UNIVERSITY OF CALGARY

POST PROJECT EVALUATION OF AGRICULTURAL DRAINAGE IN THE SILVER CREEK BASIN

By

Wesley D. MacLeod

A Master's Degree Project
Submitted to the Faculty of Environmental Design
in partial fulfillment of the requirements for the degree of
Master of Environmental Design
(Environmental Science)

October, 1988

THE UNIVERSITY OF CALGARY

The undersigned certify that they have read and recommend to the Faculty of Environmental Design for acceptance, a Master's Degree Project entitled

A POST-PROJECT EVALUATION OF AGRICULTURAL DRAINAGE IN THE SILVER CREEK BASIN

submitted by Wesley D. MacLeod in partial fulfillment of the requirements for the degree of Master of Environmental Design.

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ABSTRACT

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The drainage of wetlands for conversion to agricultural land has has been promoted by the Alberta Government as a means of increasing on-farm revenues.

This study addresses the direct costs and benefits associated with an agricultural drainage project in the Silver Creek Basin in Central Alberta. Landowners in the basin, responsible for a portion of the project costs, were surveyed to determine the level of benefit which had been generated since the system's completion in 1984. Alberta Environment files provided figures on total expenditures for the project.

Costs included in the evaluation were engineering and construction costs charged to the project, and maintenance expenditures to October 1987. Benefits were measured in terms of the total increased acreage, and the expected revenues from the cultivation of those lands. The magnitude and distribution of these costs and benefits were the focus of this evaluation.

It was estimated that 1100 acres of land would be gained as a result of the drainage improvements. A survey of landowners in the basin indicated that 403 acres of land had been brought into production since completion of the drainage system. The per acre cost to develop this land was $804 per acre; the net present value of the expected revenues from these lands over a 20 year project lifetime was $457. Top quality agricultural land in the basin sold for about $ 600 per acre in 1987.

The study concluded that the benefits generated from the implementation of the system were far below the projected benefits and that the costs per acre to convert the wetlands to agricultural lands were higher than net present value of the of the expected revenues which could be generated on those lands.

Key words: drainage, Silver Creek, wetlands.

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I am grateful to the landowners in the Silver Creek Basin who participated in the survey. Their insights and opinions added some color to my research and provided a unique perspective too often lacking in drainage evaluations.

My gratitude goes out to Integrated Environments Ltd., for the use of office space, computers and software which greatly enhanced the quality of the document, and the ease of analysis.

Special thanks to the Members of my Advisory Committee, Dixon Thompson, Elizabeth Wilman and Bruce MacLock, for suffering through my early drafts and helping me stay on track. Your comments and criticisms have been invaluable.

I am indebted to the members of the Coffee Club, and my other friends from EVDS, who provided just the right blend of intellect and insanity to make my time in EVDS a memorable experience.

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INTRODUCTION AND PROBLEM DEFINITION

Agricultural drainage is becoming an increasingly popular method of improving agricultural operations. Improved drainage, which collects and discharges excess moisture, can relieve farmers of periodic flooding, improve yields on cultivated land, and increase the total amount of cultivated land. These improved yields may translate into increased revenues for individual farmers.

Potential environmental problems associated with agricultural drainage include the destruction of wildlife habitat, increased sediment and chemical loading in receiving water bodies, reductions in ground water recharge, downstream flooding and soil erosion. Most of these problems can be minimized by employing management strategies which recognize the potential for such impacts and employ designs and management strategies which minimize those effects.

More complete knowledge and understanding of the costs and benefits associated with drainage projects will improve our ability to accurately and effectively evaluate, approve, design and manage wetland drainage projects. Clear policy guidelines should be in place to influence farm water management projects. Without such clear and rational guidelines, drainage will, as it has in the past, proceed in an ad hoc and incremental fashion, which may not be desirable or optimize available benefits.

Optimizing the available benefits requires that we carefully evaluate the costs and benefits associated with alternative courses of action, and select the alternatives which yield the greatest net benefit at the least possible cost.

The monitoring and evaluation of existing drainage systems could provide valuable feedback to improve farm water management practices. By evaluating past practices, problems can be identified and avoided in the future.

The following study identifies and evaluates the broad range of issues associated with agricultural drainage and provides a post project evaluation of a drainage system installed in the Silver Creek drainage basin located in Central Alberta (see Figure 1.1). Technical considerations addressed in the document include soils and agronomy, hydrology, and drainage systems design. Along with these technical considerations, economics, policy and planning, and processes associated with the approval and operation of drainage systems in the province of Alberta are addressed. An appreciation of these technical considerations helps managers and planners evaluate the benefits and costs of various drainage systems, and drainage or flood control proposals. A more complete understanding of the technical considerations is a prerequisite to better decision making.

The goal of the post project evaluation was to identify the direct costs and benefits associated with the project and the distribution of those costs and benefits, and to evaluate the overall effectiveness of the system in realizing its stated goals.

The scope of this study was restricted to an examination of the the direct financial costs incurred and the benefits generated by the individual landowners in the Silver Creek Basin. Costs are represented by direct project expenditures reported by the County of Camrose to Alberta Environment. These include all engineering and construction costs, as well as maintenance expenses to October of 1987. Benefits are represented by increased arable land areas as a direct result of the drainage improvements which should increase net farm revenues. Per acre estimates of the productive value of increased acreage were applied to the reclaimed lands. These per acre estimates were based on economic evaluations conducted for Alberta Environment by Marv Anderson Associates (1985).

Time and budget restrictions precluded a detailed evaluation of indirect and non-market costs and benefits. These include such considerations as the costs of wildlife and ecological impacts and the values of wetlands to the general public. Many issues will be raised in this document, all of which can not be addressed in great detail. It would not be possible to cover each of the topics raised in great detail in this type of research project.

THE STATE OF WETLANDS MANAGEMENT IN ALBERTA

Wetlands have long been viewed as impediments to the productive use of agricultural lands. Until recently, wetlands were drained, filled or dyked in order to bring value to what were considered useless wastelands. More recently, the values of wetlands for other uses have become more widely acknowledged. The importance of wetlands for wildlife habitat and the important role they play in the aquatic and terrestrial ecosystems is more common place in the literature dealing with wetlands in Alberta (Alberta Water Resources Commission, 1987).

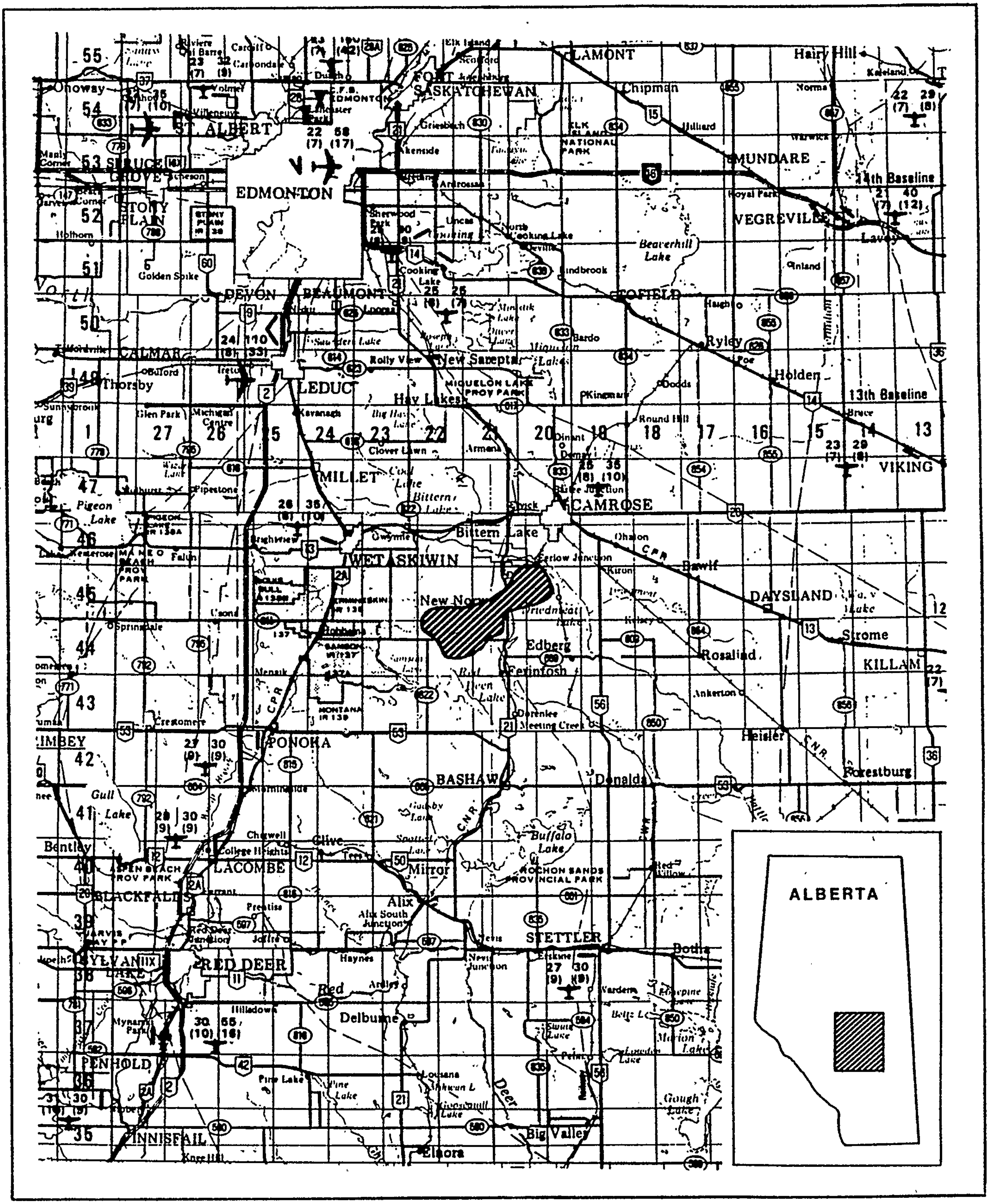


Figure 1.1: Source Map, Silver Creek Drainage Basin.

The Report and Recommendations on Water Management in the South Saskatchewan River Basin, released in 1986, spear-headed by the late Henry Kroeger, is recognized as one of the key water management documents produced in Alberta. The report covers a broad spectrum of concerns about water use and management in the SSRB. Drainage of wetlands is not identified as an important issue in the report. Irrigation, water apportionment, multiple use, storage, and hydro-electric uses are discussed in some detail. Habitat and recreation uses are grouped together and only given cursory treatment. Discussion of habitat loss is summarized in the following recommendation:

> Habitat for waterfowl, upland game birds and associated species is recognized to be limited in the SSRB. Programs exist and new ones are being examined to address this problem. The panel supports the principle of such programs and stresses the importance of landowner involvement at all stages from planning to implementation. (Alberta Water Resources Commission, 1986, p.30)

There is no discussion of the impacts of agricultural expansion on wetlands, particularly from drainage, and the associated wildlife impacts.

In 1978, the fall issue of Environment Views, a quarterly Alberta Environment publication dedicated to important environmental issues in the province, was devoted to Agriculture and the Environment. Agricultural drainage and wetland management were not discussed. Water related issues which were discussed were drought and agricultural pollution (Alberta Environment, 1978).

The fact that wetland management and agricultural drainage had received little emphasis from the provincial government is primarily a function of political realities. In Alberta, there has always been an emphasis on expansion within the agricultural sector, which has been considered a corner stone of the provincial economy, and expansion has been given a high priority. Millions of dollars have been spent on cost sharing programs to develop irrigation systems in Southern Alberta. Disparities in spending between the south and other parts of the province may be encouraging the government to implement similar cost sharing programs in Central and Northern Alberta. The fact that these programs have proceeded without any clear policy guidelines on wetland drainage support this conclusion.

Pearse, Bertrand and MacLaren address the issue of wetland habitat loss in Canada in Currents of Change: Inquiry on Federal Water Policy. In the section dealing with wildlife habitat they state that "Waterfowl habitat is seriously threatened by the drainage of wetlands for agricultural lands..." (Pearse et al., 1985. p.43). Their treatment of wetland habitat loss was limited by the lack of quantitative data.

What quantitative data is available is summarized by Usher (1988) in the Wetlands Sector Report, presented to the Environment Council of Alberta. In the prairie pothole region of Canada, including portions of southern Alberta, Saskatchewan and Manitoba, it has been estimated that up to 1.2 million ha of wetland had been converted to agricultural uses by 1976. This figure represents roughly 71 percent of the prairie wetlands (National Wetlands Working Group, 1987). Further losses were attributed to urbanization although data was insufficient to provide accurate estimates. Other estimates have wetland losses on the prairies at 61 percent up to 1961 (Schick, 1972), 21 percent in the South Saskatchewan Basin (Schmitt, 1980), and 42 percent in the Black Soil Zone (Pryor and Goodman, 1972).

Disputes over how to define and classify wetlands have hampered efforts to quantify the wetland losses on the prairies. Wetland classification schemes have been developed federally as well as by individual provinces (Usher, 1988). Most classification schemes are developed with specific regional objectives and consensus was difficult to achieve. Individual classification systems were designed to account for the unique wetland characteristics. The level of detail achieved by different classification systems was largely a function of the objectives of individual researchers (National Wetlands Working Group, 1987).

In 1987 the National Wetland Working Group (NWWG), of the Canada Committee on Ecological Land Classification, developed a hierarchical, ecologically based classification system. This study was an attempt to synthesize the existing classification systems at a national level. The classifications included bogs, fens, swamps, marshes and prairie potholes. At the same time that the NWWG was developing their system, the Alberta Water Resources Commission was developing their own classification system as part of a comprehensive study of drainage in the province of Alberta. The classification scheme developed for their purposes defined six wetland types: slough/marsh, seep, bog/fen, lake/pond, sheet water and watercourse. Each of these wetland types was further subdivided according to permanency, watershed position, form, wetland ground cover, upland ground cover and degree of disturbance (Alberta Water Resources

Commission, 1987).

Federally, there have been several initiatives designed to reduce the degradation of our wetland habitats. In the past decade the federal government has increased its emphasis on wetland management, primarily through the Canadian Wildlife Service. Beginning in the late 1960's the CWS began acquiring important wildlife habitats, many of them wetlands.

Arguably the most important federal initiative to date has been the acceptance of the North American Waterfowl Management Plan (NAWMP). The plan is a joint effort between Environment Canada and the U.S. Department of the Interior aimed at the protection of waterfowl populations in Canada and the U.S..

The primary goal of the NAWMP is the protection and restoration of waterfowl habitat.

> Reversing or modifying activities that destroy or degrade waterfowl habitat is imperative to the future success of waterfowl management. (Environment Canada; U.S. Department of the Interior, 1986, p.1).

In order to protect the wetland resource, the plan recognizes the need for coordinated planning and management from the federal governments (Canadian and US) down to the individual land owners. The Plan will actively encourage joint ventures between government agencies and private organizations. Utilizing a 15 year horizon, the plan hopes to stabilize and reverse the decreasing waterfowl populations in North America by the year 2000. The first project funded under the plan is scheduled for implementation in the fall of 1988 in the Buffalo Lake region of Central Alberta (Weatherill, 1988).

Environment Canada has worked closely with non-government organizations in an attempt to identify the important issues in wetlands management and to try to develop clear policy guidelines for wetland management in Canada (Alberta Water Resources Commission, 1987). In February of 1987 a workshop was jointly sponsored by Environment Canada and Federation of Ontario Naturalists. The goals of the workshop were twofold: first, to ensure that wetlands policy was linked to other conservation initiatives, and secondly, to arrest the loss and encourage the rehabilitation of wetland ecosystems. Specific policy strategies are summarized below:

1. Create wetlands conservation objectives.
2. Improve coordination and communication among government agencies and non-government agencies.
3. Recognize and encourage the role and efforts of non-government organizations.
4. Coordinate and rationalize government incentive programs; create landowner incentives to encourage conservation.
5. Ensure proper maintenance and management of these wetlands.

(Federation of Ontario Naturalists, 1987, pp. 5-9)

The Alberta government has only recently addressed the problems associated with wetland management. Although agricultural drainage has long been recognized as the main cause of wetland degradation and destruction, it was rarely discussed in water management literature. Programs designed to arrest the rate of degradation of wetlands and other important habitats in the province, such as the Landowner Habitat Program, have been running parallel to the cost shared drainage programs.

The Land Owner Habitat Program was established in 1986 to address the "...need to promote much stronger soil and water conservation programs in the agribusiness." (Anderson, et al., 1988). Since the programs inception in 1986, 68 agreements have been established. A total of $1.5 million dollars has been identified for the program with the majority of the funding coming from the "Buck for Wildlife Program", also administered by Forestry, Lands and Wildlife. Other sources of funding include Ducks Unlimited, and Wildlife Habitat Canada.

A recent initiative by the Alberta Water Resources Commission, jointly funded by the AWRC, Alberta Agriculture and Alberta Environment, is a good example of the Government's enhanced commitment to wetlands management and agriculture in the province. The initial goal of the study was to identify the drainage requirements in the province. This was to be accomplished by compiling an inventory of Alberta's Drainage potential, and to identify the feasibility of drainage given a number of environmental, physical and economic constraints (Alberta Water Resources Commission, 1987).

The study concluded that there are approximately 12 million acres of various wetland types in the province of Alberta. The majority of the wetlands, about 75 percent, is located in the northern portion of the province. Cost estimates for draining all the wetlands in the province totalled 1.6 billion dollars. In the majority of cases, drainage was found to be uneconomical where wildlife mitigation costs are included in the evaluations (Alberta Water Resources Commission, 1987). The major recommendations from the study are summarized below:

1. Drainage should be included in any interdepartmental water management planning for major river basins.

2. Funding for drainage projects should only be provided after integrated planning has been completed.
3. Potential drainage benefits and wildlife habitat losses should be included in the planning process.
4. Funding should be provided for drainage techniques which minimize downstream impacts.
5. Where erosion control costs and downstream impact protection costs are high, drainage should be considered not viable.
6. Funding should be provided for research on bog and fen wetlands.
7. Drainage potential and salinity problems in southern Alberta should receive further study.
   (Alberta Water Resources Commission, 1987)

The Commission is in the process of generating recommendations for legislative policy on wetlands management based on the results of the recent initiative. These recommendations will provide guidelines for other departments within the Alberta Government to follow in the management of wetlands in the province. These recommendations are due to be released in the spring of 1989 (Kemper, 1988).

CHAPTER 2 - TECHNICAL AND ADMINISTRATIVE CONSIDERATIONS

2.1 METHODS AND RATIONALE

RATIONALE FOR POST-PROJECT EVALUATIONS

With increasing fiscal restraint among government agencies and departments, decision makers should be increasingly aware of the implications of their spending decisions. All decisions involving public money should be more carefully scrutinized as governments look for ways to control the mounting public debt. As such, these decisions should be defensible and justifiable.

While it is true that most drainage projects require case by case assessments, Post Project Evaluations (PPE's) of similar projects can verify or refute many of the predictions associated with pre-construction evaluations. Likewise, those practices which have been successful or unsuccessful in the past can be identified. PPE's should be promoted as an essential part of a learning process. By observing and evaluating the consequence of our actions we may be less likely to duplicate our mistakes.

The use of PPE's as an aid to decision making can assist policy makers, planners and farmers in a variety of ways. Although technicians and scientists are improving their ability to predict the impacts and implications of certain decisions, such predictions remain uncertain until after the decision has been implemented. The only way to be certain of the impacts, good or bad, is to carefully monitor and evaluate the effects. This information can then be used to evaluate similar projects in the future.

There are three levels of analysis in PPE's (Munroe, 1986). In increasing order of complexity, these are monitoring, audits and evaluations. Monitoring is generally concerned with the measurement of suitable environmental indicators for a variety of reasons. It can be used to measure the degree of environmental impact, to ensure compliance with agreements, and for impact management. Audits make use of monitoring information and compare it to prior expectations, predictions or standards. Evaluations tend to be more subjective and complex procedures. They usually involve questions about the effectiveness of projects, and judgments about the desirability of the results.

PPE's can also be classified as either technical and scientific or procedural and administrative. Technical evaluations deal with the accuracy of the predictions or the suitability of the predicted mitigating measures. Procedural studies deal with process and tend to be more evaluative, attempting to improve upon processes and procedures.

The present study will satisfy portions of all the above descriptions, to greater or lesser degrees. Field surveys and farmer interviews attempt to measure some of the impacts of the project and as such are a monitoring tool. Reference to the original predictions about the benefits to be derived from the project and comparison to the observed values makes this study an auditing process as well. The strongest component of the study is the evaluation of the effectiveness of the project in realizing the predicted benefits, and the desirability and equity of the result. This study is more procedural and evaluative than technical.

PPE's of existing drainage systems would provide valuable information to refute or sustain the inclusion of non-monetary costs, and verify the direct monetary costs from the implementation of these projects. Direct project costs can usually be predicted fairly accurately with adequate up-front engineering and evaluation. However, maintenance costs depend on the effectiveness of the system once in place and can only be quantified after implementation. Likewise, the amount of maintenance which the system will require is subject to the vagaries of nature, which no one can predict with certainty.

By evaluating the maintenance required on existing systems we are able to quantify the costs, and possibly identify the reasons for the problems. This information should then be used in future evaluations, or in the management of existing systems. Critical evaluation of the decisions made in the past is an important part of a learning process. By identifying the successes and failures of past decisions and the rationale for those decisions, we can make better informed decisions in the future.

SILVER CREEK AS A STUDY AREA

The study area for this project was selected on the basis of discussions with personnel in Alberta Environment Planning Division and Edmonton Region Office of the Water Management Services. Silver Creek was selected as one of the representative areas for Phase Three of the Inventory of Alberta's Drainage Requirements, an interdepartmental study conducted by Alberta Environment Planning Division, Alberta Agriculture, and the Alberta Water Resources Commission (Alberta Water Resources Commission, 1987). Numerous studies have been carried out by consultants on behalf of the Interdepartmental Steering Committee (IDSC) including studies on pedology, hydrology, fisheries and wildlife, drainage engineering, and economics (Leskiw, 1985; WER Engineering Ltd., 1985; Fernet, 1987; Jensen Engineering, 1985; Marv Anderson Associates, 1985). The availability of these materials substantially reduced the amount of field work and research required for this study.

Additional studies completed prior to the implementation of the Drainage Inventory work included a drainage engineering and feasibility study conducted by Alberta Environment (1981), and a Drainage Engineering Design Report completed by Samide Engineering Ltd., (1983). The original drainage design proposed by the Department of Environment was too expensive for the County, 1.1 and 1.4 million dollars for 5 and 10 year flood protection respectively, and they retained Samide Engineering to design a cheaper version of the project on behalf of the County of Camrose (Alberta Environment, 1981; Samide Engineering Ltd., 1983). Details of the original level one report are provided in section 3.1.

A waterfowl evaluation for the area was completed by Duck's Unlimited (1981), in response to Environment's Level One Report and appended to the Samide report. DU prepared a flood control plan for the basin in this report recommending the construction of several control structures at the outlets of the major water bodies. The design proposed in the Samide report was adopted and the majority of construction completed in 1984. The work completed as a result of that study is the main focus of this evaluation.

The Silver Creek sub-basin (see Figure 1.2) is located in an area with good to very good agricultural potential and good to very good wildlife habitat, particularly for waterfowl. There is a large percentage of the land area as wetland with 15.5 percent as a basin average (Leskiw, 1985). Therefore, there is considerable potential for either agricultural development or wildlife habitat enhancement. The drainage works installed to date have only drained a small portion of the total wetlands, approximately 25 percent. Therefore, it would still be feasible to develop a wetlands management strategy for the area.

The availability of good quality information on the Silver Creek basin, the relatively small size of the area and the recent drainage works made it a good choice as study area for this project.

INPUTS TO THE EVALUATION

As mentioned previously, background reports prepared for the IDSC were the primary source of background information on the

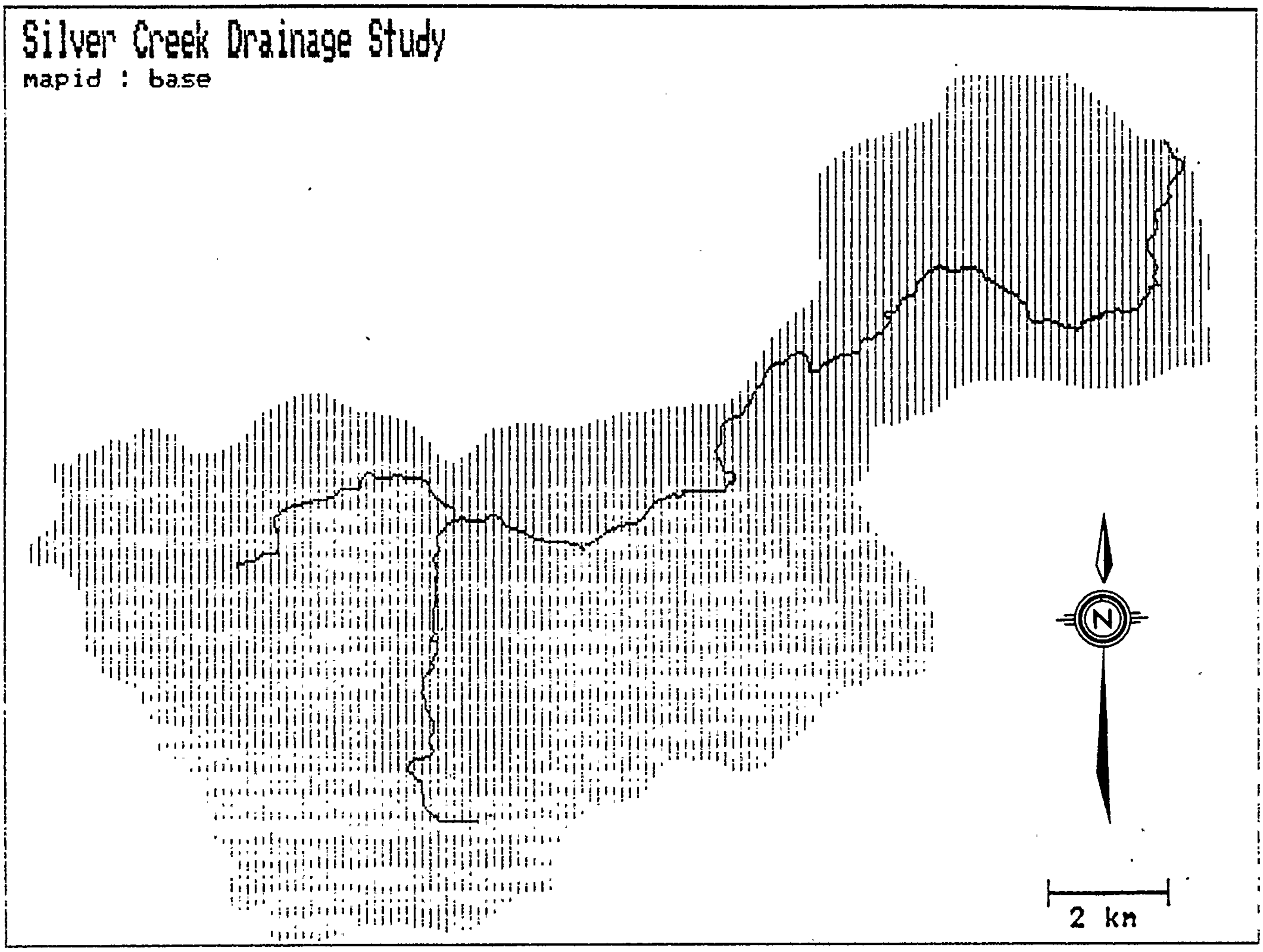


Figure 1.2: This figure shows the shape of the drainage basin and the location of the drainage channel completed in 1984.

Silver Creek basin. A limited field survey was completed which involved visual inspections of the channel and culvert crossings to identify any visible erosion or degradation problems.

