Chapter III.

Scope and Methodology

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A. OBJECTIVES

The Irrigation Water Management Study Steering Committee was established in 1996 to provide direction to a four-year study of water management within the 13 irrigation districts of southern Alberta. The overall objective of the study was to provide accurate and reliable information on current and future water requirements and to identify irrigation water management practices required for sustainable irrigation within the districts. Sustainable irrigation implies an industry that is economically viable and profitable, and preserves natural resources and the environment for the benefit and enjoyment of future generations. This report, produced by the Steering Committee, details the state of the irrigation industry in southern Alberta, provides key information for AENV's water management planning process in the SSRB, and provides a basis for planning and decision making by government agencies and irrigation districts for the foreseeable future.

Specific objectives of the study were as follows.

1) Identify and quantify current irrigation water requirements, uses and efficiencies (on-farm and within the distribution systems) for the irrigation districts.
2) Quantify the changes in water management efficiencies and water use from those used in determining the 1991 *Regulation* licence volumes.
3) Quantify possible future irrigation water use based on:
    - changes in cropping types and mixes;
    - changes in farm irrigation management;
    - improvements in the on-farm and distribution systems infrastructure and management; and
    - information on leading edge management and equipment from similar irrigation regions in the United States.
4) Assess the potential for irrigation expansion, the associated risks of water shortages, and the impacts of shortages considering existing irrigation district licensed and reserved water volumes.
5) Develop leading edge computer tools to simulate district operations and enable districts to plan and refine operations and improve management of water supplies.
6) Identify and quantify the potential contribution of irrigation expansion toward achieving the province's business and fiscal goals.

The analytical tools and databases that have been developed enable individual irrigation districts to critically examine their current operations, refine water management practices, and plan for the future. In keeping with their newly-acquired independence under the Irrigation Districts Act, the districts hope to demonstrate to their water users the benefits and risks of expanding irrigation within the constraints of their licensed water allocations. It is hoped that with this information the respective district boards can make informed decisions on the limits of expansion. This information will also be used to demonstrate to the province the merits of additional water allocations for irrigation, should the province's SSRB water management planning process find surplus water is available in the South Saskatchewan River Basin.

*"**Sustainable development**: Development which ensures that the utilization of resources and the environment today does not damage prospects for their use by future generations."*

National Task Force on the Environment and Economy (1987).

B. ORGANIZATIONAL STRUCTURE AND FUNDING

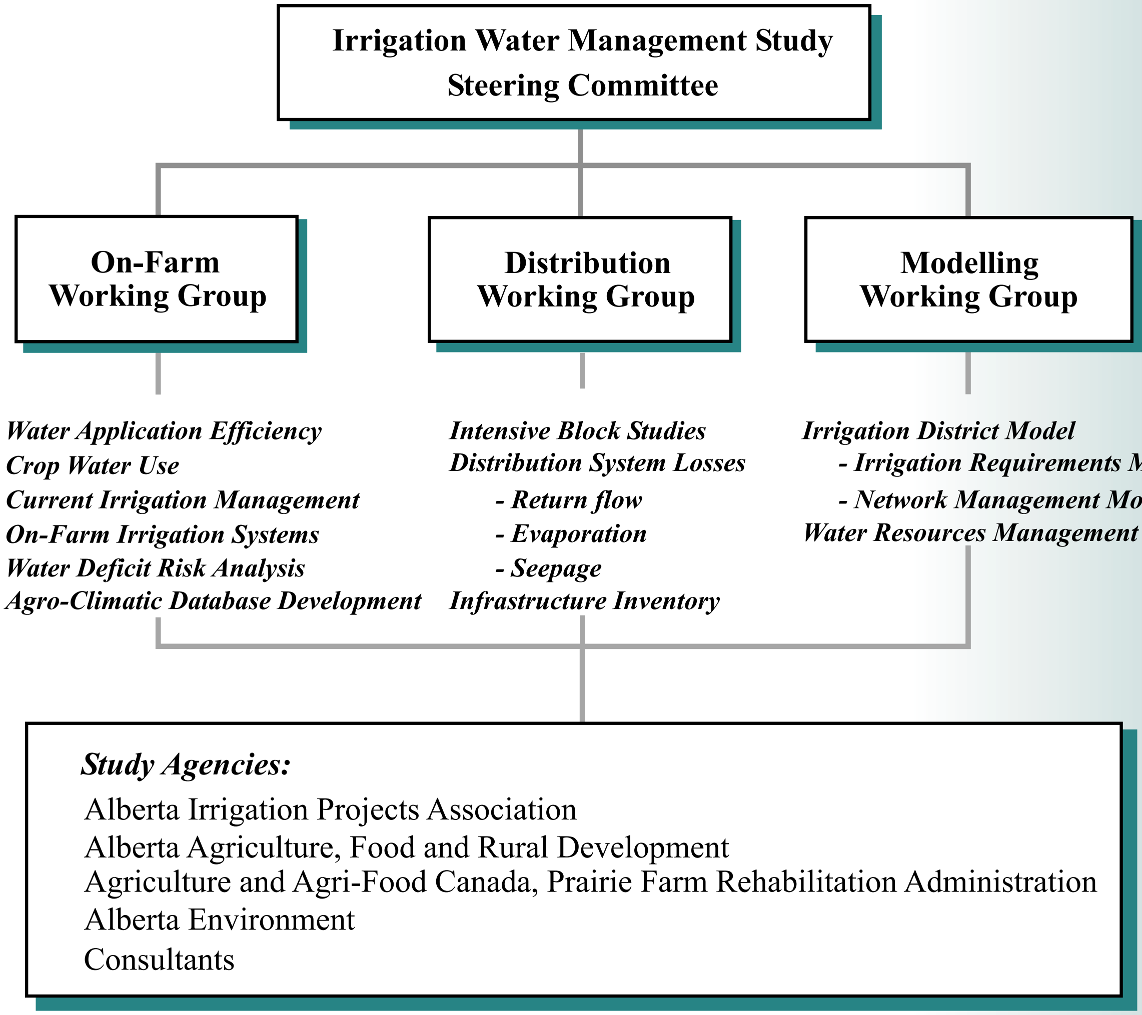
The Steering Committee was comprised of nine directors of AIPA, representing the 13 irrigation districts, three representatives from Irrigation Branch, AAFRD, and one representative from PFRA (Figure 5). A representative from AENV sat on the committee as a resource and liaison.

The committee identified three primary focus areas for research and technical analyses: On-Farm Water Use; Distribution System Efficiency; and Computer Modelling. Working groups were formed to coordinate research and studies in each of the focus areas.

Work was conducted by the staff of the irrigation districts, the Irrigation Branch, and AENV. In total, these agencies contributed more than $2.1 million in complementary, in-kind services.

Outside consultants were retained to undertake specialized tasks for the project. Funding for consulting services and instrumentation was provided by AAFRD, PFRA, and the irrigation districts, through AIPA. The irrigation districts invoked a special acreage levy to raise the required funds from their water users. In total, about $770,000 in funding was contributed by the three agencies, primarily for consulting services. During the course of the work, some of the irrigation districts contributed hundreds of thousands of dollars toward flow monitoring stations within their distribution systems and on return flow channels. In most cases, funding was provided through 75/25% province/district cost sharing under the Irrigation Rehabilitation Program. The data from these stations contributed greatly toward the Irrigation Water Management Study.

Work on the program was initiated in 1996 and was completed in 2001.



Steering Committee Membership

Brent Paterson	Alberta Agriculture, Food and Rural Development, Co-Chairman
Stan Klassen	Alberta Irrigation Projects Association, Co-Chairman
Rod Bennett	Alberta Agriculture, Food and Rural Development (former member Allan Herbig)
Wally Chinn	Alberta Agriculture, Food and Rural Development
Andrew Cullen	Agriculture and Agri-Food Canada, Prairie Farm Rehabilitation Administration
Earl Wilson	Eastern Irrigation District
Jim Brown	St. Mary River Irrigation District
Kevin Haggart	Lethbridge Northern Irrigation District (former member Rick Ross)
Keith Francis	Taber Irrigation District
Gordon ZoBell	Raymond Irrigation District
Andy Strang	Aetna Irrigation District
Henry Holst	Bow River Irrigation District
Jim Webber	Western Irrigation District
Doug Clark	Alberta Environment (resource and liaison)

Figure 5. Organizational structure for the Irrigation Water Management Study.

