Salinity Mapping for Resource Management

within the County of Warner, Alberta

J. Kwiatkowski
L.C. Marciak
D. Wentz
C.R. King

Conservation and Development Branch
Alberta Agriculture, Food and Rural Development

March 1996

Canada

Agriculture - Building a Healthy Environment

Alberta

Abstract

This report presents a methodology to map salinity at a municipal scale and applies this procedure to the County of Warner, a municipality in southern Alberta. The methodology was developed for the County of Vulcan (Kwiatkowski et al. 1994) and is being applied to other Alberta municipalities which have identified soil salinity as a concern.

Soil salinity is a major land degradation issue in the County of Warner. The information on salinity location, extent, type and control measures presented in this report will help County planners to target salinity control and resource management programs.

The methodology has four steps:

1. The location and extent of saline areas are mapped based on existing information including aerial photographs, maps, satellite imagery, and information from local personnel and field inspections.

2. Saline areas are classified on the basis of the mechanism causing salinity. The mechanism is important because it determines which control measures are appropriate. Eight salinity types are recognized within Alberta but only seven are found in the County of Warner. These are: contact/slope change salinity, outcrop salinity, artesian salinity, depression bottom salinity, coulee bottom salinity, irrigation canal seepage salinity and natural/irrigation salinity. There is no evidence that slough ring salinity occurs in the County.

3. Cost-effective, practical control measures are identified for each salinity type.

4. Colour-coded maps at 1:100 000 and 1:200 000 are prepared showing salinity location, extent and type. Also, a digital data base is compiled in ArcInfo format. This data base can be easily managed and transformed into ArcView format.

Analysis of the mapping data shows that 2 223 saline areas occur in the County and occupy a total of 22 547 ha (55 691 ac). This represents 4.9% of the County's total area. Only saline areas visible on the soil surface are mapped. This provides information needed by County staff to target sites for further investigation. The lands surrounding visible saline seeps may have weakly saline subsurface soils which can reduce yields of sensitive crops. Thus salinity control practices may benefit crop yields over a much broader area than just the visible seep.

Coulee bottom salinity occupies the largest proportion of the County's total saline area (34.5%), followed by contact/slope change salinity (32.7%), depression bottom salinity (15.8%), outcrop salinity (7.5%), natural/irrigation salinity (6.2%), irrigation canal seepage salinity (2.0%), and artesian salinity (1.3%). There are many small contact/slope change seeps (1 297), and fewer but larger coulee bottom and depression bottom seeps.

Acknowledgements

This salinity mapping and analysis project for the County of Warner was managed by the Conservation and Development Branch of Alberta Agriculture, Food and Rural Development. Funding provided by the Conservation and Development Branch, the Canada-Alberta Environmentally Sustainable Agriculture (CAESA) Agreement and the County of Warner is greatly appreciated.

The authors acknowledge the contributions made by: James Pittman and Eugene Kurinka, Conservation and Development Branch, Alberta Agriculture, Food and Development, for field work, aerial photograph interpretation and water sampling in the County; and Gerald Stark, Longin Pawlowski and Jason Miller, Conservation and Development Branch, Alberta Agriculture, Food and Rural Development, for preparing diagrams and logos, and plotting the salinity map. Comments on the salinity data from Bob Forest, Agricultural Fieldman, County of Warner, are greatly appreciated.

Contents

Tables

Figures

1.0 Introduction

1.1 Goal and Objectives

The goal of this project is to present information on salinity location, extent and type in the County of Warner. Soil degradation is a key issue in conservation planning, and salinity is one of the most visible soil degradation problems affecting the County according to its Canada-Alberta Environmentally Sustainable Agriculture (CAESA) Agreement action plan. Therefore this mapping project aims to better define the salinity problem for the County of Warner.

The project's goal is achieved through the following objectives:

1. To derive and integrate existing salinity information for agricultural land in the County of Warner.
2. To determine the salinity type based on the salinity mechanism.
3. To recommend appropriate control methods for each type of salinity.
4. To compile a map depicting salinity location, extent and type.

The project differs from most salinity surveys by specifying the type, exact locations and control measures. This information can be used in municipal and farm conservation planning.

1.2 Methodology

The methodology for mapping salinity was developed for the County of Vulcan by Kwiatkowski et al. (1994). It is being applied to other Alberta municipalities where soil salinity is a concern. The process of salinity mapping consists of four stages:

1. Scan aerial photographs and digitize saline areas on the municipal base map.
2. Determine the types of salinity occurring in the municipality, based on hydrogeology, surface water flow, geology, topography, irrigation and soils. Determine appropriate cost-effective, practical control measures based on salinity types.
3. Field check the salinity data and submit the draft salinity information to a technical team consisting of a project manager, hydrogeologist, salinity specialist, and the local Agricultural Fieldman and District Specialist for review.
4. Prepare a colour-coded 1:100 000 map, showing salinity location, extent and type, and a report with a 1:200 000 map. Also, a digital data base is compiled in ArcInfo format. This data base can be easily managed and transformed into ArcView format.

1.3 Information Sources

A variety of maps, aerial photographs and other information sources were used for this project. Information on climate, soils, parent material and geology is from the following soil survey and hydrogeology reports:

- Soil Survey of the County of Warner, Alberta, Report No. 46 (Kjearsgaard et al. 1986)
- Hydrogeology of the Lethbridge-Fernie area, Alberta, Report 74-1 (Tokarsky 1973).
- Hydrogeology of the Foremost area, Alberta, Report 74-4 (Borneuf 1976).

The Saline/Waterlogged Lands Map for the Raymond Irrigation District (1990) provided information on salinity in two categories: moderately and severely affected areas. The data were collected in 1982, 1985 and 1987 and include sloughs, stock-watering ponds and small, temporary water bodies. The main causes of salinization and waterlogging within irrigation districts are seepage from canals, poor water management, poor irrigation practices and inadequate drainage.

Aerial photographs from 1991 (scale of 1:30 000) were used to help determine the location, extent and type of salinity on a section-by-section basis. As well, satellite imagery was used, particularly to identify irrigated lands.

To ensure the accuracy of the salinity map, more than two-thirds of the County was field checked. Local personnel were also consulted to verify the findings.

2.0 Classification and Management of Saline Seeps

2.1 Transportation of Salts

The dominant salts in the County of Warner consist of sodium and magnesium sulphates. Analyses of groundwater, saline soils and parent material suggest that the primary source of salts is bedrock, and the secondary source is glacial till (Greenlee et al. 1968). Soils developed on the Bearpaw bedrock formation contain high salt concentrations.