Direct costs included in the evaluation are project expenditures and maintenance costs to October of 1987. Ecological costs such as erosion and sedimentation problems should be reflected in the maintenance costs to a limited degree. Maintenance costs have been assessed by identifying the total amount of money spent on reclamation to the fall of 1987. These figures were provide by the County of Camrose. Other ecological costs such as wildlife and fisheries impacts will not be reflected in maintenance costs. Wildlife habitat costs are evaluated with respect to the replacement costs for mitigation of wetland habitat losses. No attempt was made to quantify the fisheries impacts.

Benefits from the project are measured in terms of the increased land areas under cultivation as a result of the drainage improvements. Increased acreage has been determined by contacting the landowners in the basin. A more precise method would have been to have the area reshot with aerial photographs and the wetlands measured and compared to those before the drainage improvements. Resources were unavailable for this type of approach.

Flood damage reductions were also a consideration and are discussed later in the document. Flooding problems were identified following the drainage of a large slough in the extreme southwest portion of the basin, although no attempt was made to quantify the damages according to a memo to then Minister of the Environment from his Assistant Deputy Minister. Other correspondence seems to indicate that many of the flooding problems in the basin were attributable to upstream drainage improvements, both authorized and unauthorized (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

To assess the level of flooding damage would be a time consuming exercise in itself, so precise calculation of these benefits was not attempted. Therefore, flood control benefits and flood damages are only discussed in a general sense.

Potential earnings were calculated by applying a yield per acre estimate. This value was determined by Marv Anderson Associates (1985), by evaluating soil types, crop type, expected productivity, and average crop prices. This per acre economic value was then multiplied by the total acreage gain and net present values calculated to assess the total benefit in today's (1988 dollars). Much of the information required for Anderson's analysis came from the background report on soils and agronomy prepared for the ISC (Leskiw, 1985). Additional soils data has been collected from Alberta Soil Survey data (University of Alberta, 1977).

There is also some benefit from improved field efficiency. This has been calculated as a per acre benefit based on a quarter section of land. The amount of the benefit will depend on the size of the parcel, the number of obstacles, and the type of equipment used. Efficiency gains are estimated to be in the range of 17 cents per acre per year based on an average quarter section of land (Desjardins, 1984). The influence of this value on total benefit calculations is negligible. As such, they are not included in this evaluation.

The distribution of the costs and benefits have also been identified and equity considerations addressed. The fairness and rationale for the distribution of project costs among the various users and the general public are discussed in the later stages of the evaluation.

DATA COLLECTION

The majority of the information has been collected from Alberta Environment Planning Division and Edmonton Regional Office and the County of Camrose. Other sources included Alberta Agriculture, The Faculty of Extension at the University of Alberta, the University of Calgary Library, and the Alberta Environment Library in Edmonton. Technical data on wetlands in the Silver Creek basin was compiled by Intera Technologies and provided by the Alberta Environment.

Landowners in the Silver Creek Basin were contacted by phone to determine the amount of land drained into the system, and to get an indication of the benefits which they feel have been realized from the system. A list of these landowners and their holdings was provided by the County of Camrose. The interviews were fairly unstructured with the exception of questions regarding the acreage gains, crop selection and drainage works.

Engineers from Alberta Agriculture examined erosion problems along the main channel as part of the Soil Conservation Area Program, and have provided inspection reports outlining the problems and recommending mitigation measures (Alberta Agriculture, 1987). Funding for the mitigation works was provided by Alberta Agriculture as part of the Soil Conservation Area Program (SCAP). This information was provided by the Field Man for the County of Camrose (County of Camrose, 1987).

DATA COMPILATION

The data has been compiled on a relational database using dBase III Plus software, and on a Spatial Analysis System (SPANS) developed by Tydac Technologies Ltd., and provided by Integrated Environments Ltd.. These two systems allow for easy storage, retrieval and manipulation of the data. The information in the dBase files is used directly with SPANS for analysis and modeling. The dBase files are imported into SPANS as point data by using the legal descriptions of the individual parcels included in the data files.

The dBase files include information on landowners, locations, project costs, land areas affected, historical records of flooding and drainage problems, licensed projects and permits issued in the area.

Data imported into SPANS included soil types, wetlands classifications, road networks, channel location, topography and base maps for the study area and the province.

2.2 DRAINAGE SYSTEMS

The following sections are concerned with the technical aspects of agricultural drainage systems. The discussions will focus on the various types of drainage systems which are used, how they are installed, and what each type of system is intended to do. This section is intended to familiarize readers with the types of systems commonly used for agricultural drainage. Readers not concerned with the technical aspects of agricultural drainage systems should proceed to section 3.0 which is concerned with the Silver Creek Basin.

TYPES OF DRAINAGE SYSTEMS

Farm drainage systems are designed to relieve farmers from the problems of excess moisture. These problems include: poor quality crops and increased weed infestation in transitional lands around wet areas; inefficient field operations where wet areas act as obstacles; less than optimal productivity of the entire parcel (wetlands could be converted to productive lands); and crop damage from wildlife attracted to the wetlands.

Along with the problems caused by standing water on fields, excess moisture can lead to salinity problems. Soil salinity occurs when the capillary rise of the ground water exceeds the downward movement of water through the plant root zone. If this situation persists, eventually the soluble salts in the soil will accumulate at the surface. The rate at which the water is removed from the soil is influenced by the evapo-transpiration rate. Improved drainage can decrease or eliminate the rise of excess water to the surface and reduce salinity problems. Soil salinity is most prevalent in irrigated areas, or regions with water tables close to the surface and seepage or discharge occurs (Alberta Agriculture, Agdex 752-4, 1980).

There are three types of water found in the soils. Hygroscopic water is a thin layer of water bound to the soil particles which can only be removed by heat drying the soil. Capillary water is found in varying thicknesses as a film around the soil particles. Cohesive forces bind this water to the soil particles. Capillary water is available for uptake by plants. Gravitational water fills pore spaces in the soil and can be removed by gravity with adequate drainage. Farm drainage is intended to remove the gravitational water from the soil and allow sufficient soil aeration for plants to grow. Improved drainage will also allow the soil to dry faster which allows for earlier seeding (Alberta Agriculture, Agdex 752-4, 1980).

Non-aquatic plants must have air available to the roots. Therefore, it is essential that the gravitational water is removed from the soil if crops are to be grown successfully. Well aerated soils allow plants to root deeper in the soil, increasing the available nutrients. Generally, plant roots will only grow to within 30 cm of the water table, therefore, in areas with high water tables plants will develop a very shallow root zone close to the surface (Alberta Agriculture, Agdex 752-3, 1987).

Poorly drained or saline areas, or areas with high water tables, can be identified by the presence of certain plant species. Rushes, sedges and cattails grow in permanent water bodies or areas with water tables at or near the surface. These areas are easily identified in field surveys or air photo analysis. Color infrared imagery is particularly well suited for the identification of wet areas (Intera Technologies, 1984).

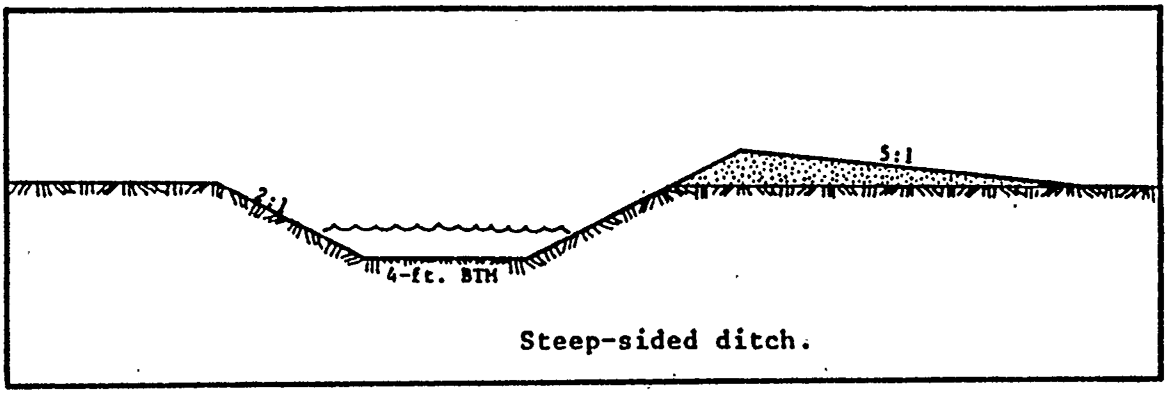
Methods of dealing with excess moisture include cropping practice, seepage control, and surface and subsurface drainage. Certain crops, such as alfalfa and other legumes, demand considerably more water than cereal grains, for example, and can be used in wet areas to consume excess moisture. Most seepage problems are associated with leaking canals, or from ground water discharge. Seepage can be controlled either at the source, which may involve lining canals or reducing the recharge of local ground water supplies, or at the problem area through the installation of some form of drainage (Alberta Agriculture, Agdex 752-1, 1980).

The following discussion deals with the different drainage systems available to farmers, construction techniques, and the advantages and disadvantages of different systems. The most common types of systems fall under either surface or sub-surface systems.

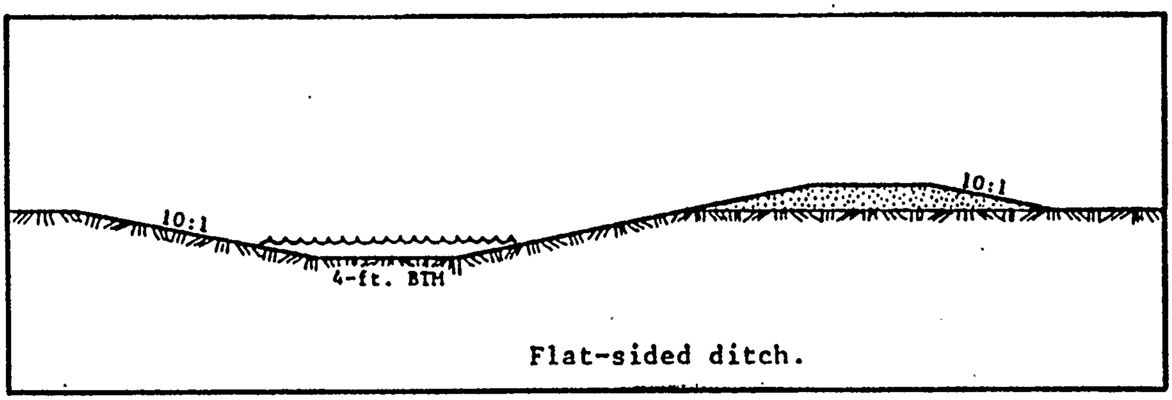
SURFACE DRAINAGE

The cheapest way to remove excess surface water from fields is to reshape the field surface to allow gravity to remove the water. This can be accomplished by recontouring the field, or constructing or deepening channels which transport water from affected areas.

The most important consideration in the construction and



Steep-sided ditch.



Flat-sided ditch.

Figure 2.1: Surface drainage ditch profiles.
Source: WER Engineering Ltd. 1985.

maintenance of surface drainage is erosion. Erosion control is a serious consideration for both newly constructed channels as well as the waterways which receive field discharges. Poorly designed and maintained channels can erode the field surface and wash away much of the soil which they were intended to benefit. Likewise, if erosion is allowed to continue unchecked it can lead to gully formation, or stream bank erosion, or, major erosion can occur in a single storm event if channel capacity is inadequate to handle the flows (Alberta Agriculture, Agdex 752-3, 1980).

The most effective method of erosion control is prevention, rather than through reclamation techniques after the problem has developed. Management practices to control erosion include forage rotations, fertilization, maintenance of crop residues, strip cropping, cover crops, and grassed waterways. These practices are designed to enhance soil structures and maintain a protective cover on the soil to prevent sheet and rill erosion and gully formation. Remedial measures include flow control structures such as hydraulic jumps to slow the rate of flow, armor to protect erodable materials on the banks and beds of streams, the use of vegetation to fix and protect soils from the cutting action of the water, and reshaping banks to provide more gradual and stable slopes (Alberta Research Council, 1984).

The use of grassed channels is popular in areas with relatively slow flows or intermittent channels. Grassed waterways are broad, shallow channels, vegetated with grasses, legumes or both. They are constructed with shallow grades to slowly conduct water without removing the vegetation. The vegetation further slows the flow of the water through the channel and resists the soil-cutting action of the water.

The channel should be nearly flat-bottomed with side slopes not greater than 25 percent to allow farm machinery to cross the channel easily. This shape spreads the water and slows the velocity of the flow. Where the grade of the channel is greater than 1 percent, drop structures may be required to reduce the velocity of the flow. Simple structures can be constructed with treated planks and posts combined with sandbags or rocks below the drop where the energy of the flow is dissipated.

Non-permanent grassed waterways should be seeded as soon as possible after construction. A mix of grasses should be selected which establish quickly, provide good hay, and have deep roots. A mix recommended by Alberta Agriculture is brome, pubescent wheatgrass, creeping red fescue, crested wheatgrass, and streambank wheatgrass. A legume should also be included in the mix; alfalfa for well drained areas, alsike clover for poorly drained areas. Recommended management practices for grassed waterways include leaving tall grass and leveling growth in the direction of flow during spring run-off, protection from tillage, regular cuttings for hay, regular fertilizer application, the removal of ground squirrels, and plowing the snow into the shape of the channel to encourage run-off through the channel during spring melt. (Alberta Agriculture, Agdex 572-5, 1980)

SUBSURFACE DRAINAGE

Subsurface drains can be used where farmers want to eliminate obstacles on the field surface or where ground water is the source of the excess water. Water table build-up, which will generally lead to salinization, can be reduced or eliminated with subsurface drainage.

Subsurface drains have been used for hundreds of years using a wide range of construction materials, the most popular being clay tiles. Today, subsurface drains are typically made of plastic or metal pipes which collect and transmit water to the outlet. These types of drains are generally very easy to install. Clay and concrete tile is still used for larger diameter drains.

These drains can collect the water directly from the soil, through perforations in the pipe, or from a surface inlet located in a depressional area. Subsurface drains are also used to collect a number of smaller sloughs into one location. Before perforated pipes were available, farmers often relied on mole drains excavated in the subsurface by a torpedo shaped, shank mounted device which was pulled through the soil. The biggest advantage of this technique was its low cost. However, it required that soils had sufficient clay content to form the walls of the drain, and would not erode quickly. The success of mole drains is highly variable. Improved installation techniques and the permanence of tile drains and corrugated plastic pipe have drastically reduced the use of mole drains, although the up-front costs are considerably higher (Alberta Agriculture, Agdex 752-6, 1980).

Subsurface systems are generally divided into two types, interceptor or relief. Design specifications depend on the amount of water, the source of the water, available outlets, textural characteristics and hydraulic conductivity of the soil, and the depth to impermeable layers. The interceptor drain is designed to collect the excess water before it reaches the problem area. These drains usually consist of a single drain tube placed between the source and the problem area. Accurate determination of the source and direction of flow are essential to the success of the system. Topography, soils, and ground water characteristics must be carefully researched before installation.

Relief drains can be used where there are numerous or indeterminate sources of excess water. These sources may include precipitation, irrigation, seepage, or ground water flows. Relief drains are installed directly in the problem area. If subsurface water is the source of excess water, the depth, placement and spacing of the drains is critical to the success of the system. The drains should be installed within the permeable layer perpendicular to the direction of the flow (Alberta Agriculture, Agdex 753-5, 1980).

In areas where salinity is a problem, the drains should be installed at around 1 - 1.5 meters below the surface, reducing the water table to that level. There must also be some means of leaching the soluble salts from the soil profile. Irrigation facilitates this. In dryland areas farmers must rely on precipitation or diverted run-off to perform this function.

Where salinity is not a problem, the water table should just be lowered enough to provide an adequate plant root zone.

Successful drainage systems require adequate inlets and outlets. Blind inlets can be used for smaller volumes of water. These usually consist of a 3 - 5 meter section of perforated drain pipe backfilled with crushed stone, pea gravel, or coarse sand. The advantage of blind inlets is that they do not interfere with activity on the surface of the field. The life of the inlet depends on the fill material and the amount of sediment reaching the inlet. Surface inlets can be placed in depressional areas where the quantities of water to be removed are relatively large. Surface inlets could be problem areas in the operation of the system if they are not designed and maintained properly. Filters should be used where there are high sediment loads, and should be cleaned regularly.

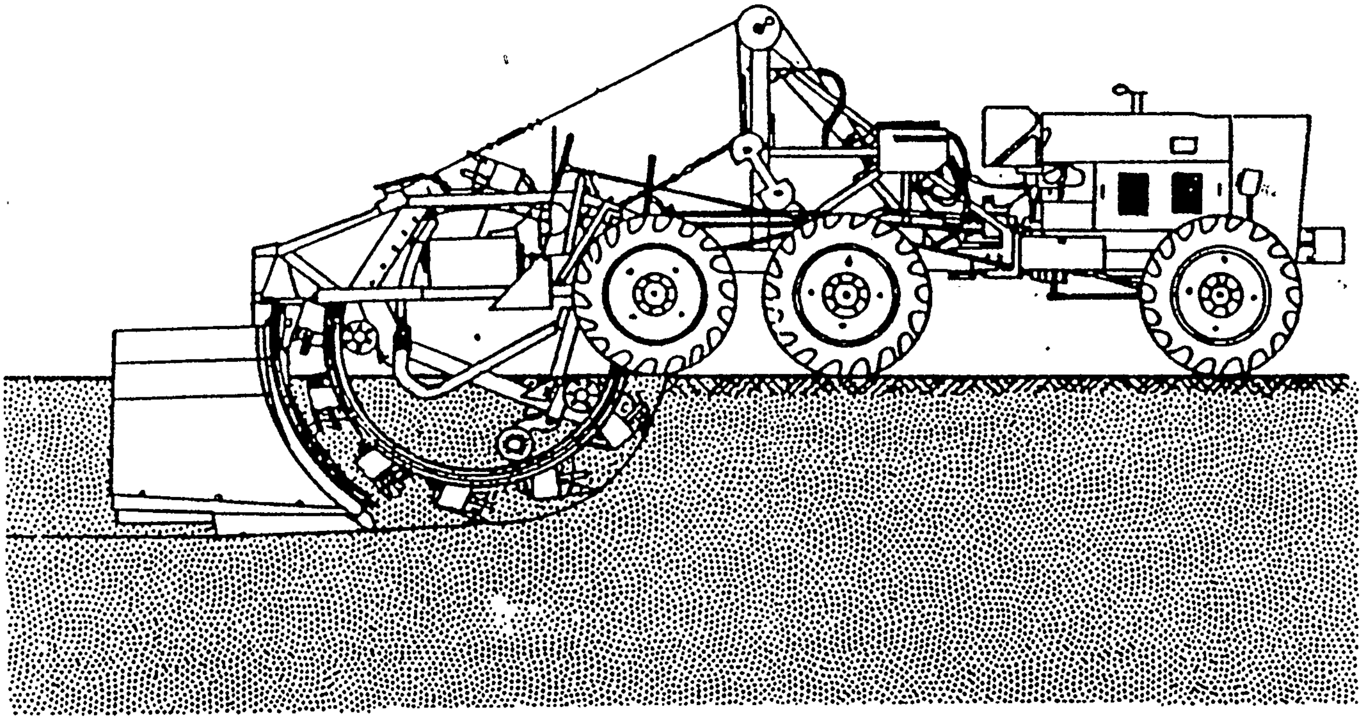
Outlets are as critical to the success of the system as any other component. Where water to be drained is at higher elevations than the outlet location, gravity can be relied on to remove the water. Gravity outlets include natural and constructed waterways. Where the water is removed from the soil below the elevation of the outlet, a pump outlet must be used. These can be either sumps or open ditches, and require pumping to remove the water when it reaches the level of the drain. The use of pumps will drastically increase operation and maintenance costs.

Relief wells should be employed to reduce hydraulic pressures in the pipes, eliminate vacuum formation, and improve flows. These wells are simply vertical risers extending from the drain to the surface and should be installed at the upper end of any long steep drain sections.

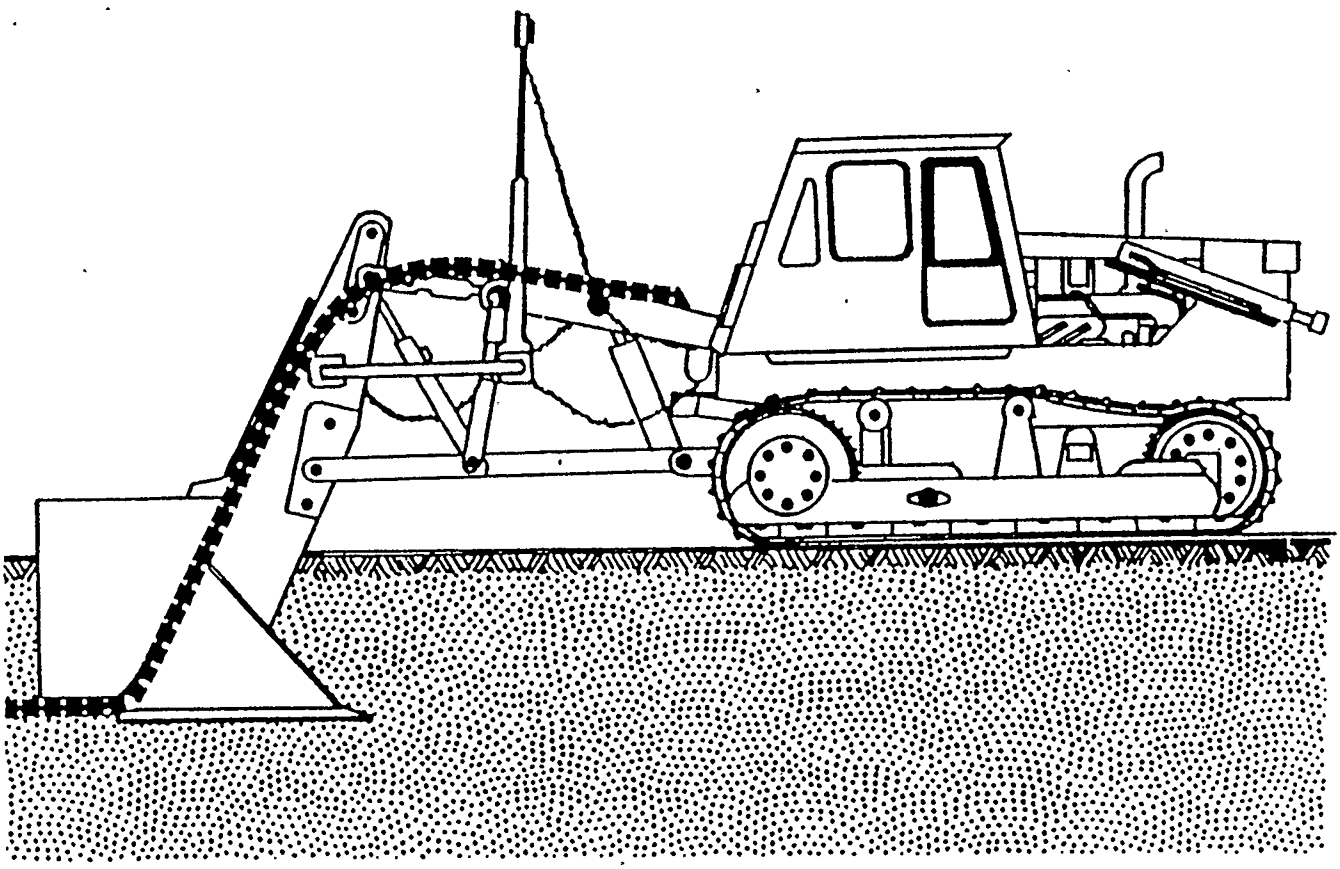
Where fine grained soils or sands are present, filters or gravel envelopes should be used to prevent the drains from becoming plugged with sediment. In fine grained soils the drains can be spaced farther apart than in areas with heavier soils. Sediment or silt traps should also be used to prevent drains from being plugged with sediments found in the drainage water. Manholes can be used to serve as sediment traps at the junctions of several drain lines. They also allow the drainage pipes to be inspected and can accommodate drains entering from a number of different elevations.

Subsurface drains can be installed in one of two ways. The first method involves excavating a trench in the soil, placing the pipe in the base of the trench and backfilling. More sophisticated machinery uses a ripper along with an automatic pipe feeder which lays the pipe directly behind the blade. This requires much heavier machinery which may not be suitable for some soils, or when the ground is wet. The depth of the drains is controlled either by periodically surveying the depth of the excavation, or by lasers which calculate the depth based on a fixed datum, and automatically adjust the depth of the blade.

The costs of the different types of drainage systems, for construction, operation and maintenance are highly variable. Subsurface systems are generally more expensive on a per acre basis than surface systems (see section 2.3). The type of soils, wetland characteristics, water volumes, system design and



Bucket-wheel type trencher.



Trenchless pipe layer

Figure 2.2: Subsurface Drainage Installation.
Source: Jensen Engineering, 1985.

topography will all influence the total cost. More specific cost estimates are discussed in the case study for Silver Creek (see section 3.0).

ENVIRONMENTAL CONCERNS

The environmental and ecological costs associated with wetland drainage can be discussed in terms of the opportunity costs foregone, or the mitigation costs associated with management strategies. The main environmental cost associated with wetland drainage is wildlife habitat loss. To a lesser degree, flooding and erosion problems are also attributed to drainage projects, but these are more easily identified and evaluated. Impacts associated with erosion and sedimentation of stream courses can be quantified by evaluating the total costs required for maintenance and reclamation.

The conflicts between wildlife interests and agricultural development are essentially land use conflicts. Drainage of wetlands to increase agricultural productivity represents a negative impact on the wildlife species which depend on those wetlands for shelter, protection, breeding habitat and staging areas, and as a source of food.

Wildlife impacts from the drainage of wetlands is becoming more prominent in project evaluations. Although wildlife interests are rarely high priority items, minimizing impacts and mitigation of habitat loss are becoming more common procedures in large scale drainage evaluations (Alberta Water Resources Commission, 1987). However, for smaller projects such as the one examined in this study, the expertise, concern and available resources seldom allow for detailed wildlife assessments.

Organizations such as Duck's Unlimited are offering financial incentives to farmers and other drainage proponents to retain wetlands, or to design drainage systems with wildlife interests in mind. Likewise, the World Wildlife Fund recently allocated $600,000 to study and promote wetlands conservation on the Canadian Prairies (World Wildlife Fund, 1987).

The Canadian Wildlife Service (CWS) has also acknowledged the importance of wetlands as wildlife habitat for a wide range of species, birds and mammals alike. In 1974 the CWS counted a total of 1.5 million ponds in southern Alberta. In 1984 they recounted the same area and found fewer than 600,000 ponds, a decline of 60 percent from ten years prior (Baily, 1986). This decline may have been due to a number of factors including drainage, drought and urbanization. Also, 1974 is generally acknowledged to have been a fairly wet year which may have skewed the results (see Table 3.6).

In 1986 the Minister of the Environment for Canada and the U.S. Secretary of the Interior signed the North American Waterfowl Management Plan (NAWMP). The primary goal of this plan is to promote the development and implementation of programs for the conservation and development of wetland habitat in key habitat zones in North America. Representatives from both Canada and the United States agree that the conservation of North American wetlands must be pursued through cooperative planning and coordinated management (Environment Canada; U.S. Department of the Interior, 1986). The committee established under this plan will promote the initiation of habitat conservation and the development of programs at the federal, provincial and municipal government levels.

Wildlife management and farm management need not be mutually exclusive. In many areas, farmers are encouraged with financial incentives to leave wet areas on their property long enough to allow waterfowl to breed and then drain the areas for cultivation. This way two benefits are generated and one cost (wildlife impact) is avoided. Ducks Unlimited will often provide money for water management projects where the design accommodates waterfowl interests.

In order to adequately address wildlife impacts from agricultural drainage and still maintain a manageable framework, it is often necessary to define specific wildlife guilds which will be affected. To assess the impacts on all species would be a labour intensive and costly procedure. Therefore, only those species which a have a relatively high profile are typically discussed. The guilds or wildlife groups discussed usually have some ecological or sociological significance, or are representative of a broader range of wildlife species (Green and Salter, 1985).

