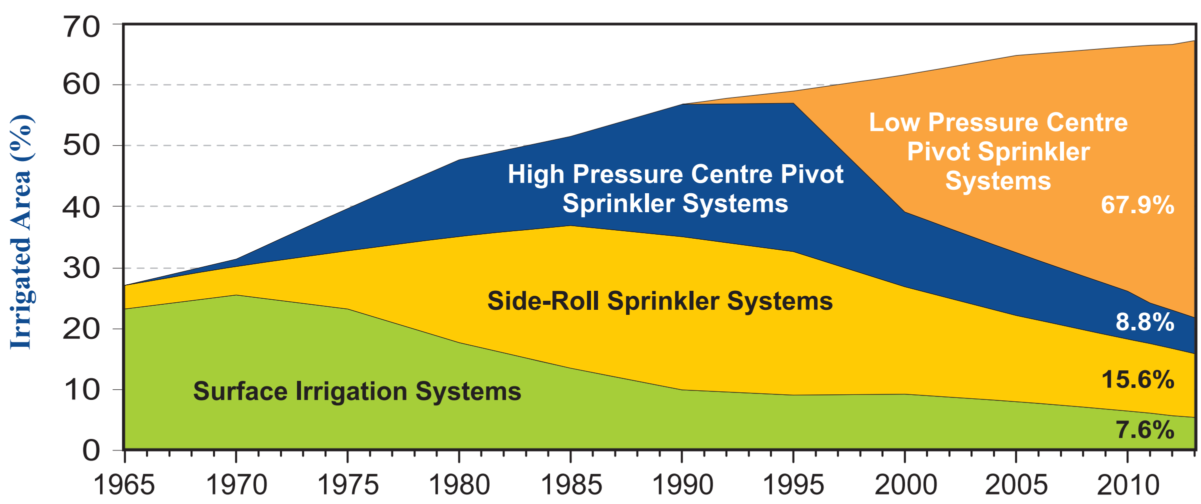
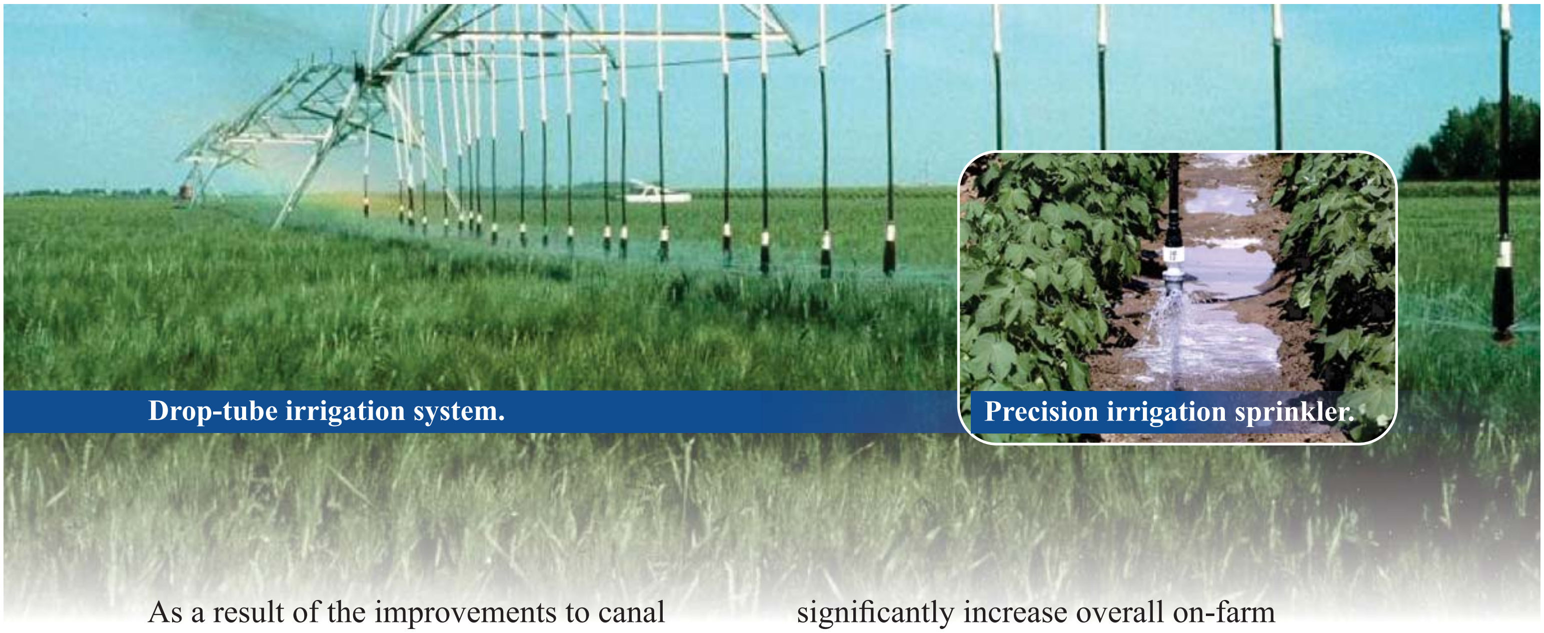


Figure 3.3. Changes in on-farm irrigation systems in the 13 irrigation districts (1965 to 2013) (ARD, 2014b).



As a result of the improvements to canal distribution infrastructure and on-farm water-use efficiencies, the average annual depth of irrigation water diverted to irrigation districts has been reduced from about 600 millimetres in 1985 to about 300 millimetres in 2013 (Figure 3.4). From 1999 to 2012, gross irrigation demand was reduced by about 200 million cubic metres (Bennett et al., 2015). Efficiency gains, combined with improved crop management technologies, will result in further reduction in water use and increased yields.

3.4 Future Expansion

Ongoing adoption of improved on-farm irrigation systems by producers will significantly increase overall on-farm irrigation water-use efficiencies. The combined water savings could provide sufficient water for irrigation districts to expand by an additional 70,000 hectares in the SSRB, without any additional water allocation (ARD, 2014a).

Private irrigation development has leveled off during the past few decades because of water supply restrictions and closure of the Bow, Oldman, and South Saskatchewan Sub-basins to new water-licence applications. Significant private expansion is not expected to occur in these sub-basins. It is unknown whether planned water supply and irrigation projects on the Red Deer River (Special Areas Water Supply Project and Acadia Valley Project) will receive the necessary funding to proceed.

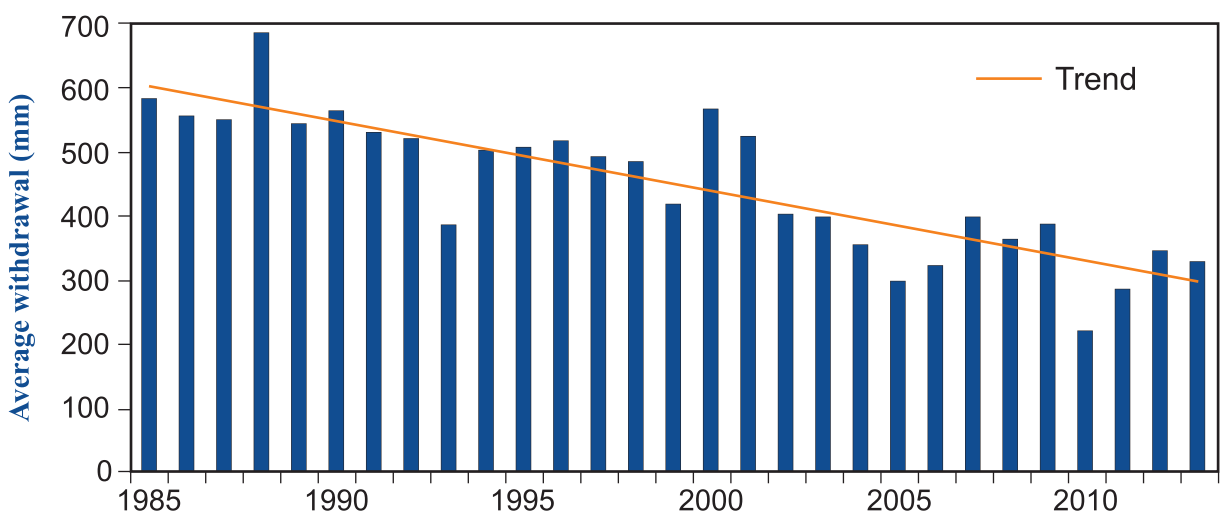
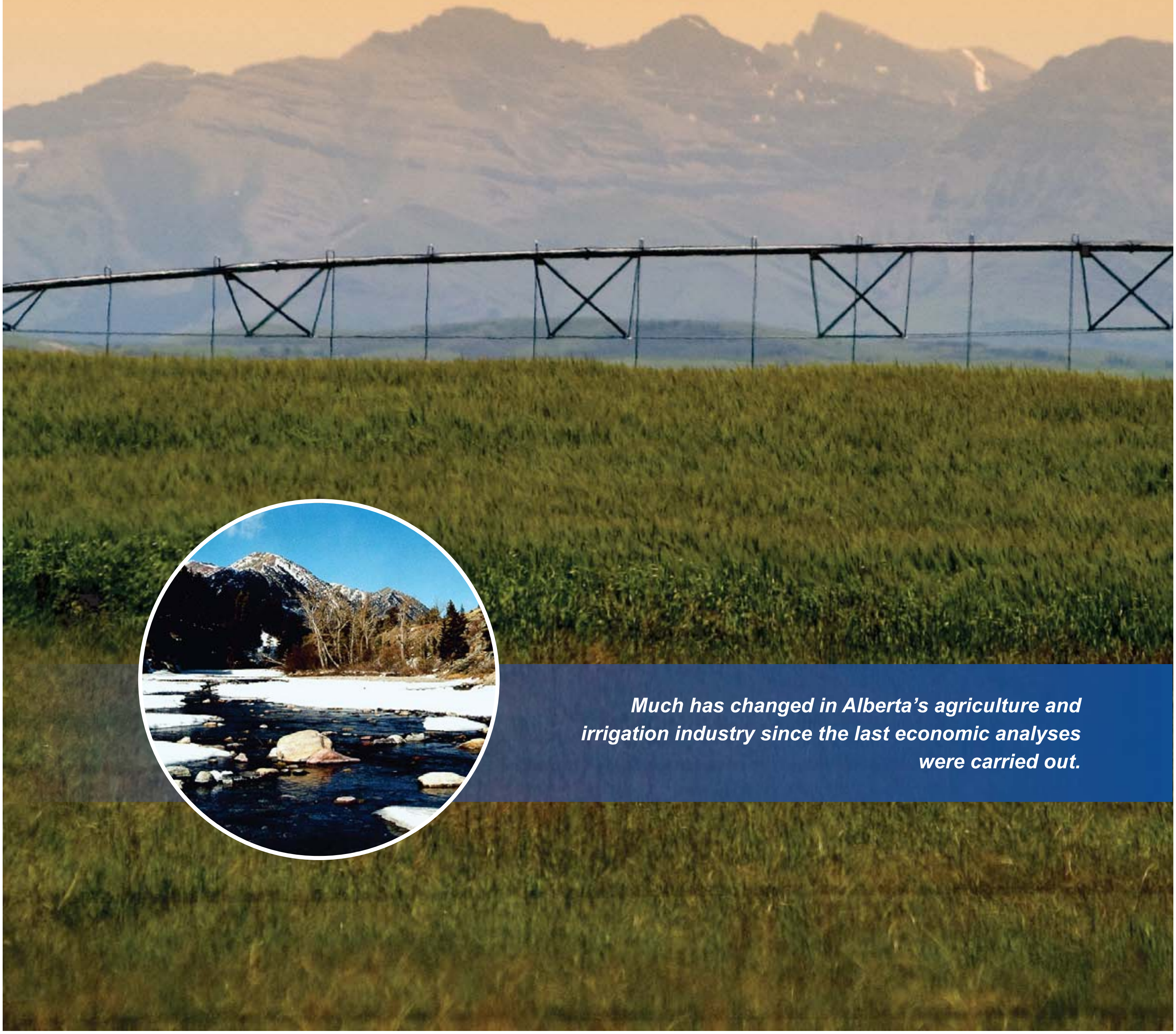


Figure 3.4. Irrigation district average annual withdrawals from source streams (1985 to 2013) (ARD, 2014b).

Chapter 4

Background and General Methodology



Much has changed in Alberta's agriculture and irrigation industry since the last economic analyses were carried out.

Chapter 4

Background and General Methodology

4.1 Methodology

This study linked the total economic impacts of irrigation related to the economic activities irrigation generated in Alberta. Some of these impacts are created by irrigation directly, while others are more indirect. The study methodology included a combination of qualitative and quantitative methods. A general description of the methodology used is presented here, with more specific details presented in later sections. This study used data from 2000 to 2011.

Six types of impacts were assessed in this study.

- **Direct impacts of farm-level irrigation activities.**

  The direct contribution of irrigation was measured using the following criteria:
  1. Value of sales (measured as gross farm income) and
  2. Employment.
- **Indirect impacts created through backward linkages.**

  These were generated through sale of inputs (goods and services) required for irrigation production. This included seed, feed, fertilizer, pesticides, machinery, irrigation equipment, and agronomic services.
- **Induced impacts created through backward linkages.**

  Businesses that sell goods and services to irrigation producers experience additional demand for their products and invest money to meet this demand. This creates additional economic activity.
- **Indirect impacts generated though forward linkages.**

  This relates to industries that purchase inputs from irrigation, and add further value to these inputs. This supports other industries in the region, thereby creating additional sales of goods and services.
- **Induced impacts created by forward linkages.**

  This relates to the additional economic activity created by the industries (above) that pay wages and salaries to workers, and retain a part of the gross sales as unincorporated profits.
- **Other quantitative or qualitative impacts of irrigation on society.**

  These include benefits to the environment, municipalities, dryland producers, industries, and the public-at-large.

Figure 4.1 shows the linkages among the irrigation components, and how these components fit into the assessment of the economic value of irrigation.

The quantitative methods of analysis in this study included development and use of three interlinked computer models.

1. **Irrigation Benefits Simulator Model (IBSM).** This model assessed farm-level economic impacts of irrigation. The model is further described in Section 4.2 and Appendix B.
2. **Alberta Regional Input-Output Model (ARIOM).** This model assessed secondary economic impacts of irrigated production activities, either related or induced. It is described in Section 4.3 and Appendix C.

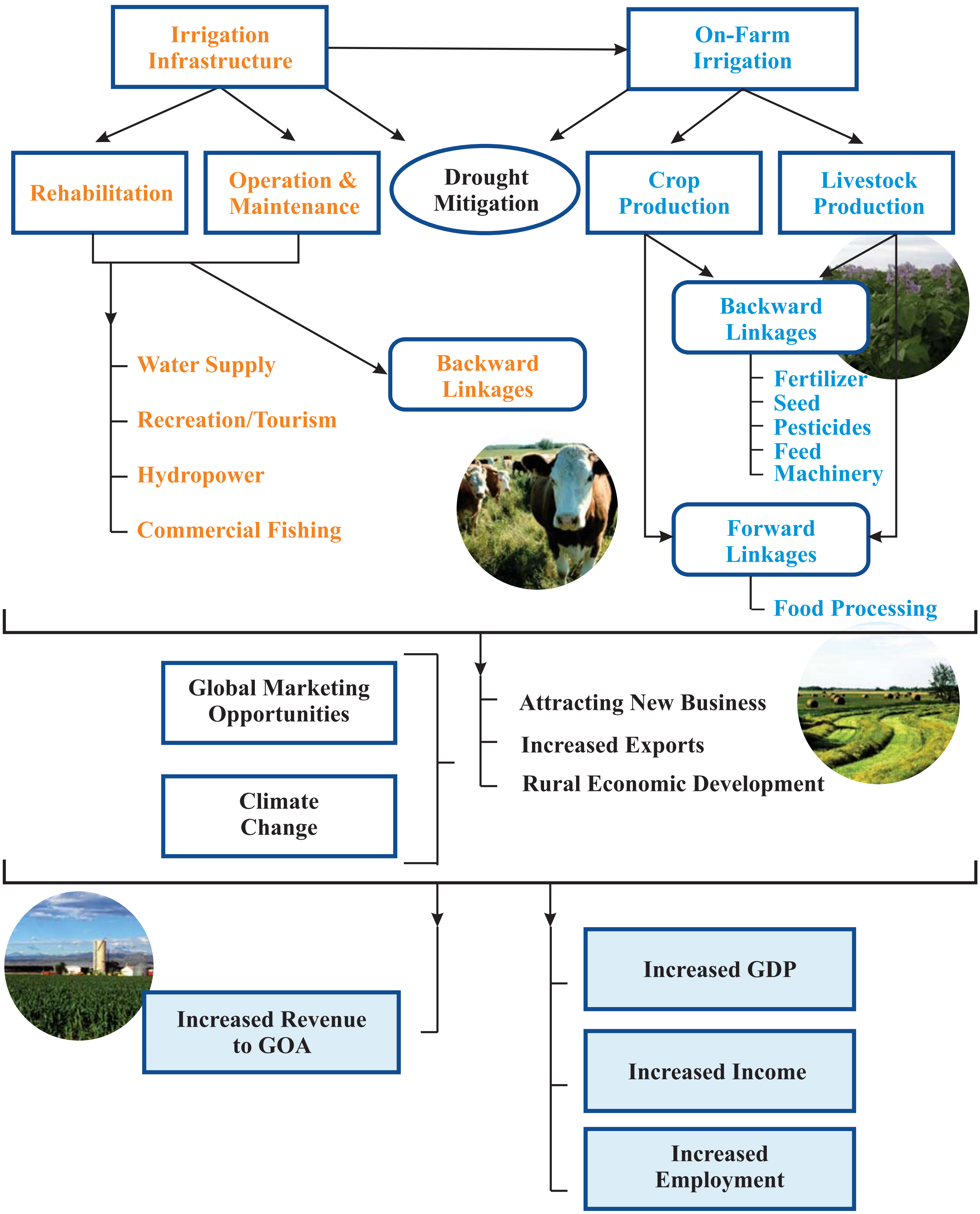


Figure 4.1. Overview of linkages related to economic assessment of irrigation value.

3. **Fiscal Impact Analysis Model (FIAM)**. This model assessed the fiscal impact on the GOA and GOC resulting from irrigation-related activities. Details on this model are presented in Section 4.4 and Appendix D.

4.2 Irrigation Benefits Simulator Model (IBSM)

The importance of irrigation through farm-level activities was evaluated using the indirect valuation method. Water used for irrigating crops results in produce that is sold in the market place. The value of irrigation to the farmer is the return after all inputs are paid.

Farm-level benefits were estimated using data for irrigated and dryland farms in the region. Data included representative crop mixes for irrigation districts, as well as for private irrigation farms. Value of production and employment levels were used to illustrate the increased value of irrigation compared with dryland production. Irrigation data were obtained from secondary sources (ARD, 2012a).

The IBSM estimated the gross value of primary production as well as linking of this value to the required production inputs. The model was extended to livestock production though linking the irrigated feed production to beef cattle to provide the farm-level forward linkages of irrigation.

4.3 Alberta Regional Input-Output Model (ARIOM)

The ARIOM assessed the economic impacts resulting from activities of a given sector, including backward and forward linkages for irrigation. This model disaggregates into buyers (production inputs) and sellers (market demand). Other inputs include labour, retained earnings of business, taxes, and subsidies provided by governments.

The ARIOM was based on the Rectangular Input-Output accounting system, and utilized a transactions table obtained from Statistics Canada. To estimate the forward linkages of irrigation, agricultural processing industries were identified separately. This was done by subdividing the manufacturing sector into six sectors, similar to the procedure used by IWMSC (2002):

1. Slaughter and meat processing;
2. Grain processing and bakeries;
3. Animal food processing;
4. Fruits and vegetable processing;
5. Other agricultural processing; and
6. Non-agricultural processing - included all other types of manufacturing in the province.

The ARIOM is a two-region model. For this study, the Southern Irrigation Region was used to reflect the irrigation area. This region includes the following census divisions, where the majority of Alberta's irrigation is located.

- **Census Division 1.** Cypress County and County of Forty Mile.
- **Census Division 2.** Lethbridge, Newell, and Warner Counties, and MD of Taber.
- **Census Division 3.** Cardston County, MDs of Pincher Creek and Willow Creek, and Improvement District No. 4.
- **Census Division 5.** Wheatland, Vulcan, Starland, and Kneehill Counties.
- **Census Division 6.** Foothills MD, Mountain View County, and Rocky View County.

The Rest of Alberta Region included the remaining census divisions in Alberta, which may have contained relatively small private irrigation projects.

After making all necessary adjustments, a transactions table was used to develop an Economic Impact Analyzer (Appendix C). This was used to estimate the economic impacts of backward and forward linkages in the two regions, or in the province as a whole.

4.4 Fiscal Impact Analysis Model (FIAM)

The GOA has assisted irrigation through financial support for rehabilitation of irrigation infrastructure, and operation and maintenance of GOA-owned infrastructure related to irrigation. Financial returns accrue to the GOA and GOC as a result of that financial support. These economic impacts were translated into changes to fiscal variables using the FIAM. Although some benefits can also accrue to municipal governments, this analysis was not attempted because of significant data gaps and complexity.

4.5 Non-Market Valuation Methods

Market-based data were not available for some of the socio-economic changes induced by irrigation infrastructure or farm-level activities. This study used non-market methods to assess the value of goods or services when users do not pay directly. For example, people spend money on recreational experiences, but a direct monetary value of recreation was not established.

The following impacts were assessed by non-market analyses.

Hydropower Generation. Economic impacts of hydropower generation were estimated using the ARIOM. The lack of data on the production cost of hydropower and thermal power did not allow for estimation of benefits to society for this water use.

Recreation and Tourism. Irrigation-related water reservoirs are visited by local and out-of-province residents for water-based recreational activities. The visitors spend money during their experience, and may also purchase goods, such as boats, water-skis, and camping equipment, thereby generating more economic activity. This value of irrigation infrastructure was estimated using a travel-cost method, where local and tourist expenditures for travel were estimated.

Industry and Community Water Use. Many communities, industries, and rural residents in southern Alberta draw their water from irrigation canals and reservoirs. The irrigation benefit was assessed using an alternative cost approach of securing an equivalent water supply in the absence of the irrigation infrastructure.

4.6 Qualitative Assessments

The following irrigation impacts were assessed qualitatively.

Diversification. Economic diversification resulting from irrigation development increases economic output and stability of the agricultural industry in southern Alberta and in the province.

New Business Development. Irrigation will attract new industries because of assured water supplies, crop quality and yield, and improved community services.

Environmental Enhancement. Wetland and riparian habitat projects, made possible using water from irrigation infrastructure, generate ecological goods and services.

Rural Development. Local governments also receive benefits through additional economic activity and increased population. Both of these result in higher revenues that support development of new infrastructure and enhance existing infrastructure, and this may also be a catalyst to attract more people and industry to the community.

Chapter 5

Economic Assessment of Primary Production

Economic net returns from irrigated crop production were consistently greater than those from dryland production.

Chapter 5

Economic Assessment of Primary Production

5.1 Crop Production

Economic net returns from irrigated crop production were consistently greater than those from dryland production. For spring wheat, irrigation generated about four times the net return compared with dryland (Table 5.1). Irrigated barley generated 3.6 times the return compared with dryland barley, and irrigated canola generated almost two times that of dryland canola.

Economic Net Returns: Profits earned by irrigation producers for their investment in irrigation production. Returns can be measured relative to cash costs, or cash and capital costs.

For comparison, Table 5.1 also shows the returns for specialty crops that were only grown under irrigation. Crops such as potatoes (processing) provided much greater net returns than any of the cereal and oilseed crops.

Table 5.1. Annual net returns for irrigated and dryland crops (2000 to 2011).[z]

Crops	Barley	Spring Wheat	Commercial Canola	Beans	Potatoes	Sugar Beets
Cost and Revenue	**Irrigation ($/ha/yr)**					
Total Variable Cost	559	617	739	932	1,432	1,432
Total Fixed Costs	161	222	210	170	3,731	295
Total Cost	720	839	949	1,103	5,162	1,727
Gross Revenue	991	1,279	1,238	1,434	7,961	2,397
Net Return (above cash and capital costs)	270	439	289	332	2,799	670
	Dryland ($/ha/yr)					
Total Variable cost	301	298	382			
Total Fixed Costs	75	71	91			
Total Cost	377	368	473			
Gross Revenue	452	477	639			
Net Return (above cash and capital costs)	76	108	165			
	Relative Performance					
Irrigated Net Returns (Proportion of Dryland Net Returns)	**3.6**	**4.1**	**1.8**			

[z] Source: ARD AgriProfit$ (2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008a; 2009a; 2010a; 2011a; 2012).
[z] Source: Statistics Canada (2013b).

As a sensitivity analysis, irrigation impacts were assessed with an assumed crop-price reduction. Results showed that irrigation provides increased resiliency compared with dryland production with an assumed 10% reduction in crop prices. Irrigation net returns were more than five times greater than dryland net returns for barley and spring wheat (Table 5.2). Net returns for canola remained about the same.

5.2 Farm Crop Returns

Average annual (2000 to 2011) sales from irrigation crops were about $689 million, which was nearly 22% of Alberta's total gross farm income from crop production (Table 5.3). The largest portion of irrigated farm sales ($458 million) was for specialty crop products. Irrigated croplands produced average revenue of $1,147/ha compared with $260/ha under dryland conditions — more than four times greater.

Table 5.2. Average net returns of irrigation and dryland crops with a 10% decrease in crop prices (2000 to 2011).[z, y]

Impacts	Barley	Spring Wheat	Canola
	Irrigation ($/ha/yr)		
Total Cost	720	839	949
Gross Revenue	892	1,151	1,114
Net Return	**171**	**311**	**165**
	Dryland ($/ha/yr)		
Total Cost	377	368	473
Gross Revenue	407	429	575
Net Return	**30**	**61**	**103**
	Relative Performance		
Irrigated Net Returns (Proportion of Dryland Net Returns)	**5.6**	**5.1**	**1.6**

[z] Source: Statistics Canada (2013b).
[y] Source: ARD AgriProfit$ (2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008a; 2009a; 2010a; 2011a; 2012).

Table 5.3. Average farm sales generated from irrigated and dryland crops (2000 to 2011).

Farm Sales	Irrigated Crops[z]	Dryland Crops[y]	Total
Cereals ($ million)	86	1,091	1,177
Forages ($ million)	84	117	201
Oilseeds ($ million)	61	1,173	1,234
Specialty Crops ($ million)	458	82	540
Sales/ha ($)	1,147	260	1,406
Total ($ million)	**689**	**2,463**	**3,152**
Total (%)	**21.9**	**78.1**	**100.0**

[z] Based on irrigated crop area of 600,796 hectares.
[y] Based on dryland crop area of 9,450,326 hectares.

5.3 Irrigated Livestock Production

Irrigated farms contributed an average of about $746 million in livestock sales per year from 2000 to 2011, and this was about 17% of Alberta's total average livestock sales (Table 5.4). The cattle feeding sector generated about 76% of the total livestock sales attributed as irrigation revenue.

Irrigation, carried out on only 4.7% of Alberta's cultivated land base, generated 19% of the total primary agricultural sales in the province.

5.4 Total Impact of Crops and Livestock

The total average annual sales of irrigation crops and livestock products were about $1.4 billion from 2000 to 2011 (Table 5.5). Although only about 4.7% of the province's cultivated land base was irrigated, it generated 19% of the total primary agricultural sales in Alberta. Irrigation sales were about seven times greater per hectare than dryland sales.

Table 5.4. Average annual sales of livestock products from irrigated areas (2000 to 2011).[z]

Livestock Type	Value of Sales ($'000/yr)		Proportion of Total Sales per Livestock Type (%)		Proportion of Total Sales per Land Use Type(%)	
	Irrigation	Dryland	Irrigation	Dryland	Irrigation	Dryland
Cattle and Calves	566,715	2,530,089	18.3	81.7	75.9	69.8
Hogs	62,894	392,859	13.8	86.2	8.4	10.8
Sheep and Lambs	3,392	13,916	19.6	80.4	0.5	0.4
Dairy	61,414	348,011	15.0	85.0	8.2	9.6
Poultry and Eggs	16,384	159,787	9.3	90.7	2.2	4.4
Other	35,633	180,323	16.5	83.5	4.8	5.0
All Livestock	**746,432**	**3,624,985**	**17.1**	**82.9**	**100.0**	**100.0**

[z] Source: ARD (2008a; 2008b; 2009a; 2009b; 2009c; 2010a; 2010b; 2011a; 2011b; 2011c; 2011d; 2012b; 2012c; 2012d); ARD AgriProfit$ (2008b; 2009b; 2010b; 2011b).
[z] Source: Statistics Canada (2013d).

Table 5.5. Average annual contribution of irrigation relative to dryland agricultural sales (2000 to 2011).

Sales	Irrigation[z]	Dryland[y]
Crops ($ million/yr)	689	2,463
Livestock (million/yr)	746	3,625
Total ($ million/yr)	1,435	6, 088
Average/ha ($)	2,388	329
Proportion of Total %	**19**	**81**

[z] Based on irrigated crop area of 600,796 hectares.
[y] Based on (cultivated + natural pasture lands) – irrigated land = 18,496,379 hectares (ARD, 2013e).

In 2011, the total number of agricultural workers in the Southern Irrigation Region (including self-employed producers) was about 54,500. About 20,000 (36.7%) were employed on irrigated farms, contributing about 2.2% of total employment in the Southern Irrigation Region. Average labour productivity of an irrigation worker was about $70,000/year, compared with about $21,000/year for dryland farm workers — about 3.5 times greater.

5.5 Total Irrigation Primary Production

From 2000 to 2011, the total irrigated crop and livestock production generated about $1.4 billion in gross sales annually, about $380 million in value-added production, and created about 20,500 jobs. To better understand the impacts of irrigation in Alberta, a comparison of incremental irrigation production impacts over dryland production was carried out, using the same land base for irrigation and dryland (Table 5.6). Irrigation generated about 3.5 times more sales as dryland on the same land base, and created about four times more jobs. The incremental value of irrigation production compared to dryland production was about $1.3 billion.

These results were compared to a similar study carried out by the IMWSC (2002), which assessed agricultural production only for one year (1999) (Table 5.7). While both studies showed that irrigation's impact on the economy is greater than dryland, the current study showed that from 2000 to 2011, average annual gross sales of irrigation products were 1.7 times greater than in 1999, and total

Table 5.6. Comparison of annual irrigation and dryland primary production impacts (2000 to 2011).

Economic Activity	Primary Benefits		Incremental Impact (Irrigation minus Dryland)
	Irrigation	Dryland	
Gross Sales ($ million/yr)			
Crops[z]	689	159	530
Livestock	746	234	512
Total	**1,435**	**393**	**1,042**
Value Added ($ million/yr)[y]			
Crops[z]	166	53	113
Livestock	214	83	131
Total	**380**	**136**	**244**
Employment (FTEs)[x]			
Crops	10,262	2,802	7,460
Livestock	10,369	2,427	7,942
Total	**20,631**	**5,229**	**15,402**

[z] Irrigation cropped area is 600,796 hectares.
[y] Value-added is the return to labour, land, management, and capital requirements - similar to GDP.
[x] Number of full-time equivalent (FTE) workers.

value-added production was 1.5 times greater. When expressed on a per hectare basis of irrigated land, these ratios are slightly smaller at 1.5 and 1.3, respectively.

Irrigation employment in full time equivalents (FTEs) per year from 2000 to 2011 was more than four times greater than in 1999. However, the IMWSC (2002) study showed that irrigation benefits relative to dryland were greater in 1999 (Table 5.7), compared with 2000 to 2011 (Table 5.6). Comparing results from the two studies showed that:

- Irrigation gross sales were more than six times greater than dryland in 1999, compared with 4.3 times from 2000 to 2011;
- Irrigation value-added production in 1999 was about 5.5 times greater than dryland, compared with 2.8 times from 2000 to 2011; and
- Both studies showed that irrigation employment FTEs were almost four times greater than dryland.

There are two important differences between the current study and the IMWSC (2002) study that may help explain the difference in gross sales and value-added sales.

- The current study compared irrigation production with dryland production throughout the province, while the IMWSC (2002) study compared irrigation district production with dryland production only in southern Alberta. Since dryland yields in southern Alberta are generally less than yields in central and northern Alberta because of reduced rainfall, the incremental difference between irrigation and dryland production would likely be greater in the IMWSC (2002) study.
- The current study assessed the average production from 2000 to 2011, while the IMWSC (2002) study assessed data for a single year (1999). Much of the 2000 to 2011 period was wetter than normal, and this positively impacted dryland crop yields. The bovine spongiform encephalopathy (BSE) crisis during that

Table 5.7. Comparison of irrigation and dryland primary production impacts in 1999 (IMWSC, 2002).

Economic Activity	Primary Benefits		Incremental Impact (Irrigation minus Dryland)
	Irrigation	Dryland	
Gross Sales ($ million)			
Crops[z]	298	59	239
Livestock	562	78	484
Total	860	137	723
Value-Added ($ million)[y]			
Crops	163	31	132
Livestock	95	16	79
Total	258	47	211
Employment (FTEs)[x]			
Crops	3,142	881	2,261
Livestock	1,821	464	1,357
Total	4,963	1,345	3,618

[z] Cropped area is 525,000 ha.
[y] Value-added is return to labour, land, management, and capital requirements (similar to GDP).
[x] Number of full-time equivalent (FTE) workers.

