Procedures Manual for the Classification of Land for Irrigation in Alberta

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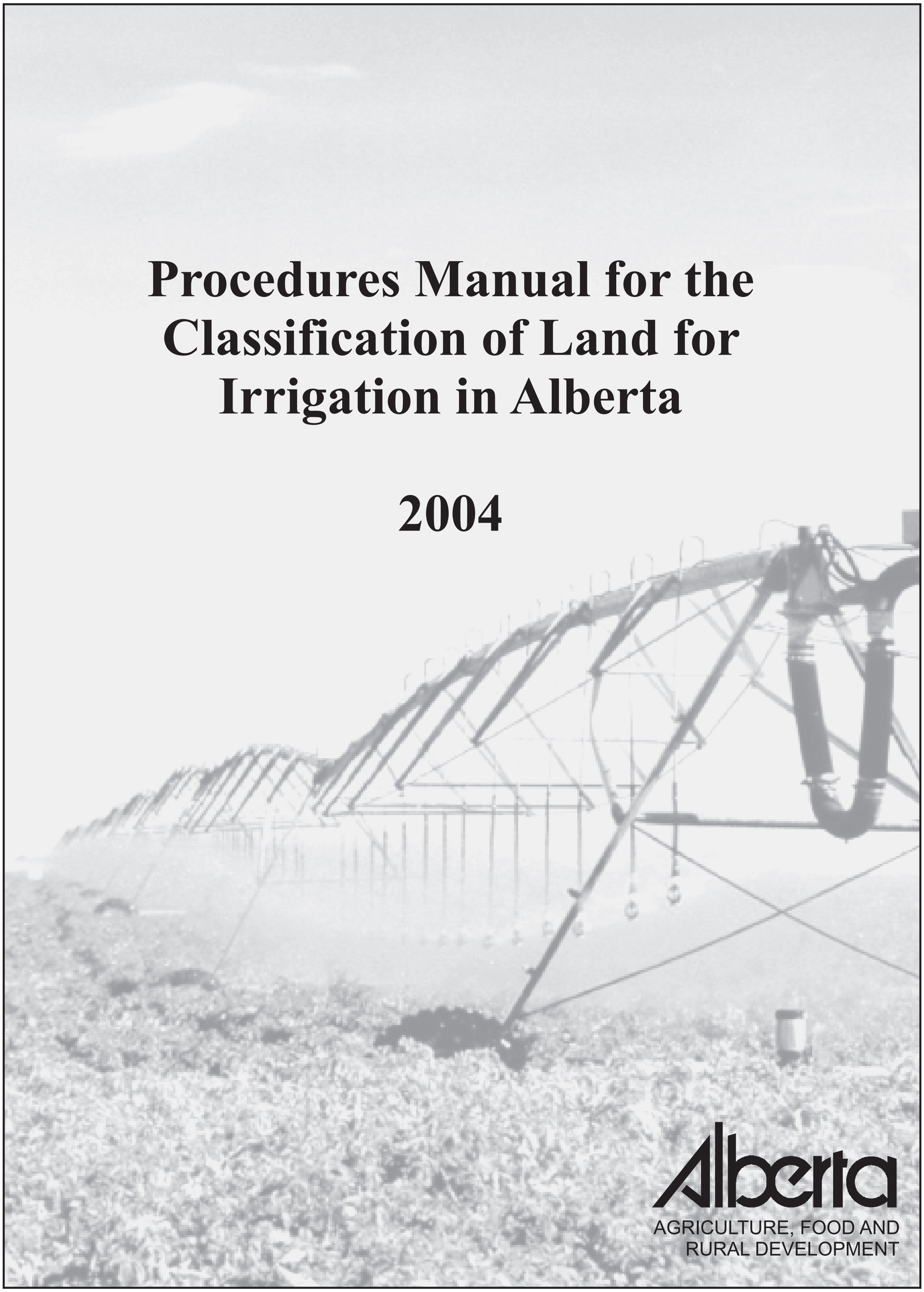

AGRICULTURE, FOOD AND
RURAL DEVELOPMENT

Procedures Manual for the Classification of Land for Irrigation in Alberta

Prepared by:

Alberta Agriculture, Food and Rural Development
Resource Management and Irrigation Division
Irrigation Branch
Lethbridge, Alberta

2004

More information and copies of the *Procedures Manual for the Classification of Land for Irrigation in Alberta* may be obtained from:

Alberta Agriculture, Food and Rural Development
Irrigation Branch
Agriculture Centre
100 - 5401 1st Avenue South
Lethbridge, Alberta, Canada T1J 4V6

Telephone: 403-381-5140
Fax: 403-381-5765

Web site: http://www.agric.gov.ab.ca

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PREFACE

This fourth edition of the procedures manual was printed following an amendment to the Irrigation Districts Act, Irrigation General Regulation, on February 24, 2003, allowing Irrigation Council to specify which standards are acceptable for land assessment purposes. On September 11, 2003, Irrigation Council approved the use of land classification reports prepared according to the 1983 or subsequent "Standards for the Classification of Land for Irrigation in the Province of Alberta" for irrigation district land assessment purposes. The Irrigation Districts Act had replaced the Irrigation Act on May 1, 2000. The land classification standards had been amended on September 8, 1999, to clarify the rating of soils over shallow bedrock and soils over shallow gravel, and on November 12, 1998, to allow irrigation of some Solonetzic soils.

The land irrigability classes in the current *Standards for the Classification of Land for Irrigation in the Province of Alberta* (AAFRD 2004) are the basis for selection of land for irrigation development. The purpose of the procedures manual is:

1. To provide a comprehensive handbook on land classification for irrigation.
2. To enhance uniformity among land classifiers.

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CHAPTER 1. INTRODUCTION

1.1 Definition and Purpose

Land classification for irrigation is the systematic examination, description, appraisal, and grouping of land on the basis of physical and chemical characteristics affecting its suitability for sustained production under irrigated agriculture. Selection of land for irrigation also involves prediction of the behaviour of land after development and application of irrigation water.

The purpose of this classification is to determine the extent and degree of suitability of land for irrigation. Land units are grouped into one of seven interpretive classes, based upon relative capability for sustained production under irrigation. This classification also provides an inventory of land characteristics, identifies potential problems that may occur with irrigation, and makes recommendations for appropriate management under irrigation.

Land classification maps required for the issuing of water rights are prepared on a quarter section basis with the information formally presented in a land irrigability classification report. This classification is required for determining the acres to be irrigated and forms the basis for the operation and maintenance charges by an irrigation district. Evaluation of the irrigation suitability of land is also conducted as part of the agricultural feasibility report required under the Water Act (1999) for water licensing of private irrigation projects, and prior to land being developed for wastewater irrigation under the Environmental Protection and Enhancement Act (1992).

1.2 History of Land Classification in Alberta

The evolution of land classification for irrigation in Alberta began in 1915 when the Government of Alberta enacted the Irrigation Districts Act. Land classification for irrigation became necessary to allow land to be placed on the assessment rolls of the Irrigation Districts.

Early classification systems gave little consideration to the properties of the soil and substrata. The selection of land was based upon the ability to deliver water to a given parcel. Land could be withdrawn from assessment rolls when it was proven that it could not produce under irrigation, usually due to salinization and/or waterlogging. Knowledge of Canadian soils was very limited during this early period. Soil surveys undertaken in the 1920's were based primarily upon surface texture (ACECSS 1987). The first soil survey for irrigation in Alberta was prepared by Wyatt and Ward (1930) for the Lethbridge Northern Irrigation Project. Land was assessed using a "Table of Ratings" which was developed for Irrigation Council and presented to the Government of Alberta for adoption in February 1930. This numbering system was intended to reflect the productive capacity of the soil, based on soil texture, organic matter content, erosion, stoniness, and salinity. Topographic factors, distance from a railway shipping point, and value of water to the farm unit were also considered. This rating system was used initially in Alberta and later in Saskatchewan, during the period from 1930 to 1949, for classification of several irrigation projects.

Bowser and Moss (1950) introduced a similar system in which the original "Table of Ratings" was modified. This soil rating system for irrigable lands used the same general principles as in rating land for dryland agriculture, with different emphasis given to soil texture and other physical factors. The numerical index system was utilized in Alberta in the St. Mary River District (S.M.R.D.) and the Bow River District (B.R.D.) West Block, wherein crown lands were rated for pricing and disposition to settlers.

The Prairie Farm Rehabilitation Administration (P.F.R.A.) established a land classification committee in 1956 to formulate a suitable land classification system for the Bow River Irrigation Project near Hays, Alberta. This system rated land according to its probable future net income per acre (CDA 1960). A handbook was later prepared for classification of irrigated land throughout the Prairie Provinces (CDA 1964). This method was similar to that of Bowser and Moss (1950) and included guidelines for assessing soil, drainage and topographic suitability of land for irrigation. In the late 1950's, Alberta Agriculture, Colonization Branch was engaged in developing a land classification and water rate assessment system for Alberta.

The Government of Alberta initiated a series of studies in 1963 under the Agricultural Rehabilitation and Development Act (A.R.D.A.) to determine the extent of rehabilitation needs within the irrigation districts. The "Irrigation Act 1968" was passed following completion of these studies. This legislation provided a uniform administration system for all but one of the organized irrigation projects in Alberta and set the framework for cost-sharing rehabilitation agreements by the Irrigation Districts. The federally owned and operated Bow River Project was exempted from the Act (Francis 1972).

The legal requirement for land classification standards to be used prior to the granting or revoking of the right to receive water came about as a result of the passing of the Irrigation Act 1968. Section 113(1) [amended from Section 112(1)] states:

> "113(1) The (Irrigation) Council shall cause to be prepared a set of standards for each district setting out the minimum requirements, taking into account all factors that it considers relevant, with which any land must comply in order to be suitable to receive water for irrigation."

Alberta Agriculture was asked by Irrigation Council to prepare a set of land classification standards to satisfy the requirements of the "Irrigation Act 1968". This set of standards, "Alberta Standards for Irrigated Land Classification" (ADA 1969), was approved by Irrigation Council on November 6, 1969. These standards divided land into six classes, depending on the extent of deficiencies in soil characteristics, internal drainage and topography. The minimum requirement for any land to be considered suitable to receive water was established as Land Class 5. The irrigation districts were given the prerogative of adopting a higher standard for their district if they wished, but could not include any land of a lower classification than Land Class 5.
Land classification provisions of the Irrigation Act began to be enforced in 1978 after Irrigation Council passed the following resolution at their regular meeting of May 11, 1978:

> "that whereas Irrigation Council has caused to be prepared the minimum requirements with which any land must comply in order to be deemed suitable to receive water for irrigation as required by Section 113(1) of the Irrigation Act,

therefore, in the future Irrigation Council will require that evidence in the form of classification reports indicating the irrigability of the land to receive water must be filed with Irrigation Council before any new lands are placed on the assessment roll of any district or before any parcel is reclassified."

Irrigation Council subsequently appointed a committee to review the 1969 standards as to their appropriateness under present day irrigation practices, and in consideration of the experience gained in irrigating land classified under those standards. The committee was asked to make such recommendations, as they deemed necessary with regard to updating the standards. A standards and procedures manual prepared by the former Land Classification Branch, Resource Planning Division, Alberta Agriculture, were approved by the committee and adopted by Irrigation Council in 1983. Land classes, soil categories, and topographic categories in the 1983 standards were revised to more accurately reflect the relative suitability of land for irrigation.

Irrigation Council adopted a change to the land classification standards on July 12, 1990, to allow irrigation of land rated Class 5R under a temporary water agreement. Class 5R land is land undergoing reclamation after the implementation of an appropriate improvement such as drainage or canal lining. Irrigation Council approved a further change to the standards on November 12, 1998, to allow irrigation of some Solonetzic soils as a result of research and monitoring studies completed in Alberta (Bennett 1988; Jim Lore and Associates Ltd. 1989; Bennett and Entz 1990; Hecker et al. 1998; Bennett et al. 2000). The standards were also amended on September 8, 1999, to clarify the rating for soils over shallow bedrock (Bennett et al. 1987) and soils over shallow gravel.

The Irrigation Districts Act replaced the Irrigation Act on May 1, 2000, to improve accountability, streamline administration, and ensure that the legislation enables the irrigation districts to operate efficiently and effectively while serving the needs of all water users. Section 94 of the Irrigation Districts Act states, in part:

> "The Minister must establish by regulation
>
> (a) land classification standards to be used by each district to classify land according to its suitability for irrigation purposes,...."

Section 4 of the Irrigation General Regulation states:

(1) For the purposes of section 94(a) of the Act, the district must use the latest edition of "Standards for the Classification of Land for Irrigation in the Province of Alberta" approved by the Council and published by the Department.

(2) Notwithstanding subsection (1), land classifications that were made in accordance with previous editions of the standards referred to in that subsection may, with the Council's approval, continue to be used for land assessment purposes.

In accordance with subsection (2) above, on September 11, 2003, Irrigation Council approved, for irrigation district land assessment purposes, the use of land classification reports prepared according to the 1983 or subsequent "Standards for the Classification of Land for Irrigation in the Province of Alberta". Section 5 of the Irrigation General Regulation outlines the land assessment criteria that must be met when revising the assessment roll of an irrigation district.

The standards (AAFRD 2004) outline the minimum requirements with which any land must comply in order to be classified as irrigable, and are the standards to be used for the classification of lands for the formation of a new district, or for the reclassification of lands within a district. These standards apply to all irrigation districts in Alberta and are also used to classify land for irrigation outside irrigation districts. They are used to prepare land classification reports needed as: a) input to agriculture feasibility reports required under the Water Act (1999) for licensing of private irrigation projects, and b) as input when developing municipal and some industrial wastewater irrigation projects under the Environmental Protection and Enhancement Act (1992).

CHAPTER 2. PRINCIPLES OF LAND CLASSIFICATION

An assessment of the land resource base is the first basic step in the development of any irrigation project. The assessment begins with the land classification process. The process is designed to assess the potential capability of land for irrigation in order to enhance project development, project management, and long term productivity of the land.

Various principles or factors, assumptions, and limitations must be considered if the information generated through land classification is to be useful for increasing agricultural productivity, and achieving conservation of soil and water resources.

2.1 Basic Principles

Land classification for irrigation involves consideration of permanent factors, changeable factors, and the predicted response to irrigation.

2.1.1 Prediction

Land that is to be irrigated should be permanently productive under the changes anticipated with irrigation. The land classes, therefore, must reflect the predicted land-water-crop interaction expected to prevail after irrigation development. It is important to identify and evaluate the changes anticipated as a result of irrigation development, reclamation, or management.

This principle recognizes that irrigation shifts the natural balance established over time between water, land, vegetation, fauna, and man. Soil structure may be modified by physical and chemical processes. Important chemical changes occur in the composition and concentration of dissolved constituents in the soil solution. Microrelief and characteristics of the soil profile can be altered by landforming, stone and brush removal, provision of drainage, subsidence, or increased erosion due to irrigation (Maletic and Hutchings 1967).

2.1.2 Permanent and Changeable Factors

The land classification process recognizes that for each setting there are land features and characteristics that may not, or will not, be changed under irrigation and those that may be, or will be changed. Many land factors including soil depth, parent material, texture, and adverse topography are considered permanent. Changeable factors may require modification prior to irrigation development or may be altered with the application of water. Typical changeable factors include: salinity, sodicity, stoniness, drainage, minor irregularities in relief, brush and tree cover, and flood hazard (Maletic and Hutchings 1967).

2.2 Assumptions and Limitations

The land classification system is based upon certain assumptions and limitations, which must be understood for proper interpretation of final maps and reports.

2.2.1 Assumptions

- The classification system is based upon existing and predictable limiting characteristics of soil, drainage, and topography under irrigation.

- Good soil and water management practices that are feasible and practical under a largely mechanized system of irrigated agriculture.

- Lands within a capability class are similar in degree, but not in the kind of limitations for irrigated agriculture. Each class may include many different kinds and degrees of soil and topography limitations that may require specific management treatments. The subclasses provide information about the kind and degree of limitation. The class indicates the overall degree of the limitation.

- Irrigation water is assumed to be of such quality that its prolonged use will not harm the land. Water from major surface streams and lakes in Alberta is primarily derived from mountain snowmelt and is considered well suited for irrigation. Groundwater and sloughwater are often not acceptable. It is advisable to determine the suitability of the irrigation water in advance, especially if the project involves water supplied to private projects outside irrigation districts (Appendix I).

- The land classification for an area considered unsuitable for irrigation may be changed when reclamation efforts are seen to alter and upgrade the limitations to a level considered adequate for irrigation.

- An external drainage outlet, pumped or gravity, for the effluent is assumed to be available.

2.2.2 Limitations

A. Technical

- Possible impacts upon non-project areas affected by irrigation development are identified to a degree depending upon the investigation performed.

- Land considered suitable for gravity irrigation is rated on the basis of soil and topographic features.

- Location of the water source is not considered.

- The allocation of a land area to a specific land class may be changed as new information about the behaviour and response of land to irrigation becomes available.

- Land units may have minor inclusions of soil or topographic features that do not meet the criteria of a given land class.

- Local climatic conditions as they affect crop selection, growth, and productivity are not considered. Crops grown under irrigation are assumed to be those adapted to the region.

B. Socio-Economic

- Distance to market, roads, location and size of farms, characteristics of land ownership, cultural patterns, and the skill and resources of individual operators are not criteria for capability groupings.

- The land classification system is not designed for use in determining project repayment ability, land appraisal value or ability to pay water rates. The system is based upon physical and chemical factors and only indirectly reflects the relative economic value associated with any irrigation project.

CHAPTER 3. SOIL CLASSIFICATION

Soil is a natural, dynamic, unconsolidated mineral or organic material occurring on the earth's surface able to support plant growth. Man is dependent upon soils. The standard of living is often determined by the quality of soils and the kinds and quality of plants and animals grown on them. Many civilizations have had their downfall through the destruction and mismanagement of their soil resource.

Soils are a reflection of their environment. Each soil has developed its own physical and morphological features as a result of the interaction of topography, climate, and biological activity on the parent geological material over time. Soil environment changes under irrigation. The soil, being a dynamic body, responds to this change.