Wetlands are diverse ecosystems which play a key role in the hydrological cycle (Alberta Research Council, 1984). They also provide critical habitat for a diversity of flora and fauna. The increasing pressure to drain wetlands for conversion to agricultural lands has enhanced awareness of the importance of wetlands and promoted research designed to provide a better understanding of their functions.

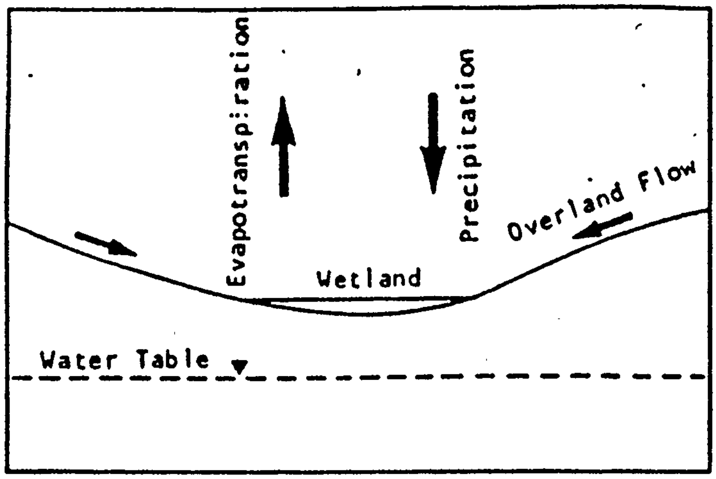
The major hydrological functions of wetlands can be summarized as follows (see figure 2.3):

- temporal and spatial modification of surface water yield
- storage of sediment and pollutants
- storage and transformation of nutrients/removal from surface water systems
- water quality determination
- storage of ground water discharge, and
- sources of ground water recharge

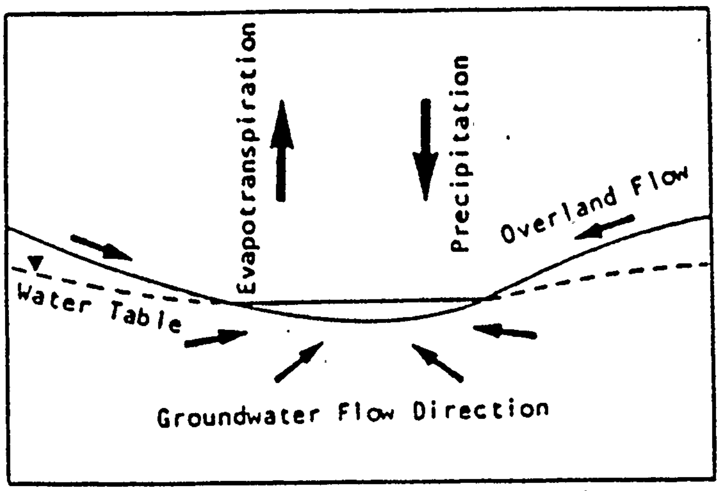
(Alberta Research Council, 1984)

The characteristics of specific wetland types will determine their functions within an area. If the wetland occurs within a ground water discharge zone it becomes the source of surface water run-off. If the wetland also falls within an area of high precipitation it may have a dramatic influence on the rate of surface run-off in the area. Wetlands may also help to store surface run-off and can act as effective flood control mechanisms by storing water and reducing flow rates.

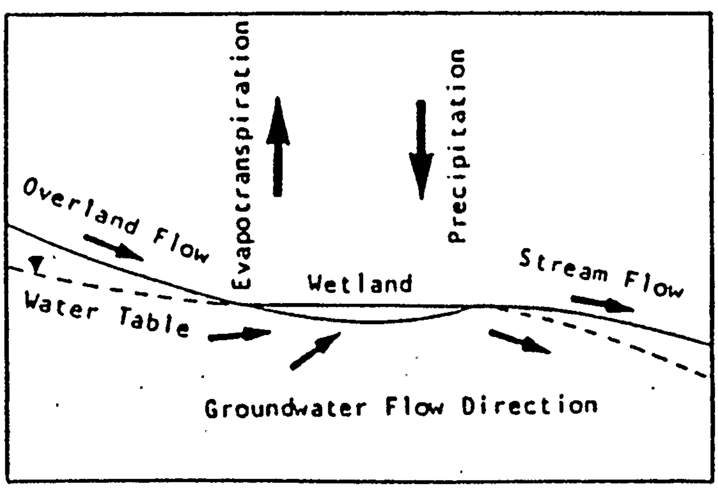
Wetland environments can act as filtering mechanisms and sediment traps which help improve surface water quality. Excess nutrients can be taken up by plants in the wetlands, and sediments removed as flow rates decrease and the water filters through the aquatic plants and vegetation. Many toxic chemicals can also be removed by certain plants (Alberta Research Council, 1984).



Hydrologic Characteristics of a Wetland Depression With a Surface Water Source



Hydrologic Characteristics of a Wetland Depression With a Groundwater Source



Hydrologic Characteristics of Wetland Slope with a Groundwater Source.

Figure 2.3: Hydrologic charcteristics of wetlands.
Source: Alberta'Research Council, 1984.

2.3 COSTS AND BENEFITS OF AGRICULTURAL DRAINAGE

MARKET BENEFITS AND COSTS

Advantages of well drained lands include increased cultivated land areas; decreased soil salinity; improved soil structures; increased soil temperatures; and with proper management, reduced soil erosion problems. The removal of excess water also allows farmers to enter and work their lands earlier in the spring with less damage to the soil from farm machinery, allows them to plant a wider variety of crops and can reduce frost problems in the spring.

The ultimate goal of drainage is to increase crop quantity and quality to provide a higher return to individual farmers. There are some economic benefits to be realized through multiplier effects the magnitude of which will vary directly with the size of the project. The normal multiplier used for the agricultural industry is 2.94, according to Marv Anderson Associates (1985). That is, for every dollar spent on the project, 2.94 dollars will flow through the local community. This multiplier is meant to represent agricultural spin-offs associated with expenditures on labor and increases in agricultural production (Marv Anderson Associates, 1985).

Multipliers are used to account for increased spending and economic activity as a result of project construction and operation. Smaller scale projects will have less influence on the local economy than larger projects. The use of multipliers in evaluating total benefit must be done with caution and the use of any multiplier should be justified.

No multiplier effects are incorporated into this analysis. The only benefits which this study addresses are the increased arable land areas to individual farmers. Although it is recognized that there are other benefits generated from drainage improvements, such as warmer, faster drying soils and improved field efficiency, these benefits were not quantified here. As mentioned previously, this study is not intended to be a complete cost-benefit analysis. Although revenues should have increased for many farmers as a result of increased crop yields, it is unlikely that there will be any significant multiplier effects.

Monetary costs associated with farm drainage include costs of construction (design costs for engineering, equipment, materials), operation and maintenance and administration costs. Most of these costs can be fairly accurately estimated before the project starts. However, there may be a tendency to exaggerate benefits and underestimate costs where proponents are eager to have the project implemented. This can lead to substantial cost over-runs and lower cost benefit ratios on completion.

DRAINAGE COSTS

Estimates for monetary and non-monetary costs are highly variable across different projects. Soil types, topography, required capacity (which is a function of the amount of wetlands, the type of wetlands, local precipitation, the size of the catchment area, and existing stream flows), pumping required, construction method, availability of outlets and the availability of personnel all influence drainage costs. Because of the large number of variables, generalizations about the costs of drainage systems should be avoided. Sub-surface systems are generally more expensive. Cost estimates for drainage in the Silver Creek Basin are discussed in section 3.2. Typical costs per linear foot for drainage ditches and sub-surface drains are provided in Table 2.1 and Table 2.2.

Increased revenues and direct money costs are referred to as market benefits and costs. The market place dictates the values which these benefits and costs will hold and these values will fluctuate with changes in economic conditions. The most dramatic influence on the available benefits is the prevailing crop prices. The installation of drainage works can do little to influence the prices per unit which products will fetch at harvest time. Increased revenues are primarily a function of the crop yields and to a lesser extent crop quality. A higher quality crop may fetch a slightly higher price, depending on the availability of markets.

Ultimately, if the improved price of the product is not sufficient to cover the costs of production, the costs of the drainage works implemented, and include a reasonable return to

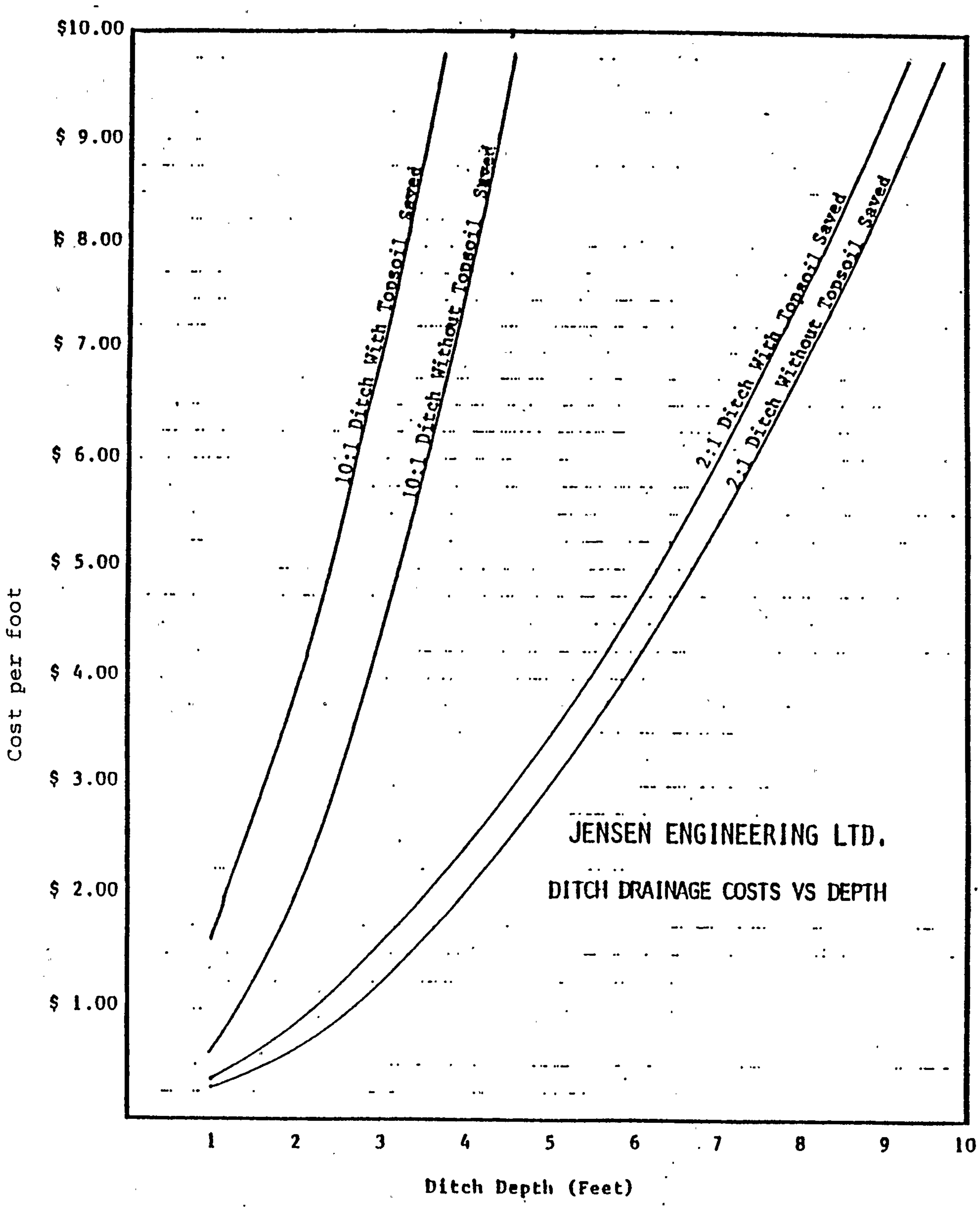


Table 2.1: Drainage Ditch Costs vs Depth.
Source: Jensen Engineering Ltd. 1985.

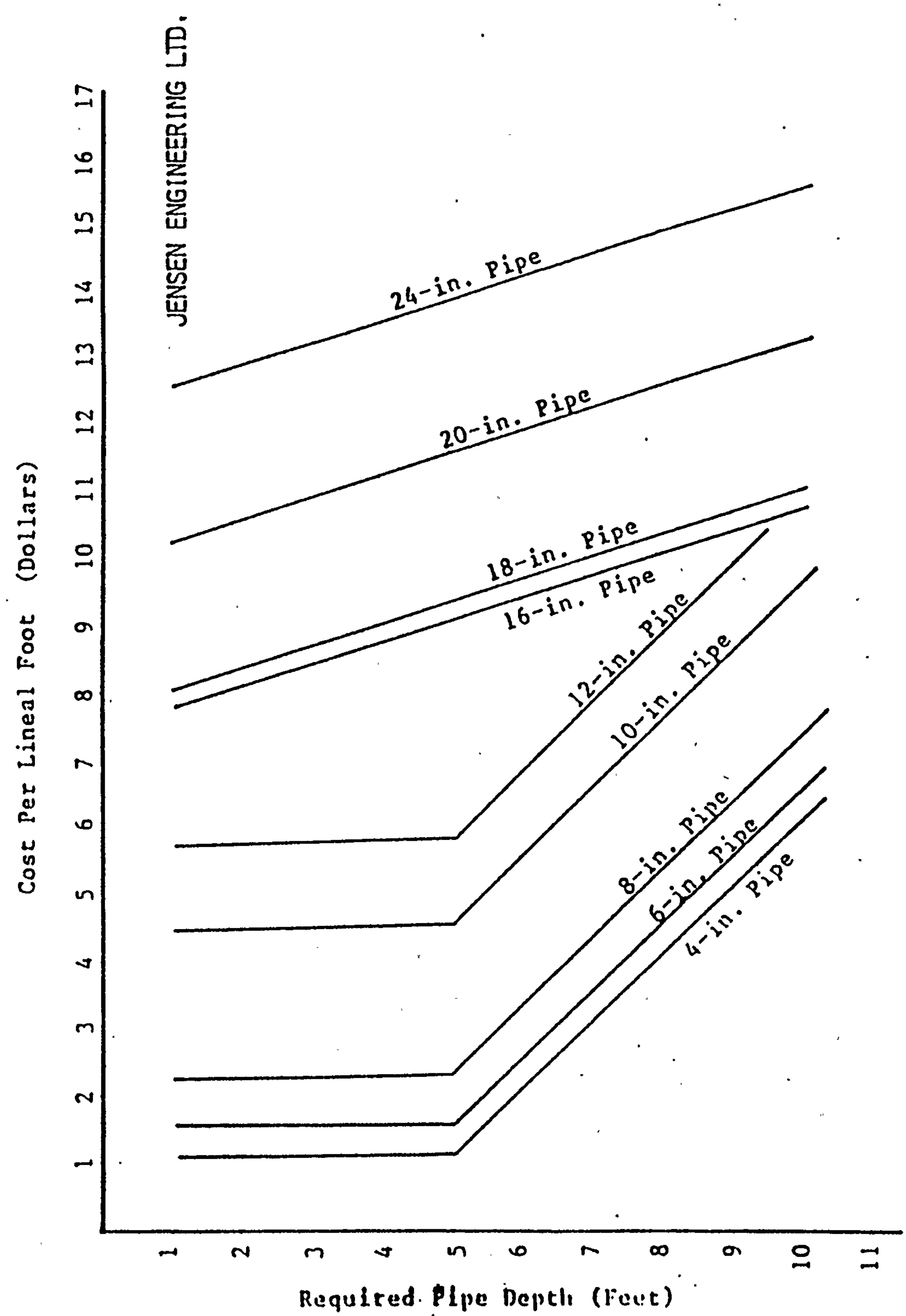


Table 2.2: Sub-surface Drainage Costs vs Pipe Depth.
Source: Jensen Engineering Ltd. 1985.

the farmer, then the benefits are negligible. Under present economic circumstances, most grain farmers in Alberta are operating at a break even level and there is little if any money left over which could be considered a return on an investment in drainage works (Achtymichuk, 1987).

NON-MARKET BENEFITS AND COSTS

There are market and non-market values which must be considered when evaluating wetlands drainage proposals. Non-market costs associated with wetland drainage include: the destruction of wildlife habitat and the decline in related wildlife populations; reductions in ground water recharge; decreased surface water quality due to increased herbicide, pesticide and fertilizer loadings and the elimination of the water purifying qualities of wetlands; loss of natural flood control mechanisms; and the loss of wildlife and aesthetic opportunities associated with wetlands.

The social and ecological benefits from wetland preservation are not easily expressed as dollar values and as a result are not readily incorporated into drainage feasibility studies. Attempts to provide dollar values for these benefits and costs often tend to be imperfect measures. However, an imperfect measure may be better than no measure at all.

Detailed review of the types of non-market resource values, their measurement and the limitations of various techniques is provided by Wilman (1985). The value of a resource, such as wetlands, can be measured by the amount of money which people would be willing to pay to protect that resource, or conversely, the amount they would accept in compensation for its loss.

Where markets exist for resources, prices represent the values which people hold. These prices reflect people's marginal willingness to pay for the resource, or the amount which is paid for the last unit purchased. The price will vary with the demand for the resource, which is in turn a function of the relative scarcity or abundance. There is a hypothetical demand curve for any resource, or a marginal willingness to pay function, which represents the amount people are willing to pay for the resource over a range of quantities. As the availability or quantity of the resource increases, the amount which people will pay is assumed to decrease. Similarly, as the cost of the resource increases, smaller quantities will be consumed.

Figure 2.4 portrays a typical demand function. Accepting that resource demand is an inverse function of the price, at any given price there will be an optimal level of consumption represented by a point on that demand curve. In this case, q1 units will be consumed at price p1. The total area under the demand curve at price p1 (area abq10) will represent the total value which people place on the resource. The area above price p1 but still under the demand curve is referred to as the consumer surplus, or the net value (area abp1).

Non-market variables in resource management can be broadly categorized as either user or non-user services (Wilman, 1985). User services will leave some trace indicators in the market place which can be measured. Sales of hunting or fishing licenses or the travel costs incurred in accessing the resource are examples of measurable indicators. User services can be

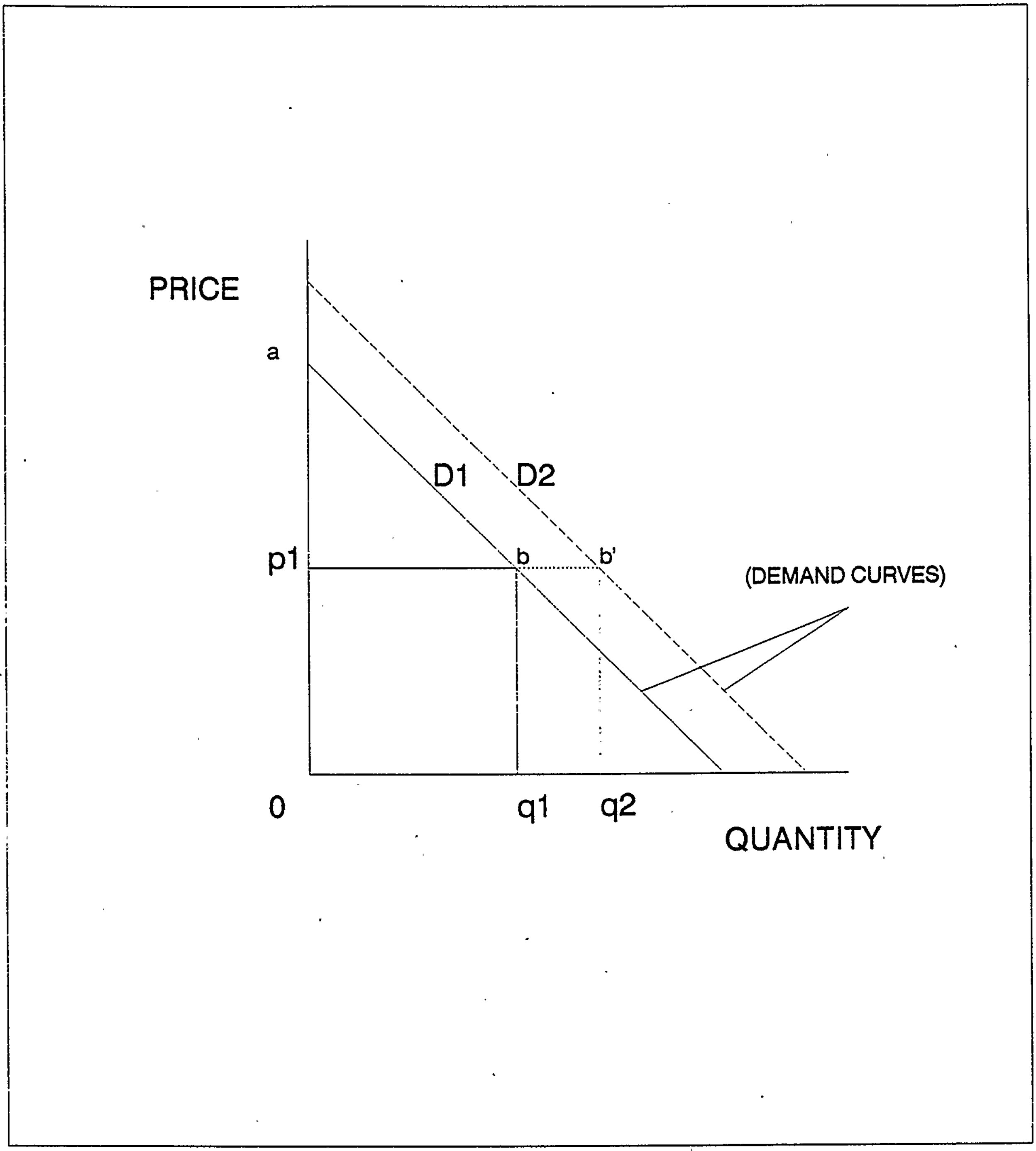


Figure 2.5 - Traditional demand function

either consumptive or non-consumptive as well.

Consumptive user services include things such as duck hunting or fishing where the level of use can be measured by the number of units consumed. These indicators approximate the level of use from which resource values can be derived. Non-consumptive user services include things such as viewing, education, or recreational pursuits such as boating or hiking. In the case of wetlands the most common non-consumptive user service would be viewing of wildlife species for education or personal enjoyment.

Non-user services are always non-consumptive; there are no indicators in the market place which can be used to approximate values. Non-user services have been discussed as option, existence and inheritance values (Wilman, 1985).

Option values reflect the uncertainty associated with decision making. We can never be sure that we won't need the resource in the future, and we place some value on the resource because we may need it some time. The maintenance of genetic diversity, a primary goal of the World Conservation Strategy (International Union for the Conservation of Nature, 1980), is a good example of the value we hold for the diversity of species in our environment even though we have not yet identified specific needs. This represents an option value for the variety of flora and fauna in our environment.

If by maintaining natural resources such as wetlands, we reduce the risks associated with our decision making, and we can be seen as risk averse individuals, then the option value of that resource is a legitimate value (Wilman, 1985). Risk averse decision makers will usually keep as many options open as possible.

Existence and inheritance values are held by individuals which may in fact never use the resource but derive some satisfaction from knowing the resource is there and that they can maintain that resource for future generations.

Measurement of non-market values usually relies on some form of proxy to represent the true values which people place on the resource. These proxies can be direct or indirect measures of indicators which represent the resource values we wish to define. The willingness-to-pay criteria outlined previously can be measured using inferential, contingent or hedonic methods of valuation (Asafu-Adjaye, et al., 1986; Wilman, 1985).

Inferential valuations rely on existing market indicators to derive values. The most common application of this technique is the travel cost approach originally developed by Hotelling (1949), and later detailed by Clawsen and Knestch (1966). Here travel costs incurred in seeking out resources such as wetlands are used as indicators of the values people place on those resources. Travel cost methods have also been developed for multiple sites to address some of the deficiencies of the single site methods and to allow the quality of the sites to influence the valuations.

For multiple site travel cost approaches, the quality of the site is influenced by the number of visits to the site, assuming that increased levels of use will decrease the quality of the site, and individual choices will be influenced by the quality of those sites. Changes in quality will shift the demand curve those sites. Changes in quality will shift the demand curve outward for higher quality sites (d2 on Figure 2.4), and inward for lower quality sites, resulting in greater or lesser consumption at any point along the demand curve at a given cost (Wilman, 1985).

Hedonic methods of valuation are discussed by McConnel and Strand (1981) and by Freeman (1984). Here recreational expenditures, such as travel costs, are expressed as a function of such variables as the number of recreation days, or in the case of hunting and fishing as the number of fish caught or animals bagged. The expenditure changes as a result of additional or fewer recreation days or animals/fish taken then represents the value of those recreation days or animals/fish. This approach is very complicated because it requires expenditure and activity/success rates over a period of time for a large number of individuals.

Contingent valuations establish hypothetical markets and people express their values based on that assumed market. Commonly, these valuations rely on a willingness to pay criteria collected from direct survey responses. The main difficulty with these valuations is trying to get an accurate representation of the consumer's willingness-to-pay. It is very difficult to acquire accurate and reliable information from hypothetical situations which are prone to response errors and inaccuracies. Individual survey responses are prone to several types of bias. These include information bias, strategic bias, hypothetical bias and instrument bias (Rowe et al. 1980; Schulze et al. 1981).

Information bias is generated when respondents do not have sufficient information or understanding of the issues to provide accurate responses. Strategic bias, which has received the most attention, results when respondents feel that their answers can influence resource allocation or the costs of the resource by failing to reveal their true willingness-to-pay. For example, if someone likes to hunt a great deal they may state a high willingness-to-pay even if they don't have the money. Strategic bias and instrument bias are generated from the fact that the responses are to hypothetical rather than real situations, and where questions are worded in a manner which favours one response over another (Wilman, 1985).

OTHER CONSIDERATIONS

Economic efficiency in resource allocation requires that reallocation only be undertaken if it will increase net income. If we are concerned with the distribution of that income then we are addressing an income redistribution goal. Resource values can be addressed with reference to either of these goals (Wilman, 1985).

One of the difficulties with non-market costs and benefits in drainage evaluations is that many of the benefits from wetlands retention are realized by individuals removed from the resource, while the benefits available from the drainage of those lands are realized by the individual landowners. However, the drainage undertaken by an individual landowner may impose a negative externality on individuals some distance from the resource by degrading the wildlife habitat. Given the financial pressures facing farmers today, it is unlikely that many would be concerned with habitat degradation in relation to the financial benefits available from wetland drainage.

The benefits available and costs incurred by the general public ought to be included in drainage evaluations, particularly where public money is involved. Benefits should be distributed among all persons who bear the costs. Otherwise, the expenditures are an inappropriate and inequitable use of public money.

Some benefits may be measured with economic values. For example, wildlife values can be measured in revenues generated from hunting licenses, guiding operations, and money spent on local business. Water quality considerations can be measured in terms of the cost of water treatment systems which would not be required if the purifying characteristics of wetlands were utilized. Likewise, maintenance of groundwater recharge areas may save people from drilling new wells for domestic water supplies.

Accurate determination of dollar values for typically non-market benefits and costs can be a contentious and time consuming exercise. As a result, these type of valuations are often discounted or ignored. Many drainage evaluations today include a section on habitat mitigation, most commonly for the provision of habitat in kind somewhere in the region. However, where complete habitat mitigation costs are included in drainage evaluations, the cost benefit ratios are often driven below unity (one to one ratio) (Alberta Water Resources Commission, 1987).

Measurable value losses from wetland habitat destruction represent only a small fraction of the total value of wetlands to society. The mere inclusion of consumptive value losses, such as decreased species and individual numbers, can not hope to cover or represent the total value of the wetland ecosystems. Therefore, judgemental values which consider these significant but obscure values should be included in the evaluation of wetlands drainage, in a qualitative sense, if detailed valuations are not possible.

Direct impacts on wildlife numbers, habitat volume and the environment are measurable. Identifying the true values associated with these numbers, beyond those consumptive market values is the more difficult problem. However, the difficulty in quantifying these values should not exclude them from consideration.