C. COMPONENTS OF THE IRRIGATION WATER MANAGEMENT STUDY

1. On-Farm Working Group

The On-Farm Working Group's overall objective was to refine estimates of crop water requirements, current irrigation water use and probable irrigation water use in the future, and to assess impacts of water shortages on crop production and financial returns to producers. The task was addressed in five component studies as outlined below.

a) Agro-climatic Database Development

Databases of climate or weather parameters that are fundamental to the understanding of crop water use and irrigation water requirements are commonly referred to as agro-climatic databases. They may be comprised of primary parameters, such as temperature, precipitation, wind speed and direction, and solar radiation, as well as calculated parameters, such as corn heat units and evapotranspiration.

Weather information in Alberta is collected by a number of agencies in different locations, for a variety of purposes. Using data from numerous sources, Environment Canada's Atmospheric Environment Service and Agriculture and Agri-Food Canada's Research Branch worked together to develop a systematic grid of weather data points across the Canadian prairies. This database, called the Gridded Prairie Climate Database (GRIPCD), is designed as a common source of baseline information available for use by researchers and practitioners involved with agriculture and climate change. The grid points are spaced at 50 km intervals. However, the GRIPCD database does not include potential evapotranspiration, a parameter of key importance for the determination of irrigation water requirements.

The primary objective of this component of the Irrigation Water Management Study was to develop a database to complement GRIPCD that would provide a basis for daily, crop-specific evapotranspiration computations for the period 1920 to 1995 for the irrigated area of southern Alberta. Databases for growing season precipitation, net moisture deficit, corn heat units, and frost-free periods were also developed.

The task involved reviewing various equations for computing evapotranspiration for a high water use crop similar to alfalfa, selecting the equation that best correlated with research data, and computing evapotranspiration at the grid points using GRIPCD data and derived data where information gaps existed. Maps showing the distribution of evapotranspiration and other agro-climatic parameters throughout southern Alberta were prepared.

The expanded GRIPCD database was used to estimate irrigation demands and losses for computer modelling.

b) Crop Water Use

Crop water requirements for irrigation in southern Alberta have been determined based on field monitoring and research conducted in the 1960s and 1970s, with the prevailing irrigation management and technology. Irrigation systems and management practices have since changed, and new crop varieties have emerged. The working group updated crop water use data based on the current state of irrigated agriculture. Alfalfa is grown on more irrigated land than any other crop, and is the largest water consumer. It was selected to represent high water use crops in southern Alberta.

Research plots, using an emerging alfalfa variety, were developed at three sites: Picture Butte, Bow Island and Rolling Hills (Figure 6). Several different irrigation management regimes, representing advanced irrigation technologies, were tested in four replicated, randomized plots. Five irrigation water treatments were used, each treatment initiating and ceasing irrigation when soil moisture in the root zone met various percentages of field capacity. Water rationing was considered in two of the five treatments. Neutron probe readings were taken to measure soil moisture conditions and water use throughout the growing season. Water wells were established to monitor deep percolation beyond the root zone.

Crop yields for each water treatment were determined based on a three-cut system of harvesting. The program included soil classification, soil sample analyses, and determination of soil moisture holding capacities. Root mass and development were determined for each water treatment.

Results of this work were used to improve estimates of crop water requirements for computer modelling.

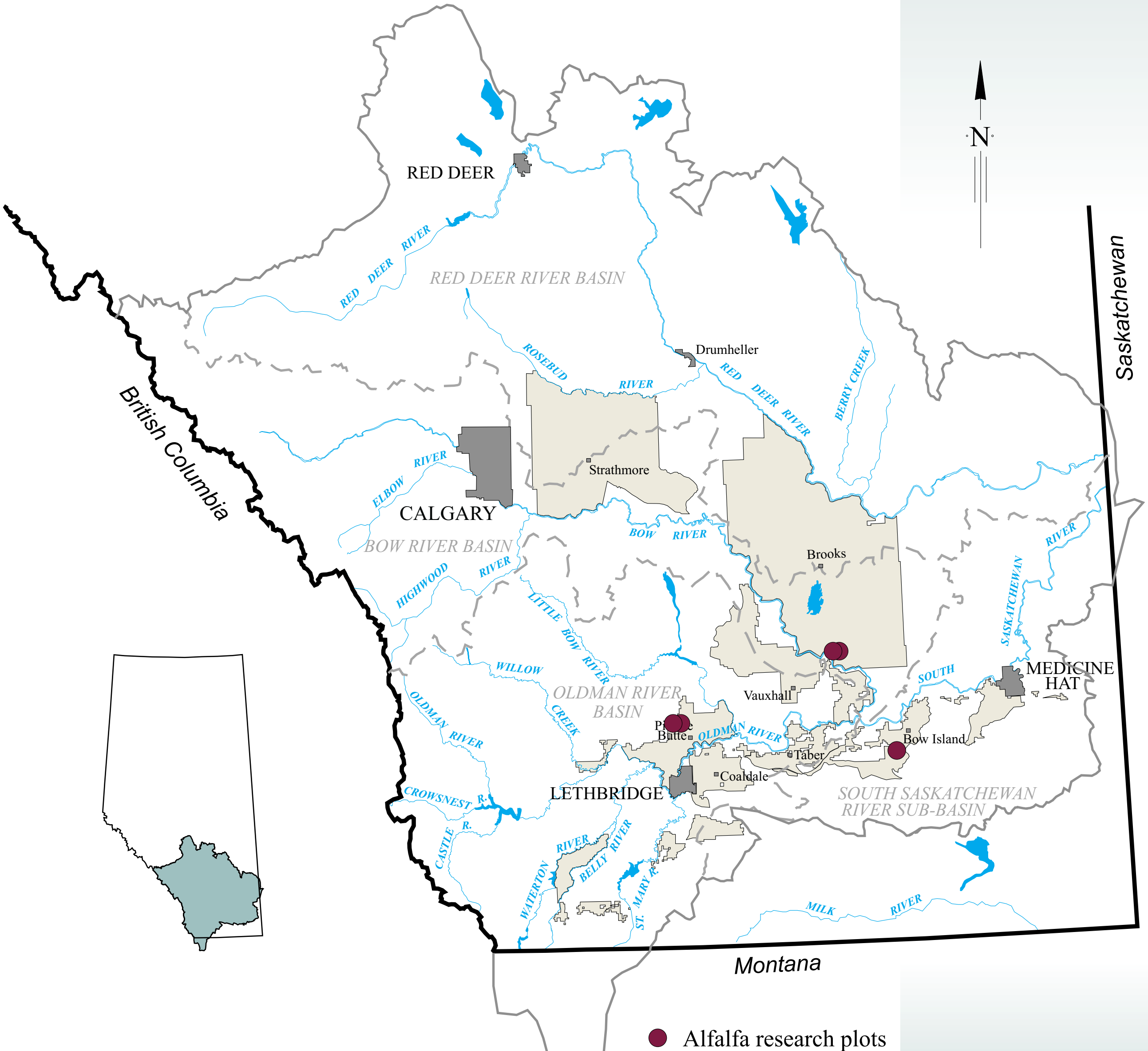


Figure 6. Locations of alfalfa research plots.

c) Irrigation Water Management Practices

Past studies have noted that irrigation water users were applying less water to their crops than required for optimum production. However, it was believed this practice was changing as technology improved. The objectives of the irrigation water management practices component of the study were to obtain an indication of the extent to which contemporary irrigation water applications compare with that required for optimum production, and to estimate possible ultimate irrigation applications with further improvements in on-farm management.

