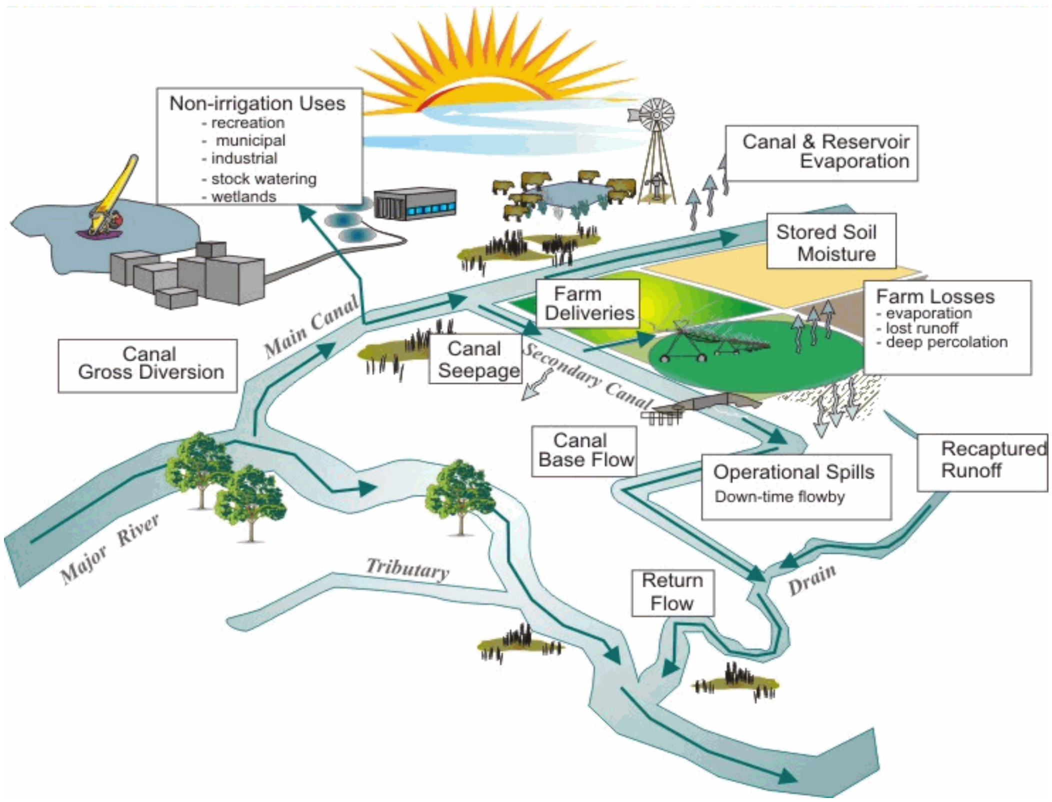
Irrigation Sector
Conservation, Efficiency, Productivity Plan
2005 - 2015



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Acknowledgements

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Stakeholder Committee members included (in alphabetical order):
Cheryl Bradley – Environmental NGO, representing environmental interests
Ray Bryant – Mayor Town of Taber, representing municipalities
Kent Bullock – TID, CEP Project Team and representing irrigation districts
Colleen de Kok – Irrigator, representing private irrigation
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Ron McMullin – representing AIPA
Richard Phillips – BRID, representing irrigation districts
Rich Smith – General Manager of Alberta Beef, representing the livestock industry, with
Jennifer Nitschelm, Alberta Agriculture and Rural Development, facilitator

Special thanks is extended to Roger Hohm and Jennifer Nitschelm who, respectively, chaired and facilitated the Committee. AIPA also thanks all the Irrigation District staff and Board members who gave of their time to review the multiple versions of the AECOM Report as well as the Irrigation Sector CEP Plan prepared by AIPA.

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Approximately 300 person-days have gone into the preparation of these documents, over-and-above the time spent by the consultant.

Preamble

Water for Life Strategy

The Government of Alberta's Water for Life Strategy has identified three key outcomes:

1) Safe, secure drinking water supply,
2) Healthy aquatic ecosystems, and
3) Reliable, quality water supplies for a sustainable economy.[1]

30% Increase in Efficiency + Productivity

One of the desired outcomes identified in the Water for Life Strategy to help achieve these goals is "The overall efficiency and productivity of water use in Alberta has improved by 30 per cent from 2005 levels by 2015...."[2] This outcome is seen as one guide to measure the strategy's success.

Water conservation was also identified as a key component of the strategy: "During all stages of the consultation on the water strategy, Albertans stated again and again that water conservation, combined with a focus on getting the most production possible from the water that is already allocated, is a fundamental component of any provincial water strategy." [3]

Addressing the concern of available water limits being reached in watersheds, the strategy document states "The solution to this looming problem comes through a combination of both improving our ability to capture and store water during high flow seasons or periods where possible and feasible, as well as improving water use practices through significant conservation efforts."[4]

One recommendation to encourage and achieve the conservation of water, and the efficiency and productivity of its use, is to "Prepare water conservation and productivity plans for all water using sectors." [5]

The seven largest water users in the Province committed to prepare Conservation, Efficiency, Productivity (CEP) Plans as a way to encourage the achievement of the 30% efficiency and productivity outcome. This plan is the fulfilment of that commitment and reinforces a longstanding drive by the Irrigation Sector to improve efficiencies and to conserve water. [6]

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[1] Alberta Environment, "*Water for Life: Alberta's Strategy for Sustainability*," Government of Alberta, Pub. No 1/955; 2003, p7. Edmonton Alberta.

[2] Ibid, p 8

[3] Ibid, p 21

[4] Ibid, p 21

[5] Ibid, p 22

[6] Irrigation Water Management Study Steering Committee, "*South Saskatchewan River Basin Irrigation in the 21st Century, Volume 1, Summary Report".* 2002. Alberta Irrigation Projects Association. Lethbridge, Alberta.

The definitions of the terms “conservation”, “efficiency” and “productivity”[7] follow:

Water conservation: Any beneficial reduction in water use, loss, or waste. Water management practices that improve the use of water resources to benefit people or the environment.

Water efficiency: Accomplishment of a function, task, process, or result with the minimal amount of water feasible. An indicator of the relationship between the amount of water needed for a particular purpose and the quantity of water used or diverted.

Water productivity: The amount of water that is used to produce a unit of any good, service, or societal value.

What do Irrigation Efficiency Gains Mean in Water Savings to Alberta?

The potential to conserve water by increasing efficiencies in the irrigation sector is considerable. Using the 2005 base-year running-average diversion of 441 mm per unit of land (as described later in this plan), a 1% efficiency gain in the irrigation industry is a saving of about 23 million cubic metres of water per year. A gain of 23 million cubic metres equates to a flow of 0.73 m^3 per second (about 26 ft^3 per second). A 4.6% efficiency gain by the irrigation sector would be a saving equal to the estimated annual consumptive water use by all municipalities in the South Saskatchewan River Basin[8]. A realized gain of 15% in efficiency in irrigation districts would equate to 25% of the annual volume of all other estimated actual uses reported in the Province of Alberta[9]. Efficiency gains in the irrigation system have tremendous potential to free-up the available water supply for environmental purposes, industry, municipal use, and irrigation growth in the South Saskatchewan River Basin.

Historically, irrigation withdrawals per unit of irrigated land have decreased from about 625 mm per year to current levels, equaling a saving of about 185 mm per year over the whole irrigated area. Although the irrigated area has increased over the years, the average gross diversion has actually decreased over time.

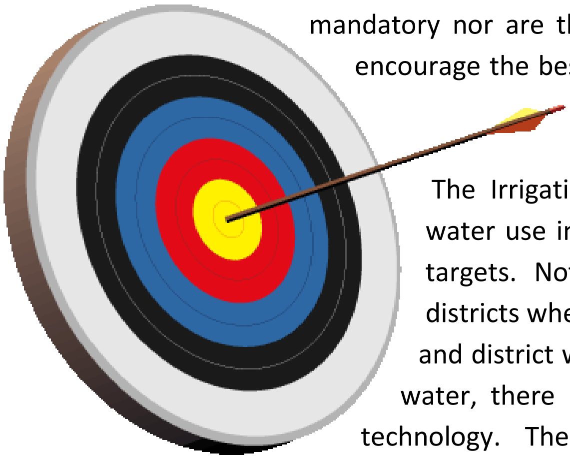
[7] Alberta Water Council Report: *“Water Conservation, Efficiency and Productivity: Principles, Definitions, Performance Measures & Environmental Indicators”, p1.*

[8] *Current and Future Water Use in Alberta*, Alberta Environment (prepared by AMEC Earth & Environmental), 2007, p 176

[9] Ibid, p 611

CEP Targets - Background

Targets set in this CEP Plan are stretch targets meant to challenge the Irrigation Sector to go beyond normal and achieve high levels of CEP in an effort to attain the 30% goal. As noted in Appendix I, "AWC Summary Report Meeting 26; item 6," the Alberta Water Council plainly states that the targets in the CEP Plans are not mandatory nor are they expected to become mandatory or regulated, but are to encourage the best possible effort of all water users to go beyond lesser targets that might be set under a mandatory system.



The Irrigation Districts, which constitute the vast majority of irrigation water use in Alberta, will work collectively toward achieving these stretch targets. Not all districts have the same potential to increase efficiency. In districts where producers have already adopted best management practices and district works have been rehabilitated to a large extent in order to save water, there is little room for further increases in efficiency with current technology. The annual percent increase in efficiency in high-efficiency districts will be low, but their operational efficiency will be high, i.e., they have already met efficiency goals over past years and are already operating far above previous levels. Variation in reservoir capacity, balancing ponds, canal and control infrastructure, crops grown, and climate all affect the ability of districts to become more efficient as well. For example, if a district owns a number of irrigation reservoirs and evaporative losses from those reservoirs is 6 % per year, that efficiency loss due to evaporation is very difficult to change and improve because the characteristics of a reservoir are essentially impossible to change.

In reality, some districts will meet the Irrigation Sector CEP targets and some will not. However, the districts will strive to collectively achieve the over-all water conservation, efficiency and productivity targets in this plan.

Stakeholder Involvement and the AECOM Report

AIPA and Alberta Agriculture and Rural Development (AARD) contracted with AECOM Canada Ltd. to prepare a CEP Plan for the irrigation sector. Alberta Environment provided AIPA with all the cash costs to hire a consultant which amounted to 60% of the funding for the AECOM study and report. A 9-member multi-stakeholder committee was struck to guide the development of the Terms of Reference and the plan, and review the CEP report produced by the consultant. The consultant also organized and facilitated a one-day workshop where about 70 attendees from diverse backgrounds participated in a brainstorming session to develop options for sector CEP progress. More than 300 person-days have been invested in this CEP process by members of the Steering Committee, workshop attendees, irrigation district staff, and AIPA staff. AECOM produced a 105-page report, "Irrigation Sector -- Conservation, Efficiency, and Productivity Planning Report," which followed the Annotated Table of Contents quite meticulously. The AECOM report is appended and contains details required by the Annotated Table of Contents that are not addressed in this shorter document.

Not all Steering Committee members and their stakeholders were in agreement with all the contents of the AECOM report, including AIPA's Board of Directors which disagreed strongly with one target because it seemed to be unachievable. With the Alberta Water Council documenting the nature of targets as per Appendix I, the Board gave approval for the AECOM report to be appended to a shorter CEP Plan to be drafted by AIPA. The AIPA drafted-plan that follows, includes nearly all the recommendations given in the AECOM report, but words them as actions rather than recommendations. The AECOM report is attached as a detailed reference, but the targets that Alberta's irrigation districts will strive to achieve are those in this document rather than those in the AECOM report.