Quantification of non-market benefits and costs is not always necessary. Monetary costs and benefits should be evaluated first. If these monetary costs alone are overwhelmingly in favour of or against the project, there is no need to incorporate the non-market costs. However, where market benefits are marginal, the inclusion of the non-market costs could drastically influence the outcome. In these cases, the inclusion of non-market costs such as ecological degradation, should influence decisions. This point is nicely summarized in the following quote:

> There is no point in going to a lot of trouble to establish a doubtful accuracy for values that do not change a conclusion reached with more easily established, well reasoned values. (Baldwin, 1972, P.21)

However it should not follow from this that non-market values should be ignored where economic indicators alone demonstrate net benefits.

The final calculation of the merit of the project must consider the non-market costs and benefits along with the market considerations. This will involve some value judgments about the relative importance of the non-market considerations which are highly variable both spatially and temporally. In evaluating decisions involving non-market benefits and costs in public projects, analysts can not ignore political influences. Where the political will and support of the constituents is there, even the most decisive arguments in opposition will have little influence.

RETURNS TO FARM OPERATIONS

Costs of production for grain farmers in the Silver Creek area average around $65 per acre. Gross revenues average around $110 per acre, yielding a net revenue of about $45 per acre (Marv Anderson Associates, 1985). These estimates are based on real crop prices and production costs for Census Division 10 in the years 1984 and 1985. These values are theoretical and should be considered as high estimates of the net revenues after factoring in loan payments, cost of living, and other off-farm expenses (Achtymichuk, 1987).

In order to calculate the value of this increased revenue over the life time of the project, net present values must be determined. Net present values (NPV) represent the total value of the benefits over the lifetime of the project. The principle behind net present values is that a dollar is worth more today than it will be in the future. Therefore, assuming that the payment remains the same year after year, the present value of that revenue becomes less the further into the future we discount it. The rate of discount is usually the prevailing rate of interest.

Table 2.3 shows a series of NPV calculations over a 20 year period at 5 different interest rates. Twenty years is considered to be a reasonable project lifetime (Desjardins, 1984). The numbers at the bottom of the table represent the total value of the income stream over the lifetime of the project. These values tell us how much the project is really worth is today's dollars. To spend any more than this amount on the project would not be a wise economic choice.

Present values of the projected 45 dollar net revenues generated from an acre of cultivated land, as defined by Marv Anderson Associates (1985), are shown in the table as well. The net present value of that annual revenue over a twenty year period ranges from $193 to $457 depending on the interest rate selected. If the total cost of the project exceeds the total discounted value, then the project is an economic loser. Therefore, no more than the total NPV per acre should be spent to bring that land into production. Anything which will increase or decrease the returns on an annual basis will directly influence the NPV of the project.

TABLE 2.3 - NET PRESENT VALUE CALCULATIONS *

	REVENUE PER ACRE RECLAIMED					
	90.00	80.00	70.00	60.00	50.00	45.00
TOTAL**	1,575.00	1,312.50	905.00	890.00	875.00	787.50

discount rate (%)	NET PRESENT VALUES (Discounted over 20 yrs)					
5	915.38	813.67	711.96	610.25	508.54	457.69
6	829.50	737.34	645.17	553.00	460.84	414.75
7	754.01	670.23	586.45	502.67	418.89	377.00
8	687.42	611.04	534.66	458.28	381.90	343.71
9	628.50	558.67	488.83	419.00	349.17	314.25
10	576.21	512.19	448.17	384.14	320.12	288.11
11	529.67	470.82	411.96	353.11	294.26	264.83
12	488.12	433.88	379.65	325.41	271.18	244.06
13	450.91	400.81	350.71	300.61	250.51	225.46
14	417.51	371.12	324.73	278.34	231.95	208.75
15	387.44	344.39	301.34	258.29	215.24	193.72

* The NPV calculations assume that no crops would be grown on the reclaimed lands for the first two years. 50 % of maximum crop yield would be realized in the third year and 100 % thereafter. Values were calculated on a Lotus 1-2-3 spreadsheet.
** Totals represent the aggregate value of the future income stream over the 20 year project life time before discounting it.

2.4 INSTITUTIONAL CONSIDERATIONS

LICENSING AND REGULATION OF DRAINAGE PROJECTS

The regulation of all water related projects in the province of Alberta is the responsibility of Alberta Environment. The authority for this control derives from the Water Resources Act which is intended to allocate water uses in an orderly way and protect the resource for all potential users while at the same time protecting the rights of individual users (Alberta Environment, no date).

Provisions in the Water Resources Act and regulations are designed to meet these objectives. Any projects which involve the alteration of water systems, ground or surface water, must be issued a water license or water use permit from Alberta Environment. The type of license or permit required depends on the nature of the project.

Licenses are required under the following circumstances:

- water diversions for domestic, municipal, agricultural or industrial purposes.
- dams or impoundments or storage structures for such uses as stock watering, flood control, flow regulation, and erosion control.
- diversions without impoundments for drainage or flood control.

Permits are required under the following circumstances:

- the placement of any structure or material which may affect water management in, over or next to water (e.g. bridges, pipelines)
- the alteration of shorelines, banks or beds of a body of water in a manner which may affect water management (e.g. sand or gravel removal, erosion control, brushing operations, docks and warfs)

(Alberta Environment, Water Resources, no date, b)

The requirements of the permits and licenses are so broad that they could apply to almost any project close to water bodies or stream courses. In reality not all such projects will have licenses issued to them. For example, it is unlikely that every lake side resident in Alberta will ever be required to secure a water use permit to put up a dock, although the Water Resources Act specifies that they require a permit (Alberta Environment, no date, b).

Other uses are specifically exempt from requiring a license or permit. These include rural domestic water supply, irrigation of gardens under one acre in size, or the construction of small dugouts for domestic stock watering. Determining what constitutes a domestic vs commercial stock watering operation appears to be at the discretion of the regulator. Licenses and permits are issued by Alberta Environment and require the applicant to complete the requisite forms and provide suitable plans and data. Which division within Alberta Environment handles the application depends on the use for which it is requested (Alberta Environment, no date, b).

For larger scale projects such as industrial uses, hydroelectric projects, or municipal water supply applications are reviewed by the Water Rights Branch, Water Resources Administration Division, Alberta Environment. Irrigation, dams and reservoirs for stock watering are often dealt with through a Federal government PFRA office. Water diversion and all other permits which are required are handled by the regional offices of the Water Resources Administration Division.

The completed application must include the actual application form, containing applicant's name, legal description of the parcel containing the proposed project, and any other related information. Accompanying the completed application must be any plans, report specifications, and other data related to the project. This information is required to evaluate the effect of the project on land and water in the area. Applications are normally dealt with on a case by case basis. However, in the event of an emergency, priority may be given to municipal and domestic water uses.

Completed applications are reviewed by the Water Resources Administration Division, Alberta Environment. The Department will look at the number of individuals involved and confirm that consent has been provided by landowners who will need to provide easements and that other land owners in the area have been informed of and provided their consent for the project and had an opportunity to provide input. The implications of the project for other land and water related projects are considered and views from other relevant departments such as Fish and Wildlife may be solicited (Alberta Environment, no date, b).

Once an application has been approved, an interim license will be issued by Alberta Environment and construction may begin on the project. The interim license will often specify terms and conditions which the applicant must meet in the design and operation of the project. These conditions may relate to matters such as easements, objections from other parties, construction and operation guidelines, and future operations. Inspections will be carried out by Department officials to ensure that the project is constructed and operated according to the requirements of the license and the original design. When the project is complete and passes inspection a permanent license will be issued for the project.

For permits, the terms and conditions are specified when the permit is issued. No other documentation is required from the Water Resources Administration Division.

RELEVANT DEPARTMENTS AND AGENCIES INVOLVED

Although the licensing and regulation of water related projects is the responsibility of Water Resources Administration Division, Alberta Environment, the range of issues which wetlands management encompasses involves a large number of agencies and departments beyond those outlined previously. Figure 2.5 shows a flow chart including 31 Alberta Government Departments and Divisions who's responsibilities affect some aspect of wetlands management.

Wetlands are diverse ecosystems which support a wide range of wildlife species. They also act as an important part of the water cycle by purifying and regulating flows, acting as recharge areas for local ground water aquifers, and offer aesthetic and ecological benefits to individuals far removed from the area. The diversity and range of influence which wetlands possess implies that their management should demand an equally diverse and comprehensive approach.

The recent study jointly undertaken by Alberta Environment, Alberta Agriculture, and the Alberta Water Resources Commission is a good example of a much needed interdisciplinary approach to

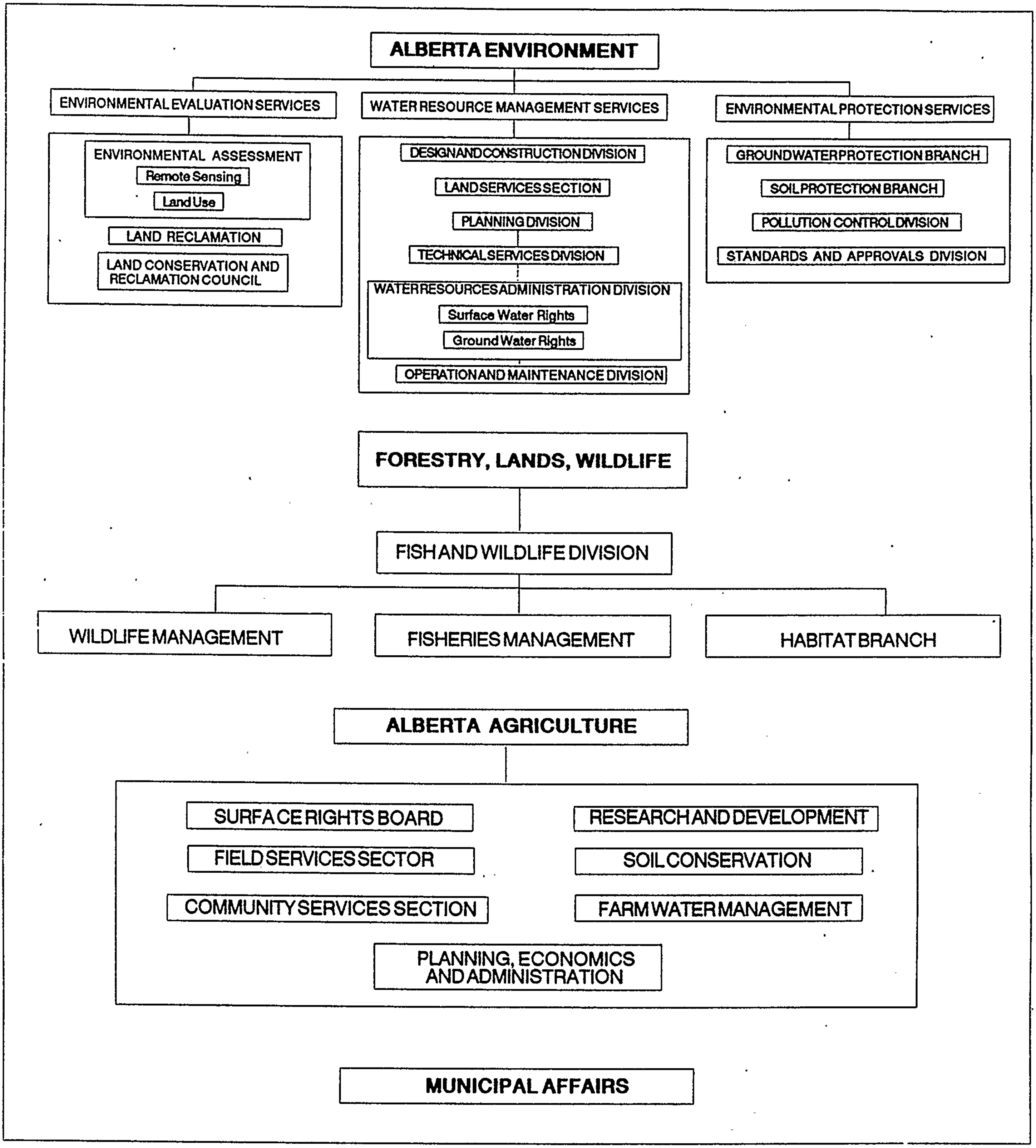


Figure 2.5: Alberta Government Agencies involved with Wetland Management Issues. Adapted from the Alberta Government RITE Directory, 1987.

the drainage issues in our province (Alberta Water Resources Commission, 1987). A great deal of time and money has been spent to develop a better understanding of the problems associated with wetlands management Alberta, and to develop recommendations for future courses of action.

The wide number of departments potentially involved with the management of wetlands poses serious problems. These problems include fragmentation of responsibility and duplication of effort. In many instances departments actually work against one another. For example, Fish and Wildlife Division of Forestry Lands and Wildlife is responsible for the conservation and development of wildlife habitat and providing funds for wetlands habitat development in conjunction with Non-Government Organizations (NGO's) such as Ducks Unlimited. At the same time the Department of the Environment and Alberta Agriculture are providing funding to assist farmers to drain wetlands.

Coordination among different government departments and NGO's is not always easy to facilitate. Many senior civil servants and representatives of various organizations meet periodically at conferences such as the recent Wetlands Wildlife and Agriculture Conference held in Edmonton (April, 1988), jointly sponsored by the Canadian Water Resources Association and the Alberta Chapter of the Soil and Water Conservation Society. Here, as with other conferences, individuals from a wide range of disciplines and professions were able to interact and exchange views on the most pressing issues of the day.

A more formal agency which promotes interagency cooperation, as well as interaction with other groups in Alberta is the

Environment Council of Alberta. The Council is made up of professionals from a wide range of companies, government agencies and privately funded organizations. The Council is intended to be the government's independent advisory body which offers advice to the government on various environmental issues.

COST SHARING PROGRAMS

There are several programs available to farmers and municipal governments which provide technical and financial assistance for water management projects in Alberta. Three of the major programs are highlighted below.

Alberta Agriculture has two main programs which provide assistance to farmers and municipal governments who wish to implement water management projects. These are the Farm Development and Reclamation Program (FDRP), and the Soil Conservation Area Program (SCAP) (Alberta Agriculture, no date a; Alberta Agriculture, no date b).

The FDRP is designed to help agricultural land owners alleviate problems caused by either moisture deficits or excess moisture. Financial and technical support is available to farmers where it is felt that the project will provide a benefit to the producer. Any project which will reduce or eliminate an on-farm surface water problem is eligible for assistance (Alberta Agriculture, no date a).

Under the FDRP priority is given to those projects where the water is to be retained and used on the farm. In cases where the water is to be drained off the farm, only the on-farm costs are eligible for assistance. For off-farm drainage proposals, licenses must be obtained through Alberta Environment prior to construction. The two main types of projects covered under the FDRP are slough consolidation and drainage and channel improvements (Alberta Environment, no date b).

SCAP is a parallel program which is designed specifically to prevent soil degradation. Degradation is caused by wind and water erosion, and from soil salinity. These forces can destroy a great deal of productive land. The logic behind SCAP is that the prevention of serious soil degradation problems is much cheaper and more effective than reclamation. SCAP is designed to encourage the implementation of soil conservation projects in Alberta. Technical and financial assistance is available for up to 60 percent of project costs (Alberta Environment, no date a).

Alberta Environment also provides assistance under their Water Management and Erosion Control Program. This program is primarily designed to assist local governments in implementing projects to correct water and erosion problems. The program is a 75/25 cost share program between the Provincial Government and the local authority respectively. The program is administered by the Water Resource Management Services of Alberta Environment and is intended to enhance and encourage the development of regional water management programs and to implement corrective measures where water in its natural state creates problems for the general public. Applications must be made through an urban or rural municipal government located within Alberta. The program is administered through the Regional Offices of the Water Resource Management Services (Alberta Environment, Water Resources, no date a).

Projects which are eligible for assistance under this program include flood control and drainage, erosion control, flow regulation, water based recreation, wildlife enhancement programs, water supply and water conservation projects. In order to qualify for assistance the project must be in the public interest, promote sound water management, be initiated by a local authority, have a demonstrated need and be feasible. Projects approved under these terms are eligible for a 75/25 cost share agreement between the provincial and local governments respectively. Special categories of projects, including Northern Erosion Control Projects and projects which enhance the agricultural land base or agricultural production, are eligible for 86/14 cost sharing with the provincial government paying the larger amount (Alberta Environment, Water Resources, no date a).

Once a project has been declared eligible the local government must prepare a preliminary engineering report which provides a cost estimate, and an assessment of the engineering, economic, and environmental aspects of the solution which it recommends. If the project is approved, the local government enters into an agreement with the Minister of the Environment. The local authority may then proceed with the implementation of the project.

CHAPTER 3 - CASE STUDY: SILVER CREEK BASIN

This chapter is concerned with the Silver Creek basin. It examines the characteristics of the basin in terms of its biophysical features, climatic influences, the land use and history of water management in the area. The later sections of the chapter deal with the drainage system which was installed in the Silver Creek basin.

3.1 STUDY AREA DEFINITION

The Silver Creek basin is located in Central Alberta east of line drawn between Calgary and Edmonton, south west of the town of Camrose (see Figure 3.1). It falls within the counties of Camrose and Wetaskiwin. The basin lies to the west of the fourth meridian within townships 44, 45, and 46, and ranges 20, 21, and 22. The only municipality within the basin is the town of New Norway. Total land area within the basin is approximately 34,200 acres covering portions of 75 sections of land. The creek drains into the Battle River in the extreme north east end of the drainage.

AGRICULTURAL DEVELOPMENT

Settlement in the region began shortly after the arrival of the railway in Calgary in 1883. Early settlements developed around stopping points for a stage coach service between Calgary and Edmonton at the crossing of the Battle River and at Peace Hills. The first real settlement of the area was marked by the completion of the Calgary-Edmonton railway link in 1891 (University of Alberta, 1977).

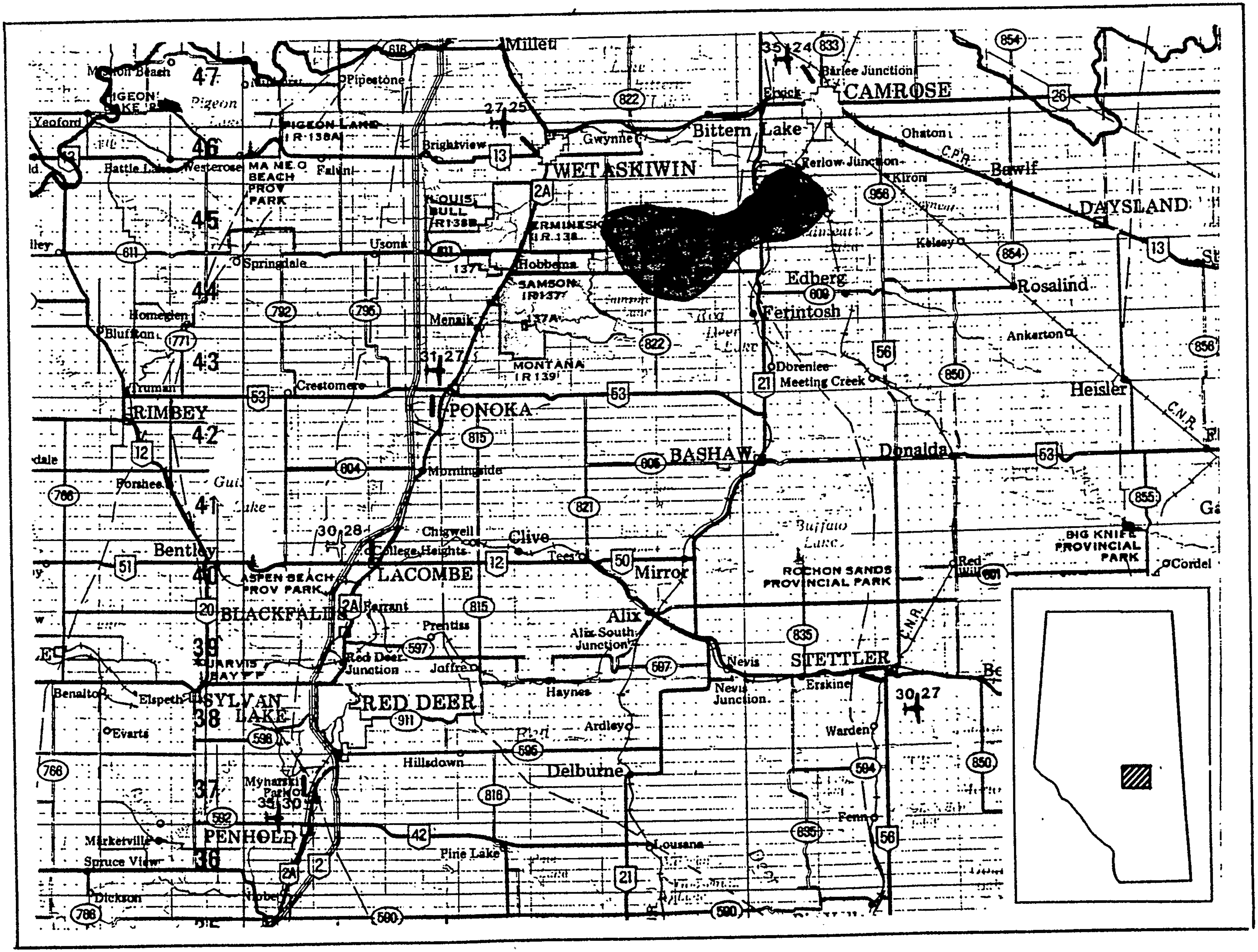


Figure 3.1: Silver Creek Drainage Basin.

Although removed from the main fur trading routes, many travelers passed through the area. The area was also the battle ground between the Cree and Blackfoot Indians. The name Peace Hills, commonly used to describe the area, commemorates an agreement reached between these two tribes. The actual Peace Hills are adjacent to the town of Wetaskiwin, an Indian name meaning Hills of Peace. A reservé was established about this time and although somewhat smaller than its original boundaries, the Hobbema reserve supports an Indian population of about 5000 members.

In 1906, construction began on the C.P.R. line east from Wetaskiwin through Camrose; this line was followed by the construction of the Tofield-Camrose-Calgary line and the Vegreville-Camrose-Stettler line (University of Alberta, 1977).

Agricultural development in the area was predominantly cereal grains. Oats, barley, and wheat were the most common crops. Limited amounts of rye and hay were also grown. Cultivated acreage was highest on the black soils, followed by the thin black and grey wooded soils. Most of the townships settled had less than 140 out of 160 acres per section under cultivation. The remaining lands were either under native tree cover, wetlands, or grasslands (University of Alberta, 1977).

BIOPHYSICAL INVENTORY

The following section presents data on the biophysical characteristics of the Silver Creek basin. The material is provided as reference material for readers interested in the specific biophysical characteristics of the basin.

The Silver Creek basin lies about half way up the third prairie steppe and can be described as an undulating plain (University of Alberta, 1977). The highest point lies in the western most reaches of the basin at 2675 feet and slopes in a north easterly direction to around 2400 feet at the top of the Battle River valley. From there it drops sharply to a low point of 2275 feet at the base of the valley (WER Engineering Ltd., 1985).

The basin lies predominantly within the Red Deer lowlands subdivision of the Interior Plains. The southern most portion of the basin falls within the Central Highlands subdivision. The Red Deer lowlands occupy the preglacial extension of the Red Deer River Valley. The Central Highlands formed as a result of the erosion resistant sandstone beds underlying the area. The Beaver Hills moraine, running north and south, crosses the basin west of New Norway. Portions of this moraine are quite hilly, particularly the southern areas (University of Alberta, 1977).

Most of the area can be described as level to undulating with very few limitations to cultivation. The remainder of the area is gently rolling hills associated with the terminal moraines.

CLIMATE

The Silver Creek Basin is too small to have any significant climatic variations. There are two meteorological stations at Camrose, one just west of town and the other at the airport. The station at the airport is the closer of the two to the Silver Creek basin.

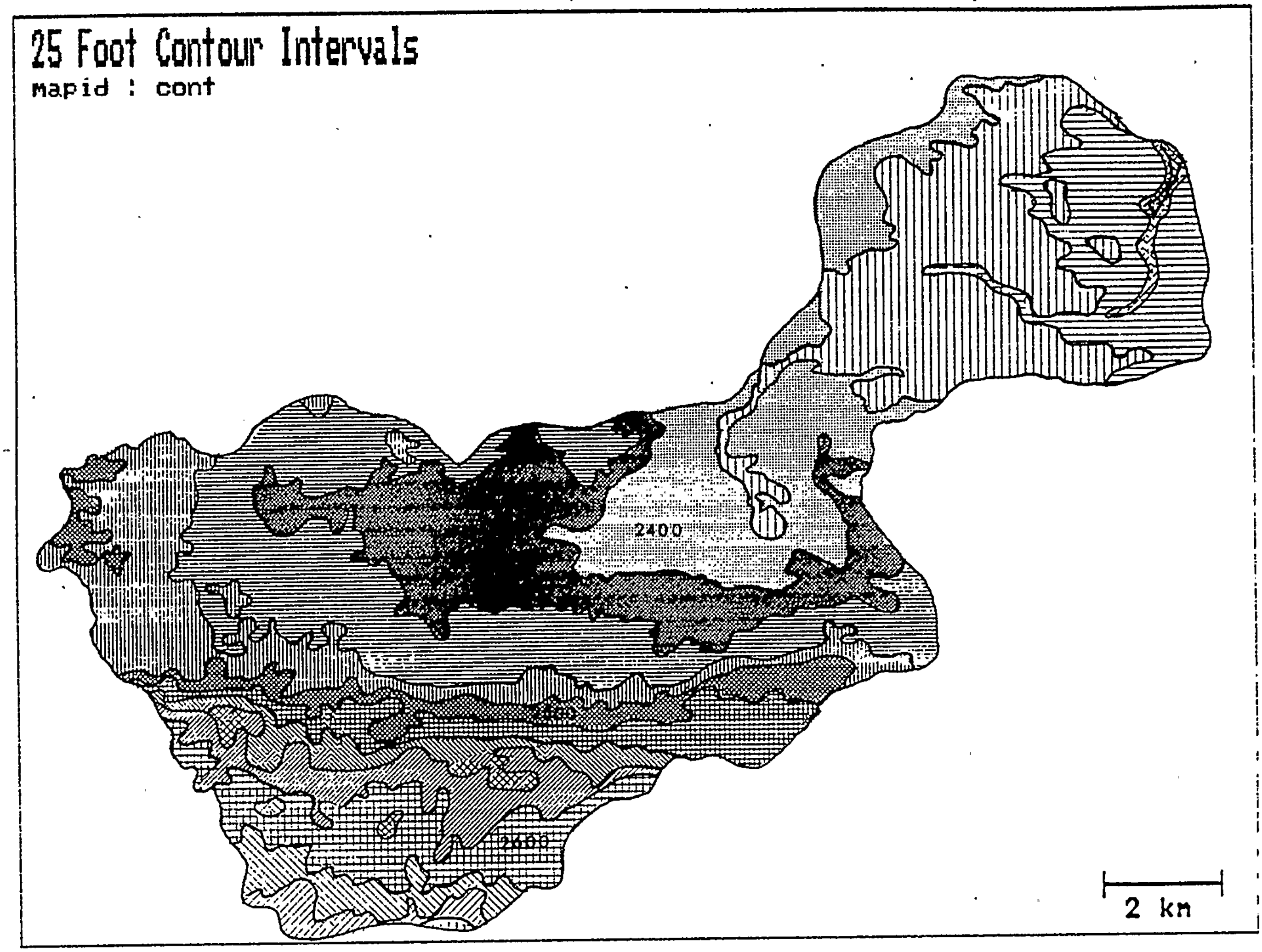


Figure 3.2: This figure presents 25 foot elevation contours. Drainage is from the Southwest (bottom left) at 2675 ft. to the Northeast (top right) at 2300 ft.

The main climatic influences on agricultural production are precipitation, and the number of frost free growing days. For the majority of Central Alberta, the growing season begins in mid April, although the risk of frosts in some areas forces farmers to delay their planting. The average date of the last frost in the Camrose area is June 1 (Longley, 1972). Total precipitation data for the weather station at the Camrose airport is provided in Table 3.1. Normals refer to average values between 1951 and 1980.