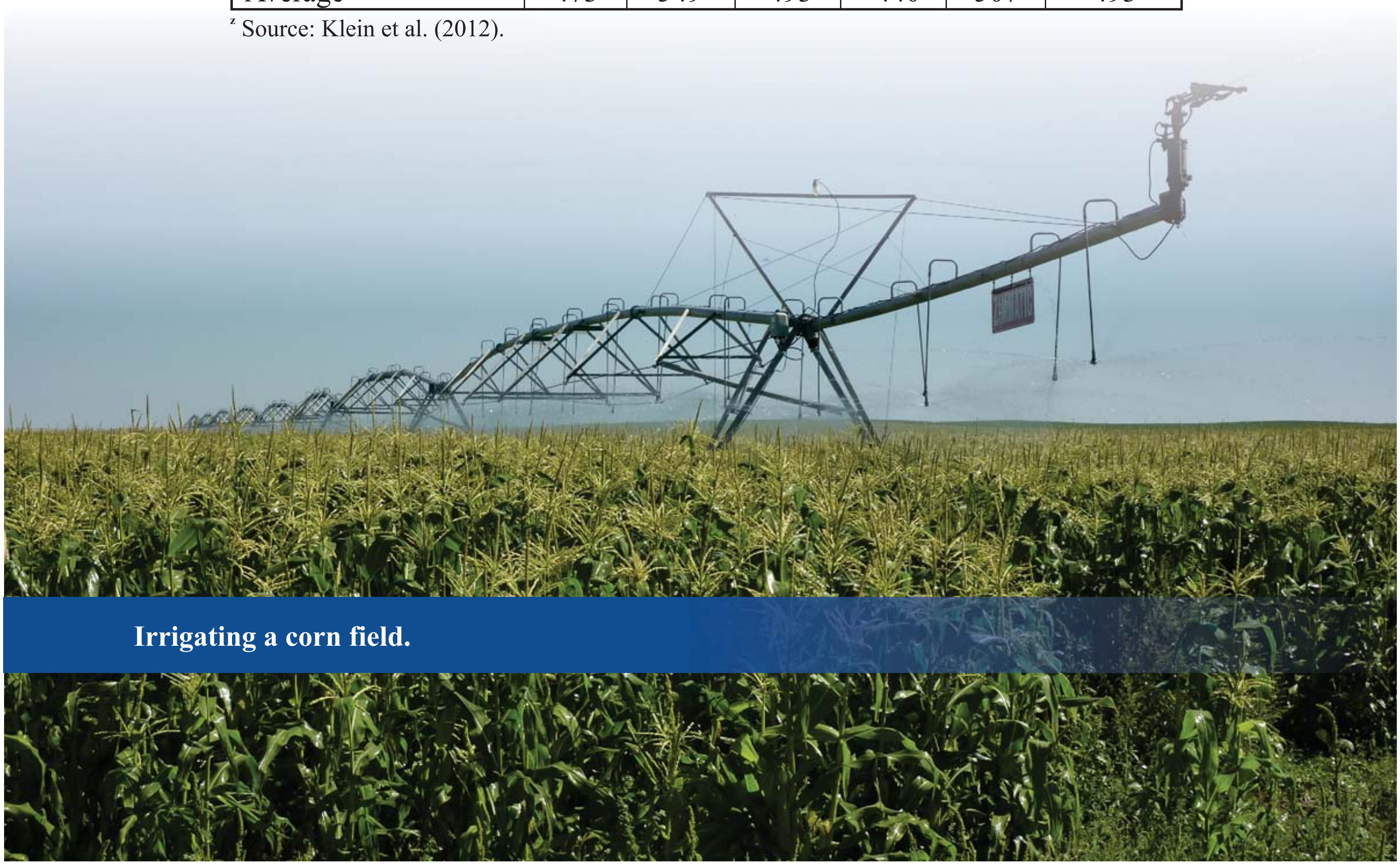
period also negatively impacted the beef feeding industry, which is a key part of the irrigation industry in southern Alberta.

Klein et al. (2012) carried out a study to compare the incremental value of irrigation cropping relative to dryland cropping in the Red Deer, Bow, Oldman, and South Saskatchewan River Sub-basins from 2004 to 2008. Irrigation had a greater incremental impact compared with dryland for all sub-basins (Table 5.8), with the least impact in the Red Deer River Sub-basin, and the greatest impact in the South Saskatchewan River Sub-basin. This is likely related to growing season precipitation levels, which are generally greater in the Red Deer River Sub-basin, and lower in the South Saskatchewan River Sub-basin.

Table 5.8. Incremental values of irrigation relative to dryland crops in the South Saskatchewan River Basin Sub-basins (2004 to 2008).[z]

Sub-basin	Incremental Impact (Irrigation minus Dryland) ($/ha)					
	2004	2005	2006	2007	2008	Average
Bow	447	532	440	388	504	462
Oldman	502	550	534	446	454	497
Red Deer	395	486	419	401	457	432
South Saskatchewan	546	628	578	525	616	579
Average	473	549	493	440	507	493

[z] Source: Klein et al. (2012).



Irrigating a corn field.

5.6 Drought Mitigation

Droughts are a common phenomenon on the prairies. From 1901 to 2001, there were eight major droughts in western Canada — a probability recurrence of 8% in any given year. In addition to the prairie-wide drought of the 1930s, several other droughts occurred in 1961, 1984, 1985, 2001, and 2002 (Wheaton et al., 2004). In the future, drought frequency is expected to increase because of increased temperatures and changing precipitation patterns (Bonsal et al., 2013).

A study by Samarawickrema and Kulshreshtha (2008) assessed the value of irrigation water for crop production during the 2001/2002 drought in southern Alberta. They estimated that the value of water, over and above a normal year, averaged about $0.04/m^3 for the Bow River and Oldman River Sub-basins. Using the Farm Products Price Index for Western Canada (Statistics Canada, 2014c), the current increase in the value of irrigation water during a drought is about $0.055/m^3.

Assuming the 13 irrigation districts annually divert about 2.1 billion m^3, the total value of irrigation in a drought year, over and above a normal year, was estimated to be about $116 million. Based on an 8% drought probability in any given year, the annual drought-proofing benefits of irrigation are estimated to be about $9 million. However, this underestimates the true value of irrigation during a drought.

- It only takes into account losses in crop production during a drought year, and excludes losses related to livestock production resulting from feed shortages.
- It excludes any additional impacts to forward-linked industries during a drought period when shortages of inputs may increase their costs from alternate sources.
- It excludes the impacts on private irrigation projects, and this may have greater impacts than irrigators within districts due to their greater dependence on natural flow of streams (i.e., less storage).

The predicted increase in drought frequency and duration (Bonsal et al., 2013) will further enhance irrigation's value to the Alberta economy. However, droughts longer than two years in duration will severely stretch the capacity of the existing storage reservoirs to sustain adequate water supply for water users in the SSRB, including irrigation producers. Development of additional storage reservoirs would provide increased water security to handle prolonged droughts.

Chapter 6

Backward and Forward Linkages to the Irrigation Industry

Irrigation generates significant economic activity far beyond the farm gate.

Chapter 6

Backward and Forward Linkages to the Irrigation Industry

6.1 Backward Linkages of Irrigation

The irrigation industry requires increased inputs such as fertilizer, pesticides, machinery, irrigation systems, and related services such as agronomic support. These are called "backward linkages". They generate additional economic activity that is directly or indirectly related to the irrigation industry (Figure 4.1). Businesses that sell these goods and services to the irrigation industry must gear up to facilitate sales, which creates additional economic activity in the region.

In this chapter, economic impacts of irrigated crop and livestock production activities and their respective backward linkages were assessed, using the ARIOM. The total economic impacts of these production activities were then developed using the Economic Impact Analyzer.

6.1.1 Investment in On-Farm Machinery and Equipment

A study by Meyers Norris Penny LLP (2011) was the basis for estimating the level of investment in farm machinery. Annual machinery cost estimates varied from about $1,200/ha for seed canola to about $4,900/ha for crops such as potatoes and sugar beets, which both require more specialized equipment (Table 6.1). For missing crops, estimates were made by assuming these to be equal to a similar crop type for which data

Table 6.1. Machinery expenditures for irrigation farms.

Crop	Machinery Investment ($/ha)[z]	Area (ha)	Total Expenditure ($ million)
Wheat	1,229	92,255	113
Durum	1,794	24,195	43
Winter Wheat	2,096	2,803	6.0
Barley	1,535	95,865	147
Canola	2,043	65,435	134
Canola Seed	1,207	1,180	1.4
Alfalfa	2,406	229,641	553
Beans	1,837	21,679	40
Potatoes	4,857	33,015	160
Sugar Beets[y]	4,857	13,290	65
Specialty[x]	3,347	12,426	42
Other crops[w]	1,651	9,012	15
Total		**600,796**	**1,319**

[z] Except as noted, based on Meyers Norris Penny LLP (2011).
[y] Assumed to be the same as potatoes.
[x] Estimated as average of beans and potatoes.
[w] Average of non-specialty crops.

were available. Total replacement cost (new investment expenditures) for all farm machinery on irrigation farms was estimated at about $1.32 billion. Assuming a productive life of 10 years, the annual investment was about $132 million.

The total farm machinery expenditure of about $132 million per year generated a GDP of about $59 million, 62% of which was through companies in the Southern Irrigation Region (Table 6.2). This value includes about $36 million in income and about 650 jobs.

6.1.2 Backward Economic Impacts of Crop Production

Annual irrigated crop sales of $689 million (Table 5.3) generated about $598 million to the Southern Irrigation Region GDP through backward linkages (Table 6.3). About $371 million in labour income was also generated, and about 6,500 jobs were created. A large increase is noted for the service sectors since they serve all agricultural and non-agricultural sectors in the region (Figure 6.1).

6.1.3 Impacts of Irrigation on Livestock Production

Livestock sales, which were about $746 million/year (Table 5.4), generated about $565 million/year to the Southern Irrigation Region GDP, and labour income of about $433 million/year through backward linkages (Table 6.4). Livestock production on irrigated farms also created additional demand for goods and services produced by other non-farm sectors. A total of 8,852 jobs were created, with the majority related to the service sector (Figure 6.2).

Table 6.2. Backward economic impacts of farm-level investment.

Region	GDP ($'000)	Income ($'000)	Employment (FTEs)[z]
Southern Irrigation Region	36,625	23,954	513
Rest of Alberta Region	22,202	12,121	141
Province of Alberta	58,827	36,075	654

[z] Number of full-time equivalent (FTE) workers.

Table 6.3. Economic impacts of irrigated crop production through backward linkages in the Southern Irrigation Region.

Sector	GDP ($'000)	Income ($'000)	Income % of Total[z]	Employment (FTEs)[y]
Other Primary	84,606	42,279	11	671
Utilities	35,832	17,234	5	202
Construction	18,290	14,050	4	103
Manufacturing	70,926	36,869	10	532
Trade	79,093	51,310	14	1,050
Transportation and Storage	32,042	18,058	5	421
Services	261,271	180,099	48	2,391
Government Sector	16,036	11,066	3	1,099
Total	**598,096**	**370,965**	**100**	**6,469**

[z] Values may not be exact due to rounding.
[y] Number of full-time equivalent (FTE) workers.

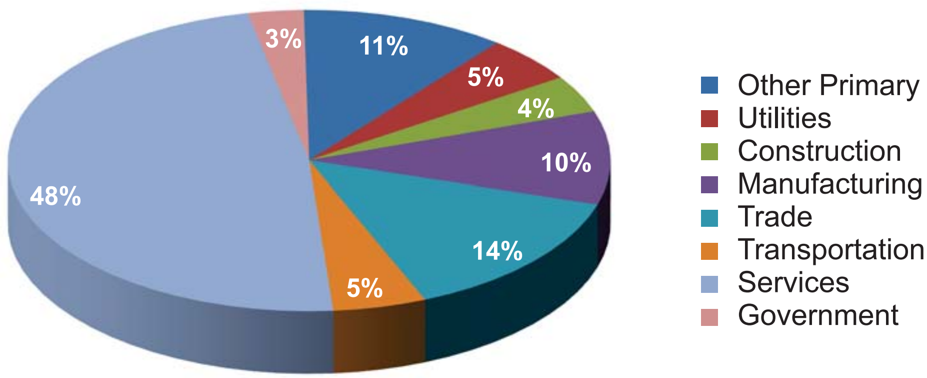


Figure 6.1. Distribution of labour income generated through backward linkages of irrigated crop production in the Southern Irrigation Region.

Table 6.4. Backward linkage-related economic impacts of irrigation on livestock production in the Southern Irrigation Region.

Sector	GDP ($'000)	Labour Income ($'000)	Employment	
			FTEs[z]	% of Total[y]
Other Agriculture	55,554	50,645	987	11
Other Primary	5,637	63,874	1,145	13
Utilities	17,346	8,343	98	1
Construction	13,221	10,114	74	1
Manufacturing	52,579	30,699	325	4
Trade	95,863	62,276	1,287	15
Transportation and Storage	26,220	14,777	373	4
Services	285,591	182,233	3,286	37
Government Sector	13,363	9,635	1,277	14
Total Impacts	**565,374**	**432,596**	**8,852**	**100**

[z] Number of full-time equivalent (FTE) workers.
[y] Values may not be exact due to rounding.

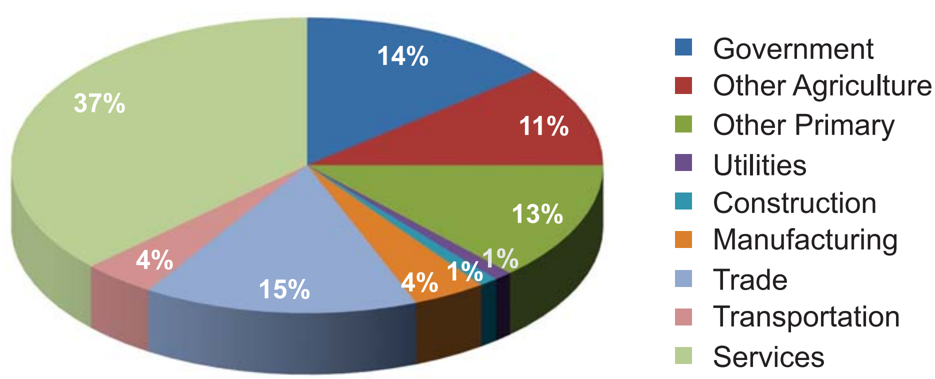


Figure 6.2. Total employment generated through backward-linkages of irrigation on livestock production in the Southern Irrigation Region.

6.1.4 Total Economic Impacts of Irrigation – Direct and Backward Linkages

Irrigated crop and livestock production generated about $1.7 billion to the provincial GDP, about $1.1 billion in labour income, and created about 38,000 jobs (Table 6.5). Almost 88% of the economic impacts of irrigation were felt within the Southern Irrigation Region, and about 12% of the total impacts were realized outside this region. There may have been economic impacts beyond Alberta, but these were not assessed in this study.

6.2 Forward Linkages of Irrigation

Forward linkages exist when one sector purchases commodities from another sector, and adds value to the inputs in production of a final product. Irrigation produces inputs that are used by other industries for further processing, which provides additional economic development in the region and the province (Figure 4.1).

Economic impacts of forward linked sectors were estimated using the ARIOM. Because Input-Output coefficients were not specifically available for the Alberta economy, they were estimated using the Canadian Input-Output aggregation table (Appendix C.5.2). It was assumed that irrigation commodity sales would be the same proportion as their share of total production of that commodity. Irrigated livestock and crop products were excluded from this calculation to avoid double-counting.

Irrigation-related agricultural processing activities generated about $2.0 billion in total sales. This accounted for about 18% of the total provincial food processing sales. Irrigation-related agricultural processing generated about $1.7 billion to the provincial GDP, about $1.0 billion in labour income, and created about 17,000 FTEs (Table 6.6). Almost all of the irrigation-related benefits were provided to the Southern Irrigation Region. Slaughter and meat processing accounted for almost 43% of the total agri-food processing sectors' employment FTEs (Figure 6.3).

Table 6.5. Total direct plus backward linkages of irrigated crop and livestock production.

Activity and Region	GDP	Income	Employment
	$'000		(FTEs)[z]
Southern Irrigation Region			
Crop Production	763,767	474,555	17,141
Livestock Production	728,045	519,783	16,608
Total	**1,491,812**	**994,338**	**33,749**
Rest of Alberta Region			
Crop Production	88,840	50,648	1,590
Livestock Production	121,899	93,772	2,679
Total	**210,739**	**144,420**	**4,269**
Province of Alberta			
Crop Production	852,607	525,204	18,731
Livestock Production	849,944	613,555	19,287
Total	**1,702,551**	**1,138,759**	**38,018**

[z] Number of full-time equivalent (FTE) workers.

Table 6.6. Economic impacts of irrigation-related manufacturing activity.

Manufacturing Activity and Location	GDP ($'000)	Labour Income ($'000)	Employment (FTEs)[z]
Southern Irrigation Region			
Slaughter and Meat Processing	725,810	448,463	6,790
Grain Processing and Bakeries	324,304	192,589	3,196
Animal Food Processing	73,299	42,881	828
Fruits and Vegetable Processing	168,751	99,833	2,111
Other Food Processing	359,101	235,893	2,881
Total	**1,651,265**	**1,019,659**	**15,806**
Rest of Alberta Region			
Slaughter and Meat Processing	21,992	14,558	617
Grain Processing and Bakeries	7,635	4,994	239
Animal Food Processing	2,027	1,331	59
Fruits and Vegetable Processing	4,198	2,730	128
Other Food Processing	6,309	4,115	244
Total	**42,161**	**27,728**	**1,287**
Total (Alberta)	**1,695,731**	**1,042,384**	**17,109**
Proportion of Benefits for the Southern Irrigation Region (%)	**97.4**	**97.8**	**92.4**

[z] Number of full-time equivalent (FTE) workers.

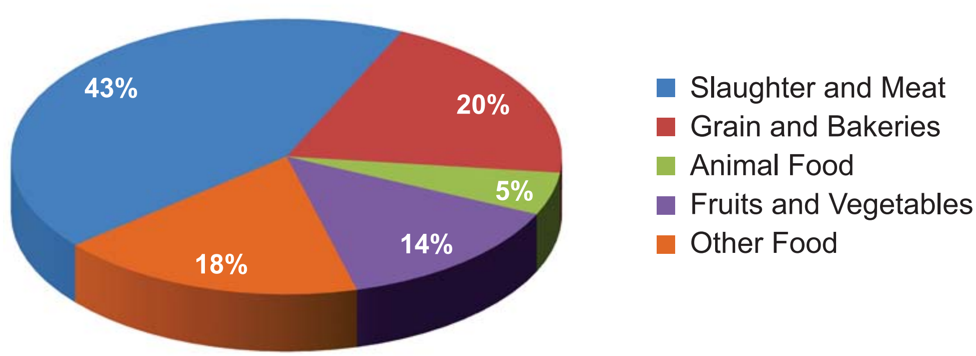
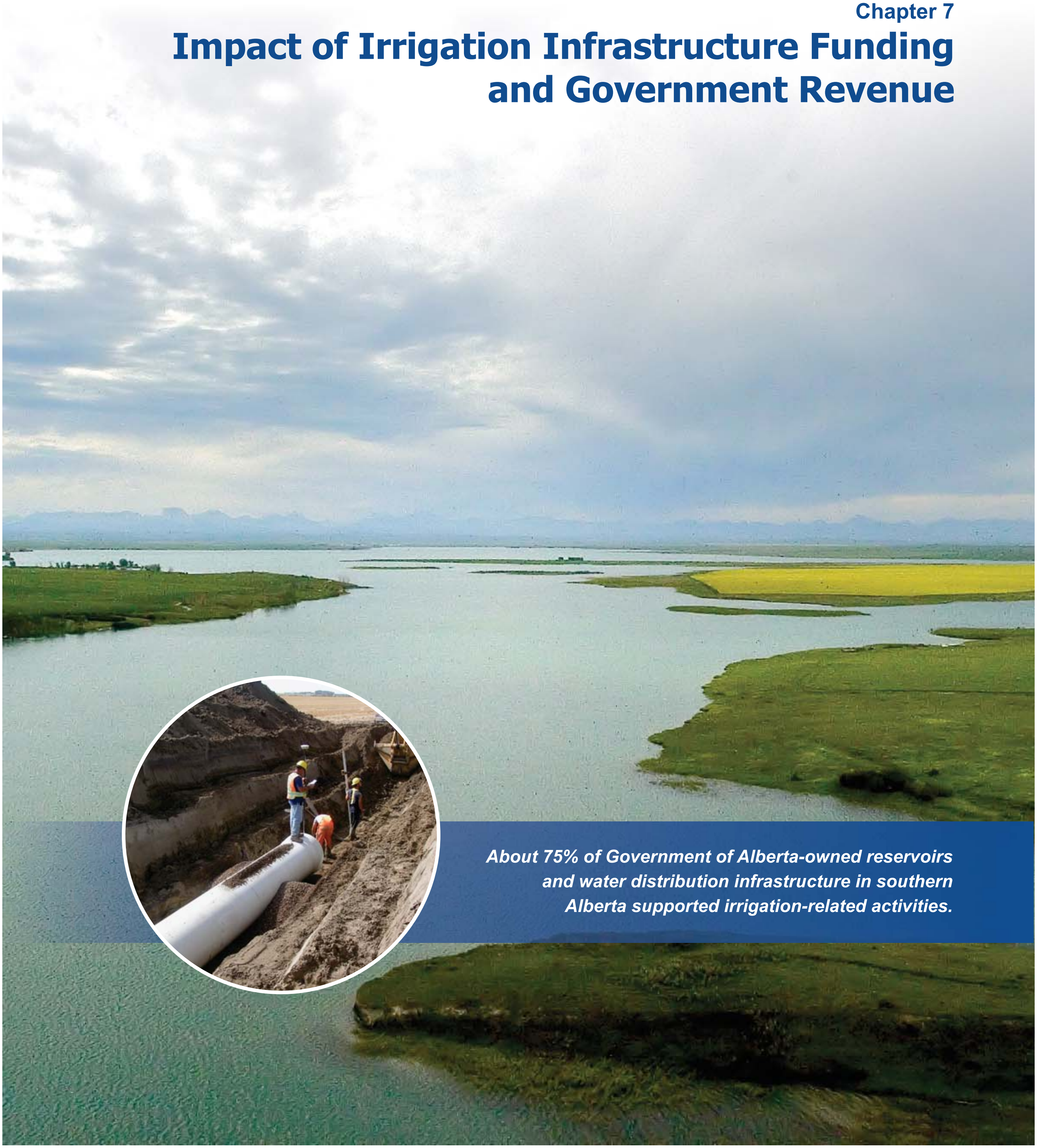


Figure 6.3. Average annual employment (FTEs) generated through agricultural processing sectors in the Southern Irrigation Region (2000 to 2011).

Chapter 7

Impact of Irrigation Infrastructure Funding and Government Revenue



About 75% of Government of Alberta-owned reservoirs and water distribution infrastructure in southern Alberta supported irrigation-related activities.

Chapter 7

Impact of Irrigation Infrastructure Funding and Government Revenue

7.1 Irrigation Infrastructure Funding

The irrigation infrastructure funding programs are examples of a secondary impact, where changes in economic activity result from expenditures of companies and public authorities that are directly involved with the irrigation industry.

About 75% of the operation and maintenance costs of GOA-owned infrastructure supported irrigation-related activities during the period (ESRD, 2014). The replacement cost of this infrastructure is estimated to be about $5.9 billion. The average annual operation and maintenance cost for the 75% irrigation-related share of this infrastructure from 2000 to 2011 was about $22 million (Table 7.1).

The GOA also provides funding support for rehabilitation of existing irrigation district-owned infrastructure in partnership with the irrigation districts. The GOA funding support is based on a 75:25 formula, where 75% of project funding is provided by the GOA and 25% is provided by the irrigation districts. The average annual funding (GOA plus irrigation district) for rehabilitation of irrigation district infrastructure was about $31 million (ARD, 2013b) from 2000 to 2011 (Table 7.2).

Annual operation and maintenance of irrigation district infrastructure is the sole responsibility of each irrigation district, and includes:

- Maintenance of irrigation works;
- Water delivery;

Table 7.1. Operation and maintenance costs for Government of Alberta-owned infrastructure associated with irrigation.

Year	Total Operation and Maintenance Costs ($)	Irrigation Share of Operation and Maintenance Costs ($)
2000	32,595,000	22,816,500
2001	27,952,000	19,566,400
2002	29,572,000	20,700,400
2003	37,363,000	26,154,100
2004	30,279,000	21,195,300
2005	29,800,000	20,860,000
2006	30,389,000	26,923,500
2007	34,882,000	32,221,500
2008	36,258,000	27,380,500
2009	22,227,000	19,133,500
2010	17,126,000	15,042,500
2011	22,038,000	17,335,000
Average	**29,206,750**	**22,444,100**

Table 7.2. Summary of revenue and expenditures related to infrastructure operation, maintenance, and rehabilitation by the irrigation districts (2000 to 2011).

	Infrastructure Rehabilitation			Irrigation District Operation and Maintenance Expenditures^{z} ($)
Year	GOA Grant ($)	Irrigation District Share ($)	Total ($)	
2000	17,200,000	5,733,333	22,933,333	46,541,291
2001	23,712,490	6,937,496	30,649,986	45,337,128
2002	20,800,000	6,933,332	27,733,332	45,341,292
2003	24,400,000	8,133,333	32,533,333	44,141,291
2004	19,000,000	6,333,334	25,333,334	45,941,290
2005	22,000,000	7,233,334	29,233,334	45,041,290
2006	24,000,000	7,083,335	31,083,335	45,191,289
2007	24,000,000	7,000,000	31,000,000	45,274,624
2008	28,000,000	9,004,557	37,004,557	43,270,067
2009	33,399,999	11,133,333	44,533,332	41,141,291
2010	23,999,998	8,000,000	31,999,998	44,274,624
2011	24,000,000	7,858,335	31,858,335	44,416,289
Average	**23,709,373**	**7,615,310**	**31,324,684**	**44,659,314**
Total Average Expenditure			**$75,983,997**	

Note: Total expenditures for the 13 irrigation districts was about $52,274,624 in 2013, and this was used as the proxy value for all years.

^{z} Operation and maintenance expenditures = $52,274,624 – irrigation district share of rehabilitation costs.

- Administration; and
- Structures and equipment rehabilitation or replacement.

Revenue to pay for the operation and maintenance of the irrigation district infrastructure, plus the districts' share of infrastructure rehabilitation, is generated from annual water rate charges to water users, plus revenue generated from outside interests (land leases, hydro power, land sales, etc.). Total income generated by the 13 irrigation districts was approximately $54 million in 2013, and it was estimated that about $52.3 million was spent on operation, maintenance, and rehabilitation activities (ARD, 2013b).

7.1.1 Impact of Expenditures on GOA-owned Infrastructure

Economic impacts of operation and maintenance expenditures related to GOA-owned irrigation infrastructure (Table 7.1) were estimated using the ARIOM, and are shown in Table 7.3. The annual expenditure of $22.4 million by the GOA on operation and maintenance of their infrastructure (Table 7.1) resulted in total expenditures for all goods and services in the Southern Irrigation Region of $72 million ($22.4 plus $49.6 million). This also resulted in labour income of nearly $16 million, and contributed about $24 million to the regional GDP. These expenditures also created an additional 259 FTEs in the region.

Table 7.3. Economic impacts of average annual expenditures on operation and maintenance of irrigation infrastructure in the Southern Irrigation Region (2000 to 2011).

Sector	Expenditures	GDP	Income	Employment (FTEs)[z]
	($'000)			
Agriculture	258	53	45	1
Other Primary	4,705	3,055	770	6
Utilities	480	330	158	2
Construction	22,864	8,990	6,844	84
Manufacturing	2,806	767	405	6
Trade	3,046	1,979	1,291	27
Transportation	1,188	514	290	7
Services	13,778	8,380	5,942	90
Govt. Sectors	459	312	227	36
Total	**49,584**	**24,380**	**15,973**	**259**

[z] Average annual number of full-time equivalent (FTE) workers.

Most of these impacts (80%) were experienced within the construction and service sectors (Figure 7.1), with small impacts for agriculture, trade, and other primary industries.

7.1.2 Economic Impact of Irrigation District Infrastructure Expenditures

The irrigation district operation, maintenance, and rehabilitation expenditure of about $76 million (Table 7.2) generated total expenditures of almost $230 million in the Southern Irrigation Region. This resulted in $75 million to the regional GDP, about $49 million in labour income, and about 1,000 FTEs of employment, as determined using the ARIOM (Table 7.4). Most of the impacts were related to non-agricultural sectors in the region. About 80% of the FTEs created under this activity were in the construction and services sector.

Canal rehabilitation.

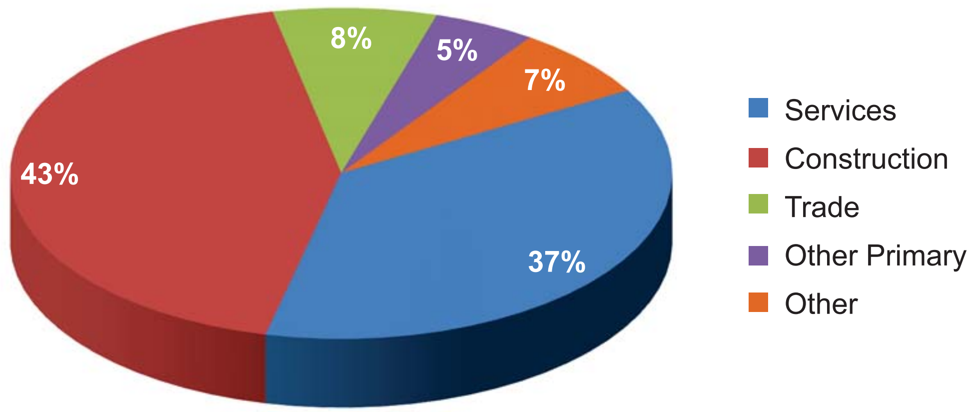


Figure 7.1. Distribution of income (%) resulting from average annual expenditures on operation and maintenance of Government of Alberta-owned infrastructure in the Southern Irrigation Region (2000 to 2011).

Table 7.4. Economic impacts of irrigation infrastructure operation, maintenance, and rehabilitation expenditures in the Southern Irrigation Region (2000 to 2011).

Sector	Expenditures	GDP	Income	Employment
	($'000/yr)			(FTEs)[z]
Agriculture	587	115	98	2
Other Primary	15,581	10,119	2,547	21
Utilities	1,300	893	430	5
Construction	151,886	29,920	22,701	563
Manufacturing	8,490	2,313	1,216	17
Trade	8,350	5,418	3,521	73
Transportation	2,758	1,467	827	14
Services	39,679	23,480	16,571	257
Government Sectors	1,240	843	613	95
Total	**229,871**	**74,567**	**48,523**	**1,047**

[z] Number of fill-time equivalent (FTE) workers.

7.1.3 Combined Impacts of Irrigation Infrastructure Funding

Operation, maintenance, and rehabilitation of irrigation infrastructure in Alberta generated about $102 million to the provincial GDP, about $66 million in labour income, and created about 1,400 FTEs (Table 7.5). About 94% of these economic impacts were in the Southern Irrigation Region, and the remaining 6% were generated for the rest of Alberta.

Table 7.5. Average annual distribution of impacts of irrigation infrastructure (2000 to 2011).

Infrastructure-Related Activity	GDP ($'000/yr)	Income ($'000/yr)	Employment FTEs/yr [z]
Southern Irrigation Region			
Operation and Maintenance	24,380	15,973	259
Rehabilitation	74,567	48,523	1,047
Total	**98,947**	**64,496**	**1,306**
Rest of Alberta Region			
Operation and Maintenance	957	556	23
Rehabilitation	2,552	1,414	58
Total	**3,509**	**1,970**	**81**
Province of Alberta			
Operation and Maintenance	25,337	16,529	282
Rehabilitation	77,119	49,937	1,105
Total	**102,456**	**66,466**	**1,387**

[z] Number of full-time equivalent (FTE) workers.

7.2 Impact of Irrigation on Government Revenues

The GOA and GOC receive revenue as a result of economic activities in Alberta (Appendix F). The GOA and GOC revenue and expenditures related to irrigation in Alberta were assessed using the FIAM and regression analysis to link economic variables generated by the ARIOM. The assessment period for this analysis was restricted to the 2000 to 2009 period because of data limitations.

7.2.1 Impact of Irrigation on GOA Revenues

Based on the analysis using the FIAM and ARIOM, the total annual revenue provided to the GOA by irrigation and associated industries was about $516 million/year (Table 7.6), compared with total expenditures of about $444 million/year. Expenditures included direct irrigation expenditures of $47 million, and $397 million in indirect expenses related to development (e,g. schools, roads, services) that result from irrigation-related activities. This provided a net revenue gain of about $72 million/year.

Fiscal Revenue: Revenues collected by government and include direct and indirect taxation, and other government income.

Fiscal Costs: Expenditures by public agencies.

Net Fiscal Revenue: Difference between fiscal revenues and fiscal costs.

Rehabilitated canal.

Table 7.6. Annual fiscal revenue to Government of Alberta generated by irrigation directly or through related expenditures from the Government of Alberta (2000 to 2009).

Activity	Income Tax	Corporate Tax	Tax on Goods and Imports	Transfers from People	Investment Income	Indirect Expenses	Direct Expenses (Irrigation)
	Revenue ($ million/yr)					Expenses ($ million/yr)	
Irrigation Rehabilitation	2.86	0.74	1.96	0.97	3.59	8.75	23.71
Irrigation O&M	0.95	0.24	0.76	0.32	1.18	2.88	22.94
Farm Investment	2.07	0.61	2.83	0.70	2.74	6.67	0.00
Sub-Total Investment	5.88	1.59	5.55	1.99	7.51	18.30	46.65
Irrigated Crop Production	28.81	10.41	27.86	9.80	37.54	91.35	0.00
Irrigated Livestock Production	35.31	6.27	34.84	12.02	39.61	96.38	0.00
Sub-Total Production	64.12	16.68	62.70	21.82	77.15	187.73	0.00
Animal Food Processing	2.53	0.84	5.27	0.86	3.51	8.54	0.00
Fruits and Veg. Processing	5.87	1.93	11.93	2.02	8.08	19.59	0.00
Grain Milling	11.32	3.72	18.48	3.85	15.47	37.64	0.00
Meat Processing	26.53	7.98	22.31	9.03	34.85	84.8	0.00
Other Food Processing	13.47	3.33	16.78	4.58	16.56	40.3	0.00
Sub-Total Agri-Processing	59.72	17.80	74.77	20.34	78.47	190.87	0.00
Total all Activities	129.72	36.07	143.03	44.15	163.12	396.90	46.65
Total[z]	**516.09**					**443.55**[y]	

[z] Total revenue does not include GOC transfers to GOA.
[y] Total expenses include about $47 million directly related to irrigation infrastructure, and about $397 million in indirect expenses related to development (roads, schools, services, etc.) that result from irrigation activities.