CEP Plan Champions and Leaders

The main organization championing this plan is the Alberta Irrigation Projects Association (AIPA). AIPA is an umbrella organization of Alberta's 13 irrigation districts. Though the AIPA has no authority over the districts, each being autonomous, the AIPA does help coordinate cross-district activities related to government policy and legislation. AIPA has representation from each district, with the exception of the smallest one, on its Board of Directors and the Board directs the activities of the Association. An Executive Committee with representation of each of the 6 largest districts and collective representation of the 7 smaller "South Districts" directs the activities of the Association between Board meetings. An Executive Director handles the day to day operation of the Association.

Each of the District Boards and their Manager will be the CEP champion in their respective district. Overall, the Executive Director of the AIPA and its Executive Committee will champion the irrigation sector CEP efforts.

Since there is no umbrella organization for private irrigators in the province, no commitments can be made on-behalf of the 2,800 individual irrigators. One private irrigator was on the Stakeholder Committee for this work, but was there to provide guidance and input, rather than make commitments on behalf of others. Little information is known about water use by private irrigators. A key report[10] on water use in Alberta assumes that the full allocation is used by private irrigators since most private irrigators are growing forages, i.e., high water using crops, and thus some water use information for private irrigation is available through estimate.

[10] *Current and Future Water Use in Alberta*, Alberta Environment (prepared by AMEC Earth & Environmental), 2007.

What the irrigation sector is all about – what does the sector do with water?

The Irrigation Sector is the backbone of rural society in much of southern Alberta and drives a $5 billion per year economic engine. The focus of the irrigation industry is providing water for crops. In addition, the irrigation sector provides water to communities and wetlands, water for livestock, creates jobs, provides recreational opportunities, attracts food processors, brings social stability and promotes rural development through assurance of a water supply, and creates habitat for fish and wildlife. Some 50 rural communities are supplied raw water for domestic and other purposes through irrigation works and thousands of rural households are now supplied water from the irrigation system in collaboration with water coops and networks. Production from the 1.6 million acres of irrigated land and its spinoffs support approximately 33,000 related jobs in the region.

Major food and feed processors and seed companies operate in this area adding value to a diversity of high quality crop products produced on irrigated land. For example, almost $1 billion is produced annually by the processing, table and seed potato industry in the Province, which is concentrated in the irrigated region. Essentially all of the sunflower, sugar beet, dry bean, and soft wheat grown for processing in Alberta is grown on irrigated land. At least forty-one different crops are grown under irrigation. Some like mint are very specialized, and it may be surprising to learn that half of the mint flavouring for North America comes from one irrigated farm in south eastern Alberta. Markets for many products from irrigated agriculture and associated food processors are global, favouring Alberta's balance of payments, while many local farmers' markets are supplied by locally grown produce from irrigated market garden farms. Assurance of a reliable, quality water supply plus primary crops for these processors were main features that attracted many businesses and growers to Alberta. These businesses, growers, and rural communities rely on the irrigation network to provide security of water supplies and opportunities for growth.

Irrigation is a key to Alberta's fed beef industry. Reliable, quality feeds, namely forages and grains, grown under irrigation, and drinking water for cattle supplied by the irrigation sector are vital to the success of much of Alberta's beef industry. The value of Alberta beef and beef products, known around the world for their quality, exceeds the value of all the crops grown in the Province.

It does take a lot of water to grow food. In dry climates, where rainfall is insufficient, irrigation is vital to grow the diversity of food required to sustain human populations. Of the world's cropland, only 16% is irrigated, but that land base produces about 36% of the global harvest.
[Reference: http://www.fao.org/docrep/x0262e/x0262e01.htm]

In the early years of the Province, irrigation was vital to encourage settlement of the dry prairies and it continues to be on integral part of rural development in southern Alberta. If you are taking a stroll around Henderson Lake, watching birds at Kitsim Park, or shooting a round of golf at Land-o-Lakes, you are benefiting from the irrigation system. Twenty-six parks and thirteen day use areas south of Calgary are on irrigation reservoirs, and many of the southern golf courses are watered from the irrigation system. Boating, water skiing, wind surfing, fishing, camping, picnicking and just sitting on the beach are favourite past-times of southern Albertans who enjoy "a day at the lake," which actually is a day at the reservoir. Eighty-nine reservoirs provide most of the water-based recreation in the prairie region south of the City of Calgary. Of the 75 water bodies listed for the Parkland Prairie Area 1 in the Alberta Guide to Sportfishing Regulations, 62 are part of the irrigation infrastructure.

In collaboration with Ducks Unlimited the irrigation districts have created 82,000 acres (312 km^2) of wetlands, 73% of DUC projects' area in southern Alberta (south of Drumheller). These created wetlands provide critical staging and nesting habitat. The 1600 km of shorelines and 448 square kilometres of open surface water composing irrigation reservoirs also contribute significantly to habitat for fish and wildlife, and districts have planted over 650,000 trees and shrubs to add habitat for upland game birds and mammals in the area. Most of the trees and shrubs and the pleasant environment and habitat they produce in the "urban forest" in southern Alberta's communities are there because of irrigation.

Who makes up the irrigation sector?

The Irrigation Sector in Alberta includes Irrigation Districts and private irrigators. A private irrigator is an individual farmer or farm company that has obtained a water licence from Alberta Environment to withdraw water from a water body for the primary purpose of irrigating crops. A licence historically allows other minor purposes such as domestic use and stock-watering on a limited basis. Some 300,000 acres (121,500 ha) of land are irrigated by private irrigators in Alberta. The distribution of private irrigation projects is given in Figure 1.

Individual irrigation districts are similar in some respects to a farmer cooperative but the districts operate as a quasi-municipal government, established and governed by the Irrigation Districts Act. Each district has an elected board whose main mandate is to deliver water to water users. The board hires a Manager, who in turn hires staff to conduct the business of the district. The primary purpose of a district is laid out in the Act and includes

1) To convey and deliver water through the irrigation works of the district in accordance with this Act,
2) To divert and use quantities of water in accordance with the terms and conditions of its licence under the Water Act,
3) To construct, operate and maintain the irrigation works of the district, and
4) To maintain and promote the economic viability of the district.

In Alberta, 13 irrigation districts (Figure 2) are incorporated and deliver water to over 6,000 water users, i.e., irrigation farmers. The furthermost district to the north is the Western Irrigation District with a northern limit of Township 28 near the community of Irricana. Districts in the southern part of the Province run from Mountain View eastward to Medicine Hat. Over 1.3 million acres (525,000 ha) of irrigated land is serviced by the districts. The districts range in size from 1,200 to 372,000 acres. Individual farmers apply water to their crops via a variety of on-farm irrigation equipment. As of the CEP base year, 2005, the irrigation systems on farms were: centre pivot sprinkler irrigation, 64% of the area, side roll wheel move irrigation 22%, and flood irrigation 14%.

When an irrigator joins a district, significant fees are paid as the person "buys into" the irrigation infrastructure and receives the right to an amount of water as determined each year by the irrigation district board. That fee in the Lethbridge Northern Irrigation District, for example, is $1250 per acre. The annual allotment of water per acre will depend on the water supply anticipated for the growing season based on water volumes in reservoirs and water volumes in the snow pack. Irrigation farmers have invested collectively about $3 billion in on-farm irrigation equipment, and district infrastructure is valued at approximately $3 billion as well. Farmers are willing to make that level of investment because they know they will get water. This water supply ensures

i) that the farm will be productive,
ii) that yields will be high relative to rainfed lands,
iii) that the quality of the produce grown will be superior and will meet processor specifications,
iv) that a diversity of cropping options can be grown far beyond those grown on rainfed lands, and
v) that certain crops can be marketed through food processors, giving needed cash flow and much higher returns per acre than traditional cereals, oilseeds and forages.

Irrigation is most profitable and practical in the southern part of the Province where summers are typically hot and dry. High evaporative demands and low rainfall create crop water demands far in excess of the precipitation normally received. The heat of the region and the length of the growing season permit the growing of high quality, high-yielding crops when irrigation water can be applied to meet crop needs. These conditions are ideal for "Taber Corn," potatoes, dry beans, sunflowers and a host of other crops that are difficult to impossible to grow in other parts of the Province.

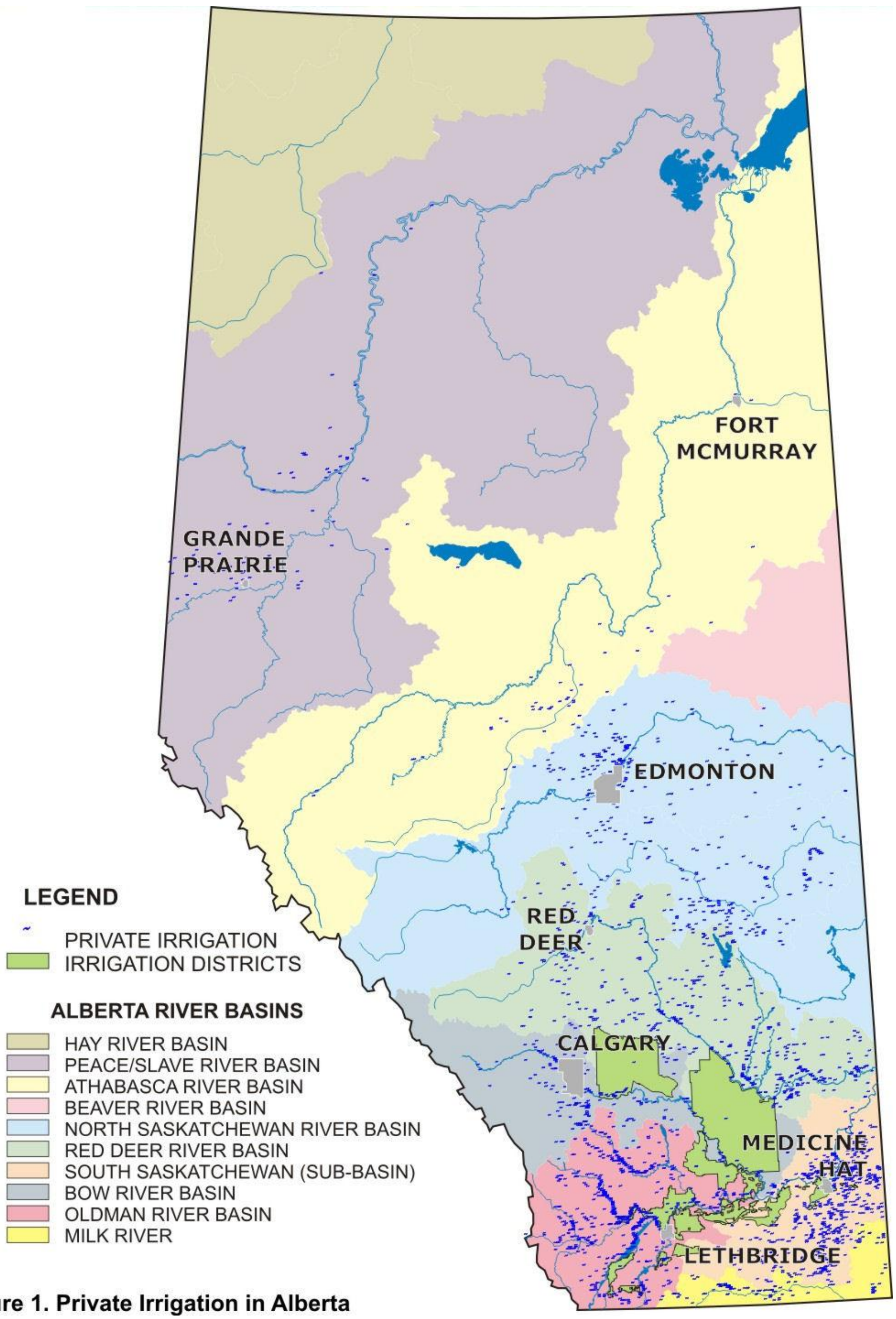
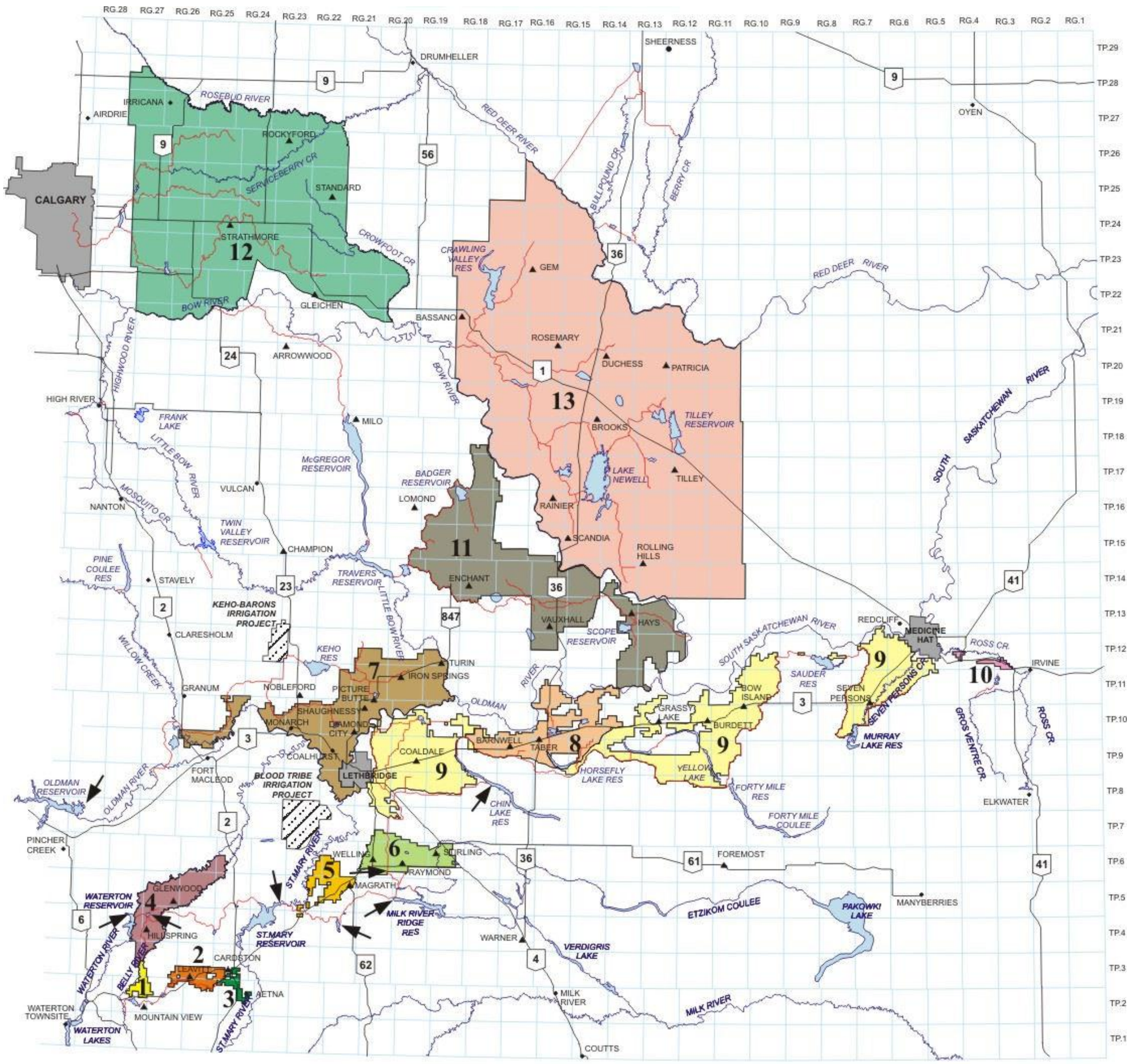