TABLE 3.1
TOTAL PRECIPITATION DATA (mm)
CAMROSE AIRPORT WEATHER STATION

	1984	1985	1986	1987	NORMAL *
JAN	----	10.7	23.0	9.0	24.6
FEB	----	21.6	20.9	11.4	17.3
MAR	----	10.2	23.9	----	19.0
APR	32.8	33.2	35.6	27.6	21.7
MAY	46.2	33.6	77.1	31.0	45.3
JUN	92.8	44.0	44.7	60.9	75.9
JUL	47.4	24.6	137.1	----	75.5
AUG	40.2	131.1	34.0	----	75.3
SEP	126.6	32.1	73.3	----	37.4
OCT	35.7	22.6	21.5	----	14.9
NOV	14.8	----	----	----	16.5
DEC	----	30.4	5.2	----	18.5

* Normal refers to long term averages for the period 1951-1980.

Source: Environment Canada, Atmospheric Environment Service, 1987.

Mean annual temperatures for the Camrose area are around 36.5 (degrees F). Highest temperatures occur in July and August with mean temperatures of about 64 degrees F. The mean frost free period for Red Deer, expressed as a ten year average from 1916 to 1970, is between May 31 and September 8, providing an effective growing season between April 25 and October 10 (Longley, 1972).

Average wind speeds and directions for Lacombe 1955 - 1966 are provided in the following Table 3.2.

TABLE 3.2

MEAN DAILY WIND SPEED AND DIRECTION
LACOMBE 1955 - 1966
(SPEED IN MPH)

DIRECTION	JAN	APR	JUL	OCT	ANNUAL
N	6	8.5	5.9	6.3	6.6
NE	4.7	6.2	5.2	5.3	5.4
E	3.6	5.6	4.1	3.4	4.4
SE	6.3	7.7	6.5	7.3	6.9
S	5.4	6.7	4.6	5.9	5.6
SW	5.0	5.9	4.8	6.7	5.6
W	4.3	5.8	4.5	5.2	4.9
NW	9.3	10.2	7.3	9.0	9.2
All Directions	6.0	7.5	5.6	6.5	6.4

Source: Longley, 1972.

VEGETATION

Native vegetation is closely linked to the soil types in the region. The Silver Creek basin is dominated by black soils. Vegetation types found in the black soil zones of the Peace Hills region are included in Table 3.3 as follows:

TABLE 3.3

NATIVE VEGETATION

Trees and shrubs

Scientific Name	Common Name
Populus tremuloides	Aspen poplar
Populus balsamifera	Balsam poplar
Picea glouca	White spruce
Salix	Willow
Lonicera involucrata	Honeysuckle
Viburnum pauciflorum	Cranberry
Rubus strigosus	Rasberry
Symphoricarpos pauciflorum	Snowberry
Amelanchier alnifolia	Juneberry
Corylus rostrata	Hazelnut
Prunus	Chokecherry

Native Grasses

Scientific name	Common name
Koeleria gracilis	Junegrass
Agropyron pouciflorum	Slender wheatgrass
Agropyron subsecundum	Bearded wheatgrass
Agropyron dasystachyum	Thicksoike wheatgrass
Agropyron smithii	Bluestem
Stipa comata	Needle and thread
Stipa viridula	Green needlegrass
Stipa spartea	Porcupine grass
Avena Hookeri	Spike oat
Poa iterior	Inland bluegrass
Poa palustris	Redtop
Poa canbyi	Canby bluegrass
Poa pratensis	Kentucky bluegrass
Festuca scabrella	Rough fescue
Bouteloua gracilis	Blue gramma grass
Sium circuteafolium	Water parsnip
Glyceria grandis	Manna grass
Hordeum jubatum	Wild barley
Calamagrostis inexpansa	Northern reedgrass
Calamagrostis canadensis	Bluejoint

Source: University of Alberta, 1977.

SOILS

The Peace Hills region was covered almost entirely by the Keewatin Glaciation. The ice sheet passed over the area in a south westerly direction mixing the underlying materials with materials transported a considerable distance. This glacial drift was deposited as a mantle over the area, the depth varying from 80 - 100 feet in the Silver Creek basin (WER Engineering Ltd., 1985). Erosive forces have removed the mantle from some of the areas exposing the underlying bedrock (University of Alberta, 1977).

Most of the basin is composed of glaciolacustrine deposits, silt and sands in texture with some clays in the western reaches of the basin. Most of the deposits in the area originated in glacial Lake New Norway fed largely with melt water from the north east and glacial lakes in the Edmonton region (WER Engineering Ltd., 1985). As a result the soils in the region tend to be course grained. Coarser grained soils are found in the north east and finer grained soils are found in the south western portions of the basin near the humocky moraine deposits.

The soils' parent material is of rock origin and greatly influences the present texture and composition of the soils in the area. Other influences include vegetation, climate and micro-organisms acting on the parent material over a long period of time. Variations in these factors will typically be reflected in differing soil profiles in different areas (Leskiw, 1985).

SOIL TYPES

Soils in the region are generally black Chernozemic soils developed on medium to fine textured materials. The western portions of the basin are characterized by coarse grained chernozems and become progressively more solodic moving in an easterly direction, the occurrence of Gleysolic and Solonetzic soil types increases, and the soils tend to become more fine textured. Wetlands are characterized primarily by Gleyed Black, Gleyed Solonetzic, Gleysolic soils (University of Alberta, 1977).

BLACK SOILS

The black soil zone in Alberta falls within the Parkland zone of central Alberta. Approximately two thirds of this zone falls within the Peace Hills area (University of Alberta, 1977). The Silver Creek basin falls entirely within the Black Soil Zone. All soil groups identified in the basin are black soils with the exception of some gravel beds identified in the south central portion of the basin (see Figure 3.3).

SOILS DEVELOPED ON GLACIAL TILL

The parent material for most of these types of soils is the Edmonton formation. Glacial till in this area is generally a brown to grey brown color and has a sandy clay texture. The till is spread as a thin ground moraine over the Camrose area. These are generally fertile soils and have upwards of 16 inches of black surface material.

ANGUS RIDGE LOAM

Angus Ridge Loam (Ar.L) is fairly well to well drained soil usually found on gently undulating topography. Native cover is grass and shrubs with bluffs of aspen poplar. This tends to be the dominant soil in this area. These soils generally occupy the higher well drained lands. No visible salt concentrations were noticed in Ar.L. profiles to at least 50 inches. These soils are

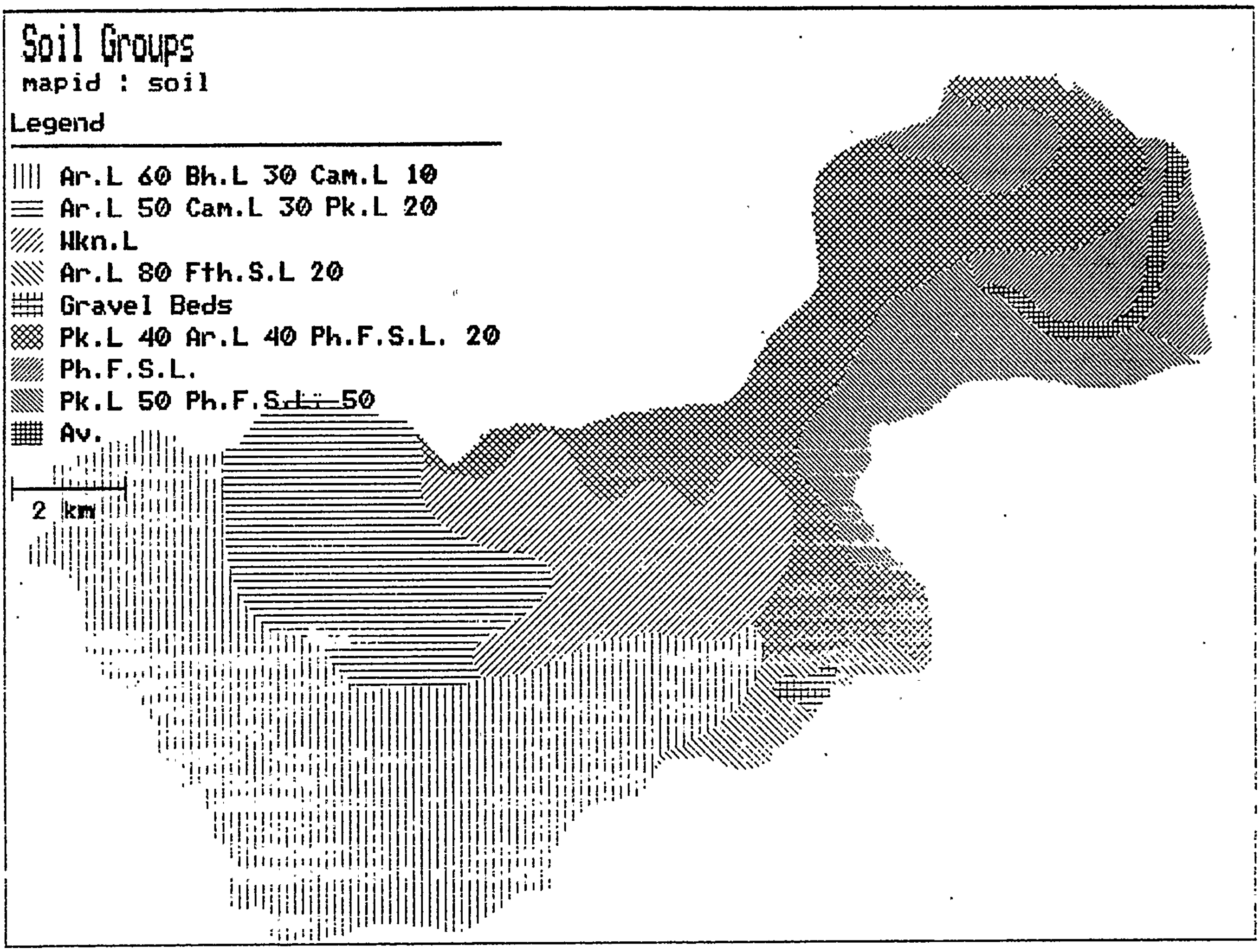


Figure 3.3: Soil groups. This figure was derived from Alberta Research Council Soil Survey Reports (Report No. 14), and shows the dominanat soil types occurring in the basin.

generally very fertile and adaptable to a wide range of crop types. Ar.L. profiles can be distinguished by a deep black surface, a thin grey subsurface horizon and a brown clay subsoil. These soils are generally good to excellent arable lands (University of Alberta, 1977).

BEAVER HILLS LOAM

Beaver Hills Loam (Bh.L) is a well drained soil found on undulating topography. Native cover is grass, shrubs and poplar. These soils are found in the Beaver Hills Moraine described earlier. These soils are generally found on the tops of hills and part way down the slopes. Dry Knolls generally have a thinner profile. Bh.L can be distinguished from Ar.L by the absence of the thin grey subsurface horizon. The change from black to brown and dark brown is more gradual in the Bh.L profile. These soils are generally good to very good arable lands (University of Alberta, 1977).

CAMROSE LOAM

Camrose Loam (Cam.L) tends to be a poor to fairly well drained soil found on gently undulating topography. Native cover is grass and small shrubs. These soils are generally found on gentle slopes. The black horizon is usually thin and the subsurface horizon hard and poorly drained. The A1 horizon is generally thin with practically no A2 horizon present. These thinner profiles are poorly to moderately drained. Salt concentrations are generally higher than in the better drained profiles. Because the black horizon is loose and thin it should be considered highly susceptible to wind and water erosion. The hard subsoil absorbs water very slowly. As a result the top soil horizon may actually flow during periods of heavy persistent rains, and may expose the less fertile subsoils. The hard subsurface horizon is also difficult for roots to penetrate. This problem is most evident during dry periods. Cam.L is fairly good to good arable land and adaptable to a fairly wide range of crop types. Cultivation practices should address the problems identified above (University of Alberta, 1977)..

WETASKIWIN LOAM

Wetaskiwin Loam (Wkn.L) is of Glacio Lacustrine deposition with a calcareous clay parent material. Its' material is sorted out of till that is mainly of Edmonton origin. The parent material is brown to olive in color. Soils are moderately to fairly well drained typically found on level topography. Native cover is grass, shrubs, willow and aspen poplar. The A1 horizon is generally 6-12 inches in depth and the A2 from 1-4 inches. The profile of these soils is very similar to the Cam.L. with a hard subsurface horizon. Agricultural problems described for the Cam.L. apply here as well. Wkn.L. provides fairly good to good arable land particularly well suited to mixed farming. Deep rooted plants which could penetrate the hard subsurface horizon would improve the quality of these soils (University of Alberta, 1977).

PARKLAND LOAM

Parkland Loam (Pk.L.) originates from Alluvial Lacustrine deposits and developed on a sandy loam to clay loam parent material. The soils tend to be lighter in texture in the upper horizons. Pk.L. is a well drained soil found on level to undulating topography. Native cover is parkland to light forest consisting of aspen bluffs with open areas covered with tall grasses and shrubs. Pk.L. is mildly solodic and can generally be recognized by a deep black surface horizon and a slightly sandy, thin and light colored subsoil. The upper profiles look similar to Ar.L., but can be distinguished by the stone free subsoil. Pk.L is good to very good arable land (University of Alberta, 1977)..

PEACE HILLS FINE SANDY LOAM

Peace Hills Sandy Loams are well to almost excessively drained soils occurring on mainly level to undulating topography. Native cover consists mainly of parkland vegetation such as aspen bluffs, shrubs and coarser grasses. These soils usually contain some coarser sands and often fine gravel. The Peace Hills Fine Sandy Loam (Ph.F.S.L.) which occurs in the Silver Creek Basin contains mostly fine sands and tends to be slightly heavier than other sandy loams. These soils can be identified by a deep black sandy surface horizon followed by a thin light colored horizon directly below the black, and a loose sandy subsoil. These soils are sufficiently sandy to be susceptible to wind erosion and have a low water holding capacity. However, the particles are generally fine enough to be fairly fertile soils. To maintain the fertility of these soils grasses and clovers should be included in crop rotations to help maintain organic matter in the soils. Unprotected areas will deteriorate rapidly (University of Alberta, 1977).

In conclusion, the soils in the Silver Creek Basin are generally very good agricultural soils. There is very little variability across the basin in terms of the productivity of the different soil types (Leskiw, 1985).

HYDROLOGY

Silver Creek flows east and then north eventually flowing into the Battle River upstream of Dried Meat Lake (the lake is actually an on-stream reservoir with control structures at the outlet). The southwestern section of the basin is drained by an intermittent channel, referred to as the South Lateral. The average gradient of the South Lateral is 0.0095 and the gradient of the main channel of Silver Creek was 0.0019 before channel improvements were completed in 1983 (WER Engineering Ltd., 1985). Details of the channel improvements are discussed later in the document. The upper reaches of the main channel meander through the basin and were poorly defined before channelization works were completed. The lower reaches of the channel are deeply incised as the creek falls 125 feet to the base of the Battle River Valley.

Wetlands in the basin cover 4955 acres (see Figure 3.4). Permanent wetlands account for 1312 acres and non-permanent wetlands make up the remaining 3643 acres, based on aerial photo interpretation carried out by Intera Technologies (1984) for Alberta Environment. The wetlands were digitized for use on the Tydac SPANS system from wetland maps produced by Riley's Data Share and provided by Alberta Environment. The majority of wet

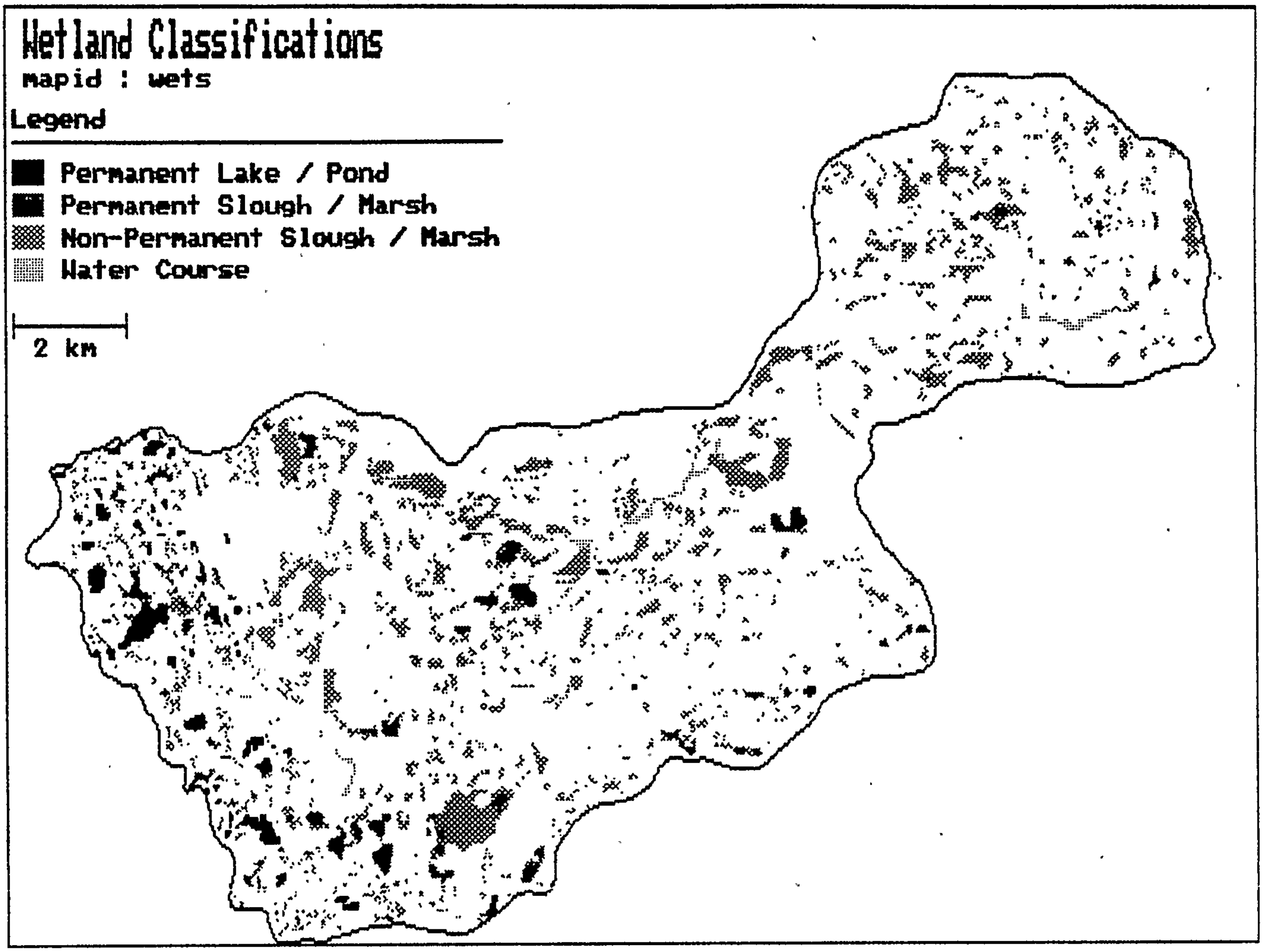


Figure 3.4: Wetlands in the basin were classified by Intera Technologies. The figure shows the location and classifications of the wetlands occurring in the basin prior to drainage improvements.

lands fall within the central portion of the basin.

Depressional storage was estimated by WER Engineering Ltd. (1985) based on the classified wetland types, including permanent and non-permanent wetlands, and spot elevations provided by Jensen Engineering (1985). These totals are included in Table 3.4. Depressional storage estimates are important in helping to determine flow requirements for receiving channels in the design of drainage systems. To accurately determine depressional storage precise mapping of one foot contours would be required. For the purpose of the IDSC study, such detailed calculations were not required. Should a more comprehensive drainage scenario be considered for the Silver Creek basin, more detailed estimates may be required.

For the calculations shown in Table 3.4, assumptions were made about average depths for "deep" and "shallow" wetlands, based on limited spot elevations together with the air photo interpretation, and "...shape factors to compensate for the cross sectional shape of the depressions." (WER Engineering Ltd., 1985. p.8).

Based on the basin characteristics, depressional storage estimates, rainfall data, and several simulation parameters, peak outflows for the basin were calculated for the existing patterns and four scenarios. These estimates are presented in Table 3.5.

		TOTAL AREA	AVERAGE DEPTH	SHAPE FACTOR	DEPRESSION STORAGE
PERMANENT	DEEP	730.6	2.3	1.0	1889.5
	SHALLOW	120.3	1.0	0.5	60.6
	CHANNEL	0.0	1.0	0.5	0.0
	BASIN	369.2	1.0	0.8	295.3
	SLOPING	0.0	0.1	1.0	0.0
NON-PERMANENT	DEEP	634.2	1.6	1.0	758.1
	SHALLOW	2803.0	1.0	0.5	7357.2
	CHANNEL	0.0	1.0	0.5	0.0
	BASIN	191.8	1.0	0.8	153.5
	SLOPING	180.8	0.1	1.0	18.0

NOTE: Table includes all polygons defined as "lake/pond" or "slough/marsh", does not include polygons defined as "watercourse" or "seep".

TABLE 3.4: Depressional Storage Estimates for Wetlands in the Silver Creek basin.
Source: WER Engineering Ltd. 1985.

TABLE 3.5: RUN-OFF FOR SILVER CREEK

CONDITION	OUTFLOW (cfs) (5 year)	(10 year)
Existing	290	420
Unrestricted Drainage of all Wetlands	690	1070
Unrestricted Drainage of Non-permanent Wetlands	650	1020
Restricted Drainage of All Wetlands	550	700
Restricted Drainage of Permanent Wetlands	550	700

Source: WER Engineering Ltd., 1985.

DOCUMENTED HISTORY OF FLOODING AND DRAINAGE PROBLEMS

Drainage problems in the Silver Creek area date back to 1948, according to records at Alberta Environment's Edmonton Region Office. The first drainage works in the area were reported to have been implemented by the County of Wetaskiwin in 1948. These works included several channels in the upstream reaches which were designed to lower sloughs adjacent to roadways which were subjected to periodic flooding. These ditches were installed in sections 10, 11, 12 - 45 - 22 - W4, shown in Figure 3.5.

The channels which were installed by the County of Wetaskiwin, as well as subsequent ditching by private landowners, introduced an additional 8 square miles of land area to the Silver Creek watershed (Alberta Environment, Water Resources Administration Division, 1985). The addition of these new areas is believed to have been a major contribution to the flooding

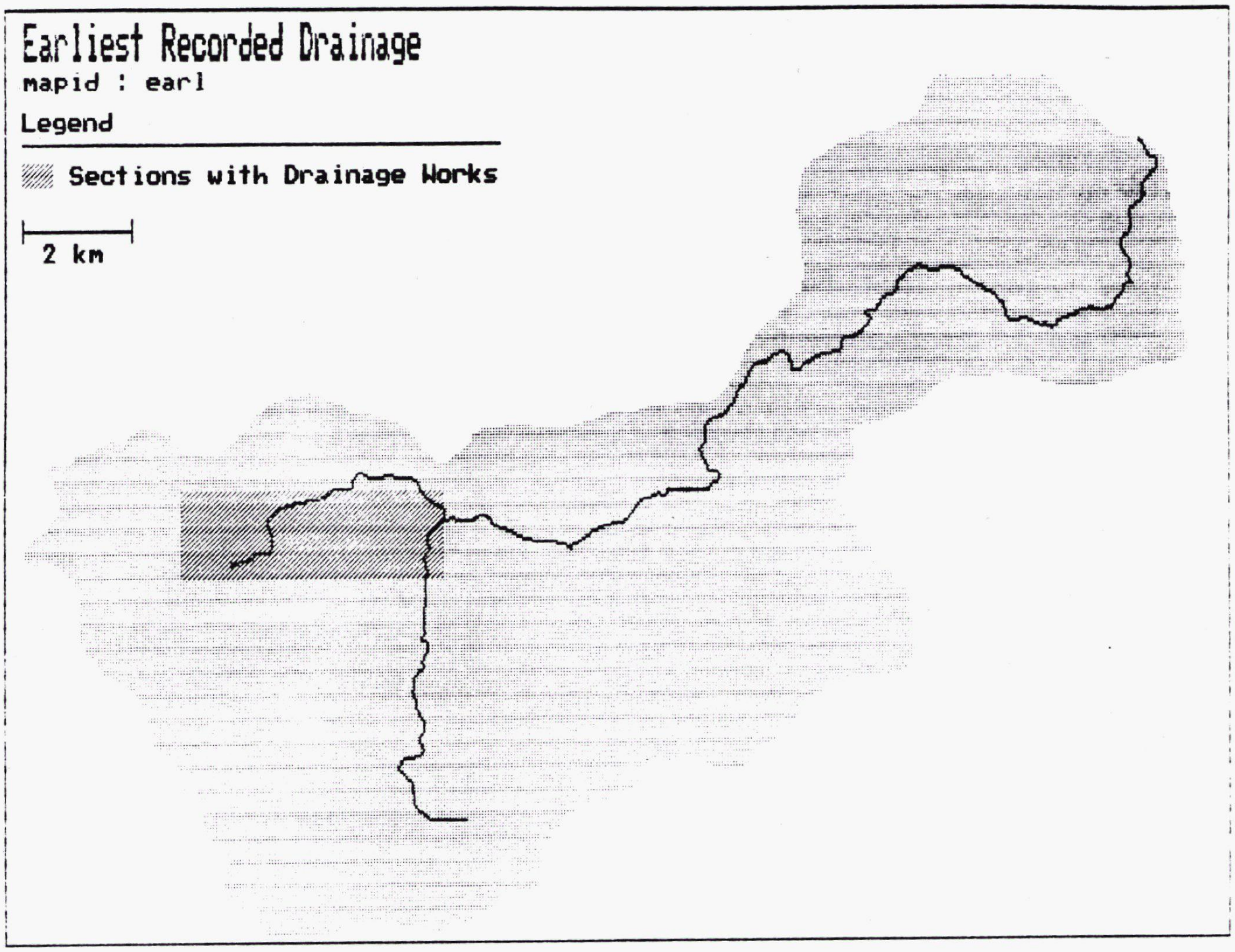


Figure 3.5: This figure shows the sections where the earliest recorded drainage was installed. Drainage improvements were designed to reduce flooding on municipal roads.

problems in the basin (Alberta Environment, Water Resources Administration Division, 1987). None of these channels were ever licensed.

For the period between 1958 - 1987 a total of 64 complaints were filed with Alberta Environment for the Silver Creek drainage. Table 3.6 provides a breakdown of the types of complaints. The reported complaints are classified as follows:

F - FLOODING - complaints relating to the general accumulation of casual surface water usually resulting from precipitation

D - DRAINAGE - requests to construct works to eliminate surface water or lower a permanent body of water

UW - UNAUTHORIZED WORKS - complaints or investigations relating to possible violations of the Water Resources Act

L - LICENSE OR PERMIT - includes final license inspections, inspections resulting from requests of the Water Rights Branch and inspections required to evaluate the progress of a report

E - EROSION - complaints or investigations relating to gully or rill erosion caused by surface water or the erosion of river banks

FD - complaints where it is difficult to differentiate between flooding and drainage or where it involves both

O - OTHER - inspections which clearly do not fall into any of the previous types

(Alberta Environment, Water Resources Administration Division, 1985)

TABLE 3.6: WATER RELATED COMPLAINTS 1958 - 1987

YEAR	F	D	UW	L	O	E	FD	TOTAL
1958	2							2
1963	1							1
1968		1						1
1969		1	2					3
1970		1						1
1973	1	1						2
1974	8	1	3					12
1975	1	2						3
1976		1						1
1978	2			1				2
1979	2	1						3
1980		1		1				2
1981		1						1
1982	3							3
1983	4	3						7
1984	4					1		5
1985						1		1
1986		5			2		2	9
1987		3			1			4
TOTALS	26	24	5	2	3	2	2	64

The distribution of these complaints is shown in Figure 3.6. The total of 64 points does not appear on Figure 3.6 because many of the reported complaints are for the same location.