7.2.2 Impact of Irrigation in Alberta on GOC Revenues

The GOC revenue generated by irrigation in Alberta was estimated in a similar way as for the GOA. Total GOC annual revenue from irrigation and associated activities in Alberta was about $827 million (Table 7.7). Since no direct irrigation-related expenditures were identified, this revenue is a net gain to the GOC.

Every $1 invested by the GOA on irrigation returned $3 in revenue to the province.

7.2.3 Total Impact of Irrigation in Alberta on Government Revenues

About $1.3 billion in total combined revenue was provided to the GOA and GOC annually related to irrigation activities in Alberta. Government revenues always exceeded expenditures, even when the GOC was excluded from the revenue stream (Table 7.8). The revenue to expenditure ratio was about 3:1, which means that every dollar invested by the GOA on irrigation returned $3 in revenue.

Table 7.7. Average annual revenues for the Government of Canada from irrigation in Alberta (2000 to 2009).

Activity	Personal Income Tax	Corporation Tax	Goods and Import Tax	Transfers	Investment Income
	Revenue ($ million/yr)				
Irrigation Rehabilitation	7.97	1.62	4.84	0.63	0.09
Irrigation Operation & Maintenance	2.64	0.52	1.89	0.21	0.03
Farm Investment	5.76	1.24	6.51	0.43	0.06
Sub-Total Investment	**16.37**	**3.38**	**13.24**	**1.27**	**0.18**
Irrigated Crop Production	80.34	22.85	68.96	6.39	0.94
Irrigated Livestock Production	98.48	13.76	86.25	7.83	0.99
Sub-Total Production	**178.82**	**36.61**	**155.21**	**14.22**	**1.93**
Animal Food Processing	7.07	1.85	13.05	0.56	0.09
Fruits and Vegetable Processing	16.38	4.27	29.55	1.28	0.18
Grain Milling	31.57	8.17	45.75	2.51	0.39
Meat Processing	73.99	17.51	55.22	5.88	0.87
Other Food Processing	37.55	7.3	41.53	2.98	0.41
Sub-Total Agri - Processing	**166.56**	**39.10**	**185.10**	**13.21**	**1.94**
All Activities	**361.75**	**79.08**	**353.55**	**28.70**	**4.05**
Total	**827.14**				

Table 7.8. Total annual fiscal revenues and expenditures related to irrigation activities in Alberta (2000 to 2009).

	Revenue	Expenditures	Net Revenue	Revenue/Expenditure Ratio
	($ million/yr)			
Revenue of Alberta[z]	516	444	63	1.2
GOC Revenue from Alberta	827	0	827	
Total	1,343	444	890	3.0

[z] Excludes transfers from GOC.

Chapter 8

Non-Irrigation Benefits

Irrigation infrastructure provides water to about 50 towns and villages, and more than 8,000 rural residents.

Chapter 8

Non-Irrigation Benefits

8.1 Water Supply

Assured water supply for all Albertans is a priority goal of the GOA *Water for Life Strategy* (GOA, 2003b). Water is also an important part of Alberta's *Rural Economic Development Action Plan* (ARD, 2014c), which assists rural industry to enhance participation in new local, domestic, and international markets.

Alberta's irrigation storage and distribution system currently provides water to about 50 towns and villages consisting of more than 42,000 individuals (ARD, 2014a). In addition, more than 8,000 rural residents obtain water through access to domestic water agreements (ARD, 2014a). Irrigation also supplies water for livestock, agricultural processing and other industries, and commercial water users (Table 8.1).

Table 8.2 lists licence allocations for municipal projects associated with GOA-owned infrastructure constructed to facilitate private irrigation in the province. Municipalities took advantage of these projects to secure and expand future growth.

Table 8.1. License allocations for projects served by irrigation district infrastructure.

Purpose	Bow River Basin ('000 m^3)[z]		Oldman River Basin ('000 m^3)[z]	
	Total Allocation	Estimated Use	Total Allocation	Estimated Use[y]
Other Agriculture	1,692	1,218	12,381	9,781
Commercial	3,270	2,387	20,311	14,624
Industry	3,239	2,170	950	95
Municipal	14,268	7,500	13,700	7,793
Irrigation [x]	24		232	
Recreation [w]	357		32	
Wildlife[w]	62,396	62,396	2,074	2,074
Other [w]	1,086		2	

[z] Allocation source: AESRD licence listing.
[y] Use factor is based on limited recorded information for municipal use.
[x] Refers to private irrigation sourced through irrigation headworks or irrigation district works.
[w] AMEC (2007).

Table 8.2. Licence allocations for municipal projects served by private irrigation infrastructure.

Sheerness[z]		Twin Valley [y]		Pine Coulee[x]		Total Non-District	
Allocation	Use	Allocation	Use	Allocation	Use	Allocation	Use
('000 m^3)		('000 m^3)		('000 m^3)		('000 m^3)	
1,233	849	1,177	624	1,486	1,359	3,896	2,832

[z] Diversion from the Red Deer River to the Sheerness Cooling Pond was primarily for power production and irrigation.
[y] Twin Valley Dam and Reservoir constructed on the Little Bow River primarily for irrigation purposes.
[x] Pine Coulee Reservoir (off-stream) constructed adjacent to Willow Creek primarily for irrigation purposes.

8.1.1 Irrigation Impacts on Water Supply

To assess the impact of irrigation distribution infrastructure on water supply, Hart (2014) reviewed three planning studies that provided information on the relative costs of supplying water from irrigation infrastructure compared with one or more alternatives not involving irrigation infrastructure. Hart (2014) assessed each of these studies as follows.

- Compared capital and annual operating and maintenance costs for delivering water through irrigation infrastructure to the next best option.
- Capital costs were converted to an equivalent annual cost, considering a 50-year life and a 5% annual interest rate. The total annual benefits of the alternative that involved irrigation infrastructure were determined in study-year dollars.
- The annual cost savings were adjusted for inflation to 2014 dollars using the Consumer Price Indices for Alberta. The annual cost saving per cubic metre was computed by dividing the adjusted cost saving by the design capacity of the project.
- The average annual cost savings per cubic metre for the three projects were used to compute the savings for the estimated actual water use for purposes defined in Table 8.3.

Annual savings realized by supplying water for non-irrigation agricultural, commercial, industrial, and municipal uses through irrigation infrastructure were about $45 million compared with non-irrigation infrastructure (Table 8.3). These savings also generated about $46 million annually to the provincial GDP and about $46 million in labour income.

8.1.2 Source Water for Rural Water Supply Pipelines

Of the approximately 700,000 rural Albertans who rely on unregulated raw water supplies, many depend on excavated dugouts that collect runoff water. Often, the water collected has high concentrations of dissolved organic carbon, nitrogen, phosphorus, and bacteria. Some ground water may be highly mineralized or subject to high concentrations of naturally occurring heavy metals (e.g., arsenic). Groundwater yield may also be insufficient or unreliable.

Water supply pipelines from reliable water sources provide the best long-term solution to provide a sustainable supply of water to rural residents in chronic water-short areas of the province. Rural water pipelines have been constructed in a number of regions of the province to provide water supplies to agricultural producers and rural residents. There are currently about 175 rural water co-operatives in Alberta. Most of these water co-ops are located in southern Alberta (Figure 8.1) and were constructed with funding assistance from the GOA.

Table 8.3. Benefits of water delivery to licensed non-irrigation projects through irrigation infrastructure.

Purpose	Actual Water Use ('000 m^3/year)	Water Savings ($/year)	Annual Savings ($ million)
Agricultural	10,999	928	10.2
Commercial	17,011	928	15.8
Industrial	2,265	928	2.1
Municipal	18,125	928	16.8
Total	**48,400**		**44.9**

There is continued demand for development of rural water supply pipelines by municipalities and rural water organizations throughout Alberta. This demand is mainly in regions of the province where groundwater supplies are limited or groundwater quality is poor. This includes the Southern Irrigation Region, as demonstrated by the number of rural water pipelines that have previously been installed (Figure 8.1).

Alberta Transportation coordinates the Water/Wastewater Partnership through the GOA *Water for Life Strategy*. Funding under this strategy is available for new regional water or wastewater systems or revisions to existing systems. The Eastern Irrigation District provides financial support to water users wishing to connect to regional water pipelines being constructed in the district.

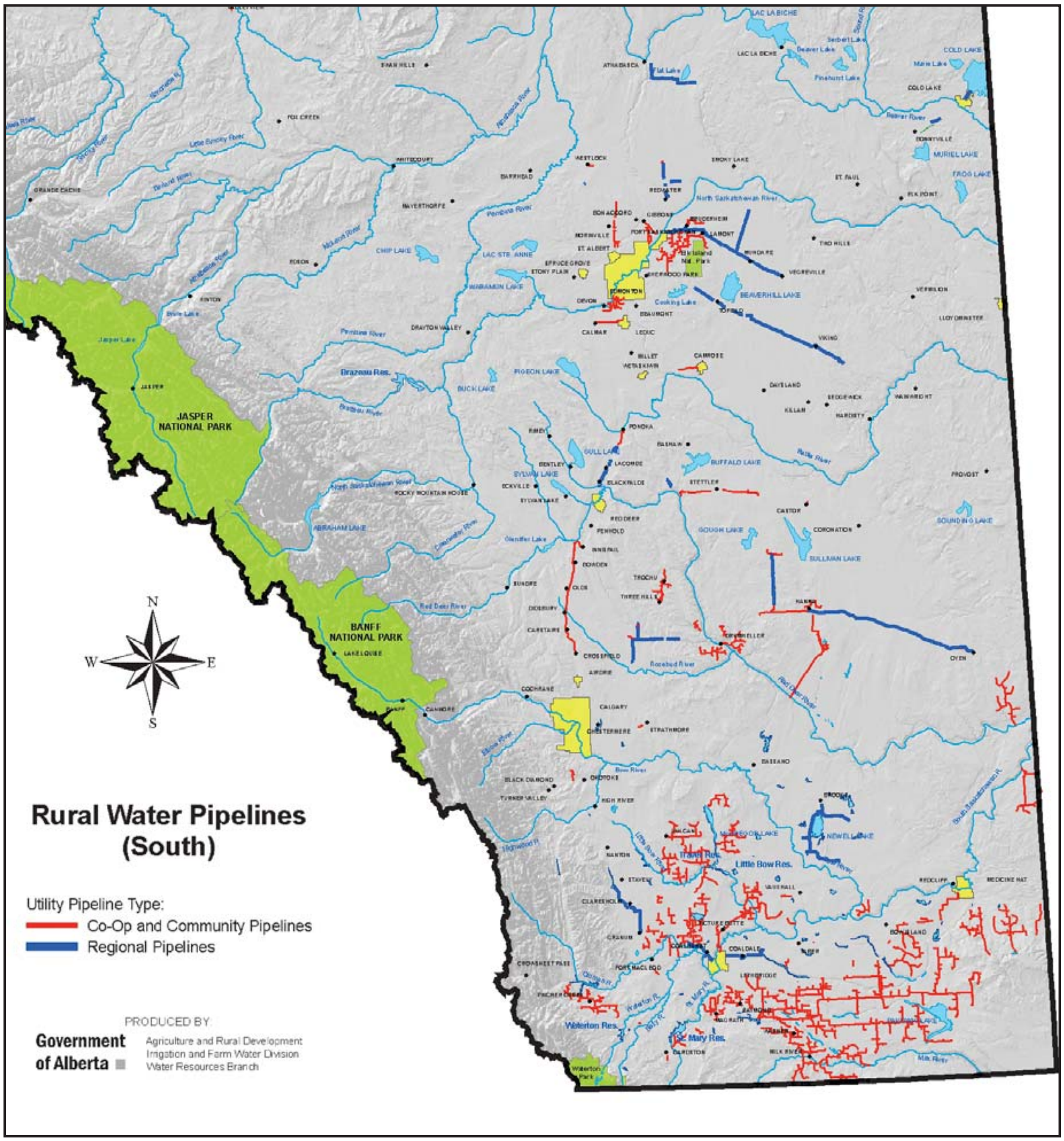


Figure 8.1. Rural water pipelines in southern Alberta (Paterson, 2012).

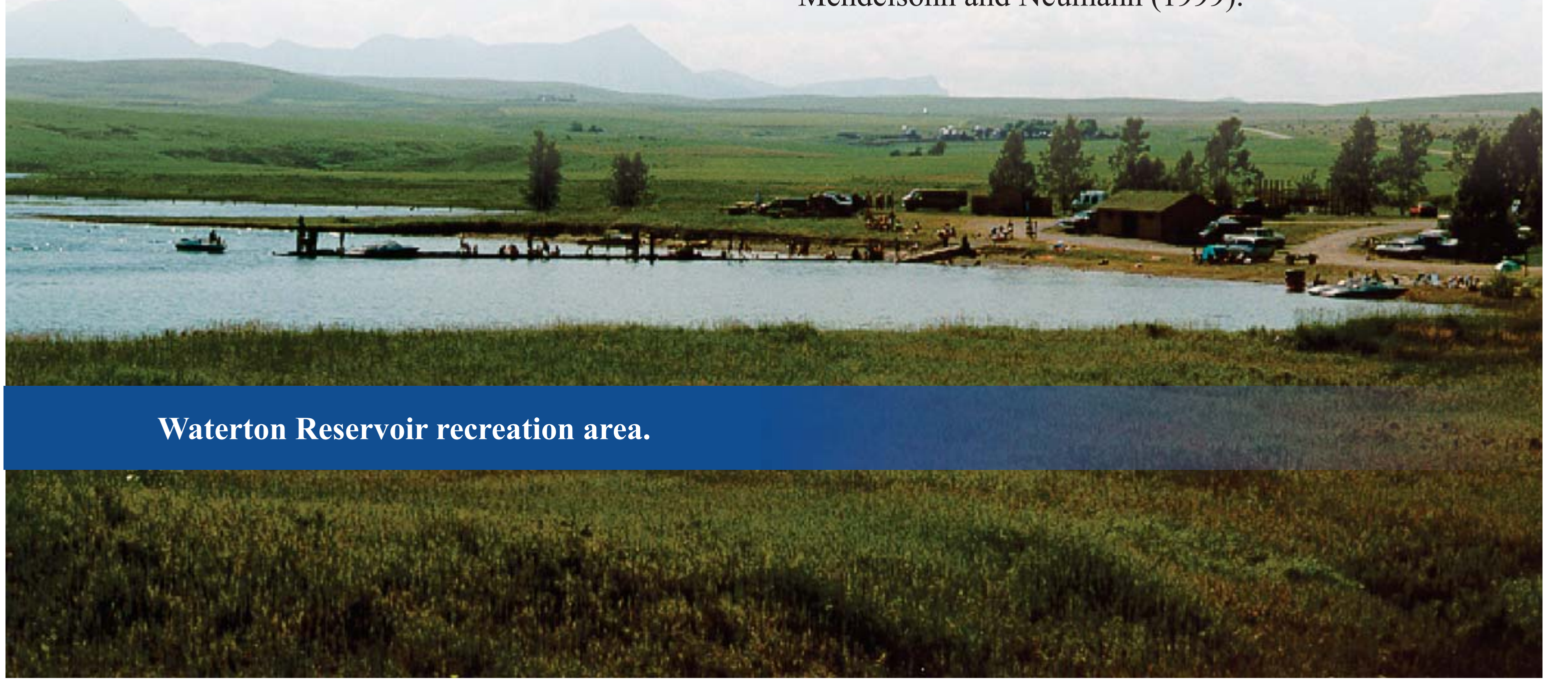
8.2 Recreation

Tourism is a key component of the Alberta economy and irrigation infrastructure plays an important role in providing water-based recreational opportunities. A GOA (2012b) study estimated that spending by all tourists in the province that year was more than $7.41 billion. This spending resulted in a net value-added economic impact of more than $8.3 billion province-wide. More than 114,000 jobs were generated through tourism and about $3.4 billion in total tax revenue accrued to all three levels of government in that year.

In southern Alberta, spending by tourists was approximately $734 million, resulting in a value-added impact of almost $800 million province-wide (GOA, 2012b; 2012c). More than 10,000 jobs were created, and approximately $322 million in total tax revenue accrued (GOA, 2012b). Within the tourism industry, water-based recreation opportunities provided by irrigation infrastructure are important, given the scarcity of natural standing water bodies in southern Alberta (McNaughton, 1993). These benefits are largely related to the recreation opportunities created by the 57 reservoirs developed primarily to support the irrigation industry. Benefits include camping, boating, swimming, fishing, wildlife watching, and hunting.

The McNaughton (1993) study assessed recreational characteristics of the reservoirs, which may include provincial parks, developed sites with facilities (including provincial recreation areas), and informal-use sites. Park operation and maintenance varies, and can include Alberta Parks and Recreation, counties, municipal districts, local towns, special committees, development boards, or commercial ventures. There are many reservoirs that do not have formally developed sites but still provide many recreational benefits.

This study estimated the benefits of recreational opportunities through the consumer surplus approach, which estimates the amount of money a consumer values a good or service, over and above its purchase price. Data were collected from a variety of sources such as Alberta Provincial Camping Statistics (ESRD, 2013a), visitation statistics for provincial parks and recreation areas (Alberta Tourism, Parks and Recreation, 2006), and a telephone survey of 20 irrigation-related park managers. For those reservoirs where data were not readily available, a factor was included that estimated visitor use based on reservoir size and location. The total consumer surplus was approximately $4.1 million for campers and approximately $10.3 million for day users (Table 8.4), using adjusted consumer surplus estimates based on Mendelsohn and Neumann (1999).



Waterton Reservoir recreation area.

Table 8.4. Estimated recreational activity and consumer surplus for irrigation reservoirs in Alberta (2013). [z]

Recreation Site	Numbers of Campers (Person-days)	Number of Day Users (Person-days)
Park Lake Provincial Park	15,523	123,904
Little Bow Provincial Park	46,887	15,744
Kinbrook Island Provincial Park	48,478	91,346
Payne Lake	4,103	554
Waterton Reservoir	385	593
St. Mary Reservoir	7,546	5,509
Jensen Reservoir	56	1,285
Little Bow Reservoir	1,795	950
Cavan Lake	790	-
Chestermere Lake	-	2,824
Stafford Lake	-	2,846
Pine Coulee Reservoir	5,542	-
Keho Lake	1,200	-
Travers Dam	9,000	2,250
Lake McGregor	24,000	6,000
Enchant Municipal Park	1,700	6,800
40-Mile	6,570	2,322
Total Campers/Day Uusers	**173,575**	**262,927**
Consumer Surplus	**$3,297,925**	**$8,216,468**
Factor for Missing Sites [y]	**$824,481**	**$2,054,177**
Total Consumer Surplus	**$4,122,406**	**$10,270,645**

[z] Accurate data were only available for 2013.
[y] For recreation areas not listed here, a factor related to location and surface area was included in the calculation.

The direct economic impacts of recreation activities on the region and on the province of Alberta were estimated using per diem expenditures reported by Environment Canada (2014). Typical water-based recreation (assumed to be water-based motorized recreation) expenditures were estimated to be $24/day for day users and $77/day for campers (assumed to be nature-based recreation). Based on these data, the total annual expenditure on recreation activities related to irrigation reservoirs was about $18.5 million (Table 8.5).

Secondary economic impacts of the $18.5 million expenditure generated about $15 million to the provincial GDP, $9 million in labour income, and created about 222 jobs (Table 8.6). Adding the total consumer surplus (about $14.4 million) in Table 8.4 to the increase in personal income (about $9.3 million) in Table 8.6 resulted in a total value of irrigation through recreational activities of about $24 million.

Table 8.5. Recreation activities associated with irrigation reservoirs in Alberta (2013).

Details	Campers	Day Users	All Visitors
Person Days	173,575	262,927	436,502
Expenditure ($/day/person)	77.00	24.00	
Distribution of Per Diem Expenditures (%)			
Transportation	30	17	
Accommodation	14	8	
Food	16	11	
Equipment	40	64	
Total	100	100	
Amount of Per Diem Expenditures ($/person)			
Transportation	23.10	4.08	
Accommodation	10.78	1.92	
Food	12.32	2.64	
Equipment	30.80	15.36	
Total	77.00	24.00	
Total Expenditures per Year ($'000)			
Transportation	4,010	1,073	5,082
Accommodation	1,871	505	2,376
Food	2,138	694	2,833
Equipment	5,346	2,840	8,186
Total	**13,365**	**5,111**	**18,477**

Table 8.6. Economic impact of expenditures related to recreational activities on irrigation-related reservoirs in Alberta (2012).

Region	GDP	Income	Employment
	($'000)		(FTEs)[z]
Southern Irrigation Region	14,894	9,042	210
Rest of Alberta	396	254	12
Alberta	**15,290**	**9,296**	**222**

8.3 Hydropower Generation

In 1988, the GOA introduced the Small Power Research and Development Program, which helped implement small power production throughout the province. To take advantage of this new program, a consortium of three irrigation districts (St. Mary River, Taber, and Raymond Irrigation Districts) was formed to assess the development potential of hydro-power generating stations on the St. Mary main canal, which runs from southwestern Alberta to Medicine Hat.

Irrican Power Generation Ltd. was formed, and two hydro plants were constructed in 1994: one near Raymond and one on Chin Reservoir south of Taber. A third plant was constructed on the main canal in 2004. The total cost of these plants was about $59 million. They operate throughout the summer months each year, when sufficient water is flowing in the St. Mary main canal. Irrigation-related hydropower generation helps Alberta reduce its carbon footprint, creates economic activity, and provides employment opportunities.

Total capacity of the three hydro plants is about 35 megawatts (MW). Revenue generated from these three plants was about $7.1 million in 2013 and $4.7 million in 2014 (IrriCan Power Generation Ltd., 2015).
An additional six hydro power stations are located on GOA-owned reservoirs or rivers that serve the irrigation regions in southern Alberta (Table 8.7). The total generating capacity of these power plants is 82 MW.

Table 8.7. Small hydropower stations located on Government of Alberta-owned infrastructure.

Hydro Station	Date Constructed	Capacity (MW)[z]	Owner
Belly River	1991	17	TransAlta
Dickson Dam	1992	15	Algonquin Power
Oldman River	2003	32	ATCO Power Piikani Nation
St. Mary Reservoir	1992	2	TransAlta
Taylor	2000	13	TransAlta
Waterton Reservoir	1992	3	TransAlta
Total Capacity		**82**	

[z] It was assumed that 70% of the power generation from these hydropower stations were related to irrigation, which is the same as estimated for other GOA-owned water infrastructure in southern Alberta.

Chin hydro plant.

Based on the average annual revenue generated by the Irrican Power Generation Ltd. hydropower stations, the economic impact was assessed using an annual power generation level of $15.5 million for all irrigation-related hydropower stations. This generated $13.7 million to the provincial GDP, $7.1 million in labour income, and created 99 jobs (Table 8.8).

8.4 Commercial Fishing

Canadian freshwater fish sales in 2003/2004 were estimated to be about $60 million, with Alberta accounting for about 10% of that total (Arthurson, 2005). Commercial fishing in Alberta took place on about 80 lakes, including about 20 reservoirs associated with the irrigation districts in southern Alberta.

Relative to the Alberta total, the annual commercial fishery on the 20 irrigation reservoirs is quite small, with the total annual harvest of about 300 tonnes (IWMSC, 2002). Using the wholesale price index for fish (Statistics Canada, 2014b), the annual value was estimated at $650,000. This generated about $626,000 to the provincial GDP, $405,000 in labour income, and created six jobs (Table 8.9). Commercial fishing on Alberta lakes was closed effective August 1, 2014.

8.5 Habitat Development

Prior to the development of irrigation in southern Alberta, the prairie landscape looked very different to what it is today. Essentially no large natural water bodies existed, except during the few exceptionally wet years.

Table 8.8. Average economic impacts of hydropower generation on irrigation-related reservoirs (2013 and 2014).

Region	GDP ($'000)	Income in ($'000)	Employment (FTEs)[z]
Southern Alberta Region	13,485	7,003	95
Rest of Alberta Region	175	83	4
Province	13,661	7,086	99

Source: IrriCan Power Generation Ltd. (2015).
Average revenue for 2013 and 2014 was $5.9 million. IrriCan Power Generation Ltd. generation capacity was estimated to be 35 MW. This yielded a total value of power generation of $15.5 million.
[z] Number of full-time equivalent workers.

Table 8.9. Economic impacts of commercial fishing on irrigation reservoirs in Alberta (2013 to 2014).

Region	GDP ($'000)	Income ($'000)	Employment (FTEs)[z]
Southern Alberta Region	544	342	4
Rest of Alberta Region	82	63	2
Province	626	405	6

[z] Number of full-time equivalent workers.

With the development of irrigation agriculture, significant changes occurred. Irrigation canals, which distributed water throughout a large area of southern Alberta, created new and different wildlife habitat than had been there previously. In particular, the canals that were constructed and operated in the early part of the 20th century often lost water through seepage to the adjacent lands. This created significant areas of semi-permanent to permanent wetlands along much of the canal distribution system, and these wetlands became excellent wildlife habitat.

As the demand for irrigation grew, and recognition for the need to conserve water resources and improve water-use efficiency increased, concerted efforts were implemented to reduce canal seepage. Many of the 8,000 kilometres of water delivery canals have been rehabilitated or replaced with underground pipeline systems, effectively eliminating canal seepage.

While the rehabilitation has dramatically increased overall water delivery and water-use efficiency, it also removed the seepage-created wetlands. To partially compensate for these wetland losses, the irrigation districts partnered with groups like Ducks Unlimited Canada and the Partners in Habitat program to create and enhance wildlife habitat throughout the 13 irrigation districts. Today, approximately 32,000 hectares of habitat have been developed (ARD, 2014a) in association with irrigation district infrastructure and operations. In addition, about 60,000 hectares of uplands are managed for wildlife production (AIPA, 2013).

Irrigation districts continue to have strong ties to wildlife habitat organizations to enhance existing and develop new wildlife habitat areas. In 2014, Ducks Unlimited Canada worked with Pheasants Forever to upgrade 32 wetland basins located on about 800 hectares of wetlands in southeast Alberta. These wetlands were originally developed in 1954 and are close to irrigation agriculture areas in southeast Alberta (Ducks Unlimited Canada, 2014). Through the Partners in Habitat Development Program, more than 600,000 trees and shrubs have been planted in the irrigated region (EID, 2012).

While no monetary value has been determined for habitat projects within districts, the EID (2012) report notes the numerous benefits of the partnerships between the irrigation districts and habitat agencies.

8.6 Flood Control

Southern Alberta has experienced numerous floods during the past two decades, often caused by high rainfall combined with spring snowmelt. These floods caused significant damage to public and private infrastructure. While the 2013 flood was one of the most devastating on record, floods in 1995, 2002, 2005, 2010, and 2011 also caused significant damage in various parts of southern Alberta.

8.6.1. Overland Flooding

In 2010 and 2011, severe flood damage occurred throughout a significant part of southern Alberta. This was a result of overland flooding caused by excess rainfall and snowmelt, combined with runoff from the Milk River Ridge in southwestern Alberta and the Cypress Hills of southeastern Alberta. Significant damage occurred to highways, roads, irrigation canals, storage reservoirs, farm buildings, and homes. Thousands of hectares of agricultural land were flooded and many livestock were threatened.

The area south of the Oldman River and South Saskatchewan River from the Waterton Reservoir to east of Medicine Hat was

Flooding of road across Yellow Lake (2010).

particularly hard hit by these back-to-back floods because of a lack of drainage infrastructure to remove and quickly spill excess water back to the river system. It is recognized that modernization of irrigation distribution infrastructure in the irrigation districts may have altered the surface drainage in this region.

About 4,000 kilometres of canals distribute water from the Oldman River system to irrigation producers and other water users in the region. Although canals are not designed for flood water conveyance, they often served as temporary drainage and storage channels that collected surplus water from fields during rainstorm and flood events.

Irrigation districts are replacing many of these surface canals with underground pipelines, which are more efficient, less expensive to operate, and bring valuable irrigation land back into production. However, this has reduced the capacity of the distribution infrastructure to capture some of the flood flows. Studies are underway to assess the issue of surface drainage in the Southern Irrigation Region, and to develop a long-term strategy to address this issue.

8.6.2. Impact of Water Storage Reservoirs

Water storage reservoirs in southern Alberta are designed to supply water during dry periods and are not designed for flood control. However, a combination of water supply and flood mitigation benefits can be achieved if a portion of a reservoir is reserved for water supply and a portion used for flood storage. To accommodate significant flood storage in the existing reservoirs would increase the magnitude and frequency of water supply deficits. However, these reservoirs can provide flood mitigation through effective monitoring, streamflow forecasting, and judicious operations.

Three on-stream irrigation reservoirs in the SSRB are operated in this manner to provide flood mitigation benefits whenever possible. These include the Oldman River, Waterton, and the St. Mary Reservoirs. While flood control benefits of these reservoirs are not routinely analyzed, information on the operation of the Oldman River Reservoir during the 1995 flood is provided.

8.6.2.1 Case Study - Oldman River Reservoir

The Oldman River Dam was commissioned in 1991, and is owned and operated by the GOA, primarily to:

- Provide water supply to meet a variety of uses;
- Improve downstream aquatic and riparian habitats; and
- Meet water supply apportionment commitments to Saskatchewan.

On May 1, 1995, the water supply forecast issued by Alberta Environmental Protection (AEP, 1995) indicated that inflow into the Oldman River Reservoir would be 75% of average, based on snowpack, winter precipitation, and projections regarding spring and summer precipitation. This signaled operators of the dam to begin increasing storage in the reservoir.

On June 5, 1995, Environment Canada issued a heavy rainfall warning of 50 to 100 millimetres along the foothills in southern Alberta. Rainfall began near midnight on June 5, and intensified and persisted through June 6. Within 24 hours, the storm produced up to 300 millimetres of rain on an area just north of Waterton Park, and lesser amounts northward as far as the Bow River Sub-basin.

The storm caused a rapid and extreme increase in stream flows along the eastern slopes of the Rocky Mountains. As a result, much of the hydrometric instrumentation in the Oldman River Basin was quickly destroyed or disabled. Oldman Dam operation's staff were forced to calculate inflow to the reservoir from visual observation of water levels. Inflows on June 6 increased from 311 m^3/s at noon to a peak of 3,500 m^3/s by midnight.

In an attempt to draw down reservoir storage on June 6, releases were increased to bank full capacity of the Oldman River downstream of Pincher Creek, which was also in flood stage. The Piikani First Nation, landowners, and municipalities downstream of the reservoir were notified of potential flooding. Releases from the Oldman Reservoir peaked on June 7 at 2,706 m^3/s. Releases were maintained at less than inflow to the reservoir until about 3:00 PM on June 7, when reservoir full supply level was reached.

The June 1995 flood was a rare event. Flood frequency analyses suggest that the recurrence interval would be in excess of a 1 in 1000 year event. Despite extreme circumstances involving intense precipitation throughout a large area, a relatively high reservoir level at the onset of the flood, little warning of impending flood conditions that would permit reservoir drawdown, and washed out monitoring and communication facilities during the flood, judicious operation of the Oldman Reservoir reduced the flow from a peak instantaneous inflow of about 3,500 m^3/s to a peak outflow of 2,706 m^3/s. This resulted in a reduction in the peak flow of 23%.

A summary of peak flow reductions because of the Oldman River Dam in 1995 at various locations along the river are shown in Table 8.10.

The peak flow reduction of 0.7 metre at Lethbridge may have saved the Highway 3 and Fort Whoop-Up Drive bridges from extensive damage or complete washouts. The recorded flow was only slightly below the bottom of the deck on both bridges.

A reduction in stage of 0.5 m at Fort Macleod and Medicine Hat substantially reduced damages to residential, commercial and institutional properties, and recreation developments. No studies have been undertaken to determine the monetary benefits of the 1995 flood mitigation, but it is believed to be substantial.

2005 flooding of Oldman River along Highway 2.

Table 8.10. Oldman River Reservoir impact on flow reduction of Oldman River during the 1995 flood.

Locations	Natural Flow[z] (m^3/s)	Recorded Flow (m^3/s)	Reduction (%)	Stage Reduction (m)
Oldman River Dam	3,500	2,706	23	
Fort Macleod	3,150	2,500	21	0.5
Lethbridge	5,300	4,500	15	0.7
Medicine Hat	6,060	5,375	11	0.5

[z] Natural flow assumes the Oldman, Waterton, and St. Mary River Dams did not exist.
Source: AEP (1995).

8.6.2.2 Case Study - Twin Valley Reservoir

Flood mitigation benefits of existing off-stream reservoirs are generally considered to be limited because:

- The restricted capacity of downstream canals limits the potential to rapidly draw down the reservoirs in advance of peak river flows; and
- The capacity of upstream canals limits the potential to quickly divert flood-waters into the off-stream storage.

Nevertheless, some flood mitigation benefits of off-stream reservoirs can be realized. The Twin Valley Reservoir on the Little Bow River is a special case. It is primarily an off-stream reservoir that stores diverted Highwood River water for irrigation and other uses in the Little Bow River Basin. However, it also stores natural flow of the Little Bow River and Mosquito Creek. During the 2013 flood, substantial flows from the Highwood River spilled into the Little Bow River. Storage in Twin Valley Reservoir was able to store some of the excess flood water and reduced downstream flow intensity (AMEC, 2014a). It is not known what impact this flow reduction may have had on reducing the impact on downstream infrastructure.

No studies have been conducted to determine the monetary benefits of irrigation infrastructure for flood mitigation in Alberta.

Chapter 9

Cumulative Economic Impacts of Irrigation

Alberta's irrigation industry generated $3.6 billion to the provincial GDP, $2.4 billion in labour income, and created 56,000 jobs.

Chapter 9

Cumulative Economic Impacts of Irrigation

The previous chapters individually assessed the economic value of several activities related to irrigation in Alberta from 2000 to 2011. Each activity resulted in increased sales of goods and services that positively impacted the province's GDP, income levels, and employment. These include:

- Irrigated crop and livestock production;
- Backward and forward linkages to crop and livestock production;
- On-farm investment in machinery and equipment;
- Infrastructure rehabilitation, operation, and maintenance;
- Drought mitigation;
- Recreation;
- Hydropower generation;
- Commercial fishing; and
- Other non-irrigation water use.

This chapter summarizes the economic impacts of each irrigation-related activity and provides the combined economic impact of all activities.