Figure 1. Private Irrigation in Alberta



There are 13 irrigation districts in southern Alberta providing water to 1,359,153 assessed acres of farmland. The infrastructure within these irrigation districts is comprised of approximately 8,000 kilometers of conveyance system, of which 339 kilometers are owned and operated by Alberta Environment.

Figure 2: Irrigation Districts in Alberta

How much water does the irrigation sector use, for what purposes, where does the water come from, and what productivity comes of this?

The irrigation districts collectively are licensed to divert approximately 3.4 billion m^3 (3.4 million dam^3; 2.75 million ac-ft) of water. Water withdrawals for districts are exclusively from rivers: the Bow, the Oldman, the Belly, the Waterton, the St. Mary, and two streams from the Cypress Hills. Only 200 acres of privately irrigated land are irrigated with groundwater, so essentially all the irrigation water in Alberta is surface water. Though the licence conditions vary, the licences permit water to be used for irrigation purposes. In some cases, alternate uses, such as water use by communities, industry, livestock operations, wetlands, and rural domestic water users, are allowed. An interim policy states that Alberta environment will consider applications from districts to amend 1,000 acre feet of water and 2% of their remaining licensed allocation for alternate uses. Some districts are required to make an annual accounting to Alberta Environment of the water allocated under the licence amendment and to document its use. Of the total water allocation to districts, on average, 62% of the allocation is diverted each year, but this varies from roughly 1/3 to essentially all the licensed amount depending primarily on weather conditions. All districts are required to report their water diversions, and since Alberta Environment controls most diversions, this data is readily available to Alberta Environment.

In dry years, water use is high, and in wetter years, a greater portion of water is left in the rivers and runs into Saskatchewan. Two reports have documented proportions of natural flow (a calculated value equal to the actual flow plus all diversions in the basin) of the South Saskatchewan River basin that leave Alberta and enter Saskatchewan. This flow is measured at the confluence of the Red Deer and South Saskatchewan Rivers. Alberta Environment's data covering the period 1975 – 1995 summarized "Historically, Alberta has passed approximately 75% of the annual total natural discharge of the SSRB to Saskatchewan. The requirement of the *Master Agreement on Apportionment* is 50%."[11] The recent South Saskatchewan River Basin in Alberta Water Supply Study that examined flow data over a longer time period, from 1970 -2006[12], states "On average, Alberta has passed 81% of the apportionable flow to Saskatchewan compared to the 50% required under the agreement." Apportionable flow "...is the natural flow of the South Saskatchewan River....minus U.S. withdrawals from the St. Mary River system in Montana."

[11] Alberta Environment, "*Approved Water Management Plan for the South Saskatchewan River Basin (Alberta).* P4. 2006.

[12] SSRB Water Supply Steering Committee, "*South Saskatchewan River Basin in Alberta Water Supply Study." (prepared by AMEC Earth and Environmental). P. 53. 2009.*

Private irrigators can be found from the Peace River country southward through the Milk River area on the US border. In southern Alberta, private irrigators take water from the same river systems as the districts plus the Red Deer and Milk Rivers, and some ponds. Some private irrigators have the security of water stored in reservoirs, but rather than having a network of canals to the farm, these water users pump directly out of the rivers below those reservoirs. In general, private irrigators therefore have higher efficiencies than the districts, and as a result have less opportunity for increasing efficiency. Private irrigators obtained their licences knowing their risk of water shortages is greater than those in a district, but their investment is lower – less than half. In recent years, Alberta Environment has measured withdrawals by private irrigators from the Milk River using real-time data collection technology; measurement (or estimates) and reporting of water usage to Alberta Environment by other private irrigators in Alberta is done by the individual irrigators.

Productivity

Productivity, the amount of crop or dollars of crop produced per unit of water, is one measure of efficiency of water use. Productivity on farms is affected by a number of factors, but the input that makes the biggest difference in yield in southern Alberta is the amount of water. The amount of water required by different crops has been well documented over decades of research, as has been the timing of water applications to maximize yields. Other key factors affecting productivity include the following.

1) When water is applied more uniformly over the field, the crop will be more uniform and usually higher yielding, and less water goes to deep percolation (i.e., to groundwater recharge which is an irrigation inefficiency),
2) When producers use the best varieties and the best agronomic practices to increase yield, productivity per unit of water increases. The better varieties are often of better quality for food processors as well, since quality for processing is a chief goal in most crop breeding programs.
3) Fertilizer is usually the third most important input to manage for greater productivity. Fertilizer must be applied at certain times, in certain ways, in certain forms and in quantities to match crop needs. Pest control products judiciously used also increase yields per unit of water, and other factors such as seeding date and depth, antecedent soil moisture levels, weather and precipitation patterns, etc., all interact to impact productivity.
4) The vast majority of irrigation farmers under-irrigate, meaning they do not apply enough water to meet the water requirements of the crop to maximize yields. Often, this is purposeful. For example, a farmer may withhold water to reduce the chance of a barley crop from lodging as it matures, or to ensure that fields are dry enough for the upcoming harvest. In some cases, less water is applied at certain crop stages to reduce disease incidence. If farmers were to strictly use irrigation scheduling based on soil moisture levels alone, they would apply more water in most cases. This could increase productivity per unit of land where under-irrigation was yield-limiting, barring other complications caused by the additional water.

5) All famers are mindful of input costs and at times limit those based on their cash flow situation. Applying water costs money in fuel or power bills, at a rate of approximately $12 per mm per circle for a pivot. Given a typical application of 300 mm, that would equate to about $3600 per year per pivot. Farmers are careful with their on-farm applications of water. Fuel savings are one way of controlling input costs but inadequate irrigation can reduce yields.
6) Certain crops are high in dollar value production and certain crops are much lower in value. The gross number of dollars produced per acre of potatoes, sugar beets, dry beans, sunflowers, mint, spice crops, hybrid canola seed, and market garden crops, for example, is much higher than are the dollars produced from cereals, oilseeds and hay, in general. However, these high value specialty crops may not produce more net income because of high risks and high input costs.

Some people wonder why every acre under irrigation is not planted to "high value" crops. Production of high value crops is limited by many factors. A key factor limiting the area of high value crops is rotation: in general, the high value crop can only be grown one in every 3 or 4 years of a rotation. If the same crop is grown year after year, disease and pests build up and the crop yield can be dramatically reduced. Another factor is input costs and risk: costs of seed, fertilizer, pest control products, planting, harvesting and storage are often very high for these specialty crops. High costs create a great risk to the producer who has no guarantee that the weather or the banker will cooperate. Another key factor is markets: we could grow thousands of acres of carrots in Alberta but how many carrots do we eat and who would buy all those carrots and how long can we economically store carrots in marketable condition since our harvest/marketing season is so short? As a result, just under 900 acres (365 ha) of carrots are grown in Alberta. Another factor is the need for forages and grains to support the livestock industry. The most extensive crop grown on irrigated land is forage for cattle. The value of the crop may not be so high per acre, but the value of the secondary production, beef and beef products, constitute more than half the agriculture economy of the Province.

7) If a limited amount of water is available, some crops such as cereals will produce a significant portion of their yield if that limited water supply is applied at the pre- to post-blossom (boot) stage. High value crops like potatoes, sugar beets, and vegetables require uniform water applications over the entire growing season which results in higher water demands and higher usage per irrigated acre to grow the higher value crops.

Thus there are many factors that contribute to what crops are grown under irrigation and the level of productivity they achieve per unit of water.

Productivity of irrigated crops is measured annually by Alberta Agriculture and Rural Development based on three key irrigated indicator crops: potatoes, sugar beets and soft white wheat. The measurement of water delivery to these three crops versus yields and prices can be used to track the increase in productivity of irrigated crops. A broader measurement base using more of the 41+ irrigated crops than only these three would be desirable, but that historical data does not exist. The "big three" listed above will be used in this plan as a measure of productivity under irrigation, and other options such as dry beans will be explored.

Although the irrigated land base is less than 5% of the agricultural land base in Alberta, it accounts for almost 20% of the total agricultural output of the entire Province. The ratio of value-added productivity to primary production in the Province as a whole is 1.05 to 1, but in the irrigated region the value-added to primary

production ratio is 2.66 to 1. The irrigated region is highly productive both from the standpoint of yield and value-added production.

Where do water losses occur in the irrigation system and why?

