Irrigation Sector
2005 - 2015 Conservation, Efficiency, Productivity Report

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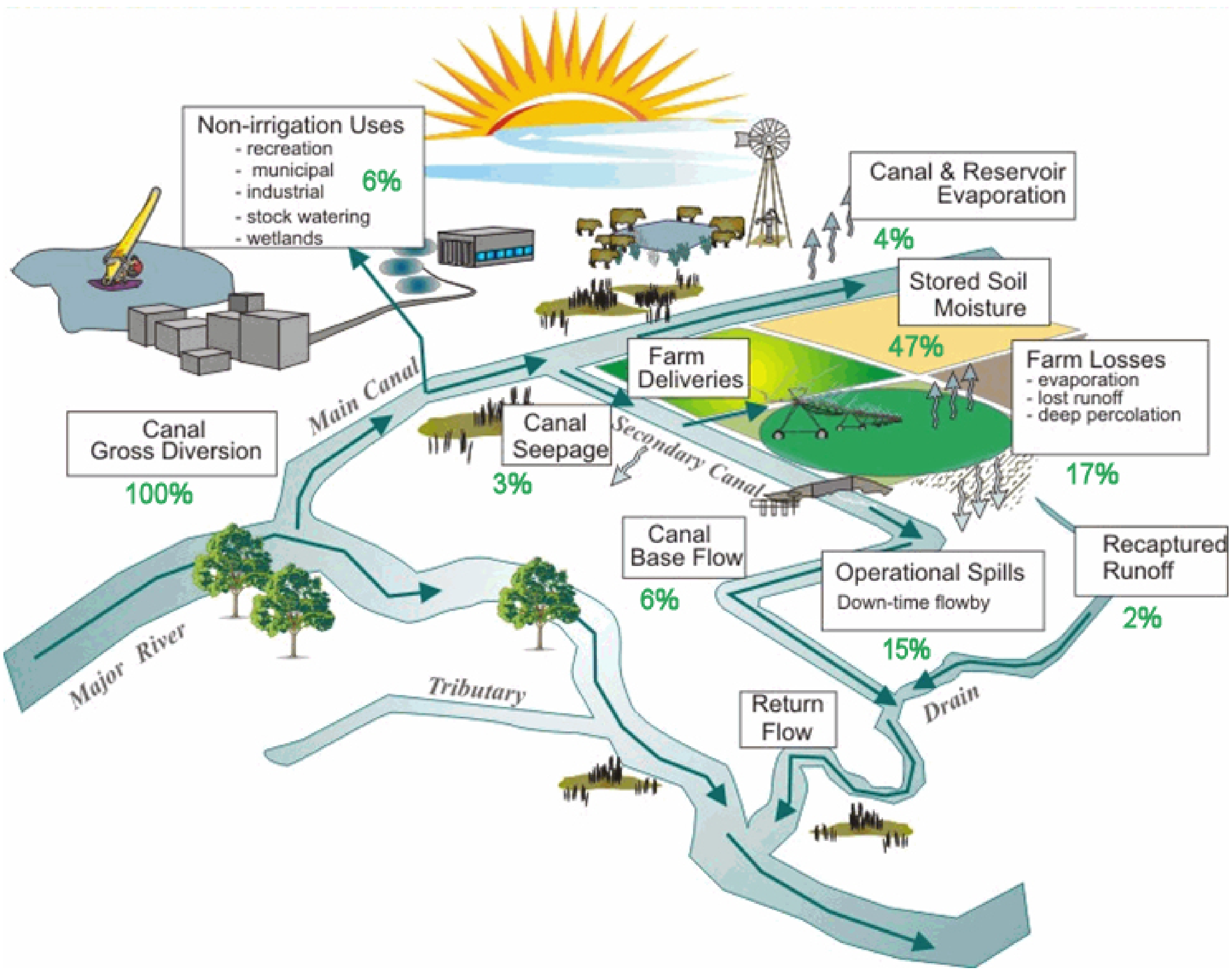
"The Water for Life Action Plan stresses the need to demonstrate best management practices in all sectors to 'ensure an improvement in overall efficiency and productivity of water use in Alberta by 30% by 2015, based on 2005 levels. Improvements will occur when water demand decreases or when efficiency and productivity increases'."[1]

In response to a request by the Alberta Water Council, AIPA prepared a Conservation, Efficiency, Productivity (CEP) Plan in 2010. Within that plan, AIPA members set eight targets to help guide and assess progress in CEP improvements enroute to achieving the 30% Water for Life goal. Over the years, AIPA district members have invested time, energy and many dollars to enhance the efficiency of the irrigation system and promote CEP activities among the farm producers who make up the districts. This report describes those efforts and whether the CEP targets were reached. The schematic in Figure 1 below from Irrigation in the 21st Century V.1: Summary Report[2] is presented to help the reader visualize where inefficiencies occur in an irrigation system.



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

The Alberta Irrigation Projects Association (AIPA) is pleased to report that the irrigation districts in Alberta, which comprise 82% of the irrigation land in the Province, have achieved the 30% increase in efficiency and productivity envisioned in the Water for Life Strategy for the years 2005 – 2015. Efficiency gains amounted to 26%, measured by the reduction in diversions on a 10-year running average basis. The productivity of the three indicator irrigated crops, potatoes, soft white wheat and sugar beets, increased 22% over that time period. Improvements in efficiency and productivity within the districts totaled 48%, exceeding the target by 18%. The details of how Target 1 was achieved will be illuminated as the other targets are discussed.

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.

Low-pressure drop-tube centre pivots have the highest efficiency of any equipment that can economically irrigate the crops grown in Alberta. They are the current best management practice for irrigation given the crop mix and extent of land under irrigation in the Province. Switching from less efficient systems to low pressure pivots is a key step irrigators can take to conserve water.

Alberta Agriculture and Forestry has listed design efficiencies of widespread on-farm irrigation systems used in Alberta as 84 per cent for low pressure pivots, 73 per cent for high pressure pivots, 69 per cent for wheel-moves, and 62 per cent for developed gravity (flood) irrigation systems. When farmers switch to more efficient equipment, less water is applied to the crop, which in turn means that less water is diverted from the river. For example, using the Alberta efficiency values, if a farmer can switch a gravity (flood) irrigated field to a pivot, 22 per cent less water will be required.