Monitoring sites were established on approximately 60 fields each year (Figure 7). Sites were selected to provide a cross-section of grain, forage, oilseed and specialty crop types, a variety of irrigation systems, and a random selection of irrigation managers. The intent was to conduct monitoring without influencing the normal irrigation management decisions of the producers. Monitoring was conducted from 1996 to 2000.

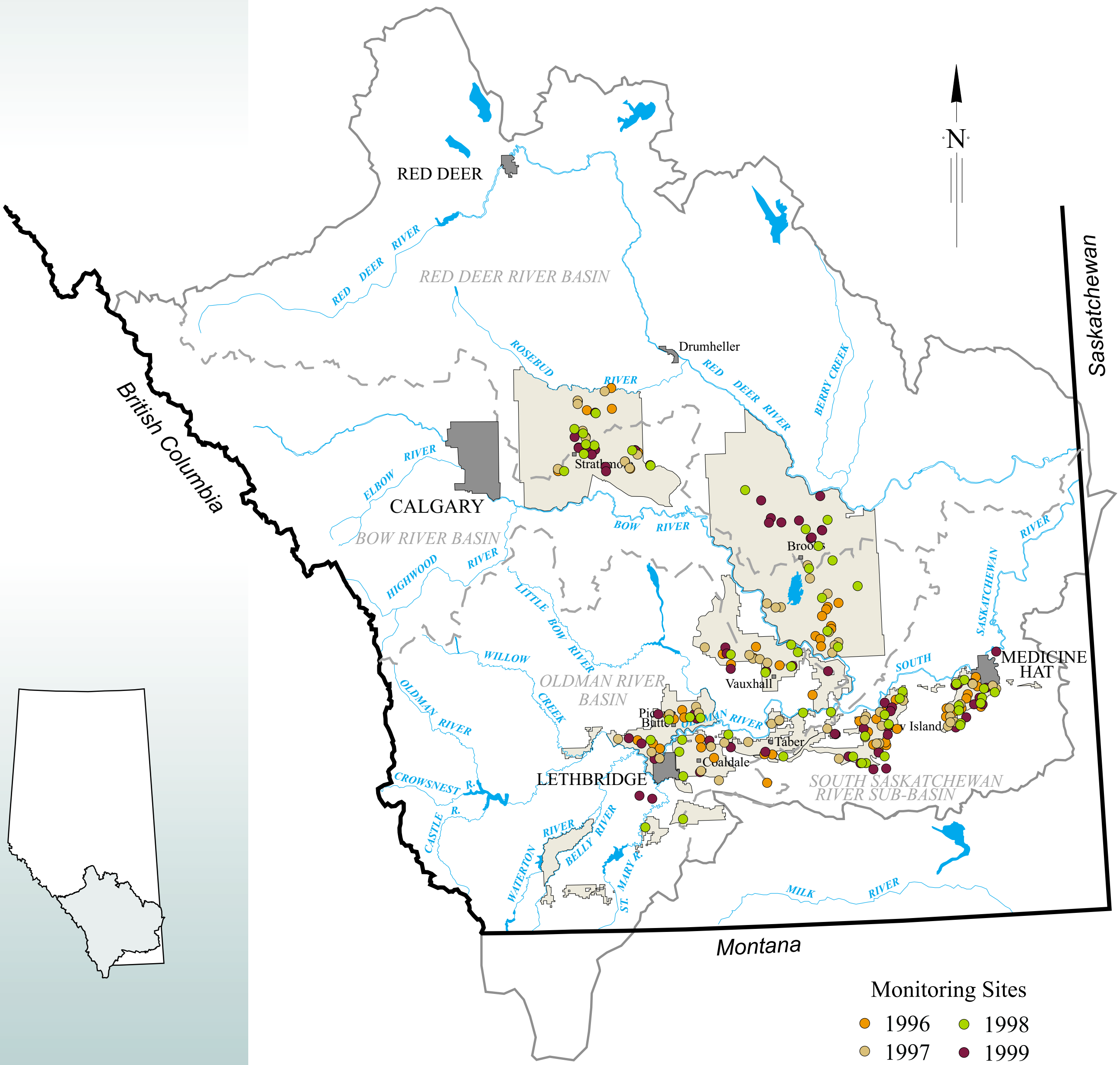


Figure 7. Irrigation management monitoring sites.

Parameters monitored included:

- Field soil moisture;
- The timing of irrigation events and the quantities of water applied;
- Agro-climatic data, including precipitation, maximum and minimum temperature, solar radiation, humidity, and wind travel; and
- Crop yields.

UMA Engineering Ltd., Calgary, was retained to conduct a literature search of current irrigation management strategies from recognized institutions and agencies across North America. The information was used to compare irrigation water requirement values used in Alberta with those across North America, and to provide insight into leading edge technology and irrigation water management that may be applicable to Alberta in the future.

d) On-Farm Irrigation System Efficiencies

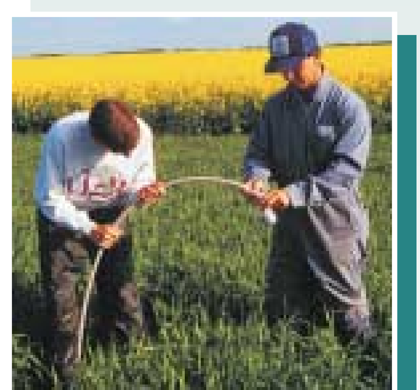
The total quantity of water diverted by an irrigation district is highly influenced by how efficiently irrigation farmers apply the water to the land for use by the crop. Improvements in on-farm efficiency offer significant potential for freeing up a portion of licensed quantities for expansion of the irrigated area. Key factors affecting on-farm efficiency are irrigation methods, the types of irrigation equipment used, and on-farm management practices.

AAFRD has maintained an inventory of on-farm irrigation methods and equipment since 1981. This database has recently been modernized and expanded through involvement of irrigation district staff and the use of electronic data collection and retrieval equipment. The efficiencies of conventional on-farm equipment have been estimated, based on monitoring, literature searches and experience.

Modern equipment with improved technologies has become increasingly efficient. On-farm equipment choices can offer significant water saving opportunities. Intensive field testing of several centre pivot sprinkler systems with various types of emerging equipment was conducted to determine "ultimate" water application efficiencies. Efficiencies of leading-edge equipment were compared to that of conventional systems to determine potential water gains. The project was conducted with participation of a local irrigation equipment dealer and the Blood Tribe Agricultural Project.

A variety of application devices were installed on centre pivot systems for testing at 12 sites. Sites were located on typical level and sloping topography. Agro-climatic and soil moisture conditions were monitored. The net beneficial catch of water within the root zone was determined.

A literature search was conducted to update the information base on North American irrigation systems and trends.



e) Risk Assessment

Major incentives for expanding irrigation are to improve the viability of individual farming enterprises, to increase the efficiency and economic viability of irrigation districts, and to contribute to the economic and social objectives of the province. As irrigated areas expand within districts, the risk of water shortages to individual users may increase. When shortages are experienced, there will be reductions in crop yields and/or quality, and associated reductions in economic returns. There could also be secondary impacts on value-added industries.

The objective of the risk assessment component was to develop a computerized Farm Financial Impact and Risk Model (FFIRM) that would enable an analyst to examine the economic impacts of a variety of water shortage scenarios, coupled with a variety of on-farm operational and financial characteristics.

A range of water shortage scenarios was provided as output from the Irrigation District Model (IDM) and the Water Resources Management Model (WRMM). Key characteristics of water shortages defined in output from the models were considered in the risk assessment. These included magnitude, frequency, duration (number of consecutive years of shortages), and timing of shortages. An irrigation management factor that recognized the degree to which water applications by irrigation water users compared to that required for optimum yields was also used in the risk analysis.

It was essential that the FFIRM be sensitive to a variety of agricultural production, operation and farm financial circumstances which could be specified as input values. These include:

- Agro-climatic conditions;
- Irrigation water supply characteristics;
- Crop mixes;
- On-farm irrigation systems;
- Energy sources;
- Farm equity conditions;
- Crop prices;
- Crop production costs; and
- Target crop yield or expectations.

