THE IDENTIFICATION AND ASSESSMENT OF SOIL AND WATER CONSERVATION DEMONSTRATION SITES IN THE TURTLE RIVER AND WHITEMUD WATERSHED CONSERVATION DISTRICTS

By
Holly N. Mackling

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ABSTRACT

This study was undertaken in response to a request from The Conservation Districts Authority to consider the identification and assessment of soil conservation demonstration sites in the Whitemud and Turtle River Watershed Conservation Districts and is one of a series of activities initiated by the Conservation Districts Authority to assist in the development of long term management plans. This study provides the framework for subsequent study phases.

Erosion on the Manitoba escarpment was examined in terms of processes and classification, historical perspective, physical land features and land use. An inventory of current problems and practices which exacerbate them was compiled. Twenty-four different structural and non-structural remedial techniques were considered in terms of their applicability to the study area. Of these, only terracing was deemed a highly unlikely solution due to excessively high development and maintenance costs.

Presently, strip cropping, zero-till, sweet-clover plowdowns and green manure plowdowns are being investigated as to their economic viability and practical feasibility under the Agri-Food program. Shelterbelts, forage crops, flax strips and grassed waterways are currently being encouraged

through subsidization programs run by the Conservation Districts. However, an economic analysis of these later techniques has yet to be done.

The Turtle River and Whitemud Watershed Conservation District Boards and the Conservation Districts Authority support the development of a comprehensive demonstration program designed to establish the viability of remedial erosion control techniques and to promote their use in the study area. In order to facilitate the identification and assessment of desireable future demonstration sites, a selection criteria was developed. The criterion consisted of accessibility, visibility, site characteristics, cost magnitude, grouping and contrast. Criterion were developed and utilized in the selection of remedial techniques as well. These were suitability, status, ease of implementation and flexibility. These criterion may later be used to select sites required for the development of soil and water conservation demonstration programs in other Conservation Dictricts.

Based upon the development of five new sites and the incorporation of seven existing sites where remedial techniques have already been implemented, a comprehensive demonstration tour of remedial techniques was designed.

Recommendations cover practical implementation considerations such as signage, future promotion, and a strategic plan for development.

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GLOSSARY OF TERMS AND ABBREVIATIONS

ASL: Above Sea Level.

Hwy.: Highway.

No.: Number.

Non-structural Solution: refers to cultural or management practices which help reduce or prevent soil erosion. Non-structural techniques include adequate fertilization, block-planting of trees, bufferstrips, contour cultivation, cover crops, forages, green manure, rotational grazing, shelter-belts, and strip-cropping.

Structural Solution: erosion control achieved by the use of a man-made, physical structure such as a drop structure, rock, wood or mesh weirs, fences, terraces, holding ponds, settlement basins, or grassed waterways.

T.R.W.C.D.: Turtle River Watershed Conservation District.

W.W.C.D.: Whitemud Watershed Conservation District.

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INTRODUCTION

1.1 PREAMBLE

A growing imperative in the field of soil conservation has recently emerged. The Standing Senate Committee on Agriculture and Forestry report, Soil at Risk, 1984, focused public attention on the problem of soil erosion and degradation in Canada. As Senator Sparrow, Deputy Chairman of the Committee noted, "conservation of the soil has become a national goal --- every hectare and tonne of soil is important to all Canadians. In the next 40 to 50 years, we are in danger of losing half, if not more of our topsoil. We are running the risk of becoming non-self-sufficient, and the consumer will end up paying the high price of poor conservation practices." (Land, 1985)

Water erosion is recognized in every province, with most having extensively affected areas. (Coote, 1980) In Agro-Manitoba, topography is the most important feature affecting erosion and therefore, the Manitoba escarpment and its surrounding area have the prominent erosion problems. (Barto et.al., 1978) The severe water erosion experienced along the escarpment is due not only to steep slopes and easily eroded soils, but also to the micro- climate which the escarpment creates. "Heavy, intense rainstorms are more frequent on the higher parts of the escarpment than elsewhere in southern Manitoba... Its higher, eastern portions annually receive 20 to 40 percent more precipitation than the surrounding plains." (Carlyle, 1980)

The combination of steep slopes, heavy runoff and erodible soils predisposes the escarpment to severe erosion. In addition to reduced agricultural yields (P.F.R.A., 1982; Adams, 1986), erosion imposes high drain maintenance costs due to sedimentation (Newbury, 1986) and can have adverse effects on downsteam water quality.

Weber (1984) provides an excellent overview of the evolution of the development and management of the agricultural drainage system in Manitoba. The reclamation of wetlands was encouraged by Federal policy early in Manitoba's past through the Dominion's transferance to the province of swamp land areas on the condition that sufficient drainage be undertaken to render the land arable. Records showing land claimed in this way date back to 1883.

On February 14, 1880, The Drainage Act (S.M. 1880. c.2 1st Session) was passed and $50,000 targeted for drainage works. Financed entirely by the Province, drainage development proved inadequate as the rate of development was too slow, and the drains created were shallow, narrow and generally ineffective.

The first large scale organized drainage works began in the province after The Drainage Act of 1880 was repealed and The Land Drainage Act (S.M. 1895. c.11) was passed. The new Act provided for the formation of Drainage Districts and the raising of funds for drainage works. By 1920, 21 Drainage Districts had been formed and over 2,500 miles of drains had been constructed.

Financial difficulties in the early thirties caused the Drainage Districts to complain that they were being taxed unfairly because they were being forced to bear the cost of "foreign water" being brought into the districts by the drains. Following the recommendations of the Land Drainage Arrangement Commission, The Land Drainage Arrangement Act was passed. (S.M. 1935. c.133) Under the Act, Drainage Districts were replaced by Drainage Maintenance Districts. The new districts were to encompass only one watershed. More significantly, for the first time in its involvement with drainage, the government agreed to assume part of the drain maintenance costs. The actual agreement was to pay one third and one half of one percent of the annual capital costs. This was roughly equal to one third of the annual maintenance costs. The level of support was limited to $40,000 per annum. This arrangement worked fairly well until the early forties when a long wet spell, coupled with rising construction costs resulted in the municipalities being unable to maintain the drains. The municipalities were also still unhappy about the "foreign water" problem.

The 1949 Lyon's report investigated the "foreign water" and maintenance problems. In 1952, the Province agreed to pay two thirds of the construction and maintenance costs of drains carrying foreign water and one third of the construction and maintenance costs of drains carrying local water, and all reconstruction costs of major drains carrying local water in the Red River Valley.

With its increased responsibility and commitment for organization of drainage, the Province reorganized its departments such that the control, use, distribution and conservation of water fell under the Department of Agriculture and Conservation in the Water Control and Conservation Branch. In 1966, this branch was transfered to the Department of Highways. In 1968, it was transfered to the Department of Mines and Natural Resources. Today it resides under the Department of Natural Resources.

In 1959, The Watershed Conservation Districts Act (S.M. 1959) was passed. Under the Act, municipalities were allowed to form Watershed Conservation Districts through which they could direct water management efforts.

Two Watershed Conservation Districts were formed under this Act: The Whitemud River Watershed Conservation District (1972); and the Turtle River Watershed Conservation District (1975).

The second act, The Resource Conservation Act (S.M. 1970, R 135), primarily concerned the conservation and use of land. One resource conservation district was formed under this Act: The Turtle Mountain Resource Conservation District (1973).

In 1976 , the two acts were replaced by The Conservation Districts Act (S.M. 1976, c. 38). Under this Act, provision is made for conservation and management of both land and water resources. To date, with the addition of Alonsa Resource Conservation District in 1978 and Cooks Creek Conservation District in 1979, five Conservation Districts have been formed.

Each district has a locally appointed board with representation from each sub-district. The boards have the mandate to "provide for the conservation, control and prudent use of resources" and are responsible for the development and implementation of a scheme or plan with respect to management of the respective districts. To this end, the boards have been granted certain powers including considerable financial powers, as set out in The Conservation Districts Act.

Due to the severity of both drainage and flooding problems, the main focus of both the Turtle River and Whitemud Watershed Conservation Districts, the two districts which make up the study area, has been upon drainage maintenance and improvement. More recently, the conservation districts are becoming more involved in soil conservation. This is a logical progression, both in terms of the legislation and in terms of the problems. Soil conservation is inevitably linked with erosion control and water management because eroded material ultimately ends up in water bodies where it causes infilling, siltation, and degradation of water quality.

Many approaches to reducing or preventing erosion are documented in the literature and may prove to be applicable in the escarpment. (Unger and McCalla, 1982; P.F.R.A., 1982; Beasley,1984; Bruce, 1984; El- Swaify, 1985) On the other hand little information is available as to soil suitability. (Cosper, 1983; Hinkle, 1983; Clarke et al., 1985) A tillage practice that proves viable on one field may yield poor results on another. The site specific nature of conservation tillage means that the ultimate test of its suitability is trial. (Lake, 1983)

Both the Whitemud and Turtle River Watershed Conservation District Boards and the Conservation Districts Authority feel that one way to promote soil conservation is through the demonstration of conservation techniques.

1.2 RATIONALIZATION OF THE DEMONSTRATION STRATEGY

Demonstration of remedial techniques is important for several reasons. Researchers realize new techniques, even if they don't increase the risk of low yields, will still increase uncertainty since the performance of a given technique is often unknown for a specific area. Certainty and knowledge are gained only through experience. (Clarke et al., 1985)

A farmer trying a new technique for the first time will generally apply it on a small scale to a field not easily visible to neighbors and friends. (Nowak, 1983) In this way, if the experiment fails, the farmer will not lose credibility with his peers. If the technique should prove viable, the farmer may then gradually adopt it on a larger scale. However, depending upon the type of technique adopted, its visibility to others may remain low.

Initial trials are likely to be plagued with misinformation or insufficient information. Typical demonstration projects draw upon a larger pool of technical expertise and are therefore more likely to establish the viability of a given technique. Demonstration projects serve both as a proving ground for techniques and as a highly visible advertisement of the availability and success of the techniques. Although it is not possible to measure the promotional effectiveness of demonstrations, the method is generally believed to be effective. (Ketcheson and Stonehouse, 1983; Nowak, 1985; Magleby et al, 1986; Clark et al, 1985; Hagen, 1977; Soil Conservation Committee of the Agricultural Institute of Canada, 1980; Richards, 1983) Farmers are also generally supportive of the idea of agencies such as locally run conservation districts demonstrating the benefits and feasibility of the techniques which they recommend to farmers. (Soil Conservation Problems, 1981)

Understanding farmers' attitudes towards soil conservation is of critical importance, for the ultimate success of any program depends upon its acceptability to the people who will be involved, and therefore, upon their attitudes. (Christensen and Norris, 1983; Soil Conservation in America, 1984)

An attitude is a mental position with regard toward a fact or state. Attitudes are worthy of concern both because they reflect current beliefs and because they are a contributing factor to the selection of an individual's course of action. Reflecting values, attitudes are shaped by, and change with time, experience and knowledge.

In order to set the stage for examination of farmer attitudes it is important to recognize two longstanding fundamental tenets which have been attached to agriculturalists. The first is the Agrarian or Jeffersonian creed. According to the creed, farmers have the God-given inviolate right to use their land as they see fit. This strongly held belief is largely responsible for farmers' unreceptive attitude towards legislated erosion control limits.

The second tenent, stewardship, claims that as stewards of the land, farmers have the responsibility of its maintenance for future generations. Many farmers believe that they have this responsibility; however, as Robroy Fisher explains, "a farmer's first responsibility is to make a profit in order to fulfill his responsibility to his family... All too often the cost of stewardship and the tools to be a good steward are beyond his capability." (Soil Conservation Problems and Practices, 1981) This concern with making short term economic gain is well represented throughout the literature. (Kraft,1978; Soil Conservation Problems and Practices, 1981; Soil Conservation in America, 1984)

The idea of stewardship rests upon the notion that land is placed in trust of present generations to be nurtured and maintained for the benefit of future generations. It implies that present generations owe future generations some certain quantity and quality of land. Edward O. Wilson (1984) suggests that the notion of the present generation owing distant descendents some tangible debt is not particularly useful because obligation becomes meaningless through the passage of time. He offers the conservation ethic as an alternative to stewardship because an ethic is a set of rules which is capable of encompassing the distant future.

He suggests "if the whole process of our life is directed toward preserving our species and our personal genes, preparing for future generations is an expression of the highest morality of which human beings are capable... We owe our remote descendants nothing, but in planning for them, we owe ourselves everything."

Without a doubt, his logic is correct. However, this does not mean that the notion of stewardship is negated but that it should actually be redefined in a more precise and logically correct manner. Instead of defining stewardship as owing remote descendants a certain amount and quality of land per se, stewardship can be defined as owing it to ourselves to ensure that a certain quantity and quality of land will be retained for the possible future use of our remote descendants. While at first blush this may seem to be a trivial distinction it is an important one because it assigns both accountability and responsibility to present generations. It clearly places the need for conservation in the present and hence is important. In short, the present generation must be accountable to itself.

Stewardship as a motivational factor is often subject to economic constraints. The literature suggests farmers are concerned with making short term economic gains. (Kraft, 1978; Soil Conservation Problems and Practices, 1981) However, stewardship motivates farmers to adopt soil conserving practices when it is economically possible. A study conducted in Ohio concluded that the farmers surveyed based their decisions to use conservation tillage mainly upon their concern for the environment with economy being cited as only a secondary reason. (Ladewig and Garibay, 1983)

Throughout the literature, land tenure is suggested as a possible factor influencing the implementation of erosion control measures. The potential significance of this relationship is due to the high percentage of rented land in agricultural production. In the U.S., only 25 percent of all cropland is owned by full owner-operators. (Lee, 1983)

Researchers theorize that conservation efforts will tend to be lower and erosion rates higher on rented land due to the short time horizons imposed upon management plans by the lease. The American Farmland Trust (AFT) survey of six different states (1984) found that there was more conservation effort on owned land. The AFT stressed that the differences were marginal and noted that on one site, rented land was actually treated better than owned land. (Soil Conservation in America, 1984) Another research study in Iowa found that tenure status was not related to the adoption of conservation tillage practices. (Bultena et. al., 1983)

Other researchers found full tenants had the highest rate of adoption and full owners had the lowest rate. (Magleby et. al, 1986) They suggest that this may be due to the larger size of renter operations, since they also found size of operation to be a significant factor of adoption. Linda Lee (1983) also found that part-owners and non-operator owners had higher use of minimum till practices than full-owner operators. Once again, small operation size and the associated low farm incomes are suggested as the reasons for this surprising finding. In consideration of the varied findings with regard to tenure, it would appear that tenure status is not a determining factor for implementation of erosion control measures.

Peter J. Nowak (1983) considered conservation tillage recommendations from the farmer's viewpoint and concluded that many non-adopters are probably making correct and rational decisions by rejecting them. The decision to switch away from conventional farming techniques must not be taken lightly since the timing, number and sequence of management decisions are more critical in conservation tillage. Furthermore, the economics of most erosion control measures except for conservation (reduced) tillage are marginal. (Napier and Forster, 1981)

Nowak describes four distinct stages through which a farmer must proceed before adopting a new technology. The first stage, often called the awareness stage, is when the farmer becomes aware of either a problem requiring a solution or of technology which could be applied to solving problems. In the second stage, the farmer gathers information and evaluates the technology. Provided the farmer has access to sufficient information and provided that the evaluation was positive, the farmer may give the new method a trial run often conducted on a low visibility back field. Finally, if the trial is a success, the farmer may adopt the new technology on a large scale.

These four stages in the adoption of agricultural innovation are widely accepted throughout the literature. (Beel and Bohlen, 1962; Wilkening, 1953) Clearly the first step, awareness, is a prerequisite to progress in soil conservation, and attitudes are closely intertwined with awareness. Indeed, growing awareness may be defined as developing attitude. The demonstration program will increase awareness, facilitate information gathering and help ensure successful initial trials.

Studies have shown that farmers often tend to underestimate erosion occurring on their own land. (Christensen and Norris, 1983; Richards, 1983) Peter Nowak points out that most people, when asked to think of severe erosion, envision huge gullies and fenceposts buried under drifts of soil. Actually, most erosion occurs in the form of sheet and rill erosion which is so subtle and insidious it is next to invisible. In short, by emphasising the dramatic forms of soil erosion, attention was directed away from the real problem.

Another probable explanation for the underestimation of the severity of the soil loss as perceived by farmers is that whereas researchers usually look at actual soil loss, farmers tend to look at soil loss in terms of reduced yields and profits. Erosion has been shown to adversely affect these factors; however, the losses are not immediately apparent because so many other variables enter into the picture. For instance, productivity losses due to erosion may be attributed to poor weather or potential losses could be nullified by increased output due to better seed, better timing or more appropriate fertilization practices.