9.1 Primary Crop and Livestock Production

Net economic returns for irrigated crops such as barley and spring wheat were significantly greater when compared with dryland crops. Irrigated cropland produced average annual revenues of about $1,129/ha compared with about $260/ha under dryland conditions – more than four times greater.

Irrigated crop sales were $689 million annually, and accounted for almost 22% of Alberta's total crop sales. This generated about $686 million to the annual GDP through backward linkages and about $421 million in labour income. About 6,900 FTEs were created.

Livestock sales associated with irrigation were $746 million/year, and accounted for 17% of Alberta's total livestock sales. This generated $635 million/year to the annual GDP through backward linkages, and about $451 million in labour income. About 8,900 FTEs were created, with about 50% of these on irrigated farms and the remainder in non-agriculture sectors.

Irrigated crop and livestock production, carried out on 4.7% of the province's cultivated land base generated 19% of the total primary agricultural sales in Alberta. Irrigation sales equated to about $2,400/ha compared with about $329/ha for dryland production – about seven times greater. Combined annual sales of irrigation crop and livestock products generated about $1.7 billion to the Alberta GDP. Irrigated crop and livestock production also generated about $1.2 billion in labour income and about 37,000 FTEs.

9.2 Agricultural Processing

Irrigation-related agricultural processing generated about $2.0 billion in total sales. This accounted for about 18% of the total provincial food processing sales. Irrigation-related agricultural processing provided almost $1.7 billion to the provincial GDP. It also generated about $1.0 billion in labour income, and about 17,000 FTEs. Slaughter and meat processing was the major contributor, accounting for almost 50% of the total agri-food processing sectors' employment.

9.3 Irrigation Infrastructure and Government Revenue

Operation, maintenance, and rehabilitation of irrigation infrastructure in southern Alberta generated about $102 million annually to the Alberta GDP and about $66 million in labour income. About 1,400 FTEs were created.

The total combined irrigation-related revenue to the GOA and GOC was about $1.3 billion annually. Government revenue always exceeded irrigation-related expenditures, with a revenue to expenditure ratio of about 3:1.

9.4 Other Irrigation Benefits

Drought Mitigation. The value of irrigation in a drought year was about $116 million. Based on an 8% drought probability in any given year, annual irrigation benefits were about $9 million.

Non-irrigation Water Use. About $47 million was saved each year by supplying water through irrigation infrastructure for agricultural, commercial, industrial, and municipal uses. These savings generated about $46 million annually to the provincial GDP, and about $46 million in labour income.

Recreation. About 436,500 annual visitor user-days of activity were associated with the 57 irrigation-related reservoirs in southern Alberta. The total annual expenditure of these visitors on recreation activities was about $18.5 million. These expenditures generated about $15 million annually to the provincial GDP and $9 million in labour income. About 220 FTEs were also created.

Hydropower. Irrigation-related hydropower plants annually generated about $16.0 million of green energy, which provided about $14.0 million to the provincial GDP. About $7.0 million in labour income was generated and 99 FTEs were created.

Commercial Fishing. Irrigation reservoirs annually generated about $650,000 in commercial fish sales, which added about $626,000 to the provincial GDP and about $405,000 in labour income.

9.5 Total Economic Impact of Alberta's Irrigation Industry

Combining all of the above economic benefits, Alberta's irrigation industry annually generated about $3.6 billion to the provincial GDP, $2.4 billion in labour income, and created about 56,000 FTEs (Table 9.1).

Gross domestic product multipliers[1] indicate that for every $1.00 of irrigation sales (Table 5.6), the total GDP increased by $2.54 and labour income increased by $1.64. Total employment increased by about 39 FTEs for every $1.0 million of irrigation sales.

Every cubic metre of water delivered for irrigation and other related uses[2] generated about $3.00 to the provincial GDP and $2.00 in labour income. Every $1.00 invested by the (GOA) in irrigation-related activities generated $3.00 in added revenue to Alberta and Canada.

Table 9.1 summarizes the combined economic impacts of the irrigation industry assessed in this study, and provides a breakdown of the relative impacts of each component.

---

[1] These are considered "Pseudo Multipliers", which are different from "Final Demand" or "Ratio-From Multipliers".

[2] Based on information in ARD (2012a). Estimated that 1.2 billion m^3 of water was delivered in 2011 for irrigation (district and private projects) and other uses, including municipal, industrial, and recreation. It does not include return flow, evaporation, and seepage.

Table 9.1. Total economic impacts related to irrigation and related activities.

Activity	Description	GDP ($ million)	Income ($ million)	Employment (FTEs)[z]
Primary Production				
1	Primary crop production	166	104	10,262
2	Primary livestock production	214	182	10,369
3	Backward linkages (crop production)	686	421	6,879
4	Machinery and equipment	59	36	654
5	Backward linkages (livestock production)	635	451	8,918
Agricultural Processing				
6	Forward linkages (value-added processing)	1,693[x]	1,047	17,093
Irrigation Infrastructure				
7	Infrastructure	102	66	1,387
Other Irrigation Benefits				
8	Drought mitigation	9	9	0
9	Water use (non-irrigation)	46	46	--
10	Recreation	15	9	222
11	Hydropower generation	14	7	99
12	Commercial fishing[y]	0.6	0.4	6
Total Economic Value		**3,639.6**	**2,359.4**	**55,889**

[z] Number of full-time equivalent workers.
[y] Effective August 1, 2014, all lakes in Alberta were closed to commercial fishing.
[x] Forward linkages can be divided into two components: Direct GDP of agri-food processing was $526 million; and indirect and induced contribution was $1.167 billion.

9.6 Irrigation's Contribution to the Alberta Agri-Food GDP

Using the ARIOM[3], the irrigation industry's relative contribution to Alberta's total agri-food GDP was calculated by combining the direct GDP contribution of the irrigation and food processing sectors with the indirect/induced contributions of the food processing sector. This is defined as the Total Agri-Food Sector GDP.

Direct GDP Contribution. The irrigation-related food processing GDP and primary agricultural value-added production was estimated. This was compared to the total GDP calculated for Alberta's five food processing sectors (Table 9.2). Irrigation-related agricultural processing directly contributed about $526 million toward the provincial GDP, accounting for about 18% of the total food processing GDP.

[3] ARIOM was used because direct estimates of the agriculture and food processing sector GDP were not available.

The total direct contribution of the irrigation industry to the provincial GDP was determined by combining the $526 million (Table 9.2) plus $380 million in primary value-added production (Table 5.6), for a total of $906 million.

Total GDP Contribution[4]. Irrigation's contribution to the agri-food sector was calculated as the sum of the:

- Direct GDP generated by primary irrigation production;
- Direct GDP generated by the irrigation-related food processing sector; and
- Backward linkages of primary irrigation production.

The total irrigation-related agri-food GDP was about $2.0 billion (Table 9.3).

This was compared to the total Alberta agri-food GDP for 2011, which was about $11 billion (Table 9.3). Based on this analysis, the irrigation-related agri-food GDP contributed about 20% of the total provincial agri-food sector GDP. Almost 90% of the GDP generated by irrigation accrued to the region and the province and 10% to irrigation producers. Using labour income as the criteria, 89% of the irrigation-related benefits accrued to the region and province, and 11% to irrigation producers.

Irrigation generated $3.6 billion to the provincial GDP – about 20% of Alberta's total agri-food GDP.

90% of the GDP generated by irrigation accrued to the region and province, and 10% to irrigation producers.

Table 9.2. Irrigation's direct share of Alberta's food processing GDP (2011).

Food Processing Industry	Alberta GDP ($ Million)	Irrigation Share (%)	Irrigation Food Processing GDP ($ Million)
Meat processing	1,416.2	16.3	230.8
Grain Milling	717.1	18.3	131.2
Animal Food	114.8	18.3	21.0
Fruits and Vegetables	102.1	61.5	62.8
Other Food	597.5	13.4	80.1
Total	**2,947.7**	**17.8**	**525.9**

[4] This analysis provides an intermediate assessment between the Direct Contribution and the Agriculture and Agri-Food System (Agriculture and Agri-Food Canada, 2015), which includes: input and food service providers, primary producers, food and beverage processors, and food retailers and wholesalers.

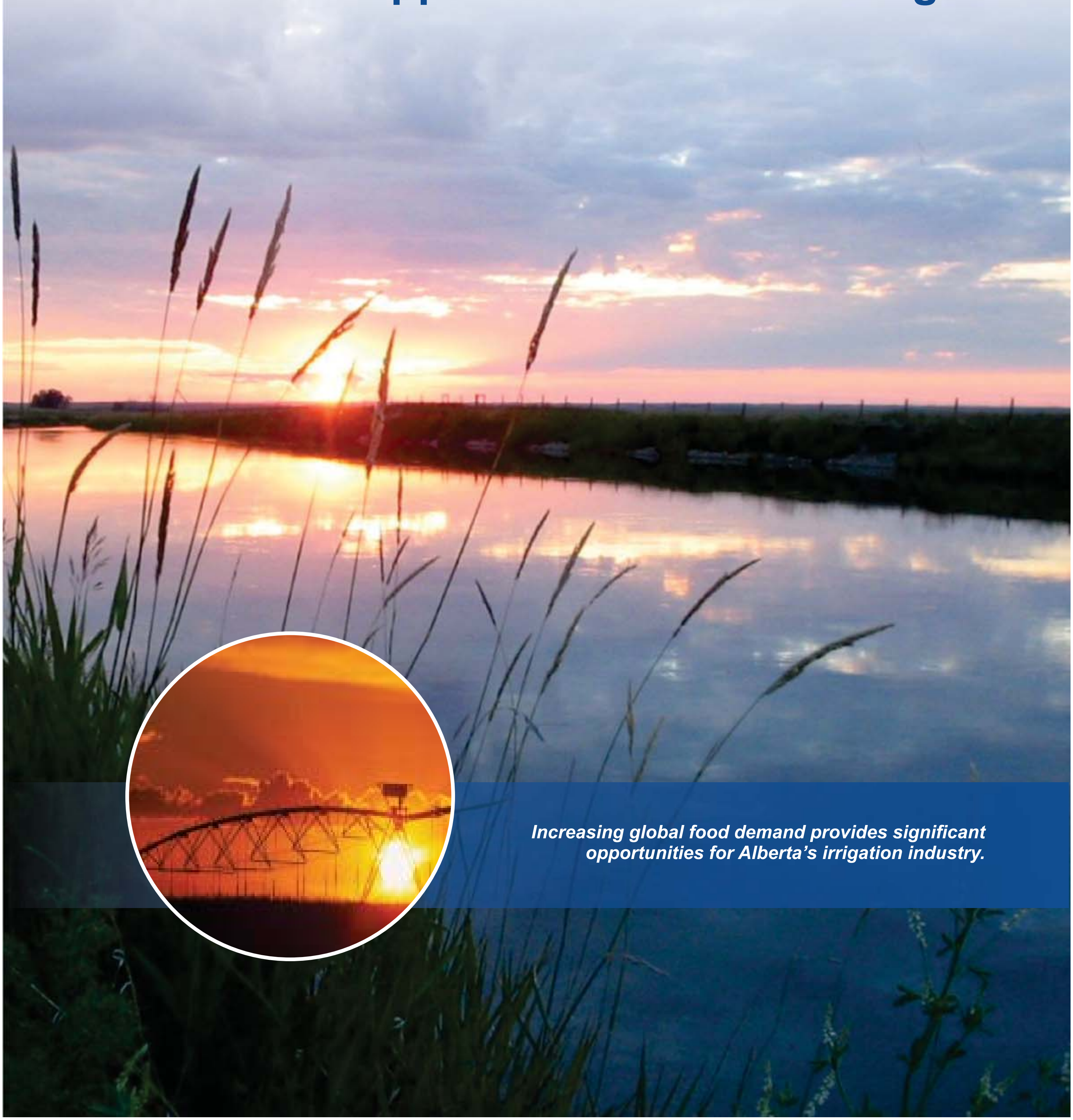
Table 9.3. Irrigation's total share of the Alberta agri-food GDP (2011).

Sector	GDP (Type)	Irrigation	Province	Irrigation Share (%)
		($ Million)		
Primary and Food Processing	Direct	906	5,382	16.8
Backward Linkages of Agriculture Production	Indirect and Induced	1,321[z]	5,595	23.6
Total Agri-Food Sector	Direct, Indirect, and Induced	2,227	10,977	20.3

[z] Source: Table 9.1. This is the sum of backward linkages for crop + livestock production.

Chapter 10

Future Opportunities and Challenges



Increasing global food demand provides significant opportunities for Alberta's irrigation industry.

Chapter 10

Future Opportunities and Challenges

10.1 Climate Change Impact on River Flow

Global Climate Model (GCM) projections indicate that temperatures in the SSRB will probably rise in response to increased greenhouse gas levels in the atmosphere. There is less certainty about precipitation, particularly on a regional level and in the mountainous areas. Some GCMs project decreases in precipitation, but most project increases. Much of the increase in temperature and precipitation is weighted toward the winter and spring months (Martz et al., 2007).

The National Water Research Institute used hydrologic modelling to assess the effect of projected climate change on stream flows in the SSRB in Alberta and Saskatchewan (Martz et al., 2007). Using a similar approach, Golder Associates (2012) predicted the potential range of impacts of climate change on flows in Alberta's South Saskatchewan Regional Planning Area.

Despite the increased precipitation for most model runs, both studies projected that streamflow would decrease under climate change conditions (Table 10.1). At the most downstream data point in each basin, Martz et al. (2007) projected that stream flows would decrease by about 13% in the Red Deer Basin, 10% in the Bow Basin, and 4% in the Oldman Basin, on average. Golder Associates (2012) projected the average impacts to be -24%, -3%, and -14%, respectively.

Given such large uncertainties in projected impacts on water resources, it is difficult to formulate meaningful next steps toward adaptations in water management. An international assembly of researchers, water managers, and environmental scientists reviewed 11 case studies of climate change impacts on water resources within global mountainous areas (Viviroli et al., 2011). The objectives were to make recommendations on global research needs for the advancement of water management adaptations under climate change conditions. They concluded that:

- Current water management regimes will likely be inadequate under a changed climate;
- Adaptation options are hampered by a limited understanding of climate change and the hydrologic response to that change;
- The highest research priority is to improve projections of precipitation, particularly in the mountain areas;
- The GCM projections of changes in mountain precipitation in the most recent Intergovernmental Panel on Climate Change report were highly variable; and
- Since the eastern slopes of the Rocky Mountains are the primary source of water supply in Alberta, uncertainties in other components of the hydrologic cycle (stream flow, water demand, operation of infrastructure) appear to be minor in comparison.

Table 10.1. Projected changes in natural flow by 2050 due to climate change.

Location	Mean Flow 1961 to 1990 (billion m^3)	Climate Change Impact (%) (Martz et al., 2007)			Climate Change Impact (%) (Golder Associates, 2012)		
		Maximum	Mean	Minimum	Maximum	Mean	Minimum
Red Deer River							
• City of Red Deer	1.35	-30	-13	10			
• Nevis	1.55				-32	-23	-5
• Drumheller	1.59	-32	-13	12	-41	-20	-2
• Bindloss	1.67	-32	-13	13	-44	-24	-7
Bow River							
• Banff	1.24	-12	-5	1	-15	-4	7
• Calgary	2.85	-19	-10	0	-18	-5	8
• Mouth	3.84	-19	-10	1	-15	-3	12
Oldman River							
• Waldron's Corner	0.39	-18	-6	4	-29	-14	5
• Monarch	1.36				-30	-15	3
• Lethbridge	3.29	-12	-3	7			
• Mouth	3.29	-12	-4	7	-28	-14	3
South Sask. River							
• Medicine Hat	7.10	-17	-6	6			
• Highway 41	7.20				-22	-8	8

10.2 Climate Change Impact on Irrigation

Irrigation in southern Alberta is not immune from the impacts of drought. The prolonged drought in the 1980s significantly impacted irrigation districts and many non-irrigation water users in this region. This drought provided the stimulus for construction of the Oldman Dam and Reservoir, approximately 100 kilometres west of Lethbridge. This was the last major on-stream reservoir to be constructed in Alberta.

The demand for water by some dryland and irrigated crops and livestock may increase with projected temperature increases under a changing climate. Preliminary work carried out by Harms (2010) suggests that alfalfa, potatoes, and sugar beets are crops that could see the highest water demand increases. For an average 2° Celsius temperature increase during the growing season, alfalfa's water demand could increase by 28%. A 4° Celsius increase could cause the water requirement to increase by 63%. On the positive side, the overall yield of crops such as alfalfa could increase by as much as 50% if sufficient water is available.

Climate change, combined with improved crop genetics and hybrid development, may lead to increased diversification of the crops grown under irrigation in southern Alberta. For example, corn (grain and silage) and soybeans may replace more traditional cereal grain crops in the irrigated area (Gabruch and Gietz, 2014). Both crops are gaining popularity within the irrigation districts of southern Alberta, and this is expected to increase substantially as new hybrids are introduced.

Hemp is another crop with potential to be grown under irrigated and dryland conditions in Alberta. In 2013, approximately 2,100 hectares of hemp were grown within the irrigation districts (ARD, 2014b). A study by Serecon Management Consulting Inc. (2012)

Oldman Dam and Reservoir.

indicated that significant opportunities exist for hemp production in Alberta. The study also showed that irrigated hemp production could provide increased financial returns compared to irrigated crops such as feed barley, spring wheat, and field peas.

In most years, winter precipitation and snowpack levels are sufficient to fill the on-stream and off-stream reservoirs during the spring snowmelt. Irrigation districts generally have more than enough water to meet expected irrigation and non-irrigation demands, even if snowpack levels for one year are below normal. However, high summer temperatures combined with low growing season precipitation can draw heavily on water stored in reservoirs, potentially leaving irrigation districts vulnerable if there is a second consecutive year of low winter snowpack.

The total storage capacity of the on-stream and off-stream reservoirs in the SSRB is about 3 billion cubic metres, which is about 30% of the annual natural flow of the Alberta SSRB Rivers (Red Deer, Bow, Oldman and South Saskatchewan). In 2000, the summer was relatively hot and dry, and irrigation districts diverted about 2.2 billion cubic metres of water to meet irrigation and non-irrigation demands. Recognizing that many other water users share the water stored in these reservoirs, it is unlikely there is sufficient water in storage to sustain more than one to two hot, dry years with current water management practices. In comparison, the system of reservoirs on the Colorado River in the United States has the capacity to store about four years of the river's natural flow (United States Department of the Interior, 2012).

It would be prudent for irrigation districts to assess, plan, and develop a long-term drought strategy that provides a proactive plan to deal with pending water shortages before they become critical. Development of additional water storage reservoirs or re-management of existing reservoirs should also be considered to increase water supplies during prolonged drought periods. A study commissioned by ARD (AMEC, 2014b) identified a number of potential storage sites to increase the overall water supply for the region. Recognizing that up to 20 years may be required to plan, design, review, and construct a new water-storage reservoir, initiating detailed assessment and planning for new reservoirs as soon as possible is recommended.

10.3 Market Changes and Global Market Opportunities

10.3.1 Global Markets

Increasing world food requirements are projected because of population growth, a growing middle class in developing countries, increased per capita food consumption, and shifts in diets throughout the developing world. In 2000, approximately 56% of developing countries were considered as middle class (Premier's Council for Economic Strategy, 2011). This is expected to increase to 93% by 2040. This larger middle class will continue to shift their diets towards more animal protein (meat, milk, eggs), particularly in Asian countries like China (including Hong Kong), Taiwan, South Korea, and Malaysia (FAO, 2006).

The implications of this shift in diet are significant, particularly for cereal grain production. Production of meat requires considerably more cereal production than if cereals are consumed directly. The increasing middle class will also increase demand for higher quality food products, more processed food products, and potentially more environmentally sustainable production of crop and livestock products.

All of these changes provide significant opportunities for Alberta's irrigation industry, which excels at producing high quality crop and livestock products that can be processed and exported to world markets. In addition, marketing environmental sustainability can be an important and unique advantage for Alberta's irrigation industry, and this would further strengthen the high quality products produced under irrigation.

Recognizing that Asia is and will continue to see the greatest increase in food demand, additional focus needs to be on development of a long-term marketing strategy by Alberta and Canada, with input from Alberta's irrigation industry. The Canadian Agri-Food Policy Institute (CAPI) suggests that Canada has the potential to be one of the world's leading producers of sustainably produced food (CAPI, 2011). The report indicates that Canada could increase its annual exports from $39 billion to $75 billion. To achieve this goal will require a dramatic change from thinking about "sectors, value chains, and product lines" to thinking about "agri-food systems". Alberta's irrigation industry can play a key role in this transition.

10.3.2 Food Processing

The irrigation industry has helped attract numerous multi-national food processing companies to set up operations in Alberta. However, there is room for additional food processing industries to establish plants in Alberta to take advantage of irrigated crop and livestock products. This would add value to the economy and provide diversification opportunities for irrigation producers.

A key requirement for any food processing company is an assured supply of good quality water, and this has been identified as a potential issue in the western United States, especially in drought-prone areas (Donavan, 2009). The extended and serious drought in California may have long-lasting implications on existing and new food processing companies in that state. Water supply shortages, combined with increasing population pressures and high land values, may force companies to consider moving their operations to areas where water supplies are more accessible and assured. The irrigation region of southern Alberta possesses all the necessary attributes for food processing companies to establish plants in this region. Climate change will see even greater opportunities as new irrigated crops are grown in the region.

Closing the Bow, Oldman, and South Saskatchewan River Sub-basins to new water allocation licence applications has left the impression that irrigation districts and the SSRB are closed to new development, including new food processing industries. This is incorrect, as sufficient water resources are available to support many new development opportunities.

Nearly all irrigation districts have amended their water licences to set aside water for other uses, including food processing and other value-added industries. The message, that water, land, skilled irrigation producers, and diversified, high quality irrigation product are available to support value-added processing industries, needs to be communicated to international food processing industries. This could be facilitated through a partnership among the irrigation districts, Southgrow, and the GOA.

10.3.3 Rural Economic Development

Alberta's rural economy has a $77 billion impact on the Alberta economy (ARD, 2014c). A strong rural economy benefits all Albertans, and establishment of strong, vibrant rural communities will support primary agricultural production and value-added processing industries. Assured water supply is a key element of the GOA's Rural Development Strategy, and is a priority goal of the GOA's *Water for Life Strategy*. Alberta Agriculture and Forestry's *Rural Economic Development Plan* is taking steps to increase economic development capacity and communities throughout Alberta. Alberta's 13 irrigation districts are an excellent template for what a strong, vibrant rural economy can look like, because of water.

The irrigation districts can play an important role in expansion of rural development opportunities to the surrounding dryland regions of southern Alberta. Their water storage reservoirs can supply the water necessary to successfully attract new business into the region and revitalize rural development opportunities. This would further enhance the existing linkage between the irrigation districts and the dryland agriculture industry, and expand their role in rural economic development outside of the irrigation district boundaries.

10.4 Invasive Mussel Species

Quagga and zebra mussels are one of the most destructive invasive aquatic species to invade North American fresh waters (Western Regional Panel on Aquatic Nuisance Species, 2010). Quagga and zebra mussels were introduced to the Great Lakes in the 1980s from the Black and Caspian Seas, carried on the hulls of trans-Atlantic ships. They were first introduced in Lake Mead in January 2007, and this is the first known invasion of this species in the western United States. Once established, they can block water intakes, delivery pipes, and dam intake gates and pipes.

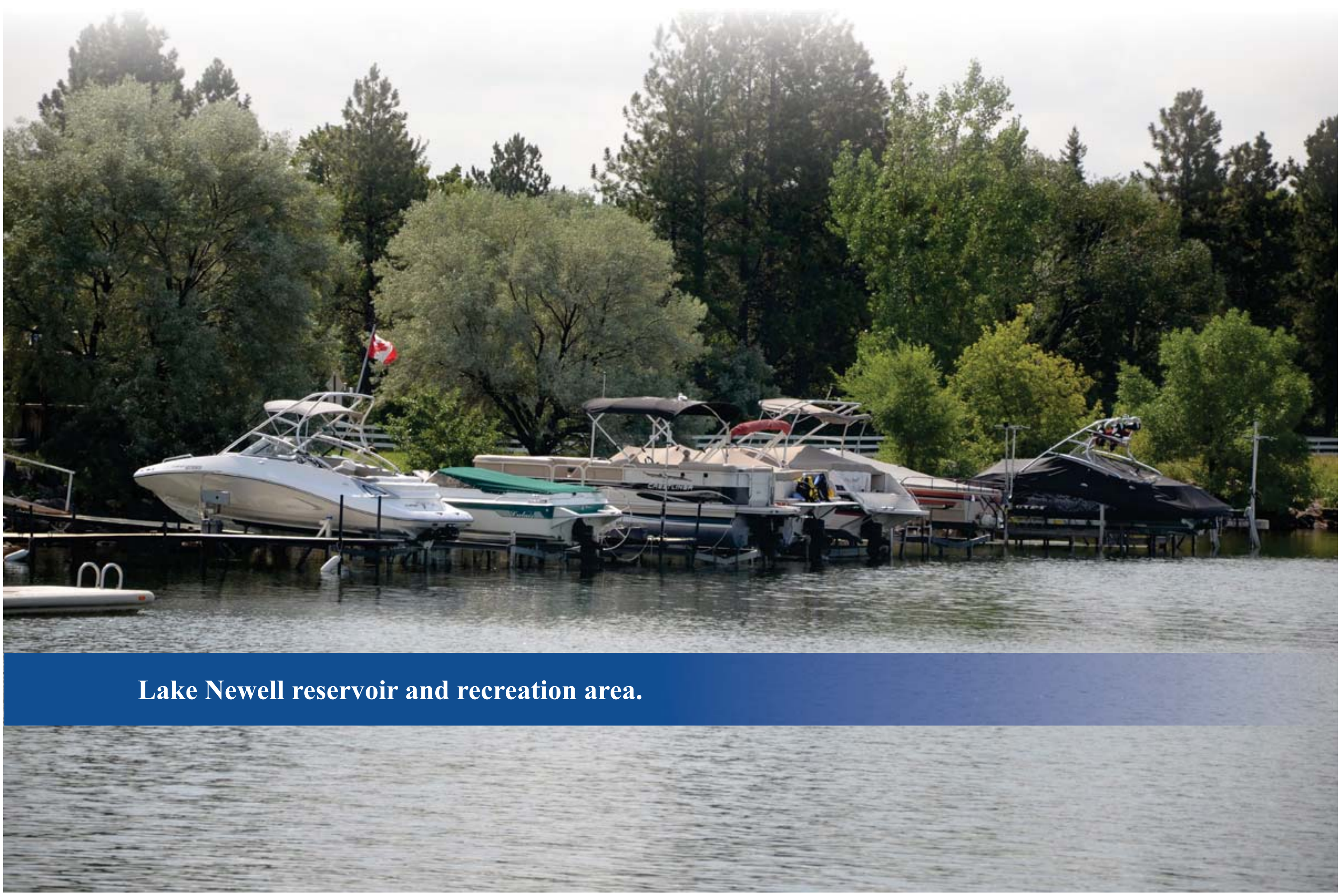
Pipe clogged with mussels.

Invasive mussels were discovered in Lake Winnipeg in 2013. While they are not yet present in Alberta waters, there are growing concerns about the risk of invasion because of the mobility of boat travel from locations in the United States and Canada where these mussels are present.

Alberta's reservoirs are a critical part of the water storage and supply system, and the presence of quagga and zebra mussels in the reservoirs would be potentially devastating to the irrigation industry and all other water users in the Southern Irrigation Region.

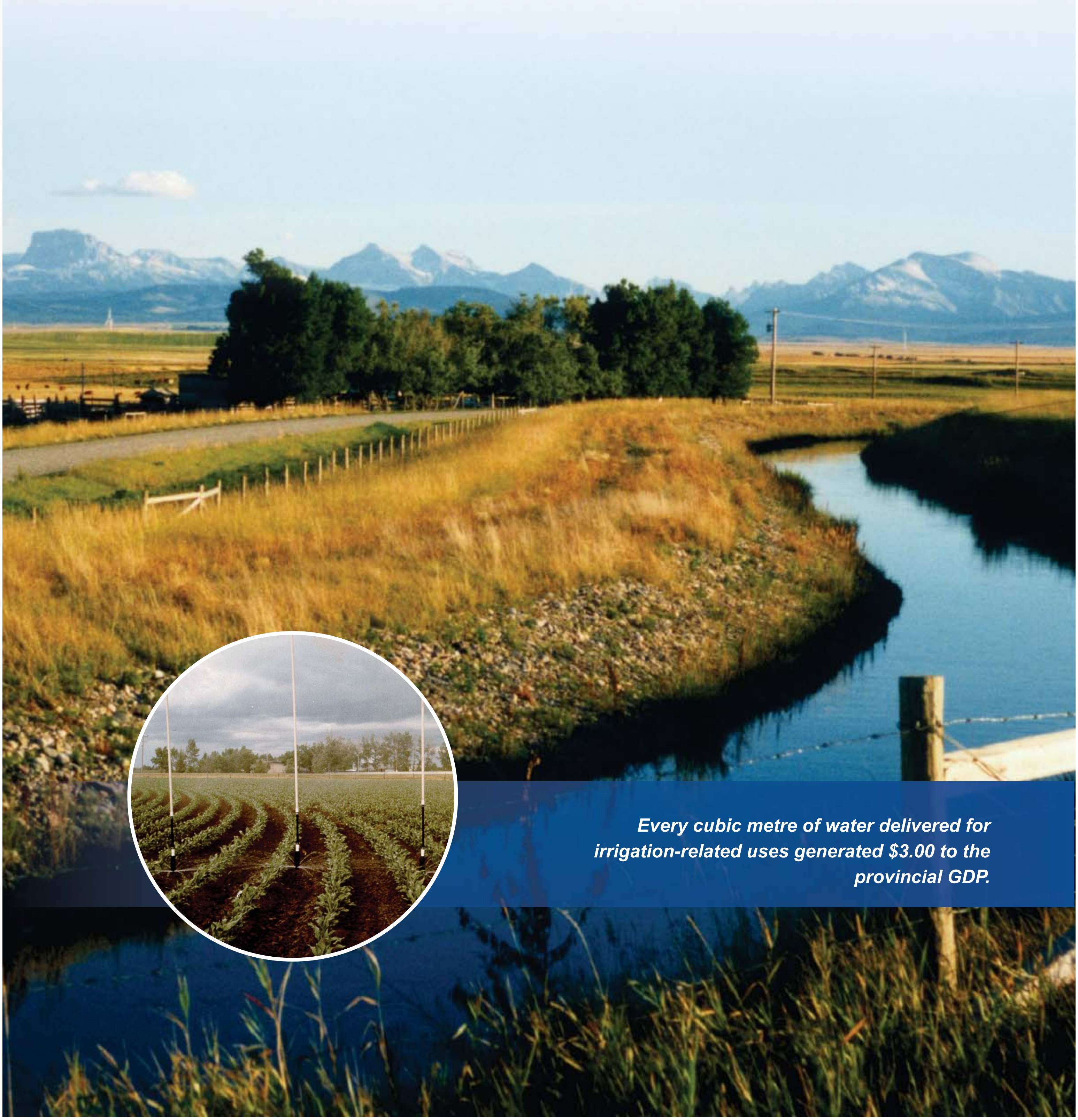
A study carried out by ESRD (2013b) assessed the potential economic impacts if the quagga and zebra mussels were to find their way into Alberta's waterways. Just to treat several key dams and 21 irrigation reservoir outlets was estimated to cost about $8.8 million annually. The study also estimates that annual costs to treat private irrigation intakes could be about $1,000/intake/year. Total costs are likely to be considerably greater when considering the large number of off-stream reservoirs and thousands of kilometres of pipelines that exist within the 13 irrigation districts. The greatest concern is for the pipelines within the irrigation water conveyance system, and each year, more canals are replaced with pipelines.

In 2015, Alberta enacted legislation for mandatory inspection and decontamination of any watercraft suspected of carrying invasive species such as quagga and zebra mussels (GOA, 2015). The GOA and irrigation districts are working together to further assess the threat of a quagga and zebra mussel invasion. Work is also underway to develop preventative and mitigation strategies to minimize the impacts on irrigation and other water users in southern Alberta.



Lake Newell reservoir and recreation area.

Chapter 11
Conclusions



Every cubic metre of water delivered for irrigation-related uses generated $3.00 to the provincial GDP.

Chapter 11

Conclusions

This study provided the most comprehensive assessment to date of the impacts that Alberta's irrigation industry has on the provincial economy and its value to all Albertans. It analyzed the economic effects of primary and value-added irrigation production, including backward and forward linkages related to that production. It also assessed the contribution of irrigation water storage and canal infrastructure on government revenues, and the value of irrigation to non-irrigation water users in southern Alberta. Finally, this study also looked at future opportunities and challenges the irrigation industry may face with changing world market opportunities and changing climatic conditions.

The results of this study show that Alberta's irrigation industry continues to play a significant role in growing the province's economy and increasing the social well-being of Albertans. In the future, irrigation will become an even more important economic driver as the world's demand for high quality processed food products continues to increase.

Irrigation productivity and efficiency has increased significantly during the past 20 years. Improvements to canal distribution infrastructure and on-farm irrigation management conserved about 200 million cubic metres of water from 1999 to 2012, even with about 30,000 hectares of irrigated area expansion.

Alberta's irrigation industry annually generated about $3.6 billion to the provincial GDP, created about $2.4 billion in labour income, and about 56,000 FTEs. The irrigation agri-food sector contributed about 20% of the total provincial agri-food sector GDP on 4.7% of the province's cultivated land base. Almost 90% of the GDP generated by irrigation accrued to the region and the province and 10% to irrigation producers. Using labour income as the criteria, 89% of the irrigation-related benefits accrued to the region and province, and 11% to irrigation producers. Irrigation also generated about $1.3 billion in annual revenue for the GOA and GOC.

Gross domestic product multipliers indicate that for every $1.00 of irrigation sales, the total GDP increased by $2.54 and labour income increased by $1.64. Total employment increased by about 39 FTEs for every $1 million of irrigation sales.

Every cubic metre of water delivered for irrigation and other related uses generated about $3.00 to the provincial GDP and $2.00 in labour income. Every $1.00 invested by the (GOA) in irrigation-related activities generated $3.00 in added revenue to Alberta and Canada.