Output from the FFIRM included yield, quality and economic value of farm production, production costs, and impact on farm operations.

Information generated by this model can be used by individual irrigation districts to make difficult management decisions related to irrigation expansion and operations within the districts. These decisions may involve compromises and trade-offs related to matters such as water supply security, financial risk, water rationing, and distribution of impacts.

2. Distribution Working Group

The overall objective of the Distribution Working Group was to determine the physical and operational characteristics of infrastructure within the irrigation districts, and to identify and quantify opportunities for continued improvements in water management efficiencies. The results of this work were needed to calibrate the IDM and to provide insight into the ultimate water savings that could be realized through infrastructure improvements and operational adjustments within districts. The task was addressed under four component studies as outlined below.

a) Irrigation Block Studies

Two irrigation blocks were established and fitted with a variety of monitoring equipment to record inflows to and outflows from the blocks, and flows to and from individual farm units within the blocks.

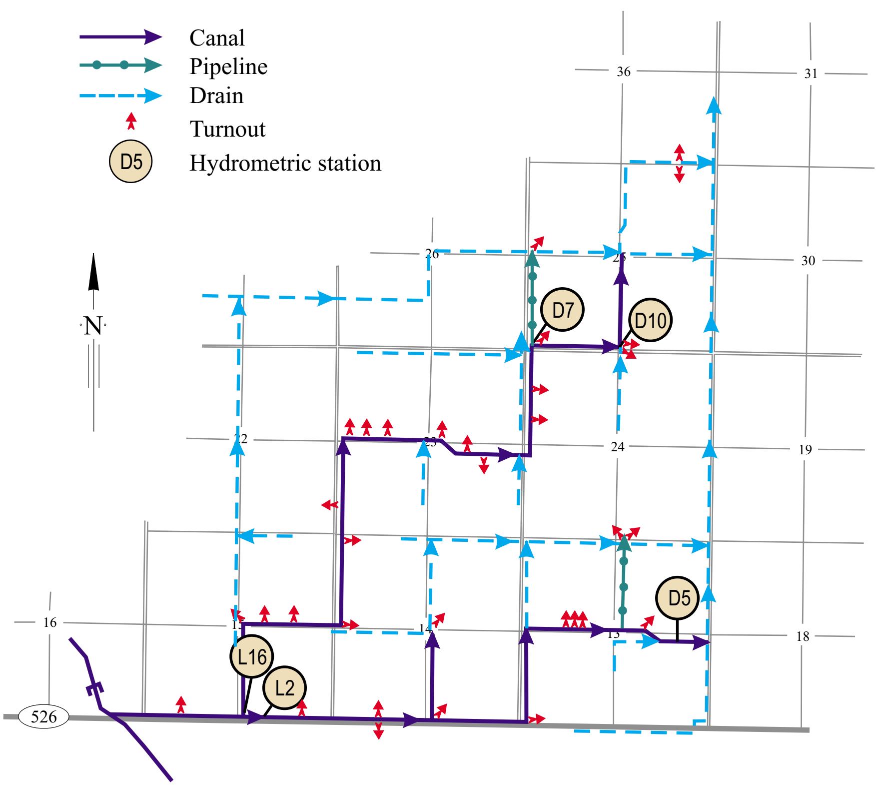
Block K5 was established within the BRID in 1994 (Figure 8). It has an area of 1,467 hectares, about half of which is irrigated by surface methods and half by sprinklers. Block J12, with an area of 1,435 hectares, was established within the LNID in 1995. It is irrigated entirely by sprinkler systems.

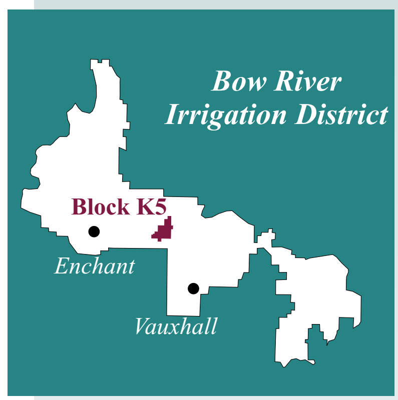
Data collected included crop type, on-farm irrigation system, field area, weather, canal capacities and farm management characteristics. Flow data were collected at 20-minute intervals at turnouts, drains and spill channels.

Inflows and outflows were monitored on two larger blocks, Block B in the BRID and Block K in the LNID, to further assist in calibrating the IDM. Each of these larger blocks contain within them the more intensively monitored smaller blocks. Information from all blocks was used to relate area irrigated, on-farm water management, and irrigation methods and systems to flows within the distribution systems. Model output was compared with recorded flows and appropriate calibration adjustments were made.

b) Canal Seepage

Seepage from canals is wasteful. More importantly, it may lead to waterlogging and/or salinity of productive agricultural lands. The Moritz formula, recommended by the United States Bureau of Reclamation, was used to determine the canal seepage component of water allocations associated with the 1991 *Regulation*. However, it was felt that local research could improve the estimates of seepage losses. Ponding tests were conducted to provide estimates of seepage losses that could be expected from both rehabilitated and un-rehabilitated, unlined, earthen canals.





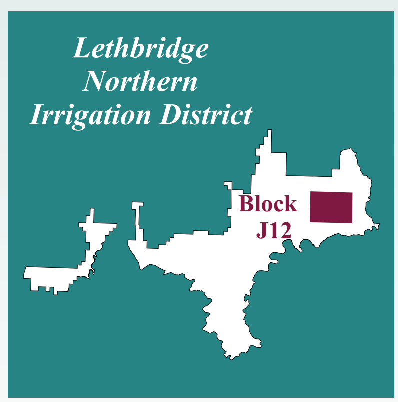


Figure 8. Intensively monitored Block K5 in the BRID.

A literature search was carried out to compile information on seepage coefficients and to guide field testing procedures. Twenty-nine ponding test sites were carefully selected to represent a variety of typical soil conditions and canal characteristics (Figure 9). Tests involved constructing earth plugs at the ends of 150-metre long canal sections. The isolated sections were filled with water to their operational depth. Water levels were recorded for five to 22 days. The drop in water level was adjusted for evaporation and precipitation, and seepage was computed in terms of cubic metres of water lost per square metre of wetted area per day. This can be reduced to metres per day.

The computed seepage losses from the test sites were used to estimate seepage losses in each of the 13 irrigation districts based on the inventory of canal characteristics and soil texture. It was assumed seepage would be zero for canals with plastic lining and for pipelines.