Gordon Bultena and Eric Hoiberg (1983) found evidence suggesting that in Iowa, "the eagerness with which neighbours and friends are perceived to embrace innovations may be an important determinant of the tendency of persons themselves to adopt new practices, especially when these adoptions challenge pervasive beliefs." In other words, farmers' attitudes may be influenced by the actions of or attitudes of other farmers. Bultena and Hoiberg extend the argument even further. "The skepticism of neighbours may also be a barrier to adoption, especially for more extreme forms of conservation tillage." It is this skepticism which demands the demonstration of conservation techniques. It is one thing to tell a farmer how erosion should be controlled in his area --- convincing him that the method should be used is quite another matter. The challenge is to instill belief, to change attitudes. As Merlin Scarborough of Hayes, South Dakota says, "most farmers like someone to prove to them that there are benefits to the practices they're asked to use." (Soil Conservation Problems and Practices, 1981)

Men's actions are influenced by their attitudes. Therefore, if policy makers or planners wish to change the actions of men, they must first change the attitudes of men. They must change the degree of value or perceived level of value as seen by the farmer.

How can values be effectively changed in the field of soil conservation? Several options exist. These include legislation, education, and economic incentives. Many farmers are not warmly responsive towards the idea of legislating erosion controls. (Napier and Forster, 1982) Legislating erosion control effectively reduces the property rights of farmers to use their land as they see fit. Worse yet from the farmer's perspective, a legislative approach may result in increased farm gate costs. In an era when many farmers are losing their farms due to financial insolvency, the last thing farmers wish to see is increased costs. Secondly, there is the question of equity. Legislated erosion control could, in effect, penalize farmers located on erosive lands. Finally, policing could prove costly and difficult. Since the erosion control measures would be designed to benefit future generations of the general public, not just farmers, farmers question why they should have to bear the burden. For all of these reasons, farmers are opposed to legislated controls. One researcher concluded laws do not motivate; communication is the key to motivation. (Davis, 1985)

Robroy Fisher of Glen Allen, Mississippi is succinct and to the point with regards to his attitude towards the joint nature of the conservation responsibility. He says "because all of our children will benefit equally from cheaper and more plentiful food suplies, it becomes a public responsibility to share in the cost of preserving our mighty food-producing factory." (Soil Conservation Problems and Practices, 1981)

Farmers are generally receptive to and supportive of financial and educational initiatives because they are seen as voluntary. While financial incentives subsidize risk, education attempts to minimize risk by increasing the knowledge base. Napier and Fōrster (1981) found "farmers support educational programs, but prefered economic inducement."

While demonstration may cause a farmer to become aware of erosion problems and can even teach him how to solve those problems, unless the solution is economically viable it is unlikely to be adopted.

The prime objective of this study was the identification and assessment of suitable soil and water conservation demonstration sites as the prerequisite requirement for the effective demonstration of structural and non-structural remedial techniques.

1.3 PROBLEM STATEMENT

Erosion in the Manitoba escarpment results in a variety of problems such as sheet and rill erosion, gullying, down-cutting of stream channels, bank slumping, loss of soil nutrients and organic matter, reduced agricultural output, sedimentation in drainage ditches, increased sediment loads, and decreased downstream water quality.

Although the escarpment is particularly susceptible to erosion due to its physiographic characteristics, the tendency to erode is exacerbated by inappropriate agricultural practices like overgrazing, under-fertilization, watering cattle from ditches, extensive land clearing, over-tillage, and attempting to crop land which is too steep.

Government involvement in the management of land in the study area dates back to the early 1880's when the development of marginal lands was encouraged through drainage subsidization. While the drains were necessary to allow agricultural production, by changing the course, destination and action of the water, the drains became contributory factors of erosion.

Although remedial techniques for reducing or eliminating erosion exist, they are not being implemented to any significant degree. (Bruce, 1984) The Turtle River and Whitemud Conservation District Boards and Conservation Districts Authority should encourage soil and water conservation through the demonstration of remedial techniques.

This study addresses the identification and assessment of soil and water demonstration sites in the Whitemud and Turtle River Watershed Conservation Districts where a variety of remedial works will be put into place to demonstrate their feasibility.

1.4 STUDY AREA

The study area encompasses both the Whitemud Watershed Conservation District (W.W.C.D.) and the Turtle River Watershed Conservation District (T.R.W.C.D.). Figure 1 shows the location of the study area.

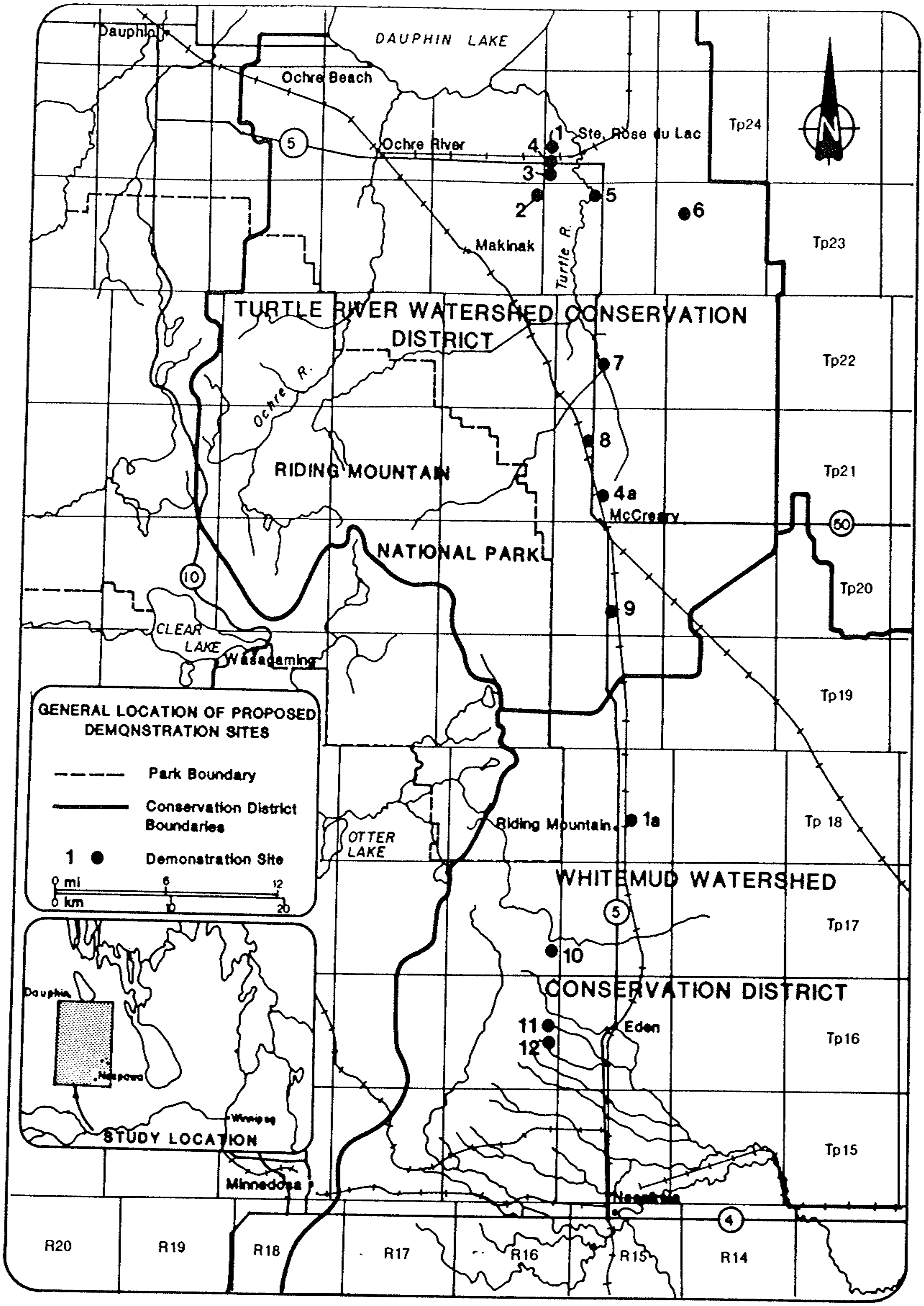

Figure 1: Location of Study Area and General Location of Demonstration Sites.

Established in 1972, the W.W.C.D. covers all or part of the municipalities of Alonsa, Elton, Glenella, Lakeview, Langford, Landsdowne, McCreary, Minto, North Cyprus, North Norfolk, Odanah, Portage la Prairie, Rosedale and Westbourne. With a drainage area of 4468 square kilometers, the district is named after its main waterway, the Whitemud River. Six major tributaries of the Whitemud make up the subdrainage basins for the district as follows,

1. Arden Creek
2. Big Grass River
3. Neepawa Creek
4. Pine Creek
5. Squirrel Creek and
6. Willowbend Creek.

Minor tributaries entering the Whitemud are Bear Cat Creek, Bear Creek, Birnie Creek, Eden Creek, Silver Stream, Spring Creek, Pelican Creek and Wapus Creek.

Established in 1975, the T.R.W.C.D. covers all or parts of the municipalities of Dauphin, Lawrence, McCreary, Ochre River, Rosedale, Ste. Rose, and the L.G.D. of Alonsa. With a drainage area of approximately 2253 square kilometers, the district has two main waterways, the Turtle and Ochre Rivers. The subdrainage basins are as follows,

1. Bennet Drain

2. Crawford Creek
3. Hansen Creek
4. Henderson Creek
5. McKinnon Creek
6. Meezee Lake Drain
7. Norgate Drain
8. Scott Creek and
9. Wilson Creek.

The W.W.C.D. consists of four physiographic areas: the Lowlands, the Sub-Escarpment, the Escarpment and the Uplands. Within these areas, surface features such as topography, drainage, elevation and surface materials are reasonably similar. The Lowland area is that land below 290 meters (900 feet) above sea level (ASL) in the north and 275 meters (950 feet) ASL in the south. Soils of the boulder till plain in the north vary in texture from loamy sand to clay loam and suffer from severe stoniness. They are moderate to low in fertility and are poorly drained. Soils of the dry lake plain in the south are also imperfectly to poorly drained, but are moderately high in fertility. Stream gradients in the Lowland area are very gradual, dropping less than one foot per mile. Stream channels are poorly defined and marshes occur frequently.

The Sub-Escarpment area is the area of transition between the Escarpment and the Lowlands. Elevation ranges from 290-365 metres (950-1200 feet) ASL in the north to 275-320 metres (900-1050 feet) ASL in the south. The Calcareous Meadow and Dark Grey Wooded soils of the north were developed on fine to coarse lacustrine to medium boulder till. The Black Meadow soils of the south were developed on a gently sloping sand plain upon medium to coarse lacustrine deposits. Stream gradients in the Sub-Escarpment are moderate, dropping five feet per mile. Although the stream channels are well defined to the west, they are disrupted by low ridges and depressions in the east. Marshes and wetlands occur at these points of disruption.

The Escarpment area actually refers to two areas, the Manitoba Escarpment and the Riding Mountain Escarpment. The Manitoba Escarpment divides the Upland and the Lowlands. Its elevation ranges from 320 metres (1050 feet) ASL to 380 metres (1250 feet) ASL. Soils of the northern section are of the Black association and were formed on coarse sands to clay loam. Soils in the southern section are of the Degrading Black association and were formed on sands and silts. Stream channels in the Escarpment are well defined. The gradient is steep, falling eighty feet per mile. Soil drainage is excellent.

The Riding Mountain Escarpment occurs in the northwestern portion of the watershed. The land rises sharply from 290 metres (900 feet) ASL of the Sub-Escarpment to 700 meters (2300 feet) ASL. The surface of the Riding Mountain slopes are covered with loose highly erodible shale. The soils in the area are of the Grey Wooded association and have a coarse sand to clay loam texture.

The Upland area occurs in the southwest portion of the watershed, with the Upland Till Plain to the north and the Upland Sand Plain to the south. Elevation ranges from 380 to 550 meters (1250 to 1800 feet). Soils are of the Black association and were developed under grassland cover. Stream gradient is moderate, falling about six feet per mile.

The T.R.W.C.D. is also divided up into the four same physiographic regions.

The Lowland area includes all land below the 300 metre (1000 foot) contour. Soil drainage ranges from poor to good. Stoniness varies from stone free to exceedingly stoney. The surface texture ranges from gravel to clay. This area is the most extensive in the watershed. It is characterized by flat lake and alluvial deposits and glacial till deposits.

The Sub-Escarpment area is a narrow band of land between the 300 and 360 metre contour. Numerous alluvial fans and beach ridges occur in this area. Soils are sandy loam to silty clay. Soil drainage is good to imperfect. Stream channels are well defined and have moderate gradients.

The Escarpment area is the steeply sloping band of land dividing the Sub-Escarpment and the Uplands. It ranges in elevation from 360 to 600 metres. Soil texture ranges from sandy loam to silty clay. Beach and alluvial deposits lie at the foot of this region. Only the Riding Mountain Escarpment occurs in the T.R.W.C.D..

The Upland region is the forested rolling till plain located within the Riding Mountain National Park. It ranges in elevation from 600-675 meters.

1.5 RESEARCH OBJECTIVES

The primary purpose of this study was to identify and assess soil and water conservation demonstration sites in the Whitemud and Turtle River conservation districts. Specific objectives were as follows,

1. to identify individual drainage basins in the Turtle River and Whitemud Watershed Conservation Districts associated with man-made drainage systems
2. to identify land-use/management problems contributing to loss of soil and sedimentation in the freshwater systems of the study area
3. to identify structural and non-structural remedies applicable to the study area
4. to identify specific sites associated with river basins of these two districts that are characterized

by one or more land management problems and to identify one or more possible structural and/or non-structural solutions with potential to either minimize or correct the problem(s) and

5. to recommend to the W.W.C.D. and T.R.W.C.D. Boards sites most suitable for demonstrating the effectiveness of proposed remedial works to local landowners and other groups interested in soil and water conservation.

1.6 METHODS

1. A review of the related literature provided a thorough understanding of the processes of erosion, indicated the type of erosion problems which occur in the area, described remedial solutions both structural and non-structural, and investigated the likely acceptability of these measures to farmers. Four criterion were used in the selection of remedial solutions to be demonstrated in the study area:

   a) Suitability to soil, climate and topography
   b) Status
   c) Ease of implementation, physical and financial and
   d) Flexibility.

2. Working in conjunction with the Turtle River and Whitemud Watershed Conservation Districts Managers, spe-

cific land management problems and problem areas were determined.

3. The information from the above was taken into the field where, by the use of maps and ground truthing, possible demonstration sites were identified according to the following criterion:

   a) Accessibility for extension purposes
   b) Visibility to passers-by
   c) Site characteristics in terms of erosion problems
   d) Cost of remedy
   e) Grouping - preferably the demonstration sites will be grouped together to facilitate viewing and to provide a solid set of solutions and
   f) Contrast - ideally there should exist a second area adjacent to or nearby the demonstration site possessing the same problem characteristics such that the effectiveness of the remedial techniques will be clearly apparent through simple visual comparison.

4. Possible soil and water conservation demonstration sites were catalogued.
5. Using the above criteria, recommendation of suitable demonstration sites and the remedy(ies) to be demonstrated on each site were made.
6. The recommended demonstration sites were both mapped and catalogued .

In order to determine the priority of the selection criteria, the audience to which the demonstration is directed must be identified. The demonstration projects which will be implemented by the W.W.C.D and the T.R.W.C.D. should be targeted towards a wide audience. While the demonstrations encompass a scientific role as the efficacy and economic feasibility of various remedial measures are tested, high visibility to farmers and the general public is extremely important and therefore should be a primary concern.

As a result of the demonstrations, farmers will become more aware of the sometimes invisible erosion on their own fields, more aware of the remedial solutions, and will have access to detailed information as to the economic feasibility of the techniques demonstrated in their area. The demonstrations will also serve to ensure farmers' awareness of all existing government supports for conservation techniques.

Observed at even the most superficial level by passersby, the demonstrations will serve to elevate the level of awareness of both erosion problems and remedial techniques. The general public will immediately realize that there must be a problem, that solutions do exist, and that active promotion of conservation techniques and remedies is being carried out.

Accessibility of the demonstration sites is important for anyone interested in viewing the sites, but is especially important for extension purposes where a bus-load of people, perhaps school children, wish to see the full set of demonstrated techniques in a reasonable amount of time. Convenient grouping of the sites is desireable for the same reasons.

Chapter II

EROSION IN THE STUDY AREA

2.1 PROCESSES AND CLASSIFICATION OF EROSION

Soil erosion is generally divided into two categories, wind and water erosion. Water erosion occurs when soil particles are detached by flowing water or by raindrop impact. While raindrop detachment occurs over broad areas of land, overland flow tends to be concentrated in defineable channels or rills. Crust formation is a prerequisite for the development of rills and is inhibited by aggregates, which are more dependant on the organic matter than the clay content of the soil. (Blair-Rains, 1983)

Rills are ephemeral in nature, as those formed during one storm are often obliterated before the next storm of sufficient intensity to cause rilling occurs. New rills often develop as entirely new networks of channels. Concentration of the water in the rills results in more erosive force on the soil than in inter-rill erosion.