Looking at the yearly totals on the right there are two noticeably bad years, relative to the others. The first was in 1974 which is generally acknowledged to have been an unusually wet year on the prairies. The second highest year of recorded complaints is 1986, two years after the implementation of the drainage system in the basin. Overall, there does not appear to be a high number of complaints for the area relative to other areas in Central Alberta.

The first movement towards the implementation of drainage improvements in the basin was initiated by two landowners in the

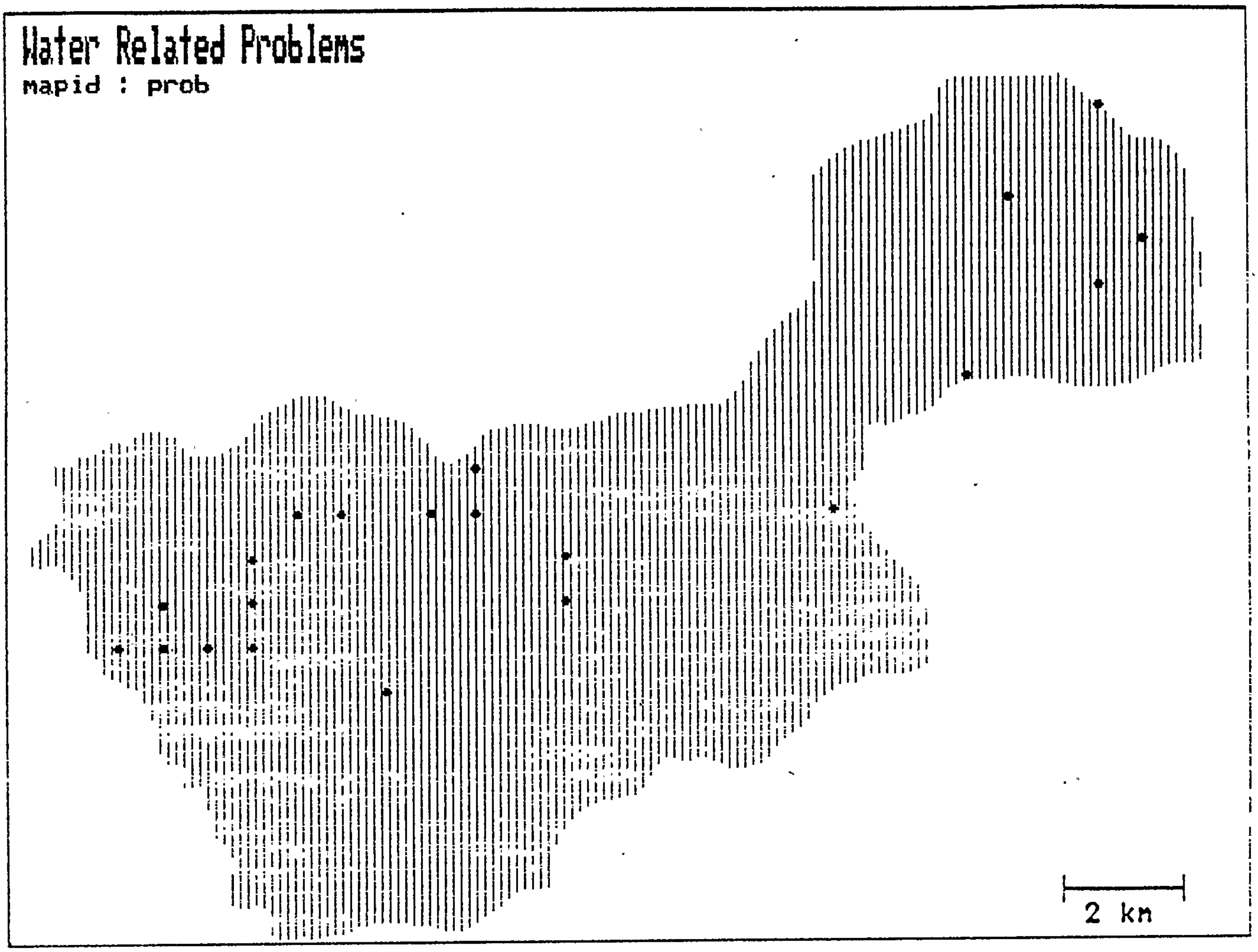


Figure 3.6: The points shown in this figure are the locations of land owners who reported flooding or drainage problems on their lands since 1958. There may be more than one complaint associated with any point.

upstream reaches of the basin in sections 24, 25 - 44 - 22 and sections 19, 30 - 44 - 21. These wetlands were located at the southern tip of the present South Lateral extension of the drainage channel. The project was to drain approximately 1 square mile of land area covered by permanent and temporary wetlands (see Figure 3.7).

In 1974, following an excessively wet year, the Department of the Environment was asked to evaluate the feasibility of providing drainage improvements to allow for the drainage of a large wetland in the upstream reaches of the channel. Concerns were expressed by downstream landowners and the Department of the Environment that the drainage of these wetlands would exacerbate flooding problems in downstream areas (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

As a result of these concerns, several proposals for drainage improvements were addressed. These proposals looked at the possibility of providing channel improvements and at the feasibility of draining additional lands into the creek as well as the wetlands originally under consideration. The total size of the drainage area was expanded to the north and west and is referred to as the West Extension (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

The County of Camrose considered acting as the licensee for the project and participating in the construction. When they realized that they would be responsible for the maintenance of the system they withdrew their support fearing the maintenance

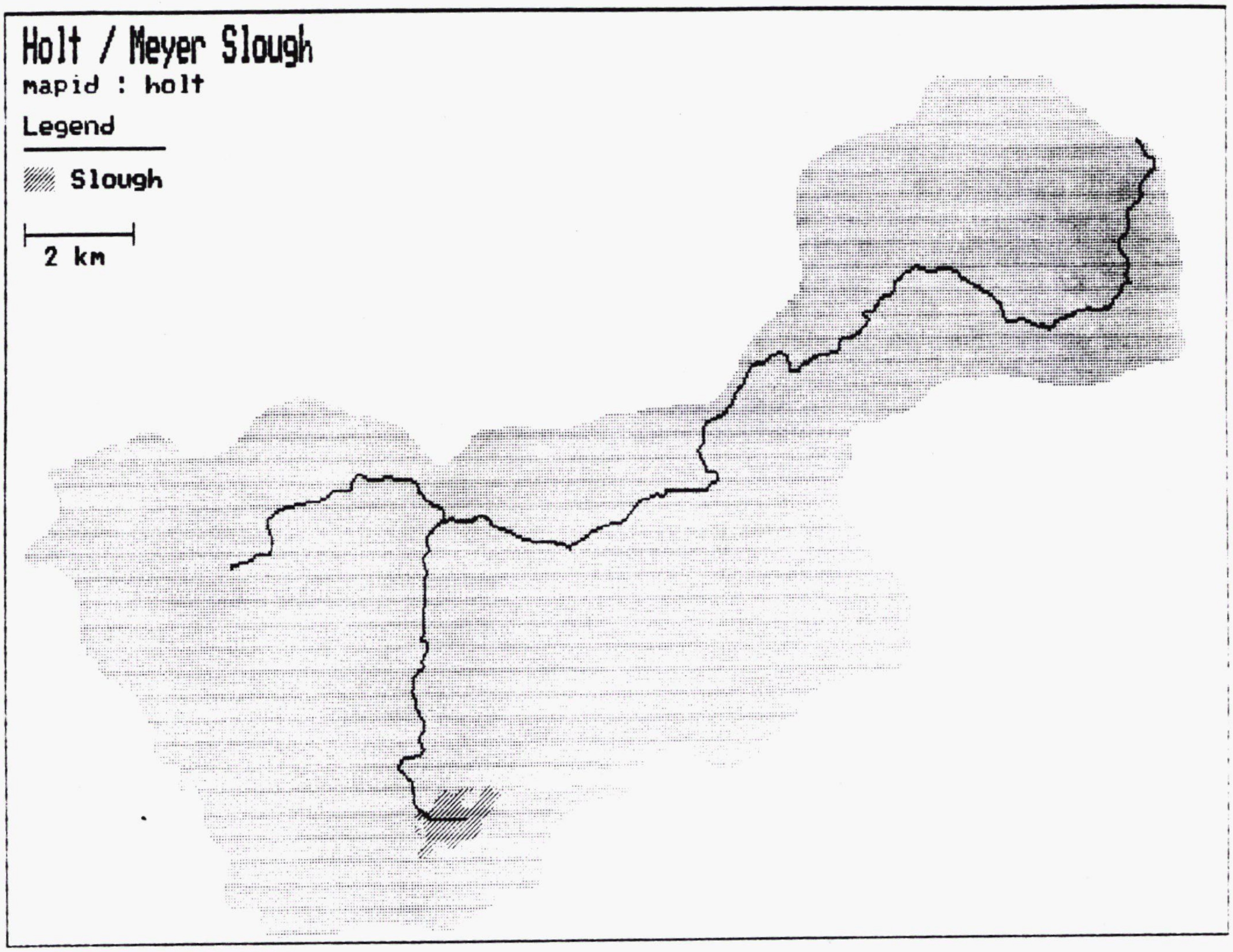


Figure 3.7: The area indicated in the lower portion of the map shows the total area which was drained under a licensed issued prior to the implementation of the Silver Creek Drainage System. The South lateral stretch of the channel was improved to accommodate these flows.

costs would be an unreasonable burden. The County was also uncertain as to how they would be able to raise the money to construct the project. With the support of the County withdrawn, ad hoc committees were established among the landowners in the basin to review problems and address possible cost sharing programs.

The original two landowners who wanted to drain their wetlands secured consent forms from 28 downstream landowners, as required by the application for license. The signatures provided easements which would allow the increased flows, which would likely result from the drainage works, to cross their lands. The landowners included all individuals who owned land over which the discharged water would flow. Once the consent forms were secured, the areas were surveyed and procedures initiated to secure the necessary permits to drain the wetlands.

An interim license was not issued for the drainage of the area until November of 1979 at which time the water was released from the wetlands. Inspection of the areas downstream of the wetlands showed some flooding in SW-6-45-21 during discharge of the water but the flooding did not top the road so nothing further was done (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

As a result of the County withdrawing their support for the project, and their refusal to act as licensee, the land owners started proceedings to establish a Drainage District in order to raise the necessary funds to construct and operate the system. Landowners were petitioned by members of the new Drainage Committee and signatures were collected in support for the establishment of a Drainage District. A petition was submitted to the Minister of the Environment with a strong endorsement from Gordon Stromberg, the MLA for the area at the time, who also owned land in the basin (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

The establishment of a Drainage District for the area raised a great deal of concern in the County Office, and with Ducks Unlimited which tends to act as a drainage watchdog in the province and elsewhere. In a memo dated May 26, 1981, DU stated the following:

> We do not feel that (the Silver Creek Drainage Project) is in the best interest of the environment. The possible formation of a Drainage District is particularly disconcerting as this invariably results in the total destruction of wetland habitat in any area. (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

Before the Drainage District was formed the County was informed that they would be able to levy a tax on the land owners in the area under section 96.1 of the Water Resources Act, and threw their support behind the project again (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

Section 96.1 of the Act provided for the levy of a "special local water control benefit assessment" which could be assessed against each parcel of land in the vicinity of a water control project (Water Resources Act, sec 96.1 (2)). Section 96.1 (2) reads:

> For the purposes of paying for its share of the cost of a water control project fixed in an agreement under section 96 ... a local authority ... may impose an assessment called a "special benefit assessment"

> which shall be assessed against each parcel of land in the vicinity of the lake or stream that is to be controlled or stabilized by the water control project.

Section 96.1 (3) outlines which parcels are to be assessed.

> Each parcel referred to in subsection (2) shall be assessed whether or not the parcel abuts on the lake or stream that is to be stabilized or whether or not the parcel is increased in market value or is otherwise specially benefited by reason of the water control project.

The act does not clearly specify what constitutes a special benefit, and as a result there is considerable room for interpretation.

The solicitor for the County of Camrose expressed concern that the Silver Creek Drainage Project did not fall within the definition of a water control project and they once again withdrew their support for the project. However, a legal opinion from the Attorney General's Department confirmed that the County was within its' rights to impose a special benefit assessment and they once again agreed to act as licensee for the project (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

In 1977 Alberta Environment surveyed the area and started working on a design concept for drainage in the Silver Creek Basin. This report was completed and presented to the County in March of 1981 (Alberta Environment, 1981). They prepared and presented costs for a one in ten year flood protection plan and a one in five year plan. They also presented a third alternative which involved channel cleaning and the removal of flow restrictions.

The County indicated that they could not afford either of the flood protection plans and that the eventual drainage concept, which basically involved repairs and improvement to the existing channel, was inadequate. In 1983 the County retained Samide Engineering to produce a more cost effective design (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

The main difference between the Samide design and Environment's Level One Design Report was that Samide decided to use the culverts along the main channel as chokes to restrict the flow of water to the existing 5 year peak flows (approximately 5 cfs/square mile) thereby eliminating the need to expand the capacity of the main channel by the amount indicated in Environment's Level One Report. In peak storm events the choke culverts would simply back up excess water and release this water at a rate which the main channel was designed to accept. It was assumed that the water would drain off the flooded lands before crops were damaged (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

3.2 PROJECTED AND ACTUAL BENEFITS AND COSTS

PROJECTED BENEFITS

The major benefit which was put forward for the implementation of the system was the relief of flooding problems and the increase in available land for cultivation (Samide Engineering Ltd., 1983; Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987). The engineering report prepared by Samide Engineering Ltd. (1983) became the standard benefit assessment when approval was being sought for the project.

According to the Samide Report, the system "...could eventually provide increased agricultural capability for about 1100 acres of privately owned land." (Samide Engineering Ltd., 1983. p.13). This increase was attributed to the drainage of 900 acres of potholes and 200 acres of wetland along the main channel. The major benefit identified was to provide an adequate channel for land owners to drain excess water into.

The County of Camrose estimated that the total benefit, where benefits are measured in increased acreage, from the implementation of the system would be 1550 acres (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987). This figure was used in their assessment of charges to land owners. This figure was arrived at by an independent assessment completed after they had received the report from Samide Engineering.

In petitioning for approval of the project, the nature of the words used to describe the benefits changed slightly from the engineering report. In memos to the Water Resources Administration Division and to the Assistant Deputy Minister it is stated that "The project **will** (my bold) provide drainage and flood control for approximately 1100 acres of privately owned agricultural land." (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987). Additional benefits were attributed to roads in the County by reducing the number of washouts. Social benefits were attributed to the elimination of personal conflicts between landowners in the basin.

There was some confusion about the actual benefits to be realized as evidenced by internal correspondence within Alberta Environment. In a memo dated March 2, 1981, from the Program and Finance Officer to his director, the former states that the present level of benefit is "...approximately 400 acres." (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

An independent assessment completed by Ducks Unlimited concluded that the area of agricultural land proposed to be drained amounted to approximately 245 acres, based on air photo evaluations, review of the Level One Design Report (Alberta Environment, 1981) and field surveys (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

Assessment of the benefits to be realized from the project was never extended to a complete cost-benefit assessment.

PROJECTED COSTS

The total cost for the implementation of the system was estimated to be $285,000 (1983 dollars). This figure included all engineering and construction costs. This figure was substantially lower than the previous estimates made by the Department of the Environment which were 1.1 and 1.4 million dollars for 1:5 and 1:10 year flood protection designs respectively (Alberta Environment, 1981).

The environmental impacts predicted from the project in the engineering report are summarized as follows:

> "...it would appear that the project would have a negative impact on Waterfowl production in the area." (Samide Engineering Ltd., 1983. p.15)

An assessment of the potential impacts on waterfowl was prepared by Ducks Unlimited (DU) in response to Environment's Level one design report.

DU felt at that time that the non-permanent and permanent wetlands in the Silver Creek basin function as important brood salvage areas, and the non-permanent wetlands as important brood-rearing habitat. According to their calculations, the 5 major wetlands along the main channel provide salvage habitat for nearly 100 acres of non-permanent wetlands within one half mile of their perimeters. Further, they estimate that these wetlands also provide salvage habitat for other non-permanent wetlands located along Silver Creek. They estimated that the area produced approximately 866 ducks annually and provided habitat for an undetermined number of other aquatic based wildlife species (Ducks Unlimited, 1981).

Operation and maintenance costs were not included in the original cost estimates provided by Samide Engineering Ltd. (1983). The County of Camrose has included a 5000 dollar addition to their fund raising efforts to cover maintenance costs in the future (Alberta Environment, Water Resources Administration Division, Edmonton Regional Office, 1987).

According to the Samide Report, the design would have the following effects on the wetlands adjacent to the main channel:

> "...this project would leave one wetland as is, lower three wetlands below the (DU's) recommended levels, and drain three wetlands completely." (Samide Engineering Ltd., 1983)

This represents the only assessment of the wildlife costs from this proposed drainage system. While acknowledging that the project will have a negative impact on waterfowl, they discount the importance of this impact by pointing out that they were unable to locate the wetlands on a 1918 township map. Therefore, the wetlands must have been dry in the past and they would not necessarily be changing the wetlands from what they had been in the past (Samide Engineering Ltd., 1983).

The engineers responsible for Environment's Level One Report recommended that should the drainage proposals be considered, detailed cost-benefit analysis should be undertaken, and the potential impacts of the system on the channel below the outlet should be examined. They did not discuss in any detail the particular impacts of their proposals, however, they state that their third alternative, the minor channelization program, would have minimal impact (Alberta Environment, 1981).

ACTUAL COSTS

An As Constructed Report was given to Water Resources Administration Division in February of 1986 (Samide Engineering Ltd., 1986). This report outlines the costs incurred in the implementation of the system, the final design specifications and comments on the effectiveness of the system. There was no benefit cost assessment in the report.

The complete system included 19 km of channelization, the installation of two drop structures and the installation of ten culverts. The contract was awarded in the fall of 1983 and the majority of the work completed in the spring of 1984. Final details were complete by the fall of 1985 (Samide Engineering Ltd., 1986).

The project was constructed according to the design with the exception of a 2.2 km reach in the upstream portion of the basin. Here, the grade of the channel was lowered an additional 0.6m from the original design to facilitate more complete drainage of the wetlands in the area (Samide Engineering Ltd., 1986).

The final cost of the project was $315,875.26, according to the engineer's report (Samide Engineering Ltd., 1986). The cost overruns were due to changes in the design, as outlined previously, and unforeseen changes which were deemed necessary to complete the project. These changes included the following:

- lowering of the channel grade in two upstream sections
  cost - $20,000.00
- channelization in areas where no work was considered necessary in the original report
  cost - $5,000.00
- lowering of a pipeline struck during construction
  cost - $ 4,000.00

- installation of two extra gravel crossings not included in the original estimates
  cost - $ 3,000.00

- repair of slumped bank occurring along a stretch of the channel
  cost - $2.000.00

- additional channelization works below C.P.R. mainline
  cost - $6,000.00

- seeding costs not included in the original design
  cost - $5,000.00

The estimated cost of these additions was to be $45,000.00 bringing the total cost of the project to $330,000.00. The actual cost overruns totaled $28,498.00 bringing the total expenditures to $315,875.26 (Samide Engineering Ltd., 1986).

This total does not include the administration costs incurred by the County of Camrose or the Department of the Environment, the on-farm costs incurred by farmers, any maintenance and operation costs, or any wildlife habitat mitigation costs.

The costs were shared by the County of Camrose and the Department of the Environment. The County was responsible for 25 percent of the total and the Department of the Environment provided a grant for the remaining 75 percent.

In order to raise the money for the County share of the project, a one time tax was levied on selected landowners falling within the Silver Creek Basin whom the County felt would benefit from the system. The majority of these owners were within the County of Camrose and several were within the County of Wetaskiwin.

The County adopted the notion that those who benefit from the system should pay for the system. Landowners were told by members of the Drainage Committee that those who did not benefit from the project would not be charged. Personnel in the County of Camrose Office and members of the Drainage Committee (made up of a select few landowners) felt that everyone in the basin would benefit from the drainage improvements, and that those benefits would best be reflected in increased land values as a result of the drainage improvements (R. Cote, 1987).

A charge was assessed based on a basic rate per acre of land owned, and a rate per acre of wetland on the property. The basic rate per acre was $3.75 and was multiplied by the number of acres in the parcel. The $3.75 seems to havé been determined arbitrarily.

The rate per acre of wetland was determined by assessing the property value of the land. The County assumed that the best agricultural land in the basin would sell for approximately $600.00 per acre. The wetlands were considered to be inferior lands even when drained so they were valued at $300.00 or less per acre. Assessments ranged from $150.00 to $300.00 per acre, lands directly adjacent to the channel were valued at $300.00 per acre, those parcels once removed from the channel (i.e. an easement would be required to access the channel) were assessed $250.00 per acre, those parcels twice removed were assessed at $200.00 per acre, and so on (R. Cote, 1987). Assessments were conducted by the County of Camrose Land Appraiser. This per acre value was then multiplied by the number of acres of wetland on each parcel, and added to the basic rate per acre of the entire parcel to determine the total charge per landowner.

The total wetland acreage was calculated by Jensen Engineering (1985) out of their Olds Office. 1984 black and white air photos were used to identify wetlands. Wetlands were plotted with a CADD (Computer Aided Drafting and Design) system and total wetland areas calculated for each land holding.

The County's share of the costs came to $78,374.57 and was divided among 131 parcels which the county felt had benefited from the system.

The data was used in spatial analysis system to examine the distribution of the data. Thematic maps were generated by calculating the values around every sample point and generating areas which represent averages over a larger area. Figure 3.8 shows the locations of all the sample points used in the analysis. What is produced is a series of equal potential areas around each point. Ten intervals were specified between the highest and lowest values.

Figure 3.9 shows the distribution of the payments made by individual land holdings. The majority of the payments were made by individuals owning land directly adjacent to the channel. Slightly over 50 percent of the total assessments were made on land parcels directly adjacent to the channel.

The assessments did not consider whether the individual landowners ever intended to drain their property, whether the drainage of their property was economically feasible, or whether drainage into the system was even possible. A great deal of anger was expressed by landowners in the area who felt they had not gained anything from the system.

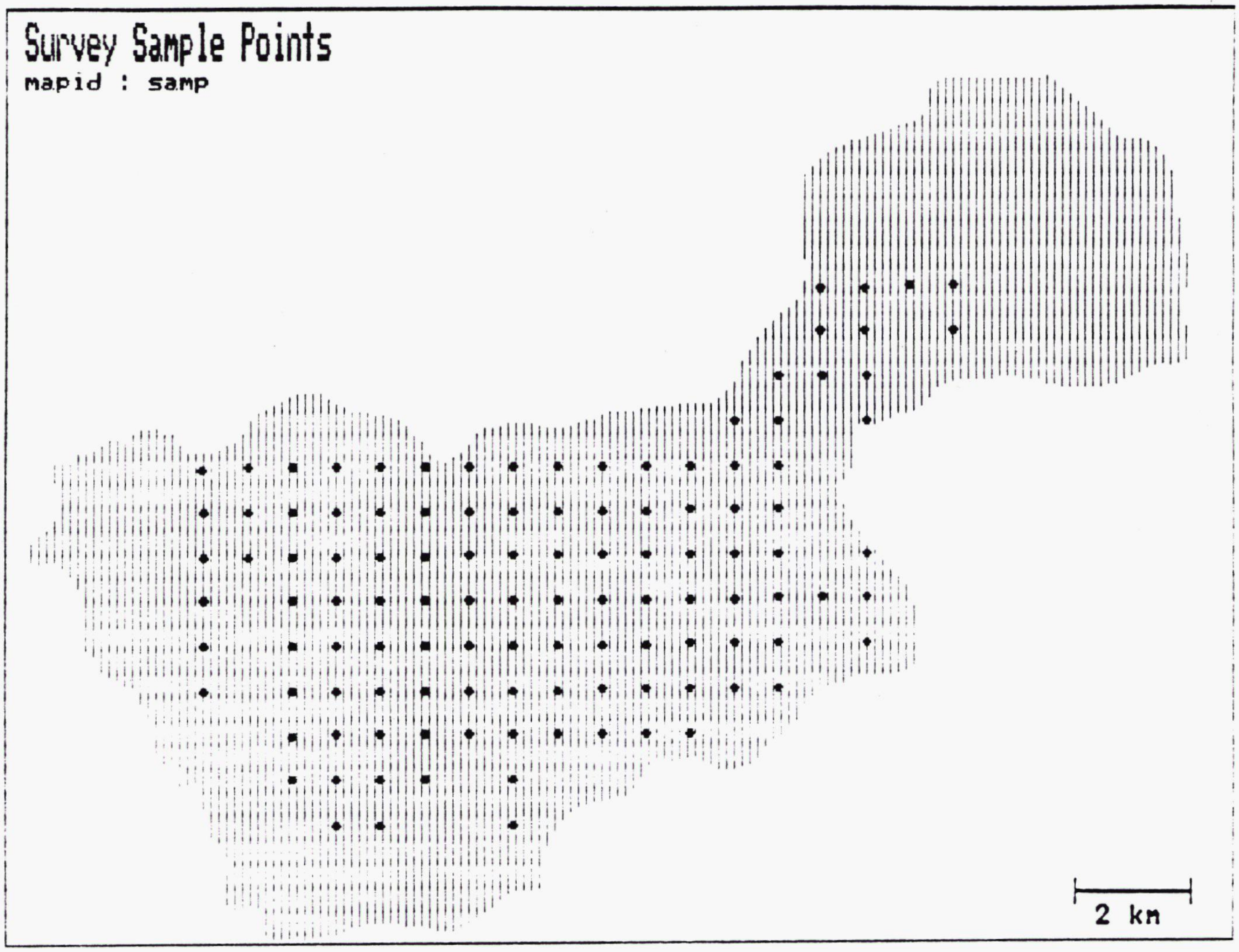


Figure 3.8: The points shown in this figure represent the locations of land owners property within the Silver Creek Basin. Each point has specific values assigned to it which are used to generate other thematic maps. These points were are used to generate the thematic maps to follow (Figure 3.9 and Figure 3.10).

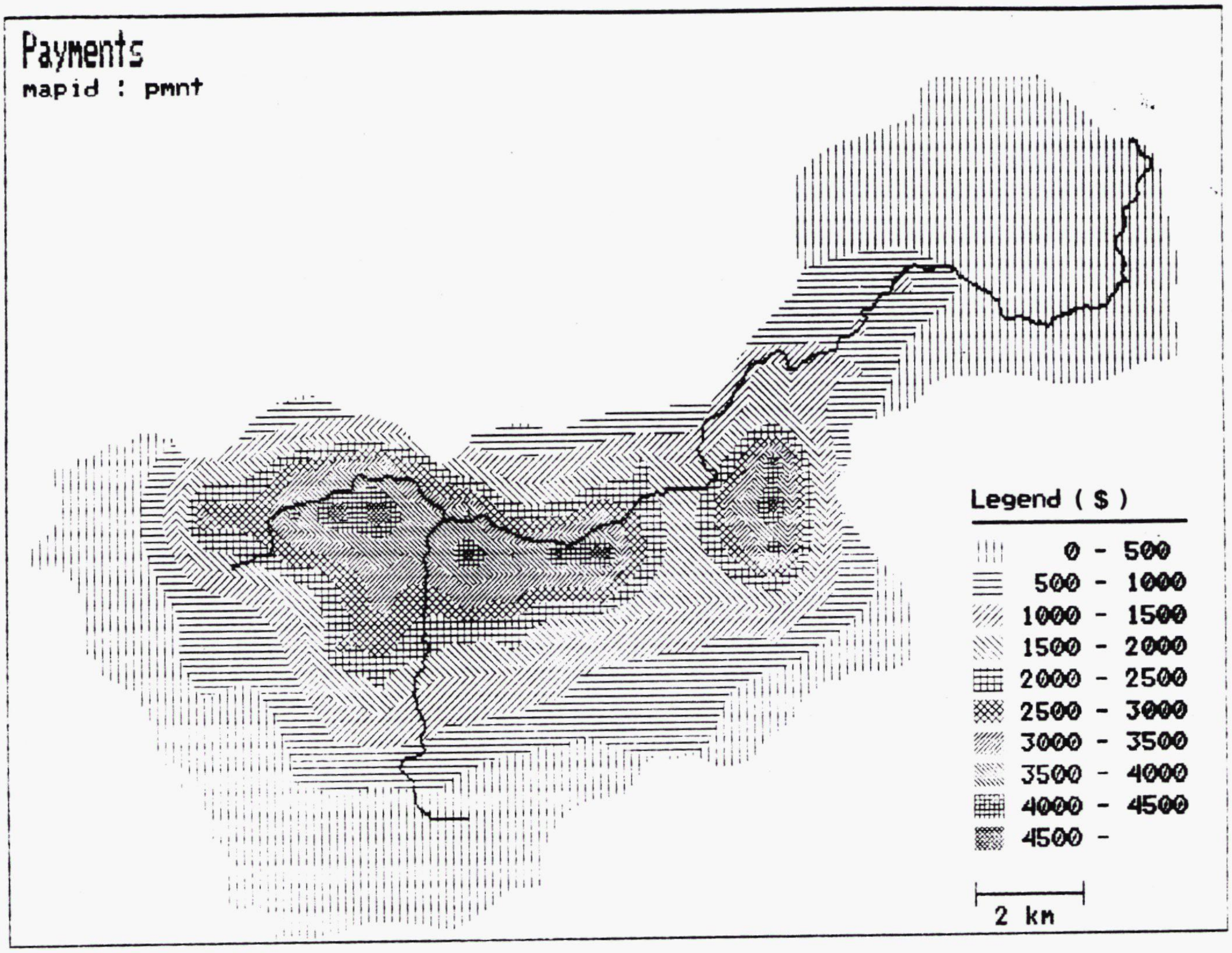


Figure 3.9: This map is a thematic representation of the distribution of payments made for the County of Camrose's share of the drainage improvement costs. The map is intended to provide a general indication of the magnitude and distribution of payments.