Much of the losses in gravity (flood) systems are due to poor uniformity of application, deep percolation at the top end of the field, and water running off the lower end of the field. Deep percolation and runoff are not an issue with low pressure pivots. Research has found that pivot irrigators in Alberta apply only 90 per cent of the water needed to maximize yields, i.e., they under-irrigate with the result that deep percolation from pivot-irrigated fields is negligible and runoff rare. Because a pivot essentially is moving all the time, it applies water much more uniformly than a flood or wheel move system.

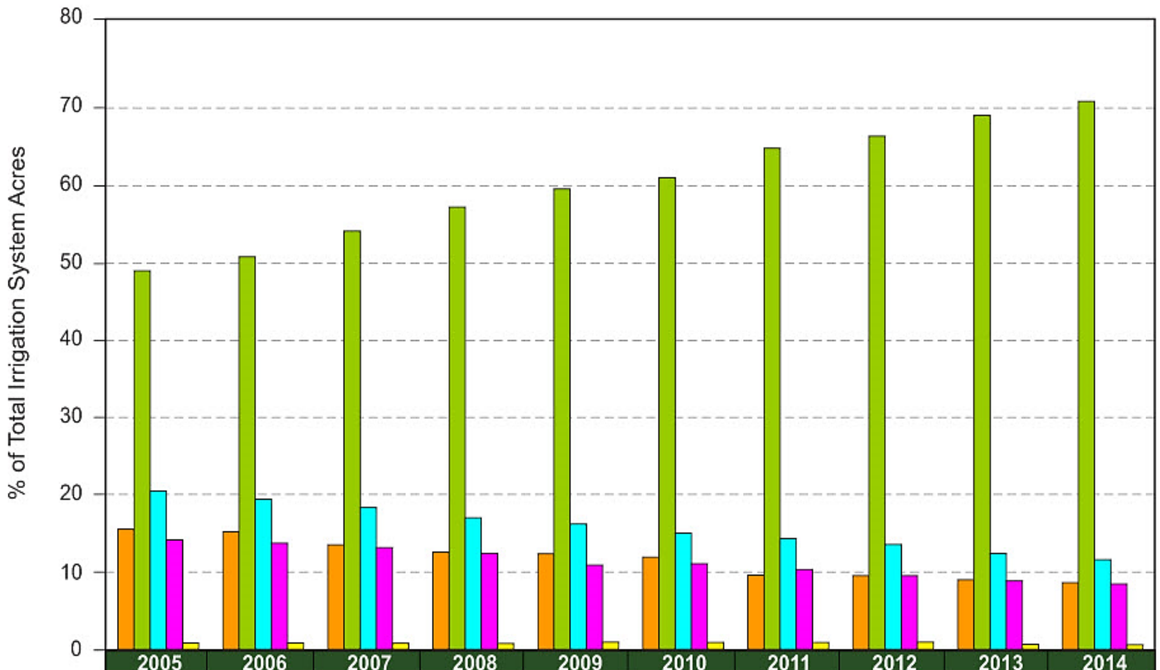
Wind speed, temperature and relative humidity are important factors in evaporative losses from irrigation systems. For example, due largely to high winds in their area, scientists at an agricultural experimental station in Texas give the design efficiency for high pressure pivots as only 60 per cent.

Figure 2. High pressure pivot showing degree of exposure of water droplets to evaporative forces.

Water droplets produced by a low pressure pivot are larger than those produced by high pressure pivots or wheel moves and are subject to less evaporation and wind drift. The drop tubes apply the water closer to the ground and so reduce the time that the droplets are in the air, reducing exposure to wind and sun even more. The nozzles of low pressure systems throw the water droplets over a smaller area than high pressure pivots or wheel moves, resulting in less wetted crop canopy and soil exposed to evaporative forces. As a result, a higher proportion of the water applied by farmers using low pressure pivots will reach the crop than when using high pressure, wheel move or gravity (flood) systems.

Figure 3. Low pressure pivot showing much reduced exposure of droplets to evaporative forces.

Figure 4 shows that the acreage irrigated with low pressure pivots in Alberta has increased to 70.7% of the irrigated area at the end of 2014, exceeding our target. One incentive encouraging farmers to make this switch is a “Growing Forward 2” program of the federal and provincial governments. Alberta Agriculture and Forestry reintroduced this incentive program for farmers to replace less efficient equipment with low pressure pivots. The incentive is $5,000 toward the cost of a pivot, which is typically about $100,000. In addition, some irrigation districts have offered cash incentives to farmers to convert to more efficient irrigation systems. Other benefits of low pressure pivots have also encouraged farmers to make the switch: crop quality and yields improve, less energy is required, labour is considerably lower than for wheel moves or flood irrigation, farmers can monitor pivot operations remotely, and, as a former Chair of AIPA and irrigation farmer said, “We get more crop using less water.” The added incentive through the Growing Forward Program, district incentives, and the drive for energy efficiency, lower labour, and water uniformity will continue to promote adoption of this best management technology. A slowdown in the rate of adoption hereafter is expected as many of the parcels that are not yet irrigated by a pivot are not of appropriate size and/or shape for pivot irrigation. It is reasonable to expect that most high pressure pivots will eventually be replaced with low pressure pivots.



	Acres	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
High Pressure Pivot		201,601	198,011	176,421	164,072	160,665	156,784	126,864	126,430	120,124	117,111
Low Pressure Pivot		635,880	660,168	705,260	747,187	773,538	802,173	856,707	879,651	922,716	956,422
Wheelmove		265,897	252,831	239,140	222,247	210,606	198,043	189,410	179,837	165,561	157,056
Gravity		183,811	178,411	171,487	162,063	141,885	145,879	136,709	126,217	118,307	114,122
Other		10,600	10,579	10,380	9,870	11,935	11,826	11,626	12,444	8,785	8,941

Figure 4. Acreage under the main on-farm irrigation systems in Alberta, 2005-2014.

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.

This is a key conservation target which indicates how much water remains in the rivers that could otherwise be legally diverted. The volume of district licences total 3.45 billion m^3 of water. Figure 5 shows that the 10-yr running average diversion rate has declined from 2.186 billion m^3 in 2005 to approximately 1.61 billion m^3 in 2015, i.e., roughly a reduction of 0.6 billion m^3. Therefore, target No. 3 has been met. Figure 6, showing the average precipitation at three key points in the irrigated region, illustrates that this downward trend in diversion is not primarily a response to rainfall patterns.