Inter-rill erosion, also refered to as sheet erosion, is overland flow between defineable rills. Overland flow occurs when surface depression storage, soil moisture storage or infiltration capacity of the soil are exceeded.

Overland flow is seldom in the form of a sheet of water of uniform depth; it is more commonly a mass of braided water courses with pronounced micro-channels.

By itself, inter-rill erosion can only transport fine particles. However, rainfall augments the erosive capability as raindrop impact lifts larger soil particles into the flow which carries them downslope a short distance before they settle out again. Clark et al. (1985) report that raindrops may lift soil particles three feet into the air and toss them five feet to the side. As the number of raindrops in a single storm may reach one million per square meter, it is clear that the erosive potential is great. (Forster and Meyer, 1977)

In many respects, gully erosion is like large-scale rill erosion. However, gully erosion has an additional important factor --- side-slope stability. Even though water flowing through a gully may not directly erode the sides of the channel, it will often wash away soil which has slumped from the banks into the flow. Without the weight of the slumped material at the base of the bank walls, slope failure occurs and the banks slump into the flow again.

Two process of gully formation are known. Rills may continue to erode until they become too large to be removed with normal tillage operations. Rills can develop into gullies in a short period of time.

Alternately, gullies may form as a result of localized weakening of vegetative cover. On an overgrazed hillside, small knicks or depressions may form where the vegetative cover is particularly weak and sparse. Water concentrates in these depressions and enlarges them untill several coalesce and form an incipient channel. Erosion is concentrated at the head of the depression where scouring at the base of the scarp undermines the headwall. This leads to the collapse of the headwall which then retreats further upslope.

Susceptibility of soil to water erosion depends upon five factors:

1. soil erodibility - this is a function of infiltration, permeability, friability, texture and soil type
2. topography - slope steepness and length of slope
3. land use - especially tillage practices
4. vegetative cover and
5. rainfall intensity and duration.

Zachar (1982) identifies climate as "the most important factor governing gully erosion since it determines the aggresivity of the erosion process and the rate and type of plant growth -- the most important element in erosion control." While controlling climate is not yet feasible, understanding the climate and how it influences erosion is important for developing rational conservation management plans.

Soil which is highly permeable allows water infiltration. Runoff is reduced and the land is less susceptible to erosion.

In the study area, water erosion tends to be most problematical in the escarpment and sub-escarpment areas due to the slope of the land whereas wind erosion is confined mainly to the lowlands. (Whitemud River Watershed Resource Study, 1974). The main factors effecting the soil susceptibility to wind erosion are soil texture, soil structure, topography, land use and vegetative cover. Soil structure refers to how the soil particles cling together to form aggregates. The aggradation depends upon mineral and organic particles which chemically bind the soil particles together. Topography is an important factor in wind erosion in that the windward side and tops of knolls tend to be eroded while the leeward side and hollows tend to receive soil deposits. This scalping problem is exacerbated by large cultivation equipment which tends to scrape the soil from hilltops.

Vegetative cover is a function of land use. Sections 2.3 and 2.4 cover this area.

As discussed earlier, intense heavy rainfall is a contributing factor to soil erosion in the study area. (Carlyle, 1980)

2.2 CONSEQUENCES OF EROSION

2.2.1 Economics

It has been noted that the costs of soil conservation are usually obvious and therefore seldom overlooked whereas the benefits are less obvious, especially where conserving the soil "merely" preserves the status quo of productive potential that would otherwise be eroded away. (Troeh et al., 1980)

Although less obvious, the benefits of soil conservation have been the focus of much attention. A large and well developed body of literature exists with regard to the economic consequences of soil erosion. For the purposes of this study, a brief review is sufficient to establish that soil erosion imposes a significant cost on both farmers and society.

In 1982, the PFRA estimated that the direct cost of erosion on the Prairies is $368 million per year, which translates to about $12.31 per hectare of cropped land. Lyles (1975) estimated that the loss of one centimeter of soil reduces wheat yields by approximately 40 kg/ha. or 0.6 bu/acre. This compares well with the PFRA's 1982 estimate of 0.47 to 1.34 bu/acre loss per every centimeter of topsoil lost.

Both wind and water erosion tend to strip off the top layer of soil which is the most fertile portion of the soil profile. To a certain degree, this loss of fertility can be offset by increased use of fertilizers; however, the loss of organic matter and clay particles degrades the soil structure, resulting in decreased soil porosity and friability. Not only is the soil less suitable for crops, but it is also even more likely to erode because reduced porosity means greater runoff.

Further economic costs of soil erosion are associated with the major by-product of erosion, namely sedimentation.

2.2.2 Sedimentation

Sediment deposition is the unavoidable ultimate consequence of erosion. Deposition in drainage channels results in reduced capacity and increased risk of flooding. Plate one shows gullying in a grain field caused by overland flow following the overtopping of a clogged drainage ditch in the spring of 1986.

Although dredging prolongs the useful life of drains, and helps prevent flood damages, it is an extremely costly ameliorative measure which does nothing to address the true root cause of the problem. (Plates two and three depict the Reeve Drain before and during shale cleanout in 1986.)

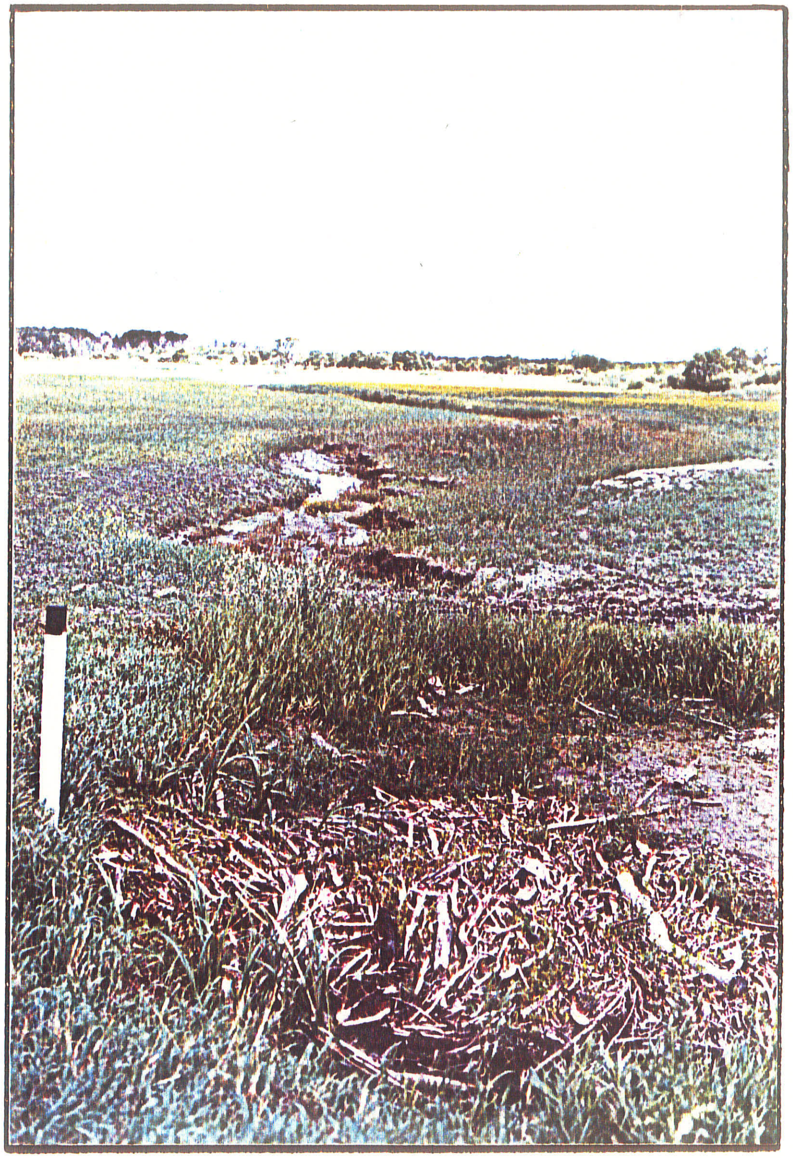

Plate No. 1: Gullying of field due to overtopping of a drainage ditch. Shale deposits reduced ditch capacity causing overtopping.

Plate No. 2: Reeve Drain prior to shale removal.

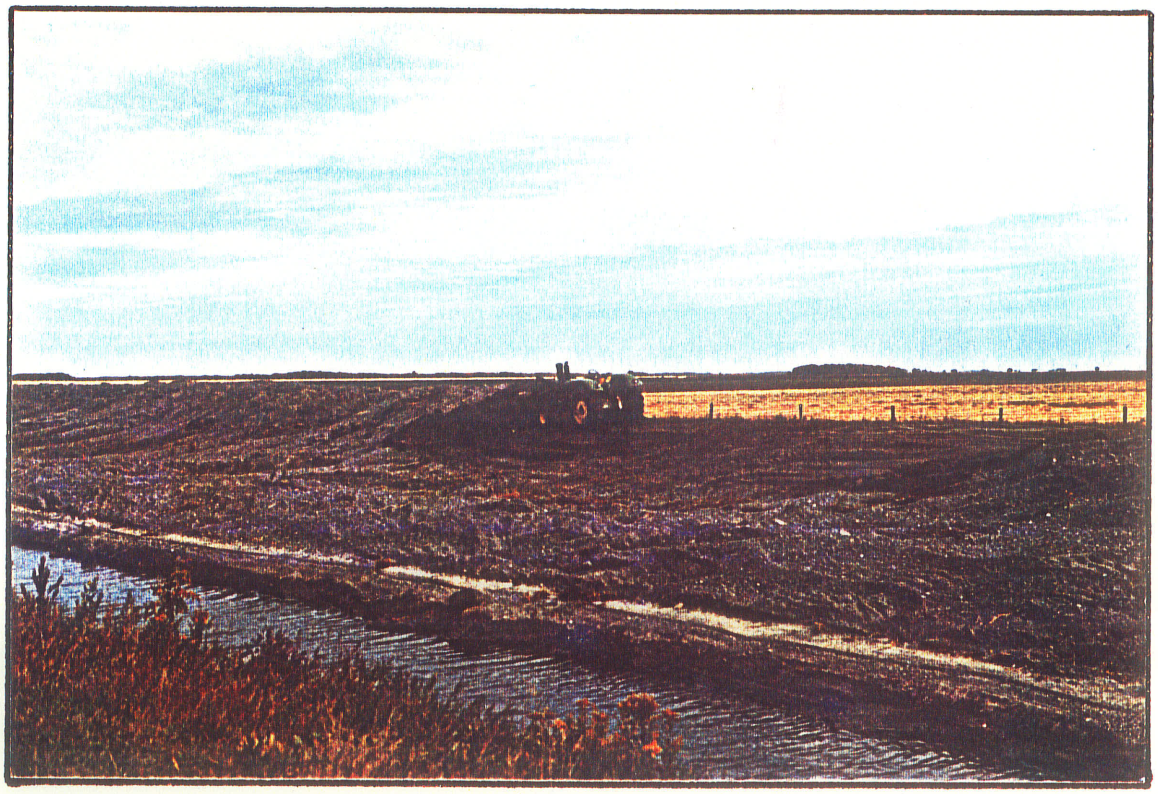

Plate No. 3: Reeve Drain during shale removal.

In the study area, deposition in drainage channels and in Lake Dauphin is an immense problem both in terms of cost and sheer volume. Consider Wilson creek, a typical representative of the many streams coming off the escarpment. It is estimated that from 1928 to 1978, 920,000 cubic yards or 18,400 cubic yards of deposits per year have eroded from the Wilson Creek Canyon. (Newbury, 1980) On average, the Wilson Creek Drain must be dredged out every two to three years at a cost of approximately $10,000 per mile. (Bowering, 1987)

At one time it was believed that the escarpment (Plates four and five) was the source of the shale deposits in drainage channels; however, studies in the Wilson Creek Watershed showed that only about 25 percent of the deposits were coming directly from the escarpment; approximately seventy-five percent of the material was being re-eroded in the subescarpment alluvial fan area drains. (Wilson Creek Headwater Control Committee, 1983)

Perhaps the only positive aspect of the shale dredged from the drainage channels is its use on farm driveways. (Plate six) Shale not required for shoring up channel banks is free for the taking.

Plate No. 4: Escarpment shale, Wilson Creek area.

Plate No. 5: Escarpment shale near Kelwood, Manitoba.

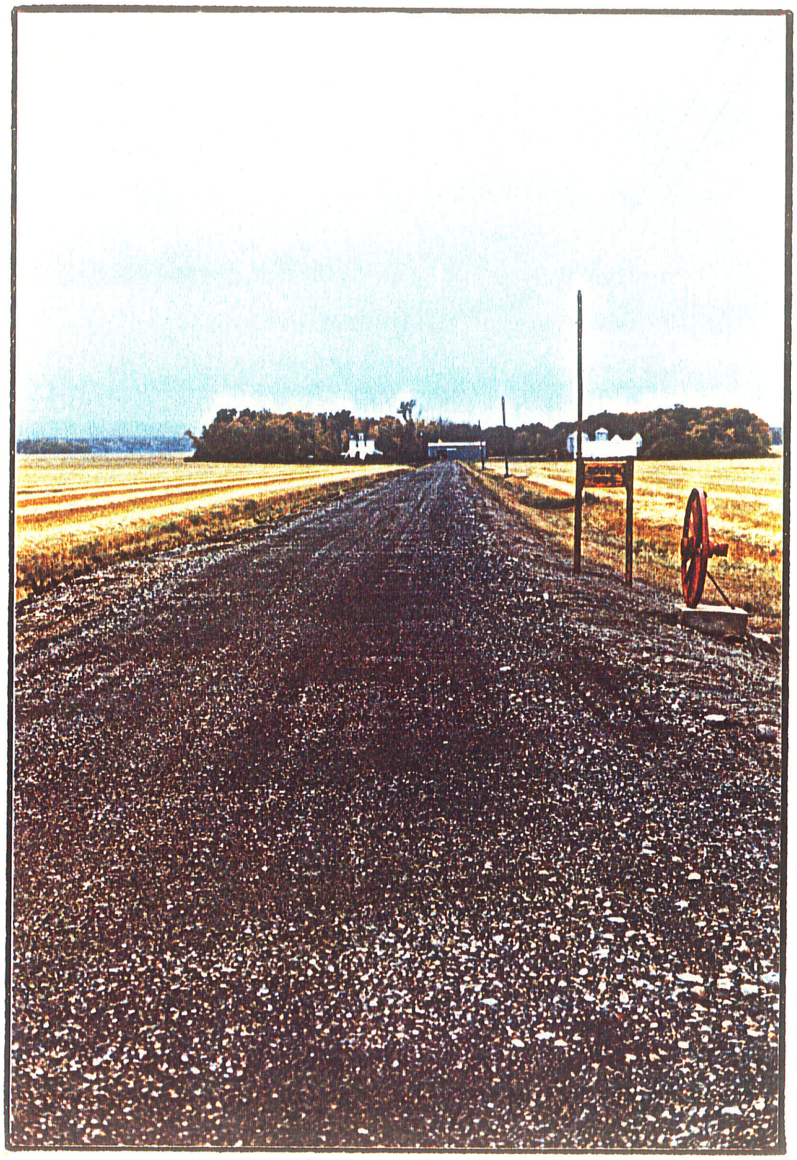

Plate No. 6: Shale driveway on a farm near the Reeve Drain.

A study on sediment deposits in Ohio drainage ditches found evidence to support the hypothesis that "gross erosion near waterbodies causes more sediment deposition than distant soil erosion." (Forster and Abraham, 1985) Given the vast quantities of sediment generated within the drains, it is not surprising that soil erosion from agricultural fields tends to be overshadowed.

A review of the historical drainage patterns of the area provides insight with regard to the phenomena of re-eroding drains. In order to maintain continuity, this review is presented following the discussion on sedimentation.

While argueably the most dramatic problem associated with sediments, the filling of ditches is not the only problem of consequence. Edwin H. Clark (1985) identifies three ways in which sediment can increase flood damages:

1. by causing aggradation of streambeds it increases the frequency and depth of flooding
2. suspended sediment increases the volume of floodflows and
3. many flood damages are caused by the sediment rather than the water.

All three mechanisms occur in the study area. In terms of flood damages by sediments, crops in the seedling stage may be smothered by even a fairly thin layer of sediment. In some cases, sediment deposition can significantly reduce the productive capacity of a field. For instance, plate seven shows a large bare spot in an alfalfa field. The "bare" spot is actually a bed of shale over a foot deep which was washed out of Beristow drain by spring runoff. (Plate eight) The shale effectively removed the land it covers from production.