Sales of irrigation crop and livestock products, on 4.7% of Alberta's cultivated land base, generated 19% of the total primary agricultural sales in Alberta. Irrigation sales equated to about $2,400/ha compared with about $329/ha for dryland production – about seven times greater. Combined annual sales of irrigation crop and livestock products contributed about $1.7 billion to the Alberta GDP. Irrigation-related agricultural processing also contributed almost $1.7 billion to the Alberta GDP.

Benefits from irrigation water used for non-irrigation purposes, such as recreation, hydropower generation, drought mitigation, and commercial fishing, generated an additional $85 million to the provincial GDP and $71 million in labour income. While an economic value was not determined for the 32,000 hectares of habitat development in the irrigation districts, their value in enhancing wildlife populations and biodiversity is considered priceless.

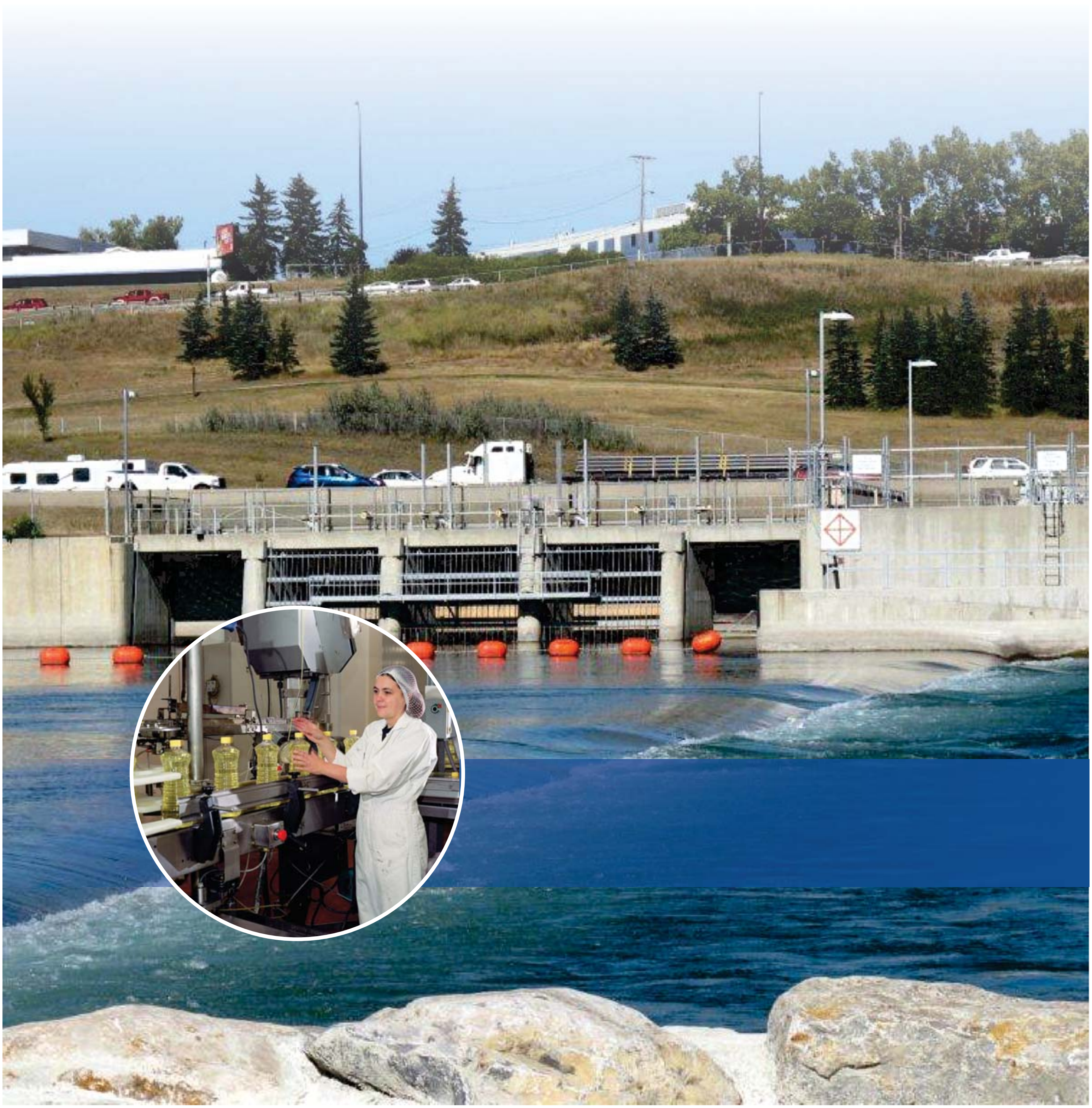
Climate change may provide opportunities and challenges for Alberta's irrigation industry, particularly in southern Alberta. Increased frequency, duration, and intensity of droughts in the region are possible. Long-term water and drought management strategies will allow irrigation districts to better optimize water supply and irrigation production during prolonged droughts.

Climate change may also lead to more diverse and high value irrigated crop production, and encourage establishment of additional processing industries in the region. The message, that water, land, skilled irrigation producers, and diversified, high quality irrigation products are available to support value-added processing industries, needs to be better communicated to international food processing industries.

Communities and industries supported by Alberta's 13 irrigation districts are an excellent template for what a strong, vibrant rural economy can achieve, because of water. Irrigation districts can play an important role in expansion of rural development opportunities to surrounding dryland regions in southern Alberta.

Alberta Environment and Parks main canal.

References



References

Aboriginal Affairs and Northern Development Canada. 2013. The Blood Tribe Irrigation Project. Accessed at https://www.aadnc-aandc.gc.ca/eng/1363285677771/1363286730194#chp5. October 23, 2014.

AECOM Canada Ltd. 2009. Irrigation Sector – Conservation, Efficiency, and Productivity Planning Report. Edmonton, Alberta, Canada. Alberta Irrigation Projects Association.

Agriculture and Agri-Food Canada (AAFC). 2015. An Overview of the Canadian Agriculture and Agri-Food System 2014. Accessed at http://www.agr.gc.ca/eng/about-us/publications/economic-publications/alphabetical-listing/an-overview-of-the-canadian-agriculture-and-agri-food-system-2014/?id=1396889920372c.

Agriculture Financial Services Corporation (AFSC). 2012. Yield Alberta 2012. Lethbridge, Alberta, Canada.

Agriculture Financial Services Corporation (AFSC). 2015. Price Lists. Accessed at https://www.afsc.ca/Default.aspx?cid=82&lang=1.

Alberta Agriculture, Food and Rural Development (AFRD). 2004. Irrigation Development in Alberta: Water Use and Impact on Regional Development, St. Mary River and "Southern Tributaries" Watersheds. International Joint Commission Submission, Alberta, Canada. 17 pp.

Alberta Agriculture and Rural Development (ARD). 2001. Alberta Irrigation Information: Facts and for the year 2011. Basin Water Management Branch, Lethbridge, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2006. Agriculture Statistics Yearbook 2006. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2007. Agriculture Statistics Yearbook 2007. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2008a. Evaluation of Business Risk Management Strategies for Hog Production in Alberta. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2008b. Agriculture Statistics Yearbook 2008. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2009a. Evaluation of Business Risk Management Strategies for Hog Production in Alberta. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2009b. Economics of Milk Production (Dairy Cost Study): Dairy Enterprise Cost & Returns. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2009c. Agriculture Statistics Yearbook 2009. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2010a. Evaluation of Business Risk Management Strategies for Hog Production in Alberta. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2010b. Economics of Milk Production (Dairy Cost Study): Dairy Enterprise Cost & Returns. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2010c. Cost of Production Raising Profitable Sheep: The Lamb Traceability Pilot Project Data (LTP). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2010d. Agriculture Statistics Yearbook 2010. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2011a. Evaluation of Business Risk Management Strategies for Hog Production in Alberta. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2011b. Economics of Milk Production (Dairy Cost Study): Dairy Enterprise Cost & Returns. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2011c. Cost of Production Raising Profitable Sheep: The Lamb Traceability Pilot Project Data (LTP). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2011d. Agriculture Statistics Yearbook 2011. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2012a. Alberta Irrigation Information: Facts and Figures for the year 2011. Basin Water Management Branch, Lethbridge, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2012b. Evaluation of Business Risk Management Strategies for Hog Production in Alberta. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2012c. Economics of Milk Production (Dairy Cost Study): Dairy Enterprise Cost & Returns. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2012d. Agriculture Statistics Yearbook 2012. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2013a. Agriculture Statistics Yearbook 2013. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2013b. Alberta Irrigation District Information: Irrigation Council. Lethbridge, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2013c. Irrigation in Alberta (Four Part Report). Accessed at http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/irr7197. October 7, 2014.

Alberta Agriculture and Rural Development (ARD). 2013d. The Economics of Sugar Beet Production in Alberta, 2011. Economics and Competitiveness Division, Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2013e. Agriculture Statistics Factsheet 2013. Accessed at http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sdd12807.

Alberta Agriculture and Rural Development (ARD). 2013f. Economics of Milk Production (Dairy Cost Study): Dairy Enterprise Cost & Returns. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2014a. Alberta's Irrigation: A Strategy for the Future. Irrigation and Farm Water Division, Lethbridge, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2014b. Alberta Irrigation Information: Facts and for the year 2013. Basin Water Management Branch, Lethbridge, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2014c. Rural Economic Development Action Plan. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2015a. Alberta Food Data Facts – No. 2. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD). 2015b. Alberta Crop Production Statistics. Accessed at http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sdd12061.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2000. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2001. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2002. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2003. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta,Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2004. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2005. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2006. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2007. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2008a. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2008b. AgriProfit$ Benchmarks for Alberta Cattlemen. Cow/Calf Enterprise Unit Cost & Returns Detail. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2009a. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2009b. AgriProfit$ Benchmarks for Alberta Cattlemen. Cow/Calf Enterprise Unit Cost & Returns Detail. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2010a. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2010b. AgriProfit$ Benchmarks for Alberta Cattlemen. Cow/Calf Enterprise Unit Cost & Returns Detail. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2011a. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development(ARD) AgriProfit$. 2011b. AgriProfit$ Benchmarks for Alberta Cattlemen. Cow/Calf Enterprise Unit Cost & Returns Detail. Edmonton, Alberta, Canada.

Alberta Agriculture and Rural Development (ARD) AgriProfit$. 2012. AgriProfit$ Cropping Alternatives for Alberta Crop and Forage Producers. Production Costs and Returns ($/acre). Edmonton, Alberta, Canada.

Alberta Cattle Feeders Association (ACFA). 2014. Facts and Statistics. Accessed at http://www.cattlefeeders.ca/industry/stats.aspx. October 13, 2014.

Alberta Environment. 1991. South Saskatchewan Basin Water Allocation Regulation. Alberta Environment and Sustainable Resource Development. Edmonton, Alberta, Canada.

Alberta Environment. **2006.** Approved Water Management Plan for the South Saskatchewan River Basin. Edmonton, Alberta, Canada.

Alberta Environment. 2007a. Establishment of Bow River Sub-Basin Water Conservation Objectives. Calgary, Alberta, Canada.

Alberta Environment. 2007b. Establishment of Oldman River Sub-Basin Water Conservation Objectives. Calgary, Alberta, Canada.

Alberta Environment. 2007c. Establishment of Red Deer River Sub-basin Water Conservation Objective. Red Deer, Alberta, Canada.

Alberta Environment. 2007d. Establishment of South Saskatchewan River Sub-basin Water Conservation Objective. Lethbridge, Alberta, Canada.

Alberta Environmental Protection (AEP). 1995. Oldman River June 1995 Flood Summary Report. Water Resources Operations Division, Lethbridge, Alberta, Canada.

Alberta Environment and Sustainable Resources Development (ESRD). 2013a. Alberta Provincial Camping Statistics. Edmonton, Alberta, Canada.

Alberta Environment and Sustainable Resources Development (ESRD). 2013b. An Estimate of Annual Economic Cost of Invasive Dreissenid Mussels to Alberta. Edmonton, Alberta, Canada.

Alberta Environment and Sustainable Resources Development (ESRD). 2014. Estimated Share of GOA Owned Infrastructure in the Southern Irrigation Region Related to Irrigation. Email from S. Higgins, 12/02/14. Edmonton, Alberta, Canada.

Alberta Irrigation Projects Association (AIPA). 2010. Declaration: Sharing Water for Human Needs and Livestock Sustenance during Water Shortages. Lethbridge, Alberta, Canada.

Alberta Irrigation Projects Association (AIPA). 2013. Water for Wildlife and Wetlands. Accessed at http://www.aipa.ca/what-waters-does/wildlife-wetlands/. Lethbridge, Alberta, Canada.

Alberta Tourism, Parks and Recreation. 2006. Visitation Statistics, Provincial Parks and Recreation Areas, 2005/6. Edmonton, Alberta, Canada.

Alberta Treasury Branch. 2013. Seeds of Success. Accessed at http://www.wearealberta.ca/albertans/seeds-success.

AMEC. 2007. Water for Life - Current and Future Water Use in Alberta. Edmonton, Alberta, Canada.

AMEC. 2009. South Saskatchewan River Basin in Alberta: Water Supply Study. Alberta Agriculture and Rural Development, Lethbridge, Alberta, Canada.

AMEC. 2014a. Southern Alberta Flood Recovery Task Force, Flood Mitigation Study Questionnaire. Calgary, Alberta, Canada.

AMEC. 2014b. Water Storage Opportunities in the South Saskatchewan River Basin in Alberta. Alberta Agriculture and Rural Development. Lethbridge, Alberta, Canada.

Arthurson, W. 2005. Gone, Fishing? Accessed at http://albertaventure.com/2005/06/gone-fishing/.

Bankes, N. 2011. The Legal Status of the Commitment by Alberta's Irrigation Districts to Share the Shortage. Accessed at http://ablawg.ca/2011/04/01/the-legal-status-of-the-commitment-by-alberta%E2%80%99s-irrigation-districts-to-share-the-shortage/

Bennett, D.R. and Harms, T.E. 2011. Crop Yield and Water Requirement Relationships for Major Irrigated Crops in Southern Alberta. Canadian Water Resources Journal 36: 159–170.

Bennett, D.R., Heikkila, R., Riewe, R.V., Oyewumi, O, and Harms, T.E. 2013. Farm Economic Impacts of Water Supply Deficits for Two Irrigation Expansion Scenarios in Alberta. Canadian Water Resources Journal 38:210– 22.

Bennett, D.R., Riewe, R.V., Entz, T., and Woods, S.A. 2015. Water Conveyance and On-Farm Irrigation System Efficiency Gains in Southern Alberta Irrigation Districts from 1999 to 2012. Canadian Water Resources Journal 40.:173–186.

Bonsal, B., Aider, R., Gachon, P., and Lapp, S. 2013. An Assessment of Canadian Prairie Drought: Past, Present, and Future. Climate Dynamics. 41: 501 516. DOI 10.1007/s00382-012-1422-0.

Bouma, J. 2007. Enhancing Value Added Food & Agriculture on Irrigated Lands. Toma and Bouma Management Consultants. Edmonton, Alberta, Canada.

Bruinsma, J. 2009. The Resource Outlook to 2050: By How Much Do Land, Water Use and Crop Yields Need to Increase by 2050? Expert Meeting on How to Feed the World in 2050. Rome, FAO and ESDD. Accessed at ftp://ftp.fao.org/docrep/fao/012/ak542e/ak542e06.pdf

Canadian Agri-Food Policy Institute (CAPI). 2011. Canada's Agri-Food Destination – A New Strategic Direction. Ottawa, Ontario, Canada.

Dennis, J. S. 1894. General Report on Irrigation and Canadian Irrigation Surveys–1894. Water Survey of Canada, Ottawa, Ontario, Canada.

Donavan, D.J. 2009. Food Processing Location Trends. *In* Trade & Industry Development. Accessed at http://www.tradeandindustrydev.com/industry/food-processing/food-processing-location-trends-635.

Ducks Unlimited Canada. 2014. Accessed on January 28, 2014. Accessed at http://www.ducks.ca/your-province/alberta/programs-projects/circle-e-project/.

Eastern Irrigation District. 2012. Partners in Habitat Development. Accessed at http://www.eid.ca/partners-in-habitat-developement/. Brooks, Alberta, Canada.

Environment Canada. 2014. 2012 Canadian Nature Survey: Awareness, Participation and Expenditures in Nature-Based Recreation, Conservation, and Subsistence Activities. Ottawa, Ontario, Canada.

Food and Agriculture Organization (FAO). 2003. World Agriculture: Towards 2015/2030. Summary Report. Food and Agriculture Organization of the United Nations, Rome, Italy.

Food and Agriculture Organization (FAO). 2004. Economic Valuation of Water Resources in Agriculture. Food and Agriculture Organization of the United Nations, Rome, Italy.

Food and Agriculture Organization (FAO). 2006. World Agriculture: Towards 2030/2050. Interim Report. Food and Agriculture Organization of the United Nations, Rome, Italy.

Food and Agriculture Organization (FAO). 2011. The State of the World's Land and Water Resources for Food and Agriculture – Managing Systems at Risk. Food and Agriculture Organization of the United Nations, Rome, Italy.

Gabruch, M. and Gietz, R. 2014. The Potential for Grain Corn in Alberta. Alberta Agriculture and Rural Development, Edmonton, Alberta, Canada.

Golder Associates. 2012. Hydro-Climate Modelling of Alberta South Saskatchewan Regional Planning Area. Alberta Environment, Calgary, Alberta, Canada.

Government of Alberta (GOA). 1999. Water Act. Queen's Printer, Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2000a. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2000b. Irrigation Districts Act. Queen's Printer, Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2000c. Environmental Protection and Enhancement Act. Queen's Printer, Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2001. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2002. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2003a. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2003b. Water for Life: Alberta's Strategy for Sustainability. Alberta Environment and Sustainable Resource Development. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2004. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2005. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2006. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2007a. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2007b. Bow, Oldman and South Saskatchewan River Basin Water Allocation Order, Alta Reg. 171 / 2007, Queen's Printer, Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2008. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2009. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2010. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2011. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2012a. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2012b. The Economic Impact of Tourism in Alberta, 2012, Alberta, Canada. Accessed at http://tpr.alberta.ca/tourism/research-and-statistics/statistics/economic-impact-studies/pdf/2012/EconomicImpactAlberta2012.pdf.

Government of Alberta (GOA). 2012c. Tourism works for Alberta. Accessed at http://tpr.alberta.ca/tourism/research-and-statistics/statistics/economic-impact-studies/pdf/2012/EconomicImpactAlberta2012.pdf.

Government of Alberta (GOA). 2013. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2014. Annual Report: Consolidated Financial Statements. Edmonton, Alberta, Canada.

Government of Alberta (GOA). 2015. Fisheries (Alberta) Amendment Act. Queen's Printer. Edmonton, Alberta, Canada.

Harms, T. 2010. Water Needs for Crops Grown in Alberta (Unpublished). Alberta Agriculture and Rural Development, Lethbridge, Alberta, Canada. 39 pp.

Hart, J.R. 2014. Summary of Irrigation Infrastructure Water Supply Benefits. Calgary, Alberta, Canada.

Hart Water Management Consulting. 2001. South Saskatchewan River Basin: Irrigation in the 21st Century. Economic Benefits and Opportunities. Alberta Agriculture, Food and Rural Development, Lethbridge, Alberta, Canada.

IrriCan Power Generation Ltd. 2015. Financial Statements. Calgary, Alberta, Canada.

Irrigation Water Management Study Committee (IWMSC). 2002. South Saskatchewan River Basin: Irrigation in the 21st Century. Volume 5: Economic Opportunities and Impacts. Alberta Irrigation Projects Association, Lethbridge, Alberta, Canada.

Klein, K.K., Yan, W., and Le Roy, D.G. 2012. Estimating the Incremental Gross Margins due to Irrigation Water in Southern Alberta. Canadian Water Resources Journal 37:89–103.

MacGregor, J. G. 1981. A History of Alberta. Hurtig Publishers Ltd, Edmonton, Alberta, Canada.

McNaughton, R.B. 1993. Recreational Use of Irrigation Infrastructure in Southern Alberta. Prepared for the Alberta Irrigation Projects Association. Lethbridge, Alberta, Canada.

Martz, L., Bruneau, J., and Rolfe, J.T. (eds). 2007. Climate Change and Water – SSRB Final Technical Report. Climate Change Impact and Adaptation Program, Natural Resources Canada, Ottawa, Ontario, Canada. 252 pp.

Mendelsohn, R. and Neumann, J. E. (eds). 1999. The Impact of Climate Change on the United States Economy. Cambridge University Press, Cambridge, United Kingdom.

Meyers Norris Penny LLP. 2011. Study of Investment Levels and Costs of Production of Irrigated Specialty Crops in Alberta for the 2009 Crop Year. Report prepared for Economics and Competitiveness Division, Alberta Agriculture and Rural Development, Edmonton, Alberta, Canada.

Nicol, L. 2005. Irrigation Water Markets In Southern Alberta. A Thesis Submitted to the University of Lethbridge in Partial Fulfillment of the Requirements for the Degree Master of Arts. Lethbridge, Alberta, Canada.

Nicol, L., Bjornlund, H., and Klein, K.K. 2010. Private Irrigators in Southern Alberta: A Survey of their Adoption of Improved Irrigation Technologies and Management Practices. Canadian Water Resources Journal 35:339–350.

Nicol, L.A. and Klein, K.K. 2006. Water Market Characteristics: Results From a Survey of Southern Alberta Irrigators. Canadian Water Resources Journal 31:91–104.

Paterson, B. 2012. Rural Water Supply Program. Alberta Agriculture and Rural Development, Lethbridge, Alberta, Canada.

Prairie Provinces Water Board (PPWB). 2013. Annual Report for the Fiscal Year April 1, 2012 to March 31, 2013. Regina, Saskatchewan, Canada.

Premier's Council for Economic Strategy. 2011. Shaping Alberta's Future: Report of the Premier's Council for Economic Strategy. Edmonton, Alberta, Canada.

Rogers, W.B., Manning, T.W., and Grubb, H.W. 1966. The Economic Benefits and Costs of Irrigation in the Eastern Irrigation District in Alberta. University of Alberta, Edmonton, Alberta, Canada.

Rood S.B. and Vandersteen, J.W. 2010. Relaxing the Principle of Prior Appropriation: Stored Water and Sharing the Shortage in Alberta, Canada. Water Resources Management 24:1605–1620.

Russell Consulting. 1998. Western Irrigation District Regional Impact Analysis. Alberta: Western Irrigation District, Lethbridge, Alberta, Canada.

Samarawickrema, A. and Kulshreshtha, S. 2008. Value of Irrigation Water for Drought Proofing in the South Saskatchewan River Basin. Canadian Water Resources Journal 33:1–10.

Schreier, H. S., and Wood, C. 2013. Better by the Drop: Revealing the Value of Water in Canadian Agriculture. RBC Blue Water Project.

Seckler, D., Upali, A., Molden D., de Silva, R, and Randolph, B. 1998. World Water Demand and Supply, 1990 to 2025: Scenarios and Issues. Research Report 19. International Water Management Institute, Colombo, Sri Lanka.

Serecon Management Consulting Inc. 2012. Alberta Hemp Cost of Production and Market Assessment. Edmonton, Alberta, Canada.

Serecon Services Inc. 2014. Economic Impact of Agriculture in Lethbridge County. Edmonton, Alberta, Canada.

Statistics Canada. 2010. Provincial and Territorial Economic Accounts: Data Tables, CANSIM Table Number 13-018-X. Ottawa, Ontario, Canada.

Statistics Canada. 2012. Census of Agriculture, Land Use. CANSIM Table 004-0203. Accessed at www5.statcan.gc.ca/cansim/a26. December 23, 2014.

Statistics Canada. 2013a. Annual Survey of Manufactures (2002); New Annual Survey of Manufactures and Logging (2003 and 2004); and Monthly Survey of Manufacturing (2005 and 2006). Ottawa, Ontario, Canada.

Statistics Canada. 2013b. Farm Products Price Index (PPPI). CANSIM Table 002-0022. Ottawa, Ontario, Canada.

Statistics Canada. 2013c. Employment by Type of Employee for Selected Industries. Accessed at http://www5.statcan.gc.ca/cansim/a47.

Statistics Canada. 2013d. Number of Cattle, by Class and Farm Type. Accessed at http://www5.statcan.gc.ca/cansim/a26.

Statistics Canada. 2013e. Provincial and Territorial Economic Accounts, Data Tables. Catalogue No. 13-018-X. Ottawa, Ontario, Canada.

Statistics Canada. 2014a. CANSIM Table 002-0001 "Farm Cash Receipts - Agriculture Economic Statistics"; Accessed at http://www5.statcan.gc.ca/cansim/pick-choiSouthern Irrigation Region?lang=eng&p2=33&id=0020001.

Statistics Canada. 2014b. Gross Domestic Product, Income-based, Provincial and Territorial. CANSIM Table 384-0037. Ottawa, Ontario, Canada.

Statistics Canada. 2014c. Gross Domestic Product, Expenditure-Based, Provincial and Territorial. CANSIM Table 384-0038. Ottawa, Ontario, Canada.

Statistics Canada. 2014d. Estimated Areas, Yield, Production, Average Farm Price and Total Farm Value of Principal Field Crops (annual). CANSIM Table 001-0017. Ottawa, Ontario, Canada.

Statistics Canada. 2014e. Provincial Input-Output Tables, Inputs and Outputs, Summary Level, Basic Prices, Annual (Dollars), 2007 to 2011. CANSIM Table 381-0028. Ottawa, Ontario, Canada.

UMA. 1984. The Economic Impact of Irrigation in Alberta. Prepared for Alberta Irrigation Projects Association. Lethbridge, Alberta, Canada.

UMA. 1993. Irrigation Impact Study. Volume 4 of 7 – Economic Input-Output Model Analysis. Prepared for Alberta Irrigation Projects Association. Lethbridge, Alberta, Canada.

United Nations. 2009. World Population Prospects: The 2008 Revision Population Database. United Nations Population Division, New York, New York, United States.

United Nations. 2012. Managing Water Under Uncertainty and Risk. The United Nations World Water Development Report 4. United Nations Educational, Scientific and Cultural Organization, 7 place de Fontenoy, 75353 Paris 07 SP, France.

United Nations World Water Assessment Programme. 2015. The United Nations World Water Development Report 2015: Water for a Sustainable World. Paris, UNESCO.

United States Department of the Interior. 2012. Colorado River Basin Water Supply and Demand Study. Washington, D.C., United States.

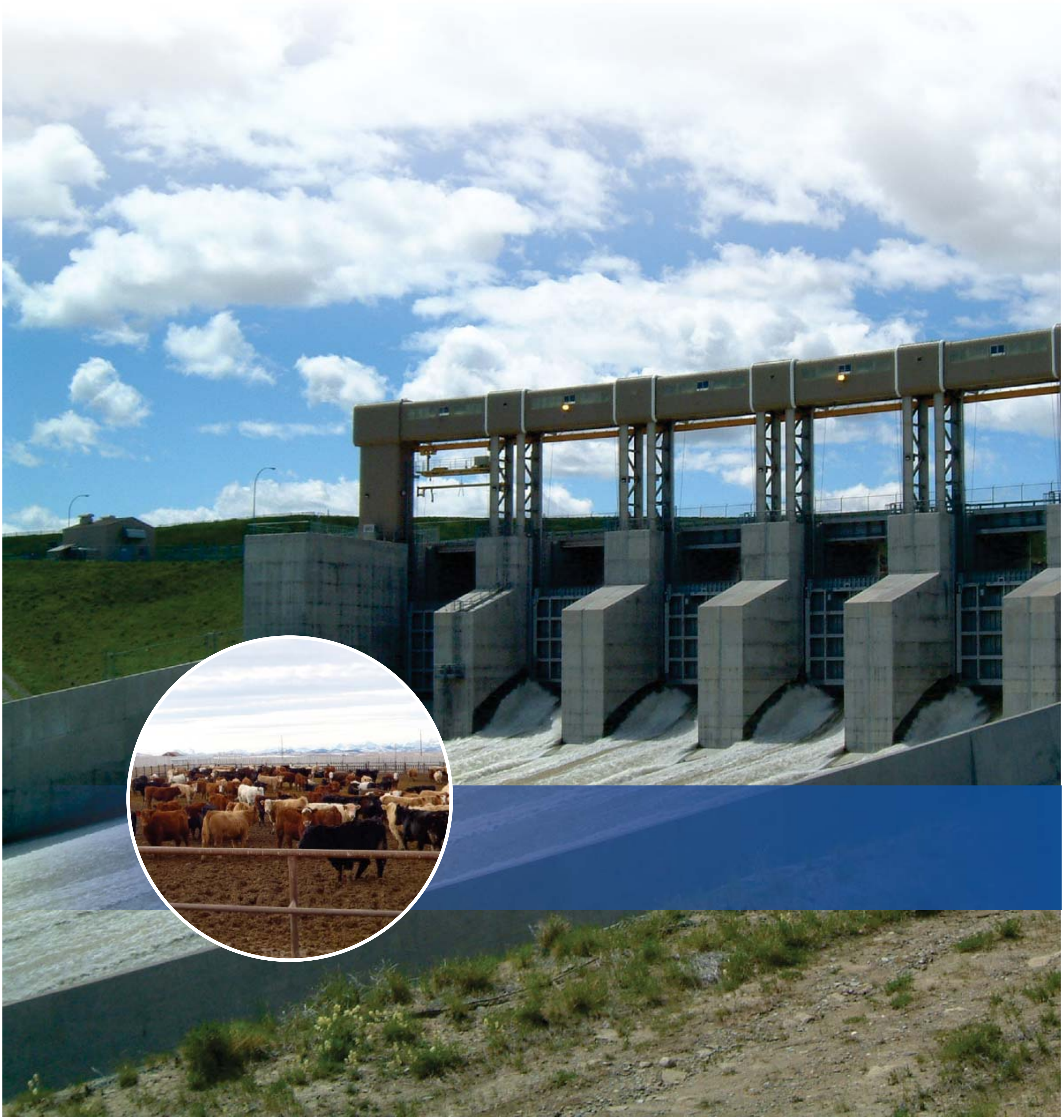
Viviroli, D., Archer, D.R., Buytaert, W., Fowler, H.J., Greenwood, G.B., Hamlet, A.F., Huang, Y., Koboltschnig, G., Litaor, Lopez-Moreno, J.I., Lorentz, S., Schadler, B., Schreier, H., Schwaiger, K., Vuille, M., and Woods. R. 2011. Climate Change and Mountain Water Resources: Overview and Recommendations for Research, Management and Policy. Hydrology and Earth System Sciences 15: 471–504.

Western Regional Panel on Aquatic Nuisance Species. 2010. Quagga-Zebra Mussel Action Plan for Western U.S. Waters. Accessed at http://www.anstaskforce.gov/QZAP/QZAP_FINAL_Feb2010.pdf.

Wheaton, E., Kulshreshtha, S., and Wittrock, V. (eds). 2004. Canadian Droughts of 2001 and 2002: Climatology, Impacts and Adaptations. Report prepared for Agriculture and Agri-Food Canada—PFRA. Publication No. 11602-1E03. Saskatchewan Research Council, Saskatoon, Saskatchewan, Canada.

Woods, S. 2012. Crop Productivity Potential for Alberta's Irrigation Districts. (Unpublished). Alberta Agriculture and Rural Development, Lethbridge, Alberta, Canada. 23 pp.

Appendices



Appendix A

Water Management and Irrigation in Alberta

A.1 History

The development and management of irrigation in Alberta began about 130 years ago. A series of events and circumstances that mirrored life in the early settlement years of the Northwest Territories and later in the Province of Alberta influenced resource management decisions. Decisions made in those formative years continue to play a significant role in today's management of water resources and irrigation.

As settlement began on the Prairies, farmers were quick to realize the need for and benefits of irrigation in increasing and stabilizing crop yields. The first irrigation project in Alberta was reportedly developed in 1878 by John Quirk, using water from Sheep Creek (now Sheep River). This was followed by John Glenn's project on Fish Creek in 1879, and then developments by Mormon pioneers on Lee Creek in 1880 (MacGregor, 1981).

William Pearce, a federal government resource management official located in the Northwest Territories in the late 1800s, saw irrigated agriculture as a key factor in stimulating settlement on the arid Canadian Prairies. He and the federal Chief Inspector of Surveys and Irrigation, J. S. Dennis, recognized that the water law of the day, British common law riparian rights, would be a deterrent to large-scale irrigation on the prairies. The primary limitations were that diversions to non-riparian lands would be prohibited and the flow in streams could not be significantly depleted. These concerns led to the development of the *North-West Irrigation Act* (*NWIA*) and its assent by the Dominion Parliament in 1894. Key aspects of the *NWIA* were:

> Following an extensive review of irrigation development and administration in the northwest United States, J. S. Dennis indicated that; **"....., *I am satisfied that this Act* (the proposed North-west Irrigation Act), ... *will enable us to undertake and carry on the principle of irrigation in our Territories without being met with the many disputes and endless litigation which has characterized this work in the United States.*"** *(Dennis, 1894).*

- Changes to riparian rights;
- Declaration that water was the property of the Crown;
- Individuals or corporations could obtain the right to use water upon compliance with provisions of the *Act* and approval of government; and
- Water was allocated to applicants based on the principal of prior allocation, often referred to as "first-in-time, first-in-right".

Water administrators of the day felt that the *NWIA* was the statutory tool that would control the orderly use and distribution of water in a manner that would encourage investment in irrigation infrastructure, protect the investment of corporate and individual developers, and result in the greatest public good. The legislation and administrative procedures were amended on numerous occasions since 1894, but the basic principles of the 1894 *Act* remain essentially unchanged and are in force today.

Some of the more significant changes in irrigation and water management legislation were as follows.