It is important that soils be assessed as to their potential for sustained production under irrigation. This assessment allows the classifier to predict soil behaviour under irrigation and to better understand soil characteristics useful for efficient irrigation management.

Soil quality significantly influences production capacity and production and development costs. Soil conditions required for profitable, diversified crop production under sustained irrigation include (U.S. Bureau of Water and Power 1980):

- Adequate moisture holding capacity for the proposed methods of irrigation and cropping pattern.

- Adequate internal soil drainage through the root zone to permit proper aeration, replenishment of soil-water reservoirs, and leaching of soluble salts.

- Adequate infiltration rates to facilitate replenishment of moisture lost through evapotranspiration, to minimize erosion, and to prevent excessive deep percolation under the proposed irrigation method.

- Sufficient depth of suitable material to allow necessary root development and provide adequate storage of moisture and plant nutrients.

- Suitable texture, structure, and consistency to permit necessary and timely field operations.

- Absence of injurious amounts of salinity, sodicity, or toxic elements.

3.1 Soil Characteristics

Soil properties that determine suitability for irrigation are considered either permanent or changeable.

Permanent characteristics include:

- Texture
- Structure
- Profile
- Porosity
- Bulk density
- Proximity of lime to the surface
- Infiltration rate
- Hydraulic conductivity
- Water holding capacity
- Uniformity and depth of geological deposit
- Depth to bedrock

These characteristics are discussed in section 3.1.1.

Changeable characteristics include:

- Fertility
- Drainage
- Depth to groundwater
- Salinity
- Sodicity
- Soil reaction (pH)
- Erodibility

These characteristics are discussed in section 3.1.2.

3.1.1 Permanent Characteristics

A. Soil Profile

Climate, living organisms, parent materials, and topography interact over time to give rise to natural bodies called soils. The morphological expression of this interaction is displayed by the soil profile. The texture, structure, kind, thickness, and arrangement of horizons in the soil profile can be used selectively or collectively along with other characteristics to predict how well a given soil might perform under irrigation.

Several characteristics related to the soil profile, which influence the movement of water and plant growth, should be considered:

(1) Soil Structure and Porosity

The nature and degree of aggregation of soil particles is called soil structure and the term porosity refers to the nature and amount of voids between and within these aggregates. An abundance of larger air filled pores is associated with stable aggregates and a productive soil.

Under dryland conditions, a well aerated soil is readily identified by its profile characteristics, such as texture, structure, color, porosity, and root development. The addition of water could, however, induce adverse chemical and physical conditions, which affect aeration. Thus, a dense, compact soil horizon, such as occurs in Solonetzic soils, results in impeded water movement, reduced aeration, and decreased crop production.

Other guides to the suitability of soil structure and porosity are suggested by measurements of bulk density, pore space, infiltration rate, and hydraulic conductivity. Soil tilth can be altered by management and thus, is not totally suitable as a soil assessment criterion.

(2) Bulk Density and Pore Space

Bulk density has been defined as the mass of dry soil per unit volume, expressed in Mg m^{-3}. Bulk density is seldom used as a criterion for irrigation suitability since bulk densities are generally favorable, but high bulk densities at any depth in the solum may justify a lower suitability rating. Excessive bulk densities inhibit root penetration and impede drainage. Infiltration rates and hydraulic conductivity are usually low in medium- to fine-textured soils with bulk densities exceeding 1.65 Mg m^{-3} (FAO 1979).

Pore space and bulk density are inversely related (Table 3.1). High bulk densities usually mean low porosity. Assuming an absolute particle density of 2.65 Mg m^{-3}, total porosity associated with bulk densities of 1.1 to 1.6 Mg m^{-3} would be 58 to 39 percent, respectively. Porosity and bulk density can be considered jointly when these data are available (FAO 1979).

(3) Infiltration

The flux or the rate water enters the soil surface is called the infiltration rate (Skaggs et al. 1980). It is usually expressed as length/time or volume/unit area/unit time. The infiltration rate decreases rapidly with time as water is applied to a soil until eventually it approaches a constant rate known as the basic equilibrium or final infiltration rate. This constant infiltration rate is generally assumed to be equal to the saturated hydraulic conductivity, but due to entrapped air will actually be somewhat less.

The infiltration rate is influenced by the soil profile, including soil texture and soil structure. The least permeable layer at shallow depth regulates the vertical permeability and hence the infiltration rate (FAO 1979). As long as the application rate is less than the infiltration capacity of the soil, water will infiltrate as fast as it is supplied and the infiltration rate will be controlled by the application rate (Skaggs et al. 1980). Any water applied in excess of the infiltration capacity will pond or run off. Application rates should be such that surface runoff does not occur. This is usually assured by choosing an application rate that is less than, or equal to, the steady state infiltration capacity. However, this may not be practical in all cases because the infiltration may not reach a steady state or the steady state is prohibitively small (Skaggs et al. 1980).

Table 3.1. Average porosity and bulk density values for southern Alberta soils.

Texture class	Bulk density (Mg m^{-3})	Porosity (%)	Texture class	Bulk density (Mg m^{-3})	Porosity (%)
Loamy sand	1.60	40	Clay loam	1.40	47
Sandy loam	1.55	42	Silty clay loam	1.40	47
Loam	1.50	43	Sandy clay	1.45	45
Sandy clay loam	1.45	45	Silty clay	1.40	47
Silt loam	1.45	45	Clay	1.35	49

Source: AIMSAC 1983

If the infiltration rate after six hours remains in excess of 125 mm h^{-1}, gravity irrigation may not be practicable except in small basins because of difficulties with water distribution and excessive percolation losses. With rates from 1 to 2 mm h^{-1}, surface waste may be excessive or ponding may reduce yields, crops may be damaged in hot weather by scalding, and leaching may be difficult. Below 1 mm h^{-1} the soils are generally considered nonirrigable. Optimum infiltration rates for gravity irrigation are between 7 and 35 mm h^{-1}. On cracking clays, the infiltration rate is very rapid at first but soon decreases to about zero. Such soils are more favorable than impermeable non-cracking clays but irrigation with poor quality water may be hazardous (FAO 1979).

The method used to determine infiltration is the ring or cylindrical infiltrometer method (Haise et al. 1956; Bertrand 1965). Carefully chosen sites, each with three to five replicates, usually provide sufficiently reliable data (FAO 1979).

Even though the actual intake rate is different when irrigation water is applied by furrow or sprinklers, the measurements obtained can be a useful guide in rating soils for irrigation. Both the initial intake rate on dry soil and the initial and basic rates on soil at moisture levels near that, at which irrigation would commence, are useful for land classification purposes.

(4) Hydraulic Conductivity

Hydraulic conductivity refers to the rate at which water moves through the soil. The average vertical hydraulic conductivity of a soil profile can be used to assess internal drainage and to evaluate the possibility of perched-water-table conditions developing under irrigation. If the hydraulic conductivity of surface soil is as low as 1 mm h^{-1}, leaching and irrigation may present serious difficulties (U.S. Salinity Lab Staff 1954). Irrigated agriculture, under average conditions of management, water quality, and drainage, would have doubtful success unless the hydraulic conductivity could be increased by soil improvement measures.

Soils suitable for sustained irrigation in the western U.S.A. have permeable profiles with field hydraulic conductivities ranging from 1.3 to 130 mm h^{-1} (Maletic and Hutchings 1967). However, these authors point out that some clay soils can have hydraulic conductivities measured in place as low as 0.131 mm h^{-1} and still adequately produce under irrigation. In fine-textured soils, a suction gradient can exist that may enhance infiltration to the point of allowing sprinkler irrigation and good crop growth even though very low hydraulic conductivity values were obtained in the field or laboratory (U.S. Salinity Lab Staff 1954). At the other end of the scale, specially adapted irrigation methods can be successful even though hydraulic conductivities exceed 130 mm h^{-1}.

No universally acceptable minimum values for hydraulic conductivity can be established when assessing irrigation potential (FAO 1979) . Such values depend upon depth and intensity of heavy rainfall during the cropping season and upon crops grown. The upper root zone should not be saturated for more than 48 h during most of the crop growth period to obtain high yields. Thus, the minimum hydraulic conductivity should be adequate to ensure that a saturated condition, whether from rainfall, irrigation, or both, is unlikely to occur for more than a 48 h period (FAO 1979).

Field measurement of vertical hydraulic conductivity can be carried out using the cylinder or ring infiltrometer method (Winger 1956). The final results obtained by this test yield a range of measurements from the initial to basic infiltration rate. Saturated hydraulic conductivity is equated to the basic infiltration rate when this method is employed.

Hydraulic conductivity can be measured in the laboratory by the use of soil cores (Klute 1965). Since the ring infiltrometer and soil core measurements are carried out under differing conditions, comparison of results is difficult.

Hydraulic conductivity can be measured in the field using the piezometer method (Hvorslev 1951), the auger hole pump-out test (Winger 1956), or the pump-in test (U.S. Bureau of Reclamation 1951).

King and Franzmeier (1981) used the piezometer method to determine saturated hydraulic conductivity (K_{sat}) of surface horizons below a water table. The confidence limits they developed for similar soil horizons ranged from one-half to one order of magnitude. They suggested that estimates of K_{sat} be made in units of millimetres, centimetres, decimetres, or metres per day. King and Franzmeier (1981) concluded that K_{sat} classes developed for soil survey purposes, covering a wide range and representing a whole order of magnitude, may be realistic and representative of actual field conditions.

(5) Proximity of Lime to the Surface

Lower ratings should be given to soil profiles in which high concentrations of calcium carbonate ($CaCO_3$) occur close to the soil surface. Shallow "high lime" profiles are found chiefly in Chernozemic and Regosolic soils. The presence of high concentrations of calcium carbonate at or near the soil surface affects both the physical and chemical characteristics of the soil. The presence of carbonates in the soil may (FAO 1979):

- Reduce the ability of the soil to retain moisture.
- Affect water movement.
- Cause surface crusting, which can create serious problems for seedling emergence (especially for soils low in organic matter).
- Result in plant nutrient deficiencies of phosphorus, iron, and some micro-nutrients.

Knowledge of the depth to carbonate-rich horizons is of greatest importance in planning land shaping or leveling operations prior to irrigation. Redistribution of the relatively more fertile surface layers leading to the exposure of carbonate-rich subsoil could create severe soil management problems.

B. Geological Deposit

The uniformity and depth of the geological deposit determine the depth of soil that can be utilized by plant roots. Soil and substrata characteristics are closely related to moisture retention and water movement and thereby influence the depth and frequency of irrigation and drainage requirements.

(1) Parent Geological Material

The parent materials from which soils in the irrigated areas of southern Alberta have developed are almost all unconsolidated mineral deposits of glacial or post-glacial origin, and include poorly consolidated and weathered bedrock. During the Late Pleistocene Epoch, an ice sheet overran most of Alberta and left behind glacial deposits ranging in thickness from a few centimetres to 30 m or more (Pawluk and Bayrock 1969). The dominant surficial deposit is glacial till which has been defined as material deposited directly from glaciers without washing or sorting (Pawluk and Bayrock 1969). Most of the till material was derived from local or nearby, underlying strata. A scattering of stones from the Canadian Shield also characterizes glacial till found in Alberta. The Cordilleran tills generally contain more carbonates and stones than the Continental tills (Pawluk and Bayrock 1969).

The bedrock of southern Alberta consists of interbedded marine and non-marine Cretaceous and Tertiary sandstones and shales laid down in the Alberta Geosyncline. The predominant deposits are sand, silt, and clay with minor beds of coal, ironstone, and bentonite. Many of the beds are only weakly consolidated or unconsolidated (Stalker 1960; Pawluk and Bayrock 1969). One of the main compositional features of these rocks and the resulting surficial deposits is the abundance of montmorillonite (Pawluk and Bayrock 1969; Kodama 1979). Pawluk and Bayrock (1969) concluded that the occurrence of soluble salts in glacial till parent material relates closely to the distribution of Solonetzic soils in the province, with sodium sulfate being the dominant salt present. Salt concentrations in the tills do not coincide with specific bedrock units and are more likely related to hydrogeological phenomena (Pawluk and Bayrock 1969).

During deglaciation, large areas of southern Alberta were covered with lacustrine, outwash, and eolian sediments derived through the sorting of glacial deposits by meltwaters, wind and in proglacial lakes. Soil parent materials are differentiated on the basis of essential properties, which reflect their mode of deposition, and are defined as follows (ACECSS 1987; Nikiforuk 1998; SCWG 1998):

Anthropogenic: These materials are artificial or modified by people and include those associated with mineral exploitation and waste disposal. They include materials constructed or deposited by people or geological materials modified by people so that their physical properties (structure, cohesion, compaction) have been drastically altered.

Bedrock: Geological materials so hard and consolidated they cannot be dug with a shovel (i.e. by hand). Indurated layers created by soil-forming processes are excluded.

Colluvial: Massive to moderately well stratified, nonsorted to poorly sorted sediments with any range of particle sizes from clay to boulders and blocks that have reached their present position by direct, gravity-induced movement. They are restricted to products of mass-wasting whereby the debris is not carried by wind, water, or ice (except snow avalanches).

Eolian (adj.): Descriptive of materials transported and deposited by wind. Sediments, generally consisting of medium to fine sand and coarse silt particle sizes, that are well sorted, poorly compacted and may show internal structures such as cross-bedding or ripple laminae, or may be massive. Individual grains may be rounded and show signs of frosting.

Fluvial (adj): Descriptive of materials transported and deposited by flowing water. Sediments generally consisting of gravel and sand with a minor fraction of silt and rarely clay. The gravels are typically rounded and contain interstitial sand. Fluvial sediments are commonly moderately to well sorted and display stratification, but massive, non-sorted fluvial gravels do occur.

Fluvioeolian (adj.): Descriptive of materials transported and deposited by the combined action of streams and wind. These deposits are expressed by an eolian landform on a fluvial plain with slopes usually within the 2 to 5 percent range (Kjearsgaard et al. 1982).

Fluviolacustrine (adj.): Descriptive of materials pertaining to sedimentation partly in lake water and partly in streams, or to sedimentation under alternating or overlapping lacustrine and fluvial conditions.

Lacustrine (adj): Descriptive of materials that have either settled from suspension in bodies of standing fresh water or have accumulated at their margins through wave action. Sediments generally consisting of either stratified fine sand, silt, and clay deposited on the lake bed; or moderately well sorted and stratified sand and coarser materials that are beach and other near-shore sediments transported and deposited by wave action.

Lacustro-Till: Fine-textured, stratified materials that contain some stones, deposited mainly under fluctuating lake-water conditions (Scheelar and Macyk 1972).

Morainal (adj.): Descriptive of materials transported by glacial ice. Sediments generally consisting of well-compacted material that is non-stratified and contains a heterogeneous mixture of particle sizes, often in a mixture of sand, silt, and clay that has been transported beneath, beside, on, within, and in front of a glacier and not modified by any intermediate agent.

Saprolite (residual): Rock containing a high proportion of residual silts and clays formed by alteration, chiefly by chemical weathering. The rock remains in a coherent state, interstitial grain relationships are undisturbed and no downhill movement due to gravity has occurred.

Till: Material transported and deposited by glacial ice.

(2) Irrigation and Drainage of Shallow Till Soils

The permanency of irrigation in southern Alberta has been questioned for many years due to the presence of glacial till at shallow depth throughout most of the irrigated area. Maierhofer (1956) stated that many of the irrigated lands and those being developed for irrigation in Alberta are experiencing, or will experience, serious subsurface drainage problems. Stanley/SLN Consulting Limited (1978) concluded that subsurface drainage is the only method available that will allow sufficient water to flow through the soil profile to maintain a favorable root zone salinity level in most irrigated areas of the Oldman River Basin. Several studies provide evidence, however, that natural internal drainage is adequate to accommodate precipitation and current irrigation practices in southern Alberta.

Studies related to the behavior of the water table under normal irrigation practices were initiated in the Vauxhall District, Bow River Project, wherein 45 percent of the irrigable land has till within 90 cm of the surface. Rapp and Van Schaik (1971) concluded that the duration and frequency of occurrence of water tables shallower than 122 cm was insignificant, even under the most intensive irrigation schedule. They attributed rapid recession of the water table after an irrigation mainly to consumptive use but also to natural downward movement. A 15 year water table study (Rapp and Van Schaik 1972) indicated that the seasonal mean water table depth was 169 cm (±10 cm) and no serious drainage problem was considered to exist in the Vauxhall District.

Salinization of soils underlain by slowly permeable till was also studied in the Bow River Irrigation District (B.R.I.D.) near Vauxhall, Alberta. Maximum crop yields and an adequately low level of salinity were maintained in a Brown Chernozemic soil (Chin loam) with till at a depth of 100 to 200 cm (Krogman and Hobbs 1972). Sommerfeldt and Oosterveld (1977) concluded that continued irrigation under present management appears favorable if till is at depths of 150 cm or more and the soil above it is moderately or well drained. Continued irrigation under present management was considered questionable where till is within 60 cm of the surface. However, a study (Sommerfeldt and Chang 1980) of water and salt movement in a saline-sodic loam having till at 51 cm indicated that internal drainage of this soil is sufficient to accommodate infiltrated water under normal conditions. This soil had become salinized primarily from seepage or possibly irrigation mismanagement. Oosterveld et al. (1978) concluded that the long term salinity status of soils in two drainage basins in the B.R.I.D. appears to be quite stable. Slow downward movement of water appears to be adequate to maintain the soil-salt balance under the climatic and water management conditions in the area.

Chang and Oosterveld (1981) studied changes in soil salinity after long-term irrigation at 13 sites within four major irrigation districts. These soils were underlain by relatively slowly permeable tills. The soils and substrata at these sites have sufficient internal drainage to prevent waterlogging and soil salinization from becoming problems under normal irrigation. Sufficient water had been applied from irrigation and precipitation to leach salts from the root zone and maintain productivity for 60 years (10 sites) and 25 years (3 sites). Further study of soils in the Tilley area indicated that a leaching fraction of 0.16 was sufficient to reduce the total soluble salt content of two soils (a Brown Chernozemic and a Brown Solodized Solonetz) and thereby improve the suitability of the sites for crop production (Chang et al. 1982).