Last, but not least, sediments carried by the waters result in reduced water quality and hasten the eutrophication of lakes. The lakes are the catchbasins for the finer particles of silt and the pesticides, herbicides and fertilizers which are washed and blown off fields along with soil.

Plate No. 7: Shale deposit in alfalfa field.

Plate No. 8: Shale deposits reduced capacity of Bearistow Drain, pictured here, and overtopping caused deposits shown in previous plate.

2.2.3 Historical Drainage Patterns

Occuring approximately every six kilometers, streams coming off the escarpment historically terminated in the relatively flat subescarpment area. Here the water spread out over the land, lost its energy, and slowly seeped into the ground. Materials carried downslope by the water were deposited as the water lost its energy, forming vast alluvial fans at the base of the escarpment.

In the late 1920's, strong demand for arable land by settlers led to the drainage of the fans. Ditches were constructed to take the water away from the fan areas, routing it instead to the lowland waterways. Energy that was once dissipated over the alluvial fan was thus confined to the man-made drainage channels. Instead of depositing alluvium, the water now erodes the original deposits. In the Riding Mountain section of the escarpment, 14 streams are actively eroding their fan areas. Severe erosion is evident on six streams which have developed large alluvial canyons. (Chapman, 1987) In the case of Wilson Creek, the canyon is 10-15 meters deep and approximately 1.5 miles long and covers about 44 acres of land. (Newbury, 1980) This material, consisting of sands, silts and shales, is carried a few miles downstream to the lowland ditches where the flatter gradient slows the water and causes the material to settle out.

By eroding and downcutting, the streams are in effect trying to adjust their gradients to match that of their new lower reaches - the drainage ditches. Since the sediments must be dredged out in order to maintain ditch capacity, the gradient can not be equalized and downcutting continues, with the headcutting moving farther and farther back into the subescarpment area.

It is believed that the only feasible solution to this problem is the installation of a series of energy dissipation weirs.

The weirs should be installed so as to reestablish the historical gradient of the streambed above each weir and thereby stabilize the streambed. The change in the overall total gradient of the stream would be accommodated for by dropping the water over the top of each weir down to the next stabilized level. The weirs should be located such that the water is continuous from one weir to the next. In other words, water flowing over one weir will tumble into water held back by the next weir and so forth.

In 1980, two experimental weirs were installed on Wilson Creek. Shale buildup above the weirs is not as problematical as might be suspected. Although shale filling has occured, especially above the uppermost weir, the shale deposits are not confined to the area immediately above the weir, but extend far into the upper reaches of the stream.

Consequently, the gradient immediately above the weir, being the same as that of upper reaches, is not prone to washout of shale held back by the weir. (Newbury and Gaboury, 1987)

While the initial cost of installation is high, given the high cost of drain maintenance into perpetuity that will be incurred otherwise, the proposed solution is expected to be cost effective in the long run. Based on a $23,000 capital cost and average annual maintenance costs of $1,000 per dam, and a 5% discount rate, a benefit- cost ratio of 1.3 was estimated for the two weirs on Wilson Creek. (Bowering, 1987)

In addition to stabilizing the streambed, energy dissipation weirs may actually improve habitat for wildlife as vegetation becomes established along the banks.

A more detailed discussion of these large scale weirs is beyond the scope of this study; however, to ignore the problem entirely would be inappropriate as the erosion problem within the drains is due to the agricultural demands upon the landscape.

2.3 LAND USE

2.3.1 Land Use: A Historical Perspective

A brief historical review of the development of the area aids understanding of present-day land use problems.

Settlement of the area followed the construction of the Manitoba Northwestern Railway. In the mistaken belief that hard work and ready access to markets could make any land productive, early settlers industriously and indiscriminantly cleared land along the railway. Some of the land cleared proved too steep to crop successfully. It washed out, became badly gullied, and eventually had to be abandoned. Although almost all of the lowlands required drainage, homesteading continued till about 1931, with the better land being claimed, and the worst being abandoned.

In response to public pressure, and in order to encourage homesteading, the government passed the Drainage Act of 1895; construction of drains soon followed. As detailed in Chapter One, the unwitting consequence of drainage works initiated in the Sub-Escarpment area so many years ago is a major problem today, namely, erosion and sedimentation by and in the ditches.

2.4 CURRENT LAND USE

Although land use in the study area includes residential, recreational, and wildlife habitat use, agriculture has retained and increased its command over the majority of the land base. While the first three categories of land use generally provide adequate soil protection via permanent vegetational ground cover, traditional agricultural practices tend to increase the susceptibility of the land to the erosive forces of both wind and water.

Land use-management problems contributing to the loss of soil and to sedimentation are dual faceted. One side of the problem stems from the physical geographic features of the land itself. The second aspect of the problem is the implementation of inappropriate agricultural practices or techniques.

2.4.1 Problematical Land Features

The land features common to the physiographic areas of the study area pose particular challenges to land management.

In the lowlands, lack of relief, poor internal drainage and high water tables make the land prone to excess moisture. This condition is exacerbated by heavy siltation in drainage ditches. Under flood conditions, rivers and drains overtop their banks washing away valuable topsoil and leaving sand and shale behind. Culverts and crossings are damaged necessitating costly repairs. Flooding and drainage problems are more obvious than soil erosion in the Lowlands; however, wind erosion manifested in the form of severe dust storms in 1983-1984 served to focus increased attention on this chronic problem.

In the Sub-Escarpment, excess runoff results in rill and gully erosion. Stream channels downcut and the banks slump into the flow.

The Escarpment area is even more prone to water erosion as the very steep shale slopes gully easily.

In the Uplands, over fifty percent of the topsoil was lost to wind erosion before the conversion to permanent forage under the Alternate Land Use Program. (Jenkins, 1972)

2.4.2 Land Use Problems, Problematical Practices

2.4.2.1 Inappropriate Land Clearing

Although the folly of trying to crop slopes which were simply too steep was learned by early settlers, the stark evidence of heavily gullied steep hillsides provides mute testimony to the more recent mistakes of later generations. Plate nine depicts land adjacent to the Rosedale experimental farm. Note the uneven, broken roughness in the upper field area. Once seeded to small grains, this land is now riddled with numerous large gullies which can no longer be crossed by tillage machinery. The farmer has been forced, of necessity, to abandon these lands. This particular form of inappropriate land clearing is found in both the escarpment and subescarpment areas.

Plate No. 9: Badly gullied land adjacent to the Rosedale Experimental farm. The lower, flat portion of the field is still cropped, but the upper portion is too badly gullied and has been abandonned.

A second form of inappropriate land clearing involves marginal wetlands. Given the high maintenance and upgrading costs presently incurred on drains serving areas which have already been developed, farmers should be encouraged to carefully consider the advisability of clearing wetlands, especially where the productivity of the land is likely to be poor.

2.4.2.2 Straw Burning and Overtillage

Straw burning and overtillage are considered together because although they are separate management practices, they both result in reduced trash cover.

In the early 1900's, farmers were advised by agriculturalists to burn off straw after harvest. A black field looked tidy and well maintained. Burning straw residues made achieving a clean black field easier and was believed to have the added benefits of destroying weed seeds and returning nutrients, in the form of ash, back to the soil. In fact, although burning does not destroy the mineral elements contained in the straw, it does destroy valuable nitrogen and organic matter.

Following the horrendous dust storms of the "Dirty 30's", the wisdom of straw burning came under fire. It was recognized that straw residues help protect the soil from wind and water erosion, add nutrients and tilth to the soil, and improve texture, permeability and friability. Straw residues trap snow which provides protection from the wind and helps distribute moisture more evenly across fields. Even distribution of moisture gives the field more of a chance to absorb spring melt-water and thus helps reduce runoff and erosion. Even without the added protection of snow, straw residues slow wind velocity reducing its erosive power and protect soil from raindrop impact. By the 50's, agriculturalists were trying hard to convince farmers that burning was bad. (Wallace, 1957)

Old beliefs die hard, and straw burning is still fairly common in Manitoba. Although some straw burning occurs in the study area, this is the exception, not the rule. (Personal Communication, Bruce, 1986)

Typical straw yields on Manitoba fields have doubled since 1945 and now average about 2,600 Kg per hectare (2,300 lbs per acre) every year. Burning the straw residue destroys up to $8.00 per ha. worth of nitrogen ($3.00 per acre) and causes long term yield reductions of 25% as compared to non-burned fields. (Manitoba Department of Agriculture, 1984)

Using both a straw chopper and chaff spreader when combining results in a more even distribution of trash over the field. This ensures even erosion protection, makes trash incorporation easier, and especially under zero-till operations, helps ensure even germination of the next crop.

Overtillage is excessive tillage. It wastes fuel and soil moisture, and by pulverizing the soil and buring trash, makes the soil more susceptible to wind and water erosion. Farmers in the United States have found that they could drastically reduce the number of passes over their fields without compromising on effectiveness. This conservation practice is refered to as reduced tillage. In addition to reducing the number of passes over a field, farmers also combine numerous cultivation practices in one trip. Combining practices has the added advantage of reducing the amount of time required for completion of all operations. This means that the farmer can go more slowly over the field and thus reduce pulverization. Alternately, the farmer will be able to apply the time to further management practices.

An opinion poll conducted in late 1986 by the Manitoba Co-operator showed that more than 55% of grain farmers in Manitoba and Saskatchewan pass over their fields an average of seven or more times each year. With reduced tillage, more trash could be maintained on the soil surface and the erosion risk reduced.

2.4.2.3 Summerfallow

Like straw burning, summerfallow was once generally espoused as a desireable practice. The advantages of summerfallow were discovered by accident when the farm horses of Indian Head, Saskatchewan, were conscripted to haul supplies for the army in 1885. By the time the horses returned, it was too late to seed the fields so the farmers tilled the soil to kill the weeds. The following year, the fields that had been inadvertently fallowed produced well even though crop failure due to drought occured on almost all the other land. This phenomena led the first superintendent of the experimentation station at Indian Head to investigate the practice of summerfallow. (Sniatynski, 1986)

The theory behind summerfallow is that by keeping the land black for one season, weed populations are reduced and the moisture level in the soil is allowed to recharge. The major drawback to this cultural method is that with little to no vegetative cover, summerfallow fields are extremely susceptible to wind and water erosion.

Of all agricultural practices, summerfallow is responsible for the greatest proportion of soil lost in Canada. (AIC, 1980) Although summerfallow may be needed to permit production of cereal grains in particularly arid regions, in most areas, continuous cropping is both possible and desireable. Continuous cropping yields a harvest every year. The vegetation stabilizes the soil and protects it from blowing winds and raindrops. The spread of saline seeps is reduced because the crops use up moisture and hence reduce seepage of ground water. In some cases, the combined effect of drier soil and a lowered moisture zone can result in the increased productivity of saline soils as the salts are flushed deeper into the soil by increased absorption of rainwater.

Where insufficient moisture levels prohibit continuous cropping, alternate fallow methods may be employed. One recent alternative to traditional summerfallow is chemical fallow. Under this system, as little as one or as many as all mechanical weed control tillage operations may be replaced by chemical control. As each tillage operation costs about a half inch of moisture, and summerfallow fields are generally tilled four or more times, chemical fallow may be especially appropriate in very dry areas. (Sniatynski, 1986) Adoption on this practice will depend largely upon the relative cost efficiency of chemicals over conventional weed control.

In Manitoba, summerfallow acreages have fallen from about 33% of cultivated land to about 10%. (Manitoba Co-Operator, 1986)

2.4.2.4 Field Size

When early settlers first cleared and broke the land, fields were small because it took a long time for a team of horses or even a tractor to cultivate a field. Today, large powerful tractors best suited to large continuous fields dominate the scene. Big machinery does not lend itself to working small areas. It excels in long straight runs up and down large fields planted to a single crop.

Conversion to monocropping large fields presents several opportunities for increased erosion. Since field length is increased, in most instances, the length of slopes also are increased. This gives runoff a greater opportunity to erode soil since the volume of water at the bottom sections of the field will be greater and the velocity, momentum and energy of the water, and hence its erosive capacity will be larger.

Adoption of large tractors has meant that less land can be cultivated according to its contours. This is especially true for areas characterized by multiple slopes. Tire tracks left by a tractor which travelled up and down a slope instead of parallel to it can channel runoff concentrating its erosive forces into a small area resulting in rills and gullies.

Not surprisingly, large open fields are also more susceptible to wind erosion.

Finally, in order to extract the maximum yield from their land and to help control weeds, many farmers till their land right up to the very edge. In some cases, farmers actually till the ditch! Without a stable border, fields are much more likely to slump material into the ditch. Slumped material impinges on ditch capacity, degrades water quality and necessitates costly repairs. While it is required to maintain a clean black border of land around a certified seed crop, this does not justify needless erosion.

2.4.2.5 Pastures

Agricultural erosion is not limited to loss of soil from cultivated land. Poor pasture management practices can also result in significant loss of soil and reduction in water quality. In the study area, common practices which contribute to these problems are overgrazing, stockwatering in drainage ditches, and inadequate fertilization.

2.5 CHAPTER HIGHLIGHTS

Erosion has long been a problem in the study area. Shortly after settlers broke the land the first cases of agricultural related erosion appeared in the form of severe washouts and gullies. While spectacular cases of erosion continue to occur today, the significance of less obvious incremental types of erosion is also receiving increased recognition and concern by farmers, scientists and society as represented by the government.

In the past, inappropriate land use has exacerbated the erosion problem. Sound management practices are a must to prevent further degradation. Over the years, many remedial techniques to control erosion have evolved. Unfortunately, the efficacy and economic viability of the techniques varies from place to place. As little is known about soil suitability, evaluation must be based upon in-situ trial. A demonstration program will facilitate evaluation of promising remedial measures.

Chapter III

REMEDIAL TECHNIQUES APPLICABLE TO THE STUDY AREA

Many remedial techniques, structural and non-structural, have been developed for reducing and controlling erosion and are documented in the literature. In order to be considered suitable for recommendation and demonstration in the study area, techniques had to meet the following criteria,

1. suitability to soil, topography and climate
2. status
3. ease of implementation and
4. flexibility.

The first three factors, soil suitability, topography and climate, eliminated many techniques. Status refers to the established past performance record of a given technique. Techniques which have been proven effective under similar conditions were accepted whereas techniques which are still very experimental in status, such as stubble mulching (Bates, 1986) and slot mulching (Saxton et al., 1981) were rejected.

The criterion "ease of implementation" refered to both physical and financial ease. This was considered especially important given the present economic slump in the agricultural sector. Techniques which require extremely high initial capital outlay such as terracing and sub-surface tile drainage were eliminated under this criterion.

Finally, the last criterion, flexibility, was considered to be not essential, but a definite asset in that flexibility generally is associated with multiple options. Flax strips and perennial grass strips were considered more flexible than shelterbelts, and cultivation conservation techniques such as strip cropping, zero-till and field borders were considered far more flexible, and hence more appealing than terraces.

Vegetation has been called the first line of defense against erosion. (Highfill and Kimberlin, 1977) A vegetative canopy shields the soil from the erosive forces of rain and wind. The roots bind and stabilize the soil, and may increase permeability and enhance infiltration. Surface residues reduce erosion indirectly by increasing the size and stability of wet and dry soil aggregates. (Black and Power, 1965) Even dead vegetation is more effective than surface roughness in reducing erosion. (Moldenhauer et al., 1983) The effectiveness of tillage methods for controlling erosion ultimately depends upon the amount of crop residue left on the soil surface. Soil conservation practices which do not depend upon vegetative cover for their success include terracing, contour tillage, slot mulching, and weirs. No indication is given in the literature as to whether or not these techniques are best demonstrated all on one site or on many sites.

Non-structural remedial techniques rely on vegetative cover for erosion control protection whereas structural remedial techniques may or may not. The balance of this chapter describes the following conservation techniques, considered for their suitability in the study area:

a) terracing (Section 3.1)

b) contour tillage (Section 3.2)

c) strip cropping (Section 3.3)

d) buffer strips (Section 3.4)

e) contour cropping (Section 3.5)

f) block planting (Section 3.6)

g) land retirement (Section 3.7)

h) grassed waterways (Section 3.8)

i) rotational grazing (Section 3.9)

j) forage crops (Section 3.10)

k) limited access to waterways (Section 3.11)

l) adequate fertilization (Section 3.12)

m) green manure and cover crops (Sect. 3.13)

n) conservation and zero till, continuous cropping (Sect. 3.14)

o) shelterbelts, grass and flax strips, (Sect. 3.15)

p) drop structures and weirs (Sect. 3.16).