- **1915.** The province passed the *Irrigation Districts Act* (GOA, 2000b) providing the mechanism for co-operative farmer-owned financed and operated irrigation districts. The Taber Irrigation District was the first district to be established under the *Act*. Others were quick to follow (Table A.1).
- **1930.** Through the *Natural Resources Transfer Act* and Agreement, the federal government transferred jurisdiction over natural resources, including water, to the Province of Alberta.
- **1931.** The provincial *Water Resources Act* was passed. Almost all provisions of the federal *Irrigation* and *Water Power Acts* were incorporated in the new provincial *Act*. Water rights issued by the federal government prior to the transfer were subject to the *Water Resources Act* only if provisions of the new *Act* were consistent with the terms under which the rights were created.
- **1999.** On January 1 the new *Water Act* (GOA, 1999) replaced the *Water Resources Act,* bringing in a number of significant changes to address new water realities of supply limitations, environmental protection, and related challenges. The focus for water management shifted from supply management to sustainable development and protection of the aquatic ecosystem. Significant changes include the following.
    - **Riparian Uses.** The *Act* provides that riparian users may commence or continue to divert small quantities of water for traditional agricultural or household purposes without a licence. The maximum volume of water that can be diverted for traditional agricultural purposes is 6,250 m^3/year or the maximum value specified in an approved water management plan.

Table A.1. Establishment of the existing irrigation districts in southern Alberta.

Irrigation District	Year Established	First Water	Comments
Taber	1917	1920	Water supplied through St. Mary River system.
Lethbridge Northern	1919	1923	Water source: Oldman River.
United	1921	1923	Water sources: Waterton and Belly Rivers.
Mountain View	1923	1931	Water source: Belly River.
Raymond	1925	1900	Water supplied through St. Mary River system.
Magrath	1926	1900	Water supplied through St. Mary River system.
Eastern	1935	1914	First water through CPR works.
Leavitt	1936	1944	Extension of Mountain View system.
Western	1944	1907	First water through CPR works.
Aetna	1945	1959	Extension of Mountain View and Leavitt system.
Ross Creek	1949	1954	Sources: Gros Ventre and Ross Creeks.
St. Mary River	1968	1900	First St. Mary River water through Canadian Northwest Irrigation Company works.
Bow River	1968	1920	First Bow River water through Canada Land and Irrigation Company works.

Source: IWMSC (2002).

    - **Term Licences.** Under former legislation, licences issued by the province were normally in perpetuity. Under the *Water Act* the province issues licences for specified periods, typically five years. At the end of the term the licences could be renewed; or cancelled for valid reasons such as impact on in-stream flow needs, other users, or the environment.
    - **Allocation Transfers.** In watersheds where licensing is at or near full allocation, the provision for allocation transfers from willing sellers to willing buyers can make water available for new uses. Applications for transfers are subject to review by the Director (named under the *Act*). The Director may withhold up to 10% of the water transferred to assist in protecting the aquatic ecosystem.
    - **Closure of a Basin.** The *Water Act* has provision for the Director to close a basin to new allocations if further allocation would degrade the aquatic environment or experience frequent deficits and have little chance of being useful to the applicant.
    - **Water Conservation Objectives.** The *Act* makes provision for protection of all or part of the aquatic ecosystem through establishment of Water Conservation Objectives (WCOs). The strategy is to strike a publically-acceptable balance between consumptive use and environmental protection to support the dual values of economic development and quality of life. The *Act* requires watershed management plans to consider appropriate WCOs for major streams in the watershed.
    - **Water Management Planning.** Alberta's water legislation recognizes the need for and value of water management planning to align the Director's ongoing decision making with specific requirements of a watershed, and to address issues such as allocation transfers, holdbacks, basin closures, and WCOs for protection of the aquatic environment. The *Act* compels the Director to consider the recommendations of a government-approved water management plan in issuing approvals under the *Act*.
    - **Protection of Existing Licences.** The government made a commitment to protect existing licences that are in good standing by bringing them forward into the new *Act*.
- ***Irrigation Districts Act.*** Came into force in 2000 (GOA, 2000b). The *Act* established the structure, governance, powers and duties for the formation and operations of irrigation districts. This *Act* provided the districts with more autonomy in decision making, more independence from government, and more responsibility and accountability to their water users. Producers within irrigation districts are provided more flexibility to improve efficiencies and maximize yields.

Many aspects of that early legislation have endured and been incorporated within current legislation. This has resulted in a thriving irrigation industry, primarily in southern Alberta, providing economic and social benefits to producers and society at large within Alberta and beyond its borders.

A.2 Growth of Irrigation in Alberta

Southern Alberta is fortunate to have several natural attributes that favor irrigated agriculture, and these attributes were recognized early by the Dominion Government. It has gently sloping topography east of the Rocky Mountains and foothills that enables a distribution of water to irrigable lands without the requirement of high-energy pumping. While rainfall during the growing season is limiting for optimum, sustained dryland agriculture, the Rocky Mountains provide a reliable and renewable source of water most years in several eastward flowing streams and rivers across the southern prairies, spanning from north to south by the Red Deer, Bow, Oldman, Castle, Belly, Waterton, St. Mary, and South Saskatchewan Rivers.


Chin Reservoir (off-stream).

The landscape of southern Alberta is traversed by numerous glacial outwash channels that provide excellent off-stream water storage facilities that can be located and sized for effective and efficient distribution of water. These attributes are largely responsible for Alberta currently having almost 690,000 hectares of irrigated agriculture; an area that exceeds the combined total of irrigated agriculture in all other provinces in Canada (ARD, 2014a; 2014c).

Early irrigation projects were generally small and did not significantly contribute to the federal government's goal to colonize the Prairies. Later interest in large-scale irrigation was fueled by competition between the United States and Canada to establish "precedence of use" for water from the St. Mary and Milk River Basins. Attempts by Canada to negotiate a Canada/United States water sharing agreement for the St. Mary and Milk Rivers were met with resistance from United States officials who claimed the United States had a right to use all water arising from within United States territory. Their plan was to divert St. Mary water into the upper Milk River for conveyance through Canada to the lower Milk River where it would be utilized for irrigation in eastern Montana. Canada proceeded with plans to develop irrigation, including a northward diversion from the Milk River, presumably with its enhanced flow from the St. Mary River, to irrigate Canadian lands. This initiative brought the United States into water sharing negotiations that eventually led to the Boundary Waters Treaty in 1909.

In his 1894 report to the Surveyor General, Department of the Interior, **J. S. Dennis** indicated that; ***"..... under proper government control, the future agricultural prospects of Southern Alberta and Western Assiniboia are very bright, and that within a comparatively short time we will see those portions of our territories, which nature has possessed so bountifully with climate and soil, supporting a large and successful agricultural population."*** *(Dennis, 1894).*

The Galt family, with interests in coal mining and rail transportation, is credited with taking the first step toward large-scale irrigation in southern Alberta. The Galts were assisted by the Mormon community that had settled in the area of Lee Creek and demonstrated what could be done with irrigation. By 1920, approximately 77,000 hectares were being irrigated within areas of the current St. Mary River, Magrath, Raymond, and Taber Irrigation Districts in the Oldman Basin, and within the Western and Eastern Irrigation Districts of the Bow River Basin. In comparison, private irrigation development was in its infancy, with about 10,000 hectares developed by 1920. The growth of district and private irrigation in Alberta is shown in Figure A.1.

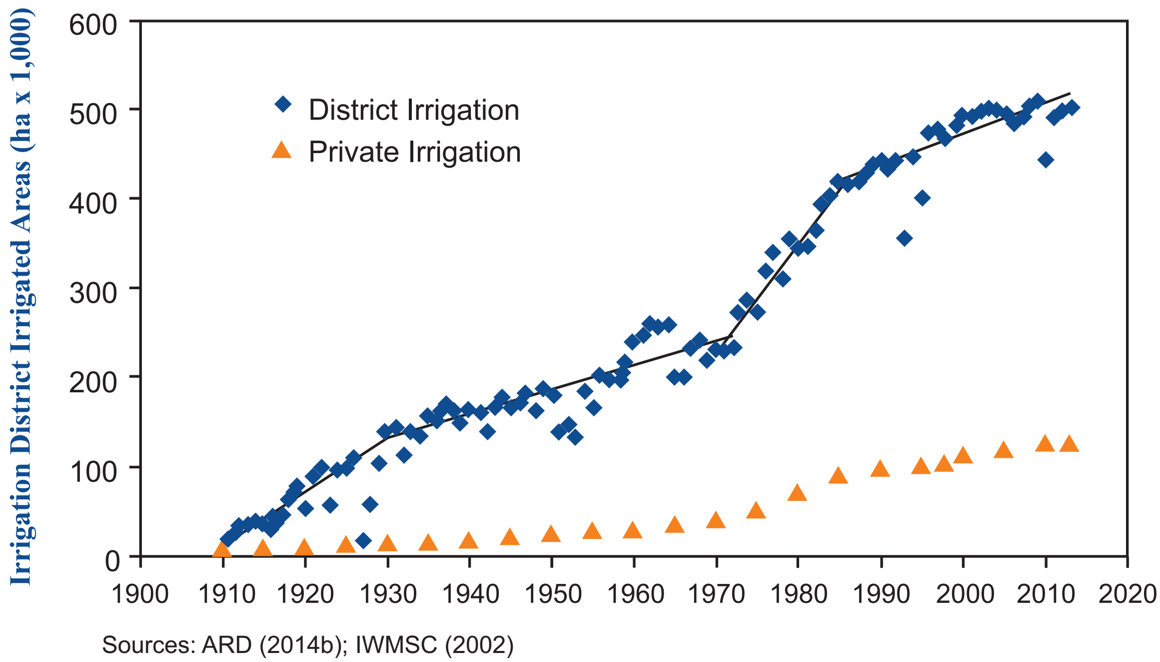
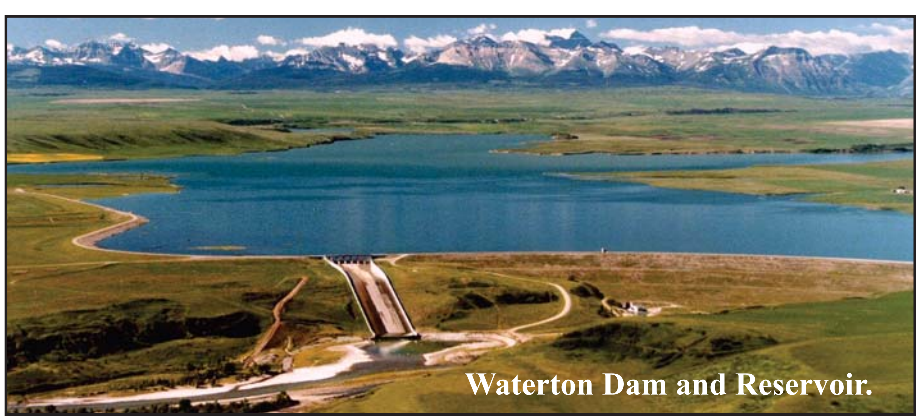


Figure A.1. Historical growth of irrigation district and private irrigation in Alberta.

The years between 1920 and 1950 were characterized by technical, financial, and administrative challenges facing Alberta's fledgling irrigation industry. During this period, most irrigation projects became farmer-owned enterprises through provisions of the *Irrigation Districts Act*, 1915. Irrigation districts proved to be the most effective administrative bodies for day-to-day management of irrigation projects, and governments recognised that the benefits of irrigation extended well beyond the farm gate. The creation of the Prairie Farm Rehabilitation Administration (PFRA) in 1935 increased GOC involvement in the irrigation industry.

By 1950, about 182,000 hectares were being irrigated within the areas of the current irrigation districts, with an additional 24,000 hectares of private irrigation. By 1950, major construction work was required to bring the irrigation infrastructure up to standards and, in some cases, enlarge the works. From 1950 to 1970, major rehabilitation and expansion of irrigation infrastructure was carried out primarily by the GOA and GOC. The PFRA became a major developer in 1950 when the GOC agreed to construct and operate the St. Mary, Milk River Ridge, and Waterton Reservoirs and related canal infrastructure. The province committed to undertake rehabilitation and expansion of the delivery works between the Milk River Ridge Reservoir and Medicine Hat. In addition, the PFRA and the



Waterton Dam and Reservoir.

GOA began rebuilding and enlarging the delivery system and developing new irrigation blocks for the present day Bow River Irrigation District. By 1970, the GOA and GOC were involved in rehabilitation and expansion of infrastructure in almost all 13 present-day irrigation districts. By 1970, about 240,000 hectares were being irrigated within the area comprised by today's irrigation districts. Private irrigation had also expanded to about 40,000 hectares.

Major changes in the industry have taken place since 1970. In 1973, the GOC transferred all their interests in the Bow River and St. Mary River developments to the province. The province assumed greater responsibility for improvements to irrigation infrastructure. Milestones in this regard are as follows.

- In 1969, a cost-sharing program was announced to rehabilitate and expand distribution works within the irrigation districts. The distribution of costs between the GOA and the irrigation districts used in 1969 was 86% and 14% respectively, and this reflected the distribution of benefits to Alberta and Canada, and to the producer (Rogers et al., 1966). The cost-sharing ratio was changed to 80%:20% in 1984 and to 75%:25% in 1995, where it remains today.
- In 1975, the province announced a policy whereby GOA would assume responsibility for rehabilitation, operation and maintenance of irrigation headworks (the infrastructure required to divert water from the source streams and convey it to the districts).
- In 1980, the province announced that a multi-purpose dam and storage reservoir would be constructed on the Oldman River upstream of Fort MacLeod. Construction of the Oldman River Dam was initiated in 1986 and completed in 1992.

From 1970 to 1985, the irrigation districts experienced rapid growth, largely due to the shift in irrigation methods from gravity flood irrigation to sprinkler irrigation. Sprinkler irrigation was less labour intensive, provided better control of water and greatly increased the land area that could be irrigated from the existing distribution system. No longer was irrigation limited to lands "under the ditch". By 1985, the irrigated area within the districts was about 417,000 hectares. Private irrigation had expanded to about 100,000 hectares.

By 1990, the irrigation districts were operating as progressive enterprises, with crop diversity and value-added enterprises increasing and contributing to the regional economy. The districts were well informed and responsive to current water management issues. The Alberta Irrigation Projects Association (AIPA) was established in 1946 to provide a single voice for the irrigation districts for dealing with senior governments and the public. The AIPA continues to be an active and respected voice for the irrigation districts.

The rapid growth of irrigation from 1970 to 1985 prompted the provincial government to establish irrigation expansion guidelines for the SSRB, with due consideration for the needs of all other consumptive users, in-stream flow needs, and interprovincial apportionment (Alberta Environment, 1991). The guidelines limited the amount of water that could be allocated for irrigation within each district and within each of the four major sub-basins as a whole. With government approval of the SSRB Water Management Plan in 2006 and closure of the Bow, Oldman, and South Saskatchewan Sub-basins to new licence applications, the 1991 South Saskatchewan Basin Water Allocation Regulation was repealed.

A.3 Water Storage

The GOA, GOC, and the irrigation districts developed 57 water-storage reservoirs (ARD, 2014b) throughout southern Alberta (Table A.2). Forty-two are owned and operated by the irrigation districts, while the other 15 are owned and operated by the GOA. Twin Valley Reservoir in the Little Bow Basin and Pine Coulee Reservoir in the Willow Creek Basin are GOA-owned and were constructed to provide support for the development of private irrigation projects. Total capacity of all reservoirs is estimated to be about 3.0 billion cubic millimetres. In addition to the reservoirs, there are almost 8,000 km of canals and pipelines within the irrigation districts that distribute water to farmers, communities, and industries. In 2012 dollars, the value of all irrigation-district owned infrastructure was estimated at $3.6 billion (ARD, 2014b).

The GOA provides cost-shared funding to help the irrigation districts with rehabilitation of water storage and distribution infrastructure. The irrigation districts are responsible for operation, maintenance and meeting their share of the rehabilitation costs of their infrastructure. These activities employ construction workers and utilize inputs from various industries in the regions. Goods and services that are not available in the region may be imported, creating economic activity in the source areas.

It is estimated that about 75% of the GOA-owned infrastructure was dedicated to support irrigation-related activities from 2000 to 2011 (ESRD, 2014). The total irrigation-related replacement cost of this infrastructure is estimated to be about $5.9 billion.

Table A.2. Irrigation-related reservoirs in southern Alberta.

Location	Irrigation District Owned		Province Owned		Total	
	Number	Capacity ('000 m^3)	Number	Capacity ('000 m^3)	Number	Capacity ('000 m^3)
Bow River	6	78,810	3	476,780	9	555,590
Eastern	12	546,350	0	0	12	546,350
Lethbridge Northern	3	3,050	2	585,820	5	588,870
Raymond	3	1,480	0	0	3	1,480
St. Mary	12	443,520	4	626,800	16	1,070,320
Taber	3	16,560	0	0	3	16,560
United	1	3,100	0	0	1	3,100
Western	2	12,840	0	0	2	12,840
Ross Creek	0	0	1	4,630	1	4,630
Mountain View, Leavitt, & Aetna	0	0	1	8,690	1	8,690
Other Areas (GOA Headworks)	0	0	4	126,740	4	126,740
Total	**42**	**1,105,710**	**15**	**1,829,460**	**57**	**2,935,170**

Source: ARD (2014b).

A.4 Current State of Water Management

With the passing of the *North-West Irrigation Act* by the Dominion Parliament in 1894, the parts of western Canada now known as Alberta and Saskatchewan had in place the statutory tool needed to control the distribution and use of water in a manner that would minimize conflicts and encourage development. Responsibility for managing natural resources was transferred from the federal government to the GOA in 1930.

A.4.1 Government Responsibility

The GOA is responsible for administering the provisions of the *Water Act*. The *Water Act* requires that a licence be obtained before diverting and using surface water or groundwater for all uses except statutory household, traditional agricultural, fire-fighting, and other small quantity uses available primarily to riparian landholders. Licences identify the purposes of the projects, water sources, points of diversion, maximum allocations (withdrawal, diversion or storage), the rates of diversion or withdrawal, the operating periods, and the priorities of the water right. The priorities are based upon the dates of complete applications, and this priority system is known as "first in time, first in right".

The Director may reject the application or issue a preliminary certificate for construction of the project. Upon successful completion of construction, a licence would be issued granting the allocation and use of water with conditions relating to in-stream flow needs, monitoring, and reporting. Presently, licences expire after a maximum of 20 years. Decisions by the Director are subject to appeal to the Environmental Appeals Board.

Approvals under the *Alberta Environmental Protection and Enhancement Act* (GOA, 2000c) are required for activities with a high potential to impair or damage the environment, property, or human health and safety. Environmental Impact Assessments (EIAs) are mandatory for:

- Dams greater than 15.0 metres high;
- Diversion structures and canals with capacities greater than 15.0 m^3/s; and
- A reservoir with a capacity greater than 30 million cubic metres.

For non-mandatory projects, the Director decides (with public input) if potential impacts can be adequately addressed through the approval process, or if a more detailed EIA is required. Full EIAs may be referred to the Natural Resources Conservation Board to hold public hearings and a decision on whether or not the project is in the public interest considering social, environmental, and economic impacts.

A.4.2 Enforcement of Licence Priorities during Water-Shortages

Licences are given a priority number based on the date that a completed application was received by the GOA. Senior priority licensees are potentially entitled to divert their full water requirements before licences with lower or junior priorities have a right to divert. Water masters work closely with all licensees to ensure that all water requirements are met if possible.

Some licences may be subject to a minimum flow requirement (now referred to as the In-stream Objective or IO), while others may not, depending on the time that the licence was issued. In-stream Objectives began to be put into licences in the late 1980s. The new *Water Act* came into force in 1999 and contained the ability for the government to create a Water Conservation Objective (WCO) for a water body, in consultation with stakeholders (GOA, 1999). The WCOs provide a higher level of aquatic protection than the previously established IOs. The WCO became a limiting condition on licences with priority dates later than May 1, 2005. In some cases, a WCO could be retroactive if the licence contained a provision for retroactivity.

The IO or the WCO condition on a licence stipulates that the licence holder cannot divert when the flow in the source stream reaches a certain minimum value. When stream flow and demand data indicate a trend toward deficits, the status of GOA-owned storage projects are reviewed to see if there is an alternative to restricting diversions. If no other options are available, the water master initiates stop-diversion orders beginning with the most junior licence holder and continuing in this way until the IO or WCO has been restored and the needs of all higher priority users can be met. This procedure can lead to user requests to waive certain conditions, make water-sharing arrangements, investigate other sources, or take conservation measures to try to provide some relief. Meetings are held between GOA and water user groups to share information and discuss options.

A.4.3 Deficit Sharing

Deficit sharing has been practised on a limited scale from time to time in the Bow River and Willow Creek Sub-basins since the early 1980s, and on a much broader scale in the St. Mary, Belly, and Waterton Sub-basins during the 2001 drought. This involved more than 600 water users and was considered to be a major success in surviving the severe drought situation. The irrigation districts worked with GOA and other licensees to share water so that the impacts of the drought would be reduced for communities, industry, and non-district agricultural operations.

The success in 2001 had three prerequisites.

1. **Discretionary use of water stored in reservoirs.** In the 1990s, legal opinions supported the view that the principle of prior appropriation applied only to the natural flow of the source stream (Rood and Vandersteen 2010). Water legally stored in reservoirs and subsequently released to augment downstream flows is no longer considered natural flow and is not subject to the priorities established under prior appropriation provisions of the *Water Act* and its predecessors. The Government of Alberta, as owner of several major storage reservoirs, could therefore operate them to maintain IOs or WCOs that were established after most of the large consumptive use licences were issued in the SSRB.
2. **The assignment provision of the new *Water Act.*** Section 33 of the *Water Act* (GOA, 1999) contains a provision that permits a licensee to assign or share a portion of their allocation with another licensee to reduce the deficit to the receiving water user. Assignments are temporary transfers that can be used to distribute the impacts of water deficits among a large number of licence holders to minimize the impact on any one user.

3. **Community-minded senior licensees that put the welfare of the region ahead of personal prosperity.** Without a sharing arrangement, senior priority users would potentially have a right to receive their full requirement before junior users receive any water during periods of low flow in rivers.

A post-project review of the 2001 drought experience by Nicol (2005) and Nicol and Klein (2006) concluded the following.

- The temporary assignment provision of the *Water Act* helped to ensure that irrigation users growing high-value crops were able to meet processing contracts in 2001, in spite of the drought.
- In general, water moved from lower to higher value uses, enhancing the productivity of water. Water also moved from less efficient to more efficient on-farm irrigation equipment, thus improving the overall irrigation efficiency.
- Sellers viewed the assignment market as an opportunity to earn additional income.

The water-sharing market functioned relatively smoothly in 2001, and the process may have been used again in the event of future droughts. Judging by the actions of water users and water managers during the droughts of the 1980s and in 2001, the well-being of water users in the region takes precedence over individual prosperity. This spirit of community cooperation among nearly all licensees was recognized with an award from the Irrigation Association, an international organization based in the United States (AIPA, 2010).

Recognizing that water supply security is vital for human health and well-being, and for the livestock industry in southern Alberta, the 13 irrigation districts signed a declaration in 2010 indicating that the districts will participate in water sharing by temporary assignments in accord with Section 33 of the *Water Act* so that sufficient water can be distributed for human needs and livestock sustenance (AIPA, 2010). No fee will be assessed for these assignments. An independent legal review of the Declaration concluded that, while the Declaration is not legally binding, it is a commitment that the districts will participate in good faith to share water with municipalities, other domestic licensees, and with livestock users in times of need (Bankes, 2011).

A.4.4 Apportionment with Neighbouring Jurisdictions

The natural flow of water in southern Alberta is shared with the United States under the 1909 Boundary Waters Treaty, the 1921 Order of the International Joint Commission (IJC), and with Saskatchewan under the 1969 Master Agreement on Apportionment.

- **The Boundary Waters Treaty and 1921 Order of the IJC.** This order defines the apportionment arrangement between the United States and Canada with respect to the St. Mary and Milk Rivers. During the irrigation season (April to October, inclusive), when the natural flow of the St. Mary River at the point where it crosses the international boundary is 18.86 m^3/s or less, Canada is entitled to 75% of the flow and the United States is entitled to 25% of the flow. When the natural flow exceeds 18.86 m^3/s, Canada is entitled to 14.15 m^3/s plus 50% of the flow in excess of 18.86 m^3/s. During the non-irrigation period (November to March, inclusive), the flow is divided equally between the United States and Canada.

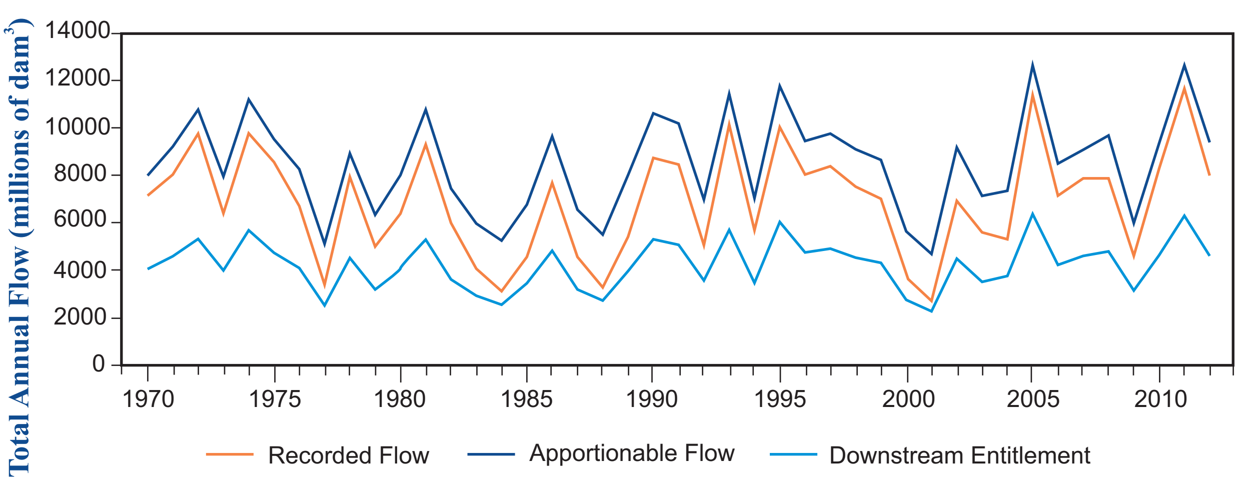
The apportionment arrangement for the natural flow of the Milk River at its eastern crossing of the International Boundary is the same as for the St. Mary River except that the United States is entitled to 75% during the irrigation season and Canada is entitled to 25%.

- **The 1969 Master Agreement on Apportionment.** This agreement specifies that, as a basic principle, Alberta is entitled to consume or store 50% of the apportionable flow of eastern flowing inter-provincial streams. With respect to the SSRB, Alberta has the option of considering the South Saskatchewan and Red Deer River basins as a single basin for apportionment calculations. The agreement includes a clause that allows Alberta to take a minimum annual "prior allocation" volume of 2.59 billion cubic millimetres, even if that amount is more than 50% of the annual volume, provided that a minimum flow of 42.5 m^3/s or 50% of the instantaneous natural flow, whichever is less, is maintained at the provincial boundary.

  The historical performance in meeting Alberta's SSRB commitment to Saskatchewan from 1970 to 2012 is shown on Figure A.2.

Apportionable flow of the South Saskatchewan River at the Alberta-Saskatchewan Border is the natural flow of the South Saskatchewan River downstream of its confluence with the Red Deer River, minus United States withdrawals from the St. Mary River system in Montana.

Alberta has always met its volume and minimum flow commitment to Saskatchewan. The average delivery to Saskatchewan for this period has been 80%, which is well in excess of Saskatchewan's 50% entitlement. The minimum delivery was 57.0% in 2001. From 1970 to 2013, there has been no decreasing trend in apportionment delivery to Saskatchewan in spite of irrigation district expansion from 228,000 to 494,000 hectares during that period. This is probably a reflection of significant improvements in irrigation efficiency resulting in reduced withdrawals from source streams.



Source: PPWB (2013).

Figure A.2. South Saskatchewan River apportionable flow, recorded flow, and Saskatchewan entitlement (1970 to 2012).

A.4.5 Water Management Planning in Alberta

Section 7(1) of the *Water Act* of 1999 called for the preparation of a framework for water management planning to provide consistent direction while at the same time recognizing the differences among watersheds and local and regional perspectives. Central to the framework is the strategy for protection of the aquatic environment. *Water for Life: Alberta's Strategy for Sustainability* (GOA, 2003b) strengthened the framework by emphasizing a watershed approach and shared governance in water management planning. *Water for Life* identified three types of partnerships that are key to watershed planning and management in Alberta.

- The Provincial Water Advisory Council oversees implementation of the *Water for Life Strategy*, investigates province-wide issues, and makes recommendations to government.
- Watershed Planning and Advisory Councils (WPACs) to report on states of the watersheds and to lead watershed planning activities.
- Watershed Stewardship Groups to take the lead in protecting local creeks, streams, river reaches, or lakes, and participate with the WPACs in developing watershed management plans.

In the SSRB, WPACs have been formed for the Red Deer, Bow, Oldman, and South Saskatchewan Sub-basins (Red Deer River Watershed Alliance, Bow River Basin Council, Oldman Watershed Council, and South East Alberta Watershed Alliance). Numerous Watershed Stewardship Groups have also been formed. State-of-the-watershed reports have been prepared for the Red Deer, Bow, and Oldman River Sub-basins. Planning activities are continuing in these watersheds.

In recent years, three water management planning studies have been carried out that have significant implications for the irrigation industry in southern Alberta. All three studies analyzed the impacts of current and future water use in the SSRB. The primary analytical tool used was simulation modelling using ESRD's Water Resources Management Model. Key recommendations or findings and their implications for the irrigation industry are noted below.

- **Water Management Plan for the South Saskatchewan River Basin** (Alberta Environment, 2006).
  - ***Recommendation.*** ESRD no longer accepts applications for new water allocations in the Bow, Oldman and South Saskatchewan River Sub-basins until the Minister of Environment specifies, through a Crown Reservation, how water not currently allocated is to be used. A Crown Reservation is now in place. The Bow, Oldman, and South Saskatchewan River Basins Water Allocation Order stipulates that reserved water may be allocated:
    - -For use by First Nations;
    - -To contribute toward meeting WCOs;
    - -For storage of peak flows to mitigate impacts on the aquatic environment and to support existing licences; and,
    - -For meeting outstanding completed applications received as of the date of this reservation.

Implications for irrigation industry. No new district or private irrigation licences in the Bow, Oldman, or South Saskatchewan River Sub-basins beyond those that have been applied for or committed to in some other manner.

- ***Recommendation.*** When allocations in the Red Deer River Sub-basin reach 550 million cubic metres, a thorough review will be conducted to identify the maximum allocation limit.

  Implications for irrigation industry. Probably no new private irrigation licences will be issued in the Red Deer River Sub-basin after the 550 million cubic metres milestone is reached.

- ***Recommendation.*** ESRD should establish Water Conservation Objectives (WCOs) for the Red Deer, Bow, Oldman, and South Saskatchewan River Sub-basins. The WCOs should be 45% of the natural rate of flow, or the existing in-stream objective plus 10%, whichever is greater at any point in time. Any licences issued for applications received after May 1, 2005 should be subject to the WCOs. Existing licences should retain their original conditions for in-stream objectives.

  The WCOs were established by the designated Directors under the *Water Act* on January 16, 2007. The reader should consult the specific decision documents for variations in the WCOs and their implementation requirements (Alberta Environment, 2007a; Alberta Environment, 2007b; Alberta Environment, 2007c; Alberta Environment, 2007d).

  Implications for irrigation industry. Increased magnitude and frequencies of deficits for any irrigation projects that are subject to the WCOs.

- ***Recommendation:*** Consideration of water-allocation transfers and water-conservation holdbacks were approved in the SSRB.

  Implications for irrigation industry. Existing irrigation licences may be targeted for transfers to municipal users, industrial users, or users for other purposes requiring new or an additional licences to meet their needs.

- **South Saskatchewan River Basin in Alberta: Water Supply Study** (AMEC, 2009).
  - ***Conclusion.*** With full utilization of their existing allocations and improvements in efficiencies, irrigation districts could expand their irrigated area by up to 32% in the Bow River Sub-basin, and by up to 19% in the Oldman River Sub-basin from their 2007 irrigated areas. However, irrigation districts are being cautious in their expansion plans because of potential climate-change scenarios in southern Alberta that may result in warmer and drier conditions.

    Implications for irrigation industry. Simulation modelling has indicated that considerable irrigation expansion in the Bow Sub-basin, and to a lesser extent in the Oldman Sub-basin, may be possible without increases in their licence allocations.

- **Water Storage Opportunities in the South Saskatchewan River Basin in Alberta** (AMEC, 2014b).

This study was a follow-up to the AMEC (2009) study. It focused on potential storage development in the Oldman River Sub-basin to reduce deficits to WCOs and junior licence holders. While numerous potential storage sites were considered, most were eliminated in a screening process. The three most promising sites (expansion of Chin Reservoir off-stream storage, Kimball Reservoir on the upper St. Mary River, and Belly Reservoir on the lower Belly River) were modelled to determine their effectiveness in reducing deficits. The modelling assumed the prevailing licence priorities and ESRD policies on in-stream requirements downstream of new storage developments.

- ***Conclusion.*** Potential reservoirs at the Chin, Kimball, and Belly sites would not significantly support the aquatic environment, support First Nations development, or improve water supply security to junior licensed projects, if they are required to adhere to the current licensing priorities and the current ESRD WCO regulatory requirement. If the ESRD WCO policy was amended to require releases equal to the current In-stream Objective plus 10%, then the Belly River site may be viable.

  Implications for irrigation industry. None of the three storage projects modelled performed well under the current in-stream flow policy and only the potential storage project on the lower Belly River was effective if the in-stream flow policy was modified to be the current IO plus 10%. The Belly Reservoir is partially located on the Kainai First Nation Reserve and, as such, will require negotiations and a lengthy implementation period.

Appendix B

Irrigation Benefits Simulator Model

B.1 Introduction to the Model

The primary purpose of this model is two-fold: (1) to develop details of irrigated and dryland production for estimating direct impacts of irrigation and (2) to create transactions of irrigated farms in order to estimate economic impacts using the Alberta Regional Input-Output Model (ARIOM). Crop and livestock production activities were included. The simulator is based on "Microsoft Excel" with a total of 24 worksheets (Table B.1).

The simulator is divided into five sections. Section 1 is devoted to irrigation and dryland crop production activities. Details are provided for the irrigation districts as well as private irrigation projects. Section 2 calculates the estimated gross farm income, first as reported by Statistics Canada, and then for irrigation and dryland crop and livestock activities from 2000 to 2011.