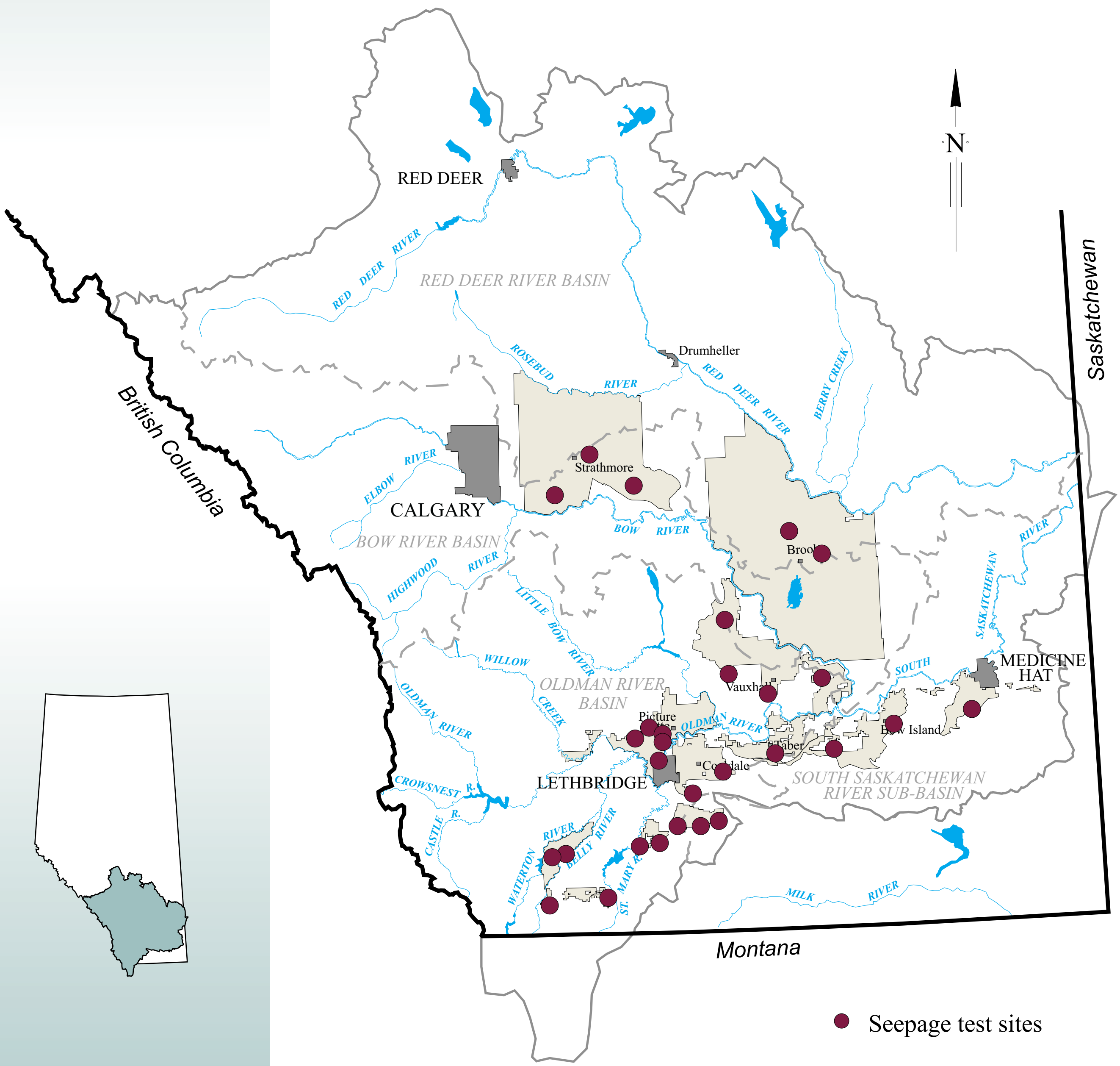


Figure 9. Seepage test sites.

c) Canal and Reservoir Evaporation

Although usually a small component of conveyance losses in a distribution system, canal evaporation was accounted for in modelling the irrigation districts. Evaporation from large storage reservoirs can be significant and was also considered.

A review of various methodologies was carried out to determine an appropriate approach for computing evaporation losses from canals and reservoirs. The irrigation districts have established nine weather stations and 34 rain gauges to supplement the existing agro-meteorological network. Data from these stations were standardized and converted to a format that could be used in the model.

d) Irrigation Return Flow

Return flow from irrigation districts is a major consideration in the quest to make additional water available for expanding the irrigated area within districts. Additional return flow data were required to gain a better understanding of the amount of return flow from the districts, its variability, its components and cause and effect relationships. The information was required to calibrate the IDM and to determine the extent to which reductions in return flow are possible.

Five irrigation districts (BRID, EID, LNID, SMRID and TID) established 15 inflow and 87 return flow stations to provide data for return flow analyses (Figure 10). Additional information was collected in the irrigation block monitoring programs. MPE Engineering Ltd., Lethbridge, was retained to develop standards for data collection, storage and handling, to maintain quality control, and to ensure the data were in a form that could be readily used in modelling (MPE Engineering Ltd. 1997).

The impacts of rainfall on return flow were reviewed to determine their significance and to assess the validity of algorithms used in the model.

3. Modelling Working Group

The objective of the Modelling Working Group was to develop and calibrate computer models that could be used to reliably simulate a range of water supply and demand conditions. The simulations were required to test a variety of crop type and on-farm water management scenarios and district operational strategies. The model output will assist government and irrigation district decision-makers to make informed decisions related to long-term planning and development, as well as in their day-to-day operations. The implications of various levels of irrigation expansion, within the constraints of existing district licences and reservations, were explored.

Computer simulation modelling of water demand and supply is an essential analytical technique for assessing water management options and optimizing the performance of complex water management systems. In the Irrigation Water Management Study, simulation models were used to compute water demands, water deliveries required to meet those demands, stream flows, canal flows, losses and reservoir levels for various scenarios of development, management options and operational policies. The models developed were sufficiently flexible that they could be used for both long-term planning and day-to-day operational purposes.

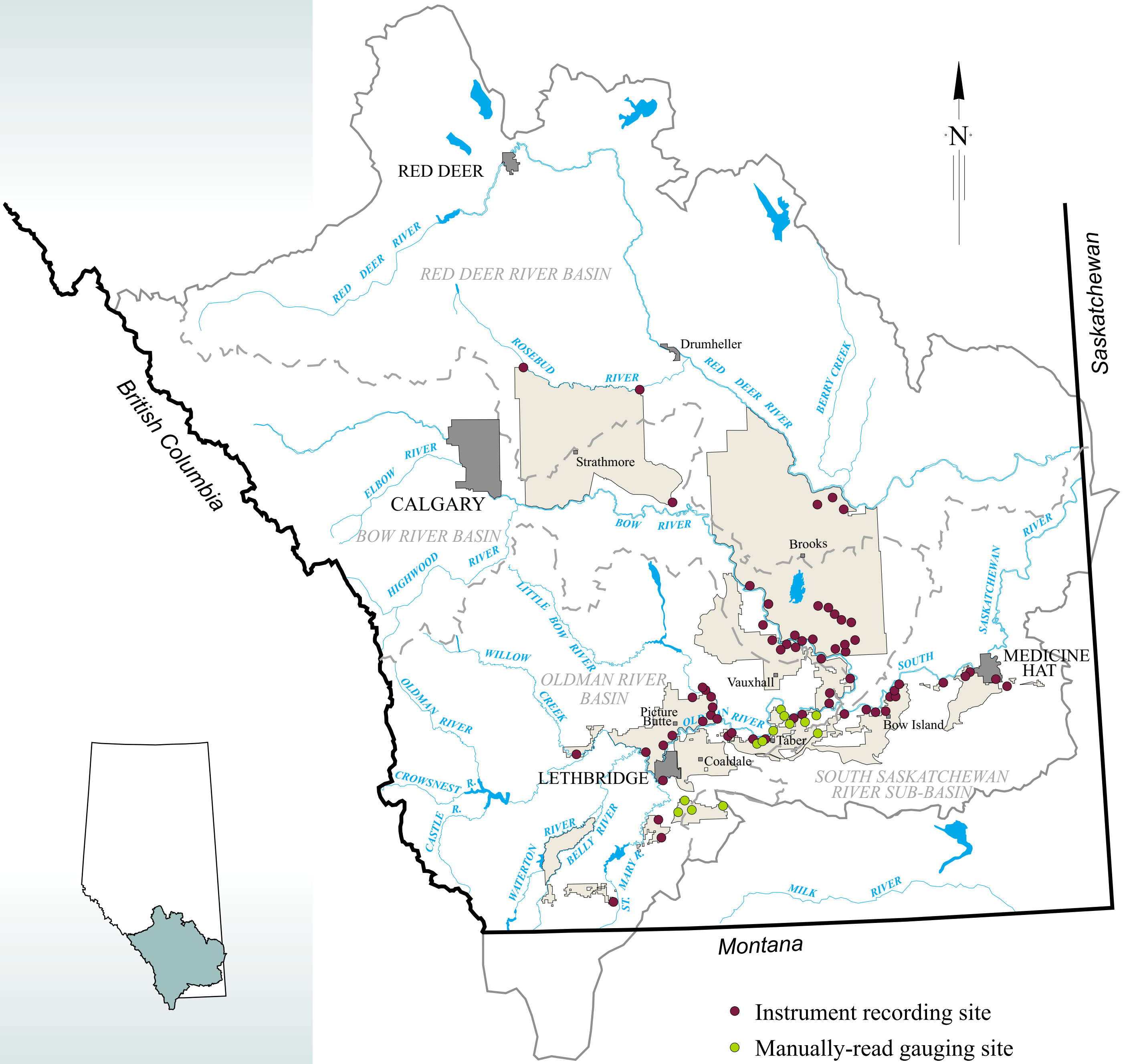


Figure 10. Return flow monitoring stations.