Natural leaching from winter and spring precipitation, snow and ice melt, coupled with a low evapotranspiration rate and a relatively short season (2 months) of high evapotranspiration, have been noted as factors reducing the danger of widespread salinization in southern Alberta (Sommerfeldt and Oosterveld 1977). The hydrogeological characteristics of glacial till may also account for successful long-term irrigation. Nielsen (1971) reported a net outflow of water during the winter months through the slowly permeable substrata. Grisak et al. (1976) and Nielsen (1971) observed visible vertical cleavage lines in the glacial tills studied. These fractures are typically coated with secondary mineral precipitates. The bulk hydraulic conductivities of the fractured tills are generally one to three orders of magnitude greater than the intergranular conductivities determined in laboratory tests. Groundwater velocities in the fracture networks may be many orders of magnitude larger than in the unfractured till mass (Grisak et al. 1976). A hydrogeological study of a shallow till area in the B.R.I.D. (Hendry 1980) indicated the presence of large scale fractures in the weathered till which were sufficiently permeable to permit movement of irrigation water to the groundwater flow system and to prevent development of a perched water table above the till.

In southern Alberta, fine-textured soils, and soils underlain by glacial till at shallow depth, have been irrigated successfully under careful water management without development of a high water table and associated salinization of the root zone.

C. Texture

Texture is a permanent physical characteristic of a given soil. Texture describes the relative proportions of the three soil separates (sand, silt, and clay), which comprise the soil's mineral component. Eight size classes of primary particles are defined (Table 3.2). Thirteen texture classes are recognized (Figure 3.1).

Table 3.2. Named size classes and diameters of primary particles.

Name of separate	Diameter, mm
Very coarse sand	2.0 - 1.0
Coarse sand	1.0 - 0.5
Medium sand	0.5 - 0.25
Fine sand	0.25 - 0.10
Very fine sand	0.10 - 0.05
Silt	0.05 - 0.002
Clay	0.002
Fine clay	0.0002

The texture class of a given soil horizon is determined by measuring the size distribution of the primary particles of its mineral component. In the field, manual texturing provides a convenient procedure for swiftly estimating particle size distribution. Soil Sieve and Sedimentation Analysis, the Pipette Procedure, and the Simplified Hydrometer Method (Gee and Bauder 1986) are three recognized laboratory procedures, which are used to measure particle-size distribution.

Texture influences or reflects physical soil characteristics such as available moisture holding capacity, hydraulic conductivity and infiltration rate. The available moisture holding capacity, for example, is observed to be directly proportional to the content of clay-sized particles found in the soil mineral component (Figure 3.2). Available moisture holding capacity, measured in millimetres of water stored per metre of soil profile or as a volume percentage, is computed as the mathematical difference between field capacity and permanent wilting point. These two physical properties are also seen to be higher in fine- than in coarse-textured soils (Table 3.3). Infiltration rates and hydraulic conductivities are observed to be slower in fine than in coarse-textured soils.

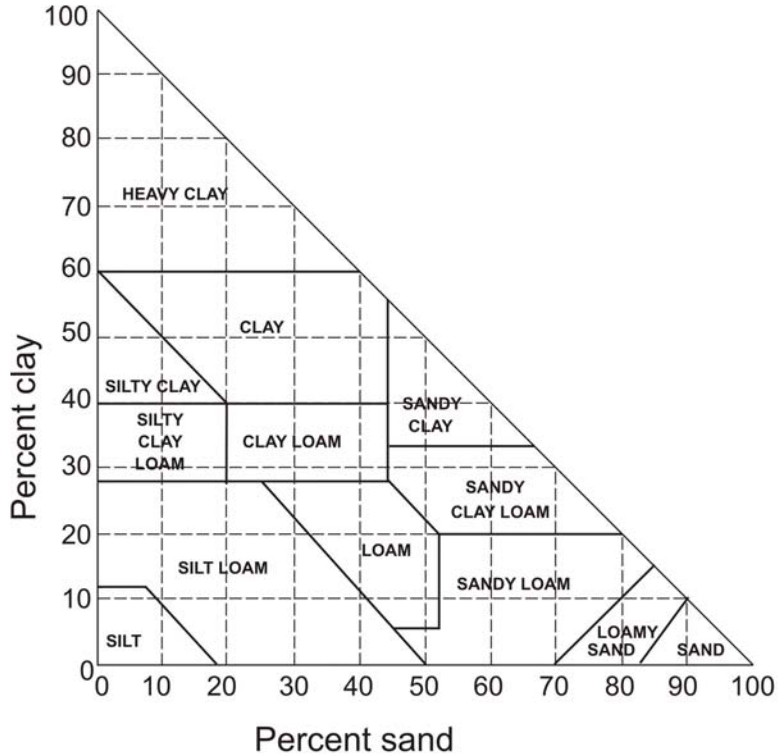


Figure. 3.1. Soil texture classes. Percentages of clay and sand in the main textural classes of soil; the remainder of each class is silt (SCWG 1998).

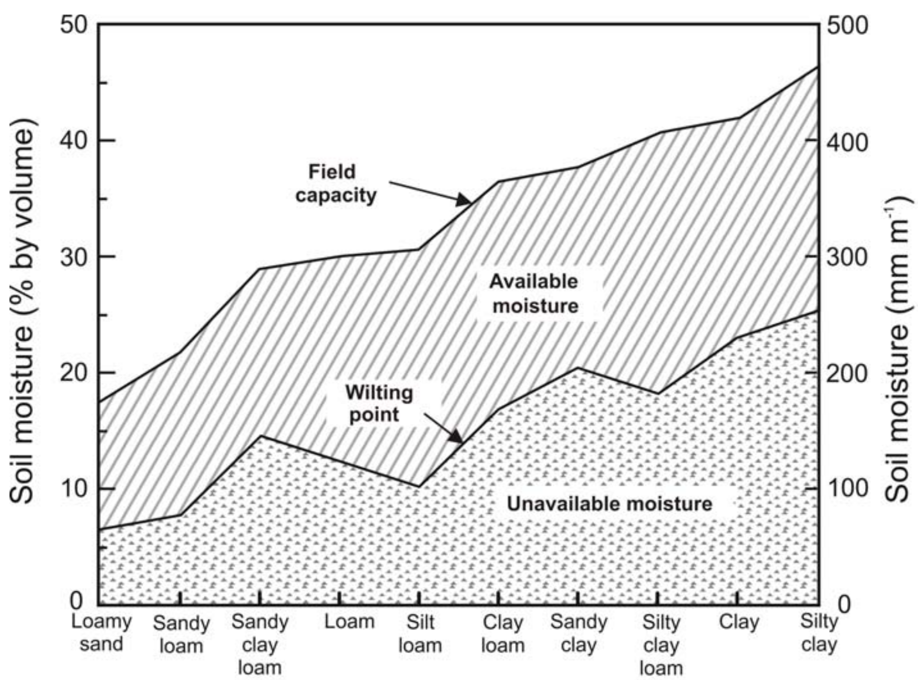


Figure 3.2. Relationship between the field capacity, wilting point, available water, unavailable water, and soil texture (AAFRD 1998).

Texture is an important factor to consider when rating soil as to its suitability for irrigation. Two general soil conditions required to promote crop production under irrigation are (U.S. Bureau of Water and Power 1980):

- Texture that is suitable to permit necessary and timely cultural operations.
- Available moisture holding capacity adequate for the proposed method of irrigation and cropping pattern.

Measurements of texture and available moisture holding capacity are useful for the development of land management strategies, influence the design and pattern of irrigation water application, and aid in determining the depth and frequency of irrigation required (FAO 1979).

Table 3.3. Some average physical characteristics of southern Alberta soils.

Texture class	Bulk density ($Mg\ m^{-3}$)	Porosity (%)	Field capacity[2] (% by weight)	Wilting point[2] (% by weight)	Available moisture holding capacity[1]		
					(% by weight)	(% by volume)	($mm\ m^{-1}$)
Loamy Sand	1.60	40	10 (9-12)	4 (2-5)	6	10	100
Sandy Loam	1.55	42	14 (13-15)	5 (2-8)	9	14	140
Loam	1.50	43	20 (15-25)	8 (8-11)	12	18	180
Sandy Clay Loam	1.45	45	20 (15-24)	9 (7-12)	11	16	160
Silt Loam	1.45	45	21 (14-28)	7 (3-11)	14	20	200
Clay Loam	1.40	47	26 (22-29)	12 (10-14)	14	20	200
Silty Clay Loam	1.40	47	29 (26-32)	13 (11-15)	16	22	220
Sandy Clay	1.45	45	26 (22-30)	14 (12-17)	12	17	170
Silty Clay	1.40	47	33 (29-37)	18 (14-21)	15	21	210
Clay	1.35	49	31 (26-37)	17 (13-21)	14	19	190

(1) Readily available moisture is approximately 75% of total available moisture.
(2) Normal ranges were shown in parentheses.
Source: AIMSAC 1983.

3.1.2 Changeable Characteristics

Non-permanent soil characteristics considered in the soil rating are salinity and sodicity, soil drainage, fertility, and erosion.

A. Salinity and Sodicity

A saline soil is a non-sodic soil containing sufficient soluble salts to impair its productivity (EC_e > 4 dS m^{-1}; SAR < 12). Soil salts induce osmotic pressure in the soil solution and reduce the range of moisture available to plants. Crops have varying levels of tolerance to soil salinity and moisture stress. Once a threshold salinity level is exceeded, crop yield may decline rapidly.

The location of salinity within the soil profile is important with respect to adverse impact. Since crops are believed to take 40% of their water from the upper quarter of the root zone, 30% from the next quarter, 20% from the third quarter, and 10% from the lower quarter, the respective impact of soil salinity would be expected to decline accordingly (Ayers 1977). In other words, the higher salinity of the lower root zone becomes of less importance as long as plants are reasonably well supplied with moisture in the upper "more active" root zone. In addition, as long as a crop can become established, water uptake from non-saline soil zones will be proportionately greater than from saline soil zones (Mass and Hoffman 1977).

Salinity levels may improve under irrigation provided internal drainage of the soil is favorable. However, soils with EC_e levels greater than 6 dS m^{-1} in the surface 0.5 m prior to irrigation generally require improvement prior to irrigation development. Irrigation of such soils may also result in unfavorable relocation and accumulation of salts in lower lying areas.

A sodic soil is a soil that contains sufficient sodium to interfere with the growth of most crop plants (EC < 4 dS m^{-1}; SAR > 12). Northcote and Skene (1972) described a non-sodic soil as having an SAR < 5; a sodic soil as having an SAR between 5 and 12; and a highly or strongly sodic soil as having an SAR $\geq$ 13. High concentrations of sodium in soils lead to eventual deterioration of soil structure, resulting in decreased water infiltration and hydraulic conductivity (Jensen 1980).

B. Soil Drainage

Drainage is an important factor in land classification because of its effect on productive capacity, costs of production, and the costs of land development (U.S. Bureau of Water and Power 1980). Removal of excess water from the root zone is essential in preventing salinization and waterlogging of the soil, since most crop plants have a low salinity tolerance and require an aerated root zone. Satisfactory drainage, either natural or artificial, involves (U.S. Bureau of Water and Power 1980):

- Rapid removal of excess surface water.
- Maintenance of the groundwater level below the root zone.
- Sufficient leaching to maintain the concentrations of soluble salts in the soil solution within a range favorable to plant growth.

The following conventional drainage terms are used in this manual (FAO 1979):

- **Surface drainage** - the removal of water from the surface of the land.
- **Subsurface drainage** - the removal or control of groundwater to maintain it at desired depth for successful crop production.
- **Drainage** - the removal of excess surface and subsurface water.
- **Soil drainage** - the flow of water through the soil, and the frequency and duration of periods when the solum is free of saturation under natural conditions.
- **Internal soil drainage** - that quality of a soil that permits removal of excess water by downward or lateral flow through the soil, subsoil and substrata.
- **Drainability** - the ability of soil and substrata to respond to subsurface drains.

Existing soil drainage problems may be identified by careful field observations. The following generally indicate adverse soil drainage conditions (Maletic and Hutchings 1967):

- Water standing in topographic depressions for prolonged periods.
- Occurrence of salt-affected soils with barren surfaces.
- Soils containing high concentrations of soluble salts in surface layers or having distinct surface crusts.
- Shallow water table.
- Mottling or presence of gleyed horizons.
- Crop symptoms such as stunted growth or late maturity, disease, and shallow root development.
- Presence of halophytic or phreatophytic vegetation.

Recognition of potential drainage problems requires field observations and measurements coupled with careful analysis. In general, a potential drainage problem may exist when (Maletic and Hutchings 1967):

- Soil and substrata have low hydraulic conductivities.
- Soil or unconsolidated substrata consist of textures of fine sandy loam or finer and exchangeable sodium usually greater than 15%.
- Impervious strata or shale or sandstone occur within 3 m or less and demonstrate an unevenly weathered or eroded surface obstructing both lateral and vertical water movement.
- Obstructions to surface drainage occur such as road and railroad embankments.
- Land lies adjacent to large unlined canals.
- Land borders natural drainage channels such as stream bottoms and low terraces.
- Land lies adjacent to lakes and reservoirs whose water elevations may rise sufficiently to unfavorably influence the groundwater levels.
- Irrigation water, groundwater, or both contain an ionic composition that may induce imperviousness in the soil or substrata through chemical reactions.

Drainage problems are often associated with soil salinity. Soil salinity can develop as a result of net upward movement of soil water due to a shallow depth to groundwater. A net downward movement of water may be expected in southern Alberta soils if the water table is at a depth greater than 90 to 100 cm (Van Schaik and Stevenson 1967; Pawluk 1978). Salinization of the top 90 cm of soil may result if water tables lie between 120 and 180 cm (Pawluk 1978).

Maintenance of water tables below 150 cm can prevent salinization of the soil surface (Milne and Rapp 1968).

Depth to groundwater can be used to assess the suitability of land for irrigation development (Table 3.4):

Table 3.4. Irrigation suitability vs depth to groundwater.

Depth to groundwater (m)	Suitability for irrigation
> 2	good
1 - 2	fair
< 1	poor

C. Fertility

Fertility is considered a changeable characteristic. However, it may be a permanent problem if the soil is not amendable to an adequate supply of plant nutrients. Soil fertility is influenced by other factors such as soil profile characteristics, soil texture, geological deposits, salinity, erosion, and drainage. Hence, it is difficult to rate fertility without applying a double deduction. It may be desirable to make provision for rating features that are associated with low fertility such as low content of soil organic matter (not caused by erosion); low content of essential mineral elements, or highly alkaline reaction (pH values > 9.0).

D. Erosion

Soil erosion, either by wind or water, has a very detrimental effect on natural soil fertility. Eroded soils are less fertile and more difficult to manage. Factors considered in evaluating soil erosion include extent of previous erosion and susceptibility to erosion with irrigation development.

3.2 Soil Rating

3.2.1 Soil Categories

Soils are grouped into one of four irrigability categories based on a soil rating calculated from the characteristics discussed in Section 3.1:

Soil category	Final soil rating index
1 - Excellent irrigation capability	72 - 100
2 - Good irrigation capability	46 - 71
3 - Fair irrigation capability	26 - 45
4 - Nonirrigable	$\leq$ 25

The first three categories are considered suitable for irrigated agriculture whereas the fourth category is considered nonirrigable. The final soil rating is determined by calculating a Basic Soil Rating (B.S.R.) from the permanent characteristics - soil profile (P), geological deposit (G) and texture (T) and by modifying the B.S.R. by considering the influence of changeable characteristics.

3.2.2 Basic Soil Rating

The B.S.R. is calculated as follows:

$$\text{B.S.R.} = P \times G \times T, \text{ expressed as indices.}$$

Example: Calculate the B.S.R. of an Orthic Brown Chernozemic soil that has formed in a veneer of moderately coarse-textured (i.e. FSL), fluvial or eolian sediments overlying moderately fine-textured (i.e. CL), morainal sediments. The depths to the "Cca" horizon and the glacial till are 40 cm and 65 cm, respectively.

P = 100. The Orthic Chernozemic profile has a depth greater than 30 cm to "Cca" horizon.
G = 70. This is a variable geological deposit, characterized by a textural change of two classes between the fluvial or eolian veneer and the underlying, morainal sediments.
T = 90. The texture class of the surface is fine sandy loam.

$$\text{B.S.R.} = \frac{100 \times 70 \times 90}{10\,000} = 63$$

This is a good irrigation soil, since the B.S.R. of 63 places it within soil category two.

The ratings for the P, G, and T factors are for the average or normal situation. Slight adjustments can be made to any factor rating when soils have characteristics that vary significantly from the average or normal. Ratings for Brown, Dark Brown, and Black soil series in southern Alberta are in Appendix II.

A. Soil Profile Rating

Determination of the soil (S) rating begins with assignment of a soil profile rating. These ratings are assigned from Table 3.5.

Table 3.5. Ratings for the soil profile factor.[1,2]

Soil order, great group or subgroup, and characteristics	Rating index
Chernozemic soils	
Orthic Chernozemic, > 30 cm to Cca	100
Orthic Chernozemic, 15 to 30 cm to Cca	90
Orthic Chernozemic, < 15 cm to Cca	80
Calcareous Chernozemic	80
Rego Chernozemic	70
Rego and Calcareous Chernozemic, minimal or no structure, coarse	70
Eluviated Chernozemic, ≥ 15 cm to Bt	90
Eluviated Chernozemic, < 15 cm to Bt	80
Solonetzic Chernozemic, ≥ 15 cm to Blocky Btnj	90
Solonetzic Chernozemic, < 15 cm to Blocky Btnj	80
Gleyed Chernozemic[3] (average situation)	70
Solonetzic soils[4]	
Solonetz, very hard and/or massive Bn	30
Alkaline Solonetz	20
Solodized Solonetz, ≥ 15 cm to Bnt	80
Solodized Solonetz, < 15 cm to Bnt	70
Solod, ≥ 15 cm to Bnt	90
Solod, < 15 cm to Bnt	80
Gleyed[3]	30
Regosolic soils	
Regosol	60
Cumulic Regosol	60
Humic Regosol	70
Gleyed[3]	50
Gleysolic soils[5]	
Orthic Humic Gleysol	70
Rego Humic Gleysol	60
Orthic Gleysol	60
Rego Gleysol	50
Orthic Luvic Gleysol	50
Humic Luvic Gleysol	60

(1) Infiltration rate and hydraulic conductivity measurements can be undertaken to supplement evidence of restricted vertical permeability as indicated by morphological features such as gleying and mottling, adverse structure, layering, or presence of a hardpan or fine-textured layers. These measurements may be used as a guide in rating soils for irrigation, although high or low infiltration rates or hydraulic conductivity will generally be associated with other undesirable soil properties already evaluated in the soil profile rating.

