Alberta's Water for Life Strategy: Some early indications of its acceptance by the irrigation industry in Southern Alberta

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ABSTRACT

Water is essential for sustainable agricultural development – for irrigation of crops, livestock watering, processing, and sustaining farm families. Agriculture uses 71 percent of all water diverted for consumptive use in Canada (Environment Canada, 2004), and is by far the greatest water consumer in Canada. In the absence of a Canadian national water strategy, Alberta has developed a long-term water management plan called the *Water for Life Strategy*. Its successful implementation will depend largely on the participation of irrigators. This study explores the reaction of irrigators to one of the strategy's main goals – a 30 percent increase in water use efficiency and productivity by 2015 over 2005 levels. The study reveals that irrigators vary significantly in their views as to the extent to which this goal can be reached, and the means by which it should be achieved within agriculture. Further, these responses reflect differences among irrigation districts relating to the extent of water stress, on-farm irrigation water efficiency and natural factors that limit crop diversity in some areas. Ultimately the government may have to revise its 30 percent target and tailor the strategy to irrigation districts as opposed to a broad-based approach.

INTRODUCTION

Managing Canada's water resources is complex and in the absence of a national strategy, fragmented. Provinces have broad powers in managing water. Since water supply and demand factors differ so significantly across the country, provinces have pursued very different policy objectives. Within this national context, comprehensive water management strategies have been attempted at the provincial level with various degrees of success and urgency. Alberta is seen as being at the forefront of a new water management strategy. Since 2001 the province has included in its water management framework, public participation, water planning, environmental flow needs, and the use of economic instruments such as markets and pricing. This strategy has been embodied in the new W*ater for Life Strategy* announced in November, 2003. The objective of this study is to assess how one of the policy's main objectives, a 30 percent increase in water use efficiency and productivity, is perceived by the irrigation sector in southern Alberta.

Efficiency gains in water used for irrigation generally have been achieved through the adoption of new irrigation and water conveyance technologies. Additional progress will depend on the extent to which efficiencies have already been made, the availability of new technology, and whether economic conditions warrant further investments in new technology. Efficiency and productivity gains within agriculture will also largely depend on the ability of irrigators to shift water application away from lower value crops and towards crops of higher value. Also, farmers can plant more water efficient crops and modify their tillage practices to conserve moisture. That will depend on water availability (including water storage and precipitation), suitable growing conditions (including a long enough growing season and the required heat units), and accessibility to local markets and processing industries. It is anticipated that differences in the above factors among irrigators in different regions will result in very diverse views on the extent to which the efficiency and productivity targets can be achieved and the means by which any improvements can be made.

This paper first provides an overview of Alberta's *Water for Life Strategy* followed by a description of irrigation districts in southern Alberta. Efficiency and productivity factors are detailed in the next section, highlighting the differences among irrigators in different areas of southern Alberta. Study procedures are outlined in the following section, followed by results and analyses. The final section provides conclusions.

ALBERTA'S WATER FOR LIFE STRATEGY

The *Water for Life Strategy* starts with the premise that current and future demand for water to ensure economic growth, support a growing population, and secure healthy rivers and lakes, combined with an increased uncertainty related to the variability of future water supply, will result in water demand exceeding water supply. The foundation of the strategy is therefore based on the need to implement a major shift in Alberta's approach to managing water. A set of three principles provides the strategy's framework. These include the preservation of a healthy aquatic ecosystem, groundwater and surface water quality, and the first-in-time, first-in-right principle for granting and administering water allocations. Central to the strategy is an assurance that existing water entitlements will not be reduced and reallocation of water away from existing users to new users will be based on voluntary actions. The strategy relies on economic instruments, best management practices and public involvement in water planning processes to direct the voluntary actions to achieve the strategy's objectives.

Some of the specific goals of the strategy are quite ambitious and have narrow timelines. Aside from the 30 percent efficiency and productivity targets, other goals include:

- to evaluate the merits of using economic instruments to meet water conservation and productivity objectives by 2007;

- to ensure that Albertans understand the value of water to the economy and quality of life by 2007;
- to prepare water conservation and productivity plans for all water using sectors (best management practices) by 2010;
- to implement economic instruments as necessary to meet water conservation and productivity objectives by 2010;
- to complete watershed management plans by 2015.