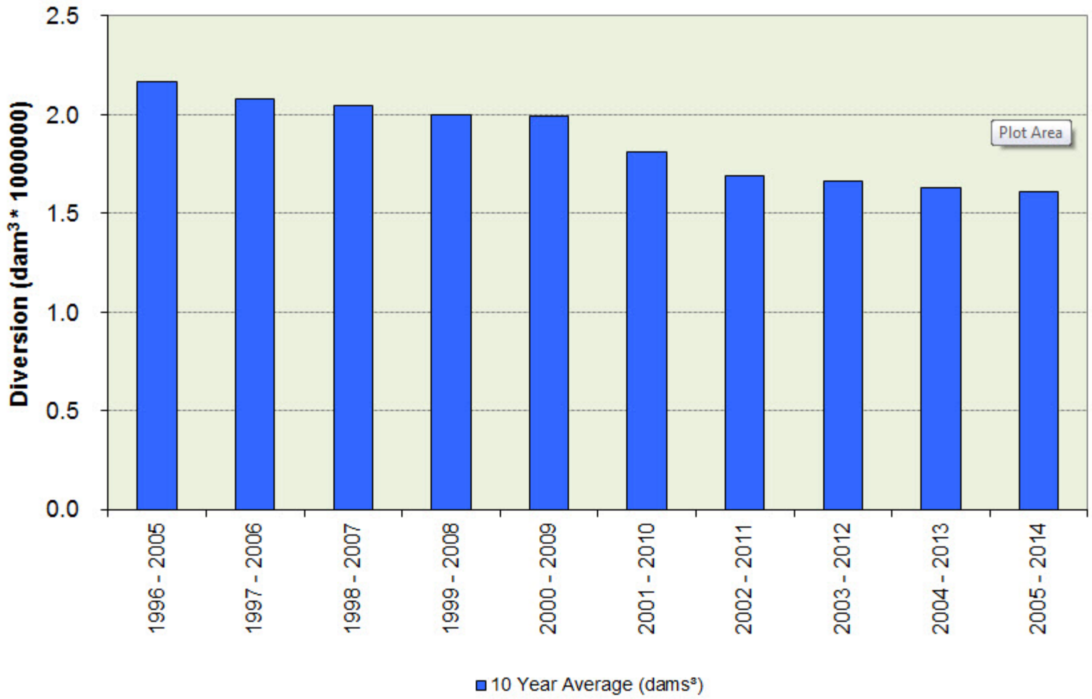


Figure 5. Diversion rate (Billion m^3 or dam^3 x 1 million; 10-year running average) for irrigation in districts.

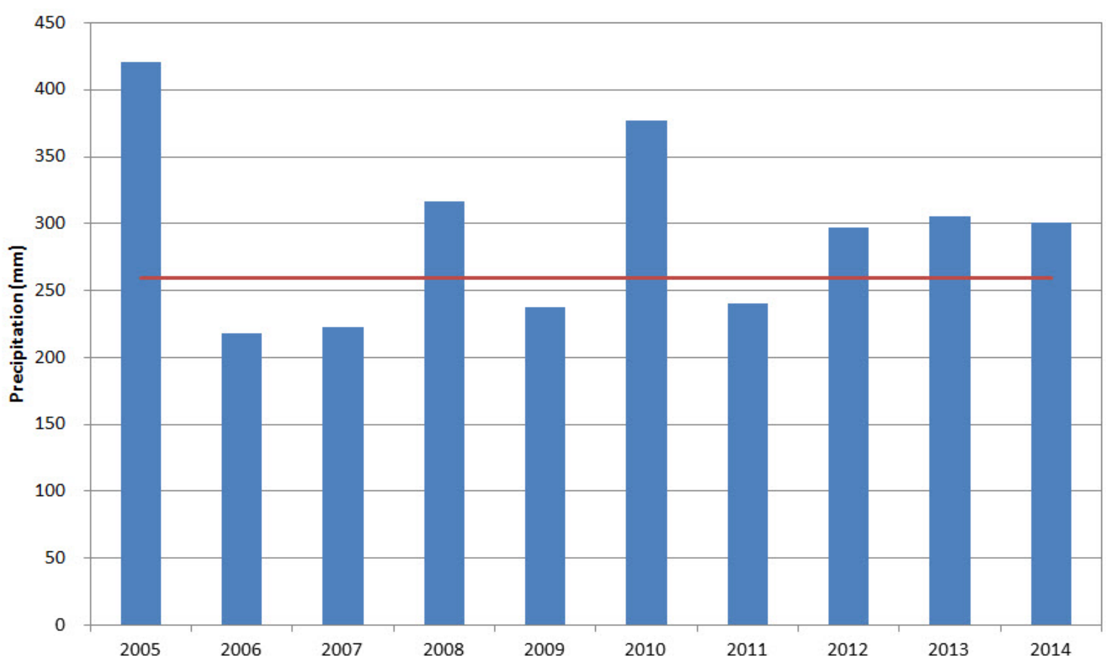


Figure 6. Growing season precipitation (mm) received in the irrigated region of Alberta, (average of Brooks, Bow Island and Lethbridge). The horizontal line is mean precipitation 1970-2014, i.e. 260 mm.

This ongoing reduction in the diversion rate achieved in the target period of 2005 -2014 as shown in Figures 5 and 9 is the result of the accumulated effects of many contributing factors:

a) The changeover to low pressure pivots reducing evaporation, deep percolation and runoff,

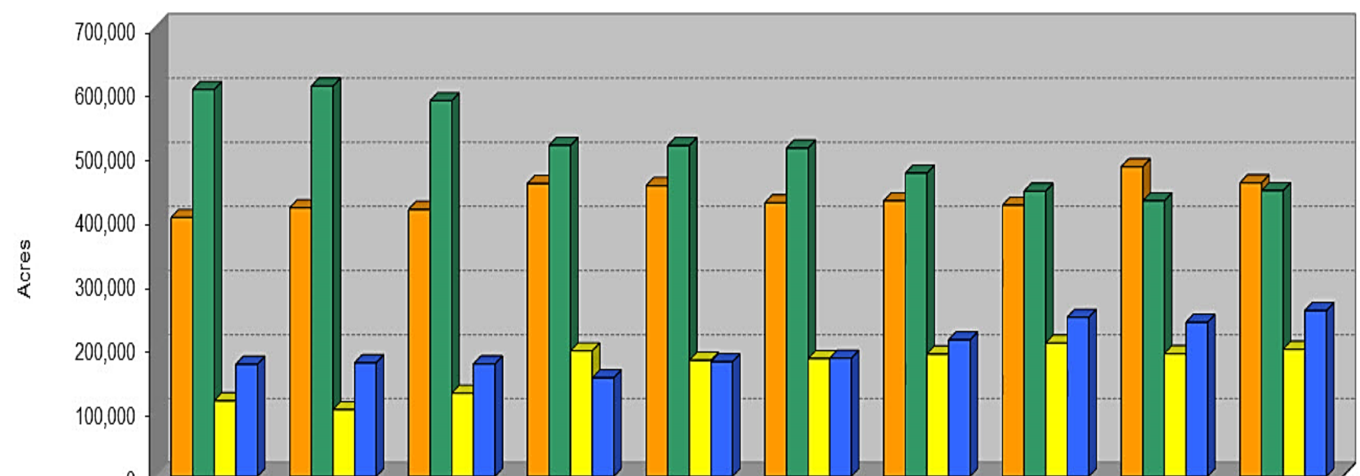
b) The replacement of smaller canals (laterals) with pipelines which saves losses from evaporation, seepage and water use by plants along the laterals, and reduces return flow,