The T.R.W.C.D. provides financial and technical assistance to farmers on a cost share basis for installing shelterbelts, grassed waterways, grass and annual barriers, strip cropping, green manure plowdowns, and conservation and zero tillage.

The W.W.C.D. provides financial and technical support on a cost share basis to farmers through forage seed assistance, shelterbelt and block planting, grassed waterway and gully stabilization programs. Saline soil management, zero, conservation and minimum till demonstrations are also funded.

3.1 TERRACING

Terraces reduce erosion by decreasing slope length and reducing or preventing damage caused by surface runoff. Generally, the grade of the land on each individual terrace is reduced and water in excess of the infiltration capacity of the soil is either held back by a ridge at the lowermost edge of the terrace or is channelled away from the terrace via a diversion channel to a stable waterway. Terraces have been used to control erosion for centuries in many countries, especially where land is scarce and labour inexpensive.

Although terraces are an effective method of reducing erosion on land with less than a 12 degree slope (Clark et al., 1985), the PFRA (1983) concluded that terraces have only a limited application on the Prairies due to prohibitive costs, maintenance requirements and limited life expectancy. They are costly to till, plant and harvest (King, 1983) and are not well suited to large machine cultivation which is becoming increasingly prevalent today.

Especially during periods of intense rainfall, terraces are subject to the risk of overtopping. Typically, erosion due to overtopping is severe. For these reasons, the installation of terraces in the study area is not recommended.

3.2 CONTOUR TILLAGE

Contour tillage involves tilling and cropping across the slope with the contour instead of up and down the slope. Tillage up and down the slope creates multiple furrows which convey water quickly off the field and are therefore prone to erosion. In contour tillage, the tillage furrows and tire tracks running parallel to the contour of the land hold back soil and water. This method is effective on slopes from 3 to 8 percent (FAO, 1965).

Contour cultivation practices can reduce soil loss on sloping land by up to 50% compared to cultivation up and down the slope. (Morgan, 1979) Although cross slope tillage can be very inexpensive to implement, costs can increase greatly where topography is highly variable and where large scale machinery is used.

For example, Fortin (1982) found cross-slope tillage cost an additional $12.00 per ha. in 1982 dollars in the Stratford/Avon River Project in Ontario. This represents a substantial increase in operation costs.

In the Uplands, the Escarpment and Sub-escarpment areas of the study area, topography tends to be highly variable with multiple slopes. Gullies and waterways divide many fields such that relatively short cultivation runs following the contours of the land require turning cultivation machinery far more often than would be required if tillage was conducted up and down the slopes. Where field size and configuration permit, Seecharen (1980) recommends contour tillage in the Manitoba Escarpment area. However, Morgan (1979) cautions that contour tillage is inadequate as a sole conservation measure for fields longer than 180 m at one degree steepness and is only effective during storms of low rainfall intensity. As heavy intense rainstorms are common in the study area from May through June (Carlyle, 1980) the practice may not prove very effective in the escarpment region.

3.3 STRIP CROPPING

Strip cropping for wind erosion control utilizes strips of erosion resistant crops and erosion-susceptible crops planted at right angles to the prevailing erosive winds.

Erosion is reduced because the strips trap the blowing soil. Strip widths of 6 meters are recommended for sandy soil while on silty clay loam soils strips of up to 130 meters may be needed. (FAO, 1960) Strip widths are determined by even units of machinery widths.

It is important to ensure that there are no critical levels of herbicide such as atrazine where cereal or forage crops are to be established.

3.4 BUFFER STRIPS

Buffer strips are strips of vegetation maintained at field edges bordering drains and waterways. They may consist of forages or cereal crops and are generally rotated in order to maintain vitality. Buffer strips serve to stabilize field borders, reducing slumping into drains. They trap sediments which would otherwise be washed into the drains and provide protection against the scouring action of flood water when drains are overtopped.

Buffer strips often border woods and hedgerows where shading and moisture competition result in poor crop productivity anyway. (USDA, 1953)

Buffer strips can also consist of brush or woody plantings. While these offer excellent wind and water erosion protection, they have the disadvantage of trapping large amounts of snow during the winter and insulating it from the sun in the spring. Water from higher up in the drainage system could be constricted when it reached the still frozen brush protected sections of the drains and would back up flooding the land. For this reason, brush buffers can only be recommended in the uppermost sections of a watershed, with forage buffers strongly recommended in the remainder of the watershed.

Farmers may be reluctant to employ buffer strips, fearing weed or insect infestation. However, the strips, if properly managed, need not harbour weed and insect pests. Where certified seed is grown, farmers may wish to consider maintaining both the required vegetation free strip and a buffer strip. This combination would not only help keep the crop weed free, but would also protect the field edges from erosion.

3.5 CONTOUR CROPPING

Strip cropping for water erosion control is called contour farming. Strips of erosion resistant crops are alternated with strips of erosion-prone crops approximately on the contour. The erosion resistant strips check the flow of runoff down the slope by decreasing its velocity. The strips may also reduce the volume of the flow by increasing infiltration. The degree, length and complexity of the slope and soil texture determine the width and arrangement of the strips. Strips generally range from 15 to 45 metres wide.

Forage crops such as alfalfa are commonly used in contour cropping and may reduce soil loss by 70 to 75%. (FAO, 1965)

Erosion is proportional to the length of the slope; therefore, cutting the length of the slope by contour cropping reduces erosion. Compared to terracing, contour cropping is much less expensive and requires far less maintenance. However, like strip cropping, the cost of this technique increases as topography becomes more varied.

3.6 BLOCK PLANTING

Block planting of trees is recommended for stabilizing land that can not be stabilized by cultural methods. Trees and brush are reestablished on land that should not have been cleared and is subject to erosion or on land which will no longer support grain production. On poor, eroding land, trees are able to stabilize the soil, tapping nutrients and moisture which lie deep in the soil. A wide variety of trees and shrubs may be planted. Determination of which varieties to plant, and where, is based on site characteristics such as soil type and moisture.

Rosedale farm is an excellent example of the successful implementation of block planting within the study area. Severely eroded and gullied land was successfully reclaimed through the use of forages, shelterbelts, and block planting of trees. The land was once little more than highly erosive barren shale. Today it boasts beautiful stands of trees, and between the blocks of trees, productive alfalfa fields. Grain has even been grown on a rotation basis with the alfalfa.

3.7 LAND RETIREMENT

Probably the most drastic measure of soil conservation, land retirement involves the permanent conversion of land from agricultural use to its natural state. The Alternate Land Use Program (A.L.U.) under the joint Federal-Provincial Agricultural Rehabilitation and Development Act (A.R.D.A., 1962) led to the retirement of 4,405 hectares of scarp face and 1,359 hectares of south slopes in the Riding Mountain area, purchased at the cost of $395,980 and $112,859 respectively. Most of the cultivated land was planted to permanent hay with the remainder planted to trees or allowed to return to its naturalized state.

At one time actively and severely eroding, these lands are now stable and productive. Although no grazing of these lands is allowed, permission to hay the land is often granted to farmers. The land has greater capacity to store water, which helps reduce runoff and downstream flooding and also has greater capacity for wildlife and recreational uses.

3.8 GRASSED WATERWAYS

Grassed waterways have been called one of the most common and basic conservation practices recognized, accepted and used by farmers. (Bosworth et al., 1982; FAO, 1965) Grassed waterways are designed to convey runoff safely from a field to a drain. Grass or legume sod lining the waterway reduces the velocity of the flowing water and resists the erosive scouring and gullying action of the water. The vegetation also provides the additional benefits of increasing infiltration and trapping some sediment and nutrients.

They are relatively inexpensive to construct with costs ranging from $1-3 per lineal foot. (Graham and Knight, 1982)

In general, the most satisfactory location for a grassed waterway is a natural drainageway as runoff flows toward the drain naturally and good soil depth in the drainageway and good moisture availability help insure the establishment of vegetation.

Shallow gullies may be filled with a farm tractor and disker. Deeper gullies may require road graders or dozer blades mounted on caterpillar or farm tractors. Tractor drawn earth scrapers prove useful when fill or topsoil must be hauled for any distance.

The topsoil should always be removed first and replaced after the gully is filled and packed. Packing should be done in stages with no more than eight to 12 inches of loose fill added between compactions. In order to prevent erosion, gullies should be filled all at once, not in stages.

A parabolic or saucer shape is recommended as it more closely resembles the shape of a natural waterway and is less likely to induce meandering than a trapezoidal shape. (FAO, 1965) Trapezoidal waterways are difficult to construct and tend to end up parabolic in cross section after a few years. (Bosworth et al., 1982) Side slopes should not exceed 1:4 (one meter vertically to four meters horizontally). The gradient in the flume should not exceed 1:6 and ideally should not exceed 1:10. (Bosworth et al., 1982) Manitoba Agriculture (1983) recommends gradient ideally should not exceed 1:100. The channel should be no less than 5 meters (16 feet) in width and no less than 0.15 meters (0.5 feet) in depth.

A firm seedbed is required to ensure establishment of the sod. High quality seed should be sown at roughly twice the rate normally used for pasture seeding. The sod should continue at least least 5 meters beyond the edge of the waterway, and a jagged edge should direct water over the grass into the waterway.

Construction in late spring and early fall is prefered as the soil can generally be worked easily and germination of the grass seed is most successful at these times. Conversion of gullies to grassed waterways is best limited to gullies which are less than 15 feet deep and have drainage areas not exceeding 150 acres. In order to make haying worthwhile, width should be at least 20 meters (65 feet).

Grassed waterways should be hayed at regular haying time, but should not be grazed during the first two years. (Bonnefoy, 1983) Depending upon conditions, grazing may or may not be recommended after the sod has become well established. When the ground is soft and wet, animal traffic should be restricted.

Maintenance is extremely important. Fertilizers or manure should be applied in sufficient quantity to keep the sod dense and strong. Although the waterways are designed to allow crossing by farm machinery, care must be taken to ensure tillage implements do not disturb the sod. The waterways must be protected from accidental herbicide application and should never be used as a roadway. If the sod becomes damaged, it should be repaired promptly or the damaged area will become increasingly extensive and therefore more costly and difficult to repair with each storm. Occasionally, obstacles such as rocks may cause erosion through established sod. The rock should be removed, the hole filled and packed, and live sod should be tamped in place.

In order to ensure the continued effectiveness of a grassed waterway, care should be taken in the form of complementary soil conservation techniques to insure that infilling from field erosion does not occur. For example, it is adviseable to avoid cultivating parallel to the waterway as the furrows could begin to gully and the grassed waterway would no longer be able to perform effectively.

3.9 ROTATIONAL GRAZING

Rotational grazing involves moving cattle from one field to another as the season progresses in order to ensure that overgrazing does not occur. By maintaining adequate vegetational cover on the soil, protection from erosion is achieved. As different types of forage grow at different rates and have peak growth at different times of the season, movement of the herd is adjusted to achieve optimum grazing.

Tame forage is a key component in any rotation grazing system as it develops much faster than native grasses in the spring and can therefore be safely grazed as early as mid-May. (Ducks Unlimited, no date) Cattle should be rotated between relatively small spring paddocks every seven to ten days such that the forage is not cropped shorter than about four inches in height. This ensures the vitality and quick recovery of the grasses. About mid-June, the cattle can be moved onto native forage with about a 14-18 day rotation. In mid-September, the cattle should be moved back onto tame forage.

In early spring and mid-summer, the tame forage should be fertilized with a high nitrogen fertilizer. Soil tests should be conducted to determine optimum selection and rates of application.

Rotational grazing requires greater management and labour from the operator. These disadvantages are offset by the benefits of reduced erosion and optimum forage utilization. Secondary benefits are increased wildlife opportunities due to the maintenance of greater cover and reduced parasite populations.

Rotational grazing requires that the land be cross fenced into two or more separate fields. This can be done economically with one or two strand electric fencing, provided that a power source is available. Strong posts are not required for cross fencing with electric fencing because the animals quickly learn not to touch the fence. Another advantage of electric fencing is its flexibility. Changing the layout of cross-fences is relatively easy. If standard barbed wire fencing is used, stronger posts are required as cattle tend to lean heavily on these fences.

A water source is also required in each of the pastures. In some cases, it may be possible to arrange fencing such that the same water source can be accessed from several fields. In other cases, rotational grazing may require installation of additional watering facilities such as dug-outs.

3.10 ACCESS TO WATERWAYS

Wherever possible, cattle should not be allowed direct access to waterways, but instead should have their own dug-out or trough. The reasons for this are twofold. Firstly, cattle tend to defecate directly into the water. This contamination has a negative impact on water quality and can be a source of infection and disease. Secondly, the impact of their hooves augments streambed erosion and bank slumping. Fencing should be set back a minimum of three meters from the top of the ditch bank. While fencing along waterways can reduce erosion dramatically, as demonstrated in the Thames River Project (Grant and Fortin, 1982), reduction in nutrients reaching the water may not be nearly as great since nutrient runoff would continue from the adjacent land. The cost of fencing off waterways may be prohibitive where long stretches must be fenced. Currently no economic support is offered for fencing off waterways in the study area.

Plates ten and 11 show typical riparian cattle damage in the study area.

Marlow et al. (1987) studied the effects of cattle on streambank erosion in Montana and concluded that until a greater data base becomes available, riparian grazing should be deferred till mid- to late-summer, rather than strictly excluding livestock.

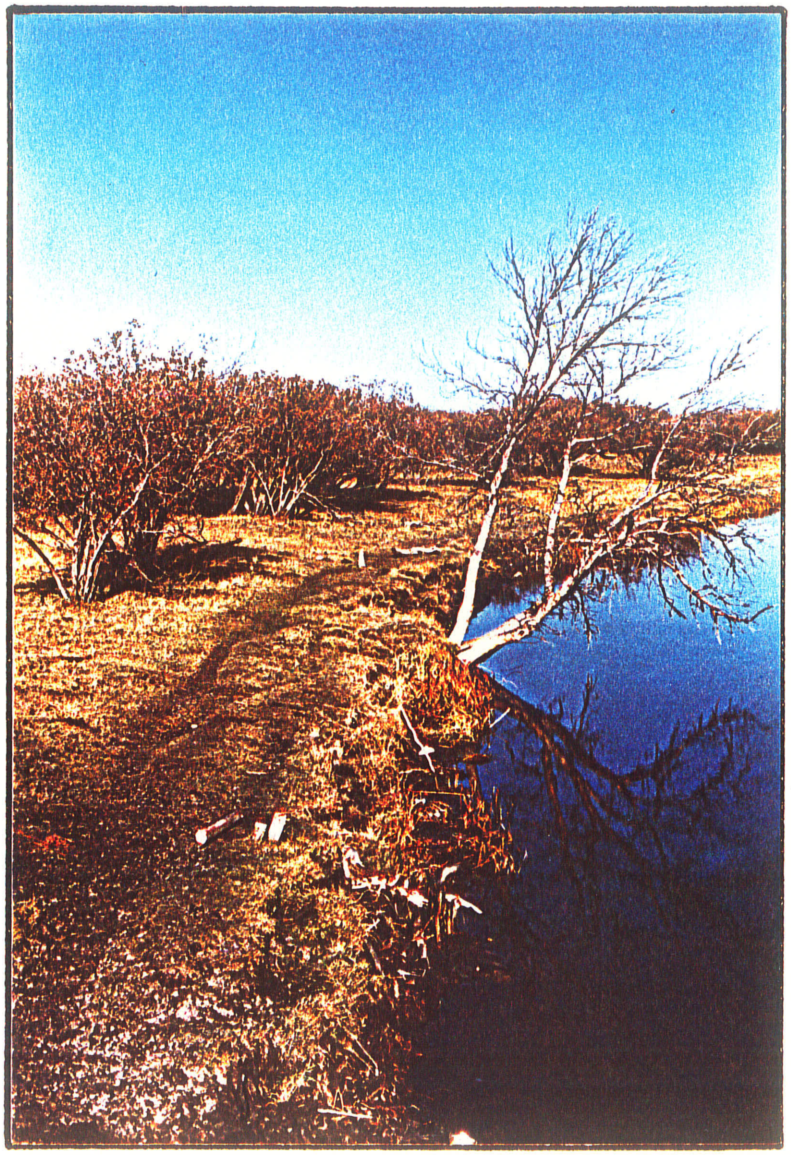

Plate No. 10: Typical cattle damage evident along the bank of the Turtle River. Cattle access not limited by fencing.