IRRIGATION DISTRICTS

There are 13 irrigation districts and many private irrigators located in the Alberta portion of the South Saskatchewan River Basin (SSRB). Together, private irrigators and irrigation districts account for 75 percent of the total volume of SSRB allocation (AENV, 2002). Major urban centres in the basin include Calgary, Lethbridge, Red Deer and Medicine Hat. The source of water for irrigation purposes is from two major river systems – the Bow River and Oldman River. Three districts, the Bow River, Eastern and Western, receive their irrigation water from the Bow River. All other districts receive their water from the Oldman River and the southern tributaries of the SSRB. Figure 1 depicts the 13 irrigation districts in this geographic setting.

Two appropriation agreements exist that involve water sharing: one with Saskatchewan and one with the United States. The Prairie Province Master Agreement on Apportionment governs the share of water that must flow from the SSRB to Saskatchewan. The International Boundary Water Treaty between Canada and the United States governs water diverted from the St. Mary and Milk rivers to the United States.

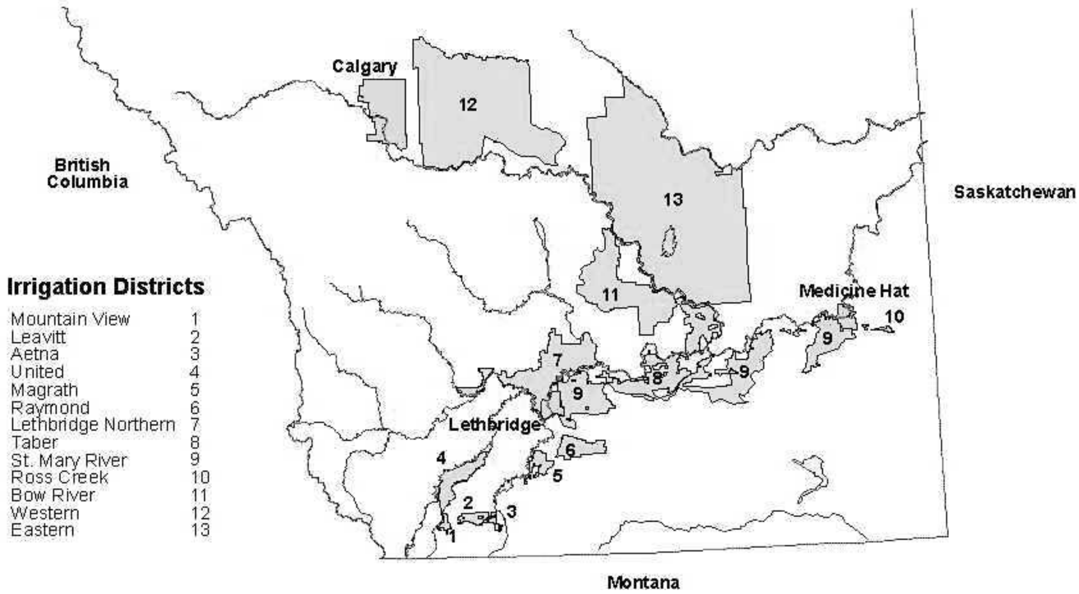

Figure 1. Thirteen irrigation districts in southern Alberta

Source: http://www.agric.gov.ab.ca/irrigate/irrbase.html

The irrigation districts are managed under the Irrigation Districts Act of 2000. Each irrigation district operates independently and the manner in which their functions are carried out can vary considerably due to their differing sizes and physical characteristics (Southern Alberta Regional Planning Commission, 1982). Irrigators have their irrigable area on the district's assessment role and these irrigators constitute the district's ratepayers. Irrigators pay a flat fee per acre for administration and maintenance and some rehabilitation of infrastructure, varying from as high as $17.90 per acre in the St. Mary River Irrigation District (SMRID) to as low as $7.50 per acre in the Eastern Irrigation District (AAFRD, 2005a). This large variation in rates is reflective of whether or not the irrigators have piped and pressurized water supply and if irrigation districts have alternate sources of funding. Irrigators do not pay for the water itself nor do they pay for the cost of the major head works and other infrastructure required to deliver the water to the point where the districts extract the water from the main supply system. Some districts also supply water to municipalities, golf courses, feedlots, oil and gas and other industries, resulting in a complex fee structure. Due to non-irrigation incomes, some districts can offer lower fees; in one instance the district has waved fees for two years to support irrigators through the BSE crises.

Together, the irrigation districts have about 1.3 million acres on the assessment roll. For most of the irrigation districts, irrigation expansion limits set in 1991 have been reached Based on 2004 data (AAFRD, 2005a), the Bow River and Eastern irrigation districts have the greatest scope to increase acreage, by about 15,500 and 27,400 acres, respectively. Other irrigation districts, including Lethbridge Northern, Ross Creek and United have some room for expansion but significantly less than do the Bow River and Eastern irrigation districts[1].