Understanding three key components of an irrigation system and the water losses associated with them will help in understanding the potential for efficiency gains by the irrigation sector:

1) water storage and water delivery system to farms,
2) return flow channels, and
3) on-farm water application systems.

Water losses occur at various rates from these three components primarily via: a) evaporation and seepage, b) application inefficiencies, and c) bypass water as depicted in Figure 3.

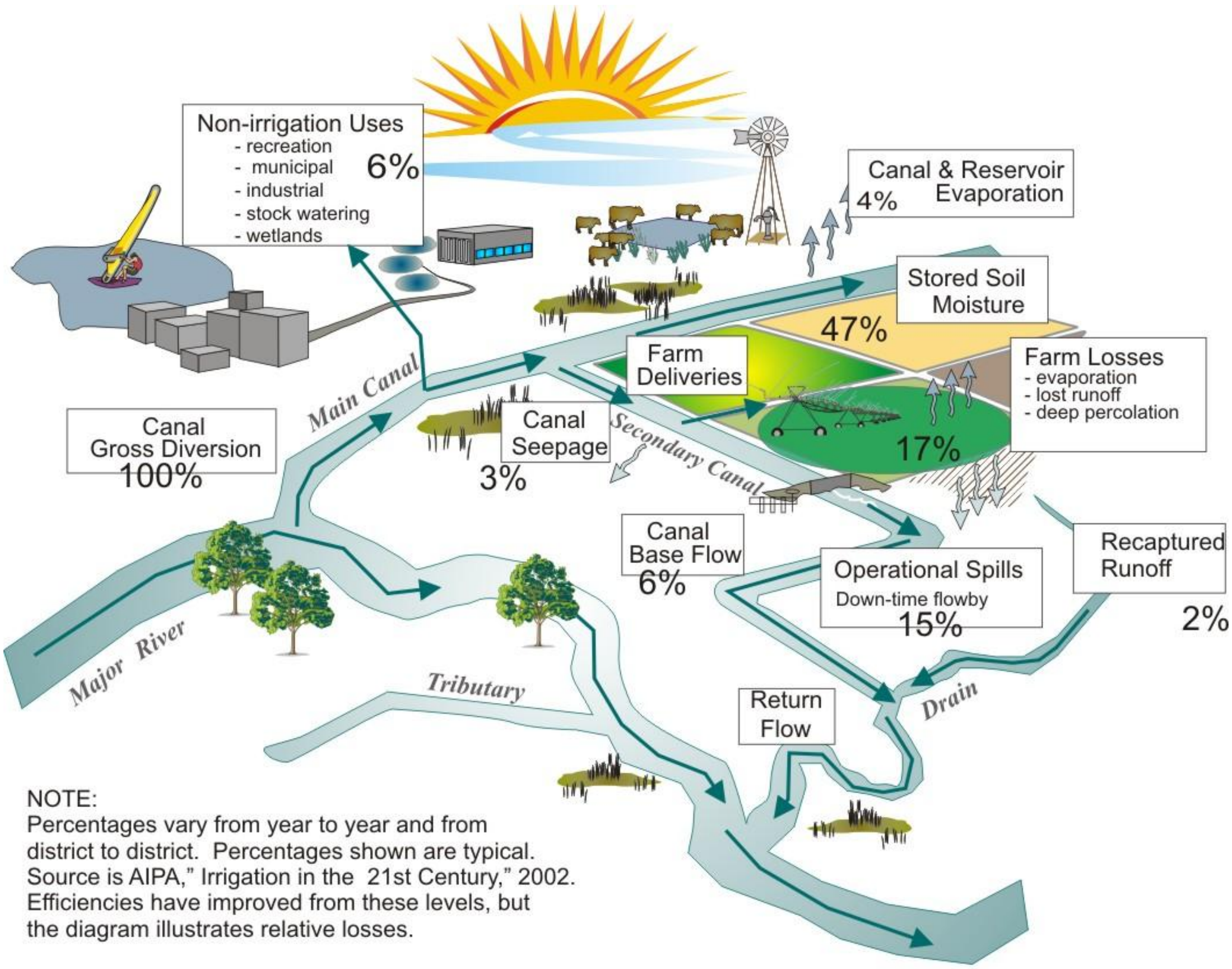


Figure 3: Components of the irrigation district gross diversion demand.

i) Water storage and delivery systems to farms, plus associated return flow channels

Water for irrigation is usually diverted from a river, with diversion rates being greatest during peak flow periods in the spring, smallest during low flow periods in summer months, and non-existent during periods of freezing weather. Diversions are regulated by Alberta Environment and water licence specifications. Only the Eastern Irrigation District and the United Irrigation District own diversion structures. In supplying the water needs of the majority of districts, diverted water is stored in reservoirs for use in times when the flow in the river is low and that flow is needed to maintain the aquatic environment. Districts own and operate a total of 78 reservoirs, ranging in capacity from 125 dam^3 to 320,215 dam^3 (101 to 259,000 acre-feet). Henderson Lake is an example of a very small reservoir and Lake Newell is an example of a very large reservoir. Complementing this infrastructure, Alberta Environment owns and operates 11 reservoirs, namely Little Bow, McGregor Lake, Travers, Cavan Lake, Keho Lake, Oldman River, Payne Lake, Jensen, Milk River Ridge, St. Mary, and Waterton, ranging in capacity from 4,625 dam^3 to 490,180 dam^3 (3,746 to 397,000 acre-feet .)

Some 8,000 km of canals, laterals and pipelines link these reservoirs to farms and other water users. The diversion canals and reservoirs owned and operated by AENV are collectively called “the headworks.” The Irrigation Districts have no control over the headworks but work as a team with AENV staff to ensure that water is available for delivery to farms, rural domestic water users, cattle operations, industries, communities, and the environment. The district delivery system is composed of a network of canals, smaller delivery channels called laterals, and pipelines connected to and fed by, in many cases, a supply reservoir. Water flows through open channels and most pipelines by gravity. Some districts pressurize pipelines from a central pumping station on behalf of water users in an area.

Inefficiencies in irrigation are the result of water losses, i.e., any water which is diverted that does not get uniformly applied to land under an irrigation system. Water evaporating from a reservoir or from a canal or lateral surface reduces the district’s efficiency (in total about 4%). Seepage of water out the bottom of a canal or lateral also contributes to water losses and inefficiencies, as does water use by water-loving plants (phreatophytes) that grow along the canals. These losses, reservoir evaporation, canal seepage, and water use by plants along ditch banks are in the order of 7% when combined.

The greatest inefficiency in the water delivery system of most districts is bypass water. Bypass water is water that runs through the irrigation system and back into the river. Bypass water is the result of an open channel system that attempts to deliver water on-time and in an adequate amount to irrigators. It takes many days to fill up a long canal that is running to numerous farms, perhaps tens of kilometres away from a supply reservoir (SMRID’s main canal is 312 km long). Once the channel is charged with water in the spring, a stream of water is kept running in the canal so that water delivery can happen within 24 hours of a water order. The flow of water running in the canal is closely controlled and the amount of water over-and-above water users’ needs is usually a small percentage.

Water in the canal must also be in excess of pump demand – if water in the supply canal cannot supply the withdrawal rate of all the pumps operating along the canal, then one or more of the pumps will be without water. In the case of pumps with a suction line, the prime of the pump is always lost, i.e., the pump will no longer pump water until someone comes and re-primes the pump. If a pump were to lose its prime, all the water that would have been applied to that field now runs down the canal and is discharged back to the river. To avoid the problems of pump shutdowns, a small percentage of extra water is carried through the system to ensure the flow is adequate and so shut downs do not happen; this extra water is part of the bypass water attributed as an inefficiency in district operation.

Bypass water can also be generated when it rains sufficiently that farmers quit irrigating. Farmers will shut down their equipment when rainfall fills the soil profile of the irrigated land and no more irrigation is required for a period of time. The irrigator will cancel his water order, giving a 24-hour notice, and adjustments will be made to reduce the flow into the canal accordingly. However, some of the water is already flowing down a canal or lateral on its way to the farm and will pass the pumpsite and be discharged into the river. A few farmers might shut down without cancelling their water order and all their water is discharged back into the river. Collectively, all sources of bypass water equal about 21% of flows.

Another source of return flow is runoff, primarily from flood-irrigated fields. When water is applied by flood methods, it moves downslope over a cropped field, wetting the soil as it flows on the soil surface. Some of the applied water will soak in the ground to supply the crop and some will run off the lower end of the field. That runoff water may enter a drainage ditch and return to the river as a portion of the return flow. Most return flow channels are natural drainage channels and are subject to collecting natural runoff from surrounding lands. This runoff is sometimes erroneously termed irrigation return flow and cannot be proportioned out of the flows because of the difficulty in measuring non-point sources. Thus we see that a number of sources of return flow water occur in an open ditch system and these are the largest inefficiencies in most districts.

Some return flow is desirable, inasmuch as many wetlands have been developed by the districts in collaboration with Ducks Unlimited on these return flow channels. Return flows are viewed by some people as being vital for downstream users as well. However, it is important to realize that when less water is spilled, even less water needs to be diverted in the first place and water that is not diverted remains in the river longer to enhance the riverine aquatic ecosystem.

ii) On farm water application systems

Inefficiencies also occur when water is not uniformly applied over fields. For example, a side roll wheel move system is stationary and applies water over a space of about 60 feet (18.3 m) along the length of the system, using high impact nozzles installed every 40 feet (12.2 m) along the wheel move's central line. After a set time that matches the sprinkler output to the soil's water holding capacity, the wheel line is moved forward another 18.3 m (60 feet) and the system then runs again for a set time. This process continues until the field is irrigated. If the nozzle size and set time are not matched to the water holding capacity of the root zone, over irrigation can occur. Most farmers use the right combination of set time and nozzle size for the water holding capacity of their fields, but some inefficiencies do occur because of mismatching equipment to soil and crop needs. Sprinkler pattern overlaps built into the wheel move system of irrigation and the effects of wind on the pattern causes some spots in the field to receive more or less water than others. That is an inefficiency as well. Wind can carry away and evaporate fine droplets produced as the stream coming out the nozzle breaks up so it can spread over the ground. These combined inefficiencies are in the order of 25 to 30% of the water delivered to the farm.

Flood irrigation, which constitutes 14% of the irrigated area, does tend to over-irrigate the top ends of fields and under-irrigate the lower ends of fields. Excess water in flood systems also runs off into return flow channels and this runoff water is often in the order of 35 to 50% of applied water. In contrast, runoff is miniscule from pivot irrigated fields and unusual from a wheel-move irrigated field unless caused by a rainfall event.

High pressure pivots, like wheel moves, produce a spray that is a combination of droplet sizes from very fine to coarse, as the stream from each nozzle is shot into the air. Fine droplets are subject to wind drift and evaporation, and thus high pressure pivots are about 5% to 6% less efficient than low-pressure drop tube pivots.

Many people have the impression that farmers over-irrigate, which was true in the days when flood irrigation was the predominant method. However, a recent study[13] of the water actually applied by centre pivot systems showed that farmers tend to under-irrigate when using these systems. Results of the study show that, on average, farmers using centre pivots applied 90% of the optimum crop water needs.

Results varied with crop types, specialty crops being irrigated more closely to optimum levels. A few reasons for less than optimum irrigation are given in the "Productivity" section, item 4. Irrigation scheduling under pivots to maximize or optimize production is unlikely to reduce water use, and may, in fact, increase it. Technology to schedule irrigation is advancing and includes moisture sensors that can be installed in the soil and can turn a pivot system on or off according to the soil moisture level. Wireless technologies also allow a farmer to control pivot operations from a home base or using a cell phone.

[13] Jennifer Nitschelm, AARD Irrigation Workshop, 2010, Lethbridge, Alberta.