According to survey responses, several individuals who wanted to drain their lands found that the system was not designed to accept water drained from their property. For example, the culverts were installed too high to facilitate any drainage from some fields, or fields were too low or too far removed from the channel to use surface drainage and subsurface drainage was prohibitively expensive. Some landowners simply liked having the wetlands on their property and had no intention of draining them even if feasible.

In effect, landowners were being charged for having wetlands on their property. There was no effective determination of the benefits realized. At best, potential benefits have been estimated, and it is questionable whether property values are a reasonable indicator of those benefits. They certainly do not reflect benefits to landowners who chose not to drain their wetlands, or those who those who are unable to.

WILDLIFE COSTS

Identifying specific impacts on wildlife and the quantification of those impacts would require detailed assessments and comprehensive monitoring. Therefore, wildlife costs are often evaluated in terms of replacement costs for the lost habitat units.

The selection of significant wildlife guilds for the Silver Creek, as part of the Water Resources Commission study, was a four step process (Green and Salter, 1985):

1. Identification of resident or migratory species in Alberta closely linked to wetland habitats in the agricultural zones;

2. Evaluation of the political socio-economic, and ecological significance of these species;

3. Identification of the groups or associations which have similar habitat requirements; and

4. Selection of representative guilds for wetland habitat evaluations.

Based on this process, eighteen species of birds and mammals were identified as representative species of important wildlife guilds for wetlands assessments. In order to reduce this number to a more manageable size, the Interdepartmental Steering Committee (IDSC) selected the following ten groups:

- dabbling waterfowl (e.g., mallards)
- diving waterfowl (e.g., canvasbacks)
- bog/fen shorebirds (e.g., common snipe)
- marsh songbirds ('e.g., red-winged blackbirds)
- upland gamebirds (e.g., ring-necked pheasants)
- ungulates (e.g., white tailed deer)
- open water furbearers (e.g., beaver)
- marsh associated furbearers (e.g., muskrats)
- ground dwelling wildlife (e.g., meadow voles)

Although the assessment focused on these ten guilds, each group represents a moderate to large number of wildlife species with similar habitat requirements. It is assumed that these guilds are representative of the majority of wildlife species within the basin.

The wetlands where drainage occurred were mostly temporary wetlands. Mitigation costs were estimated by Green and Salter (1985) in terms of the costs of similar mitigation projects implemented by DU in the Camrose area. These costs were collected for small wetland projects under 30 acres. The maximum single acreage gain reported in the survey was approximately 45 acres. These costs included costs of supervision and construction and have been standardized to 1985 dollars. These estimates do not include the purchase costs of the land. Costs of acquisition were estimated at around $415.00 per acre (Marv Anderson Associates, 1985).

Based on the above numbers average mitigation costs were estimated to be $1090.00 per acre plus the costs of acquisition where required. The total mitigation costs with the purchase of the land is $1500.00 per acre. This value should be multiplied by the total number of acres drained to determine the mitigation costs associated with the project. This should be done for different scenarios such as 100 percent mitigation, 50 percent mitigation. Mitigation costs were substantially lower where consolidation of sloughs was considered in the design, $200.00 per acre as opposed to over $1000.00 per acre.

CHANNEL IMPACTS

The hydrological impacts of the drainage system are measured in terms of the expenditures on maintenance since the system was completed. Engineers from the SCAP program surveyed complaints along the channel and have provided inspection reports for each site (Alberta Agriculture, 1987). Costs for the mitigation of these impacts were provided by the District Agriculturalist for the County of Camrose. The results of these inspections are summarized below.

WATER EROSION PROBLEMS (SCAP)

SITE 1

LEGAL: NE 23 45 21 W4

PROBLEM: Erosion problems identified where surface run-off enters Silver Creek. Siltation of main channel (Silver Creek) identified.

MITIGATION: Grassed waterway to be constructed where surface runoff enters the channel. Waterway constructed at no greater than 1 degree slope and seeded to grass. Degradable erosion control mat to be used to a distance of 20 meters from the bank of the main channel.

COSTS: $952.68

SITE 2

LEGAL: NW 11 45 22 W4

PROBLEM: Erosion problems (small gully/ravine) identified where field run-off enters steep sided drainage improvement. Soils identified as moderately erodible. Slope of ditch which run-off drains into estimated at 16 percent. Siltation of Silver Creek identified. Site identified as having moderately erodible soils.

COSTS: $928.20

SITE 3

LEGAL: NE 11 45 22 W4

PROBLEM: Lateral ditch constructed by landowner has lead to the erosion of the field surface (large gully/ravine) where surface run-off enters Silver Creek, and along the lateral ditch. Soils on-site described as erosion resistant clay. Slope identified as aproximately 5 percent.

COSTS: Not complete as of Jan, 1988.
Estimated cost $800.00

SITE 4

LEGAL: SW 13 45 22 W4

PROBLEM: Erosion identified (small rills/gullies, too large to cultivate) where surface run-off enters the main channel of Silver Creek. Slope of project estimated at aproximately 1.5 percent.

MITIGATION: Land Owner has been advised to maintain a vegetative buffer along the edge of the Silver Creek. Where run-off enters the channel, the field is to be shaped and seeded to grass. Erosion control matting to be used to help establish grass in waterway.

COSTS: $932.48

SITE 5

LEGAL: SW 23 45 21 W4

PROBLEM: Bank erosion identified where surface runoff enters Silver Creek. Soils described as moderately erodible. Slope estimated at 30 percent.

MITIGATION: Bank to be shaped to permit controlled entry into Silver Creek. Constructed channel to be seeded to grass; biodegradable erosion control matting to be used.

COSTS: $366.30

TOTAL COST OF EROSION CONTROL AND RECLAMATION WORKS = $3051.46
Government share of cost (60%) = $1830.88

BENEFITS REALIZED

Land owners in the basin were contacted by the researcher and asked about the benefits which have been realized from the implementation of the drainage system. The benefits were expressed in terms of the increased cultivated land areas as a result of the system. No attempt was made here to identify secondary benefits such as improved crop quality or decreased production costs. The primary purpose of the drainage system was to increase the available land for cultivation and to reduce downstream flooding problems.

The benefits realized from the relief of flooding problems were not quantified in this study. Although flooding problems were corrected, it is questionable whether these benefits should be included in the total benefit calculation, without including the costs borne by those same landowners from what may have been drainage induced flooding problems. After discussions with landowners who had been experiencing flooding problems it appears that the flooding had largely been a result of unauthorized drainage in the upstream portions of the basin. Relief of the flooding problems merely returned the downstream farmers to the levels which they were at forty years ago, before any drainage had occurred. However, it must be acknowledged that the system has relieved certain farmers of periodic flooding problems, irrespective of the reasons for that flooding.

Those landowners who were unavailable for comment were not excluded from the analysis. Where no contact was made, estimates of the total wetlands compiled by the County were used and 1986 air photos examined to verify whether any drainage improvements had been installed. In all cases acreage improvements were rounded up to the nearest whole number.

The total increase in arable land as a result of the drainage improvements came to 403 acres, based on farm surveys and air photo analysis. The distribution of the benefits by land holding is shown on Figure 3.10. From the map it is clear that the benefits have been restricted to those areas very close to the channel and primarily in the upstream portions of the basin.

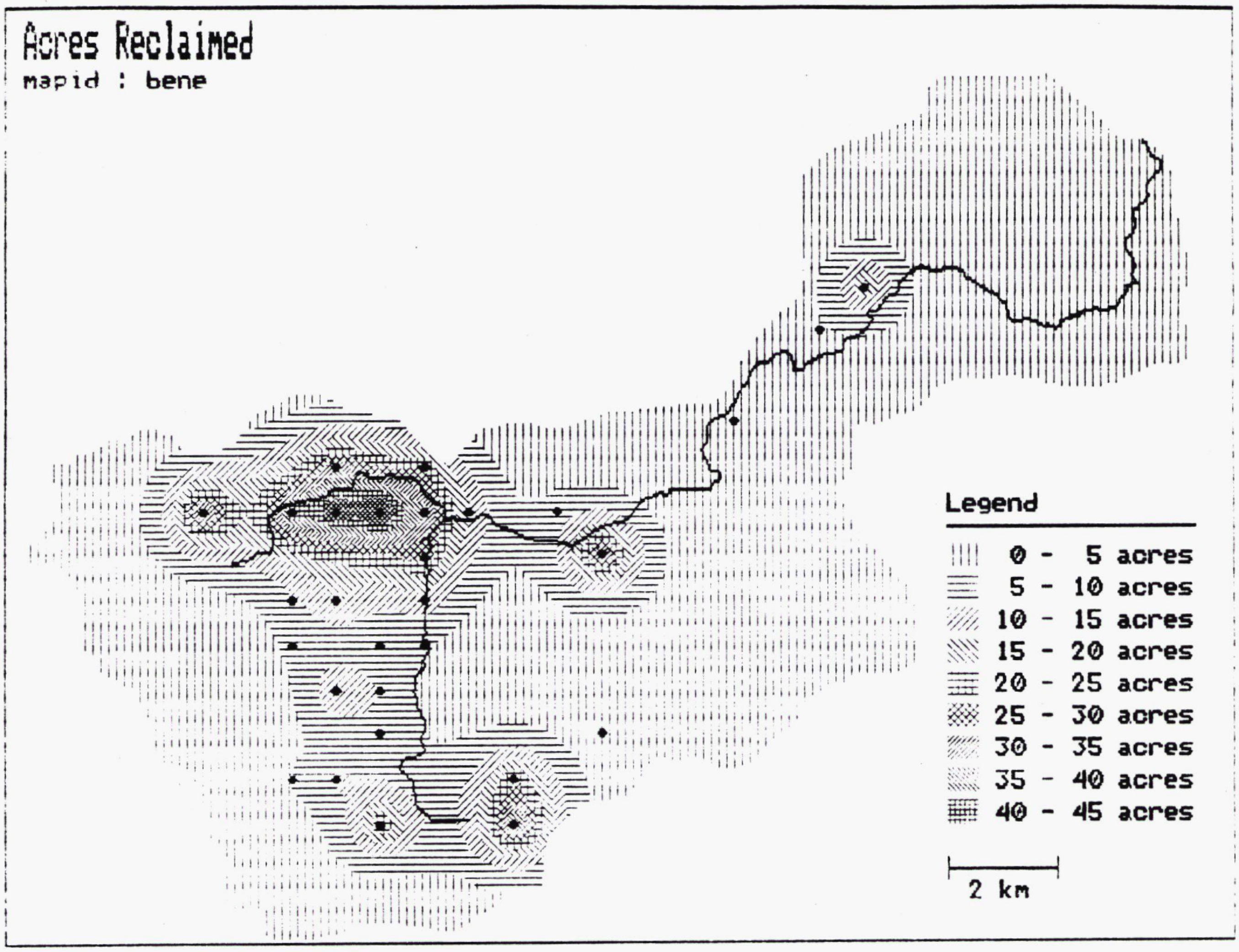


Figure 3.10: This map represents the magnitude and distribution of benefits realized by the land owners in the basin. Units are in acres per land holding. The points shown represent the land owners who had reported that benefits had been realized.

3.3 PROBLEMS IDENTIFIED AND PROBABLE CAUSES

The following section deals with some of the problems which have been identified in this evaluation. Along with the identification of the problems, probable causes and potential solutions are provided.

PROBLEM: MINIMAL BENEFITS

CAUSES: **Failure to adequately address the potential benefits and to consider alternative strategies to realize those benefits.**

There were very few real benefits realized from the drainage system. Approximately 25 percent of the land owners surveyed were able to increase their agricultural land area. The opportunity to generate additional benefits or minimize the costs to wildlife in the area was never considered in the evaluations. Ducks Unlimited submitted a flood control plan which would have alleviated all the flooding problems at a minimal cost to wildlife habitat, but the proposal was not considered.

The failure to consider the flood control option proposed by Ducks Unlimited or to evaluate any other flood control strategies implies that the flood control was in fact a secondary consideration. The primary goal of this system appears to have been to increase the amount of arable lands in the basin, although this benefit was not emphasized in the documents put forward in support of the system. Flood relief was always the principle objective.

SOLUTION: MORE CAREFUL PLANNING AND EVALUATION OF THE COSTS AND BENEFITS PRIOR TO IMPLEMENTATION.

By examining the full range of benefits available a more efficient program could be developed to help realize those benefits at the least possible cost. Designs and management strategies which attempt to optimize all available benefits, habitat enhancement for example, would provide better solutions. Proponents should be required to prove that they are worthwhile and to justify the solutions chosen. Cost benefit evaluations should be a mandatory requirement.

PROBLEM: INEQUITABLE DISTRIBUTION OF COSTS AND BENEFITS

CAUSES: Failure to identify beneficiaries and to address the distribution of benefits

The distribution of costs and benefits among those individuals who paid for the system suggests that there are some serious problems with the allocation system used in the implementation of this drainage project. Forcing all the landowners within the basin to pay for the system according to the amount of wetlands on their property has provided an impetus for additional drainage to recover some of those costs. However, the additional costs required to realize those benefits will often be too great for the individual land owner, or inappropriate given the level of benefit.

The provisions in the Water Resources Act which allow for the levy of these types of assessments does not adequately define what constitutes a legitimate benefit. As a result, the levy can be spread across all landowners in the area irrespective of the real or potential benefits.

The manner in which support was solicited for the drainage project appears to have been less than fair and objective. Several land owners were able to convince the majority of the other land owners that they would realize a benefit from the installation of the system, or that they would not be charged. A large number of individuals contacted in this survey were either misinformed or ill informed about the details and implications of what they were agreeing to.

SOLUTION: IMPLEMENTATION OF MULTI-PURPOSE PLANNING PRINCIPLES.

The provisions of the Water Resources Act which allow municipal government to assess landowners for "Special Benefits" does not address the issue of what constitutes a legitimate benefit. If individuals are paying for a benefit, that benefit should be measured, or at least identified. Individuals who do not receive benefits should not be required to pay for the system.

Alberta Environment supports the concept of Multi-purpose use in water management. This concept is outlined in its Water Resource Management Principles for Alberta. Water Management Principle No. 9 reads as follows:

> Multi-purpose use is the underlying principle in all water resource planning and development. Planning and management especially consider the requirements of other resource development. (Alberta Environment, no date, p. 11)

Although this concept of multiple use planning has been formalized in the government's planning objectives, it appears not to have been implemented in the planning process which allowed for the development of the Silver Creek Drainage System.

The potential benefits to wildlife and the general public were not addressed in the design, management or implementation of the project. Makuk (1988) provides a detailed account of the problems associated with multi-purpose planning. Although the concept has been adopted by the Alberta Government as a principle for water management (Alberta Environment, no date), implementation has proven difficult. Whereas single purpose planning need only address one variable in the costing and evaluation, where multiple objectives are addressed planning becomes much more difficult. Efforts should be directed toward the implementation of the principle of Multi-purpose planning.

PROBLEM: POOR MAINTENANCE AND UPKEEP

CAUSES: **Failure to adequately police landowners to maintain and manage the channel and culvert crossings. Poor education of landowners may be a major problem.**

During the field survey portion of this study of poor management practices were evident. Among the problems identified were the lack of buffer zones along the edges of the main channel, the construction of ad hoc and unauthorized ditches, excessive weed growth in the main channel and at culvert crossings, and soil erosion problems from either inadequate design or inappropriate structures (i.e. surface run-off directly into steep sided channels).

These problems are primarily due to a lack of effective monitoring and policing of good management practices among land owners. An educational program to inform farmers about the benefits of conscientious management of water courses would greatly reduce the rate of degradation of the system. Provision for policing of farmers who do not live up to their responsibilities and the assessment of fines should be in place. At a minimum the least, some individual(s) should be responsible for the monitoring and upkeep of the system.

SOLUTION: MONITOR OPERATION OF THE SYSTEM ONCE COMPLETE. ESTABLISH A MAINTENANCE FUND TO COVER UNFORESEEN PROBLEMS. EDUCATE FARMERS ON APPROPRIATE MANAGEMENT PRACTICES.

Drainage systems should not be designed and operated as turn-key systems where the project managers and planners walk away once construction has been completed. If the government is willing to provide funding for these types of projects they should be prepared to protect their investment by ensuring that the system operates as it was intended, and that individuals do not take actions which will degrade the system.

An educational program should be in place to inform farmers and municipal planners of the benefits of conscientious management of water resources within their properties and jurisdictions. Implementation of effective management programs could greatly reduce the rate of degradation of the system. Provision for policing of farmers who do not live up to their responsibilities and the assessment of fines should be implemented. At a minimum, an individual within the local government, or a local representative should be responsible for ensuring that the system operates as it was intended to.

Where the system is administered by a local authority, such as a County or Municipal District, by-laws could be established to provide standards for the operation and maintenance of the system and impose fines for non-compliance.

The establishment of a maintenance fund, to be included in the total cost calculations should be used. Proponents should be required to post bond to ensure that the system has adequate funding to maintain the system, and cover unexpected costs. Farmers should also be educated about how to maintain drainage systems and to employ management strategies which minimize adverse impacts.

5.0 DISCUSSION AND EVALUATION

A FRAMEWORK FOR WATER MANAGEMENT

Although the majority of this document deals with the situation within the Silver Creek basin, the results and recommendations to follow should apply to all wetland management programs. The problems identified in the planning, evaluation, administration and management of the drainage program for the Silver Creek Basin are symptoms of a much larger problem. A planning process which allows for the development of drainage programs with such minimal benefit is inherently flawed and demands attention.

Water management is a complex, diverse and often emotional issue. Multiple demands for water resources increase pressure on managers and planners to develop water policy consistent with over-all land use objectives. The task facing planners and policy makers is summarized in this quote found in The Inquiry on Federal Water Policy completed in 1984.

> ... Canada now faces some complicated and persistent problems... which overtax traditional approaches... They are likely to call for new directions in water policy and new arrangements for cooperation between private and public sectors, between different orders of government in the public sector and between Canada and the United States. (Pearse et al, 1984. p.16).

The authors of the report go on to say that effective management of our water is best achieved through coordination among different jurisdictions rather than through stricter regulation and enforcement. Coordinating and rationalizing existing programs rather than a complete restructuring of management systems, or the creation of new agencies, should achieve the objectives of sound water management (Pearse et al., 1984).

The jurisdictional framework for water management in Canada is discussed by Pearse et al. (1985) in Currents of Change. Legislative authority for water management is scattered among various federal, provincial and municipal powers as defined in the constitution. Although water is not dealt with directly in the constitution, jurisdiction to legislate in water matters derives from the interpretation of the various federal and provincial responsibilities. In Canada, specific powers are defined for the provinces and any residual powers, or those not specifically stated, rest with the Federal Government.

Provincial powers derive from their jurisdiction over management of public lands, over property and civil rights, and over matters of a local and private nature. This grants the provinces authority to legislate into areas of domestic, industrial water supply, pollution control, non-nuclear thermal and hydro-electric power development, irrigation and recreation (Pearse et al, 1985).

The federal government holds ownership rights over all federal lands and water in the territories, national parks, and Indian Reserves. The federal parliament has exclusive jurisdiction over navigation, inland and ocean fisheries, and it shares jurisdiction over agriculture and health (Pearse et al, 1985).

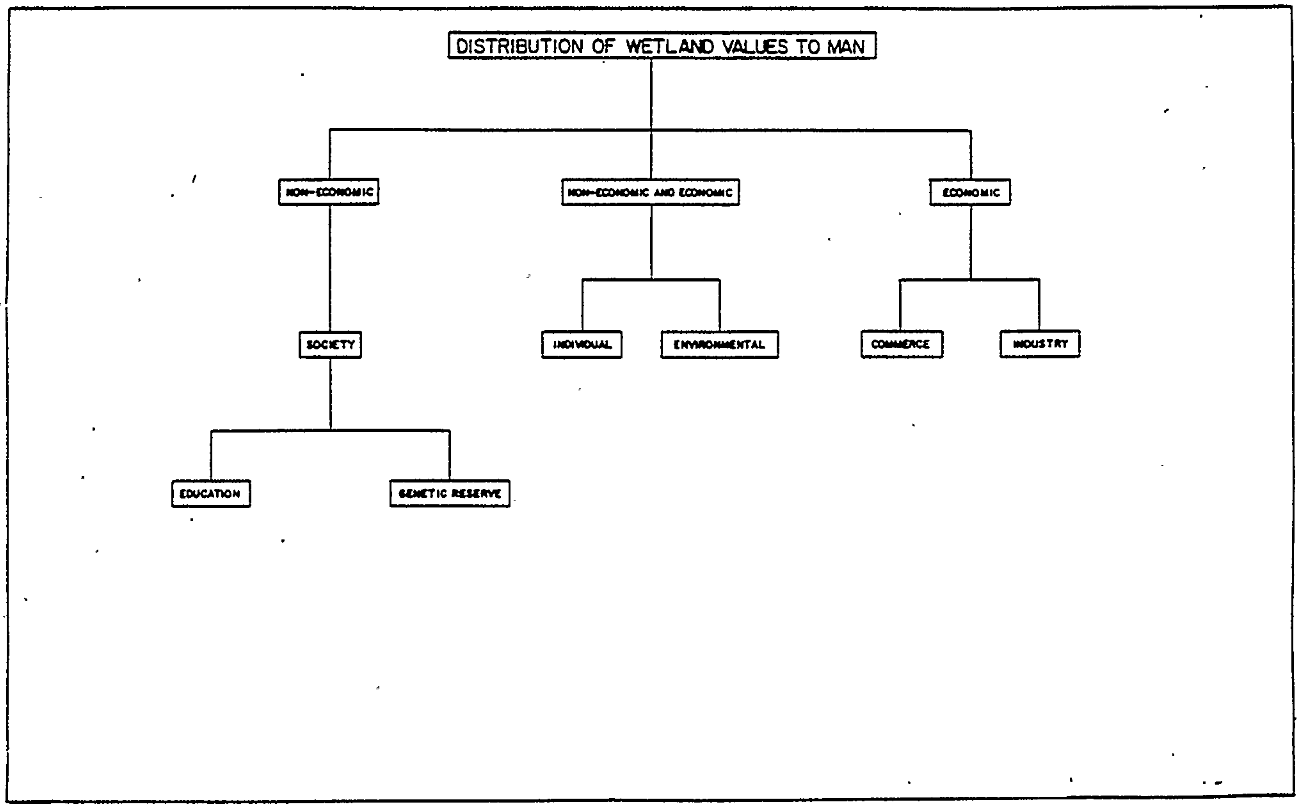
Since water in its natural state flows over, under and around political boundaries, and because it is intimately connected to everything we do, precise delineation of legislative authority is often difficult. Historically, the provinces and the federal government, as well as individual provinces, have been able to reach agreements over the management of water which crosses political boundaries. Examples of such agreements include the Lake of the Woods Control Board (1918) formed between the Federal government Ontario and Manitoba; the Prairie Farm Rehabilitation Act (1930's) dealing primarily with water supply; The Canada Water Conservation Assistance Act (1953) dealing with large scale water conservation projects; and the Prairie Provinces Water Board (1949) (Pearse et al., 1984).

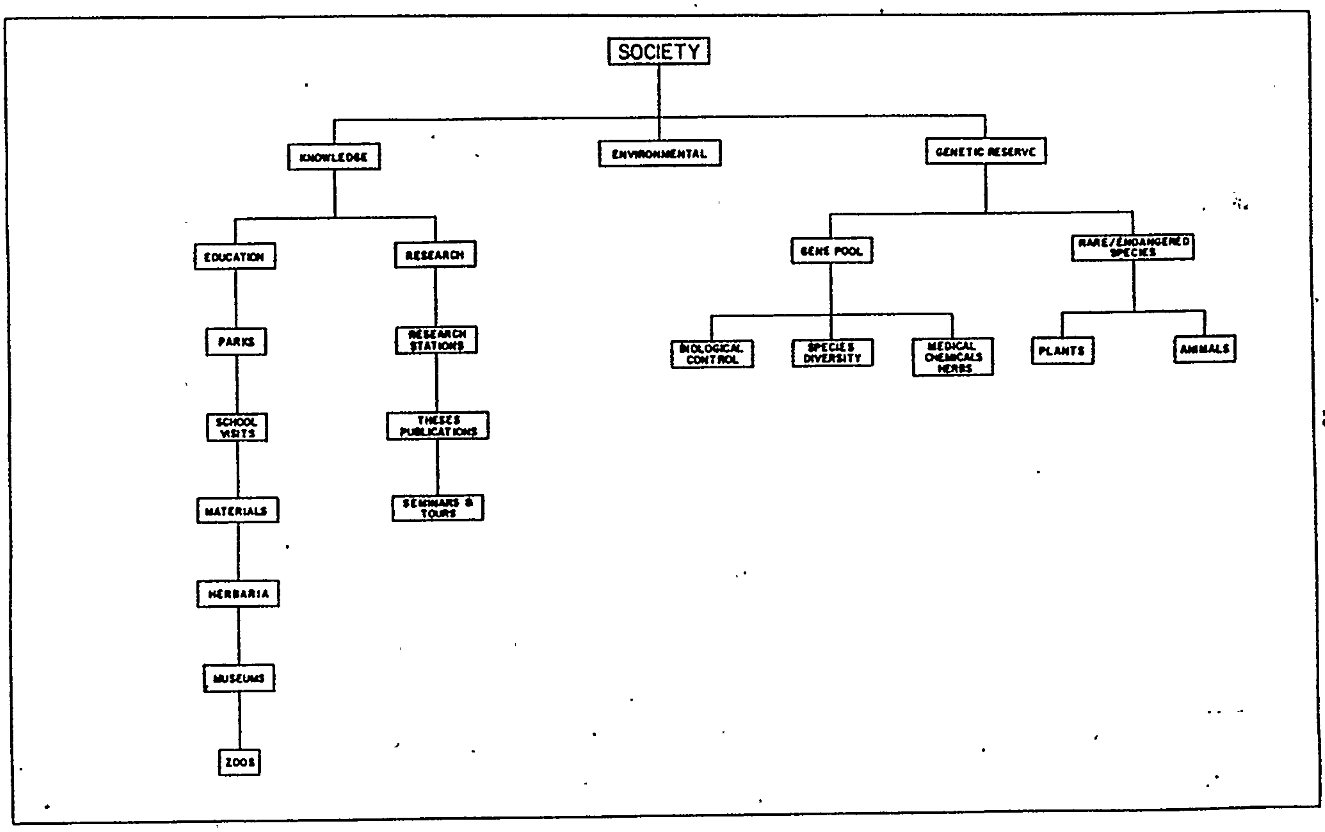
The number and diversity of actors in the wetlands management debate, and the numerous related issues, makes wetlands management a very difficult problem. The complexity of this issue is well illustrated by the organizational chart of wetland issues presented by Cowan (1983) (see Figure 4.1). Cowan details the numerous wetland values in a series of five diagrams shown in the following pages. Although detailed discussion of each of these related values is not warranted here, the complexity and diversity of values identified is worth noting.