(2) Depending on the severity of erosion, eroded soils could be rated either as a Rego Chernozemic or Regosol.

(3) Gleyed soils - Because drainage limitations are variable and can be corrected, adjustments can be made to the rating, depending on the severity of the limitation, and ease with which it can be corrected. Drainage is considered a changeable soil characteristic.

(4) Solonetzic soils - Soil salinity and sodicity are taken into account in section 3.2.3, Modified Soil Rating, using the salinity and sodicity levels of Table 3.9. The depth to a water table (Table 3.11) and the salinity profile (Table 3.9, note 4) are also considered. This could result in an irrigable rating for Solonetzic soils having an SAR less than 12 in the B horizon, provided all other criteria for salinity and sodicity, depth to a water table, and net downward water movement are met.

(5) Gleysolic soils - All are nonirrigable in their natural state. However, if proper drainage is provided, the permanent soil characteristics resulting from the poor drainage must be rated lower than those in the well drained counterpart on similar parent material. Gleysolic soils may crust and bake when drained, making seed bed preparation difficult (Kroven and Heinrichs 1975).

B. Geological Deposit Rating

The geological deposit is an important consideration in the overall soil rating. The parent geological material, in association with topography, biological activity, climate, and time, has given a soil its characteristics. Soil and geological deposit characteristics affect moisture retention and water movement, thereby influencing the depth and frequency of irrigation, and the drainability. Since drainability is determined by soil and substrata characteristics, and in particular, by characteristics of the substrata, it is assessed as part of the geological deposit. The type of geological deposit identified in the field is assigned a rating from Table 3.6.

Table 3.6. Ratings for the geological deposit.

Geological deposit[1, 2, 3]	Rating index
Uniform wind and/or water lain (excluding outwash), gradual texture change[4]	100
Fairly uniform water lain, textural change of 1 class within 1 m	80
Permeable tills (those with Chernozemic profile development)	90
Variable deposits	
(1) Abrupt material change between 50 and 100 cm of surface	
(a) Both upper and lower materials of similar texture	90
(b) Textural change of 1 class between overlay and lower material	80
(c) Textural change of 2 classes between overlay and lower material	70
(d) Textural change of 3 classes between overlay and lower material	60
(2) Abrupt material change within 50 cm of surface. Reduce appropriate rating by 10 units.	
Outwash and variable coarse materials[5]	40
Impermeable sedimentary bedrock within 2 m of the surface[6]	20

(1) The water content of fine-textured soil overlying a coarse layer is greater than that in non-layered soil (Miller and Bunger 1963; Miller 1964). The water holding capacity of very sandy soils may be inadequate for surface methods of irrigation (FAO 1979).

(2) With saline parent material ($EC_e > 8$ dS m^{-1} and/or SAR > 12) present below 1 m, the material rating is reduced by 10 units (i.e. till rated at 90 is reduced to 80).

(3) Hydraulic conductivity less than 1 mm h^{-1} may present difficulties under irrigation and require careful irrigation management.

(4) For rating purposes, use seven textural classes as follows:
(Gr, S) - very coarse; (LS) - coarse; (SL, FSL) - moderately coarse; (L, VFSL, SiL) - medium; (CL, SCL, SiCL) - moderately fine; (SiC, C, SC) - fine; (HC) - very fine.

(5) Variable coarse materials include coarse-textured ice contact deposits, which are often quite variable throughout. Soils with less than 50 cm to gravelly outwash or variable coarse material are rated nonirrigable (soil category 4).

(6) Soil profiles with impermeable sedimentary bedrock within 2 m of the surface are rated nonirrigable (soil category 4). Soil profiles with impermeable sedimentary bedrock between 2 and 3 m of the surface would be placed in soil category 3 or 4, depending on the physical and chemical characteristics of the overburden. Total available moisture holding capacity of the 2- or 3-m profile must be greater than 200 mm for an irrigable rating to be applied.

(1) Impermeable Barrier

The presence of impermeable material or bedrock close to the surface limits the rooting depth of crops and reduces the water holding capacity of the shallow soil profile. Lateral movement of excess water along a barrier may lead to salinization of soils in lower slope positions. Poor drainage conditions, such as a perched water table, may develop and may injure crop roots or lead to salinization of the root zone. See Table 3.6, note 6.

A drainage barrier is defined as any strata which will cause a perched water table to persist, even under careful water management, long enough to seriously harm roots of common crops (FAO 1979). The depth of permeable material through which water can move laterally to a natural or artificial outlet is also limited by such a barrier (FAO 1979). Impermeable barriers within 3 m of the surface must be considered in assessing the potential to develop a high water table and in evaluating the impact of irrigation on non-project areas. The presence of an impermeable barrier within 2 m of the surface should be considered when assessing drainability.

(2) Drainability

Drainability refers to the ability of the soil and the substrata to respond to subsurface drains (FAO 1979). Fly (1961) noted that the generally constant and determining factors of drainability are the hydraulic conductivity of the aquifer zone and depth to barriers.

The zone evaluated for drainability is between 1 and 2 m because drains are generally installed within this zone. The major role of the land classifier in assessing drainability is to estimate the potential of a given geological deposit to permit water movement through the substrata based on hydraulic conductivity and/or associated soil and substrata characteristics.

Hydraulic conductivity gives an indication of the drainability of the substrata. It may be estimated by one of the following field tests:

- auger hole pump-out test (Winger 1956)
- piezometer pump-out test (Hvorslev 1951)
- shallow well pump-in test (U.S. Bureau of Reclamation 1951)

This measurement integrates the combined effects of texture, structure, bulk density, porosity, water holding capacity, and chemical characteristics of both substrata and water on water movement (Maletic and Hutchings 1967).

Morphological descriptions, which emphasize features that influence or reflect permeability, such as presence of gleying or mottling, layering, cleavage planes, and visible pores, are especially desirable in evaluating hydraulic conductivity measurements (FAO 1979; McKeague et al. 1982).

Since it is not always possible to do the field tests, Table 3.7 may be used to obtain an estimate of hydraulic conductivity and drainability. These values are only guides since the hydraulic conductivity, and therefore drainability, varies considerably within each textural group due to the influence of other morphological characteristics, i.e. structure, bulk density, stratification, presence of fractures, and restrictive layers.

The internal drainage of fine-textured, slowly permeable soils may be more of an irrigation and soil management problem than a drainage problem (Fly 1961). Careful irrigation management, for minimum deep percolation losses, allows the possibility of maintaining a suitable crop environment on shallow soils over barriers and on soils having a much lower hydraulic conductivity than commonly acceptable (Fly 1961). Hydraulic conductivity less than 1 mm h^{-1} may present difficulties under irrigation and require careful irrigation management.

Table 3.7. Drainability is a description feature inferred from the most permeable layer in the 1- to 2-m zone.

Map symbol	Drainability	Hydraulic conductivity (mm h^{-1})	Texture
X	Moderately to rapidly permeable	> 10	Gr, S, LS, SL, FSL, L, SiL
Y	Slowly permeable	1 - 10	SCL, CL, SiCL, SiC, C, SC
Z	Relatively impermeable	< 1	Heavy clay and bedrock

Further investigations will be required for drainage design and to assess the feasibility of an on-farm drainage project. Drainage studies may include (Maletic and Hutchings 1967):

- Stratigraphy - thickness, position, continuity, and characteristics.
- Sources of excess water - deep percolation, seepage, hydrostatic pressure from an artesian aquifer.
- Groundwater conditions - position, extent, fluctuation, direction of movement, water quality, and areas of discharge.
- Ground surface - potential outlets, drainage design.

C. Texture Rating

Medium-textured Chernozemic soils developed in uniform deposits are the most desirable for irrigation. The degree to which soil textures deviate from this optimum determines their suitability for sustained irrigated agriculture. Coarse-textured soils are limited by low available moisture holding capacity. An available moisture holding capacity of less than 80 mm m^{-1} identifies a severe limitation to irrigation suitability and management (CDA 1964). Fine-textured soils are less suitable due to slow infiltration and low hydraulic conductivity. Soils having infiltration rates or hydraulic conductivity less than 1 mm h^{-1} are generally considered nonirrigable. Water application rates under sprinkler irrigation can be controlled to partially compensate for low infiltration rates and low hydraulic conductivity.

Ratings for surface soil texture are presented in Table 3.8.

Table 3.8. Ratings for soil texture.

Texture class	Rating index
With normal textural gradients:	
Loam, silt loam, very fine sandy loam	100
Fine sandy loam	90
Clay loam, silty clay loam, sandy clay loam	80
Sandy loam	70
Coarse sandy loam, silty clay, sandy clay	60
Loamy sand, clay	50
Loamy coarse sand, heavy clay	40
Sand	30
Gravel	20

3.2.3. Modified Soil Rating

A. Salinity and Sodicity

Soil salinity and sodicity levels may be determined from Table 3.9.

Table 3.9. Soil salinity and sodicity levels.[1,2]

Salinity-sodicity level	Salinity (EC_e, dS m^{-1})[3,4]			Sodicity (SAR)	
	0-0.5 m[5] "a"	0.5-1 m "b"	1-2 m[6] "e"	0-1 m "n"	1-2 m[6] "m"
1	< 2	< 4	< 8	< 6	< 6
2	< 4	< 8	<12	< 9	< 9
3	< 6	<12	<16	<12	<12
4	< 8	<16	<20	<15	<15
5	<12	<20	<24	<18	<18
6	>12	>20	>24	>18	>18

(1) The degree of salinity and/or sodicity may vary widely within short distances and there may be no clear indication of the area occupied by each salinity/sodicity level. Unless a very detailed mapping and sampling program is carried out, it is impossible to estimate the acreage occupied by each salinity level (CDA 1964).

(2) It is very difficult to accurately predict the amount and extent of salinity that may develop after irrigation water is applied, but some general estimate can be made. Salinity and sodicity levels may improve under irrigation provided internal drainage of the soil profile is favorable.

(3) Soluble salt concentration may change rapidly throughout the growing season when water application and evaporation are at their maximum (Graveland 1970). In irrigated surface soils, EC readings are generally higher in the spring as compared to the fall (Pohjakas 1983). The time of sampling is significant when soluble salt content of the surface soil is being investigated.

(4) Salinity along a profile is a useful indicator of net downward movement of water and salts. Regular soil salinity profiles, where salinity is increasing with depth, indicate net downward water movement. Inverted salinity profiles, where salinity is higher near the surface and decreases with depth, indicate a possible discharge gradient, and possibly a high water table where irrigation could result in an increase in soil salinity.

(5) The 0-0.5-m depth usually refers to the solum (A and B horizons), but also includes the C horizon if present within the upper root zone.

(6) High EC_e and SAR levels at lower depths present a potential salinization hazard under poor irrigation practices, but are primarily a soil and water management consideration. Salinity ("e" factor) and sodicity ("m" factor) at lower depth are evaluated as part of the Geological Deposit under the Basic Soil Rating. Parent material is downgraded if the EC_e is greater than 8 dS m^{-1} and/or the SAR is greater than 12.

The salinity and sodicity of the upper root zone have a profound influence on soil productivity. The salinity (a and b) and sodicity (n) of the root zone are used to modify the B.S.R. (Table 3.10). Salinity (e) and sodicity (m) below the root zone are evaluated with the Geological Deposit.

Table 3.10. Salinity-sodicity modifier.

Salinity-sodicity levels ("a", "b" and/or "n")	Rating index
1	B.S.R. x 100
2	B.S.R. x 90
3	B.S.R. x 70
4 - 6	Soil Category 4

Soil salinity and sodicity levels in each category are useful guidelines in assessing the severity of soil chemical restrictions, however, the chemistry of a given soil unit must finally be assessed in light of the total hydrogeological and pedological environment.

B. Soil Drainage

Soil drainage may also modify the B.S.R. (Table 3.11).

Table 3.11. Soil drainage modifier.

Soil drainage	Rating index
Well to imperfectly drained	B.S.R. x 100
Poorly drained[1,2]	Soil Category 4

(1) Gleysolic soils and soils restricted by the presence of shallow groundwater (less than 1 m).

(2) Solonetzic soils, where the depth to groundwater is less than 3 m under dryland conditions or less than 2 m under irrigation.

3.2.4 Soil Complexes

Soil units, which are mapped as complexes having more than approximately 30% (±10%) nonirrigable soils that are solonetzic, saline, sodic, gleyed, or gleysolic will be rated nonirrigable.

Soil units mapped as complexes having minor occurrence (< 20%) nonirrigable soils, or as complexes of irrigable soils, will be rated by multiplying the proportion of each soil type by its respective soil rating. Rating of nonirrigable portions of a complex should **not** be added to irrigable portions to determine the final soil category.

Example:

Proportion of Unit (%)	*x*	*B.S.R. Index*	*x*	*Modifier(s) Index*	*=*	*Partial Soil Rating Index*
50	*x*	*100*	*x*	*100*	*=*	*50*[Z]
30	*x*	*90*	*x*	*100*	*=*	*27*
20	*x*	*20*	*x*	*90*	*=*	*(4)* ---
				Final Soil Rating	*=*	*77*
				Soil Category	*=*	*1*

$$^{Z}\left(\frac{50 \text{ x } 100 \text{ x } 100}{10\,000} = 50\right)$$

The final category assigned to a given soil unit must satisfy the best judgment of the land classifier.

CHAPTER 4. TOPOGRAPHY CLASSIFICATION

4.1 Topography Categories

Topography classification involves the grouping of land into categories according to surface features, such as: relief; size and shape of fields; earth-moving requirement; stoniness; brush/tree cover; and surface drainage requirements. Topographic features are extremely important in irrigated agriculture since they may determine the choice of irrigation method, as well as affect labor requirements, irrigation efficiency, drainage, erosion, range of possible crops, size and shape of fields, and the cost of land development. Operational expenses also increase with rough surface features, small fields, stoniness or brush/tree cover, and greater surface drainage requirements. These factors are reflected in four topography (T) categories:

Category 1: This category includes all land suitable to develop for gravity or any other method of irrigation.

Category 2: This category identifies land that is suitable for conventional sprinkler irrigation systems in common use in Alberta.

Category 3: This category identifies extremely rolling or hummocky terrain that is only irrigable with specialized sprinkler systems designed to operate on rough ground to minimize runoff and water erosion and to prevent prolonged surface ponding. This category also includes small, irregularly shaped fields that are irrigable with modified conventional sprinkler systems.

Category 4: Land in this category is **not** suitable for irrigation development due to one or a combination of factors, such as: steep slopes, hummocky relief, stoniness, brush/tree cover, small or irregularly-shaped fields, and rough-broken topography.

4.2 Topography Rating

The limiting factors evaluated to arrive at a land development recommendation are:

A. Earth moving (U).
B. Field size, shape, and length of irrigation run (J).
C. Water distribution, slope, and erosion control (G).
D. Stoniness (P) and brush/tree cover (B).
E. Surface drainage (F).

A. Earth Moving (U)

The "U" factor refers to the amount of earth that needs to be moved in land leveling operations and head ditch construction, measured in cubic metres per acre ($m^3\ ac^{-1}$). The following design criteria are used when estimating earth moving:

(1) The side slope is not to exceed 0.3%.
(2) The maximum downfield slope should not exceed 2% for all soil textures. Even though steeper slopes could be irrigated on medium- and coarse-textured soils, the lengths of run required are impractical from a development and farming point of view. Changes in grade should not exceed 0.6%.
(3) The minimum downfield grade for border and furrow irrigation is 0.2% and may be 0% for basin or dead-level irrigation.
(4) The use of partial terraces may be considered to reduce earth-moving requirements during final classification but should not be considered for preliminary classification.

Fields having earth-moving requirements greater than 400 $m^3\ ac^{-1}$ are placed in a sprinkler category (T-2, T-3) or are rated nonirrigable (T-4).

The design criteria are based on designs for border dyke methods of irrigation. Slopes of 0.2 to 2% are usually considered ideal for gravity irrigation. Such slopes reduce the cost of ditches, structures, and labor requirements and do not restrict the choice of crops as compared to steeper sloped land. Slopes greater than 2% are best suited for sprinkler irrigation. A side-roll sprinkler system, for example, will be able to irrigate slopes up to about 9% (T-2). Complex slopes up to 20% or simple slopes up to 30% (T-3) could possibly be irrigated with careful management and special nozzle and system design such as a center pivot designed for rough terrain.

The irrigation of nearly level land (0 to 0.5% slopes), with soil infiltration rates of 8 to 13 mm h^{-1} and where a large flow of water is available, is conducive to high irrigation efficiency. In Alberta, irrigation by the basin method is rare due to the lack of flat land and often the lack of the large volume of water required. To distribute the water uniformly on flat land requires very precise leveling, which can now be done with laser-controlled machines. To create a slope on flat land, earth-moving requirements could be high. For example, to create a slope of 0.1% on flat land requires the movement of 110 to 130 $m^3\ ac^{-1}$ (FAO 1979). Level land with very high infiltration rates may have more uniform water distribution with a sprinkler system.

B. Field Size, Shape, and Length of Irrigation Run (J)

Field divisions are established by grouping similar topography, and by the direction of irrigation run. Field boundaries can be physical or imaginary. Physical boundaries are any permanent feature that will obstruct the flow of water such as a canal, a lateral, a drain, a coulee, a road, buildings, etc. Farm ditches that are easily relocated are not usually field boundaries unless they separate fields of differing topography or direction of irrigation run. Imaginary boundaries are used to separate fields with differing topography, direction of irrigation run, or slope where no physical boundaries exist.

More efficient irrigation is possible with less labor where irrigation runs are parallel to field boundaries. Irrigation and farming efficiencies are increased on large fields with uniform lengths of run. Fields should be rectangular or square, rather than triangular or some other irregular shape.