c) The growing of crops that require less water, particularly replacing forages with oilseeds and cereals, and

d) Installation of automatic flow monitoring and remotely controlled structures providing better control of flows to and within irrigation districts.

e) The lining of major canals so they do not seep.

Switching to crops that require less water increases water savings simply by reducing demands. For example, forages require 150 to 200 mm more water for optimum yield than do many of the oilseed, cereal and specialty crops, so switching to these lower water use options will save water. Figure 7 shows the reduction in the area of irrigated forages and the increase in oilseeds (canola for seed and crushing) and cereals (particularly hard red wheat). This shift to more water-efficient crops may have saved upwards of 0.1 billion m^3 per annum in recent years.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Cereals	403,826	419,112	416,594	456,907	453,637	426,825	429,805	423,112	483,144	458,084
Forages	603,520	608,972	585,966	516,321	515,957	512,310	473,073	444,967	430,037	445,907
Oil Seeds	118,181	104,359	129,990	195,962	181,309	183,895	191,154	208,167	191,586	198,543
Specialty	175,127	177,486	175,669	153,962	179,008	184,500	213,149	248,461	240,747	258,839

Figure 7. Crop area (acres) based on four crop categories

Figure 8, a water balance of the districts for the year 2014, tells the story of water deliveries and losses. Diverted water is used for irrigation and by other water users like communities, agri-business, habitat, etc. Significant amounts of water are lost via seepage and evaporation and a considerable percentage of the diverted water is returned to the river. Reduction of seepage, evaporation and return flows will reduce diversions.

Water Balance Category	OLDMAN RIVER BASIN	BOW RIVER BASIN	IRRIGATION DISTRICTS
Gross Diversion	562,900	706,900	1,269,800
Net District Storage Change	8,400	18,000	26,400
TOTAL DISTRICT USE	**571,300**	**724,900**	**1,296,200**
Delivered for Irrigation	336,200	397,100	733,300
Other Use	21,200	56,500	77,700
Canal & Reservoir Seepage	13,600	17,000	30,600
Canal & Reservoir Evaporation	40,800	54,300	95,100
Return	159,500	200,000	359,500
TOTAL DISTRICT OPERATIONS	**571,300**	**724,900**	**1,296,200**

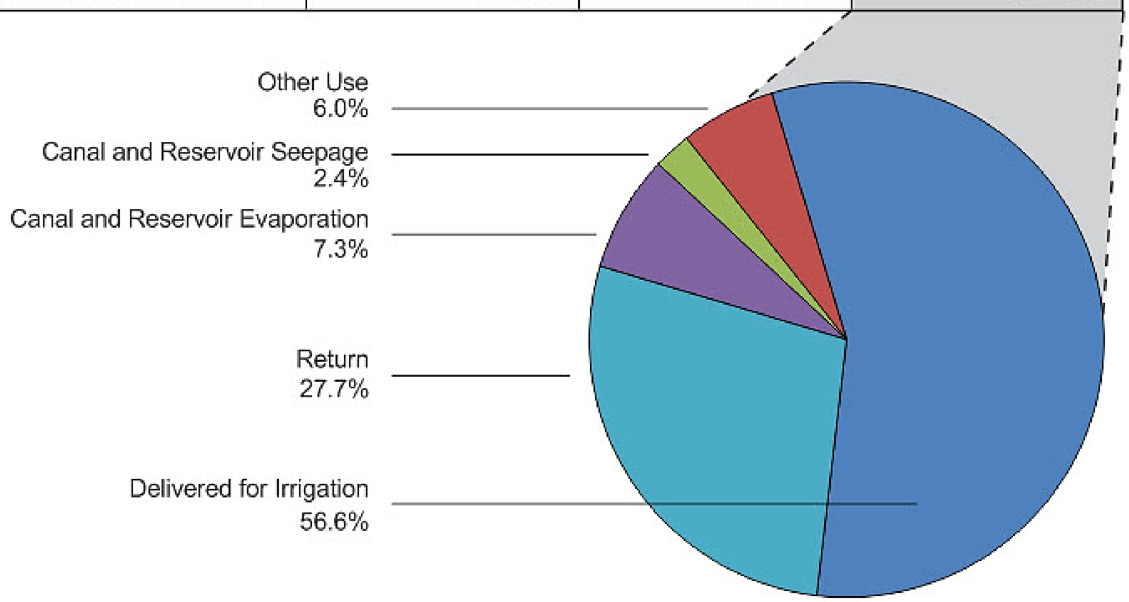


Figure 8. Water balance for irrigation districts in Alberta, 2014. (Units are ac-ft. Multiply by 1233 to convert to m^3).

Part of the reason for the rapid decline in diversion rates shown in Figures 5 and 12 is the rehabilitation of irrigation infrastructure. Districts are replacing earthen ditches with pipelines, effectively eliminating losses from evaporation, seepage, and water-use by ditch-bank plants and reducing return flows. Although return flow is not ultimately lost water, return flow is generally returned far downstream of the point of diversion, so reducing return flow, with the corresponding reductions in diversion, results in higher flow through vast reaches of our rivers. Where canals are too large to put into pipes, they are lined to eliminate seepage.

The Government of Alberta has provided a cost-share program for infrastructure rehabilitation since 1969, known as the Irrigation Rehabilitation Program (IRP). In addition to this program, many districts have invested heavily in rehabilitation using their own funds.