For ease of analysis, districts were aggregated into three groups based on location, irrigation water source and farm size (see Table 1). The first group is the "Bow River" group, consisting of the Western, Eastern, and Bow River irrigation districts, generally situated between Calgary and Medicine Hat. Irrigation water for these districts is derived solely from the Bow River. As Table 1 shows, the Eastern and Bow River irrigation districts are among the largest of the 13 districts and have the highest percentage of large farms. Over 50 percent of farms are over 160 acres. These two districts can increase their irrigated acreage considerably before their expansion limit has been reached.

The second group is the "central" group, consisting of the irrigation districts of Lethbridge North, St. Mary River, Taber and Ross Creek. These are generally located between Lethbridge

[1] Expansion of irrigated acreage requires approval of district irrigators through a plebiscite.

and Medicine Hat. The primary sources of water are the St. Mary and the Oldman Rivers. As shown in Table l, except for Ross Creek, the irrigation districts in this group are relatively large and between thirty and forty percent of farms are greater than 160 acres.

Table 1: Irrigation district acreage, farm size and irrigation water source

Group	Assessment roll acres	Percentage of farms less than 160 Acres	Water source (river)
Bow River			
Bow River	216,533	43	Bow
Eastern	283,625	52	Bow
Western	96,535	77	Bow
Central			
Lethbridge North	175,569	63	Oldman
Taber	82,515	75	St. Mary, Waterton, Belly
St. Mary River	372,979	64	St. Mary, Waterton, Belly
Ross Creek	1,210	N/A	Gros Ventre Creek
Southern Tributary			
Aetna	3,611	95	Belly
Mount View	3,712	80	Belly
Leavitt	4,763	95	Belly
Magrath	18,320	74	Belly, St. Mary, Waterton
United	34,093	72	Belly, Waterton
Raymond	46,296	80	Belly St. Mary, Waterton

Source: Column 2 data are from AAFRD, 2005a. Column 3 data are adapted from personal correspondence, Bob Winter, September 28, 2005. Column 4 data are from AIPA, 2002.

The third group of districts is the "southern tributary" group, consisting of the irrigation districts of Aetna, Leavitt, Mount View, United, Raymond, and Magrath. These irrigation districts are located in the southwest area of the province. All irrigation activity in this group is fed by the southern tributaries of the Oldman River. Three of the irrigation districts in this group are sourced entirely from the Belly River with the rest from the St. Mary and Waterton Rivers. The irrigation districts in this group are among the smallest in terms of assessed acreage. Many of the farms are also relatively small, with the vast majority consisting of less than 160 acres and some holdings comprising recreational properties.

EFFICIENCY AND PRODUCTIVITY FACTORS BY GROUP OF IRRIGATION DISTRICTS

The two primary means to enhance water efficiency and productivity are improvements to on-farm irrigation systems and shifting water from lower value to higher value crops. Gains through irrigation equipment are achieved primarily through reduced evaporation, although reduced return flow will occur with the conversion from gravity irrigation. It however has to be noted that reduced return flow does not reflect real water savings as less water will be left in the rivers for the environment and downstream users. Different irrigation equipment provides various degrees of water efficiency and has been the basis for the most significant gains in water efficiency in the past. Depending on whether pivot irrigation pressure is high or low, for example, efficiencies[2] range from 74 to 80 percent. Lateral and hand move wheel systems deliver between 65 and 70 percent efficiency. Undeveloped surface irrigation delivers 30 percent efficiency (AIPA, 2002). Hence, efficiency gains can be made by shifting from gravity to wheel move to pivot irrigation systems. On-farm efficiency gains have been considerable over the 34 year period from 1965 to 1999. As Table 2 demonstrates, across all groups, efficiency has approximately doubled.

[2] Efficiency in delivering water to the soil root zone.

Table 2: On-farm irrigation efficiencies, 1965, 1999 (Average %)

Group	1965	1999
Bow River	34.7	69.0
Central	36.3	73.0
Southern tributary	30.7	61.1

Source: Adapted from AIPA, 2002

Table 3 shows on-farm irrigation methods by group of irrigation districts. Scope to increase water efficiency by changing irrigation methods is greatest in the southern tributary group where the least efficient system, gravity, is applied to over 20 percent of the acreage and the most efficient method, pivot irrigation, is applied to less than forty percent of the acreage. The central group has the greatest percentage of irrigated acreage under the most efficient equipment (pivot) - over 70 percent -with virtually no acreage under gravity. Like the southern tributary group of irrigation districts, the Bow River group may also have the potential to increase efficiency through modifications to irrigation methods. Although a relatively high percentage of acreage is under a pivot system, 55 percent, that group has the lowest percent of acreage on a wheel move system and the highest percent, 26 percent, under gravity. Potential for increased efficiency might, however, be hampered by soil quality and topography.