In some parts of the world more efficient irrigation is made possible through drip systems. These systems are up to 15 per cent higher in efficiency than pivots. Drip irrigation is used in Alberta on about 4,000 acres of crop, primarily Saskatoon orchards, other small fruits, and nursery stock, where lines can be laid on the surface and remain in-place for the life of the crop. A small amount of market garden is also drip irrigated. The high density of drip lines needed for field crops and the need to bury the lines or take them up annually, and hence the extremely high cost of this type of system, makes drip irrigation impractical for more than 99% of Alberta's irrigated agriculture. As Alberta increases specialty crops suited to drip irrigation, drip irrigation will increase, but it is anticipated that the proportion will always be small. Even in California, only 15% of the irrigated land is drip irrigated. Worldwide, 85% of irrigated land is flood irrigated. The International Commission on Irrigation and Drainage recognizes that Canada has a very efficient irrigation system by world standards, ranking Canada #2 in water saving technologies in countries with an equal or larger irrigated area than ours[14]. Alberta accounts for over 75% of Canada's irrigated area, the districts being more than 62% of the Canadian total.

So, water losses in the irrigation system include

1) Evaporation from water surfaces,
2) Seepage,
3) Water use by phreatophytes,
4) Field runoff,
5) Bypass water, and
6) Application inefficiencies.

How can the sector reduce those loses?

i) Putting Canals and Laterals Into Pipelines

To reduce these water losses, Irrigation Districts put open water channels into pipelines. Pipelines do not seep nor do they lose water from evaporation nor from consumptive use by water-loving plants, and a pipeline can be a closed system with little to no bypass water lost (little to no return flow). This pipeline rehabilitation of the delivery system conserves water and increases the efficiency of the district. A portion of the rehabilitation of the irrigation distribution system is funded by the Government of Alberta on a cost-share basis, with the Government paying 75% of the cost and the districts paying 25%. This program is called "The Irrigation Rehabilitation Program" and is administered under the Department of Agriculture and Rural Development by Irrigation Council. Putting large canals into pipelines is impractical at the current time because of the large size and hence very high cost of the pipes that would have to be used. To increase efficiency of large canals, sections of canals that seep are lined with impermeable material that prevents seepage out the bottom and sides of a canal. This reduces water loss and damage to

[14] M. Gopalakrishnan, Sprinkler and micro-irrigated areas in some member countries of ICID. Irrig and Drain. 57:603-604. 2008.

nearby lands, increasing both efficiency and productivity. Reducing seepage can reduce habitat if mitigative steps are not taken.

ii) Automating Water Controls and Deliveries, Use of Balancing Ponds

The rehabilitation program also funded installation of automatic water control structures and measurement devices for a two-year period. Since 2005, over $2 million have been invested in engineering solutions to enhance automated water controls and flow accounting. The collaborative Irrigation Rehabilitation Program of the Government of Alberta and the irrigation districts has been a major contributor to efficiency gains. It takes time and resources. Year to year gains may not be large (usually less than 1%) but add up over a period of time.

Return flows make up the largest portion of "controllable" losses in the irrigation system. Return flow volumes can be reduced by coordinating the flow of water into supply canals with water required at the farm gate. In particular, to reduce bypass water, farmers need to notify ditchriders, district staff who control the flow of water to farms, well in advance of the time the farmer will be shutting down their system. The ditchrider can then notify those diverting water into a canal system that the needed flow will be less than that currently being delivered. In cases where flow control is automated, the ditchrider can control flows from a portable computer in his/her pickup truck. Districts are making progress developing this rapid response capability. The earlier that a notification of shutoff is given, the less water will still be moving down the ditch toward the farm when a farm pump shut off is made. Rapid response is accomplished more readily if water control gates are automated and if balancing ponds between the supply and the user can store some or all of the water that is already headed down the canal to a water user. These technologies accommodate a shorter notice for shutoffs such as the case precipitated by a sudden thunderstorm downpour on a field being irrigated. When the soil reservoir is not full of water, a farmer may continue to irrigate during a rain storm to fill the water holding capacity of the rootzone. This is efficient use of time and water, and reduces the amount of bypass water lost.

iii) Installing Low-Pressure Drop-tube Centre Pivots on-Farm

Water use efficiency on the farm can be determined in many different ways, but the measure that is used most widely is called "application efficiency." Basically this efficiency is the proportion of water that is delivered to the farm which is uniformly applied to the land and absorbed by the soil. The current best management practice for irrigating the various crops grown on irrigated farms in Alberta is the use of low-pressure drop-tube centre pivots. These pivots have an application efficiency of over 80%. Their high efficiencies result from the following:

- Drop tubes bring the water closer to the crop surface before the water is spread by a nozzle. The nozzle breaks the water into droplets and spreads it out over the land. When the water coming from the pivot is applied closer to the ground, less water evaporates because the water is exposed less to the evaporative forces of wind and hot, dry air.

- The droplet size from a low pressure nozzle is large relative to a droplet from a high pressure nozzle and, as a result, less of the water applied by a low pressure system drifts in the air and evaporates. As well, the surface area to volume ratio of larger droplets is smaller, meaning less evaporation occurs from the larger droplets as they fall.
- A centre pivot moves in a circle around a central point and because it is moving, the application pattern on any given day, including a windy day, is more uniform. Systems that are stationary, while applying water, tend to over-apply water in some areas and under-apply water in others, i.e., they are inefficient. Because a pivot moves almost continuously, it has a higher application efficiency than stationary equipment.

In summary, there are three key practical engineering ways to increase water efficiency in the irrigation industry

1) Rehabilitate canals and laterals by lining large canals to prevent seepage, and by putting smaller canals and laterals into pipelines to reduce seepage and evaporation, reduce water use by phreatophytes, and reduce bypass water;
2) Increase automation in water flow control and measurement in delivery and return flow systems, accompanied by construction and use of balancing ponds, and
3) Switch to high efficiency low-pressure drop tube centre pivots from lower efficiency irrigation systems, namely flood, side roll wheel move, and high pressure pivots.

The main conservation efforts to achieve CEP goals in irrigation districts will then be based on these engineering opportunities for saving water, by increasing efficiencies in the delivery of water to farms and increasing efficiencies of on-farm water applications. Simple and yet accurate surrogate measures of efficiency gains in the irrigation districts include the length of canals lined, the length of open ditches put into pipelines, the number of automated water control structures, and the number of low-pressure drop tube centre pivots that have replaced less-efficient sprinkler or flood irrigation systems. Private irrigators rarely have reservoirs or canals or laterals, and thus the key measure for increased efficiency of private irrigators will be the conversion of less efficient on-farm systems to low pressure drop tube pivots. Because the efficiency of these various types of irrigation systems is well documented, the percent increase in on-farm efficiencies resulting from adoption of efficient pivots can be determined quite accurately based on the number of systems installed and the type of system they replaced.

In addition to measurement of on-farm application efficiency, efficiency can be measured on a district basis. Overall district efficiency requires a knowledge of how much water is delivered to the district and how much water a district returns to rivers. These measures provide what is called a "mass balance" on a district scale and refinement of those measurements within the district can identify areas of inefficiency. A mass balance is simply the amount of water coming into the district versus the amount going out of the district, usually as return flow, which provides an efficiency ratio. In addition, measurement of the amount of water diverted from rivers for irrigation purposes is used to determine how productive irrigation is with that water per unit of irrigated land.

With that as background, the following irrigation sector targets for Conservation, Efficiency and Productivity are given.

Irrigation Sector's Targets to Enhance CEP

Target 1. The irrigation sector will achieve a 30% increase in combined Conservation, Efficiency and Productivity from 2005 through 2015.

In keeping with the Water for Life goal of increasing efficiency and productivity 30%, approximately 15% of the irrigation sector gains will be from increased efficiency and 15% from increased productivity (see Targets 7 and 8 for more detail).

Target 2. By the year 2015, 70% of irrigated lands in districts will be under best management practices, namely low pressure drop-tube centre pivots, an increase from the 47% documented in 2005.

The long term target is to have 80% of all irrigated land under best management practices, as high pressure pivots, wheel moves and flood irrigation are phased out and replaced with the more-efficient low-pressure pivots.

Target 3. On a ten-year rolling average, the irrigation districts will keep diversions at or below the year 2005 reference benchmark of 2.186 billion m^3 per year.

It is important to note in the Figure 4 following that the variability of diversions range from the licensed volume to less than half the licensed volume as a result of annual weather variations. As the irrigation sector becomes more efficient, the average diversion declines, as reflected in the trend-line, but in any given year, the diversion could be higher or lower.

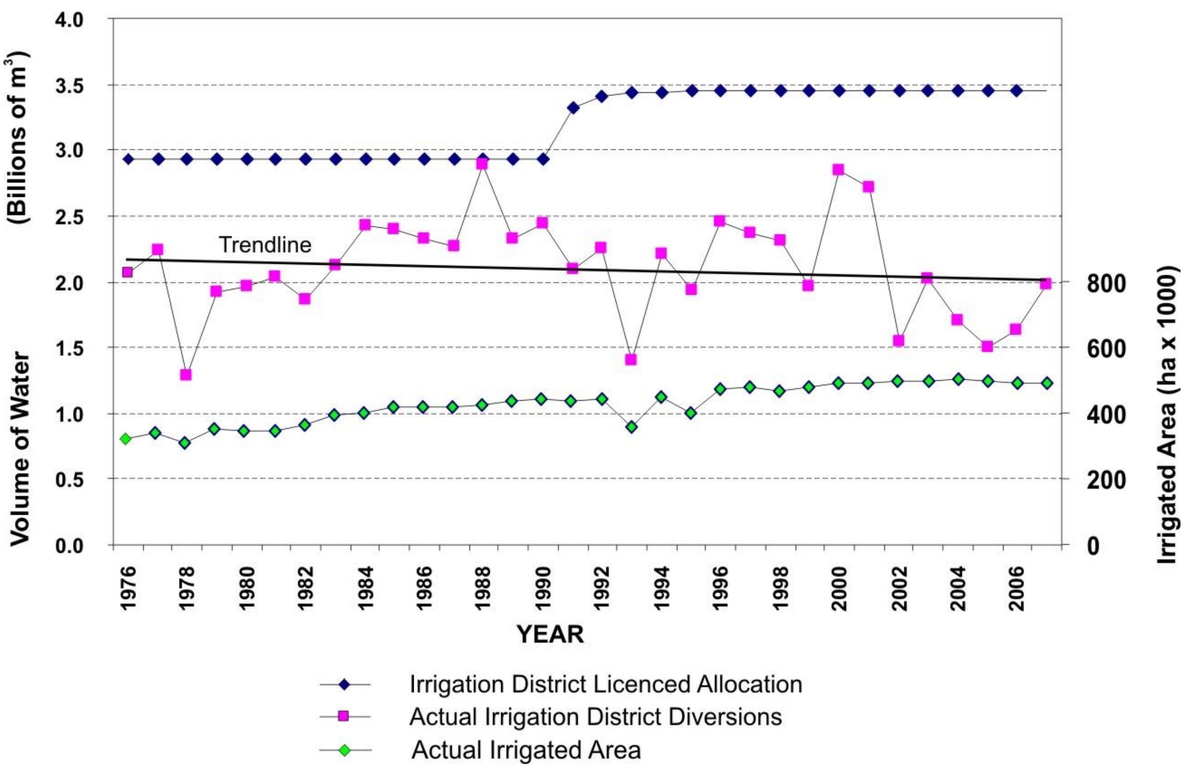


Figure 4: Development of Irrigation District area growth and licence allocations relative to actual diversions. (Source: AARD Annual Irrigation Information and AENV State of the Environment)

Target 4. Within regulations and utilizing water conserved through efficiency gains anticipated through these CEP efforts in the irrigation system, the irrigation sector will make additional water available for other uses such as food processing, environmental objectives, rural water networks, agribusiness, and other water sharing.

The Alberta Water Act permits transfers of water licences in whole or in part as a means of distributing water to various needs in society. Some districts can share water through an amendment to their licence while other water sharing has happened by transfers or assignments. Working within the legal framework, irrigation districts will share saved water in a free market system in keeping with government policies and legislation. All must work together to develop a system that is fair and that meets the needs of Albertans.