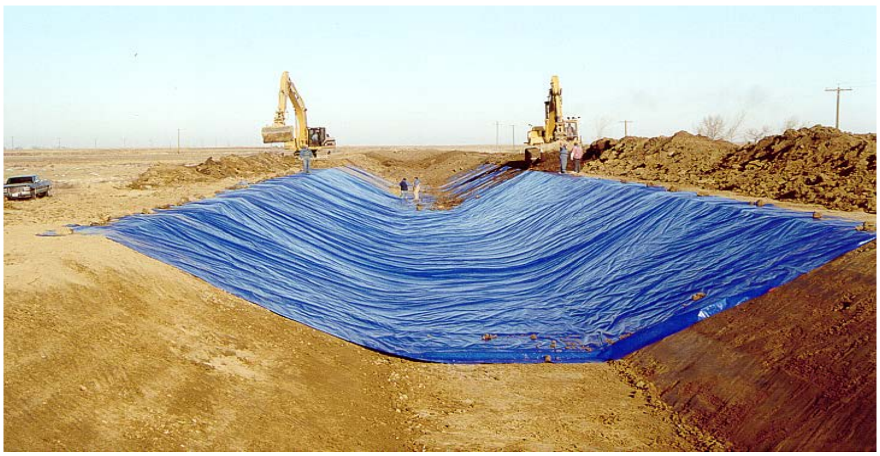


Figure 9.
Lining a canal to prevent seepage losses

Figure 10.
Installing a pipe to reduce seepage and evaporation

Figure 11 shows the number of kilometres of infrastructure rehabilitated as of 2005 and as of 2014. One thousand one hundred and eighty kilometres of infrastructure has been enhanced since 2005, the vast majority being the installation of pipelines, at a rate of over 100 kilometres per year. A net decrease in canal lining occurred. Some smaller canals previously lined with concrete to prevent seepage were damaged by heaving and cracking in Alberta's severe winters with the result that many of these lined canals began seeping again. Those that leak are being replaced with buried pipelines.

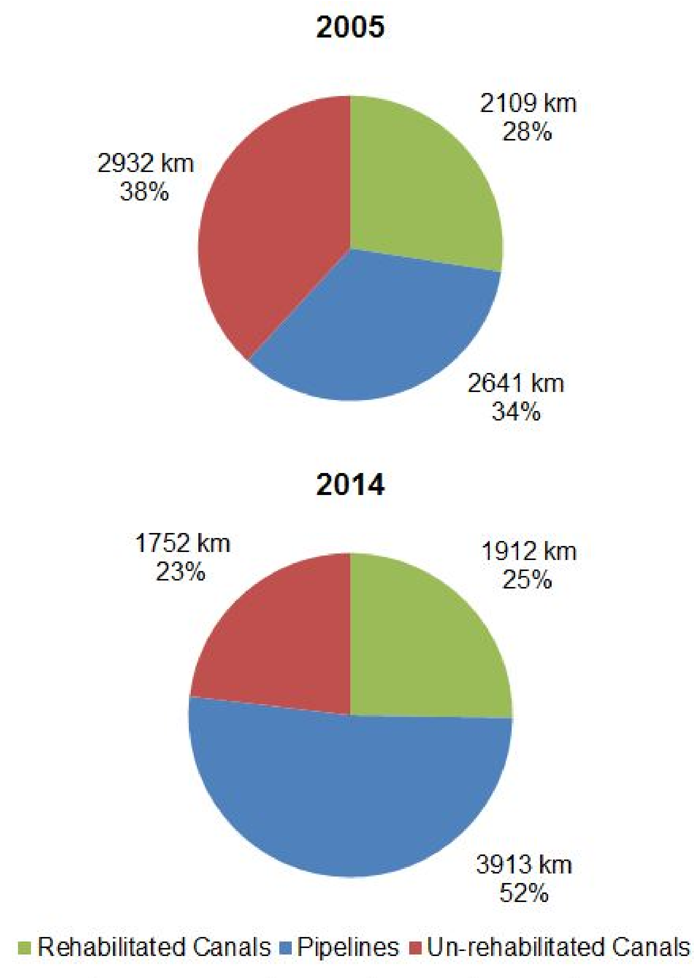


Figure 11. Delivery system, canals and laterals, that have been replaced with pipe or lined.

Although no formal assessment has been made of the contribution of flow measurement and remote activation of water control structures to efficiency gains, these refinements of the system do allow for better matching of flow to demand. Improved management of flows will lead to a reduction of operational spills and downtime flow-by depicted in Figure 1.

Adding efficiencies gained from switching to low pressure pivots, growing lower water use crops, lining canals and installing pipelines, and measuring and controlling water flows more closely results in significant reductions in diversions as shown in Figure 12.

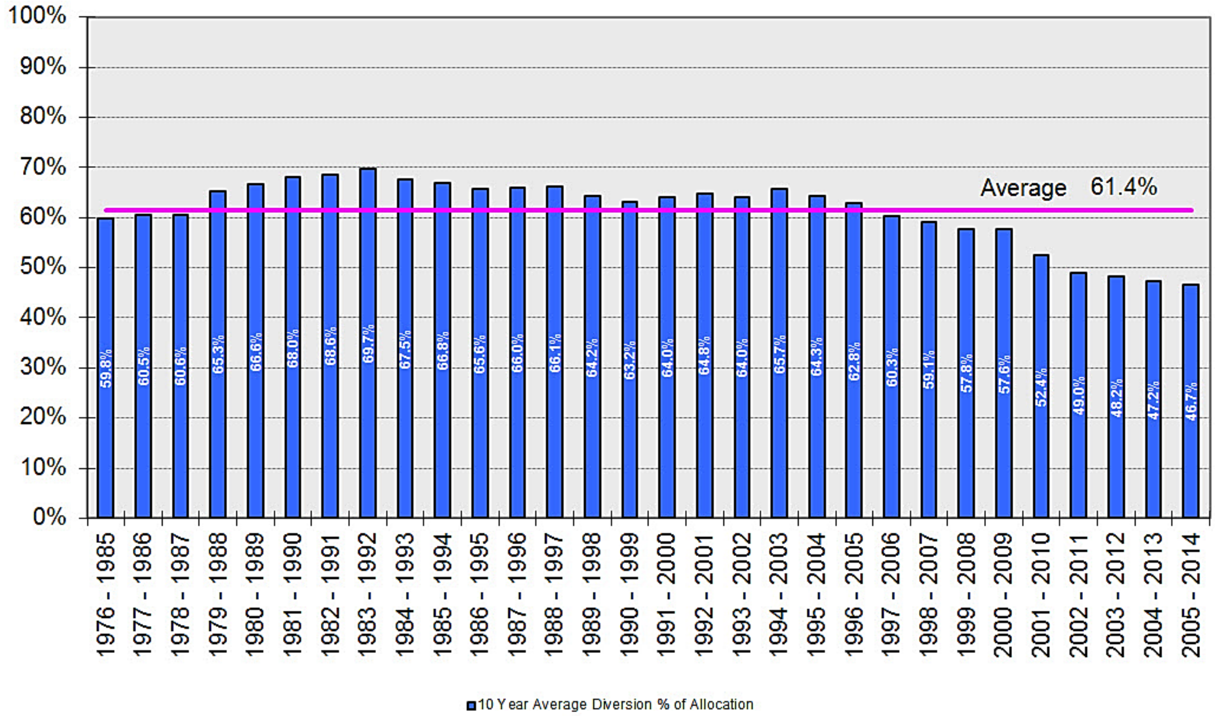


Figure 12. Historical diversion rate to districts (% of licenced volume, 10-year running average).