Simulation modelling for planning purposes was conducted over a historical period of stream flow and climatic conditions. The output (water deliveries to meet demands, stream flows, reservoir levels, canal flows) represented what probably would have occurred if the management scenario had been in place during the period simulated. The simulation period was long enough, and comprised representative sequences of high and low stream flow and demand conditions, so statistical analyses of the model output could assess the performance of the system, the benefits of the scenario being tested, and its social and environmental impacts.

The amount of water that Alberta can consume or store from the South Saskatchewan River system is limited by terms of the Prairie Provinces Water Board Master Agreement on Apportionment. In general, this agreement stipulates that Alberta must allow at least one half of the natural flow of the South Saskatchewan River, which includes the Red Deer, Bow and Oldman Rivers, to flow into Saskatchewan each year. Because of the apportionment commitments, water management and planning in the Red Deer, Bow and Oldman River basins are inextricably linked. Development in any of the three basins can affect existing or future development in the other two basins. In assessing management options where water supply is an issue, it is essential that simulation modelling include the entire SSRB.

The SSRB is large and some parts of the basin are intensively developed. Water management is facilitated through a complex system of physical works, legal and institutional arrangements, operational procedures and constraints. The size of the basin and the complexity of its water management are such that it cannot yet be simulated using one, all-inclusive computer model. A nesting approach has been taken, whereby some parts of the basin are modelled separately from others. Smaller, more detailed models feed into larger models. For each scenario simulated, this approach may require two or more iterations before the analyst is assured the objectives of the model run are met to the utmost degree possible.

Models that were developed (or refined) and used in a nesting approach in this study are the Irrigation District Model (IDM), which includes the Irrigation Requirements Module and the Network Management Module; the Water Resource Management Model (WRMM); and the Farm Financial Impact Risk Model (FFIRM). FFIRM was discussed earlier. The IDM and the WRMM are discussed below.

a) Irrigation District Model (IDM)

An irrigation requirements model was initially developed by Alberta Environment primarily to generate irrigation demands for use in the Water Resources Management Model (WRMM). In late 1994, the model was turned over to AAFRD for further development and support. Phoenix Engineering Inc. was retained to thoroughly review the model logic, and make it more flexible and user friendly. A specific objective was to make the IDM a useful decision support tool for both day-to-day operations and long-term planning.

The IDM is comprised of two integrated modules. The Irrigation Requirements Module contains meteorological and field-based data needed to determine farm delivery requirements. The Network Management Module represents the physical characteristics of each district, including pipelines, canals, reservoirs and return flow channels, and their respective operating characteristics and losses. The Network Management Module combines the demands from the Irrigation Requirements Module, and converts them into the canal flows and diversions required to meet the demands.

The task of the Modelling Working Group was to review all aspects of the modules to ensure they were technically sound, flexible, user friendly and properly interfaced so they could be conveniently used with other models.

A major task carried out to support the Irrigation Requirements Module was a detailed inventory of all on-farm irrigation systems and associated crop types. An interface program was developed to ensure irrigation districts' staff compiled data for every system and crop type within their respective districts in a model-compatible format.

Pilot trials using software from various districts led to several modifications and enhancements. The final product is a powerful database that will serve a variety of needs within the irrigation districts.

In addition, all irrigation districts and AAFRD committed considerable staff resources to develop an updated database on infrastructure locations and characteristics within the districts. A standardized GIS (Geographic Information System) format was used for the database. The IDM can tap this database for use in the Network Management Module.

b) Water Resources Management Model (WRMM)

The WRMM has been used extensively over the past 15 years, primarily by Alberta Environment, as the key analytical tool to assist in developing long-term plans, as well as to address current water management issues in the SSRB. The model has continuously been updated and improved. The WRMM (and its sub-models) models the entire SSRB, including all major storage reservoirs, diversions, water uses and apportionment commitments. Licence priorities are modelled for major water allocations. The model operates on a weekly time step for the historical period of stream flow and climatic conditions from 1928 to 1995. It will be used extensively in the province's SSRB water management planning process led by AENV.

Because of the number of scenarios simulated with the IDM and the WRMM, the Modelling Working Group made every effort to ensure the configurations and operating modes of the two models were compatible, and the interfaces were completely seamless.

D. SIMULATION MODELLING

The Irrigation Water Management Study included simulation modelling to determine the following.

- The significance of changes in crop mixes, on-farm management improvements and irrigation equipment, and future related trends.
- The significance of improvements in the distribution system and district water management, and related trends.
- The frequency and magnitude of water shortages and their impacts on producers at various levels of irrigation expansion, considering existing irrigation district licence amounts and reservations.

Modelling conducted in this study is integrated with that conducted in AENV's SSRB water management planning process.

Simulation modelling in this study used the following assumptions.

- The rights and priorities of existing licences and licence-holders were recognized and adhered to.
- Alberta's interprovincial apportionment commitments were respected.
- Allowance was made for future municipal and industrial water demands.
- All established instream flow objectives were considered.
- Private irrigation demands included the existing licensed area and reservations for new irrigation blocks as defined in the 1991 *South Saskatchewan Basin Water Allocation Regulation*.
- No new provincial flow regulation works were considered beyond the existing and committed works.

Each planning scenario consisted of basic criteria, which included crop mix, on-farm equipment mix, on-farm management capability, distribution system efficiency, and irrigated area within the districts. The modelling tools were applied in a cycle comprised of the following steps (Figure 11).

- The ideal irrigation demands were generated by the Irrigation Requirements Module.
- The ideal water delivery requirement was generated at main delivery points by the Network Management Module.
- The ideal water delivery requirement was input into the WRMM to determine if the requirement could be met, considering the hydrology, water demands, priorities, flow regulation capabilities and apportionment commitments in the SSRB. The WRMM output identified the frequency and magnitude of deficits in delivery of the ideal requirements.
- The deficits were input to the FFIRM to determine their financial impact.

Phoenix Engineering Inc. and AAFRD staff conducted the IDM and FFIRM runs. AENV staff conducted the WRMM runs.

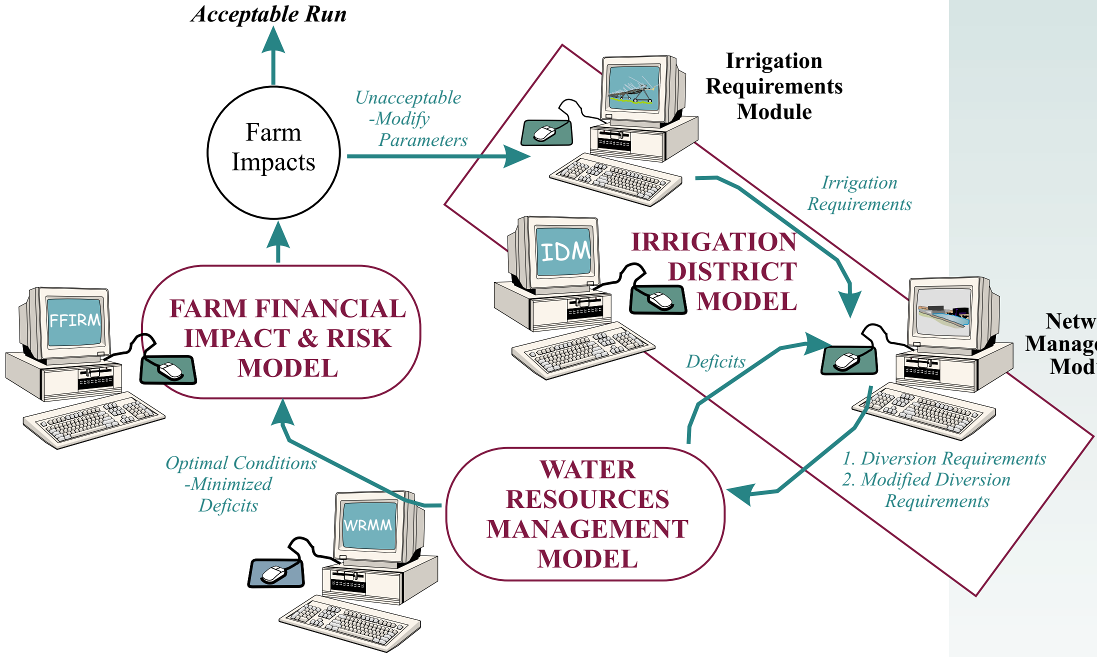


Figure 11. Inter-relationships among IDM, WRMM and FFIRM.