Table 3: On-farm irrigation method, 2004 (Percent of total acres)

Group	Pivot	Wheel Move	Gravity	Other
Bow River	55.4	17.8	26.0	0.8
Central	70.7	25.1	3.6	0.7
Southern Tributary	38.8	36.9	22.2	2.1

Source: Adapted from AAFRD, 2005a

System efficiency for water delivery ranges from very low for open ditches to very high for closed ditches and pipes. Considerable improvements in efficiency have been achieved but additional gains in efficiency will mainly result in reduced seepage which in turn, will result in reduced return flow to the rivers, hence leaving less water for environmental purposes.

Shifting irrigation water application from lower to higher value crops provides a second means for efficiency and productivity improvements. However the flexibility in changing crop production depends on soil quality, water availability, number of frost free days and heat units. As demonstrated below, these factors vary across groups of irrigation districts and can restrict crop production flexibility.

Figure 2 highlights the differences in soil type among the groups of irrigation districts in southern Alberta. Soils are primarily brown in the Bow River and central groups but higher quality black in the southern tributary group. As soil changes from brown to black the surface layer increases in thickness and the percentage of organic matter is higher.

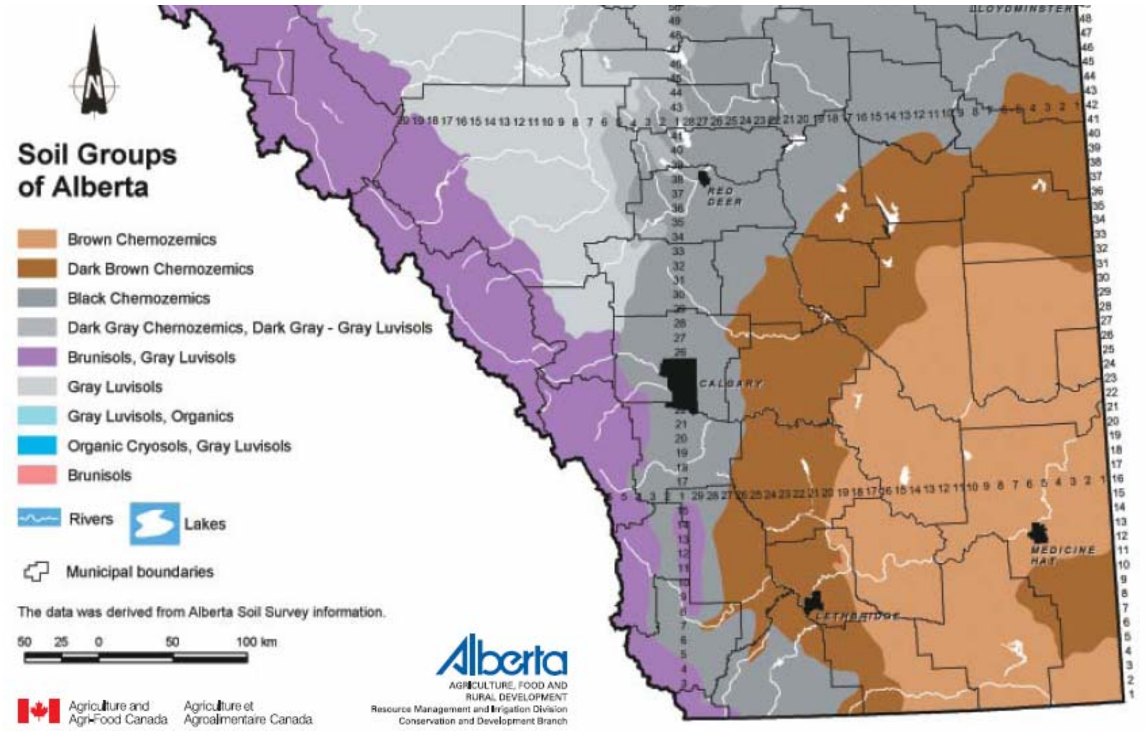

Figure 2. Soil Zones in Alberta.