Saline seeps form when saline groundwater rises to the ground surface. Contact and slope change seeps (described in Section 2.2.1) develop when water in a recharge area percolates down through the soil profile beyond the root zone and dissolves soluble salts (Figure 1). The water moves laterally to a lower position in the landscape and through capillarity rises to the surface, resulting in a saline seep. High evapotranspiration rates cause the capillary rise and the deposition of salts on the soil surface.

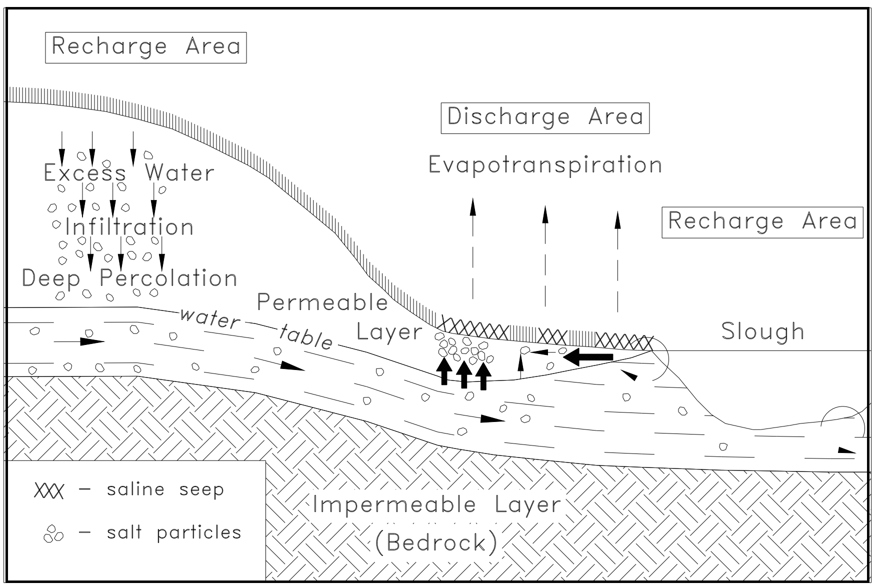


Figure 1. Generalized saline seep mechanisms

Three different types of flow may be recognized within a groundwater basin: local, intermediate and regional. A local flow system occupies a relatively small area, with the recharge area at a higher elevation than the discharge area. An intermediate system consists of several interconnected local systems. A regional system has its recharge area at the water divide of a basin while the discharge area lies at the bottom of the basin. In the County of Warner, most of the groundwater flow systems are local, and the recharge areas are within a few hundred metres of their discharge area. Intermediate flow systems extend beyond 1 km (0.6 mi) of their recharge area. Regional flow systems extend over several kilometres.

Groundwater movement is influenced by topography as follows:

- In large, flat areas, groundwater movement is minimal or even impeded.
- In areas with well-defined local relief (e.g. hummocky or rolling landscapes), local systems are prevalent.
- In areas with one large slope, regional systems are prevalent.
- In large valleys, regional systems predominate.

2.2 Salinity Types

Eight salinity types have been identified in Alberta (Kwiatkowski et al. 1994). They can be grouped into six dryland and two irrigation types. Based on hydrogeology, surface water flow, geology, topography, irrigation and soils, only seven of the eight types occur in the County of Warner.

2.2.1 Dryland Salinity Types

1. Contact/Slope Change Salinity
Contact salinity and slope change salinity are grouped together because they cannot be differentiated on aerial photographs and because the same methods are used to control both types (see Section 2.3). The two types are described as follows:

a. **Contact salinity** occurs where a permeable water-bearing surface layer thins out above a less permeable layer (such as a fine-textured layer). This forces the groundwater flow closer to the surface (Figure 2). Contact salinity is the second most common type of salinity in the County, occupying more than 32% of the total saline area. It dominates in sandy, gently rolling areas. Contact/slope change salinity dominates in two main areas: north of Kipp Coulee and the town of New Dayton (Twp. 6 Rge. 17, 18, 19, 20); and a broad band running from south of the Milk River Ridge Reservoir (Twp. 4, 5 Rge. 20) to near the town of Milk River. Contact salinity also occurs at the shoulders of coulees and as small seeps scattered throughout the County.

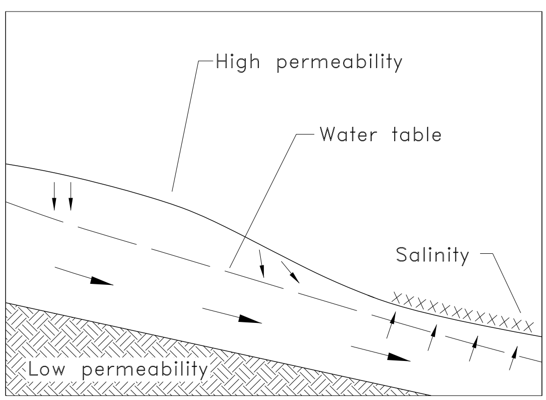


Figure 2. Contact salinity

b. **Slope change salinity** occurs where the slope decreases. This decrease results in a slowing of the groundwater flow and a shallower water table (Figure 3). This type of seep expands upslope. It occurs in association with contact salinity and is found throughout the County as a minor salinity type.

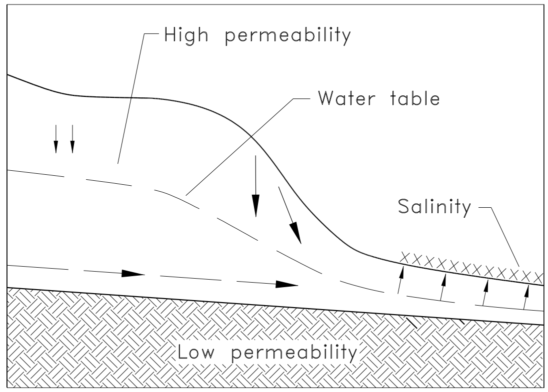


Figure 3. Slope change salinity

2. Outcrop Salinity

Outcrop salinity occurs where a permeable, water-bearing layer, such as a coal seam or fractured bedrock layer, outcrops at or near the surface (Figure 4). Outcrop salinity occurs along a slope at similar elevations. In the County of Warner, this salinity type occupies 7.5% of the total saline land. It occurs mainly in conjunction with contact/slope change salinity and, like contact salinity, occurs as a broad band running from south of the Milk River Ridge Reservoir (Twp. 4, 5 Rge. 20) to near the town of Milk River. It creates a ridge of contact salinity in this area. Outcrop salinity is also found in the eastern portion of the County (Twp. 4 Rge. 16 and Twp. 11, 12 Rge. 3).