Target 5. Growth in irrigation districts will occur using saved water.

Before an irrigation district can increase in size by adding acres to its assessment role, or a portion of a water licence is transferred to some other societal good, a plebiscite must be held and a majority of district farmers must vote in favour of that action. Farmers will not vote in favour of any expansion or reallocation of water if they think that their own water supply and hence their crop production will be jeopardized: they want the same amount of water each year so they can plan which crops to grow and they are relatively assured of having the water required to grow those crops successfully. Each district sets the amount of water it will deliver to farms within its licence and its ability to supply that water with some surety. Many districts set a cap on the water they will deliver per unit of land within their district. Farmers do not want to see this number lowered through a water transfer or irrigation district expansion. Thus, the only way that growth of an irrigation district will occur or water will be reallocated via water transfers to other societal needs from district allotments, is if water is saved and the district members vote that some of that saved water can be used to service that growth or those needs.

Target 6. On a ten-year rolling average through 2015, irrigation districts will reduce the volume of water diverted from Alberta's rivers, lakes and streams per unit of irrigated area to a level below the 2005 benchmark of 441 mm.

Reducing the water diverted per unit of land indicates an increase in productivity per unit of water and indicates progress toward greater efficiency. As district and on-farm efficiencies increase, less water needs to be diverted to irrigate a parcel of land to produce an economic yield. The trend in lower diversions per unit of irrigated land is clearly visible in the figure below, despite peaks that occur in dry years when most of the licensed volume was needed to meet crop demands.

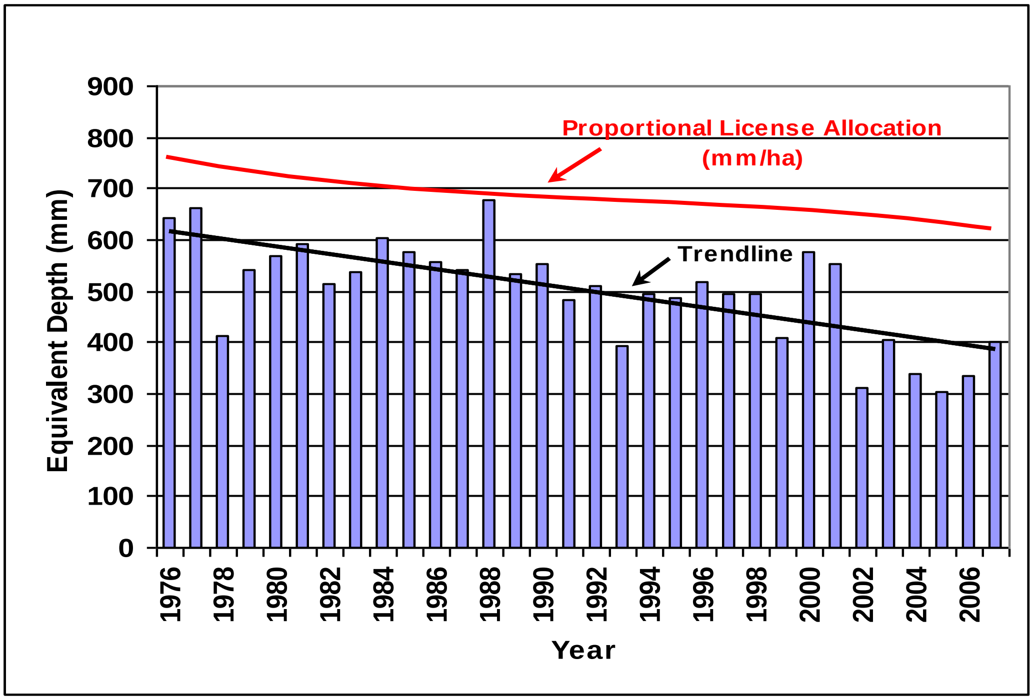


Figure 5: Trend line shows decreasing Irrigation district water diversions expressed as an equivalent depth of water diverted per actual unit area irrigated. (Data Source: AARD Annual Irrigation Information - 2007)

As the irrigation area has increased through time, the allocated water per-unit area of irrigation declined significantly during the past 30 years, as reflected in the overall downward allocation curve. Actual diversions per unit of land have declined at a steeper rate, as shown in the trend line, indicating increased efficiency per acre. With the exception of very dry years, diversions have also tended to decline despite an increase in irrigated acreage. Lower diversions leave more water in rivers to help sustain the aquatic ecosystem and buffer effects of climate change.

Though a steep decline is shown in the figure above, the rate of decline will taper off in the 2005 to 2015 period and will bottom out at some point as efficiency of the irrigation system reaches a maximum based on technology of the day. For example, as pipelines replace leaky canals and laterals, and as low pressure pivots replace less efficient on-farm water application systems, the percentage of leaky canals and inefficient systems to fix decreases and the opportunity for further improvements decrease as well. Those situations with the greatest efficiency gains are usually the first ones to be “fixed,’’ so future gains must be made from a smaller percentage of “fixable” situations and the more costly situations will be the last ones remaining to be “fixed.”

Target 7. The irrigation sector will achieve a 15% increase in efficiency, relative to 2005 levels, by the end of 2015 as follows:

Table 1: Projected Efficiency Gains

Irrigation Component	Net Gross Irrigation Demand
On-Farm Use	4.4 %
Conveyance/Distribution	1.2%
Return Flow	9.4 %
Total	15.0 %

i) On-Farm Use Gains

The increasing use of higher-efficiency low pressure drop-tube centre pivots has led the way to recent on-farm efficiency gains. The number of low pressure centre pivot systems will increase and projections are that the proportion of irrigated land covered by these drop-tube pivots will go from approximately 47 percent of the area in 2005 to more than 70 percent of the irrigated area by 2015. The irrigation district community, in striving for higher water use efficiencies, looks to a long range goal of at least 80 percent of the irrigation land base being irrigated through higher efficiency centre-pivot sprinkler irrigation. Some areas will be irrigated by other means as not all parcels of land can accommodate a pivot and not all operators will choose to invest in pivot technology because of the expense. (For a chart on the historic shift in irrigation systems, see Page 29, AECOM Canada Ltd.[15]). Much of the conversion to a more efficient system has already happened, but more will occur as producers strive to save water, get higher yields, improve crop quality, and reduce costs by adopting efficient low-pressure drop tube pivots.

Table 2 projects a scenario based on data trends in 2005 and 2007. This projected shift in on-farm irrigation application technologies would generate a 4.4 percent gain in overall on-farm water-use efficiency from 72.0 percent to 76.4 percent.

[15] *Irrigation Sector – Conservation, Efficiency, and Productivity Planning Report,* Alberta Irrigation Sector CEP Plan Steering Committee. 2009.

Table 2. A limited sample illustrating the efficiency improvements that accompany shifts in the proportion of on-farm system-types within the 13 irrigation districts

Type of System	2005		2007		Future	
	Hectares	Proportion	Hectares	Proportion	Hectares	Proportion
Centre Pivot	336,357	63.90%	349,956	67.15%	433,726	81.2%
Wheel-Move et al	115,428	21.93%	100,226	19.23%	67,851	12.7%
Gravity	74,592	14.17%	70,954	13.62%	32,509	6.1%
TOTALS	526,377	100.00%	521,136	100.00%	534,086	100.0%
Overall Efficiency	**72.0%**		**73.3%**		**76.4%**	

ii) Conveyance/Distribution Gains

Of the 7,631 kilometres of current conveyance works, 38.5% are in pipelines (see Table 3). It is estimated that approximately 70 percent of the open channel conveyance works still needing rehabilitation could be replaced with pipelines, which would eliminate associated seepage and evaporation losses, and potentially curtail some return flow losses.

Table 3 summarizes, by construction-type, the extent of irrigation district works that have been rehabilitated and the extent of those works that remain to be rehabilitated.

Table 3. Summary of progress in irrigation district conveyance works rehabilitation. (Data Source: AARD - Alberta Irrigation Information – 2007)

Conveyance Works Type	Length of Works (km)	Proportion of Total Length of Works
Earthen Canals	1,416	18.56%
Membrane-Lined Canals	736	9.64%
Concrete-Lined Canals	144	1.89%
Sub-Total	**2,296**	**30.09%**
Open Pipelines	176	2.31%
Closed Pipelines	2,759	36.16%
Sub-Total	**2,935**	**38.46%**
Un-Rehabilitated Canals	2,400	31.45%
TOTAL Conveyance	**7,631**	**100.00%**

Using pipelines to rehabilitate 70% of the remaining 2,400 km of un-rehabilitated canals, and lining any of the other un-rehabilitated large canals, will net a savings of approximately one percent of the gross diversion demand by reductions in seepage and evaporation losses. Control of return flow losses is another benefit of canal and lateral rehabilitation.

iii) Return Flow Efficiency Gains and Water Quality

As noted earlier, the greatest opportunity to increase efficiency in the irrigation sector is to reduce return flows. This is accomplished by increased automation in flow control structures, enhanced ordering and shutoff mechanisms, in-district balancing ponds and reservoirs, and the installation of pipelines that can work as closed systems. The largest irrigation district which constitutes about 28% of the irrigated area has already surpassed the reduced return flow goal of 43 mm per unit area of land as per the appended AECOM report, meaning that all the other districts will need to reduce their losses even more to achieve the overall goal. This will be very challenging, particularly for districts with long canal systems per unit of land irrigated or that have a large quantity of flood irrigation.

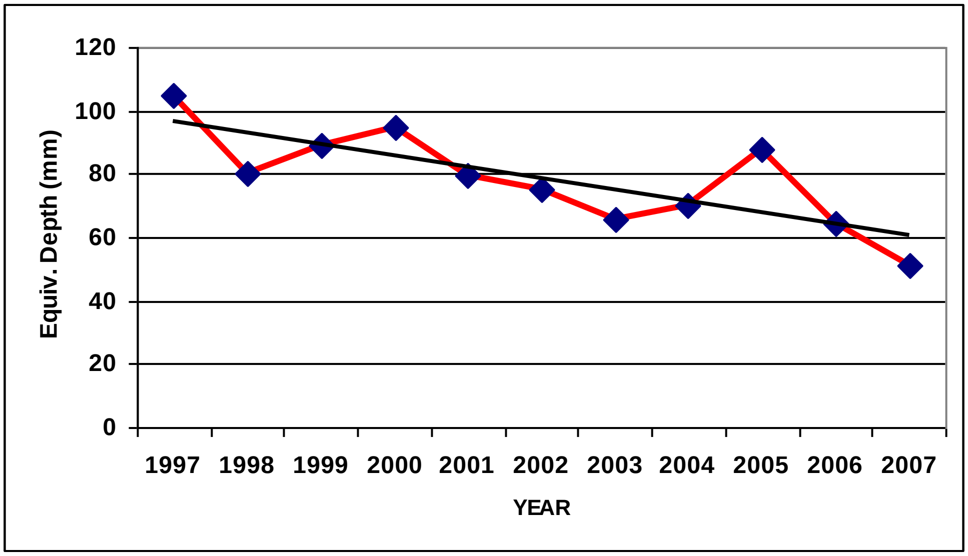


Figure 6: Irrigation district return flow expressed as an equivalent depth per-unit area actually irrigated. (Data Source: AARD)

Records indicate that, as a percentage of the total diversion amount, return flow has remained more or less constant at about 19 to 20 percent. This means that the volume of return flow has decreased in pace with the reduction in water diverted and vice versa. Return flow savings lower diversions from rivers and increase overall efficiency. Savings by 2015 are projected to be 9.4 percent (53.3% to 62.7%).