Source: AAFRD, 2005b

While the southern tributaries group has the best soil quality, other factors relating to water storage, precipitation, number of frost free days and limited heat units result in this group growing lower-value crops relative to those in the other irrigation areas. Table 4 provides calculations of water storage as a percentage of water licenses by irrigation district. The data combines water storage capacity of reservoirs owned by irrigation districts and the province. The data show that, except for the Western Irrigation District, water storage capacity diminishes significantly from the Bow River group to the southern tributary group of irrigation districts, from as high as 150 percent in the Lethbridge North Irrigation District to as low as four percent in the United Irrigation District.

Table 4: Dam^3 water storage capacity as a percentage of dam^3 water license (2004)

Irrigation district(s)	Percentage
Western	7
Bow River	100
Eastern	69
Lethbridge North	150
St. Mary, Taber, McGrath, Raymond	51
Mount View, Levitt, Aetna	24
United	4

Source: Adapted from AAFRD, 2005a

Water availability from rivers tends to be the least favorable for the southern tributary group and most favorable for the Bow River group. The water source for the southern tributary group, the Oldman River, is more highly allocated than is the Bow River, which provides water for the Bow River group. The Oldman River has 70 percent of median flow allocated compared to 68 percent for the Bow River. Within the Oldman River, 87 percent of the water is allocated for irrigation compared to 76 percent of the Bow River. The southern tributaries of the Oldman River have such high allocations (St. Mary – 118 percent of median; Belly – 80 percent of median; Waterton 75 percent of median) that the issuance of new licenses ceased in 2001. The Bow River group of irrigation districts has never experienced restrictions on water use, the central group has experienced restrictions during exceptional drought years, and the southern tributary group has experienced the most frequent and severe restrictions on water use.

Table 5 provides a summary of historic precipitation data. Data collected from meteorology stations across the irrigation districts from 1970 to 2003 indicate that average precipitation throughout the growing season and on an annual basis has been highest in the Bow River group, with slightly lower levels in the central group and the lowest in the southern tributary group[3].

Table 5: Precipitation by irrigation group - Averages 1970-2003

Group	Precipitation[1] April 1- October 31	Annual precipitation[1]
Bow River	10.2	13.0
Central	9.3	12.3
Southern tributary	8.7	11.3

[1] Measured in inches
Source: AAFRD meteorology stations.

Critical to the ability to grow a range of crops and enhance flexibility of production is the length of the growing season and the amount of heat received. The central group has the most favorable conditions, experiencing the longest growing season and the greatest amount of heat units as demonstrated in Table 6. These conditions are less favourable in the Bow River group and are least favourable in the southern tributary group.

Table 6: Heat variables by irrigation group - Averages, 1970-2003

Group	Average frost free days	Average corn heat units
Bow River	164.8	2311.0
Central	172.2	2417.6
Southern Tributary	164.0	2263.5

Source: AAFRD meteorology stations.

The number of frost free days can be depicted graphically. Figure 3 shows that the central group captures the most heat, with less heat within the Bow River and southern tributary groups.

[3] Some caution should be used in using this data since there are few stations and they exist in specific locations.