Table B.1. Structure of the Irrigation Benefits Simulator Model.

Section	Worksheet No.	Description of Contents
Title	Sheet 1	Title and List of Worksheets
Section 1: Crop Production	Sheet 2	Land Use in Alberta Agriculture
	Sheet 3	Total Crop Area in Alberta -- Irrigated and Dryland
	Sheet 4	Irrigation districts and Private Irrigation Area Details
	Sheet 5	Total Crop area by Irrigation District and Private by Crops
	Sheet 6	Private Irrigation Area -- Hectares and Crops
	Sheet 7	Alberta Crop Prices
	Sheet 8	Irrigated Crop Yields
	Sheet 9	Irrigated Crop Cost of Production
	Sheet 10	Dryland Crop Yields
	Sheet 11	Dryland Crop Cost of Production
Section 2: Farm Income	Sheet 12	Farm Cash Receipts for Alberta
	Sheet 13	Irrigated and Dryland Farms Gross Revenue
Section 3: Livestock Production	Sheet 14	Sales of Cattle
	Sheet 15	Hogs Cost of Production and Cash Receipts
	Sheet 16	Sheep and Lambs Cost of Production and Cash Receipts
	Sheet 17	Dairy Cost of Production and Cash Receipts
	Sheet 18	Poultry and Eggs Cost of Production and Cash Receipts
	Sheet 19	Total Value of Livestock
Section 4: Input-Output Model Vectors	Sheet 20	Input-Output Vector of Cattle Cost of Production
	Sheet 21	Vector of Input-Output Crop Inputs
	Sheet 22	Final Vector for Input-Output Model
Section 5: Miscellaneous	Sheet 23	On-Farm Investment of Machinery and Equipment
	Sheet 24	Older Dryland and Irrigated Area by Irrigation Districts

Section 3 contains data related to livestock production categories. Section 4 reports the commodity breakdown for irrigated and dryland crop and livestock activities in the ARIOM (Table C.1). Section 5 includes farm level investment details. A total of 21 tasks were undertaken, and are described below.

B.2 Section 1: Crop Production Related Tasks

Task 1. The estimation uses Census data from ARD (2013a). It includes the distribution of major agricultural land use in Alberta. The categories of data reported in this sheet include (1) total farm area, (2) cultivated land area, (3) total land in crops (including summer fallow and tame pasture), (4) summer Fallow area, (5) tame or seeded pasture area, (6) natural land for pastures, (7) all other land, and (8) irrigated area. All data were collected in acres, and converted to hectares. It was assumed that 2001 census data reflected 2000 data.

Task 2. The next step in calculating the farm level economics of irrigation and dryland production in Alberta was to collect information on irrigated and dryland area by major crops and their respective yield per unit of land. This included data on total area under crops, summer fallow, and pastures, and separates the area under crops by major types.

Dryland crop areas were based on ARD (2006; 2007; 2008a; 2009c; 2010d; 2011d; 2012d; 2013a) and were estimated as the difference between the total cropped area and the cropped area under irrigation.

Task 3. The irrigated areas from 2000 to 2011 were obtained from ARD (2012a). These data included the 13 irrigation districts plus private irrigators (collected under Task 6).

Task 4. The total irrigated area in Task 2 was divided into major crops for irrigation district.

Task 5. Private irrigated area data were obtained from ARD (2012a) plus Nicol et al. (2010). The largest private irrigation area is under the jurisdiction of the Kainai (Blood Tribe) First Nation. Data were also obtained from Aboriginal Affairs and Northern Development Canada (2013). Although this publication reports several enterprises, in this study the entire area of the Blood Tribe Agriculture Project was assumed to be in forages.

Task 6. Prices of agricultural products in Alberta were obtained from Alberta Financial Services Corporation (AFSC, 2012; 2015). These prices were assumed to be received by both irrigation as well as dryland crops (if grown).

Task 7 and 9. Crop yields under irrigated and dryland production were also obtained from AFSC (2012; 2015). Yields and prices were converted into metric units using conversion factors reported on the inside back cover of this report.

Task 8 and 10. To estimate economic impacts of agricultural activities, information was obtained on cost of production. Cost of production data for irrigated crops were obtained from ARD AgriProfit$ (2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008a; 2009a; 2010a; 2011a). Cost data were available only for major crops, and not for several specialty crops. As a substitute, the cost of potato production was used for these crops.

B.3 Section 2: Farm Income Related Tasks

Task 11. The data on farm area under crops, and their respective yields and prices were used to develop gross revenue for irrigation and dryland crops. Since the economic impact model is based on farm cash receipts, Alberta's farm cash receipts for major crops were obtained from Statistics Canada (2014a).

Task 12. The data from Task 11 were used to estimate farm cash receipts using the area, yields, and price data. These values were estimated for irrigation and dryland farms separately. The combined irrigation and dryland farm cash receipts were compared with those in Task 11. For some crops the estimated value was greater than that estimated by Statistics Canada. The possible explanation for this is that, for some crops, not the total quantity produced is sold, some of it is kept for farm-level use or added to farm-level stocks (for non-perishable crops). In these cases, adjustment factors were calculated and applied so that estimated farm cash receipts matched the Statistics Canada estimates.

B.4 Section 3: Livestock Production Related Tasks

Livestock activity in Alberta consists of cattle and calves, hogs, dairy, sheep and lamb, poultry and eggs, and other livestock. The cattle and calves sub-sector is dominant, contributing about 71% of total livestock cash receipts from 2000 to 2011. Hogs are the next most important livestock activity with 10% of the total livestock farm cash receipts, followed by dairy at 9% of total livestock farm cash receipts. The remaining 10% is contributed by sheep and lamb, poultry and eggs, and other livestock products.

Tasks 13 to 17. The first step in estimating irrigation and dryland livestock values was to estimate the share of each type of livestock production activity on irrigated and dryland farms. Alberta farm cash receipts from livestock products were taken from Task 12. The share of irrigation numbers were obtained from a previous study by IWMSC (2002), and are shown in Table B.2.

Task 18. Applying these proportions to the total livestock farm cash receipts of each of the six livestock sub-sectors, annual sales were estimated from 2000 to 2011. The livestock values for dryland farms were the difference between the total livestock value and the irrigated livestock

Table B.2. Share of irrigation in Alberta's livestock production activities.

Livestock Sector	Share of Irrigated Farms to Provincial Total (%)
Cattle and Calves	18.3
Hogs	13.8
Sheep and Lambs	19.6
Dairy	19.6
Poultry and Eggs	9.3
Other	16.5

Source: IWMSC (2002).

values. The total value of livestock farm cash receipts was a total of the six different livestock sub-sector farm cash receipts, weighted by the proportions shown in Table B.2 for irrigation.

B.5 Section 4: Input-Output Tasks

Task 19. Annual production costs for the livestock categories from 2000 to 2011were obtained as follows.

- Cattle and calves: Canadian Cattlemen's Association (Personal Communications with Brenna Grant) and from ARD AgriProfit$ (2008b; 2009b; 2010b; 2011b).
- Hogs: ARD (2010a; 2010b; 2011a; 2012b).
- Dairy: (ARD, 2009b; 2011b; 2012c; 2013f).
- Sheep and lambs: (ARD, 2010c; 2011c).

These data were translated into those commodities used for the economic impact model.

Task 20. For production costs on dryland and irrigated crops from 2000 to 2011, data were obtained from ARD AgriProfit$ (2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008a; 2009a; 2010a; 2011a; 2012).

Task 21. Each of the vectors in Task 19 and 20 were in purchased prices. These were converted into producer' prices using margin data for Alberta.

B.6 Section 5: On-Farm Machinery Investment Tasks

Task 22. Farm-level investment in machinery and equipment were estimated by determining expenditures from 2000 to 2011. While estimates were not available for Alberta irrigated farms, data were obtained from Meyers Norris Penny LLP (2011). These data are shown in Table 6.1.

Machinery and equipment costs in Meyers Norris Penny LLP (2011) were available for only nine crops. These were taken at face value and total value of machinery and equipment for these crops were estimated by multiplying them by the study average area for each crop. For the remaining crops, it was assumed that machinery and equipment costs for sugar beets are similar to those for potatoes. Since no data were available for other specialty crops, these were assumed to be an average of those for beans and potatoes. Other non-specialty crop estimates were assumed to be an average of the first six irrigated crops in Table 6.1.

Data on the replacement period for various types of machinery and equipment are also different. Therefore, a replacement rate of 10 years was assumed. Using these assumptions and data, average annualized investment cost for farm machinery and equipment on irrigated farms was estimated at $132 million.

The data estimated in this model were used for economic impact of irrigation in the two regions of Alberta: Southern Irrigation Region and Rest of Alberta Region using the economic impact model presented in Appendix C.

Appendix C
Alberta Reginal Input-Output Model

C.1 Background

The direct effects of any economic activity can be seen relatively easily. However, direct contributions do not show the true nature of economic changes that are created by the existence of that type of economic activity. In other words, direct impacts of irrigation are not the same as total economic impacts. In order to illustrate the importance of irrigation, its total contribution must be estimated.

There are a number of assessment methods, including the Export-Base Model, the Income-Expenditures Model, and the Input-Output Model. The first model is appropriate for a smaller community where there is a single industry with its production being destined for exports. This model relates the total growth in the region to the level of export sales. However, this type of model would only be appropriate for a single industry region, which is not the case in Alberta. The assumption of a single export sector is removed if one uses the Income-Expenditures Model for impact analysis. The focus of the analysis here is on the income (regardless of how many sectors generate it) and the manner in which it is spent. The impact of the direct income on the total income generated in the region can then be calculated.

The above two models do not offer a good basis for impact analysis since both of them are aggregates and their assumptions are somewhat restrictive. Most economic activities in a region are undertaken by a number of industries. These industries trade with each other. Each industry can produce a number of products. For this type of an economy, the best way to undertake economic impact assessment is through the use of an Input-Output Model.

An Input-Output Model is a useful method of estimating secondary impacts of economic development projects. Secondary impacts in this context refer to any other changes beyond those experienced by the firms that are affected by a given initial change (called direct impacts above). An Input-Output based economic impact analysis is preferred for the following reasons.

1. Every industry's impact is treated to be unique, allowing its specific economic impacts to be estimated.
2. Different types of economic stimulus can be applied to undertake economic impact analysis. Thus, economic impacts of consumer spending, exports, or purchases by other firms, for example, could be estimated uniquely.
3. Development of the model can also be region specific, thereby allowing regional differences in the production processes, technology, and trade patterns.

The Input-Output Model used in this study is described in detail in the next section.

C.2 Terminology

The Input-Output Model methodology uses certain terms that need to be explained further. These include:

- **Commodity.** A name given to any good or service that is purchased or sold by a firm. Goods and services with some commonality are grouped into one of the categories.
- **Sector.** Firms selling similar goods or services (commodities) are grouped into a sector.
- **Final Demand.** Sales of a commodity for final use. These sales do not enter back to any producing sector.
- **Intermediate Commodities (for sale or purchase).** Transactions made by one sector from another sector. These are typically inputs required for the production of commodities by that sector.

C.3 Study Input-Output Model

Total economic impacts of various facets of irrigation-related activities on the Alberta economy were estimated by developing the Alberta Regional Input-Output Model (ARIOM). The model was developed for two regions within Alberta: (1) Southern Irrigation Region, and (2) Rest of Alberta Region. In addition, a provincial model was also used. The ARIOM is a disaggregated model in terms of commodities (goods and services) that are bought and sold by various economic agents in the province, as well as by sectors. It is based on the transactions that took place in the Alberta economy during 2011. Selected inputs of various commodities were based on the North American Industrial Classification System (NAICS).

The commodities being traded were grouped under two types: intermediate commodities, which are sold to other industries for their use in producing other commodities, and value-added commodities, which comprise the GDP for the region. The model contained 66 intermediate commodities (1 to 66) and eight value-added commodities (67 to 74) that are sold or purchased by various sectors (Table C.1).

All firms producing similar commodities are grouped in a sector, which can produce more than one commodity. This provides the rectangular Input-Output sector. In the ARIOM, the Alberta economy was portrayed by 43 sectors (Table C.2). Sectors include those producing primary products (Sectors 1 to 8), utilities and construction (Sectors 9 to 14), manufacturing (Sectors 15 to 20), trade (Sectors 21 and 22), transportation (Sectors 23 and 36), services (Sectors 24 to 35), non-profit institutions (Sector 37), and government services (Sectors 38 to 43).

Table C.1. List of commodities included in the Alberta Regional Input-Output Model.

Comm No.	Commodity	Comm. No.	Commodity
1	Grains and other crop products	40	Published and recorded media products
2	Live animals	41	Telecommunications
3	Other farm products	42	Depository credit intermediation
4	Forestry products and services	43	Other finance and insurance
5	Fish and seafood, live, fresh, chilled or frozen	44	Real estate, rental, and leasing and rights to non-financial intangible assets
6	Support services related to farming and forestry	45	Imputed rental of owner-occupied dwellings
7	Mineral fuels	46	Professional services (except software and research and development)
8	Metal ores and concentrates	47	Software
9	Non-metallic minerals	48	Research and development
10	Mineral support services	49	Administrative and support, head office, waste management, and remediation services
11	Mineral and oil and gas exploration	50	Education services
12	Utilities	51	Health and social assistance services
13	Residential construction	52	Arts, entertainment, and recreation services
14	Non-residential buildings	53	Accommodation and food services
15	Engineering construction	54	Other services
16	Repair construction services	55	Sales of other services by Non-Profit Institutions Serving Households
17	Food and non-alcoholic beverages	56	Sales of other government services
18	Alcoholic beverages and tobacco products	57	Fictive materials
19	Textile products, clothing, and products of leather and similar materials	58	Fictive services
20	Wood products	59	Transportation margins
21	Wood pulp, paper, and paper products and paper stock	60	Services provided by non-profit institutions serving households
22	Printed products and services	61	Education services provided by government sector
23	Refined petroleum products (except petrochemicals)	62	Health services provided by government sector
24	Chemical products	63	Other GOC services
25	Plastic and rubber products	64	Other provincial and territorial government services
26	Non-metallic mineral products	65	Other municipal government services
27	Primary metallic products	66	Other aboriginal government services
28	Fabricated metallic products	67	Taxes on products
29	Industrial machinery	68	Subsidies on products
30	Computer and electronic products	69	Subsidies on production
31	Electrical equipment, appliances, and components	70	Taxes on production
32	Transportation equipment	71	Wages and salaries
33	Motor vehicle parts	72	Supplementary labour income
34	Furniture and related products	73	Gross mixed income
35	Other manufactured products and custom work	74	Gross operating surplus
36	Wholesale margins and commissions		
37	Retail margins, sales of used goods, and commissions		
38	Transportation and related services		
39	Information and cultural services		

Table C.2. List of sectors in the Regional Input-Output Model of Alberta.

Sector No.	Description	Sector No.	Description
1	Irrigated crop production	22	Retail trade
2	Irrigated livestock production	23	Transportation and warehousing
3	Dryland crop production	24	Information and cultural industries
4	Dryland livestock production	25	Finance, insurance, real estate, rental and leasing, and holding companies
5	Forestry and logging	26	Owner occupied dwellings
6	Fishing, hunting, and trapping	27	Professional, scientific, and technical services
7	Support activities for agriculture and forestry	28	Administrative and support, waste management, and remediation services
8	Mining, quarrying, and oil and gas extraction	29	Educational services
9	Utilities	30	Health care and social assistance
10	Residential construction	31	Arts, entertainment, and recreation
11	Non-residential building construction	32	Accommodation and food services
12	Engineering construction	33	Other services (except public administration)
13	Repair construction	34	Repair, maintenance and operating, and office supplies
14	Other activities of the construction industry	35	Advertising, promotion, meals, entertainment, and travel
15	Slaughter and meat processing	36	Transportation margins
16	Cereal and grain processing	37	Non-profit institutions serving households
17	Animal feed processing	38	Government education services
18	Vegetable processing	39	Government health services
19	Other agricultural processing	40	Other GOC services
20	Non-agricultural manufacturing	41	Other provincial and territorial government services
21	Wholesale trade	42	Other municipal government
		43	Other aboriginal government services

C.4 Method of Preparation of the Model

The starting point in the development of the model was procurement of transactions tables from Statistics Canada (2014e). This model was at aggregation level 'S'. Three sets of matrices were included in the model: (1) output matrix, which shows the distribution of various commodities produced by a given sector; (2) input matrix, which shows inputs of goods and services purchased by various sectors; and (3) final demand matrix, which shows transactions of commodities purchased by consumers, government, investment, and for exports. The initial model contained 35 economic sectors and a total of 66 inputs (intermediate and primary) and eight value-added items.

One of the major limitations of this transactions table, in the context of this study, was that the agriculture and manufacturing sectors were treated as a single sector. Furthermore, in this model there is no process for estimating employment in the Alberta economy, as various sectors gear up to produce more to meet increasing demands for various commodities. To improve on these limitations, further development of the ARIOM was required, employing the following features.

- Disaggregate the original (in Statistics Canada transactions table) agriculture sector into four sub-sectors highlighting irrigation as a separate activity.
- The original transactions table has a single manufacturing sector. To amplify agricultural processing activity related to irrigation this sector was also disaggregated.
- The original model was for the province of Alberta. It was regionalized using non-survey techniques.
- The Input-Output Model was appended with an employment module to estimate the effect on number of jobs under a given irrigation development scenario.

Each of these features is described in more detail in the following sections.

C.4.1 Disaggregating the Agricultural Production Sector

The agricultural production in the ARIOM was represented by four sectors: (1) irrigated crop production; (2) irrigated livestock production; (3) dryland crop production; and (4) dryland livestock production. These calculations have been described in the Irrigation Benefits Simulation Model. In general, irrigated crop production data were based on irrigation district as well as private irrigators' crop production decisions. The cost of production of various irrigated and dryland crops were based on ARD AgriProfit$ (2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2008a; 2009a; 2010a; 2011a; 2012). Estimated livestock production related activities on irrigated farms were based on the share of total livestock on irrigated farms as reported by IWMSC (2002). Cost of production of livestock on irrigated as well as dryland farms was assumed to be identical, and were obtained by type of animals from ARD (2008a; 2009a; 2009b; 2010a; 2010b; 2010c; 2011a; 2011b; 2011c; 2012b; 2012c) and ARD AgriProfit$ (2008b; 2009b; 2010b; 2011b).

C.4.2 Disaggregating the Manufacturing Sector

As noted above, manufacturing activity in the province was included as a single sector in Statistics Canada's transactions table. Since the focus of this study was to estimate the economic impacts of food processing and some non-food manufacturing sectors, further disaggregation was required. In the ARIOM, manufacturing was represented by six sectors: (1) slaughtering and meat processing, (2) cereal and grain processing, (3) animal feed processing, (4) vegetable processing, (5) other agricultural processing, and (6) non-agricultural processing. The last sector included all other non-agricultural types of manufacturing in the province.

The starting point for this disaggregation process was Statistics Canada's estimated value of output of various aggregation 'S' level commodities and input purchases. To obtain production technology (Input-Output coefficients for production), Canadian transactions table were obtained from Statistics Canada (2014d). This table was provided at Aggregation 'L' and included 234 sectors producing 470 commodities. In order to develop manufacturing Input-Output coefficients for the ARIOM, a system of operations were undertaken, and are detailed in the Manufacturing Module. Details on the structure of the module are shown in Table C.3.

Table C.3. Structure of the manufacturing module.

Task	Description
Task 1	Alberta sales of manufactured products
Task 2	Canadian transactions table
Task 3	Alberta converted coefficient in aggregation S
Task 4	Output of agricultural products
Task 5	Gross income by agricultural sectors
Task 6	Input transactions for various manufactured sub-sector
Task 7	Final set of vectors for manufacturing and agriculture sub-sectors

Task 1 (Table C.3) uses the data on inputs required for all manufactured products at aggregation S. Data on aggregation L for Canada were collected under Task 2. In Task 3, aggregation L distribution of commodities was reduced to level S commodities. To relate manufacturing activities to agriculture sub-sectors, production of the agricultural sub-sectors was estimated in Task 4. Task 5 included the collection of data on gross sales by different products in the Alberta output matrix. Using the per unit coefficient from the Canadian table and the level of Alberta output of various manufacturing sub-sectors, Alberta coefficients were derived in Task 6. All final vectors of outputs and inputs for agriculture, manufacturing, and investment sectors were consolidated under Task 7.

C.4.3 Regionalization of the Model

The Alberta transactions were divided into those for two regions in the ARIOM: Southern Irrigation Region, and the Rest of Alberta Region. The irrigation region included Census Divisions 1, 2, 3, 5, and 6. These are the Census Divisions where all the irrigation districts as well as private irrigators are located. The Rest of Alberta Region consisted of the remaining census divisions in Alberta.

The non-survey method of regionalization was followed using the values of location quotient for each region. A location quotient (LQ) was calculated as follows:

$$LQ_{ir} = \text{Employment in Sector}_{ir} / \text{Employment in Province}_{r} \qquad (C.1)$$

If the LQ for the sector was >1, it was assumed to be self-sufficient in that commodity and met all its requirements from internal sources. If the LQ was < 1, the sector in the region did not produce sufficient quantity of the commodities and imports from other parts of Alberta were needed. The Input-Output coefficients were adjusted for those sectors in a given region with LQ < 1.

C.4.4 Estimation of Employment Coefficients

In order to estimate employment coefficients for various sectors in the ARIOM, tabulations on employment by NAICS industries at the highest level of disaggregation were obtained (Statistics Canada, 2013c). These employment data were arranged by the model sectors. Corresponding levels of output were obtained from the output matrix of the transactions table for the model. Dividing the number of workers employed by a certain sector by its output in thousands of dollars provided the employment coefficient in terms of number of persons per $1,000 worth of output (value of goods and services sold).

C.5 Other Parameters for the Model

Once the basic Input-Output coefficients were estimated, the model requires a number of adjustments. These included (1) estimation of value of missing cells, (2) balancing of the model, (3) estimation of margins, (4) estimation of leakages, and (5) estimation of marginal propensity to consume.

C.5.1 Missing cells

Statistics Canada, even at the smallest level of aggregation, does not report all the information on transactions. These cells are suppressed on confidentiality grounds. In this step, these cells are identified. Missing transactions were calculated using corresponding coefficients using the Canadian Input-Output Model.

C.5.2 Balancing Matrices

After all cell information is complete, the total inputs and total outputs were compared for each commodity. If these sums did not match, a set of balancing steps were undertaken to finalize the transactions table.

C.5.3 Estimation of Margins

All economic transactions in the Input-Output table are in producer prices. Since expenditures incurred by various economic agents are in purchaser's prices, a set of margins need to be deducted from these values in order to undertake economic impact analysis. These margins include: transportation and storage margin, wholesale margin, retail margin, pipeline margin, gas margin, and tax margin. For each commodity these margins are estimated and used in running the economic impact model (if needed). These data were obtained from Statistics Canada (2014e).

C.5.4 Estimation of Leakages

Transactions in the Input-Output Model are based on local purchases only. If any quantity of a commodity used by economic agents is obtained from outside the region, it should be netted out from the total amount spent. International imports, imports from other parts of Canada, and those from other regions of Alberta (if a regional impact scenario) were removed from the total expenditures on a commodity in a given scenario. The remaining amount was equivalent to local purchases.

C.5.5 Propensity to Consume

In order to estimate induced impacts under a given scenario, it is important to make assumptions regarding the propensity to consume. As income of consumers increases, a portion of this increase is spent on consumer goods and other personal expenditures. In the case of smaller changes, an appropriate indicator is the marginal propensity to consume (MPC). The MPC is the proportion of changed income being spent on personal expenditures. These values are typically estimated using regression analysis. In order to estimate the MPC for Alberta, a regression equation for personal expenditures (PEX) and income (INC) was estimated using 1991 to 2003 data. Data were obtained from Statistics Canada (2010; 2014a; 2014b; 2014c; 2014d; 2014e). The estimated results are shown in Equation (C.2).

$$\underset{}{PEX} = \underset{(1007.7)}{6935.96^{**}} + \underset{(0.0009)}{0.686^{**}}\, INC \qquad (C.2)$$

$R^2 = 0.996$ $\qquad$ $n = 23$

(** Coefficient is significantly different from zero at 0.01 or less probability)

According to these estimates, the MPC of Alberta consumers is 0.686, indicating that for every dollar increase in income another $0.69 is spent on personal expenditures. This situation was considered unsustainable, since this value has recently increased.

As a substitute, an attempt was made to estimate the average propensity to consume (APC). The APC is simply a ratio of average personal expenditures to average income. Averages for the study period (2000 to 2011) were estimated. This value was 0.84 and was used for the economic impact assessment.

C.5.6 Mechanism of Impact Generation

After making all the above noted adjustments, the transactions table was used for developing an Economic Impact Analyzer. This process involved inverting various impact matrices and writing a user-friendly program for undertaking economic impacts.

This analyzer can estimate economic impacts on the region or province as a whole of all direct irrigation impacts plus those from backward and forward linkages of irrigation. It also has an option of estimating impacts either on the Southern Irrigation Region or on the Rest of Alberta Region, besides undertaking these at the provincial level.

Economic impact assessment is broken down into three steps.

1. The initial step is to enter scenario values in the “Impact Analyzer Scenario Builder” (Figure C.1). This includes a detailed breakdown of total expenditures plus employment level for the scenario.
2. Estimation of economic impacts using the multiplier matrices.
3. Presentation of economic impacts for a given scenario. A sample result is shown in Figure C.2.

Impact Analyzer Scenario Builder

Step 1: AB-Province
Step 2: Enter Data
Step 3:
Step 4: Remove Margins
Step 5: Remove Imports
Step 6: Industry Vector
Step 7: Exogenize Sector
Run Impacts
Reset

	Enter Initial Impacts in $1000's
1 Grains and other crop products	0.00
2 Live animals	0.00
3 Other farm products	0.00
4 Forestry products and services	0.00
5 Fish and seafood, live, fresh, chilled, or frozen	0.00
6 Support services related to farming and forestry	0.00
7 Mineral fuels	0.00
8 Metal ores and concentrates	0.00
9 Non-metallic minerals	0.00
10 Mineral support services	0.00
11 Mineral and oil and gas exploration	0.00
12 Utilities	0.00
13 Residential construction	0.00
14 Non-residential buildings	0.00
15 Engineering construction	0.00
16 Repair construction services	0.00
17 Food and non-alcoholic beverages	0.00
18 Alcoholic beverages and tobacco products	0.00
19 Textile products, clothing, and products of leather and similar materials	0.00
20 Wood products	0.00
21 Wood pulp, paper and paper products, and paper stock	0.00
22 Printed products and services	0.00
23 Refined petroleum products (except petrochemicals)	0.00
24 Chemical products	0.00
25 Plastic and rubber products	0.00
26 Non-metallic mineral products	0.00
27 Primary metallic products	0.00
28 Fabricated metallic products	0.00
29 Industrial machinery	0.00
30 Computer and electronic products	0.00
31 Electrical equipment, appliances, and components	0.00
32 Transportation equipment	0.00
33 Motor vehicle parts	0.00
34 Furniture and related products	0.00
35 Other manufactured products, and custom work	0.00
36 Wholesale margins and commissions	0.00
37 Retail margins, sales of used goods, and commissions	0.00
38 Transportation and related services	0.00
39 Information and cultural services	0.00
40 Published and recorded media products	0.00
41 Telecommunications	0.00
42 Depository credit intermediation	0.00
43 Other finance and insurance	0.00
44 Real estate, rental and leasing, and rights to non-financial intangible assets	0.00
45 Imputed rental of owner-occupied dwellings	0.00
46 Professional services (except software and research and development)	0.00
47 Software	0.00
48 Research and development	0.00
49 Administrative and support, head office, waste management, and remediation services	0.00
50 Education services	0.00
51 Health and social assistance services	0.00
52 Arts, entertainment, and recreation services	0.00
53 Accommodation and food services	0.00
54 Other services	0.00
55 Sales of other services by non-profit serving households	0.00
56 Sales of other government services	0.00
57 Fictive materials	0.00
58 Fictive services	0.00
59 Transportation margins	0.00
60 Services provided by non-profit serving households	0.00
61 Education services provided by government sector	0.00
62 Health services provided by government sector	0.00
63 Other GOC services	0.00
64 Other provincial and territorial government services	0.00
65 Other municipal government services	0.00
66 Other aboriginal government services	0.00
67 Indirect taxes	0.00
68 Subsidies	0.00
69 Labour Income	0.00
70 Other operating surplus	0.00
71 Imports interprovincial	0.00
72 Imports foreign	0.00
73 Other leakages	0.00
74 Total employment	0.00
75 Total (not including employment)	0.00

Figure C.1. Illustration of Impact Analyzer Scenario Builder.

Summary of Total Impacts by Sectors, Type II						
$'000						
		GDP at	GDP at		Labour	
	Output	Factor Cost	Market Price	Imports	Income	Employment
1 Irg-Crops	0.0	0.0	0.0	0.0	0.0	0.0
2 Irg-LS	0.0	0.0	0.0	0.0	0.0	0.0
3 Dryl-Crops	0.0	0.0	0.0	0.0	0.0	0.0
4 DryL-LS	0.0	0.0	0.0	0.0	0.0	0.0
5 Forestry and logging	0.0	0.0	0.0	0.0	0.0	0.0
6 Fishing, hunting, and trapping	0.0	0.0	0.0	0.0	0.0	0.0
7 Support activities for agriculture and forestry	0.0	0.0	0.0	0.0	0.0	0.0
8 Mining, quarrying, and oil and gas extraction	0.0	0.0	0.0	0.0	0.0	0.0
9 Utilities	0.0	0.0	0.0	0.0	0.0	0.0
10 Residential construction	0.0	0.0	0.0	0.0	0.0	0.0
11 Non-residential building construction	0.0	0.0	0.0	0.0	0.0	0.0
12 Engineering construction	0.0	0.0	0.0	0.0	0.0	0.0
13 Repair construction	0.0	0.0	0.0	0.0	0.0	0.0
14 Other activities of the construction industry	0.0	0.0	0.0	0.0	0.0	0.0
15 Slaughter and meat processing	0.0	0.0	0.0	0.0	0.0	0.0
16 Cereal and grain processing	0.0	0.0	0.0	0.0	0.0	0.0
17 Animal feed processing	0.0	0.0	0.0	0.0	0.0	0.0
18 Vegetable processing	0.0	0.0	0.0	0.0	0.0	0.0
19 Other agriculture processing	0.0	0.0	0.0	0.0	0.0	0.0
20 Non-agriculture manufacturing	0.0	0.0	0.0	0.0	0.0	0.0
21 Wholesale trade	0.0	0.0	0.0	0.0	0.0	0.0
22 Retail trade	0.0	0.0	0.0	0.0	0.0	0.0
23 Transportation and warehousing	0.0	0.0	0.0	0.0	0.0	0.0
24 Information and cultural industries	0.0	0.0	0.0	0.0	0.0	0.0
25 Financial, insurance, real estate, rent, lease, and holding companies	0.0	0.0	0.0	0.0	0.0	0.0
26 Owner occupied dwellings	0.0	0.0	0.0	0.0	0.0	0.0
27 Professional, scientific, and technical services	0.0	0.0	0.0	0.0	0.0	0.0
28 Admin and support, waste management, and remediation services	0.0	0.0	0.0	0.0	0.0	0.0
29 Educational services	0.0	0.0	0.0	0.0	0.0	0.0
30 Health care and social assistance	0.0	0.0	0.0	0.0	0.0	0.0
31 Arts, entertainment, and recreation	0.0	0.0	0.0	0.0	0.0	0.0
32 Accommodation and food services	0.0	0.0	0.0	0.0	0.0	0.0
33 Other services (except public administration)	0.0	0.0	0.0	0.0	0.0	0.0
34 Repair, maintenance and operating, and office supplies	0.0	0.0	0.0	0.0	0.0	0.0
35 Advertising, promotion, meals, entertainment, and travel	0.0	0.0	0.0	0.0	0.0	0.0
36 Transportation margins	0.0	0.0	0.0	0.0	0.0	0.0
37 Non-profit institutions serving households	0.0	0.0	0.0	0.0	0.0	0.0
38 Government education services	0.0	0.0	0.0	0.0	0.0	0.0
39 Government health services	0.0	0.0	0.0	0.0	0.0	0.0
40 Other GOC services	0.0	0.0	0.0	0.0	0.0	0.0
41 Other provincial and territorial government services	0.0	0.0	0.0	0.0	0.0	0.0
42 Other municipal government services	0.0	0.0	0.0	0.0	0.0	0.0
43 Other aboriginal government services	0.0	0.0	0.0	0.0	0.0	0.0
Exogenous Industry Direct	0.0	0.0	0.0	0.0	0.0	0.0
Total Impacts	0.0	0.0	0.0	0.0	0.0	0.0

Figure C.2. Sample economic impacts results table.

Appendix D

Fiscal Impact Analysis Model

Fiscal impacts of a development project are felt at different levels of the government. In the case of Alberta irrigation, these impacts are mostly realized by the GOA as well as by the GOC. Although local governments may also receive some additional revenue attributable to irrigation, such impacts would be distributed among all rural communities (some with irrigation, others with no irrigation). Data requirements for such an estimation process are large; therefore, they were considered beyond the scope of this study. In this study, fiscal impacts of irrigation were estimated only for the GOA and GOC.

Net fiscal impact on any government can be stated as follows:

$$\text{NET FISCAL IMPACTS}_i = \text{TOTAL FISCAL REVENUES}_i - \text{TOTAL PROGRAM COSTS}_i \qquad \text{(D.1)}$$

Fiscal revenues are generated not only by direct irrigation activities but also by allied industries and irrigation infrastructure. Equation D.1 included only those fiscal impacts that are attributable to direct, indirect, and induced impacts related to irrigation activity in Alberta. To accomplish this, changes in major economic entities in the province were estimated using the ARIOM, as reported in previous chapters. These changes were then used to drive fiscal revenues for Alberta and for Canada. Fiscal costs were available for Alberta as reported in Chapter 7. No further estimation was needed. For the GOC, these expenditures are not available.