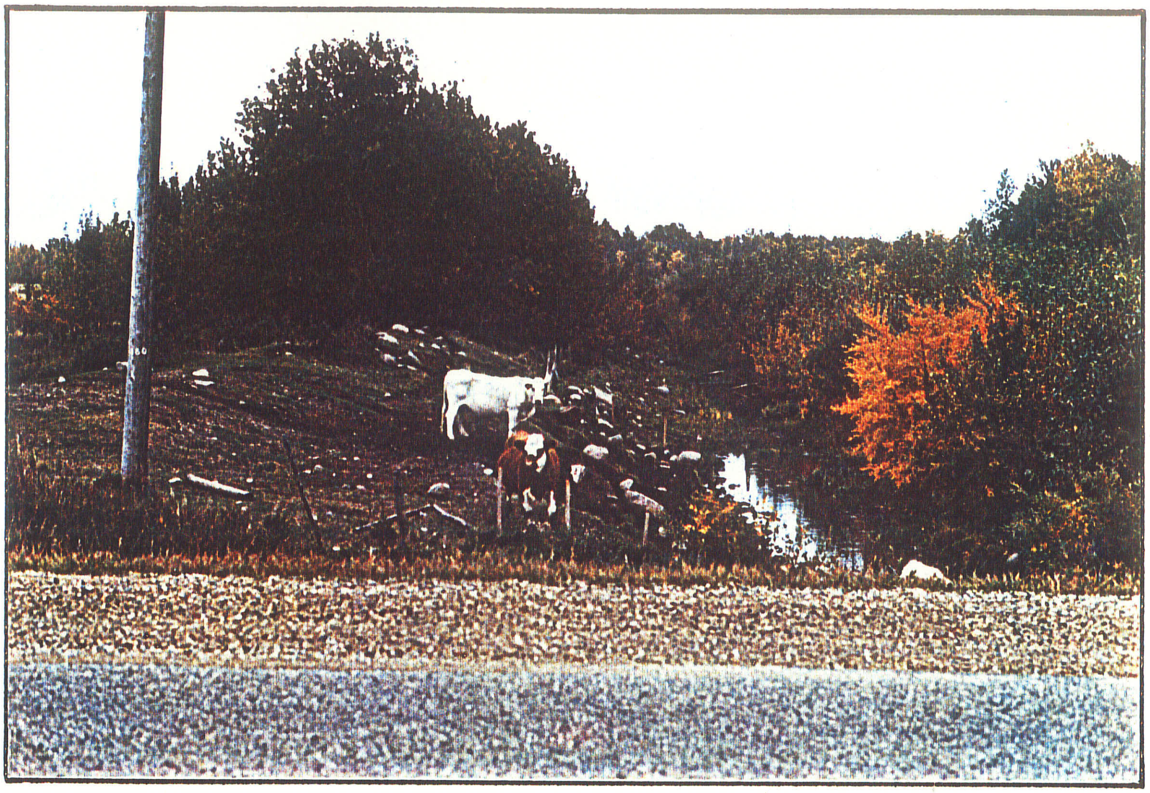

Plate No. 11: Cattle watering in a drainage ditch. Although access and hence damage has been limited to only a small section of the ditch, direct access is undesireable.

3.11 FORAGE CROPS

Due to the year round vegetative cover afforded by forage crops, greater protection from erosion is realized than from small grains. So long as there is a market for forages, their production should be encouraged. Including legumes in rotation benefits following crops as the legumes fix nitrogen, and in the case of alfalfa, the deep root system is helpful in accessing deep water from the soil which helps reduce seepage to saline areas.

3.12 ADEQUATE FERTILIZATION

Adequate fertilization is important not only on cash crops, but is highly recommended for tame pastures and grassed waterways. Adequate fertilization helps prevent erosion because vegetative cover is maximized and hence protection from wind and water is optimum. Nitrogen is particularly important as it not only increases the productivity of the land but also helps enable the vegetation to withstand drought conditions. Although general estimates are available from local chemical dealers, fertilizer requirements are most accurately determined through soil testing.

3.13 GREEN MANURE, COVER CROPS

Green manure and cover crops are planted when otherwise the land would remain fallow. They help prevent erosion, increase organic matter, improve soil tilth, increase water-absorbing capacity and infiltration, and in the case of green manure, raise nitrogen levels. Instead of summerfallowing, a nitrogen fixing green manure crop such as clover can be seeded and then tilled back into the soil. Cover crops planted in the fall reduce runoff, prevent leaching of nitrate nitrogen, help conserve moisture, prevent excessive erosion and may also provide spring and winter grazing.

In 1986, a sweet clover plowdown demonstration was initiated on a farm near Ste. Rose, Manitoba. The results of the ongoing demonstration will determine the economics of the practice under local conditions.

Researchers have found that erosion is reduced in the two years following meadow due to residual effects. (Foster and Meyer, 1977; Follett and Stewart, 1985) Reduction of erosion ranges from 40 to 75% in the first year and from 5 to 50% in the second year following meadow. Similar effects may be expected with green manure and cover crops. Cover crops temporarily tie up plant nutrients such that they cannot be washed away by runoff. (FAO, 1965) Disadvantages include the uncertainty of getting a good stand, cost of seed and labour and the refuge for weed and insect pests provided by the crop. Cover crops may also delay spring seeding due to slower drying time. (Clark et al., 1985)

3.14 CONSERVATION TILLAGE, ZERO TILL, CONTINUOUS CROPPING

Reduced tillage refers to a reduction in the number of passes or tillage operations carried out on a field. Each additional pass reduces the amount of surface residue and uses up fuel and time. However, since reduced tillage may only mean that the farmer has reduced tillage by one pass, this may or may not be significant in terms of reducing soil erosion. Researchers found that many farmers have reduced their tillage operations, believe that they are practicing conservation tillage and feel that their fields are not eroding when in fact very little surface residue remains on their fields which actually are actively eroding. (Nowak and Korsching, 1985)

Minimum tillage means the least number of tillage operations required to create the proper soil conditions for seed germination and plant establishment. If sufficient crop residue remains on the soil surface to prevent erosion, then conservation tillage is being practiced.

Zero till means that the crop is planted directly into untilled stubble land with minimal soil disturbance and, if necessary, chemical weed control. Zero-till leaves 90% of the crop residue intact. If no rotation of summerfallow occurs in zero-till or in any other tillage system, then continuous cropping is in effect.

In the literature, the term conservation tillage tends to be loosely used and may describe continuous cropping, reduced tillage or "conservation tillage" as defined above. (Mannering and Fenster, 1983) This confusion over terms makes clarification very important. Conservation tillage is best described as an array of reduced tillage and cultivational practices that protect the soil by leaving a mulch of residue on the the soil surface. Moldenhauer et al. (1982) found that conservation tillage resulted in a 40-90% reduction in erosion as compared to conventional tillage.

Substantial fuel savings are associated with reduced and conservation tillage. According to Walker (1983), fuel costs may be cut by two- thirds with conservation tillage. It is believed fuel savings have been a key factor in making conservation tillage popular with farmers. (Clark et al., 1985) In the Southern Plains area of the United States, Unger et al. (1977) found that economic returns from conservation tillage must be greater than or equal to those of conventional tillage or conservation tillage would not be practiced. Long term yields can be expected to be higher under conservation tillage due to less erosion. (Crossen, 1981)

The literature is unclear with respect to the implications on fertilizer requirements. Walker (1983) indicates a saving in fertilizer costs whereas Crossen (1981) found that the cool, moist soils of conservation tillage slow mineralization of nitrogen and therefore require more fertilizer.

Under zero-tillage, the weed control effects of tillage must be replaced by herbicides. To some extent, careful crop rotation can help control weed and insect pests. In some cases it may be necessary to incorporate a year of conventional tillage into the rotation to control weeds. Deep tilling of the field may be required on a rotational basis to combat soil compaction.

The effective agent in all of these practices is surface residue. The amount of surface residue left after tillage is effected by not only the number of passes over the field, but also by the type of tillage equipment used. Table 1 indicates the amount of trash buried by a single pass of various tillage implements.

TABLE 1

Trash Buried by Tillage

Tillage Implement	% Buried
Wide Blade Cultivator	10
Rod Weeder	10
Heavy Duty Cultivator	20
One Way Disc	45
Tandem or Offset Disc	30-70
Moldboard Plow	90

The table, from Manitoba Department of Agriculture (1984), is put into perspective by the department's reminders "on a highly erodible soil a 50% trash cover will cut erosion by two-thirds than what it would be on a bare field, and 80% cover will reduce erosion by 90%." Following primary tillage with straight chisel points or sweeps, each secondary operation with a discer reduces cover by 50%. (Moldenhauer et al., 1983) Perhaps the biggest problem farmers encounter when trying conservation tillage is planting too early, as soils under the surface residue remain 8 to 10 degrees fahrenheit cooler in the spring. (Walker, 1983) Planting in cool wet soil adversely effects germination. (Cosper, 1983)

In general, it is recognized that conservation tillage requires a higher level of management skills compared to conventional tillage. Timing of all operations becomes much more critical under conservation, reduced and zero-tillage.

This is largely because in conventional tillage, mistakes can often be repaired by an additional pass, whereas in conservation tillage, operations must be effective the first time.

Although it provides a great deal of protection, conservation tillage alone may not provide sufficient erosion control and may need to be combined with other erosion control practices such as grassed waterways and shelterbelts.

A secondary benefit of zero-till is the benefit to wildlife. In Manitoba, duck production was found to be 3.8 times greater on no-till small grain farms than on conventional farms. (Cowan, 1982) The standing stubble provides good cover for nesting. If spring tillage for weed control is done using an undercutter, nests are not damaged unless hit by a wheel, coulter or blade shank.

3.15 SHELTERBELTS AND OTHER WIND MANAGEMENT BARRIERS

Following the horrendous dust storms of the "Dirty Thirties", the PFRA actively encouraged the planting of shelterbelts to protect the land from wind erosion. Trees are planted in rows running perpendicular to the direction of the prevailing erosive winds. The belts protect the land lying within a distance of about 12 times the height of the trees. The length of the belts should be at least 24 times the height. (Morgan, 1979) Shelterbelt planting is not recommended on rolling or poorly drained fields. (PFRA, 1984)

Shelterbelts inconvenience farmers in several ways. Most evidently, they divide fields and thus reduce field size which may make cultivation more difficult. The belts can also provide a foothold for weeds and pests. In addition, large drifts of snow trapped by the belts may delay seeding operations in the spring. Old shelterbelts, which were planted on a four to five foot interval spacing with caraganas placed between each tree should be thinned and pruned in order to allow the snow to be more generally dispersed across the field. New shelterbelts planted on a five to six foot interval do not cause large drifts to build up, provided the lower branches are pruned. (Manitoba Co-operator, July 2, 1987)

Weed control should be given high priority as the presence of weeds and grass has been found the single most important factor linked to poor windbreak condition. (Schaefer et al., 1987)

Several variations on the shelterbelt idea offer less permanent wind protection. Strips of flax or crested wheatgrass can effectively shield the soil. In the case of wheatgrass, which is a perennial, care must be taken not to kill the strips with either herbicides or tillage operations. A spacing of 25 to 50 feet between the strips is recommended. Each flax strip consists of several rows sown 6-12 inches apart. Strips should be sown between July 7-30. (Manitoba Department of Agriculture, 1985)

Yet another variation of this idea is stubble shaping. A deflector is attached to the swather such that a row of tall stubble is preserved. These tall rows, one per swath width, occur over the whole field, parallel to the erosive winds. The tall straw helps slow the wind and traps snow which forms a protective layer over the filed. For this method to be of use, the stubble must not be plowed into the ground until spring. Stubble shaping can be used on no till fields and even on forage crops which are harvested late in the fall. Crop loss due to stubble deflectors is minimal, about 0.2 %. (Hoechst, 1986)

3.16 DROP STUCTURES

While small gullies can be filled and replaced with grassed waterways, the repair of large gullies is seldom justified. (Hudson, 1981) Instead, gullies are generally stabilized. Stabilization can be achieved using structures, vegetation, or a combination of both.

Hudson (1981) and Bosworth et al. (1982) do not recommend the use of temporary structures as they are subject to decay, undermining and bypassing, becoming less effective over time until they generally fail. Piest et al. (1981) maintain that inexpensive but relatively short lived structural controls are acceptable where an element of risk or failure can be an integral part of the design without causing undue hardship to property or persons.

Temporary structural controls are often required to permit the establishment of vegetative cover. Temporary structural controls include brush dams, suspended nets primed with straw, fixed wire baskets, rock filled gabions, plank and log weirs.

Several small check dams are better than one large one. Ideally they should not exceed 2.5 feet in height from the centre of the notch to the bottom of the gully. Ideal spacing requires that the crest elevation of one is the same as the bottom elevation of the adjacent check upstream. (Ayres, 1936)

For long term control, permanent structures and or vegetation is superior.

As discussed earlier, rock weirs have proven effective in restabilizing highly erosive reaches of escarpmental streams within the study area.

3.17 CHAPTER HIGHLIGHTS

There exists a wide variety of remedial techniques to control erosion. Assessment of some techniques in terms of economic and technical viability has begun and is ongoing. There is a need for more work in this area. The demonstration program will help eliminate this void as each technique will be subject to analysis.

A critical issue is adoption. There is merit in the "tried and true". Trying the unknown means less certainty. Less certainty can be equated to or be perceived to mean greater risk. One way of reducing uncertainty is to conduct a trial. A less risky method of reducing uncertainty is to base the trial on another's successful use of the technique. Demonstration sites will play an important role in enabling farmers and others to see the merits of the various techniques. The next chapter discusses specific sites in terms of the above.

Chapter IV

STUDY RESULTS

Specific land management problems and problem areas were identified in conjunction with the Turtle River and Whitemud Watershed Conservation District Managers. Altogether, 14 remedial techniques were chosen for demonstration in the study area. Nineteen possible demonstration sites were identified and another eight currently developed sites deemed ideally suited for demonstration purposes were incorporated into the list for a total of 27 sites. As the presently developed sites are accessible, visible and close to the rest of the future demonstration sites, duplication of those efforts is not required and would be inefficient.

While initially it was felt that it would be both desireable and possible to demonstrate all remedial techniques chosen for demonstration in the study area within the confines of a relatively small area, it soon became apparent that this would not be possible. Different areas have different problems which require appropriate solutions. No one section was found to possess the whole spectrum of problems. For this reason, a tight grouping of demonstration sites was not possible. Provided that the sites selected are not widely scattered throughout the area, this need not present a problem for tour planning. In fact, the time interval enroute between sites can very effectively be used to discuss any further questions regarding the last site examined and further, to introduce the next site to the group. Having demonstration sites spaced out also ensures that tour groups attain an appreciation of the size, diversity and scope of the various problems of the area. This overall perspective or vision develops as understanding grows.

Having the sites spaced out also ensures higher visibility to passersby than would be achieved if all demonstrations were carried out on one single area. If all solutions could be demonstrated on an all inclusive site, viewers would be apt to conclude that this site was a special case, an unusual problem area which required extensive remedial efforts. As the demonstrations will actually occur on many different parcels of land, the general and widespread nature of the problems should become highly apparent to all.

Naturally, erosion problems on the land are required to permit the demonstration of remedies. While it is true that a well managed field could be used to demonstrate the erosion control practices which are successfully controlling erosion, this approach has far less visual impact than the standard approach of healing a problem area. The later is particularly effective when an untreated adjacent problem area can be maintained as a control or contrast. Although highly desireable in theory, control conditions tend to be highly elusive in the field. It is recommended that a picture of the problem area before the implementation of the remedial technique be posted at the site in order to allow viewers to make a visual "before and after" comparison.

Cost was a consideration in as much as the magnitude of the cost might render certain applications less feasible for demonstration purposes.

Table 2 catalogues the 27 sites considered for demonstration of structural and non-structural remedial conservation techniques and indicates which technique or techniques are best suited to each site.

TABLE 2

List of Demonstration Sites Considered

POSSIBLE SITES	REMEDIAL TECHNIQUES	C	A-V
1 *	Rotational grazing, adequate fertilization	N	2
2 *	Active strip crop demonstration, field border	Y	2
3 *	Active shelterbelt demonstration.	Y	1
4 *	G.w.w., annual or grass strips.	Y/N	1
5 *	Active sweet clover demonstration.	Y	1
6	Grassed waterway.	N	3
7	Fence cattle out of waterway.	Y	5
8	" "	Y	5
9	Grassed waterway.	N	4
10	Grassed Waterway.	Y	1
11*	Grassed Waterway (Agri-Food project)	Y	1
12	" "	Y	1
13*	Field borders.	Y	1
14	S.belt, annual or grass strips, zero-till.	Y	2
15*	Active drop structures.	Y	1
16	Drop spillway.	N	4
17	Small multiple drop structures, retirement.	N	4
18	Fence cattle out of drain.	N	4
19*	Active zero-till demonstration.	Y	4
20*	Check dams, block planting, strip crop.	Y	2
21	Block planting, rotational grazing.	Y	4
22*	Active Rosedale farm.	Y	3
23	Block planting, forage crops.	Y/N	3
24	Fence cattle out of river.	Y	3
25	" "	Y	3
26	Fence off drain. Rotational grazing.	Y	1
27*	Grassed waterway, annual strips, strip and cover cropping.	N	3

In the table, existence of the contrast criteria (C) for each site is indicated; Y=yes and N=no. An "*" denotes recommended demonstration sites.