The irrigation run is the maximum downfield distance in any field a design stream of water travels and fills the root zone, without excessive runoff and/or deep percolation. The length of irrigation run depends on soil texture, slope, and method of irrigation. Table 4.1 illustrates the relationship between the length of run, slope, and texture. In general, a coarse-textured soil will require a shorter length of run than a medium- and fine-textured soil, respectively.

The length of run is considered as if the field has been developed. If the length of run is variable, the average length of run is estimated. The minimum length of run and field size necessary for a field to be classified suitable for gravity irrigation (T-1) are 110 m and 5 ac, respectively. Rectangular-shaped fields at least 20 ac in size are desirable for efficient sprinkler irrigation (T-2). Fields 5 to 20 ac in size or of irregular shape and suitable only for sprinkler irrigation development are downgraded to T-3 since conventional irrigation equipment has to be modified to achieve satisfactory coverage and/or irrigation requirements are increased significantly.

Table 4.1. Maximum irrigation run (m) and water application (mm) as related to soil texture and slope for sod-forming crops.

Texture	Maximum water application (mm)	% Slope 0.5	1.0	1.5	2.0
		Length of run (m)			
Fine to moderately fine (C, SC, SiC, SCL, CL, SiCL)	125	580	500	400	320
Medium to moderately coarse (FSL, VFSL, L, SiL)	100	570	440	310	270
Coarse to moderately coarse (CS, VFS, LCS, LVFS, SL)	50	360	180	150	110

Source: Spiess 1983.

Fields with extremely irregular shape, small size, short runs, steep slopes, difficult to farm or gain access to, or with other obviously undesirable features are classified nonirrigable (T-4).

Fields less than 5 ac, adjacent to or within a larger area of differing class, but not separated by a physical field boundary (i.e. canal), may be classified as part of the larger area. Highly contrasting units, i.e. sloughs, wetlands, depressions subject to ponding, large knolls that cannot be developed with the surrounding area or units that the classifier feels are significant may be separated out even though they are less than 5 ac.

C. Water Distribution, Slope, and Erosion Control (G)

Structures are required to control the distribution of irrigation water and to prevent erosion in ditches. The requirement for drop and diversion structures to do this is basically determined by the downfield slope. The greater the downfield slope, the higher is the potential for erosion and the need for structures. The maximum downfield slope for gravity irrigation is 2%.

D. Stoniness (P) and Brush/Tree Cover (B)

The classifier must consider to what extent the amount of stones present will hinder cultivation and land development.

Six phases of stoniness are defined on the basis of the percentage of the land surface occupied by fragments coarser than 15 cm in diameter (SCWG 1998):

> **Nonstony phase:** No stones or too few stones are present to interfere with cultivation (less than 0.01% of surface, stones more than 25 m apart).
>
> **Slightly stony phase:** Some stones are present that hinder cultivation slightly or not at all (0.01 - 0.1% of surface, stones 8 - 25 m apart).
>
> **Moderately stony phase:** Enough stones are present to cause some interference with cultivation (0.1 - 3% of surface, stones 1 - 8 m apart).
>
> **Very stony phase:** There are sufficient stones to handicap cultivation seriously; some clearing is required (3 - 15% of surface, stones 0.5 - 1 m apart).
>
> **Exceedingly stony phase:** The stones prevent cultivation until considerable clearing is done (15 - 50% of surface, stones 0.1 - 0.5 m apart).
>
> **Excessively stony phase:** The land surface is too stony to permit cultivation; it is boulder or stone pavement (more than 50% of surface, stones less than 0.1 m apart).

Exceedingly and excessively stony fields are rated nonirrigable (T-4). Exceedingly stony fields may be upgraded to an irrigable category with removal of stones. Consideration also has to be given to the presence of high densities of coarse fragments less than 15 cm in diameter and the presence of shallow bedrock, which may interfere with land development.

Brush and tree removal may be classified in a similar manner.

E. Surface Drainage (F)

The "F" factor gives an indication of the severity of the surface drainage problem anticipated after irrigation development. It is based on the depth of cut required to construct a drainage ditch to remove excess irrigation water. The type of ditch required for the surface drains is based on a "V" ditch with 5:1 side slope for cuts up to and including 0.9 m and a 0.6 m flat bottom ditch with a 2:1 side slope for cuts over 0.9 m. The maximum depth of cut for an open drain is 1.2 m for land to be considered suitable for gravity irrigation.

Minor ponding problems are remedied with land leveling operations. Where there is no drainage outlet the excess water may be reused for irrigation through lift pumping. A dugout or existing low area could be used to collect the excess irrigation water.

Table 4.2 may be used to obtain the final topography category.

Table 4.2. Specifications for the topography rating.

Map symbol	Limiting factors	Topography categories: 1-Gravity	2-Sprinkler	3-Sprinkler	4-Nonirrigable
U	Earth moving (m^3 ac^{-1})	< 400	> 400	> 400	DOES NOT MEET MINIMUM REQUIREMENTS OF CATEGORY 3
J	Length of run (m)	> 110	not rated	not rated	
	Field size (ac)	> 5	> 20	> 20 rough terrain 5-20 small field	
	Field shape[1,2]	Regular	Regular	Irregular	
G	Maximum downfield slope (%)	2	9 simple or complex	20 complex 30 simple	
	Minimum downfield slope (%)	0.2	not rated	not rated	
P	Stoniness (% of surface covered)	< 15	< 15	< 15	
B	brush/tree cover (% of surface covered)	< 15	< 15	< 15	
F	Surface drainage, depth of cut (m)[3]	< 1.2	> 1.2	> 1.2	

(1) Regular refers to rectangular, square, or circular shape.

(2) Topography category 2 may have irregular shape if the field is > 20 acres.

(3) Excess depth of cut for an open drain will not constitute a nonirrigable limitation.

CHAPTER 5. LAND CLASSIFICATION

The land class indicates the general capability of land for irrigation use in its present state. Land classes are based upon the rating and assessment of soil and topographic features that affect the suitability of land for irrigation. The land class represents a grouping of sub-classes that have the same relative degree of limitations or hazards for irrigation use. Land within a land capability class is alike, or nearly alike, in its potential to be developed and in its response to a similar level of management. Seven land classes are recognized in the land classification system for irrigation in Alberta. The limitations or hazards become progressively greater from Class 1 to Class 6. Land in Class 1 to Class 4 is suitable for irrigation. Class 5R is temporarily irrigable, undergoing reclamation. Class 5 is a nonirrigable provisional class. Class 6 identifies the nonirrigable land.

5.1 Land Classes

Class 1 - Irrigable: Land in this class is excellent for irrigated agriculture with no significant limitations. Class 1 land is capable of producing a sustained and a relatively high yield of a wide range of climatically adapted crops. The soils are of a medium texture, well drained, and hold adequate available moisture. Harmful accumulations of soluble salts are absent. Class 1 land is level to nearly level. This class is suitable for irrigation by gravity **and** sprinkler methods.

Class 2 - Irrigable: Land in this class is good irrigation land with moderate limitations. A narrower range of crops or slightly more input to development and management may be required for Class 2 land than for Class 1. The limitations of Class 2 land are less acceptable than those of Class 1. They can be maintained or possibly improved with proper management. The soils in this class may have low hydraulic conductivity due to fine texture or adverse structure. The available water holding capacity may be lower as reflected by the coarser texture or limited soil depth. Salinity levels may be low to moderate. Drainability may be somewhat restricted. Class 2 land may be level to gently sloping or undulating to hummocky. Land in this class is suitable for irrigation by gravity and sprinkler methods **or** by sprinkler methods only.

Class 3 - Irrigable: Land in this class is fair for irrigation. Limitations of this land under irrigation are moderately severe. The deficiencies may be due to either a serious single factor or a combination of several limitations in soil and/or topographic features. The soils may be inferior because of excess salinity, sodicity, very low hydraulic conductivity, or low water holding capacity. Subsurface drainability or surface drainage may be restricted. The range of crops that could consequently be grown may be restricted. A greater management input, such as light, frequent irrigations or more intensive soil conservation and improvement practices, may be required than for Class 2 land. Class 3 land may be level to hummocky. Land in this class is suitable for irrigation by gravity and sprinkler methods **or** by sprinkler methods only.

Class 4 - Irrigable (restricted): Land in this class has severe limitations for irrigation and requires special crop, soil, and water management practices. Limitations of Class 4 land may include moderate to strong slopes or small irregularly shaped fields. Class 4 land is suitable for irrigation with a special irrigation system design to minimize runoff and water erosion and prevent prolonged surface ponding.

Class 5R - Temporarily irrigable (undergoing reclamation): Land undergoing reclamation after the implementation of an appropriate improvement, such as drainage or canal lining. Class 5R land shall be added to the assessment roll as acres subject to a terminable agreement, for the purpose of promoting reclamation. Class 5R land shall be reviewed after the land has undergone reclamation for five irrigation seasons, after which the land shall be upgraded to an irrigable class (Class 1, 2, 3, or 4) if it meets the requirements, or remain as Class 5R for an additional 5 years. If significant improvement has not been achieved within a 10-year period to upgrade the land to an irrigable class, then the land shall be rated Land Class 6, nonirrigable, and the terminable water agreement shall be discontinued. Land in this class is suitable for irrigation by gravity and sprinkler methods **or** by sprinkler methods only.

Class 5 - Nonirrigable (pending): Land in this class is considered not suitable for irrigation under existing conditions, but has sufficient potential to warrant segregation for additional investigation or improvement. The limitations of Class 5 may include one, or more, of the following: poor drainability, a high water table, very poor soil structure, and excess salinity and/or sodicity.

Two subclasses are recognized in LAND CLASS 5:

1. Class 5 - Nonirrigable, pending a more detailed investigation. Limitations are such that a more detailed soil, drainability or land development feasibility study may be required.
2. Class 5 - Nonirrigable, pending the implementation of an improvement. An improvement such as canal lining or improved surface or subsurface drainage may be required to upgrade this land to an irrigable class or Class 5R.

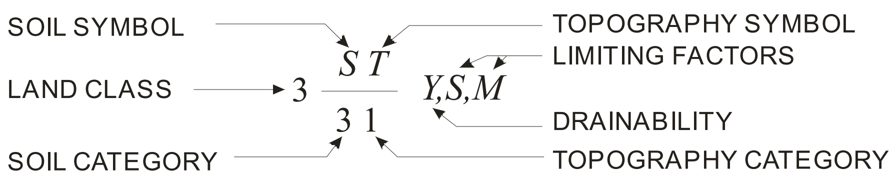
Class 5 is a tentative land class - changed to either an irrigable class or rated Class 6, nonirrigable, upon completion of the detailed study or implementation of an improvement. The topography of this land may range from level to moderately sloping, simple, or complex slopes.

Class 6 - Nonirrigable: This class may consist of steep, rough-broken, or badly eroded land, or land having soils of very poor structure, very coarse texture, excess salinity and/or sodicity, poor drainage, shallow soils over gravel or bedrock, or other deficiencies not feasible to improve. Class 6 land may also include Land Classes 1 to 5, which cannot be separated out due to small size, the intensity of the investigation, or the purpose of the project.

5.2 Land Class Determination

The land class is determined by combining the soil category (S) and the topography category (T). Drainability is part of the soil rating and is identified by X, Y, or Z.

Land Class Symbol



All combinations of "S" and "T" are categorized as follows:

Class 1: Excellent capability with no significant limitations for irrigation.

$1\,\frac{S\,T}{1\,1}$

Class 2: Good capability with moderate limitations for irrigation.

$2\,\frac{S\,T}{1\,2}$ $2\,\frac{S\,T}{2\,1}$ $2\,\frac{S\,T}{2\,2}$

Class 3: Fair capability with moderately severe limitations for irrigation.

$3\,\frac{S\,T}{3\,1}$ $3\,\frac{S\,T}{3\,2}$

Class 4: Restricted capability requiring a special system design and/or special management.

$4\,\frac{S\,T}{1\,3}$ $4\,\frac{S\,T}{2\,3}$ $4\,\frac{S\,T}{3\,3}$

Class 5R: Temporarily irrigable, undergoing reclamation. Class 5R land may be the subject of a terminable water agreement for the purpose of promoting reclamation.

$5R\ \frac{S\ T}{4\ 1}$ $5R\ \frac{S\ T}{4\ 2}$ $5R\ \frac{S\ T}{4\ 3}$

Class 5: Nonirrigable, pending a detailed investigation or implementation of an improvement. Land within this class may be upgraded to an irrigable class or will be rated Class 6.

$5\ \frac{S\ T}{4\ 1}$ $5\ \frac{S\ T}{4\ 2}$ $5\ \frac{S\ T}{4\ 3}$

Class 6: Nonirrigable.

$6\ \frac{S\ T}{4\ 1}$ $6\ \frac{S\ T}{4\ 2}$ $6\ \frac{S\ T}{4\ 3}$ $6\ \frac{T}{4}$

CHAPTER 6. LAND CLASSIFICATION PROCEDURES AND SPECIFICATIONS

This chapter describes the general procedure followed when a request for land classification is received and the general steps taken during pre-investigation activities, soil profile descriptions, laboratory analyses, and field inspections.

6.1 General Procedures

6.1.1 Pre-investigation Activities

Initial activities undertaken for land irrigability classification involve review of the following information:

- Available soil survey maps and reports.
- Pleistocene geology, bedrock geology, and bedrock topography maps.
- Previous land, soil, drainage, or topography classification within or adjacent to the project.
- Previous drilling, lab analyses, infiltration, and hydraulic conductivity tests.

Sampling sites for drilling and coring are selected through aerial photo interpretation. Site locations may be altered in the field to be sure the sites are representative of land units.

Support staff involved in drilling, laboratory analyses, drafting, and typing are notified as to time requirements and priorities. Landowners involved in a project are notified as to when the field work is to be carried out and necessary arrangements are made.

6.1.2 Soil Profile Descriptions

Representative soil profiles are described and sampled. The intensity of sampling depends on the level of investigation. The soil profile is described according to the Canadian System of Soil Classification (SCWG 1998). Soil profile descriptions include common horizon sequences, soil texture (hand), soil structure, gleying, soil color, effervescence, parent geological material, moisture status, and presence and type of bedrock. Site features such as slope class, land use, erosion, and stoniness are also noted. The soil profile is sampled according to horizons and depths, with representative samples taken from 0-0.5, 0.5-1.0 and 1.0-2.0 m.

6.1.3 Lab Analyses

Routine chemical analyses include determination of the percent saturation, pH, electrical conductivity, and soluble cations of the saturation paste extract (Rhoades 1982). The sodium adsorption ratio (SAR) is calculated.

Particle-size distribution (Gee and Bauder 1986) and water-holding capacities (Oosterveld and Chang 1980; Gardner 1986; Klute 1986; Topp 1993; Topp et al. 1993;) may be determined on selected soil samples.

6.1.4 Field Inspection

Land classifiers perform field inspections using data obtained from the field and laboratory investigations to delineate the various land class units. A sufficient number of shovel digs are included to establish that logged core and drill sites are representative of land class units. Topography ratings and field boundaries are identified through visual observation and use of available topographic information and aerial photographs.

6.2 Investigation Intensity Levels

Five levels of investigation are used when classifying land for sustained irrigated agriculture. Level I is the highest intensity, with the most detailed procedures and results in the most precise map. Level V is the lowest intensity, with the least detailed procedures and gives a generalized map. Different areas within one project may be mapped at different intensities because of previous work completed, the need for more detail, or the lack of time and money to carry out a more intensive investigation. When projects are identified as to their intensity level, the user knows how the investigation was carried out, the precision of the maps and how appropriate it may be for his purpose. Definitions of individual intensity levels include such parameters as:

A. Purpose
B. Bases of investigation
C. Inspection density
D. Map and report information
  - Scale of maps
  - Area of mapping
  - Mapping and reporting procedures

The inspection density refers to the number of soil inspections made relative to the area mapped. It is an average for the map. A soil inspection is a profile examination used by the pedologist or classifier to differentiate soil and land class units. The topography is rated at the same time. At a soil investigation site, a soil profile may be exposed with a shovel or a hand auger. A hydraulically-powered drill may also be used to examine and sample a soil profile and geological material to a 2- or 3-m depth. Road cuts or exposed embankments may also be examined. These investigation sites may, or may not, be sampled. The amount of sampling to be carried out depends on the pedologist and the purpose of the classification.

The required inspection density will vary according to the variability and predictability of soil pattern and according to the experience of the classifier. Uniform areas of good quality may require less inspection and sampling sites than generally recommended. Complex areas or areas that are questionable or have severe limitations will require a greater density of inspection and sampling sites. More information is often required in the complex and questionable areas to help the classifier reach a decision. If a soil survey has been previously completed in an area, the number of inspection sites may also be reduced.

It is generally recommended that there be one inspection site per cm^2 of final map scale with an acceptable range of 0.2 to 2 inspections per cm^2 (MSWG 1981). For example, at a scale of 1:20,000, 1 cm^2 of map area represents approximately 10 ac (Table 6.1). The inspection density at this scale will range from 1 site per 5 ac to 1 site per 50 ac or from 3 to 30 inspection sites per 160 ac.

The scale of the published map is determined by the minimum size field delineation. The minimum size field delineation is either (MSWG 1981):

(1) The smallest delineation inside which a simple map unit symbol can be printed, or,
(2) The smallest area that can easily be discerned by the map user.

The practical minimum size delineation ranges from 0.5 to 1 cm^2 of map area. The area represented by 0.5 to 1 cm^2 on the map corresponds to the minimum delineation required for the purpose of the classification. On a map having a 1:20,000 scale, 0.5 and 1 cm^2 represent 5 and 10 ac, respectively. At 1:5,000, it represents 0.3 and 0.6 ac, respectively, in the field. The minimum map delineation is only used for **strongly contrasting units** such as sloughs or saline areas. The actual field area represented at various scales is presented in Table 6.1 (MSWG 1981).

Table 6.1. Acres on ground represented by various sized areas on maps of different scales.