E. LIMITATIONS OF THE IRRIGATION WATER MANAGEMENT STUDY

The Irrigation Water Management Study focused primarily on irrigation within the 13 districts of southern Alberta. There are a number of peripheral or related issues that were not addressed. Following is a discussion of five such issues.

1. Private Irrigation

There are more than 2,500 private irrigation projects in Alberta, about 80% of which are in the South Saskatchewan River Basin (Figure 12). The rate of growth of private irrigation has followed a pattern similar to that of the districts, with very rapid expansion in the 1970s and early 1980s, attributed largely to advances in sprinkler irrigation technology (Figure 13).

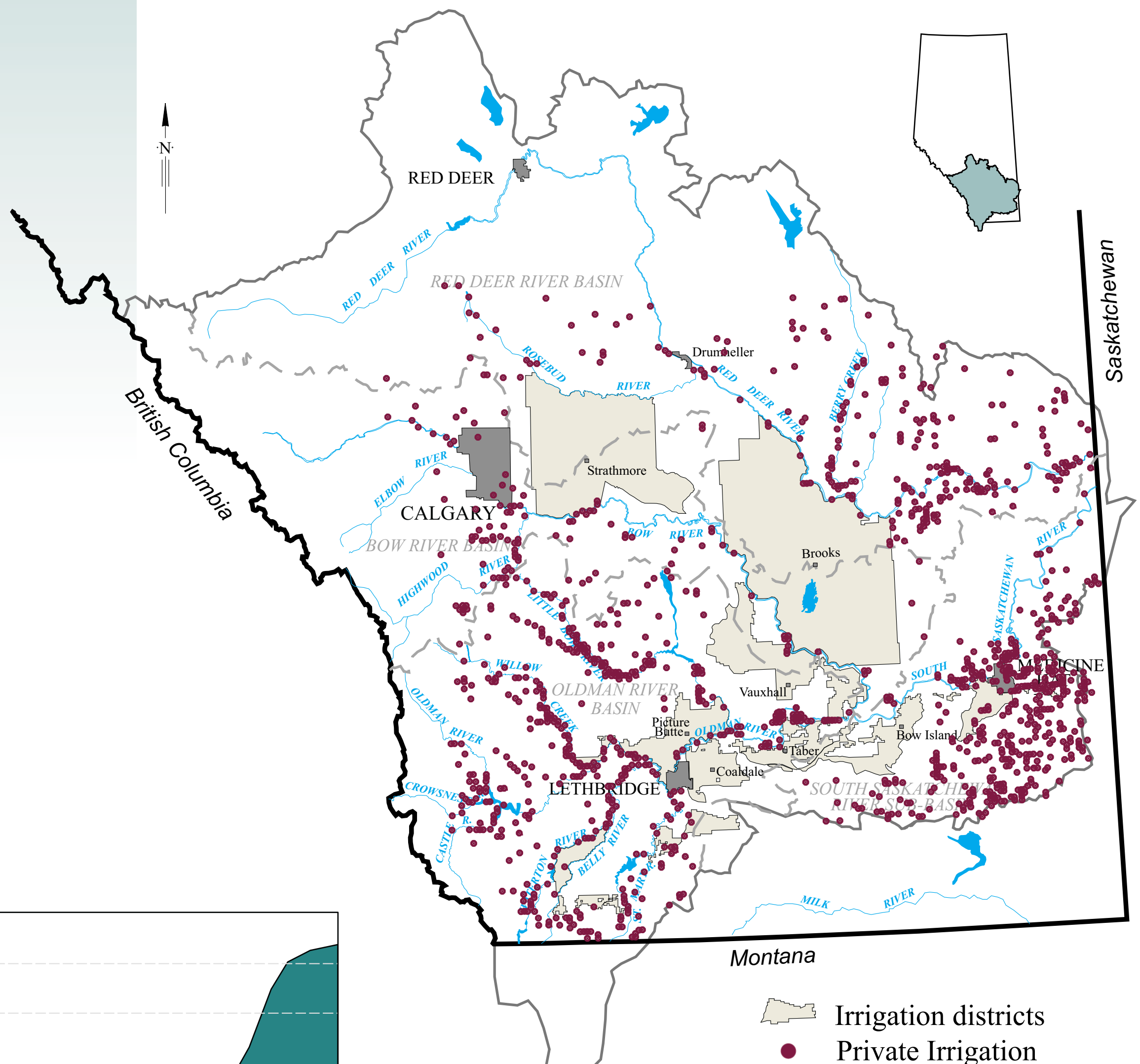


Figure 12. Private irrigation projects in the SSRB.

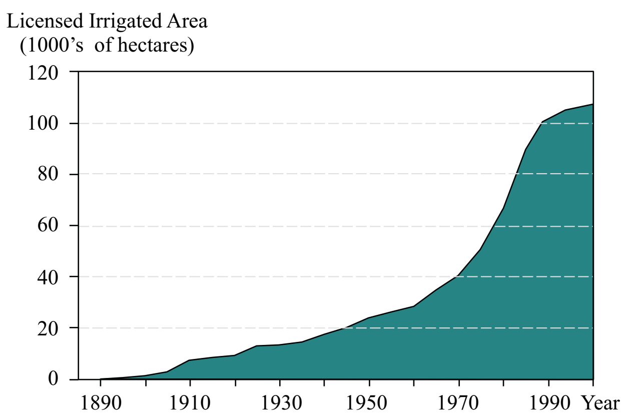


Figure 13. Growth of private irrigation in Alberta.

Since 1991, private irrigation expansion has been controlled by the *South Saskatchewan Basin Water Allocation Regulation*. The licensing authorities consider projects only in areas and up to limits defined in the *Regulation*. Water has been specifically reserved for 10 named projects in the basin (Table 5). Some of these projects may eventually become irrigation districts, or may be absorbed into existing districts.

While the Irrigation Water Management Study did not analyse the characteristics and prospects for private irrigation, information generated in the study helped to define crop types, water uses and efficiencies for private projects. The potential evapotranspiration, growing season precipitation and moisture deficit maps are directly relevant to private projects, as well as district irrigation.

All licensed private projects and all named projects in the *South Saskatchewan Basin Water Allocation Regulation* are included in simulation modelling. Variable water demands for licensed and future projects were estimated by AAFRD, based on the agro-climatic database and regional crop mixes.

Table 5. Private irrigation projects identified in the SSRB Water Allocation *Regulation*.