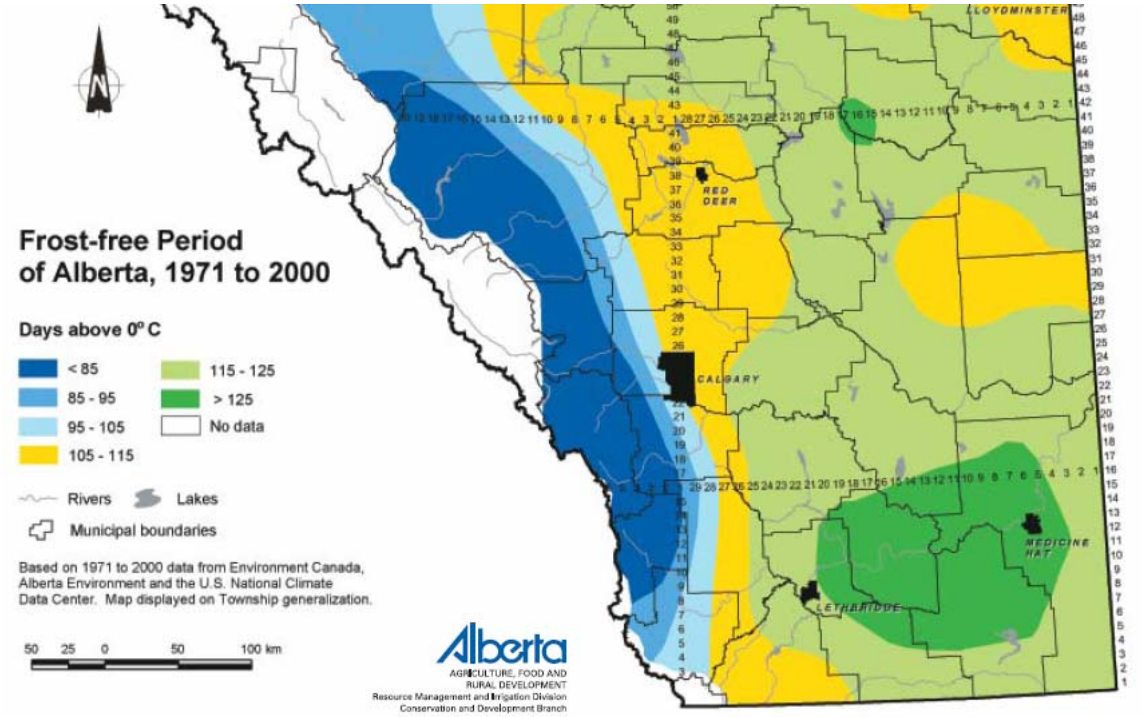

Figure 3 Frost-Free Period of Alberta, 1971 to 2000.

Source: AAFRD, 2005b

The factors described above provide the rationale for the differences seen in crops grown in the different groups of irrigation districts (Table 7). The central group of irrigation districts has the most favorable growing conditions for specialty crop production in terms of frost free days and heat units. While water storage capacity is not as high as in the Bow River group, restrictions have so far been few and limited to the worst drought(s). Although that area does not have the highest quality soil or the greatest level of precipitation, the application of fertilizers helps remedy soil quality issues and extensive irrigation supplements precipitation. It is therefore not surprising that the greatest concentration of specialty crop production is found in the central group of irrigation districts where vegetable processing industries have also concentrated and where vegetable contracting therefore is possible. Some specialty crop production also occurs in the Bow River group where frost free days and heat units permit. Lower value forage and cereals, which require less water, shorter growing season, and less heat, comprise almost the entire crop production activity in the southern tributary region where there is the least water availability through river systems and storage capacity. In years when water is available, this group of irrigation districts has considerable flexibility to increase irrigation on these lower-valued crops and grazing areas.

Table 7: Proportion of crops by irrigation group, weighted average 2004

Group	Cereals	Forages	Oil seeds	Specialty crops	Other
Bow River	28.2	48.2	10.8	10.7	2.9
Central	32.0	40.7	9.6	16.4	1.4
Southern tributaries	33.4	57.0	6.8	1.6	0.4

Source: Adapted from AAFRD, 2005a

STUDY DESIGN AND PROCEDURES

The study is based on a survey of irrigation district managers and members of the irrigation district's boards of directors. Generally there is one general manager per irrigation district and anywhere from three to seven board members, depending on the size of the district. Sixty eight potential participants were identified in the 13 irrigation districts. The questionnaires were distributed through the mail in March 2005. Forty one questionnaires were returned for a response rate of 60 percent. All districts participated in the survey.

While the survey asked a range of questions[4], this paper focuses on the findings relating to the 30 percent efficiency and productivity targets (for a discussion of the findings of other aspects of

[4] The first section related to water and the environment in general, the second section sought participant's opinions of some of the goals, principles and action plans of the strategy while the third section asked specific questions about the participant and his/her property.

the survey see Bjornlund, Nicol and Klein, 2006). Respondents were asked whether these targets were achievable and if so, which approach was most likely to be taken to achieve them. Respondents were asked to base their answers on a rating of one to five with one being very low and five being very high. The respondents were asked to respond personally, as well as from the perspective of the irrigators in their irrigation district.

Although the rate of return on the survey was relatively high, the small number of respondents in total did not provide adequate numbers to conduct a rigorous statistical analysis. Descriptive statistics, using averages and percentages, are used throughout. Cross-tabulations were used to evaluate responses by group of irrigation districts but cannot be generalized to the entire population on the basis of farmer characteristics. Additional data also were obtained through on-site personal interviews with irrigation district managers during July and August 2005. The interviews were informal and covered a variety of issues pertaining to the goals and objectives of the *Water for Life Strategy*.