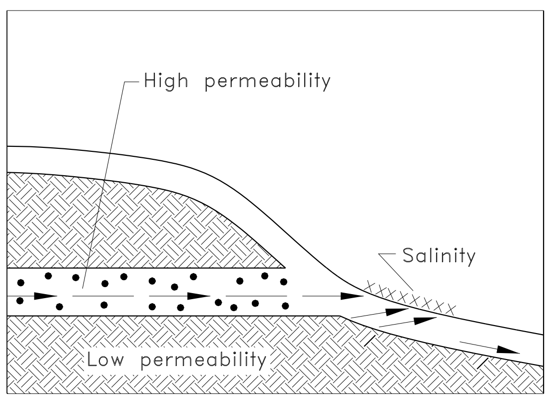


Figure 4. Outcrop salinity

3. Artesian Salinity

Artesian salinity occurs where water from a pressurized aquifer rises to or near the ground surface (Figure 5). It is usually associated with intermediate or regional groundwater flow systems. If the pressure is high enough, the water flows to the surface and produces a flowing well, spring or soap hole. Artesian seeps can be identified from the presence of these flow features and from hydrogeological maps. This type occupies only 1.3% of the total saline area in the County. It is scattered throughout the southern half of the County (Twp. 1 to 4 Rge. 11 to 20).

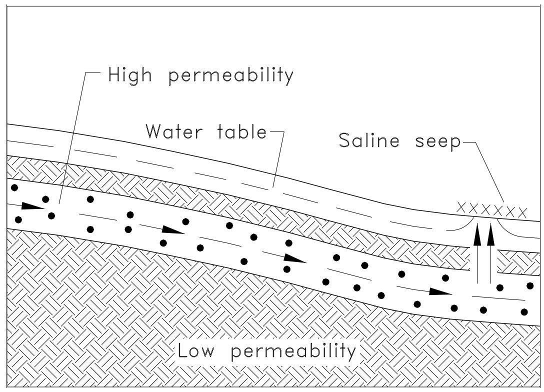


Figure 5. Artesian salinity

4. Depression Bottom Salinity

This salinity type occurs in low lying areas. Surface water is trapped temporarily in these low areas until the water drains off and/or infiltrates the soil. Some water in the soil flows upslope through the upper soil in an unsaturated state and then surfaces to evaporate and deposit salt at the edge of the ponded area (Figure 6). As well, once the surface water has disappeared, groundwater from the water table rises by capillary action to the surface in and around the previously ponded area. Depression bottom seeps are well defined with distinct, rounded edges. This salinity type occupies 15.8% of the total saline land in the County. It has the same mechanism as coulee bottom salinity but on a smaller scale. Coulee bottom and depression bottom salinity combined occupy 50% of the total saline area in the County. The main areas of depression bottom salinity are: the southwest corner of the County (Twp. 1 Rge. 18 and Twp. 3 Rge. 19); south of the town of Milk River (Twp. 2 Rge. 16, 17); and north of Warner (Twp. 5 Rge. 17). Depression bottom seeps occur in several landscapes with poor drainage, particularly in gently rolling areas. They are also associated with Solonetzic soils which occur throughout the County.

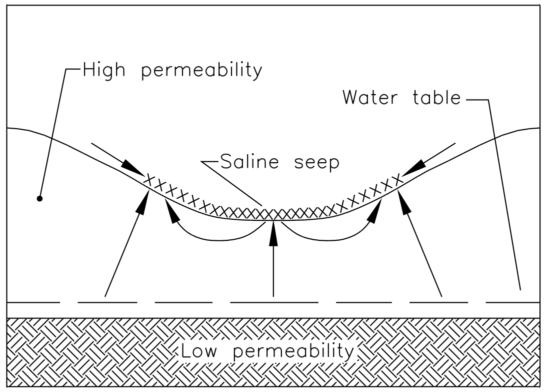


Figure 6. Depression bottom salinity

5. Coulee Bottom Salinity
Coulee bottom salinity forms in the bottoms of coulees and watercourses by the same mechanism as depression bottom salinity but on a larger scale. In the County of Warner, this is the most common salinity type, occupying 34.5% of the total saline land. It occurs in large coulees including Etzikom Coulee, Kipp Coulee and Middle Coulee, and around Verdigris Lake and its tributaries, and the Milk River and its tributaries. This salinity type typically develops over long periods of time so most of the lands affected by coulee bottom salinity have never been in agricultural production.

6. Slough Ring Salinity
This type of salinity occurs as a ring of salt immediately adjacent to a permanent water body (Figure 7). Water infiltrates from the water body into the permeable upper soil layer and flows upslope through this layer as shallow groundwater in an unsaturated state. The water may also flow downward, raising the water table. Water from the unsaturated flow and water raised from the water table by capillary action emerges at the surface where it evaporates, leaving salts at the edge of the slough. This salinity type does not occur in the County. (It is described here in case it develops in the future.)

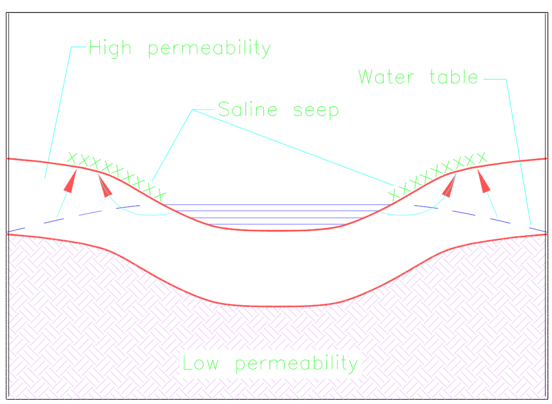


Figure 7. Slough ring salinity

2.2.2 Irrigation Salinity Types

1. Canal Seepage Salinity

This type of salinity is dominant in irrigated areas where leakage from canals contributes to seeps (Figure 8). Because many canals are located along a topographic break, canal seepage often aggravates natural salinity. This salinity type occupies only 2.0% of the County's saline land. It occurs in the Raymond Irrigation District in the area around Raymond and Sterling (Twp. 5, 6 Rge. 19, 20, 21).

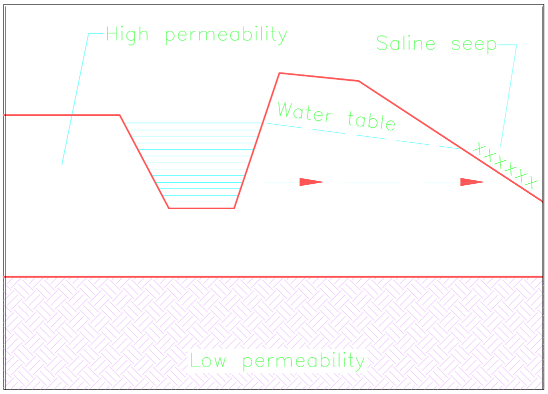


Figure 8. Canal seepage salinity

2. Natural/Irrigation Salinity

These seeps result from one or more of: natural seepage, canal seepage and excess irrigation. All seeps located on irrigated land and some distance from canals and supply ditches are given this classification. This salinity type occupies 6.2% of the total saline area in the County. It is associated with irrigated lands and irrigation canal seepage salinity. It occurs between Raymond and Sterling (Twp. 6 Rge. 19, 20, 21).