In order to effectively assess accessibility of the sites, an accessibility-visibility (A-V) index was developed. Listed in order of decreasing desireability, the A-V index is as follows, A1 . . . . visible from paved highway

A2 . . . . close to paved highway

A3 . . . . visible from all weather highway

A4 . . . . close to all weather gravel highway and

A5 . . . . not easily accessible.

"Close" was defined to mean less than two miles.

4.1 RECOMMENDED SITES

From the pool of 27 sites considered for demonstration purposes, 12 were deemed most suitable. Development of sites one, four, 13, 20 and 27 is recommended. These five sites, together with seven existing developed sites, make up a comprehensive package of conservation techniques listed in Table 3. Note that the sites have been renumbered for expediency.

TABLE 3

Recommended Sites

SITES TO BE DEVELOPED	
1	rotational grazing, adequate fertilization
4	flax strips, grassed waterway
8	field borders
10	contour crop, borders, check dams and
12	cover crop, contour crop.
DEVELOPED SITES TO BE INCORPORATED	
2	strip crop, field border
3	shelterbelt
5	sweet clover plowdown
7	grassed waterway
9	Reeve Drain drop-structures
6	zero till
11	forages, block planting, borders.

The general locations of the sites are depicted in figure one. Sites one to six lie in close proximity to one another while sites seven to 12 are farther apart. While it would be perfectly feasible to tour only the first six sites, this would provide an incomplete picture of the erosion problems and remedies characteristic to the study area, for these sites represent only the Lowland section of the study area. A detailed description of the recommended sites and remedies to be demonstrated on each follows. Note that site 14 has been included as a possible alternate for site four, and site 21 has been included as an alternate for site number one.

Site one is just over a mile away from Ste. Rose du Lac and from Highway No.5. Although the demonstration of rotational grazing would not be visible from the highway, the close proximity to the town and several other demonstration sites makes this site preferable over sites 21 or 25. At this site, a natural runway flows through a cattle pasture. (Plate 12) A small dugout was installed adjacent to the natural runway to serve as a retention pond for stock watering. (Plate 13)

A small depression next to the road culvert appears to be used by the cattle until it dries out in early summer. (Plate 14) North of the pasture is a fenced hayfield. Plate 15 shows cattle moving from the overgrazed pasture into the hayfield. The western half of this field is fertilized and hayed. The eastern half is not nearly as level, has the natural runway meandering through it, and upon inspection, did not appear to be either hayed or fertilized.

The fields could be cross fenced with one or two strands of electric wire. A second dugout should be constructed off the runway in the far field. Each dugout could serve several sub-fields. Rotating the cattle from paddock to paddock as described in section 3.9 would result in optimal grazing of the land and increased protection against erosion. If the farmer desired, it would still be possible to continue haying of the north western field. The farmer could also continue the current practice of allowing the cattle to graze the hayed field in the fall although this may no longer prove necessary.

Plate No. 12: Natural runway through cattle pasture.

Plate No. 13: Dugout adjacent to natural runway is used for cattle watering.

Plate No. 14: Overgrazed condition of cattle pasture evident in this close-up view taken near the natural runway.

Plate No. 15: Cattle moving from overgrazed pasture to fenced hayfield.

Soils on this site are predominately of the Glenhope association. Immediately around the waterway, the soil is of the Pinimuta association.

The Glenhope series is Gleyed Carbonated Rego Black soil with high organic content. It is thin, very strongly to extremely calcareous medium textured sediments overlying stoney, extremely calcareous glacial till. Surface texture is very fine sandy loam. Although these soils are imperfectly drained, with slow runoff and moderate permeability, these soils are mostly cleared and produce well. Topography is level to irregular and undulating and the soil is only slightly to moderately stony.

Native vegetation includes aspen, balsam poplar, meadow grasses, willow and sedges.

The Pinimuta series is a Carbonated Rego Humic Gleysol with a clay- loam texture. Thin, very strongly to extremely calcareous moderately fine textured sediments overly stoney, extremely calcareous medium textured glacial till. Drainage is poor, runoff is slow, and high groundwater levels can cause delayed seeding. Topography is depressional to level. Soils are slightly to moderately stoney. Native vegetation is aspen, balsam poplar, willow, and alder clumps in grass sedge meadows.

Site two is an active strip crop demonstration developed under Agri-Food. Although this site is not directly visible from the highway, it offers the multiple advantages of being close to several other demonstration sites, excellent accessibility on an all weather road, proximity to Ste. Rose du Lac, and finally, the cooperator is already receptive to being a conservation demonstrator.

The soils on this site are subject to wind erosion. Alternating strips of forage and grains are situated such that they provide protection from both wind and water erosion. The strips were planted perpendicular to the prevailing winds, and the grain strips were indented such that alfalfa borders the entire field to provide protection from spring flooding.

Site three, another current Agri-Food project, demonstrates field shelterbelts. Located along Hwy. No.5, this site offers both excellent visibility and accessibility. The soil is clay loam to very fine sandy loam and is vulnerable to wind erosion. As this site has already been developed and meets all selection criteria, it should be incorporated into the proposed set of demonstration sites. Developing a duplicate shelterbelt demonstration site for demonstration purposes is deemed unnecessary and inefficient.

Site four is located on Hwy. No.5, one mile south of site one. Across the highway, is a shelterbelt demonstration (site three) Soil is of the Glenhope and Pinimuta Associations, ranges in texture from clay loam to very fine sandy loam and is vulnerable to wind erosion. This site offers an excellent opportunity to demonstrate alternate wind control techniques such as annual strips, strips of crested wheatgrass, stubble shaping or strip cropping. Visibility and accessibility are excellent.

Demonstration of flax strips on summerfallow is recommended on this site as the efficacy and efficiency of the flax strips can be compared and contrasted to that of the shelterbelts on the field directly across the highway. Row orientation must be north-south to protect against the prevailing erosive westerly winds.

Clearly, flax strips on summerfallow can not be demonstrated on the same field year after year. Therefore, the flax strip demonstration site should be subdivided into two or three fields, depending upon the rotation desired, with flax strips applied on a rotational basis to each field as it is summerfallowed.

Soil drifting caused by wind erosion tends to be sporadic rather than general in occurance. Preventative measures such as shelterbelts, annual and flax strips should be adopted on a permanent basis on soils prone to wind erosion to ensure protection. This demonstration site should show that wind erosion need not be prohibitive, and is perfectly feasible for farmers who may not be able to establish more permanent wind erosion barriers such as shelterbelts on rented lands but can employ annual barriers.

In addition to demonstrating wind erosion control, water erosion control in the form of a grassed waterway can be demonstrated in the natural runway which empties into a dug-out. (Plate 16) Crop production in this depressed runway is minimal, probably due to excess moisture negatively impacting germination. If this area was seeded to grass, the soil would have adequate protection, and the land would be more productive. However, as the runway is short, haying would not be a viable operation unless field borders and or strip cropping were also implemented.

Site five is an active sweet-clover plowdown demonstration developed under Agri-Food. Like the flax strip site, demonstration of this technique must be on a rotational basis. This site is highly visible, is easily accessed, and should be incorporated into the set of demonstration sites, rather than duplicating this effort on another site.

Site six is an active Agri-Food zero-till demonstration farm. This site is visible and accessible from Hwy. 360.

Site seven is an active Agri-Food grassed waterway project accessible and visible from Hwy. No.5.

Site eight adjacent to Hwy. No.5, has good potential as a field border demonstration site.

Plate No. 16: Production along this natural runway is very poor. A grassed waterway would provide protection from erosion and replace the weeds with marketable hay.

Plate No. 17: Slumping along field border into the ditch.

Plate No. 18: Close-up of the same site as shown in previous plate.

Plates 17 and 18 clearly show slumping along the field edge and the resultant siltation in the ditch. A buffer or field border zone of forages would stabilize the edge of the field, act as a filter trap for sediments carried off the field by runoff, and help prevent the formation of gullies on the field edge. In order to ensure contrast, part of the field should continue to be cropped without field borders.

The soil on the northern portion of the site is Lakeland loam association and is very fine sandy loam to silty loam in texture. The dominant soil type is Calcareous Black-Meadow. The parent materials are thin, moderately alkaline, weakly calcareous, medium to coarse textured lacustrine deposits. A till substrate phase is recognized where the underlying boulder till occurs within 30 inches of the surface. Surface runoff is slow, internal drainage is moderate to slow and surface drainage is imperfect to poor. Topography is nearly level. The soil is stonefree to stoney, depending on the thickness of the soil overlying the till. Native vegetation is meadow and meadow prairie grasses, aspen, balsam poplar, reeds and sedges.

Soil on the southern portion of this site is of the McCreary association and is very fine sandy loam to clay loam developed on medium textured thin lacustrine deposits over sandy till. The dominant soil is Black Meadow. Topography is smooth and level. Surface and internal drainage is slow. Periodic waterlogging of the subsoil occurs and in wet years, may retard crops. In years of average to low precipitation, these soils are suited to grain production. These soils have fair to good natural fertility, a fair to good reserve of organic matter and a fair moisture retention capacity. Prior to clearing, native vegetation was aspen, balsam poplar and willow on imperfectly drained areas and balsam poplar, willow, reeds and sedges on poorly drained areas.

Site 14, although not immediately visible from the highway, is only one half mile to the east. The fine sandy loam to loamy fine sand soil is of the McCreary and Almissippi associations and prone to drifting. An alternate to site four, this site is denoted by 4A on the map.

The Almissippi association was developed on coarse textured lacustrine deposits underlain by a finer texture substrate. Surface runoff is slow and internal drainage is impeded by the substrate. On this site, the soil is loamy fine sand with a till substrate. These soils have low to moderate natural fertility, low moisture retention capacity, a limited supply of organic matter and an excess of free lime carbonate. The loamy fine sand phase is very susceptible to wind erosion. Crop rotations which include two years of grass or legumes in a four or five year rotation are recommended as are shelterbelts and erosion control practices such as the use of trash cover. The poorly drained sites are best suited to pasture or hay. Remedial techniques to be demonstrated on this site are the same as for site four; therefore this site can be considered an alternate to site four. A second option would be to demonstrate different techniques on each site. In this case, wheatgrass strips or stubble shaping could be demonstrated on this site.

Site nine is in the reach controlled by drop structures along the Reeve Drain. Plate 19 is a closeup of one of the drop structures. The structures are composed of vertical steel barriers and field stone underlaid with a geotextile to prevent undermining. As these structures are right along Hwy. No.5, and as similar drop structures and weirs will likely be required in other drains, the effectiveness of this technique should be established and promoted. At this site, the integral link between agricultural lands, erosion, and drainage should be defined. These are related entities, with each having the ability to negatively impact on each other. The optimum silt retention site is the farmer's field. In order to ensure that the soil does not end up in waterways, farmers must adopt conservation techniques. In some specific instances, drop structures may even be employed on farm fields.

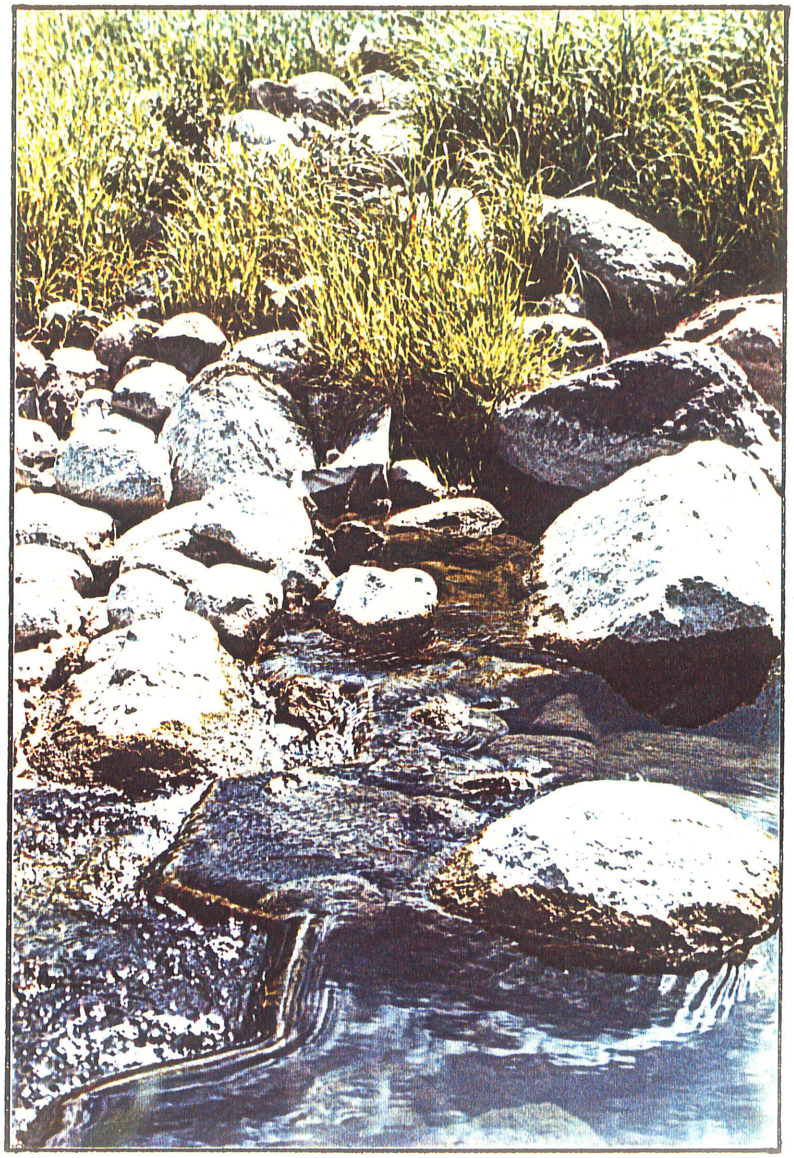

Plate No. 19: Drop structure on the Reeve Drain.

The soils of site ten are of the Wapus and Clarkesville-Wapus associations. Wapus soils are of the Grey Wooded Association. Parent materials are medium textured, shalely till deposits over shale rock low in lime carbonate content. They have low natural fertility and little to no organic matter reserve. They have good drainage because the shale till is highly permeable. They are susceptible to both wind and water erosion and are best suited to use for livestock. Smoother areas can be cultivated but should be returned to grass legumes three years out of six. These soils are well drained and tend to pulverize easily. They are moderately stony to very stony on steeper hillsides. Deep gullies and ravines are common. Native vegetation includes aspen, oak, hazel, hawthorn and wild rose.

Site ten is mostly under cultivation and is showing severe erosion in the form of large gullies. (Plates 20-23) Although these gullies could be plowed in and replaced by grassed waterways, demonstration of an alternate technique, that is, stabilization with inexpensive temporary structures and semi-permanent vegetation is recommended. Block planting trees on the rough unproductive depressed areas would slow runoff and help stabilize the soil. Contour cropping would divide the slope into shorter segments and reduce the velocity and volume of runoff.

Plate No. 20: Site ten. Note weeds, rolling topography.

Plate No. 21: Rill erosion on field shown in previous plate.

Plate No. 22: Rills grow into small gullies.