How much has been accomplished since 2005?

- Farmers replaced low efficiency systems with highly efficient low pressure pivots on 132,690 ha (327,879 ac)
- 1272 km of pipelines were installed for a total of 3913 km
- Canal lining was a net of -93 km because of replacing leaky concrete canals with pipes, but lined canals total 839 km
- Lower water use crops are now grown on 67,500 ha (166,790 ac)
- Hundreds of automated measurement sites have been installed/developed and SCADA systems for flow control are widely in use.

How much did it cost to increase efficiencies?

- Farmers invested $243,000,000 (estimated at $100,000 per pivot)
- Government of Alberta share of IRP investment totaled $243,400,000
- Irrigation district share of IRP investment totaled $78,300,000
- Irrigation district funded capital works project investments totaled $246,425,000

From 2005 through 2014, the grand total investment in improving efficiencies in order to make the best use of water allocated to the irrigation sector amounted to $811,125,000.

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.

Irrigation District	Other Purposes* (ac-ft)	Total Licensed Volume (ac-ft)
AID	700	9,000
BRID	2,380	450,000
EID	5,000	761,000
LID	1,000	12,000
LNID	39,068	334,450
MID	740	34,000
MVID	340	8,000
RCID	n/a	3,000
RID	4,500	81,000
SMRID	12,000	722,000
TID	8,000	158,000
UID	1,000	66,210
WID	3,500	158,400
Total	**78,228**	**2,797,060**

Table 1. Amount of water from district licenses assigned to other purposes.

As shown by the data in Table 1, Target 4 has been met: 78,228 ac-ft of water has been assigned by districts for other uses. Irrigation districts were created to supply water to communities, farm households, livestock operations, and industry as well as to crops. In recent years, certain districts have also supplied water to rural water co-ops. Nowadays, in order to supply water to other users, districts must use licence purpose amendments and/or water licence transfers. As of 2014, water allocated to "Other Purposes" amounted to 2.8 per cent of the collective licenced volume of Alberta's irrigation districts. Districts are a vital source of water in rural areas supplying water to 30 communities, a number of major rural water co-ops, thousands of farm families, and a multiplicity of livestock operations, habitat projects, plus agri-business. In collaboration with Ducks Unlimited and other conservation agencies over the past 75 years, districts have helped create and supply water to 33,000 ha of wetlands and other habitat projects.

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

In 2005 the assessment rolls of the thirteen irrigation districts amounted to 1,342,473 acres. In 2014, the assessment rolls totaled 1,412,836 acres or a growth of 70,363 acres as per Figure 13. This growth of 5.2% has been accommodated through the saving of water as a result of efficiency improvements: the growth has occurred while at the same time, diversions have declined. Target 5 has been achieved.

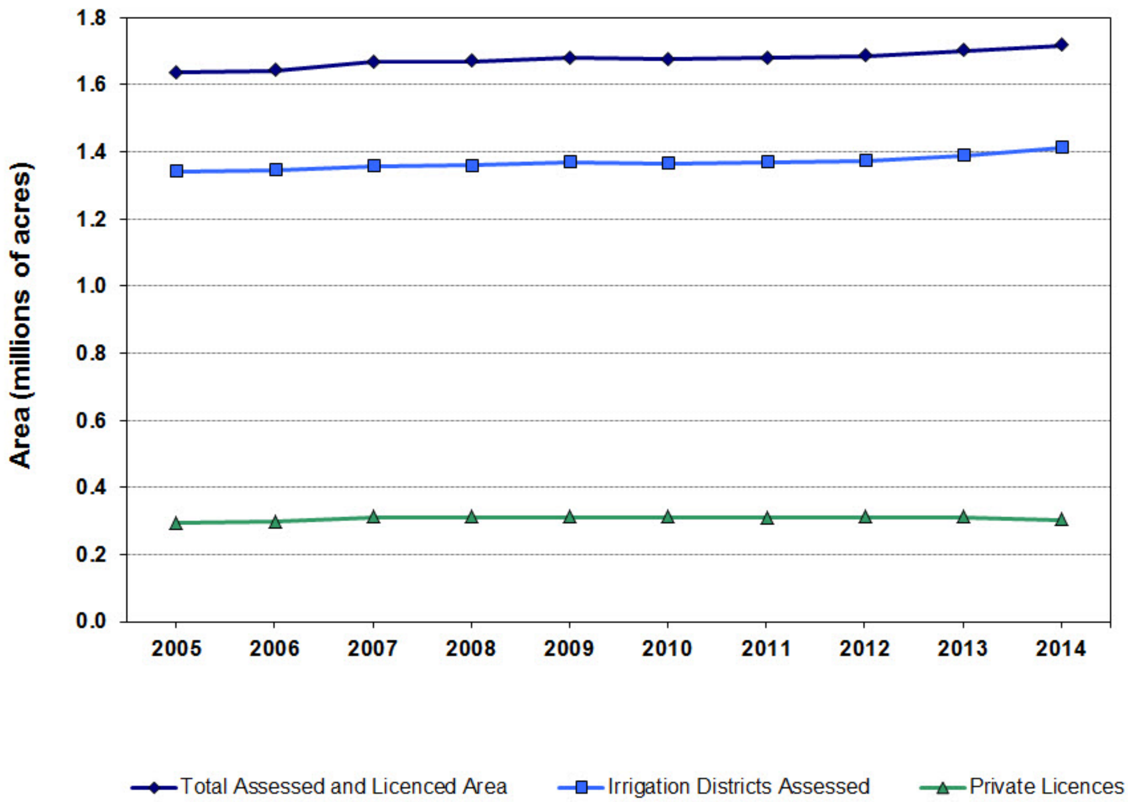


Figure 13: Growth in district assessment rolls (area of irrigated land), 2005-2014.