2.3 Salinity Controls

Salinity is a complex problem caused by climatic, hydrogeological and agricultural factors. The opportunities for moderating the effects of climate and hydrogeological processes are limited and/or expensive. Therefore appropriate agricultural practices are used to help prevent or control saline seeps. The emphasis in this report is on cost-effective, agronomic measures. Specifically, cropping systems that intercept soil water in a recharge area before the water moves below the crop root zone are recommended.

Recommended control methods for the types of salinity found in the County of Warner are summarized in Table 1 and described in more detail in Sections 2.3.1 and 2.3.2.

Table 1. Salinity types and control methods

Salinity type	Control
Contact/slope change	- salt-tolerant grasses in saline area and alfalfa in upslope recharge area (recharge area may be about three times area of seep)
Outcrop	- salt-tolerant grasses in saline area
Artesian	- salt-tolerant grasses in saline area - where applicable, install relief wells connected to suitable outlet
Depression bottom	- salt-tolerant grasses in saline area and along edge of depression in band 50 to 150 m (165 to 490 ft) wide - appropriate structural controls
Coulee bottom	- salt-tolerant grasses in saline area - appropriate structural controls
Slough ring	- deep-rooted and salt-tolerant grasses in a 20 to 60 m (65 to 195 ft) band around slough - appropriate structural controls
Irrigation canal seepage	- structural controls to prevent canal seepage (canal lining, cut-off curtains) and/or subsurface drainage of affected area
Natural/irrigation	- appropriate structural controls for irrigation-related salinity - salt-tolerant grasses for natural salinity

2.3.1 Biological Controls

Salt-Tolerant Crops
Saline areas should not be left bare for extended periods. Very saline soils should be seeded to a mixture of salt-tolerant forage crops (Table 2). Saline areas are often wet, so crops may need to be tolerant of both salt and excess moisture. When electrical conductivity measurements exceed 8 to 10 dS/m, salt-tolerant seed mixtures usually give the best results.

Establishing deep-rooted vegetation on a saline seep can be very difficult. Salt-tolerant grasses can be seeded in the fall when the saline seeps are dry and accessible. Seeding rates for saline seeps, especially when planted in the fall, should be double those for non-saline areas.

Table 2. Forage crops for saline soils and flooded areas (Henry et al. 1987)

Salinity rating (EC)*	Forage mix	Seeding rate for hay or pasture (kg/ha)
	a. Soils with little or no spring flooding (up to 2 weeks)	
Slight to moderate (2-6 dS/m)	bromegrass + Russian wild ryegrass + alfalfa (Rambler)	4+4+4
	bromegrass + slender wheatgrass + alfalfa (Rambler)	4+4+4
	Russian wild ryegrass + alfalfa	6+3
	altai wild ryegrass + alfalfa	10+3
	crested wheatgrass + alfalfa	7+3
	altai wild ryegrass	11
	slender wheatgrass + sweet clover (short-term stands and not over 1 week of flooding)	8+6
Severe (6-10 dS/m)	bromegrass + Russian wild ryegrass + slender wheatgrass	4+4+4
	altai wild ryegrass + alfalfa	10+3
	altai wild ryegrass	11
	tall wheatgrass (moist districts or seepage areas)	12
Very severe (10-15 dS/m)	Russian wild ryegrass + slender wheatgrass	4+4
	altai wild ryegrass + alfalfa	10+3
	altai wild ryegrass	10
	tall wheatgrass (moist districts or seepage areas)	12
	b. Soils with spring flooding (2 to 5 weeks)	
Little or no (0-2 dS/m)	reed canarygrass + bromegrass	4+6
	reed canarygrass + timothy	4+4
	timothy + bromegrass	4+6
	altai wild ryegrass + alfalfa	10+3
	altai wild ryegrass	11
Slight to moderate (2-6 dS/m)	reed canarygrass + bromegrass	4+6
	reed canarygrass + bromegrass + slender wheatgrass	4+6+6
	altai wild ryegrass + alfalfa	10+3
	altai wild ryegrass	11
Severe to very severe (6-15 dS/m)	altai wild ryegrass + alfalfa	10+3
	slender wheatgrass	8
	altai wild ryegrass	11
	tall wheatgrass	12

* EC - electrical conductivity based on saturated paste, in deciSiemens per metre

Deep-Rooted Crops
Deep-rooted crops prevent the buildup of groundwater, lower the water table, dry out the subsoil and restore the water storage capacity of the soil (Brown et al. 1982). The most commonly grown deep-rooted dryland crop is alfalfa. It roots up to 6 m (20 ft) in four to five years and uses more than 760 mm (30 in.) of water per year. Perennial deep-rooted crops also increase soil organic matter content, improve soil structure and reduce soil erosion.

Alfalfa should be seeded into a firm, moist seed bed as shallowly as possible at a rate of about 7 kg/ha (6.2 lbs/ac). It can be seeded using a conventional seeder. Hoe drills often give the most effective results because of good depth control and packing capability. Disk drills work best if the seed bed is uniform and moderately firm. However, in loose soil, disk drills may place the seed too deeply, and in very firm soil, they may leave the seed on the soil surface. Both conditions result in poor germination.

Recharge areas identified during a salinity investigation should be seeded to alfalfa. On average, recharge areas are about three times larger than their saline seep. The best time for seeding alfalfa is early spring. Alfalfa should be seeded without any companion crops because competition will deter establishment of the alfalfa stand.

Alfalfa has the ability to use atmospheric nitrogen through a symbiotic relationship with rhizobia nodule bacteria. Therefore, alfalfa inoculated with rhizobia will require less nitrogen fertilizer. Phosphorus, potassium and sulphur are important nutrients for optimum production. Alfalfa requires 5 kg of phosphorus per tonne of yield (10 lbs per ton of yield). This nutrient is very immobile in the soil and so application prior to seeding is highly recommended.

When alfalfa is seeded in a recharge area, it usually takes about five years to lower the water table in the associated saline seep. Once the water table is lowered to an acceptable level, the recharge area may be converted to cereal crops for a few years. The best approach is usually to establish a rotation of five years of alfalfa followed by three years of cereal crops. The cereals should be continuously cropped.