In a study of water quality in 2006 and 2007[16], total phosphorus and total nitrogen guidelines for the protection of aquatic life were met in 78% and 93% of samples taken from the return flow of 11 districts. The average total P level was 0.035 mg/L over the 0.05 mg/L guideline in samples. The nitrite-nitrogen and ammonia-nitrogen guidelines for the protection of aquatic life were met more than 99% of the time and the

[16] Assessment of Water Quality in Alberta's Irrigation Districts Summary. Irrigation and Farm Water Division, Alberta Agriculture and Rural Development. 2010. Lethbridge, Alberta.

nitrate-nitrogen guideline level was always met. Herbicide level guidelines for livestock watering and aquatic life were met at least 99% of the time, but Dicamba and MCPA guidelines for irrigation were frequently exceeded. E. coli levels in return flows often exceeded guidelines for irrigation but no guideline is given in Alberta for levels required for protection of the aquatic environment.

More crucial to a river system than concentrations is “total daily loads,” i.e., the amount of a constituent discharged in a day. This is the product of the flow of a contributing water body, such as a return flow channel, and the concentration of the contaminant. A river can buffer some “concentrations” easily if the flow volume discharged is low, i.e., if the total daily load is minimal. Reducing return flow volumes will reduce total daily loads of all water quality contaminants. On-farm buffers for cultivation and spraying near return flow channels are important in maintaining water quality, as is the reduction of livestock and wildlife traffic adjacent to and within return flow channels. WPACs are working to encourage such practices and irrigation representatives are taking an active role on those advisory committees. Some districts have fenced off portions of return flow channels to reduce the impact of livestock on those channels and associated water quality. More education at irrigation conferences would be appropriate and will be considered.

Target 8. The irrigation sector will increase its productivity by 15% from the reference yield of 2005 (as per chart below), based on the indicator crops of sugar beets, potatoes, and soft white wheat.

iv) Productivity

The assessment of increases in productivity under irrigation will be based on the yields of sugar beets, potatoes and soft white wheat per unit of water diverted to grow these crops. The 2005 base is 8.8 kilograms per cubic metre and a productivity increase to just over 10 kilograms per cubic metre is required to meet this productivity goal. Irrigation farmers, not irrigation districts, control productivity, but a “community” of partnerships is striving to enhance on-farm productivity. This community includes irrigation farmers, crop breeders, agronomists, food processors who contract raw product, and government extension services.

AARD has developed a productivity index that tracks the recorded annual yields of three major crops common to irrigated lands in southern Alberta. These are sugar beets, potatoes and soft white spring wheat. Because a long-term data set is available for the yield of these three irrigated crops, they can be used as an indicator of irrigation productivity increases. By integrating the annual volume of water diverted for use by each crop with its respective yield for a given year, a weighted-average output for the three crops per unit of water input is developed. This indicator has been derived as a productivity index for each year through the past 28 years as depicted in Figure 4. The increase in water use productivity at a rate of approximately 0.2 kilograms per cubic metre of water used each year is shown. This increase is the result of more efficient use of applied water and overall improvements in crop production practices. Climate variability, such as that shown in the unusual years surrounding 2001, causes the majority of the variability.

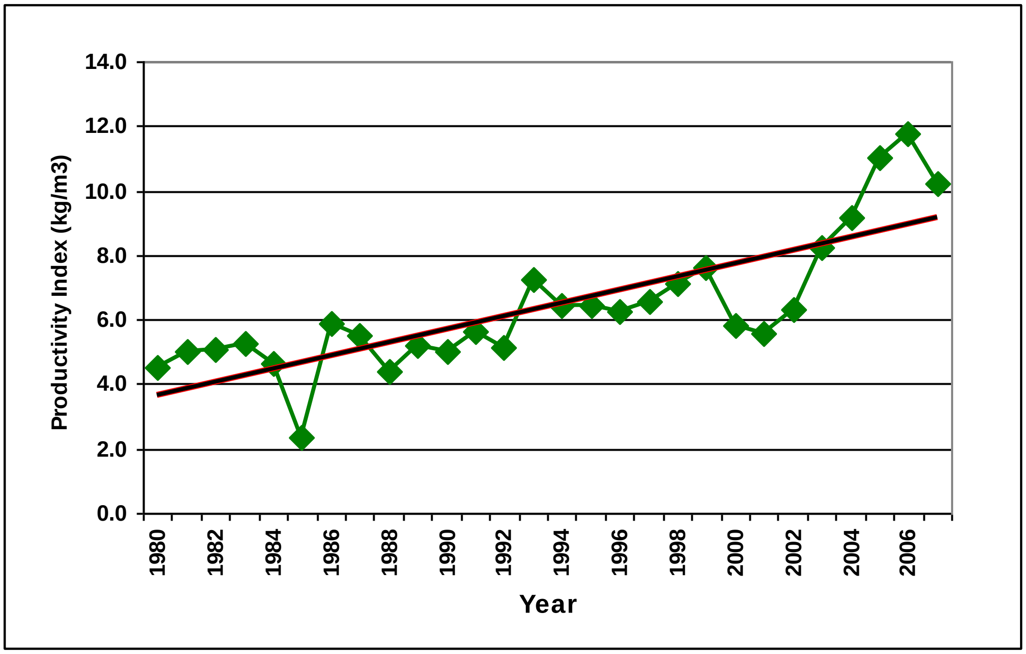


Figure 7: Quantifying irrigation water productivity through increased crop production for the combined production (kg) of sugar beets, potatoes and soft white spring wheat per m^3 of water. (Data Source – AARD)

A continuation of this productivity climb is expected as governments and industry continue to fund and drive progress that keeps food production in pace with the growing world population. Irrigation productivity gains are important as Alberta continues to supply food to a share of the growing world population.

Implementation: Steps to Move CEP Forward

AIPA will champion the CEP efforts of this CEP Plan overall, and District Boards and their Managers will champion CEP efforts within the individual districts.

In addition to the aforementioned CEP targets, the irrigation sector will act on a number of implementation commitments that will result in water being conserved, used more efficiently, and/or used more productively. AARD has already instituted one program to advance CEP on farms, as well.

1) Incorporate Attitude and Commitment into Action

   The Districts are fostering a CEP attitude, creating a CEP atmosphere and working on CEP commitments to generate actions that accomplish conservation and efficiency in their operations. CEP efforts are up and running in districts and are an important part of their business plan, as the following quotes from 2009 annual district reports demonstrate:

b) The first portion of the St. Mary River Irrigation District's new three-fold vision is: "Through the optimization and conservation of water resources, improve water delivery to users, while increasing operating efficiency."
c) Alan Harrold, General Manager of the Lethbridge Northern Irrigation District writes in the District's annual report: "The Board of Directors and staff have continued to emphasize the importance of water conservation. The majority of the District's construction program over the last number of years has focused on the replacement of open channel water delivery with buried pipelines, which eliminates losses due to evaporation and water seepage. With the completion of the Lateral F6/F7 pipeline this spring, combined with the conversion of the Piyami canal to a pipeline system for water delivery..., the District has conserved on average 5,700 acre feet ... It is the District's intention to continue our program of infrastructure rehabilitation by installing more buried pipeline to improve our water delivery system and efficiency, which will result in more water conservation. In addition, the District has continued to add automation to our main canal control gates. This has allowed our staff to make real-time adjustments as required to canal flows that has also conserved water..."
d) Richard Phillips, General Manager, Bow River Irrigation District, states in the District's annual report: "The steady conversions from other irrigation methods to pivots, and the conversion of open canals to pipelines, are very significant factors in our improved efficiency. Diligent efforts by operations staff, and by the irrigators to operate more efficiently in recent years, also make a great difference."

2) Irrigation districts will do what works to conserve water and make the districts more efficient, namely
   i) Put canals and laterals into pipelines
   ii) Line leaky portions of canals that are too large to be put into pipelines
   iii) Automate water controls and deliveries (which involves measurement of water as well)
   iv) Cap the amount of water individual irrigators can receive per unit of land, and
   v) Encourage and/or incent farmers to adopt water-saving technologies on-farm.

3) The AIPA will prepare a CEP strategy template for district use and encourage Irrigation districts to develop a tailored CEP strategy by their respective annual general meeting in 2011.

4) The AIPA will encourage and acknowledge CEP efforts of the districts.

AIPA will keep CEP on the agenda of all AIPA Board Meetings through 2015. This process has already started. For example, the Eastern Irrigation District, which has a fairly detailed CEP strategy already in place, presented their programs and successes at an AIPA Board meeting. Unique to this strategy is the enticement of growers within the EID to move toward more efficient systems through

b) cash grants to convert from lower efficiency irrigation systems to higher efficiency systems,
c) rights to expand growers' land base using a portion of the water saved by the growers,

d) the buy-back of "irrigated acres" rights on corners of fields under centre pivot irrigation and the sale of those irrigation rights to growers who can make their operation more efficient by adding those rights for a parcel of land so that a centre pivot can be used to irrigate it instead of flood or wheel lines.

This AIPA initiative, where EID shared their experience, encouraged other districts to learn about CEP options that work in an irrigation district and to consider what options they might be able to adopt.

5) AARD has initiated an on-farm Irrigation Efficiency Program.

Since this CEP planning process was instituted, Alberta Agriculture and Rural Development (AARD) initiated a program, the Alberta Irrigation Efficiency Program, to incent adoption of best management practices on irrigation farms, namely, the use of low pressure drop tube centre pivots to increase efficiencies on farms. This incentive program is accessible by private irrigators as well as those in irrigation districts. The program will provide some of the impetus to achieve the goal of having over 70% of all irrigated lands using best management practices in order to achieve CEP targets. The program can be viewed at http://www1.agric.gov.ab.ca/general/progserv.nsf/all/pgmsrv371

AARD will monitor the success of this program and estimate the amount of water saved while this program is in place. In the 2008/09 and 2009/10 program years, some $400,000 was allocated to producers to encourage their adoption of water-efficient technologies on-farm. The program is running this fiscal year as well.

6) Research and development will find new CEP opportunities

The AIPA and irrigation districts will continue to search for practical technologies that can advance CEP gains beyond those limited by current technology. Research and development may open new avenues to increase CEP. Such projects could include the introduction of new conveyance monitoring and control technologies; the adoption of higher-efficiency water application devices or systems; the application of water delivery measurement, control and accounting systems; the modeling of river systems, storage facilities, delivery and drainage systems and crop needs; the development of crop alternatives that may be more efficient in their consumptive use of water; the role of markets in water redistribution, etc.

7) Additional funding will be sought to increase CEP efforts

The irrigation district community will investigate collaborative opportunities through agencies and programs such as Alberta's Irrigation Council, the Agri-Environment Services Branch (formerly PFRA) of Agriculture and Agri-Food Canada, or Capital Planning Initiative (CPI) to acquire additional funding for the rehabilitation of irrigation infrastructure. This additional funding will be targeted to support projects which emphasize the re-development of works where efficiency and potential productivity gains can be optimized and demonstrated, such as putting earthen and failed concrete canals into pipelines.

8) Water measurement and reporting

Irrigation districts will expand and enhance the recording and reporting of their water operations data where it is insufficient.

9) River management to enhance the aquatic environment

The irrigation sector will collaborate with AENV, Alberta Sustainable Resource Development (ASRD) and other water resource management agencies in Alberta, to determine opportunities to optimize diversions to storage during periodic high river flows, thereby reducing the need for large diversions during natural low-flow periods. AIPA will participate in studies on timing of releases for establishment of riparian vegetation downstream of AB Environment reservoirs in wet years.

10) AIPA and AARD will target CEP education

AIPA, in collaboration with Alberta Agriculture and Rural Development, will prepare education opportunities in print, web, workshop, and conference formats to encourage the implementation of this plan. Target audiences will include irrigation districts, irrigators, other water users who access their water supplies through the irrigation system, and the general public.

11) Opportunities for private irrigation coordination/involvement

AIPA has very little influence on private irrigators, but Alberta Environment could encourage the development or formalization of a representative organization for private irrigators, perhaps sitting on local WPAC boards, so as to be able to address water uses on a broader scale, connect to other stakeholders and government agencies, and develop better water measurement and reporting.