Map area (cm^2)	Map scales					
	1:5 000	1:10 000	1:20 000	1:40 000	1:50 000	1:100 000
0.25	0.15	0.6	2.5	10	15	62
0.50	0.30	1.2	5.0	20	31	124
1.00	0.60	2.5	10.0	40	62	247
5.00	3.00	12.0	49.0	198	309	1 235
10.00	6.00	25.0	99.0	395	617	2 469

(1 ac = 0.405 ha)

Published maps may be a smaller scale than the original or field maps. The area mapped shall not be smaller than 0.5 cm^2 when reduced for publication.

6.2.1 Level I (Very high intensity

A. Purpose

This level may be used to obtain information for:

(1) Classification of land for irrigation where soils are extremely variable.
(2) Land classification for selection of sites to monitor soil management and/or reclamation.
(3) Land classification for selection of research sites.

B. Bases of Investigation

(1) Existing information: previous land classification, soil survey reports, surficial geology maps, geology maps, and groundwater level records.
(2) Aerial photograph interpretation.
(3) Soil profile morphology and site description.
(4) Ground truthing.
(5) Soil chemical and physical data.

C. Inspection Density

Investigation density is at least twenty (20) sites per 160 ac. At least sixteen (16) investigation sites should be sampled to a depth of 1 to 2 m. Deep drilling inspection to 3 m is at least one site per 160 ac. In case of shallow, sloping or contorted bedrock and/or a shallow subsurface water table (3 m or less), more deep drilling sites are usually inspected to satisfy the investigation.

D. Map and Report Information

(1) Scale of Maps: 1:5,000 or larger
(2) Area of Mapping: 0.5 ac for soil units and 2.5 ac for topographic units.
(3) Map and Report: The map shall show the following information:
  (a) Physical land features; e.g. water bodies, rock exposures, sloughs, etc.
  (b) Cultural land features; e.g. roads, canals, farmsteads. Temporary or movable objects are not considered.
  (c) Land classification units identified by boundaries and described accordingly.
  (d) Land irrigability classification expression.

An accompanying report usually contains a description of the land classification units and recommendations for land management and/or improvement under irrigation.

6.2.2 Level II (High intensity)

A. Purpose

This level may be used for:

(1) Determination of acres to be irrigated as specified by the Irrigation Districts Act; as input to agricultural feasibility reports required under the Water Act for the licensing of private irrigation projects that obtain water from outside irrigation district works; as input when developing wastewater irrigation projects; and also for other purposes identifying land suitable for irrigation.
(2) Guide for proper land management under irrigation and increased production.
(3) Guide for land upgrading and improvement.

B. Bases of Investigation

(1) Existing information: previous land classification, soil survey reports, surficial geology maps, bedrock geology maps and groundwater level records.
(2) Aerial photograph interpretation.
(3) Soil profile morphology and site description.
(4) Ground truthing.
(5) Soil chemical and physical data.

C. Inspection Density

Investigation density is at least 10 soil investigation sites per 160 ac of land. A minimum of three 2-m and one 3-m deep sites shall be described and sampled per 160 ac. A minimum of one 3-m site and one 2-m site shall be described and sampled for parcels 40 acres or less. The purpose of the 3-m site is to check for shallow bedrock and a water table. If shallow bedrock or a shallow subsurface water table are present, more 3-m sites are required.

Solonetzic landscapes will require a higher intensity of investigation (Table 6.2). Additional 1-m inspection sites are required to characterize Solonetzic landscapes.

Table 6.2. Minimum soil sampling and investigation sites for Solonetzic landscapes.

Area investigated (acres)	Soil sampling site depth			Total
	1 m	2 m	3 m[1]	
≤ 40	1	2	1	4
40 - 80	3	2	1	6
81 - 100	4	2	2	8
101 - 160	7	2	3	12

[1] More 3-m holes are required if shallow bedrock or a water table are found or suspected.

Soil samples shall be taken for standard chemical analyses to represent the 0 to 0.5, 0.5 to 1 and the 1 to 1.5 m depths in the minimum number of required sampling sites. Soil samples in Solonetzic landscapes shall be taken within the B horizon to determine whether a soil is classified in the Solonetzic order, and within the upper and lower C horizons to determine whether the salinity profile is regular (salinity and sodicity increase with depth) or inverted (salinity and sodicity are higher near the surface). A minimum of four sites per 160 ac should be inspected and sampled to a depth of 2 m. Deep drilling inspection to 3 m is at least one site per 160 ac of land. In case of shallow, sloping or contorted bedrock and/or shallow subsurface water table (3 m or less), more sites are usually inspected to satisfy the investigation.

D. Map and Report Information

(1) Scale of Maps: 1:5,000 to 1:20,000
    Water rights within irrigation districts - 1:5,000
    Waste water irrigation requirements - 1:5,000
    Agricultural feasibility reports - 1:5,000, 1:10,000, or 1:20,000
(2) Area of Mapping: 2 ac for soil units and 10 ac for topographic units.
(3) Map and Report: The map shall show the following information:
    (a) Physical land features; e.g. water bodies, rock exposures, sloughs, etc.
    (b) Cultural land features; e.g. roads, canals, farmsteads. Temporary or movable objects are not considered.
    (c) Land classification units identified by boundaries and described accordingly.
    (d) Land irrigability classification expression.

An example of a Level II soil and land classification map is shown in Figure 7.1. The Level II land classification map is accompanied by a report containing a description of the land classification units and recommendations for land management and/or improvement under irrigation (Figures 7.2a and 7.2b).

6.2.3 Level III (Medium intensity)

A. Purpose

This level may be used for:

(1) Feasibility studies for irrigation development in new areas.
(2) Studies for conveyance systems improvement and rehabilitation.
(3) Planning for irrigation expansion and canal extension.

B. Bases of Investigation

(1) Existing information: previous land classification, soil survey reports, surficial geology maps, bedrock geology maps, and groundwater level records.
(2) Aerial photograph interpretation.
(3) Soil profile morphology and site description.
(4) Ground truthing.

(5) Soil chemical and physical data.

C. Inspection Density

Investigation density is 3 soil investigation sites per 160 ac, including at least one inspection and sampling site to a depth of 2 m per 160 ac. Deep drilling inspection to 3 m is at least one site per 640 ac of land. In case of shallow, sloping, or contorted bedrock and/or shallow subsurface water table (3 m or less), more sites are usually inspected to satisfy the investigation. Boundaries are checked in the field at intervals but mainly extrapolated from aerial photographs.

D. Map and Report Information

(1) Scale of Maps: 1:10,000 to 1:40,000 (usually 1:20,000)
(2) Area of Mapping: 5 to 10 ac for soil units and 40 ac for topographic units.
(3) Map and Report: The map shall show the following information:
  (a) Physical land features; e.g. water bodies, rock exposures, sloughs, etc.
  (b) Cultural land features; e.g. roads, canals, urban areas. Temporary or movable objects are not considered.
  (c) Land classification units identified by boundaries and described accordingly.
  (d) Land irrigability classification expression.
  (e) Number of acres in different irrigability classes (as required).

The report shall describe all areas under investigation, rather than each parcel of land as in Level I and II. The report must satisfy the purpose of the investigation and contain all necessary information and recommendations.

6.2.4 Level IV (Low intensity)

A. Purpose

This level may be used for:
(1) Long range planning for irrigation development.
(2) Policy decisions in regard to irrigated agriculture.

B. Bases of Investigation

(1) Existing information: previous land classification, soil survey reports, surficial geology maps, bedrock geology maps, and groundwater level records.
(2) Aerial photograph interpretation.
(3) Soil profile morphology and site description.
(4) Ground truthing.
(5) Soil chemical and physical data.

C. Inspection Density

Investigation density is at least 2 investigation sites per 640 ac of land, one of which is described and sampled to 2 m. Deep drilling inspection to 3 m is at least one site per four sections of land. In case of shallow, sloping, or contorted bedrock and/or shallow subsurface water table (3 m or less), more sites are usually inspected to satisfy the investigation. Nearly all boundaries are extrapolated from aerial photographs.

D. Map and Report Information

(1) Scale of Maps: 1:40,000 to 1:100,000
(2) Area of Mapping: 40 ac for soil units and 160 ac for topographic units.
(3) Map and Report: The map shall show the following information:
  (a) Physical land features; e.g. water bodies, rock exposures, sloughs, etc.
  (b) Cultural land features; e.g. roads, canals, urban areas. Temporary or movable objects are not considered.
  (c) Land classification units identified by boundaries and described accordingly.
  (d) Land irrigability classification expression.
  (e) Number of acres in different irrigability classes (as required).

The report shall describe all areas under investigation, rather than each parcel of land as in Level I and II. The report must satisfy the purpose of the investigation and contain all necessary information and recommendations.

6.2.5 Level V (Exploratory)

A. Purpose

This level is based solely on existing information and serves as a preliminary assessment of the irrigation potential of an area. This investigation may lead to the need for an investigation at a higher intensity level. It must not be considered final or used for any of the purposes listed under Level I to IV.

B. Bases of Investigation

(1) Existing information: previous land classification, soil survey reports, surficial geology maps, bedrock geology maps, and groundwater level records.
(2) Aerial photograph interpretation.
(3) Field observation.

C. Inspection Density

No investigation and sampling sites are considered. All boundaries are extrapolated from aerial photographs, existing soil information, and field observations.

D. Map and Report Information

(1) Scale of Maps: Any
(2) Area of Mapping: Any
(3) Map and Report: The map and report shall show information dependent upon available sources and the purpose of the investigation.

CHAPTER 7. MAPPING PROCEDURES AND LEGEND

A soil inventory is required before a land classifier can rate land as to its suitability for irrigation. This soil information may be obtained from an existing soil survey map or by performing a soil survey. Soil map units can be described as follows (Section 7.2, 7.3, and 7.4):

O.DB; DB.SZ

Mu^5: $Lv^4/Mlu^5/R$ 2-3

$a_2b_1n_2e_2m_3$

R_2

The first line describes the soil taxonomy to the subgroup level.

O.DB	=	Orthic Dark Brown is dominant (>80%).
DB.SZ	=	Dark Brown Solonetz is a minor inclusion (<20%).

The second line describes the parent geological material, the surface expression, the textural class, and the slope class.

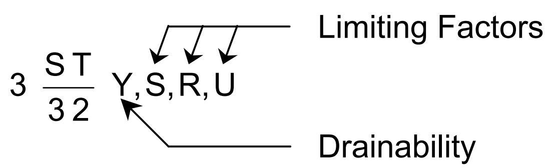
Mu^5	=	dominant parent material is morainal with undulating surface expression and the textural class is 5 (clay loam, sandy clay loam, silty clay loam).
$Lv^4/Mlu^5/R$	=	significant occurrence of a veneer (<1 m) of textural class 4 (loam, silt loam, very fine sandy loam) lacustrine parent material overlying morainal deposits that are underlain by shallow bedrock. Surface expression of the morainal deposit is level (l) to undulating (u).
2 - 3	=	slope class 0.5 to 5%.

The third line indicates the levels of salinity and sodicity (Table 3.9).

The last line describes the depth to bedrock or a water table.

R_2	=	depth to bedrock is between 2 and 3 m.

Soil and topography are rated and combined to obtain a land class. The land class description may appear as follows:



The land class description and the soil description may be combined or presented separately. The acreage of the land class unit is calculated. The final description of a unit may look like this:

$$3\ \frac{S\,T}{3\,2}\ Y, S, R, U$$

O.DB; DB.SZ

Mu^5: $Lv^4/Mlu^5/R$ 2-3

$a_2b_1n_2e_2m_3$

R_2

7.1 Land Class Limitations

The following abbreviations are used to indicate the most limiting factors for a particular land class. The most limiting factor for the land class unit is placed immediately after the drainability rating (Table 3.7) followed by the next most limiting factor. Land class units that contain a soil category 1 or topography category 1 rating would not be given any soil or topography limitation, respectively.

A. Soil Limitations

A **A combination of minor soil limitations.** A combination of minor limitations in soil profile, geological deposit, and/or surface texture.

D **Low permeability/undesirable structure.** Low permeability due to fine soil texture (i.e. clay, silty clay, or heavy clay) and/or undesirable structure, (i.e. Solonetzic soils). These soils are difficult to till, absorb water slowly or the depth of the rooting zone is restricted.

E **Erosion damage.** Previous damage from erosion limits agricultural use of the land. Erosion damage may be severe enough that lime is commonly exposed or is closer to the surface than in adjacent, non-eroded land.

I **Periodic flooding.** Periodic flooding or inundation by streams or lakes limits agricultural use.

K **Shallow profile development.** Soil profiles tend to be thin and lime occurs at shallow depths.

L **Geological layering.** An abrupt material change or variable geological deposit may affect water movement.

M **Low moisture-holding capacity.** Coarse-textured soils with low clay content impose restrictions in water management due to the relatively low water-holding capacity and rapid infiltration rate.

N **Sodicity.** Soils containing sufficient sodium to adversely affect plant growth and soil physical properties (SAR greater than 6).

R **Shallowness to bedrock or saprolite.** Depth to bedrock or saprolite less than 3 m from the surface.

S **Salinity.** Soils contain sufficient soluble salts to reduce their productivity (EC_e greater than 2 dS m^{-1}).

W **Excess wetness.** Excess water, other than flooding, limits agricultural use. The presence of water may be due to poor drainage, high water table, seepage and runoff from surrounding areas.

B. Topography Limitations

B **Brush and/or tree cover.** More than 15% of the undeveloped surface area is covered with brush or trees that require removal prior to development.

F **Surface drainage.** An indication of surface water ponding after an anticipated irrigation development. A cut estimated to be greater than 1.2 m would likely be required to drain a landscape with this limitation.

G **Steep slopes.** 2% limit for surface irrigation, 20% complex slopes, and 30% simple slopes are limits for sprinkler irrigation. Generally used for irrigable land with complex slopes of 10 to 15% and simple slopes up to 20%; and with Class 6, nonirrigable land having complex slopes greater than 20% and simple slopes greater than 30%.

J **Field size, shape, and length of irrigation run.** The small size and irregular shape of the field limits development to sprinkler irrigation, although the topography may be level enough to develop for gravity irrigation. Fields should be rectangular or square rather than of an irregular shape. The minimum length of run for gravity irrigation is 110 m. The minimum field size for gravity or sprinkler irrigation is 5 ac.

P **Stoniness.** Sufficient stones and/or gravel are present to hinder or prevent cultivation. More than 15% of the surface area is covered with stones having diameters over 15 cm. Stones are less than 0.5 m apart. This limitation may be used if gravel is present within 30 cm of the surface.

RB **Rough-broken.** Land with steep topography and numerous intermittent drainage channels (gullies, coulees, etc.) that are not practical to develop for irrigation.

U **Earth-moving requirement.** Identifies land that is not suitable for gravity irrigation due to a high earth-moving requirement. This topography is limited to sprinkler irrigation development only.

7.2 Soil Abbreviations

A. Soil Taxonomy

A	- Alkaline	E	- Eluviated	R	- Rego
B	- Brown	G	- Gleysol	R	- Regosol
BL	- Black	GL	- Gleyed	SS	- Solodized Solonetz
CA	- Calcareous	HG	- Humic Gleysol	SO	- Solod
CU	- Cumulic	HR	- Humic Regosol	SZ	- Solonetz
DB	- Dark Brown	LG	- Luvic Gleysol	SZ	- Solonetzic
DG	- Dark Grey	O	- Orthic		

See the Canadian System of Soil Classification (ACECSS 1987; SCWG 1998) for additional abbreviations.

B. Soil Phases

alk	-	alkaline
calc	-	calcareous
carb	-	carbonated
er	-	eroded
gr	-	gravelly
li	-	lithic
sa	-	saline
st	-	stony

C. Soil Textural Classes

0 - Gravel
1 - Sand
2 - Loamy sand
3 - Sandy loam, fine sandy loam
4 - Loam, silt loam, very fine sandy loam
5 - Clay loam, sandy clay loam, silty clay loam
6 - Silty clay, clay, sandy clay
7 - Heavy clay

D. Physical and Chemical Parameters

(1) Drainability rating of X, Y, or Z must accompany land class designation.
X - rapidly to moderately permeable
Y - slowly permeable
Z - relatively impermeable

(2) Depth to Groundwater

Rating	Depth (m)
W_1	> 2
W_2	1 - 2
W_3	< 1

Ratings greater than 1 are included in the description.

(3) Depth to Bedrock (R) or Saprolite (S)

Rating	Depth (m)
R_1 S_1	> 3
R_2 S_2	2 - 3
R_3 S_3	1 - 2
R_4 S_4	< 1

Ratings greater than 1 are included in the description.

(4) Salinity and sodicity[1,2] (Table 3.9)
a - salinity between 0 and 0.5 m
b - salinity between 0.5 and 1 m
n - sodicity between 0 and 1 m
e - salinity between 1 and 2 m
m - sodicity between 1 and 2 m

NOTE 1. To describe the chemistry of an individual sampling site, the a, b, n, e, and m are determined by the most limiting values encountered in the profile.

NOTE 2a. To describe a complex soil where two distinct soil chemical profiles are inseparable, the chemistry of the two components can be described as being significant (:) or minor occurrence (;).

Examples: (i) $a_1b_1n_1e_1m_1$ $a_1b_1n_1e_1m_2$

$a_4b_3n_3e_2m_4$

$a_1b_1n_1e_1m_2$ $a_1b_1n_1e_1m_2$

Description: $\mathbf{a_1b_1n_1e_1m_2; a_4b_3n_3m_4}$

(ii) $a_4b_1n_1e_1m_2$ $a_1b_3n_1e_2m_2$
$a_1b_1n_1e_1m_2$
$a_1b_1n_3e_1m_2$ $a_1b_1n_1e_1m_4$

Description: $\mathbf{a_1b_1n_1e_1m_2; a_4b_3n_3m_3}$

NOTE 2b. If the variation spans adjacent parameter levels (e.g. e_1 and e_2), then the most limiting value is used.

7.3 Landform Abbreviations and Symbols

A. Genetic Material

(Adapted from ACECSS 1987; Nikiforuk 1998; SCWG 1998) (See also Section 3.1.1(B))

A **Anthropogenic:** These materials are artificial or modified by people and include those associated with mineral exploitation and waste disposal.