Flexible Cropping
In flexible cropping, fields are seeded if stored soil moisture and rainfall probabilities are favourable for satisfactory crop yields, and they are fallowed only if yield prospects are unfavourable (Jackson and Krall 1978). Flexible cropping involves careful management and planning; it is often simpler to use continuous cropping.

Snow trapping may increase stored soil moisture for recropping. Techniques to trap and manage snow include:

- tall stubble/alternate height stubble - Leaving tall stubble or strips of stubble at different heights increases stored soil moisture.
- shelterbelts - The ability of shelterbelts to trap snow can be manipulated by such practices as tree pruning and species selection.

Snow trapping should distribute snow evenly to avoid local accumulations of snowmelt from large drifts.

2.3.2 Structural Controls

Surface Drainage
Surface drainage of recharge areas and/or discharge areas can be used to control seeps (Vanderpluym 1982). An open, shallow trench is normally used; deep trenches will obstruct farming operations. Trenches can be constructed at a reasonable cost with farm equipment or by a contractor.

Grassed waterways are often used to drain excess surface water from recharge areas. Typical grassed waterways are broad, shallow channels with shallow slopes that carry water at slow speeds, preventing soil erosion. Grassed waterways ideally have channel slopes of less than 1% and side slopes of less than 25%. The channel should be at least 15 cm (5.9 in.) deep and 5 m (16 ft) wide. The grass should extend at least 5 m (16 ft) on both sides of the channel. A commonly used forage mix for grassed waterways is:

- brome or pubescent wheatgrass	- 10 kg/ha (9 lbs/ac), plus
- creeping red fescue	- 5 kg/ha (4.5 lbs/ac), plus
- crested wheatgrass	- 5 kg/ha (4.5 lbs/ac), plus
- alfalfa	- 10 kg/ha (9 lbs/ac), plus
- fall rye	- 1 kg/ha (0.9 lbs/ac)

Subsurface Drainage
Although subsurface (tile) drainage is used on irrigated lands to control salinity and waterlogging, it is not commonly used to control dryland salinity. However, a subsurface drainage system will satisfactorily lower water tables in dryland seeps if the system is properly designed, installed and managed. If the water is of good quality, it could be stored and used for stock water.

Relief Wells
Relief wells are costly but they can effectively control springs and soapholes associated with artesian salinity. The wells should be completed in the pressurized water-bearing layer. The wells may flow free and could be connected to a buried pipe 1 to 2 m (3.3 to 6.6 ft) deep. If the water is of good quality, it could be used for domestic or livestock purposes.

3.0 Saline Water Bodies

Salt concentration is an important water quality measure for cattle health and productivity. As part of the salinity mapping project, water bodies in the County of Warner were sampled for salinity concentrations.

Livestock will normally avoid saline water if given the choice, but in some situations they may have to drink it. Use of water with total dissolved solids (TDS) concentrations higher than 3 000 mg/L should be restricted depending on livestock type, age and reproductive state (Task Force on Water Quality Guidelines 1987). Water with 7 000 mg/L TDS or more can cause a loss in overall condition and a reduction in weight gain for all livestock. Excessively saline water (greater than 10 000 mg/L), especially when used in large amounts, can cause physiological upset and ultimately death in the majority of terrestrial animals, including humans.

In most parts of Alberta, natural surface waters usually have TDS concentrations well below 3 000 mg/L. However, water bodies in some locations have 7 000 mg/L or more, high enough to be dangerous for cattle (MacAlpine and Howard 1995). If water with TDS between 7 000 and 10 000 mg/L must be used, then its use should be limited to a short period of time. A sudden change from non-saline water to very saline water can initiate toxic symptoms and in some cases may cause death.

In the County of Warner, electrical conductivity was measured in 43 water bodies. An EC reading of 8 dS/m is equivalent to 7000 mg/L TDS. Thus, water bodies with EC readings greater than 8 dS/m are a potential danger for cattle. Table 3 identifies the locations and measured EC values for the sampled water bodies. Only two water bodies had readings of 8 dS/m or more (Figures 9 and 10). Both are located in the southern part of the County. They should be avoided for watering cattle. It should also be noted that salinity and TDS concentrations will increase over the summer period if drought conditions persist.

Table 3. Water sample locations and EC measurements in the County of Warner

Legal location	EC (dS/m)	Legal location	EC (dS/m)	Legal location	EC (dS/m)
SW7-3-19 W4	1.2	~~NW2-4-18 W4~~	~~0.23~~	~~NW1-4-18 W4~~	~~0.13~~
NW16-3-19 W4	0.75	NE11-3-18 W4	2.1	NW15-3-18 W4	1.1
NE9-3-19 W4	3.4	SE10-3-18 W4	1.5	SW22-3-18 W4	0.2
NE3-3-19 W4	0.13	NE35-3-18 W4	3.3	SW16-4-17 W4	1.9
SE18-4-19 W4	2.0	NW35-2-17 W4	8.0	NW6-1-15 W4	6.0
NW5-4-20 W4	0.45	SW8-2-17 W4	4.0	NW24-1-16 W4	4.7
SE32-3-21 W4	0.5	SW27-1-18 W4	0.3	NW12-1-17 W4	3.0
SW7-3-19 W4	0.5	SE9-1-18 W4	2.9	SW4-1-15 W4	6.0
SW7-3-19 W4	3.3	NW21-1-17 W4	1.6	SE4-1-14 W4	39.0
SW28-3-20 W4	1.1	SE29-1-17 W4	1.0	SW2-4-15 W4	1.2
SW23-3-19 W4	0.5	SW17-1-17 W4	0.6	SW6-4-17 W4	2.0
SE14-3-19 W4	6.5	SW12-1-18 W4	1.0	SE17-5-15 W4	0.42
SE29-3-18 W4	0.27	NW1-1-18 W4	1.0	SE1-6-18 W4	0.6
SW17-3-18 W4	2.7	NE31-5-16 W4	0.4		
SW16-3-18 W4	0.3	NE32-1-16 W4	0.7		

figure 9

figure 10

4.0 Saline Seep Distribution

The following statistical analysis describes the number and size of saline seeps for all types of salinity and for contact/slope change salinity in the County of Warner. These two examples indicate the general tendencies for the other salinity types.

The County has 2 223 saline seeps which occupy a total of 22 547 ha (55 716 ac). This project depicts salinity which is visible on the soil surface. Most of these visible saline areas are out of agricultural production or have significantly reduced crop yields. However, the effects of salinity on crop yields are not usually limited to the visible saline areas. Often the surrounding lands have weakly to very weakly saline subsoils, reducing yields of sensitive crops. Thus, salinity control practices may benefit crop yields over a much broader area than just the visible seep.