RESULTS

EFFICIENCY AND PRODUCTIVITY FACTORS BY IRRIGATION GROUP

When asked whether or not irrigation districts should participate in the goal to achieve a 30 percent increase in efficiency and productivity - support was weak. This major objective of the Water for Life strategy was endorsed by only 43 percent of respondents (Table 8). Support was weakest in the central group, 33 percent, with somewhat stronger support in the Bow River and southern tributary groups, both with 50 percent of respondents who agreed or strongly agreed. The weaker support in the central group likely is because irrigation equipment efficiencies in this group already are relatively high and this group is already suffering supply problems during dry years. Discussions with the irrigation district managers indicated that this weak support may largely reflect the view that the 30 percent target is seen as being too ambitious and that more moderate efficiency and productivity gains may be more realistic.

Table 8: Support for irrigation district's participation in efficiency and productivity goals (percentage of respondents)

	Total	Bow River	Central	Southern Trib
Agree or strongly agree (1 and 2)	43	50	33	50
Disagree or strongly disagree (3, 4, 5)	57	50	67	50

A greater number of respondents believe that, within their district, a 30 percent increase in water productivity is more likely than a 30 percent increase in water efficiency. Table 9 shows that 49 percent of respondents believe productivity can be improved to meet the 30 percent target while only 26 percent of respondents believe efficiency can be improved to meet the 30 percent target.

Across groups of irrigation districts, respondents identified two main ways to improve efficiency – through improvements to existing irrigation equipment and by investing in new, more efficient equipment (Table 10). However, existing high levels of efficiency in the central group of irrigation districts means that the potential for further gains through improvements to existing equipment may be limited. Also, for the southern tributary group, investing in more efficient equipment received weak support, likely due to financial constraints imposed by growing mostly lower valued crops. The potential for productivity gains may be greater because, aside from the capability of some groups to modify existing equipment and/or invest in new equipment, changing the mix of crops provides a third means to enhance productivity. This additional instrument was identified by almost 60 percent of respondents overall, and by central group respondents in particular, where the greatest flexibility exists (Table 11).

Table 9: Achieving the efficiency and productivity targets (% of respondents)

	Efficiency	Productivity
Yes	26	49
No	74	51

As noted, while responses may suggest lack of support for the strategy's main initiative, a number of respondents qualified their answers about the 30 percent targets being too high by stating that a lower target might be possible. Some respondents also noted that each irrigation district should be treated separately. Most respondents indicated that poor commodity prices presented financial constraints to this initiative. Some of their comments are provided in the box below.

Should Irrigation Districts Participate in the 30% Efficiency and Productivity Goal?

"Yes, if the number is reasonable, 30 percent is not"

"Yes, using a combination of variables"

"Not as worded, the process for irrigation started before 2005 by several years"

"This is not attainable"

"Yes – we have some room for improvement, but not able to meet the proposed 30 percent target"

"Irrigation districts have already improved efficiencies by 30 percent over the last approximately 20 years and a further 30 percent increase in efficiency and productivity is probably not possible"

"Yes, within reason. Many have made big improvements"

"Yes but each district should be looked at separately. Some have already made large efficiency improvements"

"Yes, if the return from crops was such as to pay for making the changes"

"The crop does not justify new, better equipment"

"If we received a fair price for our commodity we could improve our ways"

Despite some reluctance to embrace the efficiency and productivity targets wholeheartedly, there remains a belief that some gains can be found within the system. When asked which approach irrigators would most likely take to increase efficiency, modifying existing irrigation equipment usage and investing in new equipment ranked as the most likely by 87 percent and 81 percent of total respondents, respectively (Table 10).

Table 10: Ranking of most likely method of increasing water use efficiency (Percentage of respondents answering "Most Likely"[1])

	Total	Bow	Central	Southern
Make improvements to existing irrigation equipment	87	92	73	92
Invest in new, more efficient irrigation equipment	81	85	91	67
Change time of irrigating	27	9	60	17
Irrigate less	23	17	11	42
Change from crops with relatively high water requirements to lower water requirements	40	36	46	33
Use internal transfers between crops more frequently	35	46	36	27

[1] Rated 4 to 6 on a 1 to 6 scale with 1 being least likely and 6 being most likely

Confirming the potential for the greatest efficiency gains in the southern tributary group, where on-farm efficiencies are only 61 percent, 92 percent of respondents there believed improvements can be made to existing equipment. The same percentage in the Bow River group felt this is possible as well, although on-farm efficiencies there already are 69 percent. The central group of irrigation districts, with the highest efficiency of 73 percent, had the lowest number of responses believing this is likely, but the number was still high at 73 percent. Investing in new, more efficient equipment also was thought to be possible among respondents in the Bow River and central groups but was rated less likely by those in the southern tributary group. This result might relate to the financial capability of irrigators in these two groups to undertake this investment. The Bow River and central groups of irrigation districts have considerable specialty crop production compared to that in the southern tributary group. With big investments in producing higher value crops and with irrigation water being essential for these water demanding crops, there may be a greater willingness and ability to pay for new equipment given the opportunity to expand specialty crop production in the future.