C **Colluvial:** Massive to moderately well stratified, nonsorted to poorly sorted sediments with any range of particle sizes from clay to boulders and blocks that have reached their present position by direct, gravity-induced movement.

E **Eolian (adj.):** Descriptive of materials transported and deposited by air (wind)

F **Fluvial (adj.):** Descriptive of material transported and deposited by flowing water.

L **Lacustrine (adj.):** Descriptive of material that have either settled from suspension in bodies of standing fresh water or have accumulated at their margins through wave action.

M **Morainal (adj.):** Descriptive of unstratified materials transported and deposited directly by glacier ice. A variable mixture of sand, silt, clay, and boulders.

R **Rock:** Undifferentiated bedrock deposits.

S **Saprolite (residual):** Bedrock weathered in situ.

U **Undifferentiated:** Accumulation of unconsolidated deposits where differentiation is impractical.

B. Surface Expression

(Adapted from ACECSS 1987; SCWG 1998)

a **Apron:** A relatively gentle slope at the foot of a steeper slope and formed by materials from the steeper, upper slope.

b **Blanket:** A mantle (more than 1 m thick) of one genetic material overlying another. The mantle still generally conforms to the topography of the underlying material.

f **Fan:** A fan-shaped form similar to the segment of a cone and having a perceptible gradient from the apex to the toe.

h **Hummocky:** Abounding in regular, rounded or conical knolls, mounds or other small elevations and irregular depressions. Slopes generally greater than 5%.

i **Inclined:** Areas with a pronounced slope, usually continuous in one direction throughout the entire unit.

l **Level:** A relatively flat area having few or no prominent surface irregularities.

m **Rolling:** A regular, smooth, wave-like pattern with slope length often one mile or greater and gradients greater than 5%.

r **Ridged:** A long, narrow elevation of the surface, usually sharp crested with steep slopes.

s **Steep:** Areas with a pronounced slope, usually greater than 30%.

t **Terraced:** A large bench or step-like area breaking the continuity of a horizontal or gently inclined surface.

u **Undulating:** A regular, smooth, wave-like pattern with slope length generally less than 0.8 km. Slopes from 2 to 5%.

v **Veneer:** A thin covering (less than 1 m thick) of one genetic material over another.

C. Slope Classes

The slope classes are defined as follows (adapted from SCWG 1998):

Slope class	Slope (%)	Terminology
1	0 - 0.5	Level
2	0.5 - 2	Nearly level
3	2 - 5	Very gentle slopes
4	6 - 9	Gentle slopes
5	10 - 15	Moderate slopes
6	16 - 30	Strong slopes

7.4 Abundance Designations

When describing complex soils and landforms in a map unit, components are considered **dominant** if they occupy over 60% of the unit, **significant** from 20 to 40%, and **minor** if they occupy less than 20%. Minor components are described only if they are highly contrasting. The following designations may be used when describing complex soil and landform units:

~ nearly equal ~ nearly equal
: dominant (> 60%) : significant (20 to 40%)
; very dominant (> 80%) ; minor (< 20%)
- range

The nearly equal symbol (~) is used to describe a unit having approximately equal occurrence of two different or contrasting soils (e.g. O.DB   DB.SZ). The range symbol (-) is used to describe units having a catena of similar soils (e.g. O.DB - R.DB).

An example of a land classification for water rights, completed to a Level II intensity is illustrated in Figure 7.1, Figure 7.2(a) and 7.2(b).

A soil map of the investigated area may also be prepared (Figure 7.3(a) and 7.3(b)).
Land classification for irrigation feasibility to a Level III intensity is illustrated by Figure 7.4(a) and 7.4(b).

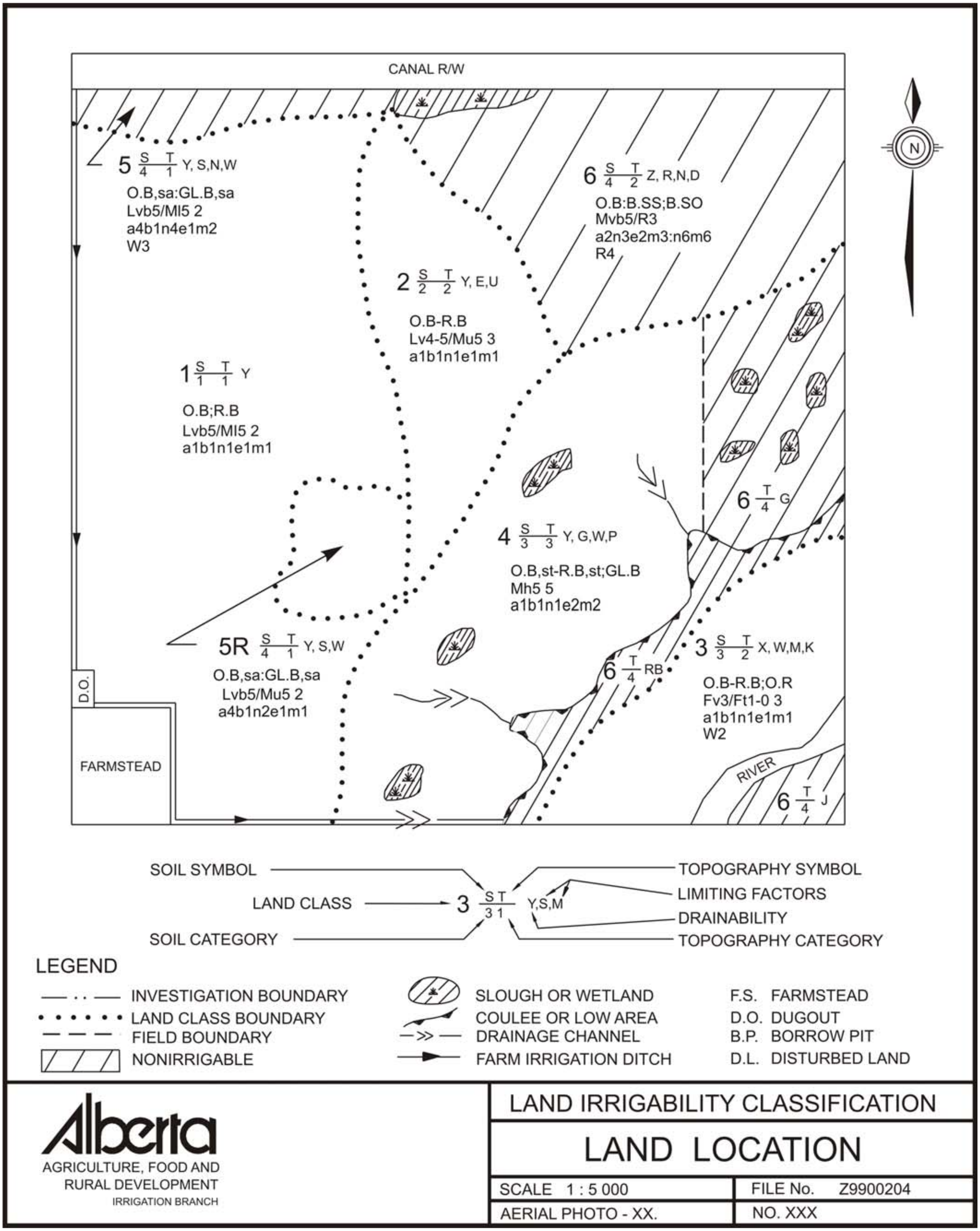


Figure 7.1. Level II soil and land classification for irrigation map (not to scale).

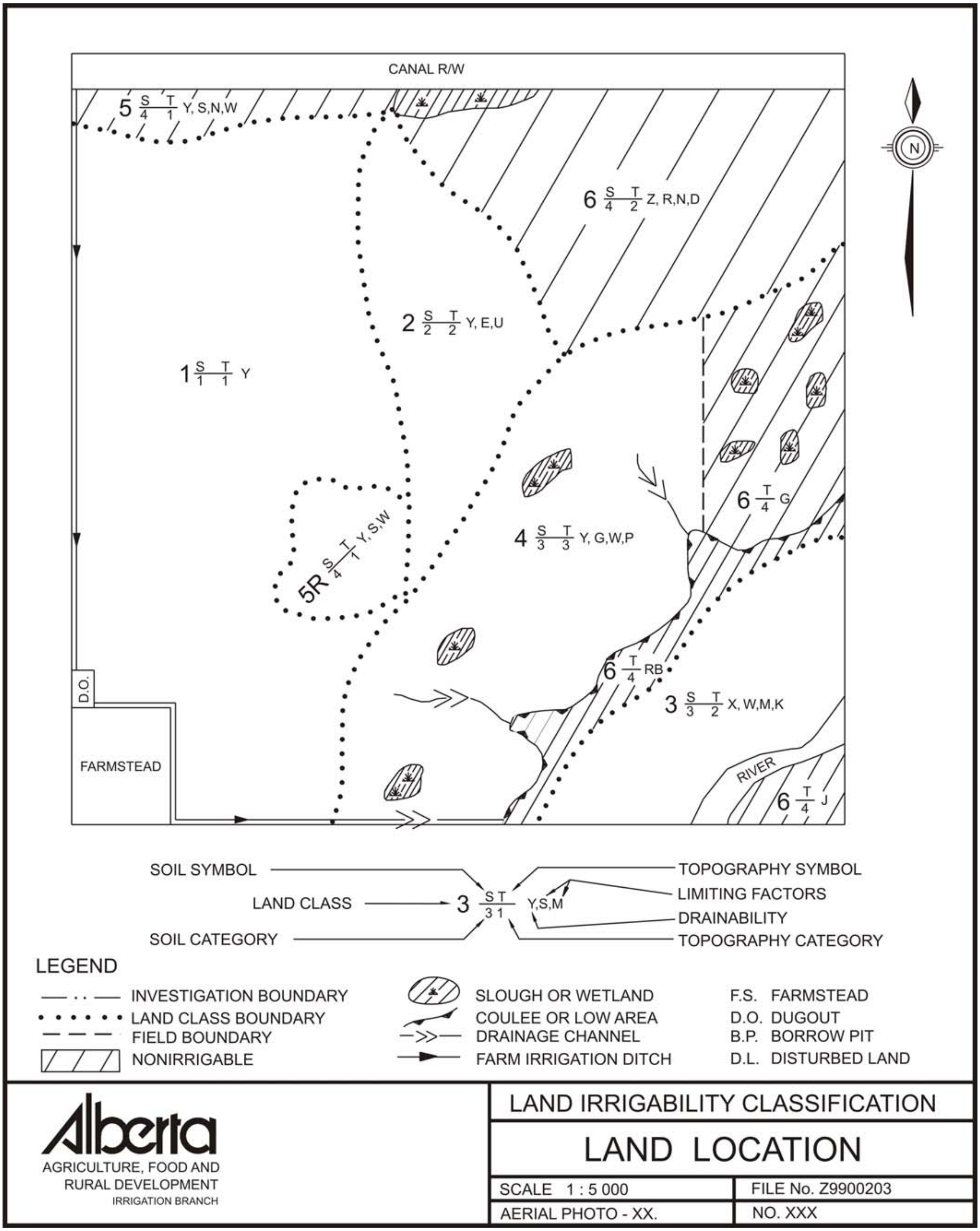


Figure 7.2(a). Level II land classification for irrigation map (not to scale).

Legend

Land Classes
1 - Excellent irrigation capability
2 - Good irrigation capability
3 - Fair irrigation capability
4 - Restricted irrigation capability
5R - Temporarily irrigable, undergoing reclamation
5 - Nonirrigable, pending further study
6 - Nonirrigable

Soil Categories
1 - Irrigable - Excellent
2 - Irrigable - Good
3 - Irrigable - Fair
4 - Nonirrigable

Topography Categories
1 - Irrigable - Gravity
2 - Irrigable - Sprinkler
3 - Irrigable - Special System
4 - Nonirrigable

Soil Limitations
A - combination of minor soil limitations
B - brush/tree cover
D - low permeability/undesirable structure
E - erosion damage
K - shallow profile development
L - geological layering
M - low moisture holding capacity
N - sodicity
R - shallowness to bedrock
S - salinity
W - excessive wetness

Topography Limitations
F - surface drainage
G - steep slopes
I - periodic flooding
J - field size, shape
P - stoniness
RB - rough-broken
U - earth moving

Drainability
X - moderately to rapidly permeable
Y - slowly permeable
Z - relatively impermeable

Remarks

The majority of this quarter is suitable for irrigation development. The Class 1, 2, 3, and 4 areas are suitable for irrigation. The Class 5R area is temporarily irrigable, undergoing reclamation. The Class 5 and 6 land is rated nonirrigable. The Class 5 land has potential to be upgraded to an irrigable class, pending implementation of an improvement.

$1\frac{S\ T}{1\ 1}Y$ Excellent irrigation capability. The soils are dominantly Orthic Brown with a minor occurrence of Rego Brown. They have developed in less than 1 m to greater than 1 m of clay loam to sandy clay loam lacustrine, underlain by clay loam till. The topography is nearly level and is suitable to be developed for gravity or sprinkler methods of irrigation. Considerable earth moving would be required if developed for gravity irrigation.

$2\frac{S\ T}{2\ 2}Y,E,U$ Good irrigation capability. The soils are Orthic Brown to Rego Brown, developed in less than 1 m of loam to clay loam lacustrine, underlain by clay loam till. They are nonsaline but are limited for irrigation by their shallow profile development, mainly as a result of erosion (E). The topography is gently undulating, suitable for sprinkler irrigation only.

$3\frac{S\ T}{3\ 2}X,W,M,K$ Fair irrigation capability, suitable for sprinkler irrigation only. The soils in this river flat are Orthic to Rego Brown with a minor occurrence of Orthic Regosol, developed in less than 1 m of fine sandy loam, underlain by sand and gravel. They are limited for irrigation by the presence of a water table (W) at approximately 1.5 m, low water holding capacity (M) and shallow depth to lime (K). The topography is very gently undulating with 2 to 5% slopes.

Figure 7.2(b). Level II legend, description, and recommendations.

$4\frac{ST}{33}$ Y,G,W,P	Restricted irrigation capability due to steep, complex slopes of 10 to 15%. The soils are dominantly Orthic to Rego Brown, stony with a minor occurrence of Gleyed Brown, developed in clay loam to sandy clay loam hummocky till. The imperfectly drained Gleyed Brown soils are located in depressions. A special system design is required to prevent runoff, erosion and ponding in depressions. A low rate of water application is essential.
$5R\frac{ST}{41}$ Y,S,W	Temporarily irrigable, pending the outcome of reclamation. Subsurface drainage has been installed to reclaim this area. The soils are moderately saline and sodic.
$5\frac{ST}{41}$ Y,S,N,W	Nonirrigable, pending a more detailed investigation and implementation of reclamation measures. The soils are nonirrigable due to shallow groundwater at less than 1 m below the surface (W) and excessive salinity (S) and sodicity (N).
$6\frac{ST}{42}$ Z,R,N,D	Not suitable for irrigation due to shallow bedrock (R) at approximately 1 m, and Solonetzic soils that are saline and sodic (N), and slowly permeable due to poor soil structure (D).
$6\frac{T}{4}$ G, $6\frac{T}{4}$ J, $6\frac{T}{4}$ RB	Nonirrigable due to steep complex slopes (G), the small size and irregular shape of the field (J) and rough-broken topography (RB).

STATISTICAL SUMMARY (acres, approximately)

Irrigable:	102	Farmstead and Dugout:	3
Temporarily Irrigable:	4	Canal R/W:	7.4
Nonirrigable:	42	River:	1

PREPARED ______________________ **LOCATION**________________________________

REVIEWED ______________________ **DATE** _________________________________

Figure 7.2(b). Level II legend, description, and recommendations, continued.

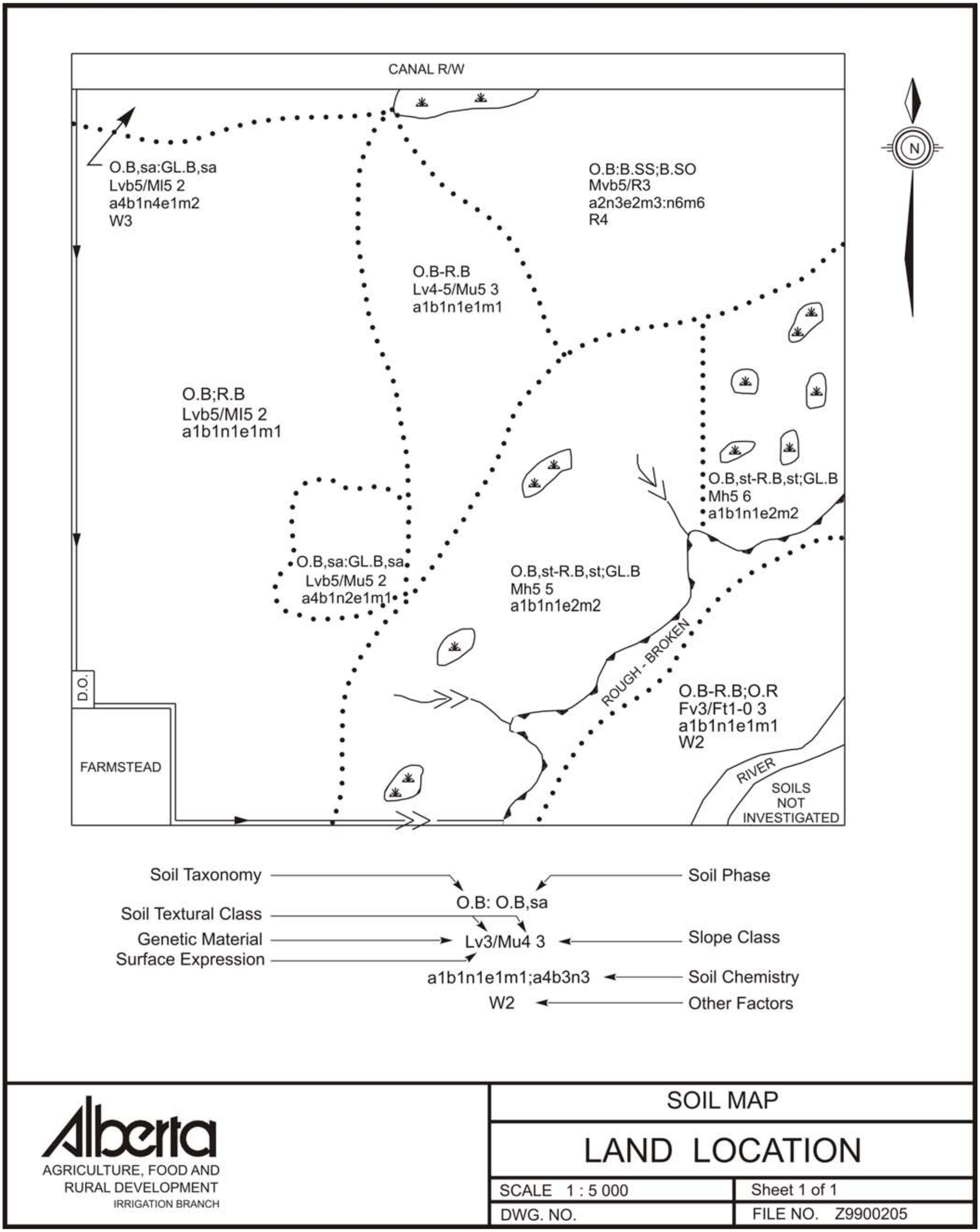


Figure 7.3(a). Level II soil map (not to scale).