Table 4 presents the number, area and percentage of the total saline area for each of the seven salinity types in the County. Coulee bottom salinity is the most common type (34.5% of saline areas in the County), followed by contact/slope change salinity (32.7% of saline areas), depression bottom salinity (15.8%), outcrop salinity (7.5%), natural/irrigation salinity (6.2%), irrigation canal seepage salinity (2.0%), and artesian salinity (1.3%). There is no evidence that slough ring salinity occurs in the County.

Table 4. Salinity distribution by type in the County of Warner

Salinity type	**Number of seeps**	**Area**		**Percent of total saline area**
		(ac)	(ha)	
Contact/slope change	1 297	18 264.88	7 391.53	32.7
Outcrop	339	4 154.8	1 681.39	7.5
Artesian	89	700.33	283.41	1.3
Depression bottom	241	8 806.65	3 563.65	15.8
Coulee bottom	152	19 201.89	7 770.73	34.5
Slough ring	-	-	-	-
Irrigation canal seepage	44	1 130.52	457.51	2.0
Natural/irrigation	61	3 457.44	1 399.18	6.2
Total	2 223	55 716.51	22 547.40	100.0

Figure 11 shows the number of saline seeps by type. There are many small contact/slope change saline seeps (1 297 seeps occupying 7 391 ha (18 265 ac)) and a few large coulee bottom seeps (only 152 seeps occupying 7 770 ha (19 202 ac)). Depression bottom salinity consists of 241 seeps occupying 3 564 ha (8 807 ac). Outcrop salinity consists of 339 small seeps occupying 1 681 ha (4 155 ac). Irrigation canal and natural/irrigation salinity combined consist of 105 saline seeps and occupying 1 857 ha (4 588 ac).

Figure 12 shows the frequency of different size ranges for all saline seeps. The seep areas vary from 0.03 ha (0.07 ac) to 1 472 ha (3 637 ac). Most seeps (59%) are between 0 and 3.0 ha (0 to 7.4 ac), and over 98% have areas less than 100 ha (247 ac). Only 256 seeps are larger than 13.5 ha (33.3 ac); these are coulee bottom and depression bottom seeps. Only 36 seeps are larger than 100 ha (247 ac); these are mainly coulee bottom seeps.

The areas for contact/slope change saline seeps show a similar distribution (Figure 13). Of the 1 297 contact/slope change seeps, 42% are between 0 and 3.5 ha (0 and 8.6 ac). About 24% are larger than 12 ha (29 ac).

The usual measures to control contact/slope change salinity are to grow salt-tolerant grasses in the saline area and alfalfa in the recharge area. On average, recharge areas are about three times the size of their saline area. Thus, as a general guide, an area about three times the size of the seep will need to be converted to alfalfa to control contact/slope change seeps.

The other salinity types have similar distributions of seep areas. In general, most saline seeps in the County are between 0 and 3.5 ha. The main exceptions are some coulee bottom and depression bottom saline seeps.