Efficiency gains through other alternatives – changing time of irrigating, irrigating less and changing from crops with relatively high water requirements to those with lower water requirements – also received considerable endorsement. Limitations to efficiency gains by changing from crops with high water requirements to lower water requirements was considered an attractive option by 40 percent. The group indicating the highest likelihood, at 46 percent, was the central group, where the greatest diversity of specialty crops exists and where this flexibility is probably the highest. This group of irrigation districts also rated changing the time of irrigating highly, at 60 percent. The other initiatives, including irrigating less and using internal transfers among crops more frequently, were rated as least possible across all groups of irrigation districts. This indicates that while two main methods of achieving efficiency gains were identified, the final efficiency improvements will be the product of a variety of approaches taken by irrigators under different circumstances.

Table 11 summarizes the results with respect to the most likely method of increasing productivity. Again, modifying existing irrigation equipment and investing in more efficient irrigation equipment seem to be the most likely methods with 82 percent believing these methods to be the most likely to achieve productivity gains. All groups of irrigation districts rated these initiatives highly, with the southern tributary group the highest. But 58 percent of respondents indicated that changing crop mix was one of the most likely methods of increasing productivity.

By far the most optimistic group was again the central group where 73 percent answered affirmatively. Few respondents believe changing time of irrigating and using internal transfers more frequently will enhance productivity. Increased fertilizer application was also infrequently rated as a likely method, except by those in the southern tributary group where 67 percent of respondents believed this was one of the most likely methods to increase productivity. This might reflect the fact that present fertilizer use is lower and less consistent in this area with lower value products and that potential gains therefore could be made if it was financially viable. As for efficiency gains, while respondents consistently rated two methods for achieving productivity gains as most likely, the other methods were also rated 'most likely' by quite a substantial proportion of the respondents. This again highlights that the best possible outcome will be achieved by using a number of methods that vary across districts. This indicates that economic instruments and best management practices ought to be designed to support or encourage the use of a variety of approaches.

Table 11: Rating of most likely method of increasing water productivity (Percentage of respondents answering "Most Likely"[1])

	Total	Bow	Central	Southern
Modifying existing irrigation equipment	82	79	73	92
Invest in new, more efficient irrigation equipment	82	79	82	83
Change time of irrigating	22	31	20	17
Change mix of crops produced	58	43	73	58
Use internal transfers between crops more frequently	31	36	46	10
Increase fertilizer application	32	7	27	67

[1] Rated 4 to 6 on a 1 to 6 scale with 1 being least likely and 6 being most likely

CONCLUSIONS

The survey results indicate that irrigation district managers and board members believe that only incremental efficiency and productivity gains are possible and that most of these gains can best be made through modifying existing equipment and purchasing new equipment. The results also suggest that to achieve the best possible outcomes a different combination of methods needs to be applied across the irrigation sector in the South Saskatchewan River Basin. Based on on-farm efficiencies, the greatest gains can be made in the southern tributary group of irrigation districts but, considering that this region accounts for only eight percent of irrigated land, this would have only limited impact on overall efficiency. Financial capabilities could be a constraining factor for improving productivity and efficiency of water use across all irrigation districts. The central group of irrigation districts has the greatest diversity of crops and recognizes that changes in crop mix may provide some productivity gains. Shifting to higher value crops may be limited especially in the southern tributary group but also in the Bow River group due to unsuitable soil, climactic constraints, lack of nearby processing industries and poor finances.

These results provide direction for implementation of the *Water for Life Strategy*. The government needs to adjust its expectations concerning the extent of efficiency and productivity gains in the irrigation sector. Also, the greatest possible gains can be made if the approach differs across irrigation districts. Because demand for irrigation water is determined by a myriad of factors that differ from district-to-district, approaches to modify irrigation water use, such as choice of economic instruments and best management practices, need to be tailored at a disaggregated level and should be mindful of the fact that best outcomes will be achieved by a combination of approaches across irrigation districts. Given these considerations, government should approach implementation of the strategy on a district-by-district and watershed-by-watershed basis, providing irrigators with an opportunity to participate in the strategy on a voluntary basis, with the expectation that results will be incremental.

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