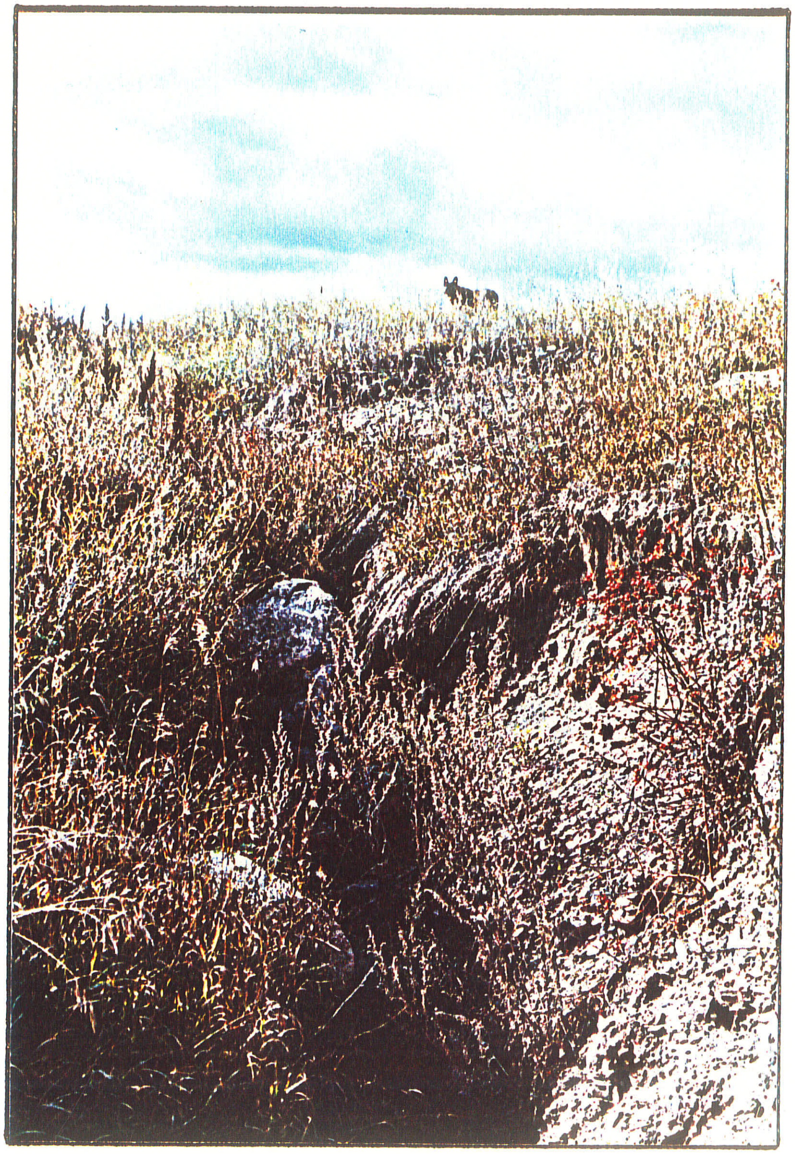

Plate No. 23: Small gullies grow into large gullies.

As the field is fenced, and the farmer currently allows a few cattle to take fall grazing from the field, contour cropping should prove to be a viable solution. A field border should be maintained at the bottom of the field where it borders the stream.

Site 21 is immediately west of site 11. On this site, alternate for site one and denoted by 1A on the map, soils are also of the Wapus and Clarkesville Wapus associations. Cattle have overgrazed the fence line and huge active gullies erode the soil. (Plates 24 and 25) In order to stabilize these gullies, it would be necessary to fence out the cattle to allow vegetation to recover. Block planting of hawthorn, a native shrub, should stabilize the soil and discourage future penetration by the cattle. This site would also benefit by subdividing the pasture in such a manner that cattle traffic and grazing would be more evenly spread across the land. However, the pasture is very large and alternate water sources would have to be created. Even if no other action is taken, care should be taken to ensure that further overgrazing does not occur.

Rather than attempting to develop this site into a rotational grazing remedial demonstration site, it should be left as is to provide excellent contrast to site 11.

Plate No. 24: An overgrazed, gullied pasture.

Plate No. 25: Close-up of gullying along the fence, same pasture as above.

Site 11 is the Rosedale Demonstration farm. Plate 26 shows an odd-looking utility pole located immediately north of Rosedale Farm. Although it might be assumed that erosion caused the pole to become "stranded" it is more likely that the soil was first mechanically depleted; wind and water then scattered the exposed material more generally. Speculation aside, the pole serves as a certain indication as to the highly erodible, shaley nature of these soils. Rosedale farm was once like a wasteland of shale. Good management practices (block planting, shelterbelts, forages, trash management) have stabilized the soil. Although these practices are effectively demonstrated on the farm, one modification should be made. Field borders should also be incorporated along waterways to provide protection from possible scouring under flood conditions. This site is visible and accessible from Hwy. No.265.

The south-east quarter of the section is privately owned, and in its badly eroded and gullied state, serves as an excellent contrast to the Rosedale solution, for this is exactly how the Rosedale farm fields looked prior to the adoption of remedial measures. (Plate 27) In order to preserve this useful contrast, no effort should be made to apply the same solutions to this quarter of land. It may even be adviseable for the Whitemud Watershed Conservation District to purchase the quarter such that it can be maintained as a contrast.

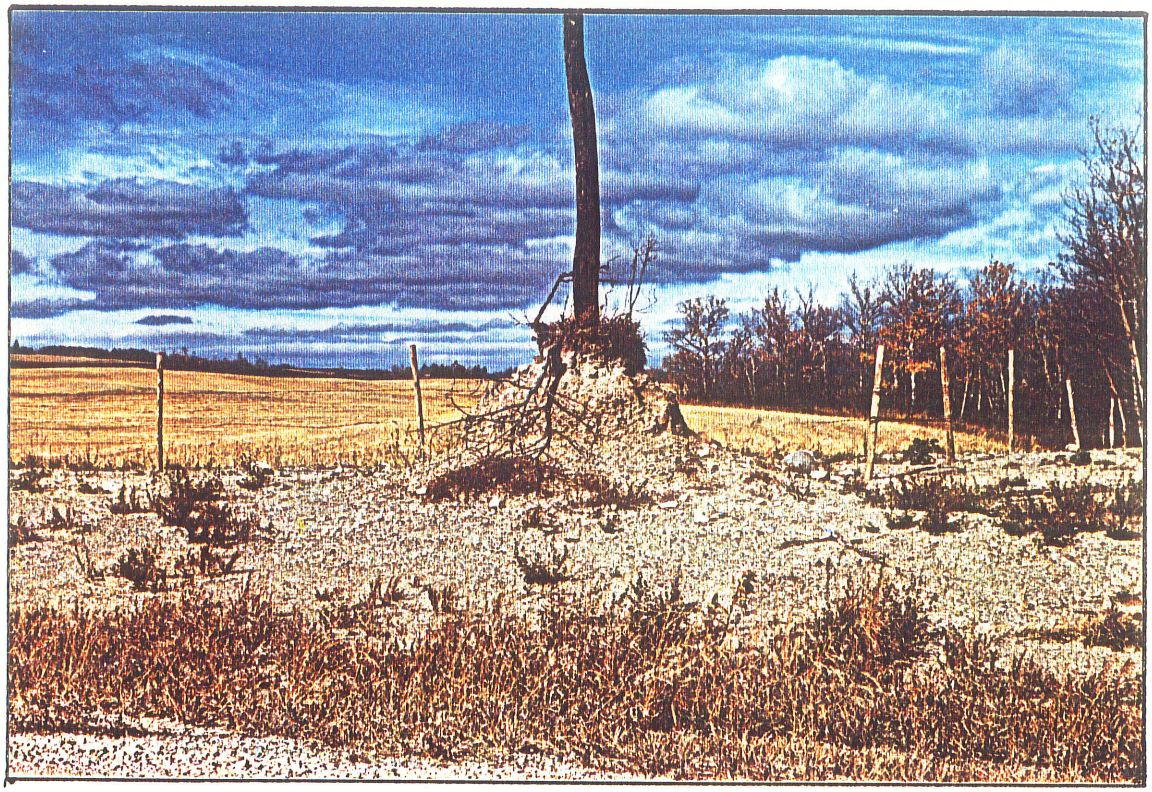

Plate No. 26: Erosion around utility pole north of Rosedale Farm.

Plate No. 27: Block planting, the Rosedale Solution.

Site 12 is directly across from the Rosedale Demonstration farm and therefore is ideal for demonstrating techniques applicable to this soil but not used on the Rosedale farm. The soil is of the Clarkesville Wapus association and is susceptible to both wind and water erosion. Ideally, this soil should be maintained in permanent forage. However farmers continue to attempt to sow cereal crops. This practice is workable on smoother areas provided that the land is returned to grasses or legumes three years out of six; however, on steep slopes, it is highly questionable. Site 27 has steep rolling topography and should not be summerfallowed. Instead, cover crops and green manure plowdowns should be utilized. Rather than plowing and sowing the whole field in monoculture, contour cropping should be utilized. The strips could be alternated every two or three years so the positive residual erosion control benefits of the grasses would be maintained over the whole field. Located along Hwy. 265, access to this site is excellent, as is visibility.

4.2 STRATEGIC PLAN

Signage will be critical to the success of the demonstration sites. Large signs should be strategically located to call attention to the sites. Plates 28 and 29 demonstrate the importance of signage.

Plate No. 28: Field gullying not visible from the road.

Plate No. 29: Same site as above, viewed from another angle.

Plate 28, taken from the road, illustrates how erosion damage may appear to a casual observer. This appears to be only a weed patch. Closer inspection, as in plate 29, reveals the erosion. Signs must be employed to make the demonstration sites easily identifiable and highly visible.

It is also recommended that secondary small signs give additional information about each site and provide a reference for interested parties to contact. These secondary signs would serve a dual purpose. They would be educational and would also serve as a incentive or reward to those whose curiosity prompts a closer investigation of the site. In most cases, the signs can be located on the sites and be visible from the highway. In a few cases directional signs will also be required. It is further recommended that an explanatory leaflet containing a map of the sites be developed and made available both at the demonstration sites and at Conservation District Board offices. The leaflet would serve a dual purpose as a guide to the sites and as an educational tool in itself.

In terms of timing, the sites which have already been developed under Agri-Food should be brought online first as the agreements are generally only for five years, and as data on costs are available immediately. In some cases, it may be deemed desirable to extend the agreements on specific sites in order to ensure a full complement of remedial technique demonstrations.

Priority for development of new demonstration sites is suggested as follows, listed in decreasing priority,

Site # 4	Flax strips, grassed waterway
# 8	Field borders
# 12	Contour crop, cover crop
# 1	Rotational grazing, adequate fertilization and
# 10	Contour crop, check dams, field borders.

Priority was based upon developing maximum visibility demonstrations of non-previously demonstrated techniques first.

Site four should be developed to demonstrate perennial grass strips or annual strips as strip-cropping and zero-till techniques are already being demonstrated in the area. This site will be very inexpensive to develop as flax strips cost only about $2.00 per acre to install. It is felt that flax strips would, in general, be prefered to perennial grass strips because the flax, being impermanent, is easy to work with and causes little or no inconvenience to the operator. As this site is highly visible and has excellent contrast to the alternate solution (shelterbelts), high priority should be given to its development.

Similarly, site eight is highly visible and will be inexpensive to develop as a field border site. Forage crop incentives which exist under Agri-Food could perhaps even be targeted towards border strips, along drains, thus making forages an even more effective erosion control technique.

Site 12, immediately opposite the Rosedale farm, is an excellent location for demonstrating contour cropping. On Rosedale farm, field borders should be demonstrated along the fields bordering the runway.

Site one will be slightly more costly to develop as it will require the installation of an alternate water source for the cattle, and cross fencing. However, both of these requirements are far from being prohibitively expensive. Although this site is not visible from the main highway, it is very close to several other demonstration sites.

Site ten is the least visible of all the sites recommended for development and so is last on the priority list. This site should be developed as it will permit the demonstration of multiple remedial techniques on one site with highly visual comparison of gullied land directly across the road.

4.3 OTHER CONSIDERATIONS

In general, landowner cooperation can be obtained through the use of a disturbance allowance and by involving the farmer in the design and development of the demonstrations. This provides compensation for the demonstrator's time when called upon to discuss the merits of the technique implemented on the demonstrator's land, and for any inconvenience caused by tours going through the site. Should a landowner still remain unconvinced, the Conservation Districts managers and boards must consider alternate sites. By evaluating possible sites in terms of the selection criteria, development can be targeted to sites which will ensure greatest exposure and utility.

Chapter V

SUMMARY, CONCLUSIONS, RECOMMENDATIONS

5.1 SUMMARY

Agricultural related soil erosion is a serious problem of national concern. Many techniques, structural and non-structural, have been developed for reducing and controlling erosion and are documented in an expansive body of literature. However, representation of the techniques in terms of on farm implementation is poor. It is believed that demonstration of the techniques would promote adoption.

This study was initiated in response to the Conservation Districts Authority, Manitoba Department of Natural Resources, interest in the identification and assessment of soil and water conservation demonstration sites in the Whitemud and Turtle River Watershed Conservation Districts.

Following rationalization of the demonstration strategy, an examination of erosion in the study area detailed processes and consequences of erosion and factors contributing to erosion. A brief historical overview contributed perspective and furthered understanding of current concerns and challenges.

Criteria for ranking desirability of demonstration sites and for determining the applicability of remedial techniques to the study area were developed. Sites and techniques were identified and assessed according to these criteria. Recommendations for the development of 12 sites representing 14 remedial techniques were made.

A strategic plan covering technical aspects of priority of development, signage, and promotional material was suggested. Finally, areas for further study were indicated.

5.2 CONCLUSIONS

Inappropriate land clearing, excessive use of tillage and summerfallow, overgrazing, and the cropping of very large unprotected fields open to uninterrupted wind and water erosion were identified as the most prevalent land use-management problems contributing to loss of soil and sedimentation in drainage systems in the study area.

Although there is a large body of literature regarding erosion control techniques, implementation of the techniques in the study area is poor. Failure to adopt the techniques may be due to a variety of reasons including uncertainty as to the expected viabilty of the techniques under local conditions. Demonstration of remedial erosion control techniques in the study area is desireable in order to establish viability and promote adoption.

14 remedial techniques were selected for demonstration on the basis of four criteria: record of past success; ease of implementation; suitability of soil, topography and climate; and flexibility of the solution. Magnitude of the cost of the solution was considered as one aspect of ease of implementation.

Six site selection criteria were developed: accessibility; visibility; site characteristics in terms of erosion problems or potential; magnitude of development cost; contrast; and grouping.

In total, 27 soil and water conservation demonstration sites were identified and assessed in terms of the selection criteria. Five sites were recommended for development as structural and non-structural remedial technique demonstration sites. These sites show high potential in terms of the selection criteria. The incorporation of seven additional sites developed under the Agri-Food program will complement the above sites.

Attempting to demonstrate all or the majority of remedial techniqiues on one given site was determined to be neither feasible nor highly desireable. Instead, a series of sites highly accessible to foot access and by bus more accurately and effectively presents the techniques.

It is important to note that site selection was based on the existence of two very different audiences, namely, tour groups and individual passers-by. This dual nature of the audience influenced the development of the selection criteria and ultimately, the final site recommendations.

Remedial technique and site selection criteria developed for this study could be used for planning and developing demonstration programs in other conservation districts. Planners must have a sense as to how much demonstration is desireable. It is suggested that if all techniques believed applicable to the area are represented on sites fitting the selection criteria, then further duplication of remedial technique demonstrations will be associated with decreasing marginal value.

5.3 RECOMMENDATIONS

I recommend that the Whitemud and Turtle River Watershed Conservation District Boards begin development of the following soil and water conservation demonstration sites, priorized as follows, within the next 12 months,

Site #4 (flax strips, grassed waterway)
#8 (field borders)
#12 (cover crop, contour crop)
#1 (rotational grazing, adequate fertilization) and
#10 (contour crop, borders, check dams).

Site 14 is suggested as an alternate for site four and site 21 is suggested as an alternate to site one.

I further recommend that the following sites, developed under Agri-Food, be incorporated into the demonstration sites planned and be continued after Agri-Food expires,

Site #2 (strip crop, field border)
#3 (shelterbelt)
#5 (sweet clover plowdown)
#7 (grassed waterway)
#9 (Reeve Drain drop-structures)
#6 (Zero-Till) and
#11 (Rosedale Farm).

In conjunction with technical expertise, the Conservation District Board managers should develop a monitoring program to evaluate the effectiveness of the remedial works over a five to ten year period. Careful analysis of the technical and economic viability of each technique should provide valuable information and boost the credibility of the techniques and the demonstrations.

I recommend that the sites be developed and designed so as to facilitate both group and self-interpretive use. Therefore, in addition to large signs which identify and designate the site, secondary signs should provide detailed information regarding the immediate site, indicate that other demonstration sites exist, and provide a referal such that interested parties may obtain further information.

In order to further enhance the general utility of the demonstration sites, I recommend the development of an interpretive leaflet. The leaflet should include a map of the demonstration sites and a brief yet concise description of the problems and solutions. The leaflet could serve a dual purpose as a guide to the sites and as an educational tool on its own. The leaflet could be distributed in many places including schools, the Conservation Districts Offices, the tourist information centre in Riding Mountain and would prove highly valuable to interpreters on guided demonstration tours.

Finally, I recommend that with regard to implementation, the Conservation district Boards consider possible conflicts, motivation to tour, and specific tour logistics.

It is paramount that any project undertaken on any site must not conflict with any other concurrent programs or project.

In implementing tours of the sites, the audience of each tour must be considered and the information level must be geared to each group. Local group tours such as school groups will require a one day or perhaps even a half-day version of the tour, whereas visiting groups are more likely to require the addition of overnight and social elements to the tour package in order to ensure the practicality and attractiveness of the tour experience. The amount of time required for each tour will depend largely upon the nature of the tour group and the degree of detail required. As the full tour encompasses just under 100 miles round trip and consists of 12 stops, it is conceiveable to do the whole tour in one day. For persons or groups with specific interests, a partial or sub-tour may be most appropriate. All of the above must be at the discretion of the persons implementing the program and the tours.

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