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 445 mm.

In Figure 14, it is easy to see that Target 6 has been achieved. This decline in water diverted per unit of land is greater than that anticipated by the districts at the time this target was developed. A consultant's report had indicated that an average level of 381 mm per unit of land across all districts was achievable, but not all districts thought this level of reduction was possible. With the improvements in water management discussed previously, the diversion per unit of irrigated land has declined quite sharply. It is unlikely that this rate of decline will continue; 327 mm per unit of land is well below the historical water requirement for many crops and we may see a rise of some sort in the future, if there is a series of dry years, or if forage crops become more profitable.

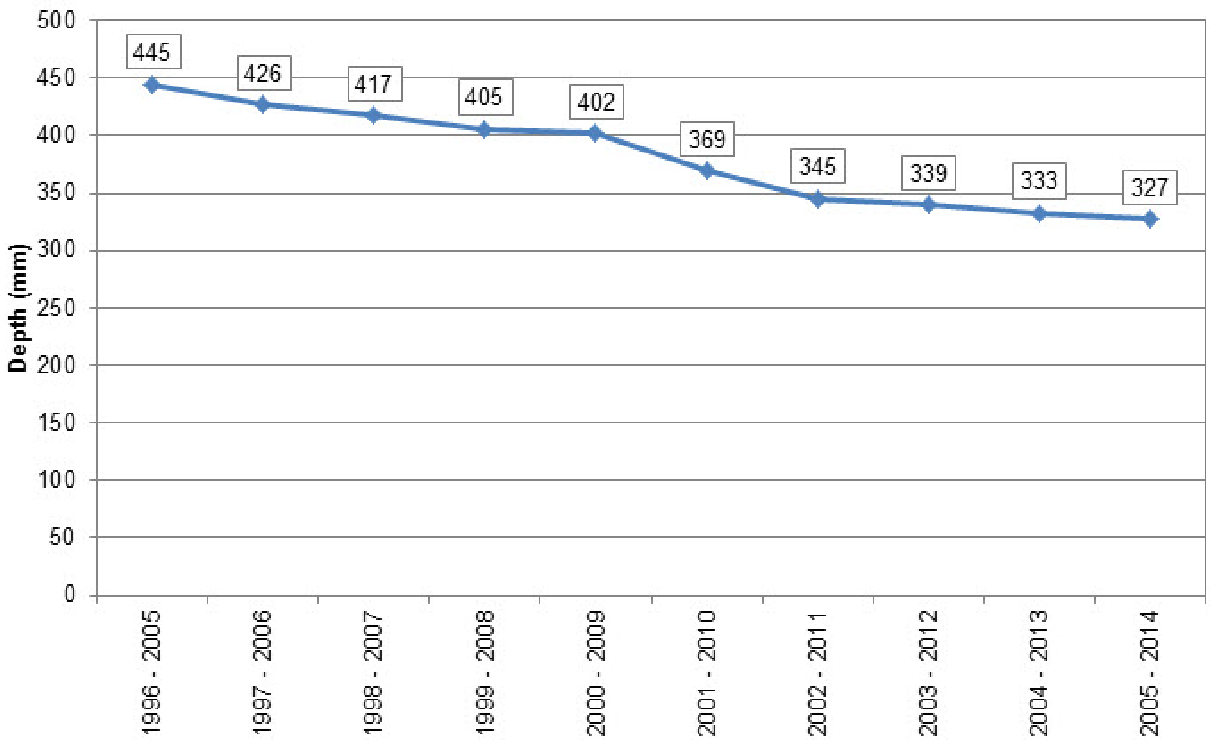


Figure 14. Depth of water (mm) diverted per unit of irrigated land, 2005-2014.

Studies have shown that, in general, irrigators using pivots tend to "under-irrigate" crops. Crops need a certain amount of water to grow and to produce optimum yields. Both quantity and quality of crop production are water-dependent. Another reason that the rate of decline in diversion will flatten out is that the more-easily achieved efficiency gains have already been achieved.

With 2015 being a relatively dry year, the diversion rate was higher, but that data is not yet available. A series of dry years would result in an upturn in the graph, but with all the improvements in the delivery and on-farm systems, the impact of that dry period would be less than had the CEP work not been done, and we expect that this measure will remain below 445 mm on a 10 year average.

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

The data in either Figure 5 or 14 can be used to determine whether Target 7 has been achieved. Water diversion per unit of land irrigated is a significant measure of efficiency gains, accumulating all factors into one easy-to-view number. Using this number as a measure of overall efficiency, the gain in efficiency from 2005 through 2014 has been 26 per cent. Target 7 has been achieved.

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

Yield per unit area, divided by the volume of irrigation water diverted per unit area provides a measure of productivity, or a productivity index, namely the number of kilograms of agricultural product produced per cubic metre of water diverted. The following chart, Figure 15, shows the productivity index of three irrigated crops, for which long-term data are available. These three crops, potato, sugar beet, and soft white wheat, are historic indicators of productivity for the irrigation industry. The on-farm yield data are courtesy of the respective commodity associations.

Variability in yield is evident in the chart and is the result of a multitude of factors such as precipitation, hours of bright sunshine, temperature, relative humidity, wind speed, erosion of seedlings, crop variety, seeding dates, amount and timing of irrigation water and fertilizer applied, pest abundance and control, length of growing season, and harvest conditions. A best fit line was calculated for the data to show the trend. The slope of the regression line is 0.22 kg/m^3 per year. Over the period of 2005 through 2014, there are fluctuations in yields, but using the regression line as an indicator, productivity has increased 22% over that time frame. Using 10-year averages, the productivity index for the 1980s was 4.9; during the 1990s it was 6.4; during the first decade of the new millennium, 8.8; and for the years 2011 through 2014, 11.7.