Total fiscal revenues for the GOA were divided into (1) personal income taxes, (2) corporation income taxes, (3) indirect taxes on goods and services, (4) investment income, (6) transfers from people for social security programs, and (6) transfers from the GOC (GOA, 2000a; 2001; 2002; 2003a; 2004; 2005; 2006; 2007a; 2008; 2009; 2010; 2011;2012a). There are other revenues but they were assumed to be not related to irrigation activities; therefore, they were not included in this analysis.

Similarly, the fiscal costs of the government can be estimated as a sum total of (1) direct program costs and (2) indirect costs triggered by the general development activity (as induced by irrigation and related activities). These direct program costs would include public support of the operation and maintenance of irrigation infrastructure and rehabilitation costs of irrigation infrastructure. In addition, given the present public debt situation, the cost of financing this additional capital investment was taken into account. Since these costs are included in the total government expenditures, they need not be accounted for separately.

The basic structure of the FIAM for irrigation development in the province is shown in Table D.1. Referring to the table, the starting point of the model is equation 11, the net fiscal revenue (NTFRV) to the province and/or GOC. This is computed as the difference between gross fiscal revenues and cost to the province of the program. However, data on direct irrigation related expenses by the GOC were not available. For this reason, NTFRV was estimated only for the GOA.

Table D.1. Basic structure of the Fiscal Impact Analysis Model for irrigation development in Alberta.

Equation No.	Description of the Dependent Variable	Major Independent Variable	Estimation for	
			Alberta	Canada
		Fiscal Revenues		
1	Individuals' Income Tax (INCTX)	Personal Income (PRINC)	X	X
2	Corporation Tax (CRPTX)	Profits of the Corporation(CORPFT)	X	X
3	Tax on Goods and Imports (GSTAX)	Retail Sales (RTSAL)	X	X
4	Other Personal Transfers (TNSFR)	Personal Income (PRINC)	X	X
5	Investment Income (INVIN)	Lagged Gross Domestic Product (GDP-1)	X	X
6	Transfers from GOC (FDTNR)	Lagged Gross Domestic Product (GDP-1)	X	
7	Total Irrigation Induced Revenue (TLREV)	Sum of Equations (1) to (6)	X	X
		Fiscal Costs		
8	Direct Irrigation Program Costs (IRGCS)	Actual Contribution by Provincial Government	X	
9	Indirect Costs (INDCS)	Lagged Gross Domestic Product (GDP-1)	X	
10	Total Cost (TTLCS)	Sum of Equations (8) and (9)	X	
11	Net Fiscal Revenue (NTFRV)	Equation (7) minus Equation (10)	X	

There were six sources of revenues and two types of costs included in the model for the GOA. The GOC fiscal model included five equations, since transfers from other levels of governments were not appropriate. In both models, Alberta provides only a part of the revenues received by the GOC. These fiscal impacts do not reflect the entire GOC operations. Specification of the model equations was kept simple, and in most cases, results were satisfactory on statistical and economic grounds. These results are shown in Table D.2 for the GOA and in Table D.3 for the GOC.

Table D.2 Results of Alberta Fiscal Impact Model.

Dependent Variable	Estimated Equation	R^2	F-value	Period of Estimation
INCTX	428.48*+ 0.0573**PRINC (170.77) (0.0025)	0.949	509.8**	1981 to 2009
CRPTX	153.27 + 0.0308**CORPF (137.23) (0.0024)	0.854	158.31**	1981 to 2009
GSTAX	497.62*+ 0.4153**RTSAL (155.79) (0.0484)	0.812	73.70**	1981 to 2009
TNSFR	214.49 + 0.0195 PRINC (109.96) (0.0016)	0.841	142.82**	1981 to 2009
INVIN	2380.18*+ 0.046**GDP(- 1) (990.1) (0.0071)	0.630	42.64**	1982 to 2009
FDTRN	1083.85*+ 0.0119**GDP(-1) (176.21) (0.0013)	0.747	74.01**	1982 to 2009
INDCS	423.01 + 0.1134**GDP (4582.89) (0.0214)	0.779	28.21**	2000 to 2009

All values are in $ million.
Figures in parentheses are standard error of estimate.
* Coefficient is significantly different from zero at α =0.05.
** Coefficient is significantly different from zero at α =0.01.

Table D.3 Results of Canadian Fiscal Impact Model.

Dependent Variable	Estimated Equation	R^2	F-value	Period of Estimation
INCTX	-732.62*+ 0.1598** PRINC (210.58) (0.0031)	0.989	260.1**	1981 to 2009
CRPTX	558.51 + 0.0676**CORPF (137.23) (0.0024)	0.795	105.02**	1981 to 2009
GSTAX	1505.79*+ 1.028** RTSAL (178.86) (0.0555)	0.953	342.63**	1981 to 2009
TNSFR	769.43*+ 0.0127**PRINC (131.73) (0.00196)	0.609	42.05**	1981 to 2009
INVIN	415.53**+ 0.00116* GDP(-1) (25 56) (0.00019)	0.596	38.42**	1982 to 2009

All values are in $ million.
Figures in parentheses are standard error of estimate.
* Coefficient is significantly different from zero at α =0.05.
** Coefficient is significantly different from zero at α =0.01.

All estimated regression coefficients were significantly different from zero at 5% or lower. The slope coefficients were used to estimate the effect of irrigation on fiscal revenues and costs for the GOA and on fiscal revenues only for the GOC.

Appendix E

Farm Trends

From 2001 to 2011, several trends were evident in Alberta agriculture, several of which were a continuation of earlier patterns (Statistics Canada, 2012). The total number of farms in Alberta continued to decrease, from 53,652 in 2001 to 43,234 in 2011, a decrease of 19.4%.

- From 2001 to 2006, the number decreased from 53,652 to 49,431 (7.9%).
- From 2006 to 2011, farm numbers declined to 43,234 farms (8.7%).

By comparison, farm numbers in Canada decreased from 246,923 in 2001 to 205,730 in 2011, a decrease of 16.7%.

As the number of farms continued to decrease, farm size continued to increase through amalgamation (Table E.1). The number of mid-size farms decreased and very large farms increased, as did very small-size farms.

- The number of farms greater than 648 hectares increased from 15.2% of total farms in 2001 to 18.8% in 2011.
- The number of farms less than 28 hectares increased from 9.7 to 10.4%.
- The number of farms in the mid-size categories (28 to 647 hectares) decreased from 75.2 to 70.7%.

Significant decreases in farm numbers for key crop and livestock sectors also took place from 2001 to 2011 (Table E.2). Livestock and wheat farms were the most impacted sectors.

- Hog farms decreased by 78.6%.
- Beef cattle and feedlot operations decreased by 47.8%.
- Wheat farms decreased by 45.9%.
- Sheep and goat farms decreased by 41.0%.
- Dairy farms decreased by 34.9%.

Table E.1. Alberta farms classified by total farm area.

Size (ha)	2001	2006	2011
	(% of total)		
Under 28	9.7	11.4	10.4
28 to 161	38.5	37.3	37.8
162 to 452	28.5	26.3	25.2
453 to 647	8.2	7.9	7.7
648 and over	15.2	17.1	18.8

Source: Statistics Canada (2012).

Table E.2. Number of farms in Alberta (2001 to 2011).

Type of Operation[z]	2001	2006	2011	% Change 2001 to 2011
	Number of Farms			
Dairy	745	605	485	-34.9
Beef cattle including feedlots	23,036	20,494	12,022	-47.8
Hog	901	598	193	-78.6
Poultry and eggs	526	416	339	-35.6
Sheep and goats	830	558	490	-41.0
Other livestock[y]	6,302	7,414	6,374	1.1
Wheat	3,853	2,809	2,083	-45.9
Oilseeds and grain (except wheat)	9,527	9,753	10,609	11.4
Fruit and tree-nut	138	227	151	9.4
Vegetable	267	286	277	3.7
Greenhouse, nursery, floriculture, mushroom	832	910	826	-0.7
Other crop[x]	6,695	5,361	9,385	40.2
Total number of farms	53,652	49,431	43,234	-19.4

[z] Each census farm is classified according to the commodity or group of commodities that accounts for 50% or more of the total potential receipts.
[y] Includes bees, horses, and fur bearing animals such as rabbits, llamas, deer, and elk.
[x] Includes hay, sugar beets, hay seed, and grass seed.
Source: GOA (2014).

Total farm area declined slightly from 2001 to 2011, from approximately 21.1 million hectares to 20.4 million hectares (3.0%) (Tables E.3, E.4, and E.5).

- With producers adopting more continuous cropping practices, the area in summerfallow decreased by almost 60%, from about 1.2 million hectares to about 500,000 hectares.
- There was a major shift away from grain production to oilseeds, which more than doubled from 11.2% in 2001 to 25.5% in 2011. Oilseeds represented 25% of the cropped area in the province by 2011.
- Agri-food exports increased from 2001 to 2011, especially in the primary commodity category.

Among all major crops, yields generally increased from 2001 to 2011, ranging from increases of 23 to 58% (Table E.6).

Table E.3. Farm area by type in Alberta (2001 to 2011).

Type	2001	2006	2011	% Change 2001 to 2011
	Area (ha)			
Total	21,065,838	21,095,413	20,428,868	-3.0
Crops	9,728,191	9,621,616	9,746,556	0.3
Tame pasture	2,229,224	2,483,704	2,395,946	7.5
Summer fallow	1,235,593	906,348	511,139	-58.6
Native and other lands	7,872,830	8,083,746	7,775,227	1.2

Source: Estimated using data obtained from GOA (2013; 2014)

Table E.4. Area of selected crops grown in Alberta (2001 to 2011).

Crop	2001	2006	2011	% Change 2001 to 2011
	Area (ha)			
Grains	5,522,220	4,988,602	4,647,409	-15.8
Oilseeds	1,093,636	1,672,710	2,489,311	227.6
Hay and fodder	2,522,079	2,454,987	2,112,272	-16.2
Other field crops	590,256	505,168	504,864	-14.4
Total	**9,728,190**	**9,621,467**	**9,753,856**	**0.3%**

Source: Estimated using data obtained from GOA (2013; 2014)

Table E.5. Changes in cropping area (2001 to 2011).

Crop	2001	2006	2011
	(%)		
Grains	56.8	51.8	47.6
Oilseeds	11.2	17.4	25.5
Hay and fodder	25.9	25.5	21.7
Other field crops	6.1	5.3	5.3
Total	**100.0**	**100.0**	**100.0**

Source: Estimated using data obtained from GOA (2013; 2014)

Table E.6. Crop yields in Alberta (2001 to 2011).

Crop	Yield (t/ha)			Change (%)
	2001	2006	2011	
All wheat	2.23	2.91	3.30	48.0
Oats	2.44	2.48	3.12	27.9
Barley	2.93	3.20	3.60	22.9
Flaxseed	1.44	1.63	1.99	38.2
Canola	1.51	1.89	2.21	46.4
All Rye	1.70	2.56	2.69	58.2

Source: Statistics Canada (2014b); AFSC (2012; 2015).

The total value of agri-food exports declined slightly from 2001 to 2006, but experienced a sharp increase from 2006 to 2011. Overall, the total export exports from 2001 to 2011 increased by 34.6% to $8.1 billion (Table E.7).

- The sharp increase (48.7%) from 2006 to 2011 increased the value of primary commodities by 58.5%.
- Value-added product exports experienced a more modest increase of 12.9% from 2001 to 2011 because of an 11.5% decline in exports from 2001 to 2006.

From 2001 to 2011, the total number of farm operators declined by almost 20%, from 76,195 in 2001 to 62,050 in 2011. The average age of those operators increased by 4.6 years, from 49.9 to 54.5 years from 2001 to 2011 (Table E.8).

The business structure of farm operations has not changed appreciably when considering that sole proprietorships still represented more than 50% of the farm operations in 2011, virtually unchanged from 2001 (Table E.9). However, there was a decline in partnerships (from 30.1% in 2001 to 25.4% in 2011), and an almost equal increase in corporate farms (12.8% in 2001 to 17.6% in 2011).

Table E.7. Value of agri-food exports in Alberta (2001 to 2011).

Sector	2001	2006	2011	Change (2001 to 2011)
	($'000)			(%)
Total	5,986,981	5,813,428	8,061,006	34.6
Primary commodities	2,852,262	3,039,976	4,520,342	58.5
Value-added products	3,134,719	2,773,452	3,540,664	12.9

Source: Statistics Canada (2014c).

Table E.8. Demographics of farm operators in Alberta (2001 to 2011).

Characteristic	2001	2006	2011	% Change 2001 to 2011
Total number	76,195	71,660	62,050	-18.6
Average age	49.9	52.2	54.5	4.6
Under 35	8,900	6,290	4,550	-48.9
35-54	40,425	35,935	26,720	-33.9
55 years +	26,875	29,440	30,785	14.5

Source: GOA (2013; 2014).

Table E.9. Farm classification by operating arrangement in Alberta (2001 to 2011).

Type	2001	2006	2011
	(%)		
Sole proprietorship	56.7	56.3	56.6
Partnership	30.1	28.1	25.4
Corporation	12.8	15.0	17.6
Other	0.4	0.6	0.5

Source: GOA (2013; 2014).

Appendix F
Government Revenues

F.1 Sources of Government Revenues

Governments have various types of instruments for collecting revenues from individuals and businesses. As economic activities increase in magnitude, so do fiscal revenues. At present, the GOA and GOC receive fiscal revenues as a result of economic activities in Alberta. Although the GOC has other revenues (from other provinces), this study only assessed the revenues contributed by Alberta. Major sources of revenues for the two levels of governments include:

1. Direct taxes (income tax) from persons;
2. Direct taxes from corporations and government business enterprises;
3. Taxes on production and imports, which includes revenues collected through fees, indirect taxes, and through licensing;
4. Contributions from persons and businesses towards social insurance plans plus other transfers from persons; and
5. Investment income.

In addition, a portion of GOA revenues are generated through transfer payments from the GOC. Total revenues for the GOA are shown in Table F.1 for the period 2000 to 2009. During this period, there was a general increase in revenue from various sources, with the exception of 2009 (Figure F.1). Although a part of this increase could be related to inflationary factors, it does show real increase in fiscal revenue for the province. Of the total GOA revenues, investment income is the most important source (39% of the total), followed by personal income taxes (18%), and tax on goods and imports (17%), as shown in Figure F.2.

Due to the suspension of these data in the format presented in Table F.1 (and publication in a different format by Statistics Canada), it was not possible to update these beyond 2009. Estimation of the fiscal analysis was therefore based on data from 1981 to 2009.

F.2 Revenues to the Government of Canada from Alberta

Some of the fiscal revenues from Alberta tax payers and businesses are payable to the GOC. Notably among these are the income taxes from people. Total revenues, as shown in Table F.2, have been as high as $40 billion, although the average revenue from 2000 to 2009 was close to $32 billion. As shown in Figure F.3, personal incomes taxes contribute about half of the total revenues.

Combined revenues for the two levels of the governments are shown in Figure F.4. These revenues, in recent years, have exceeded $70 billion annually. From 2000 to 2009, the two levels of government collected an average of $61.5 billion/year as revenue, of which 52% was received by the province of Alberta.

Table F.1. Estimated fiscal revenue for the Government of Alberta by source (2000 to 2009).

Year	Direct Taxes from Persons	Direct Taxes From Corporate and Government Business Enterprises	Taxes on Production and Imports	Contributions to Social Insurance Plans & Transfer from Persons	Investment Income	Current Transfers from GOC & Local Governments	Total Revenue
	($ million)						
2000	5,080	2,729	4,230	1,347	11,036	2,348	26,770
2001	4,357	1,961	4,368	1,596	10,393	2,378	25,053
2002	4,428	2,133	4,765	1,945	7,191	2,138	22,600
2003	4,515	1,604	5,084	2,292	10,570	3,211	27,276
2004	4,907	2,109	5,450	2,341	11,724	3,301	29,832
2005	5,777	2,623	5,784	2,406	15,755	3,848	36,193
2006	6,859	3,217	6,338	2,517	17,417	3,371	39,719
2007	7,667	3,546	6,653	2,636	14,471	3,340	38,313
2008	8,121	3,842	6,564	2,730	16,460	4,253	41,970
2009	7,231	3,923	6,393	1,708	8,562	4,498	32,315
Average (2000-2009)	**5,894**	**2,769**	**5,563**	**2,152**	**12,358**	**3,269**	**32,004**

Source: Statistics Canada (2010).

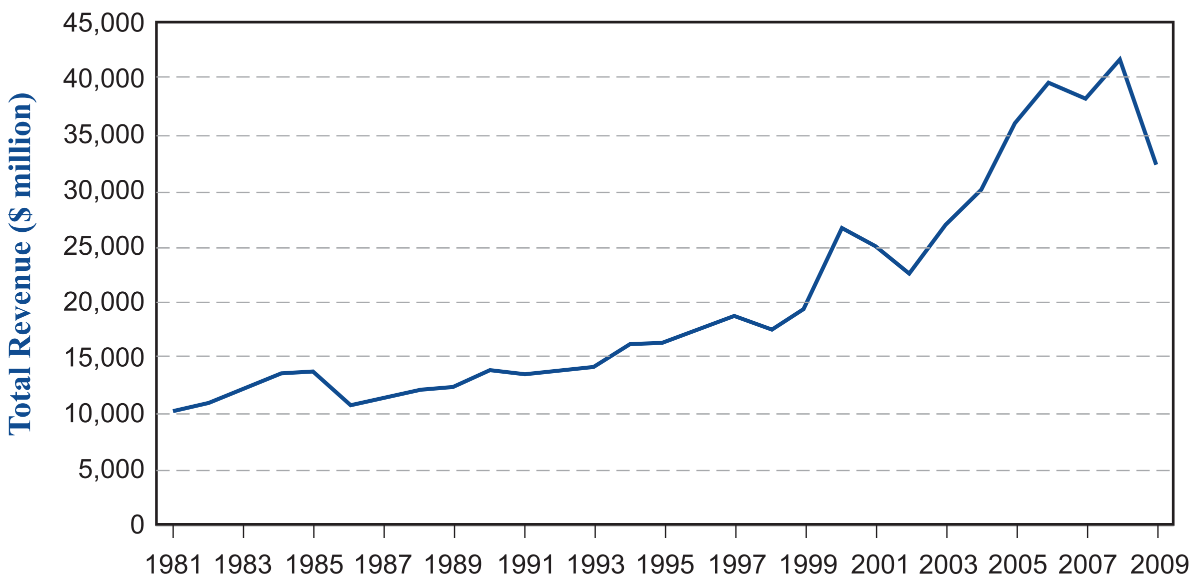


Figure F.1. Trend in fiscal revenues of Government of Alberta (1981 to 2009).

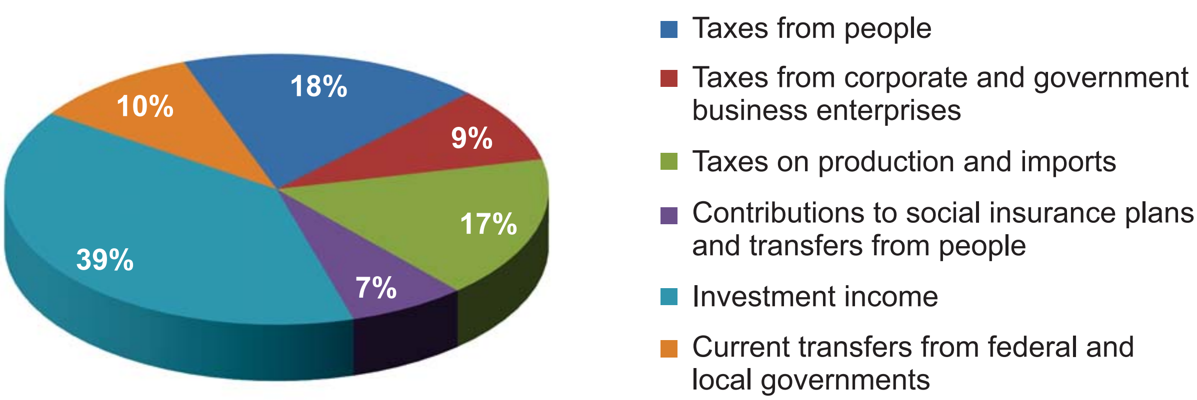


Figure F.2. Distribution of average revenues of Government of Alberta (2000 to 2009).

Table F.2. Source of Government of Canada fiscal revenues from Alberta (1981 to 2009).

Year	Direct Taxes From People	Direct Taxes from Corporate and Government Business Enterprises	Contributions to Social Insurance Plans and Other Transfers from People	Taxes on Production and Imports	Investment Income	Other Revenue	Total GOC Revenues from Alberta
	($ million)						
2000	10,496	4,497	1,806	4,317	708	263	22,087
2001	11,736	3,490	1,837	4,594	725	308	22,690
2002	10,996	3,810	1,837	5,094	637	298	22,672
2003	11,277	4,285	1,807	5,318	635	282	23,604
2004	12,564	5,175	1,789	5,568	565	316	25,977
2005	15,072	5,840	1,952	6,080	562	373	29,879
2006	17,076	7,984	2,064	6,439	596	477	34,636
2007	19,897	8,254	2,158	6,787	759	469	38,324
2008	20,547	9,384	2,190	6,212	804	531	39,668
2009	18,117	8,791	2,166	5,849	668	399	35,990
Average	14,778	6,151	1,961	5,626	666	372	29,553

Source: Statistics Canada (2013e).

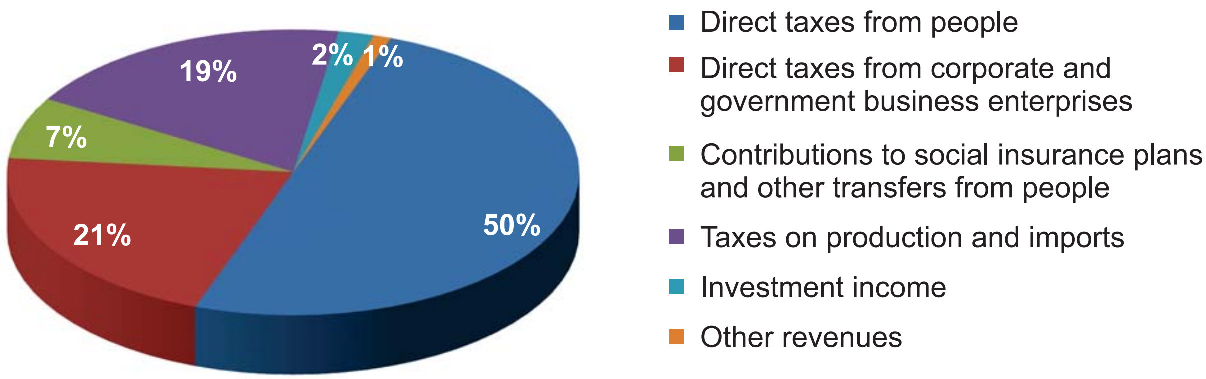


Figure F.3. Average distribution of Government of Canada revenues from Alberta (2000 to 2009).

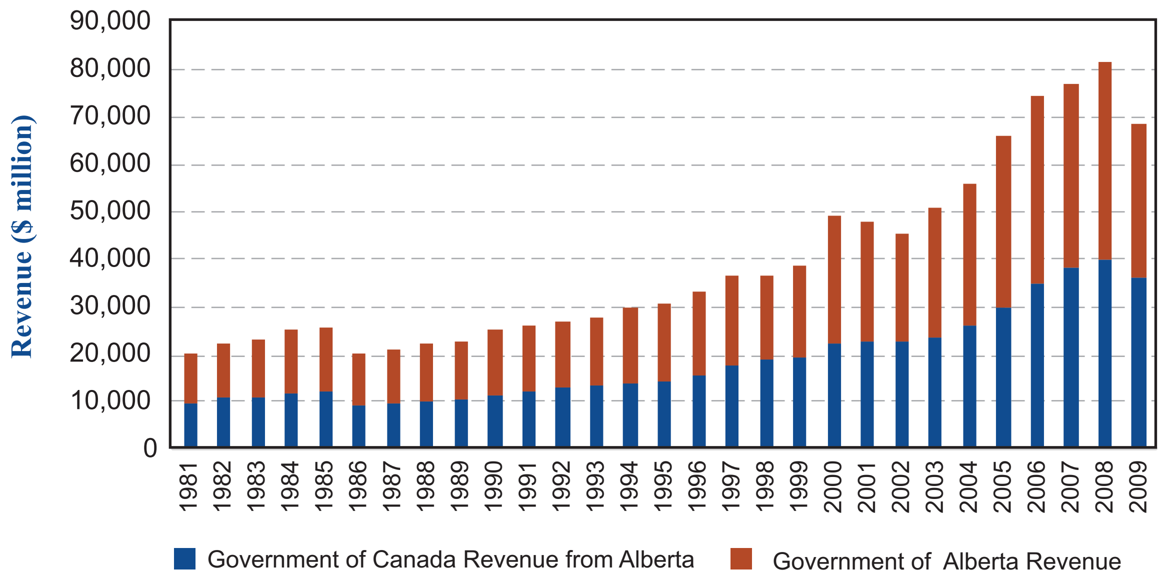


Figure F.4. Source of combined Government of Canada and Government of Alberta fiscal revenues (1981 to 2009).

Appendix G

Agricultural Food Processing Industry in Alberta

Alberta has a very diverse agricultural food processing industry. In 2014, there were 488 companies involved in a variety of production activities (ARD, 2015a), a decline of about 40% from 2008 (Table G.1). The largest decline was in dairy product manufacturing. These businesses constituted 9.1% of all manufacturing industry in Alberta. The three largest agricultural processing sectors are:

- Bakeries and tortilla manufacturing (32.2%);
- Meat product manufacturing (20.3%); and
- Animal food manufacturing (13.1%).

Food processing companies employed a total of 16,890 workers in Alberta in 2011 (Table G.2). This represented 14% of workers employed in all Alberta manufacturing sectors. Within the food processing sector, manufacturing of meat products employed 8,145 workers in 2011, about 48.2% of the total employment in the food processing industry (Table G.2). Grain milling, and bakeries and tortilla manufacturers together employed 22% of the total food processing FTEs.

Table G.1. Food processing companies in Alberta (2008 and 2014).

Type of Food Processing	No. of Active Businesses		Change (%)	% Total in 2014
	2008[z]	2014[y]		
Animal food manufacturing	82	64	-22.0	13.1
Grain and oilseed milling	20	22	10.0	4.5
Sugar and confectionary product manufacturing	13	11	-15.4	2.3
Fruit/vegetable preserving and specialty food manufacturing	39	24	-38.5	4.9
Dairy product manufacturing	248	29	-88.3	5.9
Meat product manufacturing	166	99	-40.4	20.3
Seafood product preparations packaging	6	3	-50.0	0.6
Bakeries and tortilla manufacturing	152	157	3.3	32.2
Other Food Processing	90	79	-12.2	16.2
Total food processing	**816**	**488**	**-40.2**	**100.0**

[z] Source: ARD (2008b).
[y] Source: ARD (2013a; 2015a).

Table G.2. Food processing employment in Alberta (2011).

Food Processing Type	Number of Workers	% of Total Food Manufacturing	% of Total Manufacturing
Animal food manufacturing	885	5.2	0.8
Grain and oilseed milling	610	3.6	0.5
Sugar and confectionery product manufacturing	350	2.1	0.3
Fruit and vegetable preserving and specialty food manufacturing	1,090	6.5	0.9
Dairy product manufacturing	1,030	6.1	0.9
Meat product manufacturing	8,145	48.2	6.9
Seafood product preparation and packaging	0[z]	0.0	---
Bakeries and tortilla manufacturing	2,950	17.5	2.5
Other food manufacturing	1,830	10.8	1.5
Food manufacturing	16,890	100.0	14.3
Total manufacturing	118,530		

[z] Data not released due to confidentiality rules.
Source: Statistics Canada (2013a).

G.1 Food Processing Industry Sales

In 2013, Statistics Canada (2013e) estimated Alberta's food and beverage processing industry sales totalled $11.5 billion. The industry represented the third largest manufacturing component in the province, surpassed only by petroleum and coal product manufacturing ($20.4 billion) and chemical manufacturing ($12.3 billion). Food processing accounted for 15.6% of total manufacturing sales in Alberta (Table G.3) (Statistics Canada, 2013e).

Within Alberta's food and beverage processing sector, meat products generated $5.7 billion in total sales in 2013, accounting for 49% of the total (Table G.4). Grain and oilseed milling generated $1.7 billion (14.7% of the total), and dairy food processing sales totalled $1.64 billion (14.3% of the total). From 2001 to 2013, food processing sales increased by $3.1 billion or 37%. The meat product processing sector sales increased 10.3%, while the grain and oilseed milling sector more than doubled, from $730.8 million in 2001 to about $1.7 billion in 2013.

G.2 Linkage between Irrigation and Agricultural Processing

A significant portion of Alberta's irrigated production is sold to food processing firms, and this adds further value to those products. Major processing plants are associated with irrigated areas, ensuring ready and dependable availability of speciality crop inputs central to their operations.

Table G.3. Alberta manufacturing sales by sector (2013).

Manufacturing Sector	Sales ($'000)	Total (%)
Petroleum and coal products	20,436,721	27.7
Chemical	12,309,088	16.7
Food and Beverages	**11,546,595**	**15.6**
Machinery	7,619,757	10.3
Fabricated metal products	5,942,218	8.1
Wood products	3,571,710	4.8
Non-metallic mineral products	2,253,964	3.1
Paper products	1,759,867	2.4
Plastics and rubber products	1,630,951	2.2
Beverage and tobacco products	967,994	1.3
Computer and electronic products	757,938	1.0
Transportation equipment	657,189	0.9
Furniture and related products	655,919	0.9
Electric equipment, appliances and components	560,824	0.8
Miscellaneous Products	3,122,463	4.2
Total Manufacturing	**73,793,198**	**100.0**

Source: Statistics Canada (2013e).

Table G.4. Food processing sales by sector in Alberta (2013).

Processing Sector	Sales ($'000)	Total (%)
Meat products	5,671,291	49.1
Grain and oilseed milling	1,693,723	14.7
Bakeries and tortillas[z]		
Dairy products	1,654,263	14.3
Animal food	891,399	7.7
Fruit and vegetable preserving and specialty food	401,767	3.5
Other food	1,234,152	10.7
Total Food Processing	**11,546,595**	**100.0**

[z] Not available as per confidentiality requirement of the *Statistics Act.*
Source: Statistics Canada (2013e).

Smaller speciality crop processors comprise a significant number of establishments in Alberta, many of which are family owned. As with the major processing enterprises identified above, smaller operations also depend on irrigation. Examples of firms that depend on irrigated specialty crops include a company using irrigated corn to produce corn tortillas and tortilla chips, a garlic production company that depends on irrigation, and a livestock feed manufacturer that requires sugar beets for the production of animal feed supplements, which includes molasses.

Of the 16,695 workers in Alberta's food processing sector, it is estimated that 61% are related to the irrigation industry in the Southern Irrigation Region (Table G.5). Individual food manufacturing industries, meat processing, and fruit and vegetable preserving industries have a higher share of employment in the irrigation region. Other food manufacturing that is present in the irrigation region is the bakeries and tortilla industries. Overall, 18.8% of all workers in the Southern Irrigation Region are employed in food manufacturing, compared with 10.1% in the other regions of Alberta.

This issue is further analyzed by taking into account the share of raw material from irrigated farms in the Southern Irrigation Region and the additional economic activity generated by them. These results are presented in Chapter 6 to reflect the value of irrigation to Albertans through food processing.

Table G.5. Processing and manufacturing employment in the Southern Irrigation Region and Alberta (2011).

Processing Sector	Employment			
	Total Alberta (FTEs)[z]	Southern Irrigation Region (FTEs)	Rest of Alberta (FTEs)	Irrigation Region (% of Total)
Animal food	885	435	450	49.2
Grain and oilseed milling	610	390	220	63.9
Sugar and confectionery	350	305	45	87.1
Fruit and vegetable preserving and specialty foods	1,090	670	420	61.5
Dairy products	1,030	535	495	51.9
Meat products	8,145	5,405	2,740	66.4
Bakeries and tortillas	2,950	1,325	1,625	44.9
Other foods	1,635	1,085	550	66.4
Total Food Processing	**16,695**	**10,150**	**6,545**	**60.8**
Beverages	1,940	1,385	555	71.4
Total Food and Beverage	**18,635**	**11,535**	**7,100**	**61.9**
Non-Food Manufacturing	**99,895**	**42,360**	**57,535**	**42.4**
Total Manufacturing	**118,530**	**53,895**	**64,635**	**45.5**
Food Processing % of Total	**14.1**	**18.8**	**10.1**	

[z] Number of full-time equivalent (FTE) workers.
Source: Statistics Canada (2013c).

Symbols

ha	hectare
'000	thousands
$'000	thousands of dollars
$ million	million dollars
t	tonne
kg	kilogram
bu	bushel
km	kilometre

Abbreviations for Irrigation Districts

AID	Aetna Irrigation District
BRID	Bow River Irrigation District
EID	Eastern Irrigation District
LID	Leavitt Irrigation District
LNID	Lethbridge Northern Irrigation District
MID	Magrath Irrigation District
MVID	Mountain View Irrigation District
RCID	Ross Creek Irrigation District
RID	Raymond Irrigation District
SMRID	St. Mary River Irrigation District
TID	Taber Irrigation District
UID	United Irrigation District
WID	Western Irrigation District

Conversions

1 hectare (ha)	2.47 acres
1 bushel of wheat (or durum)	0.027 tonne
1 tonne of wheat (or durum)	36.74 bushels
1 bushel of oats	0.02 tonne
1 tonne of oats	64.84 bushels
1 bushel of barley	0.02 tonne
1 tonne of barley	45.93 bushels
1 bushel of rye, corn, flaxseed or dry peas	0.03 tonne
1 tonne of rye, corn, flaxseed or dry peas	39.37 bushels
1 bushel of canola	0.02 tonne
1 tonne of canola	44.09 bushels
1 kilogram (kg)	2.20 pounds
1,000 cubic metres (m^3)	0.81 acre feet
1 tonne (t)	2204.64 pounds
1 tonne (t)	1.10 ton (short)
1 kilometre (km)	0.62 miles
1 cubic decametre (dam^3)	1,000 cubic metres (m^3)
1 cubic kilometre (km^3)	1 billion cubic metres (m^3)
1 metre (m)	3.28 feet
1 centimetre (cm)	0.39 inches
1 millimetre (mm)	0.04 inches