Project Basin / Name	Project Size (ha)	Current Status [1] (size in hectares)	
Red Deer River Basin		*Regulation* Limit for Private Projects	39,256
		Licensed Private Projects [1]	13,881
Special Areas Water Supply Project	10,118	Feasibility studies underway.	
Bow River Basin		*Regulation* Limit for Private Projects	38,447
		Licensed Private Projects [1]	15,540
Siksika Nation	6,070	Feasibility confirmed. Discussions underway.	
Little Bow / Clear Lake	8,094	Storage reservoir under construction.	
Keho / Barons North	4,047	Inactive.	
Oldman River Basin		*Regulation* Limit for Private Projects	61,514
		Licensed Private Projects [2]	37,354
Blood Indian Reserve	10,118	Licensed: 10,118 Developed: 8,094	
Peigan Indian Reserve	6,070	Under negotiation with Province.	
Keho / Barons South	4,047	Feasibility confirmed. To become part of LNID.	
Western Oldman Water Users	2,428	Individual projects. Licensed : 985	
Oldman River Reservoir Area	6,070	Individual projects. Licensed: 1,025	
Willow Creek	5,261	Reservoir filling underway. Licensed: 87	
South Saskatchewan River Sub-basin		*Regulation* Limit for Private Projects	21,044
		Licensed Private Projects	19,507
South Saskatchewan River Basin Total	62,323	*Regulation* Limit for Private Projects	160,261
		Licensed Private Projects[1,2]	86,282

[1] Current licensed area based on March, 2000 records, Alberta Environment. Licensed areas may change daily.
[2] Includes licensed area within Western Oldman and Oldman River Reservoir named projects.

2. Non-irrigation Uses in the South Saskatchewan River Basin

The Irrigation Water Management Study does not address future non-irrigation uses in the SSRB. These uses will be addressed in AENV's SSRB water management planning process.

AAFRD, working with AENV, conducted simulation modelling to test various scenarios of water use within the irrigation districts. For purposes of this modelling, an "allowance" was made for future non-irrigation uses. Instream flow needs in the SSRB were included, based on the best information available to AENV at the time of the modelling. This is not intended to preclude modelling that will be required during the course of AENV's planning process. Nor is it intended to circumvent AENV's responsibility for decision making nor to fetter its ultimate decisions. The allowances for non-irrigation uses may be modified during the course of AENV's planning and associated public consultation process.

3. Non-irrigation Uses through the Works of the Irrigation Districts

In addition to providing water to irrigation water users, the districts' systems of canals, pipelines and reservoirs are used to provide water for a variety of other purposes. For instance, the SRMID has 495 domestic users (including 5 water co-ops and 3 grazing associations), 37 industrial users, and 12 municipal users that are supplied water through district works. The BRID supplies water to 43 non-irrigation licensees, (including 7 municipal, 17 stock water, 2 water co-op, 4 industrial, 8 water fowl conservation, and 5 recreation licences). The total licensed quantity for the non-irrigation projects within the BRID is about 4,070 cubic decametres, or less than 1% of the district's licensed volume.

Non-irrigation withdrawal uses through the works of the districts require a licence under the Water Act (formerly the Water Resources Act), and an agreement between the licensee and the district. The licenced volume authorizes a diversion from the source that is in addition to the volume licensed to the district.

The total licensed volume for non-irrigation uses in the 13 districts represents a small percentage of the total volume licensed for irrigation. However, it is significant that supplying water to many of these users requires special operating procedures and results in water losses and return flows that would not otherwise be experienced. The impacts of supplying non-irrigation uses on the districts' operations and water use efficiencies have not been quantified.

Non-withdrawal uses are usually not licensed. A study by Alberta Environment (AENV 1989) determined there are more than 70 recreation sites on reservoirs that were constructed primarily for irrigation purposes. Several reservoirs are being used for commercial fishing (Lake Newell, McGregor Lake, and others). There are numerous wildlife conservation projects that rely on irrigation infrastructure for their water supply – some of these are licensed, others are not. While these non-withdrawal projects generally do not have a licensed allocation, their existence affects how the reservoirs are operated, and may affect district water losses and return flows.

It is difficult to determine the total impacts of non-irrigation uses on district operations, water losses and return flows. These impacts have essentially been ignored in the simulation modelling and in determining the efficiencies of irrigation water use.

The relatively small quantity licensed to non-irrigation users belies the significance of the irrigation infrastructure in providing water for these uses, as well as the non-withdrawal uses. The irrigation infrastructure allows industries to locate where they might not otherwise locate, improves the distribution of stock water, permits better use of grazing lands, secures good quality water supplies for communities, provides recreational opportunities that otherwise would not exist, and secures water supplies for wildlife projects.

4. Water Management Headworks Losses

By the early 1970s, the main supply works that conveyed water from the source streams to the irrigation districts were in a serious state of disrepair. Rehabilitation of these works was beyond the fiscal capabilities of most districts. In 1975, AENV committed to take over all major onstream headworks and to assume responsibility for operation, maintenance and rehabilitation. The Province's objective was to operate these works "to maintain a secure and continuous supply of water" for multi-purpose use. AENV negotiated takeover agreements with all districts except the EID and UID. Negotiations with the UID are continuing.

The headworks are comprised of about 330 km of canals, three onstream storage reservoirs and eight offstream storage reservoirs. These works have seepage and evaporation losses. In the Irrigation Water Management Study, these losses are not included in analysis of the irrigation district water demands and efficiencies for the following reasons.

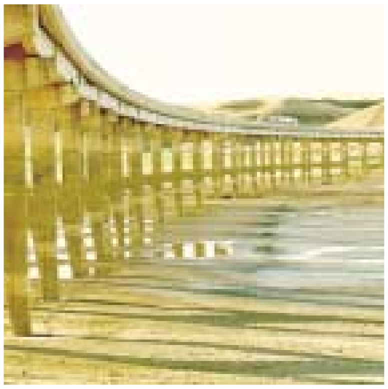
- The headworks are intended for multi-purpose use, not solely for irrigation.
- The headworks licences issued to AENV for the Lethbridge Northern Headworks, the Waterton-St.Mary Headworks and the Oldman River Dam include relevant losses.
- The licences issued to the irrigation districts (with one exception) and the 1991 *Regulation* licence volumes were based on crop water requirements, losses due to district works, and return flows. Headworks losses were not included. The only irrigation district licence that includes headworks losses is that issued to the BRID in 1982.

Headworks losses must be considered in evaluating the water supply potential of the source streams and assessing the risks of irrigation expansion. Losses are, therefore, included in all simulation model runs conducted by AENV.

5. Climate Variability

The performance of the water supply system during droughts, such as those sometimes experienced in the SSRB, is a key factor in determining irrigation expansion potential. The characteristics and impacts of such droughts on large water management systems are often addressed through simulation modelling, using a recorded period of streamflow and weather conditions. The approach infers that the performance of the system during a lengthy period of recorded conditions provides insight into how well the system might perform in the future.

However, three significant issues must be considered in interpreting the results of simulation modelling based on historical records of streamflow and weather conditions in the SSRB.



a) Historic Climate Variability

How well does the 68-year period of recorded conditions represent the variability in water supply and demand that can be expected in the future? Studies of tree rings, lake sediments and other indicators on the Canadian prairies have shed some light on the climate of past centuries. From a review of available information, Sauchyn (1997) concluded that, ".... the recent occupants of the Palliser triangle have not yet experienced the extremes of summer precipitation that occurred in the 19th and late-18th centuries, and that could reoccur in the near future." This conclusion suggests modelling results using the recorded period could present an overly optimistic picture of long-term water supply and demand.

b) The 2001 Experience in the Oldman River Basin

The 68-year simulation period (1928 to 1995) does not replicate the extensive impacts of a combination of limited water supplies and high demands such as experienced in the Oldman Basin in 2000 and 2001. Preliminary analyses of water demand and natural water supply indicate that such a combination of conditions were unprecedented in the simulation period. The deficits were exacerbated by drawdown of the St. Mary Reservoir to facilitate construction of a new spillway.

c) Future Climate Variability

How will future climate variability affect the performance of the water management system in the South Saskatchewan River Basin? Several researchers have concluded there is insufficient information to develop and analyse a credible climate change scenario at a regional level (Klemes 1990 and 1991; Muzik 2001; Filion 2000). However, the possibility that future weather and streamflow may be different than in the past must be recognised. Flexibility should be designed into management decisions and the operation of the infrastructure to allow for mitigation of negative impacts and to take advantage of positive impacts of climate change.