12) Water reallocation to meet needs

Where water savings are achieved through efficiency gains, irrigation districts and private irrigators will consider reallocating water for societal benefit, such as, economic growth in other sectors, the enhancement of aquatic environment conditions or wildlife habitat, as well as expansion of irrigation districts.

13) Working to enhance water quality

AIPA will assist Alberta Agriculture and Rural Development and WPACs in their efforts to improve water quality entering river systems through the encouragement of best management practices along natural drainage systems. Providing information and encouragement to land owners will help reduce land-based contaminants entering drainage systems and sustain water quality in both irrigation deliveries and return flows. Many of the return flow channels are natural drainage channels and some districts have agreements with counties and communities to provide drainage conveyance to reduce flooding and road damage. Some districts place restrictions on drainage water entering their conveyance systems based on water quality parameters.

14) On-going dialogue of stakeholders

The irrigation sector will continue the dialogue with other stakeholders to develop mutually-acceptable and beneficial opportunities for increased water use conservation, efficiency and productivity.

Implementation Summary for Key CEP Opportunities

Table 4. Key CEP Opportunities and Implementation

CEP Opportunity	Potential Gains	Requirements to achieve	Implementation Date, Process, and Duration
Create Irrigation District Strategies	Irrigation Districts will prepare a CEP strategy to guide efforts toward helping achieve a 30% increase in conservation, efficiency and productivity collectively.	Each irrigation district will prepare a CEP strategy tailored to their district opportunity and capacity to increase CEP.	By the districts' annual meeting, 2011, 80% of irrigation districts will have a CEP strategy document in place, and accepted by their Board.
Put Canal System Into Pipelines	Of the canals in individual districts, 9 to 70% need rehabilitation. Irrigation districts will continue to enhance water savings in their system with assistance from the GoA IRP Program and with their own funding as open canals are put into pipelines.	Replacement of 2,000 more kilometres of canal with pipeline; IRP funding will need to continue; three-year running plans in place; additional funding to be sought to speed up process; districts with sufficient funds to augment work out of own funds.	Already underway; IRP program is main driver; annual investment of $8 million from districts, $24 million from GoA; districts with sufficient funds also rehabilitate works on their own initiative -- recent totals in excess of $23 million annually. Additional funds to be sought for earthen and failed concrete canals.
Increase Use of High Efficiency Pivots on-Farm	As of 2005, 47% of the irrigated area was under low pressure pivots; target to get to 80% of area under pivots by 2015, 70% of which are low-pressure drop tube type.	Programs to encourage switch to more efficient systems; districts encouraged to institute program helping farmers to switch to low pressure drop tube pivots; farmer education to continue.	AARD program implemented in 2008/09; continuing through 2010/11. EID program operational; Other district programs to be developed by 2012; AIPA and AARD Education continuous.
Increase Automation and Flow Measurement to Decrease Return Flows	Reductions in return flow 50% from 2005 levels.	Funding from government on a 100% basis would drive this further and faster. Districts identify projects where most benefit can occur.	$2 million invested in 2006/07 and 2007/08; further funding would increase water savings; districts will continue own funding; put projects on IRP plan and increase monitoring.
Increase Water Availability for Crops and Alternate Uses to Increase Productivity	Secure water availability to attract processors for value-added production and meet environmental and other societal needs.	Irrigation scheduling on farms to optimize water applications; policies in place that provide ready access to secure water supplies for societal needs.	2010 AARD Water application study completed documenting under-irrigation; farmer education continuous next three years; by 2011, market system upgraded to ensure access to water (AENV); by 2012 optimize diversion and release of water for multi-use (AENV and AIPA).

Summation

In order to meet expanding societal needs including anticipated environmental needs in the future, CEP progress will be necessary. The greater opportunities for CEP gains in the future have been previously described, but the two main keys to success are the replacement of canals and laterals with pipelines and the installation of low pressure drop tube centre pivots in place of less efficient on-farm irrigation systems. The districts have also made progress in automating the irrigation system, accompanied by flow measurement. These combined opportunities increase management's ability to improve control and delivery of water with more precision and less loss as return flow. Furthering the districts' capabilities in monitoring and automated flow control will continue to increase efficiencies. Increased storage and diversion capacity would allow for more water to be diverted in high spring flows and less water taken from river systems later in the season. New storage should be multi-purpose in use, and could include meeting domestic and aquatic ecosystem needs, along with needs for industry, irrigation and recreation.

As districts have become more efficient, their diversion rates have decreased. It is anticipated that the diversion rates averaged over time will continue to decrease slightly while growth is achieved through water accrued due to CEP gains. This leaves more water for social and environmental goals, as well as growth in the irrigated area, as the CEP targets of the irrigation sector are achieved.

ADDENDUM

Meeting the Criteria for Review

The “Criteria for Reviewing Sector Plans” states that “The plan must:

a) Support the outcomes of the Water for Life Strategy
b) Support one or more the following CEP desired outcomes:
    - Demand for water is reduced
    - Water use productivity is increased
    - Water use efficiency is improved
c) Maintaining the following:
    - Resources are conserved to maintain healthy aquatic ecosystems
    - Water quality is maintained or enhanced.

The following demonstrates how this plan meets those criteria:

A. This plan supports the three outcomes of the Water for Life Strategy.

- Irrigation districts are a vital supplier of good quality raw water for drinking in 50 communities in Alberta and thousands of rural homes, and CEP efforts will make more water available for urban and rural water use.
- Irrigation drives the agricultural economy in southern Alberta, producing 19% of all of Alberta’s agricultural product on less than 5% of the land base, and CEP efforts will result in more water being available to food processors and livestock operators, and for the production of high value crops.
- Irrigation is making progress on contributing to healthy aquatic ecosystems; creating 82,000 acres of wetlands with DUC, creating habitat for fish and wildlife, and, through CEP, reducing diversions from river systems. The irrigation sector will explore options to enhance rivers through water management (Implementation step #9), as WPACs and researchers identify opportunities. For example, recent research shows that the Belly and Waterton River poplars are in better condition than expected, and that poplar stands can be recruited if flow recession curves during flood periods match the needs of poplars. In other words, using water from a reservoir in wet years to establish poplars and other riparian growth by maintaining the needed recession curve is an important management option to enhance the health of riparian areas. Modelling will be able to predict situations where water can be shared to the benefit of the riverine ecosystem without loss to irrigation.

Collaborative effort will bring advances in ecosystem quality and this option will be explored. One example of enhancing the aquatic environment is the augmentation of the flow in the St. Mary River and the impact this has had on the fishery there. The instream flow of the St. Mary River was doubled downstream of the St. Mary Dam and a trout fishery has re-established along the lower reaches of the St. Mary River, indicating some significant improvement in the aquatic environment. As well, though not widely recognized, the EID and Alberta Environment worked out a significant change to EID's licence for the benefit of the aquatic environment: the licence used to permit withdrawals from the Bow River to the point that only 100 cfs was flowing in the river. This licence now ensures that at least 400 cfs is flowing in the Bow River downstream of the point of diversion, and the rate of flow rarely drops below 600 cfs. The augmented flow is a significant contribution to aquatic ecosystems and is made possible by diverting more water in high runoff periods and less water when stream flows are low. This is one goal of Implementation step #9.

- Reference is made in this document to the increase in river flow which would benefit aquatic ecosystems as a result of CEP efforts of the irrigation community, and those efforts are continuing. Some of those water savings may remain in the river in trust, if that eventuality becomes legal and utilized, and some may remain even after other societal needs are met.
- Some districts have entertained the concept of supplying a portion of district-saved water to environmental trusts through a market system for the augmentation of protected river flows. This is part of Target #4.

B. This plan thoroughly documents that the Irrigation Sector's CEP activities will
- Reduce the demand for water
- Increase productivity, and
- Increase efficiency.

C. Maintaining the following
- Resources are conserved for a healthy aquatic ecosystem (see section above on healthy aquatic ecosystem outcomes)
- Water quality being maintained or enhanced is also a goal of CEP efforts (see Target 7, the section on "Return Flow Gains.")

Monitoring and Reporting

Partnerships with Alberta Agriculture and Rural Development and with Alberta Environment in data collection and reporting are necessary to measure progress toward achievement of the Irrigation Sector's targets. Alberta Environment controls and measures the quantity of diversions to all but two districts. This data is key in assessing progress toward efficiency targets. Irrigation districts will monitor water deliveries received by districts, water deliveries to farms, return flows, crop acreages, shifts to more efficient systems, and societal impacts that affect CEP progress.

1) Irrigation districts will identify annually all parcels of land where farmers have invested in and adopted more efficient on-farm irrigation practices. Of most significance, the annual increase in the number of

low pressure, drop-tube pivots will be determined and the resulting increase in efficiency and attendant water savings will be calculated.

2) Irrigation Council will track, with the help of AARD, the length of pipelines installed, canals lined, automation equipment installed, etc., in the IRP program, and districts will track projects funded solely by the district.

3) Irrigation districts will prepare an annual water balance, where water entering and exiting the district are measured and on-farm water deliveries are measured or estimated for each irrigation farm. This makes possible calculations of efficiency gains throughout the districts. With diversion data from Alberta Environment, calculations of efficiencies based on diversion per unit of land will be calculated.

4) Each irrigation district will identify which crops are grown on which parcels of irrigated land and a cropping summary will be prepared for each district. Cropping statistics will be tabulated by AARD and used to identify trends in acreage of high value crops and estimates of productivity.

   Grower organizations, the Potato Growers of Alberta, The Alberta Sugar Beet Growers Association, and the Alberta Soft White Wheat Producers Commission, will supply data on the production of the three key indicator crops used in assessing productivity trends. AARD will continue to chart productivity to help visualize trends. The option of expanding the productivity index to include dry beans, another crop grown solely under irrigation, will be investigated. Dry beans have a significant acreage and are important in irrigated rotations in the same growing area as potatoes and sugar beets. Two other crops that may add strength to an index of irrigated productivity are barley silage and corn silage. Measurements of the yields of these two crops would be very challenging to acquire as there is no agency that collects this data on an annual basis.

5) As per the Alberta Water Council direction, AIPA will prepare CEP progress reports and present those to the Council in 2012 and 2014. AIPA will continue to monitor CEP progress on a 5-year cycle to evaluate progress made and outcomes achieved after 2015.

Appendix I

Alberta Water Council Statement re "CEP Targets are Voluntary not Mandatory"

Summary Report Meeting 26
ALBERTA WATER COUNCIL
MEETING #26
November 19, 2009
Calgary, Alberta

6 Sector Planning for CEP Project Team

Giselle Beaudry and John Skowronski presented an update on the CEP team's work, summarizing the lessons learned and asking the board to re-confirm the intended use of targets and performance measures as part of the CEP planning process. Two concerns emerged from the Alberta Irrigation Projects Association as it completed its sector plan: 1) the targets are challenging and may not be achieved, and 2) if the targets are not achieved, they may become mandatory or regulated requirements in future. These concerns could also challenge other sectors that are working on their CEP plans. The team did not explicitly state the purpose of targets in its report, but intended that:

Targets should be challenging, but achievable.

Sectors should strive, in good faith, to reach their targets.

There is no expectation that the 'stretch' targets chosen during the voluntary phase of CEP Planning would become mandatory targets. If CEP planning is found to be ineffective in 2012, a new (possibly regulated) process will be developed to identify new targets for each sector.

In its discussion of the intended purpose of targets, board members made the following comments:

ENGOs explained that they discussed the intent of the original team with their member on that team, who advised that the original team did not contemplate that targets in a voluntary plan would become mandatory. ENGOs support the three points regarding the purpose of targets. The issue is not to punish a sector for not meeting an aggressive target. An issue arises if no progress is made from where we are now.

A GoA representative noted that the intent is for the plans and targets to be voluntary and to start building stewardship in all sectors. Voluntary plans allow sectors to participate and have good targets. Continuous improvement is also a factor. Once plans are developed, we can start to monitor progress.

Appendix II

Irrigation Sector – Conservation, Efficiency, and Productivity Planning Report (AECOM Report under separate cover)