There are numerous actors with a direct stake in wetlands management. These actors are found in both the public and private sectors. Figure 4.2 outlines the some of the main groups of actors involved with wetlands management locally, provincially, federally, and internationally. Each of these groups of actors is affected either directly or indirectly by wetlands management decisions.

The large number of actors and issues involved with wetland

Figure 4.1 In the five frames which follow, Cowan (1983) illustrates the range and complexity of wetland values and functions. While the detail does not warrent discussion here, readers should note the diversity and number of issues identified.

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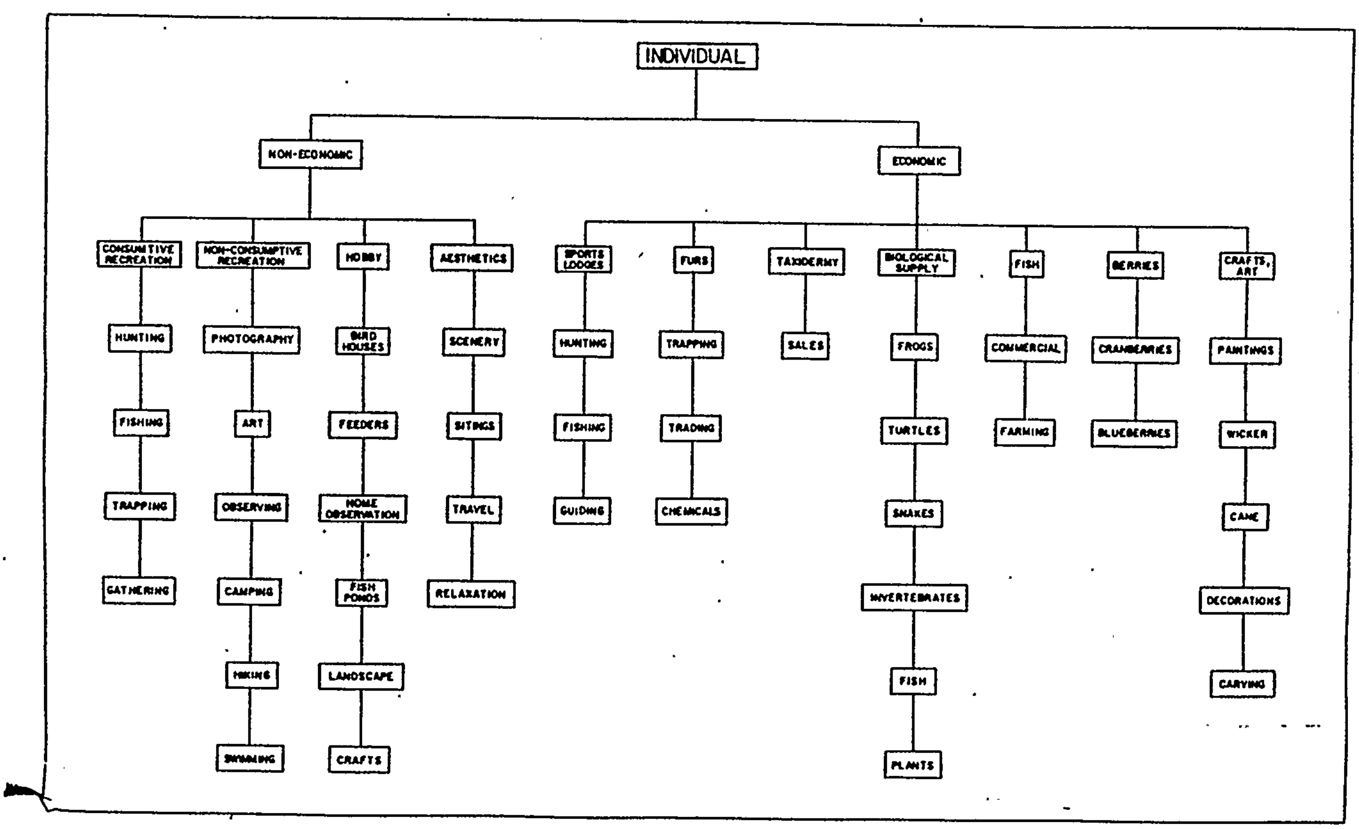
ENVIRONMENTAL
GENETIC RESERVE
EDUCATION
RESEARCH
GENE POOL
RARE/ENDANGERED SPECIES
PARKS
RESEARCH STATIONS
BIOLOGICAL CONTROL
SPECIES DIVERSITY
MEDICAL CHEMICALS HERBS
PLANTS
ANIMALS
SCHOOL VISITS
THESES PUBLICATIONS
MATERIALS
SEMINARS & TOURS
HERBARIA
MUSEUMS
ZOOS

- 13 -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NON-ECONOMIC
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CONSUMPTIVE RECREATION
NON-CONSUMPTIVE RECREATION
HOBBY
AESTHETICS
SPORTS LODGES
FURS
TAXIDERMY
BIOLOGICAL SUPPLY
FISH
BERRIES
CRAFTS, ART
HUNTING
PHOTOGRAPHY
BIRD HOUSES
SCENERY
HUNTING
TRAPPING
SALES
FROGS
COMMERCIAL
CRANBERRIES
PAINTINGS
FISHING
ART
FEEDERS
SITINGS
FISHING
TRADING
TURTLES
FARMING
BLUEBERRIES
WICKER
TRAPPING
OBSERVING
HOME OBSERVATION
TRAVEL
GUIDING
CHEMICALS
SNAKES
CANE
GATHERING
CAMPING
FISH PONDS
RELAXATION
INVERTEBRATES
DECORATIONS
HIKING
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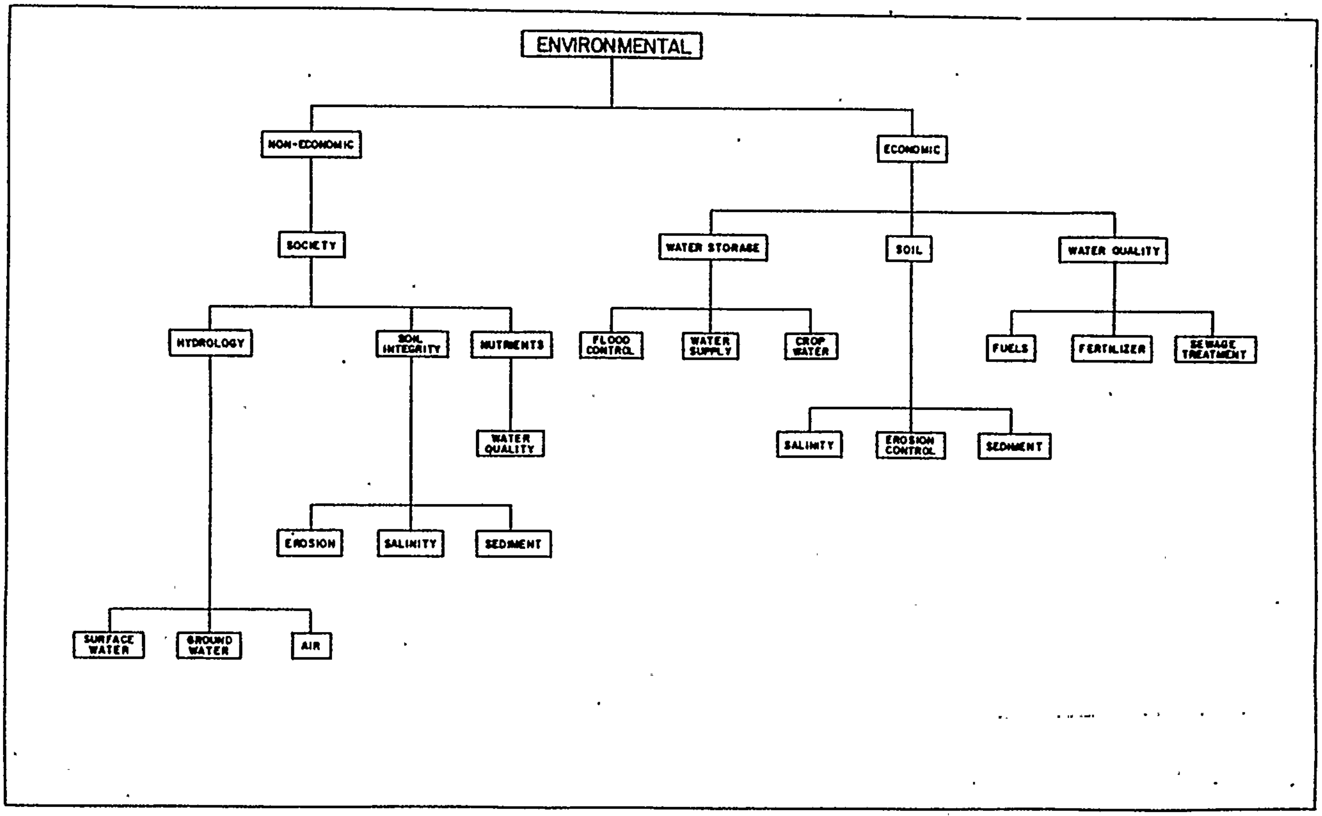
FISH
CARVING
SWIMMING
CRAFTS
PLANTS

- 14 -


ENVIRONMENTAL
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SOCIETY
WATER STORAGE
SOIL
WATER QUALITY
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FLOOD CONTROL
WATER SUPPLY
CROP WATER
FUELS
FERTILIZER
SEWAGE TREATMENT
WATER QUALITY
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EROSION CONTROL
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EROSION
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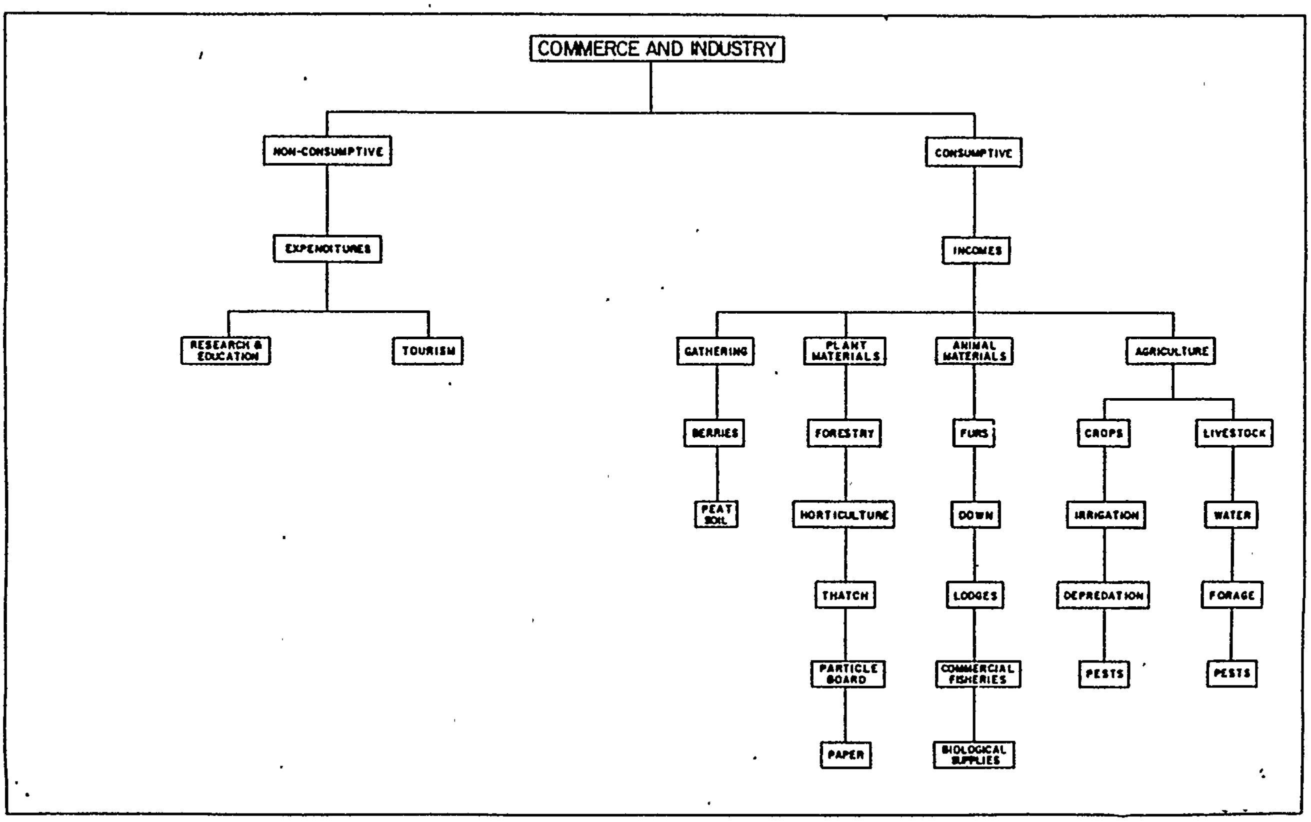
SURFACE WATER
GROUND WATER
AIR


COMMERCE AND INDUSTRY
NON-CONSUMPTIVE
CONSUMPTIVE
EXPENDITURES
INCOMES
RESEARCH & EDUCATION
TOURISM
GATHERING
PLANT MATERIALS
ANIMAL MATERIALS
AGRICULTURE
BERRIES
FORESTRY
FURS
CROPS
LIVESTOCK
PEAT SOIL
HORTICULTURE
DOWN
IRRIGATION
WATER
THATCH
LODGES
DEPREDATION
FORAGE
PARTICLE BOARD
COMMERCIAL FISHERIES
PESTS
PESTS
PAPER
BIOLOGICAL SUPPLIES

GOVERNMENT

INTERNATIONAL

- NORTH AMERICAN WATERFOWL MANAGEMENT PLAN

FEDERAL

- CANADIAN WILDLIFE SERVICE
- ENVIRONMENT CANADA
- AGRICULTURE CANADA
- PFRA

PROVINCIAL

- ALBERTA ENVIRONMENT
- ALBERTA AGRICULTURE
- FORESTRY LANDS AND WILDLIFE
- MUNICIPAL AFFAIRS

MUNICIPAL

- MUNICIPAL GOVERNMENTS
- DRAINAGE DISTRICTS
- LOCAL AUTHORITIES

NON-GOVERNMENT

INTERNATIONAL

- WORLD WILDLIFE FUND
- IUCN (WORLD CONSERVATION STRATEGY)
- DUCKS UNLIMITED
- WILDLIFE HABITAT CANADA

FEDERAL

- CANADIAN WATER RESOURCES ASSOCIATION
- SOIL AND WATER COSERVATION SOCIETY
- CANADIAN COMMITTEE ON IRRIGATION AND DRAINAGE
- PRAIRIE ASSOCIATION FOR WATER MANAGEMENT

PROVINCIAL

- ALBERTA WILDERNESS ASSOCIATION
- ENVIRONMENT COUNCIL OF ALBERTA

PRIVATE

- FARMERS AND RANCHERS
- PRIVATE INDIVIDUALS
- ADVOCACY GROUPS

FIGURE 4.2: PARTIAL LIST OF ACTORS IN WETLANDS MANAGEMENT

management, as outlined, makes the development of effective wetlands policy an extremely difficult task. Conflict resolution in water management is discussed by Pritchard (1988). The best solution will be achieved through a cooperative effort among all actors, private and public, and careful consideration of the costs and benefits associated with alternative courses of action. Emphasis should be directed towards negotiation and mediation between the various actors, as opposed to resolving conflicts through litigation and public hearings. The use of public participation and community discussion can reduce or avoid conflicts between competing interests.

It is the responsibility of the government to provide guidelines for the management of our resources. Those resources such as water which are generally considered to be public goods, must be managed for the benefit of the general public and not squandered for the benefit of a select few individuals, or isolated sectors of society. Whether that management responsibility rests with the federal, provincial or local municipal government is immaterial, as long as the interests of all affected parties are allowed to influence the decision making process.

Where informal lines of communication are inadequate in allowing all interested individuals to provide input to decision makers, these mechanisms should be formalized. Informal communication networks include conferences and workshops; more formal lines of communication include government funded advisory bodies such as the Environment Council of Alberta, or public hearings.

Government programs between different levels of governments and non-government organizations must be coordinated if we are to develop effective wetland management programs in Alberta. The Alberta Government must, however, first rationalize its own programs before it will be able to coordinate with other levels of government and non-government organizations. Programs such as the Water Management and Erosion Control Program offer financial support for drainage projects, as well as for water conservation and wildlife habitat enhancement projects (Alberta Environment, Water Resources, no date). The contradictions are glaring.

Ducks Unlimited has spent over 45 million dollars to restore or improve wetland habitat in Alberta alone (Ducks Unlimited, no date). Similarly, the World Wildlife Fund recently allocated $600,000 for wetlands preservation in the prairie provinces (World Wildlife Fund, 1987). Wildlife Habitat Canada has spent over 13.5 million dollars to support habitat projects (Jones, 1987). These are direct values which individual groups have expressed for the preservation of wetland habitat in Canada.

These numbers, at least in part, indicate that wetlands are highly valued by many sectors of society. Failure to recognize these values and develop policies which reflect them, will lead to conflicts in the future. Where possible, planners should refer to existing studies which have already established rough indicators of non-market and market values of typically non-market considerations. Hammack and Brown (1974), and, more recently, Sorg and Loomis (1984) have looked at different methodologies for valuing non-market resource commodities.

There are sufficient studies and literature available which support the inclusion of non-market costs and benefits relating to wetland drainage. These valuations, coupled with the money being spent to support habitat conservation and preservation initiatives, are evidence of the values which these resources and the associated resource services hold.

5.1 CONCLUSIONS AND RECOMMENDATIONS

In evaluating the effectiveness of any project one must look to the original objectives and decide whether the project has fulfilled its stated goals. The costs of the project must also be appropriate to the level of benefit which has been realized. Otherwise, the project should not have been implemented.

The intent of this study was to evaluate the effectiveness of a drainage system in realizing its stated goals. The benefits realized were measured in terms of the total number of acres reclaimed as result drainage improvements. The results should be viewed as a general indicator of the magnitude and distribution of the direct benefits and costs associated with the system.

This cursory evaluation of the drainage system installed in the Silver Creek Basin indicates that the benefits which have been realized are below the projected benefits, and the costs much higher than is reasonable given the benefits generated.

Several problems were noted with the system itself, the manner in which it was promoted and approved, the manner in which the costs and benefits were allocated, and in the operation of the system once complete. Table 5.1 outlines the projected and actual benefits realized from the project.

TABLE 5.1 - PREDICTED AND ACTUAL COSTS AND BENEFITS

PREDICTED BENEFITS	ACTUAL BENEFITS
1,100 acres	403 acres
PREDICTED MONETARY COSTS	ACTUAL MONETARY COSTS
$285,000	$323,927
$260 per acre	$804 per acre
COSTS WITH 50 % HABITAT MITIGATION (with 403 acre benefit)	$541,927 $1,345 per acre
COSTS WITH 100 % HABITAT MITIGATION (with 403 acre benefit)	$759,927 $1,885 per acre

The monetary cost, including the engineering and construction cost, erosion control works installed in 1987 and a $5000 assessment by the County to cover future maintenance, comes to a total of $323,927. This total excludes any on-farm drainage costs, any wildlife mitigation costs, the flooding costs incurred by downstream farmers as a result of upstream drainage prior to the installation of the system, and report preparation and administrative costs incurred by Alberta Environment and the County of Camrose.

If wildlife habitat mitigation costs are included, at $1090/acre and 100 percent mitigation, the total cost for the 403 acres gained would increase to $759,927. With 50 percent wildlife habitat mitigation the total would be $541,927.

Based on the 403 acres of land reclaimed, as reported by land owners in the basin and air photo analysis conducted as part of this study, the total cost per acre of cropland gained comes to $804. With 100 percent habitat mitigation the cost per acre would be $1885. With 50 percent habitat mitigation the cost would be $1344.

Using the $45 per acre expected revenue presented by Marv Anderson and Associates (1985), the net present value of the income generated over a twenty year project lifetime, using a five percent discount rate (low end of the scale), is equal to $457 per acre. This is $347 less than the costs per acre to reclaim the land without habitat mitigation. Marv Anderson Associates estimates the costs of land acquisition in the area at $415 per acre, $389 less than the development costs. The County of Camrose Tax Assessor valued the reclaimed lands at $300 per acre, a full $504 per acre less than the cost of development. The bottom line is, the project is an economic loser.

Because of the variability in the costs for farm drainage projects, it would be inappropriate to estimate the total on-farm and additional off-farm costs required to increase the amount of reclaimed land to the levels projected in the original reports. Much more detailed design and engineering would be required to provide precise cost estimates. Drainage costs for each project will be a function of a number of variables including the type of wetlands, distance to suitable outlets, topography, soil types, depth of cut required and the required capacity of the receiving channel. General cost estimates for drainage in Silver Creek per wetland type are provided in Table 5.2. Readers should note the variation in costs indicated.

The majority of landowners in the area, 99 out of 130, reported that they had received no benefit from the system and

WETLAND TYPE	PERMANENCY	AREA (acres)	FARM DRAINAGE Method	$/acre
SLOUGH/ MARSH	Temporary	1998.9	Ditch	250 - 500
	Seasonal	1997.2	½ ditch ½ pipe	400 - 900
	Permanent	663.7	Pipe	500 - 1000
LAKE/POND	Permanent	556.2	Pipe	600 - 1100
SEEP	Permanent & Seasonal	133.2	Pipe	800 - 1200

Table 5.2: Cost Estimates for Drainage in the Silver Creek basin.
Source: Jensen Engineering, 1985

were angry because they had been forced to pay for the system. There was some indication from discussions with landowners that they had been told they would not have to pay anything if they did not realize any benefits when signing the consent forms providing for the installation of the system.

The benefits from the system, in terms of land areas brought into cultivation and any flood control benefits, were realized by landowners directly adjacent to the main channel and primarily in the upstream reaches (see Figure 3.9). The payments for the system were spread more evenly among all land owners in the basin (see figure 3.8). Out of the 130 land holdings in the basin, 31 reported that they had received a benefit from the system. All 130 landowners were assessed charges for the development of the system.

Although the benefits realized from the implementation of the drainage improvements appear to be small, it is acknowledged that additional benefits may be realized in the future as a result of the improved drainage. Other landowners could drain additional lands into the system, and flood control benefits may accrue to landowners along the channel as long as the system operates as it was intended to. However, any additional lands gained would cost additional money to connect to the system (see Table 5.2), which may exceed the productive value of the increased land areas. Landowners have already paid for the system and it had been 4 years since it was completed at the time of this writing. If there were any cost-effective drainage improvements to be made they probably would have been completed already. The lands suitable for drainage had been drained

(Kémper, pers. comm, 1988).

Any potential benefits not yet realized would have to be evaluated against the additional costs which would be incurred to realize those benefits, as well as the ongoing operation and maintenance costs which will be required to keep the system in good condition.

With these problems in mind the following recommendations are provided.

GENERAL RECOMMENDATIONS

1. The evaluation and approval of drainage systems should more carefully consider the benefits which are likely to be generated. These evaluations should include careful consideration of the costs to wildlife and the environment and the benefits realized by the general public from wetlands retention. These evaluations should clearly identify the source of the problem, and the benefits which the system will generate. Costs and benefits should be broken down into monetary and non-monetary, direct and indirect costs. Although this study only addresses the direct costs and benefits, where decisions are being made about the implementation of drainage systems, a broader range of issues should be addressed in greater detail.

2. An independent evaluation of the attitudes of local land owners should be undertaken in conjunction with an educational program to inform farmers about the proposed project and the implications for each individual should the system be

implemented. Proponents of the system should not conduct this evaluation or the educational program without supervision. These educational programs should include details of the project costs and outline who will be responsible for those costs.

3. Because the general public bears some of cost of these projects in terms of the public money spent, the external costs should be minimized. These external costs are primarily associated with wildlife habitat loss. Where possible habitat development should be undertaken, and at a minimum, areas should be designated as protected zones. These protected zones should include habitat equivalent to the highest quality habitat lost as a result of the system.

4. Cost benefit evaluations should be a mandatory requirement for the approval of drainage systems. These evaluations should be reviewed and the legitimacy of the figures confirmed by the approving authority. Total land areas to be gained should be confirmed and follow up studies undertaken to confirm these amounts.

5. The costs of habitat enhancement and/or preservation scenarios should be included in the cost benefit evaluations.

6. Before projects are approved, provision should be made for the establishment of a maintenance fund which would be used to cover unexpected cost overruns, maintenance costs, and compensation payments to individuals adversely affected by the system.

7. The Water Resources Act and/or Regulations should be amended such that those individuals who do not benefit from the system are not required to pay for the development of the system. This would involve specifying what constitutes a legitimate benefit.

8. For Drainage Systems, a benefit should be defined as a change which improves the ability of an individual to generate revenue from the farm operation, or reduces the costs to that individual from the water related problem.

9. Assessments for benefits should be charged if and when that benefit is realized. Individuals should not be assessed a charge for a potential benefit. In the case of Silver Creek, landowners were charged amounts which varied according to the amount of wetland occurring on their property, and the distance from the channel. No consideration was given to whether or not landowners actually intended to drain their lands, whether it was economically feasible, or whether the benefits would justify costs.

10. An upper limit should be identified which controls the total amount of drainage allowable in any given area. Drainage should not be permitted in absence of an overall management plan.

11. Government programs should be coordinated to prevent the duplication of effort and conflicting programs. It make no sense to have one government department, or division within the same department, paying farmers to drain wetlands and another paying them to retain or enhance wetlands.

RECOMMENDATIONS FOR SILVER CREEK

1. Consideration should be given to the establishment of a Water Management Strategy for the Silver Creek Basin. The present strategy appears to be to drain as much land as possible, which may not optimize the available benefits.

2. Wetland habitat should be enhanced in those areas which are not likely to benefit from drainage improvements and which provide good quality habitat. Compensation, in the form of tax breaks or direct financial incentives, should be provided to landowners who provide land for habitat enhancement.

3. The magnitude and distribution of benefits which have been realized from the system should be more closely evaluated. Those individuals who have received no benefits, and are not likely to realize any benefits in the future, should be have their payments for the construction and operation of the system applied as tax credits.

4. The system should be closely monitored to identify unauthorized use of the main channel and poor management practices.

5. Easements in place for the channel sections crossing private lands should be extended to include a buffer of approximately 10 m around the channel which would not be cultivated. The buffer may be seeded to grass and cropped for hay.

CLOSING REMARKS

This research program has identified some serious problems with the agricultural drainage project in the Silver Creek Drainage Basin. Because these problems were allowed to manifest themselves, one of two conclusions can be reached: either the planning process in place is inadequate, or there has been a lapse in the process which has allowed Silver Creek to fall through cracks. Another alternative is that political interference has prevented the process from operating as it should. Additional evaluations of other drainage projects would confirm which scenario is more likely.

The government of Alberta should seriously rethink the rationale for promoting wetland drainage programs in the province. Encouraging farmers with direct financial incentives to drain wetlands flies in the face of the efforts of other groups to maintain wetland habitats.

The intent of my commentary is not to find fault with any individual, department or organization. Rather, the problems should be viewed as an indication that more attention should be directed to wetlands management. More careful evaluation of the underlying assumptions and the implications of our actions will yield better decisions. Likewise, thoughtful reflection on our decisions can be very instructive.

I believe that knowledge advances equally on the heels of successes and failures. Retrospect is a valuable perspective in either case.

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