Figure 11. Salinity Area by Type in the County of Warner

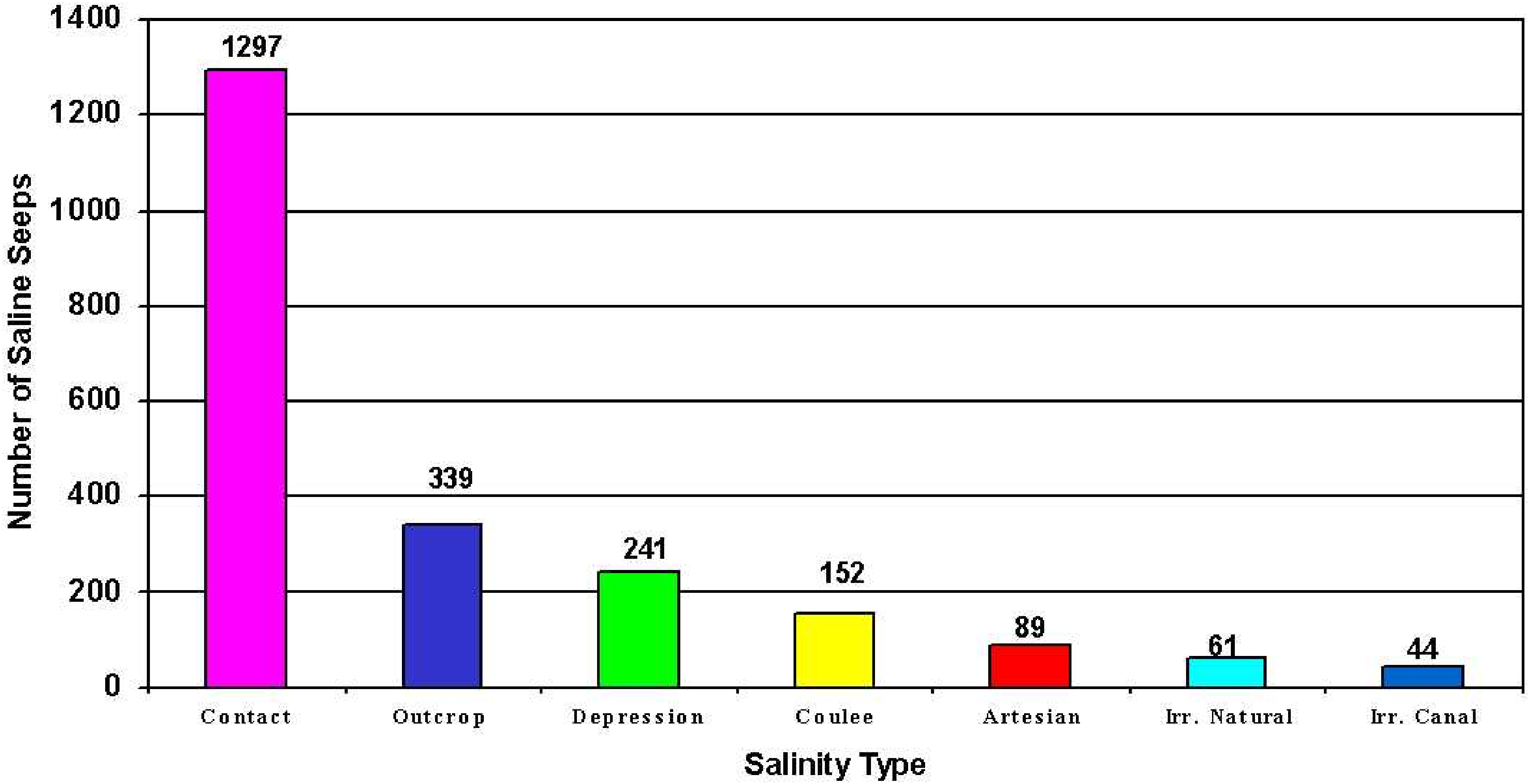


Figure 12. Number and Size of Total Saline Seeps in the County of Warner

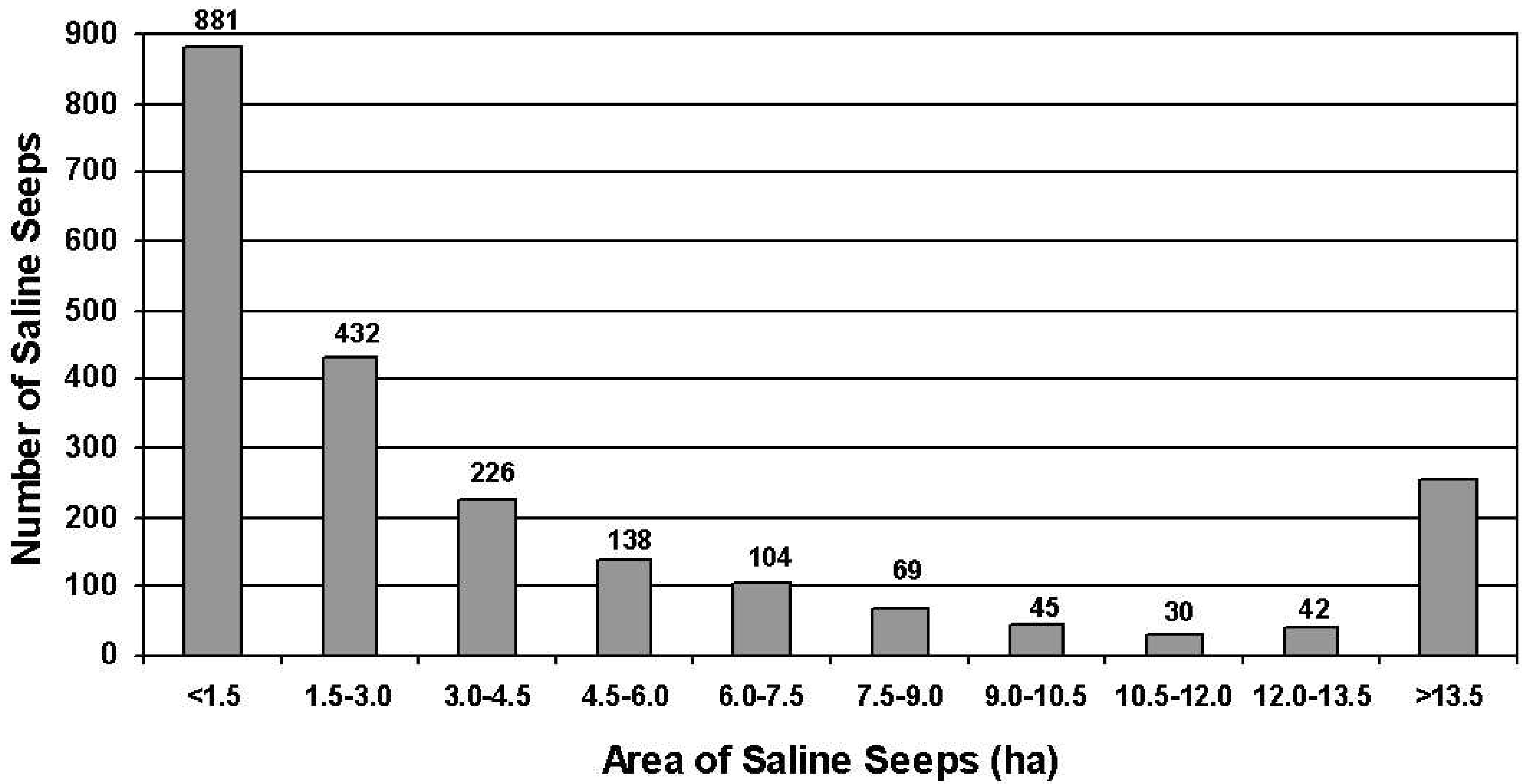
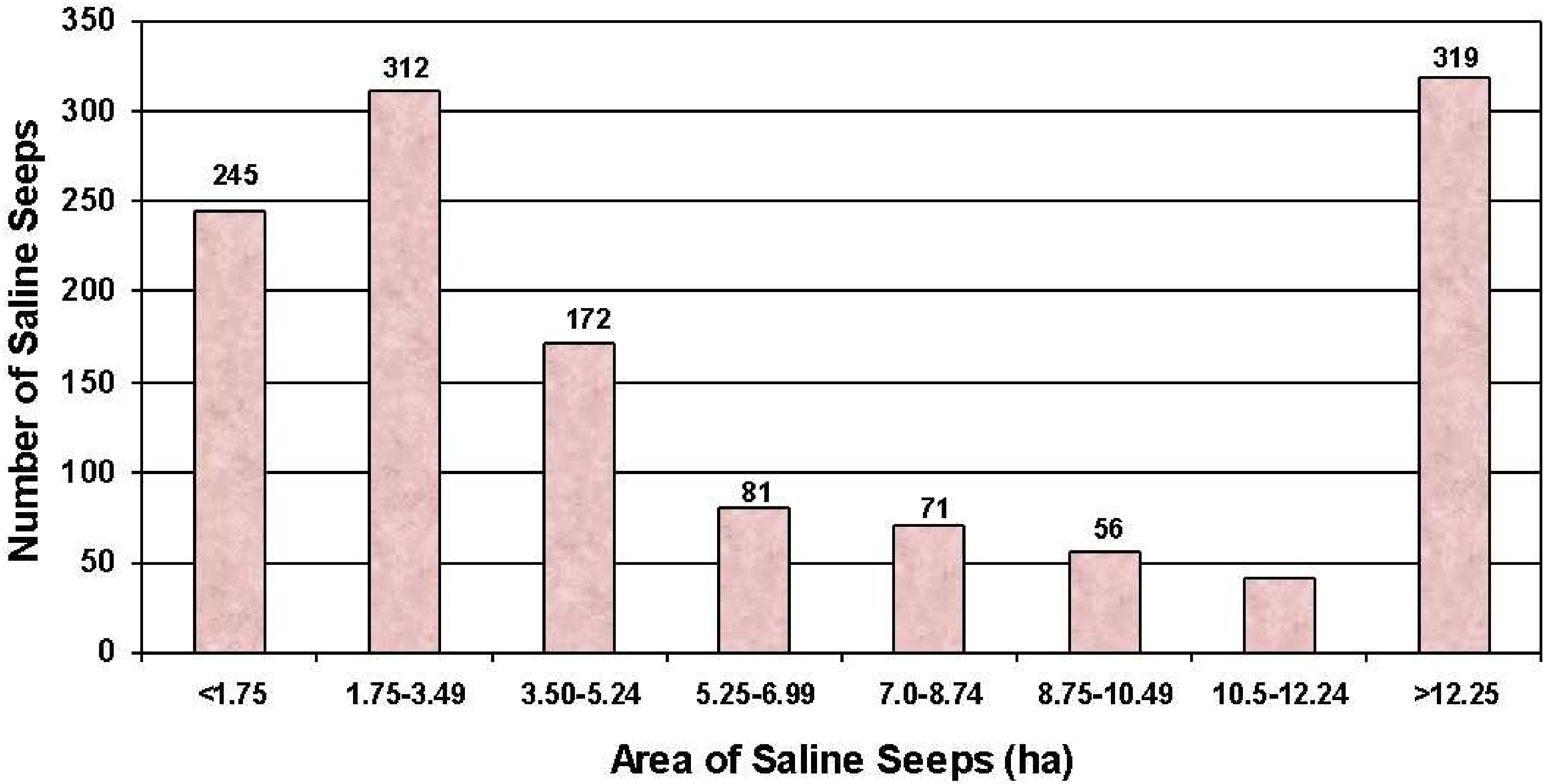