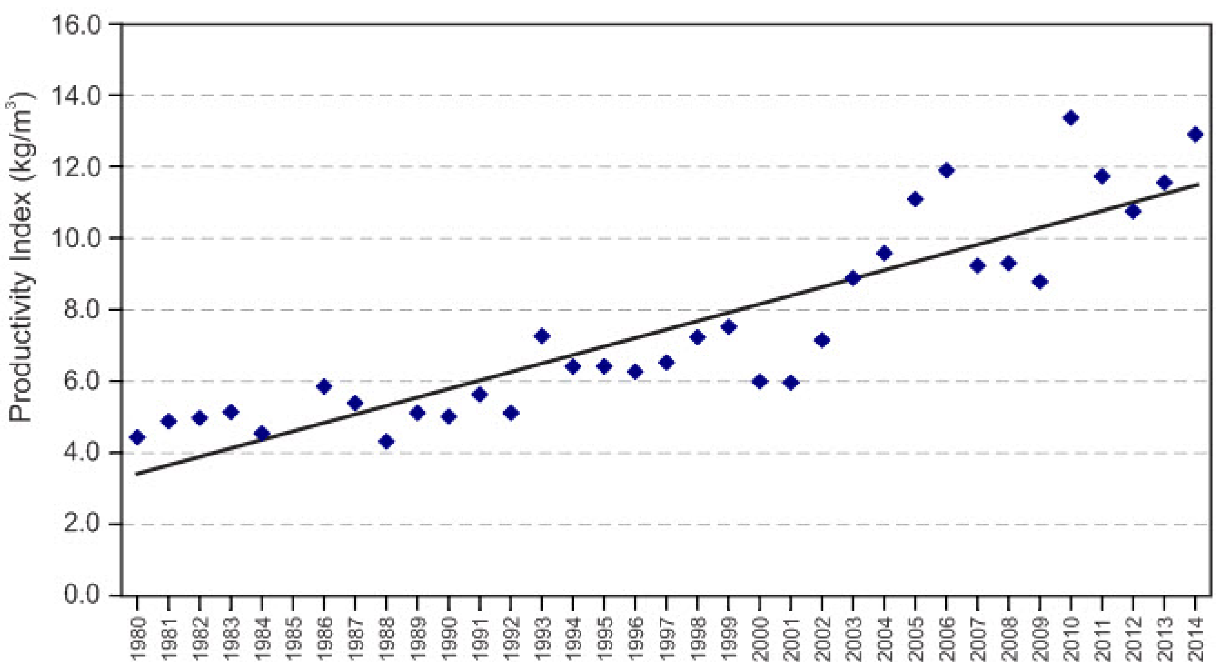


Figure 15. Productivity index (kg/m^3) sugar beet, potato, and soft white wheat in the irrigation districts.

Work with Others Involved in Watershed Management

AIPA members collaborate with a number of other stakeholders on important water issues. The following list describes briefly the collaborative work with other watershed management agencies and individuals:

a) Irrigation representatives participated on the steering committee of a functional flow study and application. To enhance and restore riparian vegetation in the Waterton, St. Mary and Oldman River valleys, the University of Lethbridge, Alberta Environment and Sustainable Resource Development, Alberta Agriculture and Rural Development, and members of AIPA have worked together to release water into the river systems to ensure establishment of cottonwood and other seedlings by slowing down the river recession rate to that needed for seedling establishment. Billions of seedlings were established[3] and in one test area 15% survived through the fourth summer[4].

b) AIPA participated on three Aquatic Invasive Species committees (teams)

c) AIPA contributed $185,000, i) to produce boat launch signs, swag, and other awareness materials, ii) to hire handlers and sniffer dogs for checking watercraft at borders, iii) and to train sniffer dogs and handlers so Alberta would have resident inspection capacity as a help to government and all Albertans in preventing aquatic invasive species introductions in the province.

d) AIPA members participate on the Boards of the Oldman Watershed Council, the Southeast Watershed Alliance, and the Bow River Basin Council.

e) Alberta Agriculture and Forestry and AIPA members are collaborating on a five-year water quality study in and around irrigation districts to determine whether the quality of water being received by irrigation districts meets water quality guidelines and to what degree irrigated agriculture impacts water quality of local rivers.

f) The University of Saskatchewan, Alberta Agriculture and Forestry, and AIPA members are collaborating in a study of the impact of manure, in feedlots and applied to land, on groundwater quality, particularly on the nitrate content of the groundwater.

g) Members of AIPA have made a commitment to supply water to communities prior to supplying water for irrigating crops in times of drought.

h) Members of AIPA participated in the modeling of the Bow River and are now participating in the modeling of the South Saskatchewan River Basin to discover ways to enhance aquatic ecosystems and meet social and economic needs.

i) Members of AIPA participated as committee team members in the Phosphorus Management Plan for the Bow River headed up by Alberta Environment and Parks.

j) An AIPA member has participated on Alberta Environment and Park's Wetland Policy stakeholder committee.

k) AIPA is collaborating with Alberta Agriculture and Forestry and Alberta Innovates – Energy and Environment Solutions to develop a model that predicts irrigation water demand throughout all irrigation districts. This data is needed by other river basin management models as well as by the irrigation industry.

l) AIPA representatives have worked on numerous working groups and teams as well as the board and executive of the Alberta Water Council.

Other Environmental Factors Affecting Water Use

Some habitat has developed along leaky canals and laterals; willows and cattails, etc., grow in these damp places. Saving water by installing a pipeline or lining a canal can result in the loss of such habitat. To compensate this loss to some degree, the irrigation districts have planted over 900,000 trees and shrubs to augment the habitat.

Summary

The Irrigation Sector in Alberta has met all eight of its CEP targets, of particular importance, it has met the Water for Life Strategy of achieving a 30% increase in efficiency and productivity over the period 2005 to 2015. Efficiency and productivity gains will continue to be achieved by the sector, albeit perhaps at a lower rate. Representatives of AIPA have participated on many projects and teams with other members of Alberta's water community and will continue their efforts to contribute to the achievement of Water for Life goals.

Acknowledgement:

The assistance of staff of the Basin Management Branch of Alberta Agriculture and Forestry, especially Andrea Gonzalez, who compiled data and prepared the charts in this report is appreciated. The charts in this report add a great deal to the visualization of the CEP efforts and results.

Thanks to the staff of irrigation districts, Alberta Environment and Parks, and Alberta Agriculture and Forestry who collected the data used in this report.

References:

[1] (page 28 of "Sector Planning for Water Conservation, Efficiency and Productivity" Alberta Water Council, March 2013.)

[2] Irrigation in the 21[ST] Century V. 1; Summary Report. 2002. Alberta Irrigation Projects Association. 175 pp.

[3] Rood, et al. 2005. Managing river flows to maintain flood plain forests. *Front Ecol Environ* 3(4):193–201

[4] Rood, et al. 2015. A twofold strategy for riparian restoration: combining a functional flow regime and direct seeding to re-establish cottonwoods. River Res. Applic. (2015) (wileyonliinelibrary.com DOI: 10.1002/RRA.2919)