Figure 13. Number and Size of Contact/Slope Change Saline Seeps in the County of Warner



5.0 References

Agriculture Canada. 1976. Glossary of terms in soil science. Agriculture Canada, Research Branch, Ottawa. Publication 1459, revised. 44 pp.

Borneuf, D.M. 1976. Hydrogeology of the Foremost area, Alberta. Report 74-4. Alberta Research Council. 26 pp. 2 maps.

Brown, P.L., Halvorson, A.D., Siddoway, F.H., Mayland, H.F. and Miller, M.R. 1982. Saline seep diagnosis, control, and reclamation. United States Department of Agriculture. 22 pp. Conservation Research Report No. 30.

Greenlee, G.M., Pawluk, S. and Bowser, W.E. 1968. Occurrence of soil salinity in the dry lands of southern Alberta. Canadian Journal of Soil Science. 48: 65-75.

Henry, L., Harron, B., and Flaten, D. 1987. The nature and management of salt-affected land in Saskatchewan. Saskatchewan Agriculture. Agdex 518. 23 pp.

Jackson, G.D. and Krall, J.L. 1978. The flexible method of recropping. Pages 7-23 *in* Dryland Saline Seep Control. Proceedings of the Meeting of the Subcommission on Salt-Affected Soils at the 11th International Soil Science Society Congress. Edmonton.

Kjearsgaard, A., Tajek, J., Pettapiece, W.W., and McNeil, R.L. 1986. Soil Survey of the County of Warner, Alberta. Report No. 46. Agriculture Canada, Research Branch, Edmonton.

Kwiatkowski, J., Marciak, L.C, Wentz, D., and Vanderpluym, H. 1994. Salinity mapping by landscape, County of Vulcan, Alberta. Alberta Agriculture, Food and Rural Development and Agriculture and Agri-Food Canada, Edmonton.

MacAlpine, N.D. and Howard, A. 1995. Farm water management manual. Conservation Manual Series. Alberta Agriculture, Food and Rural Development, Conservation and Development Branch, Edmonton.

Raymond Irrigation District. 1990. Saline/waterlogged lands map. Alberta Agriculture, Irrigation and Resource Management Division, Land Evaluation and Reclamation Branch.

Task Force on Water Quality Guidelines of the Canadian Council of Ministers of the Environment. 1987. Chapter 4.0 Agricultural Uses. *In:* Canadian Water Quality Guidelines. Environment Canada, Inland Waters Directorate, Water Quality Branch, Ottawa.

Tokarsky, O. 1973. Hydrogeology of the Lethbridge-Fernie area, Alberta. Alberta Research Council, Edmonton. Report 74-1. 18 pp. 2 maps.

Vanderpluym, H. 1982. Salinity in western Canada. Pages 9-23 *in* First Annual Western Provincial Conference of Water and Soil Research and Management, Soil Salinity. Warner.

Vanderpluym, H. and Harron, B. 1992. Dryland salinity investigation procedures manual. Alberta Agriculture, Conservation and Development Branch, and Agriculture Canada, Prairie Farm Rehabilitation Administration.

Glossary

Aquifer - A body of earth material capable of transmitting water through its pores at a rate sufficient for water supply purposes. (Vanderpluym and Harron 1992)

Artesian groundwater - Groundwater confined under pressure so that water rises up in a non-pumping well which penetrates it.

Bedrock - The solid rock that underlies the soil and regolith or that is exposed at the surface. (Agriculture Canada 1976)

Capillary action - The action by which the surface of a liquid, where it is in contact with a solid, is elevated or depressed depending on the forces of adhesion and cohesion.

Electrical conductivity - A method of expressing salinity. An electrical conductivity (EC) measurement can be used to determine the salt content of soil in a saturated soil paste extract. The EC value is usually expressed in deciSiemens/metre (dS/m). For example, topsoil with an EC value of 2 dS/m is considered non-saline; topsoil with an EC value of 16 is very saline.

Flexible cropping - Cropping according to spring soil moisture conditions. That is, seeding when the spring soil moisture is adequate.

Groundwater - 1) Water that is passing through or standing in the soil and the underlying strata. It is free to move by gravity. (Agriculture Canada 1976). 2) Water in the ground that is in the zone of saturation, from which wells, springs and groundwater runoff are supplied. (Vanderpluym and Harron 1992)

Parent material - The unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of a soil has developed. (Agriculture Canada 1976)

Permeability, soil - The ease with which gases and liquids penetrate or pass through a bulk mass of soil or a layer of soil. (Agriculture Canada 1976)

Saline soil - A non-sodic soil containing enough soluble salts to interfere with the growth of most crop plants. The conductivity of the saturation extract is greater than 4 dS/m (at 25°C), the exchangeable sodium percentage is less than 15, and the pH is usually less than 8.5. (Agriculture Canada 1976)

Seepage - 1) The emergence of water from the soil over an extensive area, in contrast to a spring where water emerges from a local spot. (Agriculture Canada 1976). 2) The slow movement of water through small cracks, pores, interstices, etc. of a material into or out of a body of surface or subsurface water (Vanderpluym and Harron 1992).

Till - Unstratified sediment deposited directly by a glacier and consisting of clay, sand, gravel and boulders intermingled in any proportion. (Agriculture Canada 1976)

For further information, please visit www.agric.gov.ab.ca