LEGEND

SOIL TAXONOMY

B....Brown	O...Orthic
DB..Dark Brown	R...Rego
DG..Dark Grey	CA..Calcareous
BL..Black	E...Eluviated
G....Gleysol	SZ..Solonetzic
HG..Humic Gleysol	GL..Gleyed
R....Regosol	CU..Cumulic
HR..Humic Regosol	A...Alkaline
SS..Solodized Solonetz	
SO..Solod	
SZ..Solonetz	

SOIL PHASES

alk...alkaline
calc..calcareous
carb..carbonated
er....eroded
gr....gravelly
li....lithic
sa....saline
st....stony

GENETIC MATERIAL

A....Anthropogenic
C....Colluvial
E....Eolian
F....Fluvial
L....Lacustrine
M....Morainal(Till)
R....Bedrock
S....Saprolite(Residual)
U....Undifferentiated

SURFACE EXPRESSION

a....apron	s....steep
b....blanket	t....terraced
f.....fan	u....undulating
h....hummocky	v....veneer
i.....inclined	
l.....level	
m...rolling	
r.....ridged	

TEXTURE

0....Gravel
1....Sand
2....Loamy Sand
3....Sandy Loam, Fine Sandy Loam
4....Loam, Silt Loam, Very Fine Sandy Loam
5....Silty Clay Loam, Clay Loam Sandy Clay Loam
6....Silty Clay, Clay, Sandy Clay
7....Heavy Clay

SLOPE CLASS	PERCENT SLOPE	TERMINOLOGY
1	0 - 0.5	Level
2	0.5 - 2	Nearly Level
3	2 - 5	Very gentle slope
4	6 - 9	Gentle slope
5	10 - 15	Moderate slope
6	16 - 30	Strong slope

DEPTH TO GROUNDWATER

CATEGORY	DEPTH (m)
W1	>2
W2	1-2
W3	<1

DEPTH TO BEDROCK(R) OR SAPROLITE(S)

CATEGORY		DEPTH (m)
R1	S1	>3
R2	S2	2-3
R3	S3	1-2
R4	S4	<1

ABUNDANCE DESIGNATIONS

~ nearly equal occurrence
: significant
- range
; minor occurrence

[— ·· — ··] INVESTIGATION AREA BOUNDARY
[· · · · · · ·] SOIL BOUNDARY
[— — ·] FIELD BOUNDARY
[slough symbol] SLOUGH
[coulee symbol] COULEE OR LOW AREA
[—>>—] DRAINAGE CHANNEL
[—►—] FARM IRRIGATION DITCH
F.S. FARMSTEAD
D.O. DUGOUT
B.P. BORROW PIT

Soil salinity and sodicity levels

Salinity-Sodicity Level	Salinity (ECe,dS/m) 0-0.5 m "a"	0.5-1 m "b"	1-2 m "e"	Sodicity (SAR) 0-1 m "n"	1-2 m "m"
1	< 2	< 4	< 8	< 6	< 6
2	< 4	< 8	< 12	< 9	< 9
3	< 6	< 12	< 16	< 12	< 12
4	< 8	< 16	< 20	< 15	< 15
5	< 12	< 20	< 24	< 18	< 18
6	> 12	> 20	> 24	> 18	> 18

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Figure 7.3 (b). Level II soil map legend.

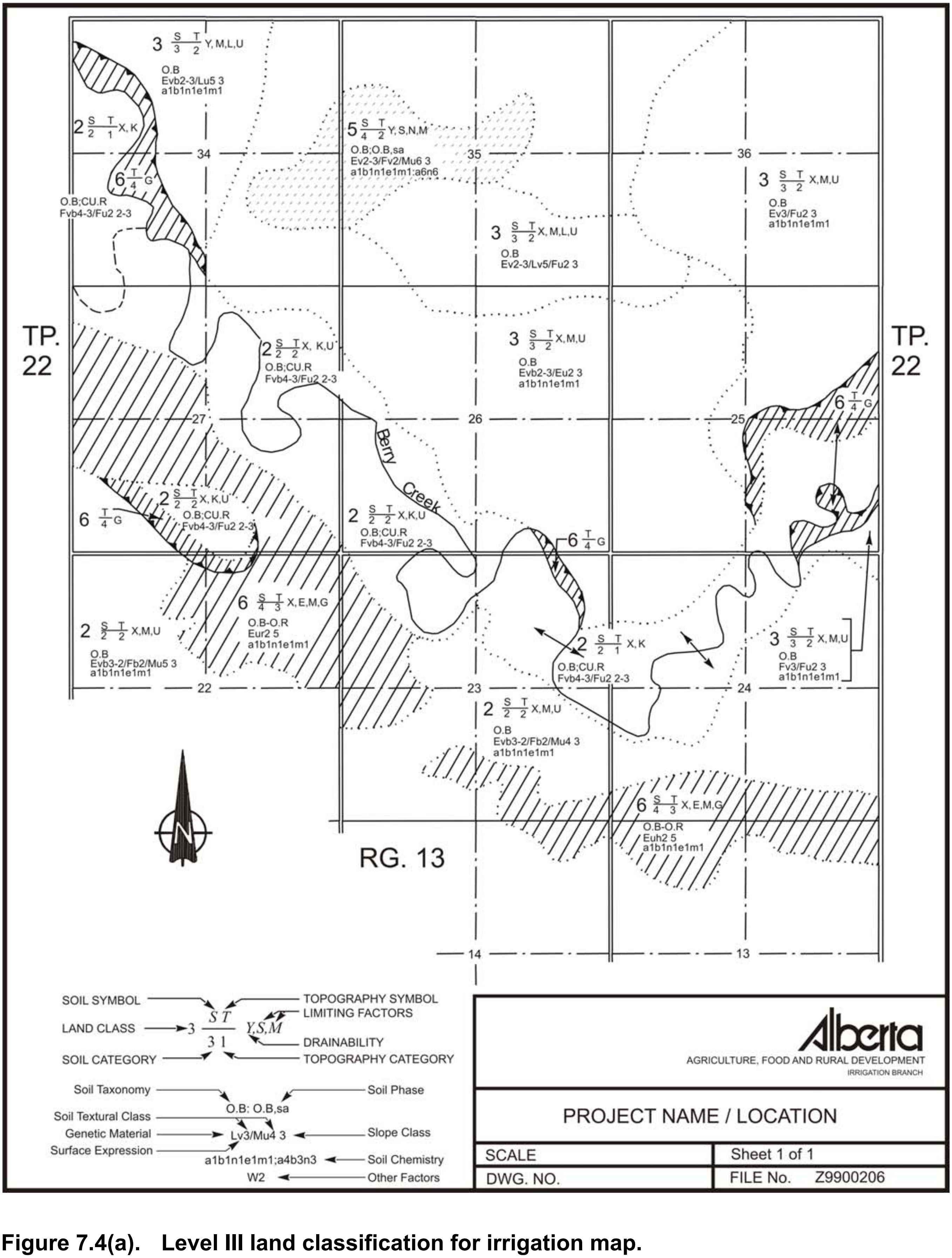

Figure 7.4(a). Level III land classification for irrigation map.

LEGEND

LAND CLASSES

- 1 : Excellent capability with no significant limitations for irrigation.
- 2 : Good capability with moderate limitations for irrigation.
- 3 : Fair capability with moderately severe limitations for irrigation.
- 4 : Restricted capability requiring a special system design and/or special management.
- 5 : Nonirrigable pending detailed investigation, implementation of an improvement and/or undergoing reclamation. Land within this class may be upgraded to an irrigable class or will be rated Class 6.
- 6 : Nonirrigable.

SOIL CATEGORIES

1...Irrigable-Excellent
2...Irrigable-Good
3...Irrigable-Fair
4...Nonirrigable

TOPOGRAPHY CATEGORIES

1...Irrigable-Gravity
2...Irrigable-Sprinkler
3...Irrigable-Special system design
4...Nonirrigable

DRAINABILITY

X...Moderately to rapidly permeable
Y...Slowly permeable
Z...Relatively impermeable

SOIL LIMITATIONS

A...combination of minor soil limitations
D...low permeability/undesirable structure
E...erosion damage
K...shallow profile development
L...geological layering
M...low moisture holding capacity
N...sodicity
R...shallowness to bedrock
S...salinity
W...excessive wetness

TOPOGRAPHY LIMITATIONS

B....brush/tree cover
F....surface drainage
G....steep slopes
I.....periodic flooding
J....field size, shape
P....stoniness
RB..rough-broken
U....earth moving

SOIL TAXONOMY

B....Brown
DB..Dark Brown
DG..Dark Grey
BL..Black
G....Gleysol
HG..Humic Gleysol
R....Regosol
HR..Humic Regosol
SS..Solodized Solonetz
SO..Solod
SZ..Solonetz

O...Orthic
R...Rego
CA..Calcareous
E...Eluviated
SZ..Solonetzic
GL..Gleyed
CU..Cumulic
A...Alkaline

SOIL PHASES

alk...alkaline
calc..calcareous
carb..carbonated
er....eroded
gr....gravelly
li....lithic
sa....saline
st....stony

GENETIC MATERIAL

A....Anthropogenic
C....Colluvial
E....Eolian
F....Fluvial
L....Lacustrine
M....Morainal(Till)
R....Bedrock
S....Saprolite(Residual)
U....Undifferentiated

SURFACE EXPRESSION

a....apron
b....blanket
f.....fan
h....hummocky
i.....inclined
l.....level
m...rolling
r.....ridged
s....steep
t....terraced
u....undulating
v....veneer

TEXTURE

0....Gravel
1....Sand
2....Loamy Sand
3....Sandy Loam, Fine Sandy Loam
4....Loam, Silt Loam, Very Fine Sandy Loam
5....Silty Clay Loam, Clay Loam Sandy Clay Loam
6....Silty Clay, Clay, Sandy Clay
7....Heavy Clay

SLOPE CLASS	PERCENT SLOPE	TERMINOLOGY
1	0 - 0.5	Level
2	0.5 - 2	Nearly Level
3	2 - 5	Very gentle slope
4	6 - 9	Gentle slope
5	10 - 15	Moderate slope
6	16 - 30	Strong slope

MAP SYMBOLS

- INVESTIGATION AREA BOUNDARY
- SOIL BOUNDARY
- FIELD BOUNDARY
- SLOUGH
- COULEE OR LOW AREA
- DRAINAGE CHANNEL
- FARM IRRIGATION DITCH
- F.S. FARMSTEAD
- D.O. DUGOUT
- B.P. BORROW PIT

DEPTH TO GROUNDWATER

CATEGORY	DEPTH (m)
W1	>2
W2	1-2
W3	<1

DEPTH TO BEDROCK(R) OR SAPROLITE(S)

CATEGORY		DEPTH (m)
R1	S1	>3
R2	S2	2-3
R3	S3	1-2
R4	S4	<1

ABUNDANCE DESIGNATIONS

~ nearly equal occurrence
: significant
- range
; minor occurrence

Soil salinity and sodicity levels

Salinity-Sodicity Level	Salinity (ECe,dS/m) 0-0.5 m "a"	0.5-1 m "b"	1-2 m "e"	Sodicity (SAR) 0-1 m "n"	1-2 m "m"
1	< 2	< 4	< 8	< 6	< 6
2	< 4	< 8	< 12	< 9	< 9
3	< 6	< 12	< 16	< 12	< 12
4	< 8	< 16	< 20	< 15	< 15
5	< 12	< 20	< 24	< 18	< 18
6	> 12	> 20	> 24	> 18	> 18

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Figure 7.4(b). Level III land classification for irrigation legend.

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APPENDICES

Appendix I. Water Quality

Water in streams and lakes contains dissolved substances, which have an effect on water suitability for irrigation. Most irrigation waters in Alberta originate in the Rocky Mountains and flow eastward through numerous streams from which water is diverted for irrigation. These waters are usually of good quality and are well suited for watering crops.

The quality of irrigation waters is considered in terms of the levels and ratios of dissolved constituents as they affect soil and plant growth. Even good quality irrigation water adds soluble salts to the soil during an irrigation season. For example, an application of 300 mm of irrigation water having 250 ppm soluble salt content, adds 310 kg of soluble salts per ac. Irrigation, without leaching, results in a gradual increase of the soluble salt content in the root zone.

Guidelines for Irrigation Water Quality
Graveland, D.N. 1983. Agdex 562-1 (Revised)

The irrigated acreage in Alberta has increased rapidly since the mid 1960's. A substantial proportion of the new acreage is the result of the development of individual projects that rely on water sources independent of organized irrigation projects where water quality is known. Individual projects may use a great variety of water sources with a corresponding variety of chemical characteristics.

In general, the quality of water from major surface streams is suitable for irrigation, while the quality of groundwater and sloughs is often not acceptable. It is, therefore, important to determine the suitability of the irrigation water in advance of other investigations.

There are a number of substances present in irrigation water, which could be detrimental or toxic to plants; however, these substances are generally of insufficient concentration in non-polluted water to warrant concern.

The parameters of general concern in relation to water quality for irrigation are as follows:

- **Electrical conductivity (E.C.):** This measurement is a reliable indicator of the total dissolved solids (salts) content of the water. The addition of irrigation water to soils adds to the salt concentration. Concentration of these salts will result in an increase in osmotic potential in the soil solution interfering with the extraction of water by the plant. Toxic effects may also result with an increase in salinity.

- **Sodium Adsorption Ratio (SAR):** This measurement is an indicator of the sodium hazard of water. Excess sodium in relation to calcium and magnesium concentration in soils destroys soil structure reducing permeability of the soil to water and air. Sodium may be toxic to some crops.

$$SAR = \frac{Na^{+}}{\left(\frac{Ca^{+2} + Mg^{+2}}{2}\right)^{1/2}}$$ Cations are expressed as $mmoles_c\ L^{-1}$

- **Boron**: This element is very toxic to most crops at levels of only a few parts per million. Fortunately, excess natural boron in soils and water has not been a problem in Alberta.

- **Bicarbonate:** Excess bicarbonate concentration is considered hazardous in some areas and not in others. Waters of high bicarbonate concentrations have been used for many years with no adverse effects in Alberta.

In view of the preceding, only two parameters are of concern when irrigating with natural waters. The limits for these parameters are as follows:

	SAFE	POSSIBLY SAFE	HAZARDOUS
EC (dS m^{-1})	< 1.0	1.0 - 2.5	> 2.5
SAR	< 4	4 - 9	> 9

The limits in column 1 are considered safe for all conditions. The limits in column 2 are considered safe for some conditions. Decisions should be based on the advice of a specialist. The limits in column 3 are considered hazardous for almost all conditions.

Conditions to be assessed when dealing with waters in column 2 are as follows:

- **Climate of the area:** The moisture deficit dictates the amount of water applied and consequently the amount of salt applied.

- **Crops:** Crops with high consumptive use require more irrigation water, which again results in higher salt applications.

- **Irrigation Practices:** Light, frequent irrigation results in less leaching than less frequent high water applications. Light, frequent irrigation results in more evaporation. Fall irrigation results in increased leaching.

- **Internal drainage:** Good internal drainage facilitates rapid leaching of salts out of the root zone.

Proposed projects with irrigation water quality in column 2 require more investigation and the services of a specialist to assess the conditions briefly discussed above.

Water Quality of Southern Alberta Rivers and Reservoirs

Information related to water quality is regularly collected by the agencies of the federal and provincial governments.

Water quality is generally best in the mountains during spring snowmelt but deteriorates as the season progresses and as the distance from the mountains increases. Evaporation from rivers and reservoirs tends to concentrate the total dissolved solids (TDS) in irrigation waters. As the original water quality is usually excellent, the concentration of soluble salts during the season has only a marginal influence on the water quality. This change can be significant, however, in shallow, stagnant bodies of water, some of which are being used as the source of irrigation water (Etzikom Coulee, Yellow Lake, etc.).

Tables I-1 and I-2 show mean water quality values, which are all suitable for irrigation. Water obtained from other sources such as lakes, sloughs, ponds and wells should be tested before plans for irrigation are finalized. For problem water bodies, it is advisable to use a mean value of several samples taken during the irrigation season. If it is not possible, water quality should be projected into the future. As the time of testing has an influence on water quality, the sampling date has to be recorded each time water samples are collected. A sample taken in the spring can be very misleading.

Table I-1. Mean water quality for southern Alberta rivers, January 1990 to March 1999.[1]

	EC[2] (µS cm^{-1})	Total dissolved solids (mg L^{-1})	Dissolved sodium (mg L^{-1})	Dissolved calcium (mg L^{-1})	Dissolved magnesium (mg L^{-1})	Bicarbonate (mg L^{-1})	Carbonate (mg L^{-1})	SAR
BOW RIVER, Cochrane								
Mean	318	173	2.5	43.3	12.9	154.3	0.7	0.08
Minimum	254	132	0.2	30.9	10.1	127	0.3	0.007
Maximum	429	205	7	53.5	16.5	185.3	7.2	0.24
Number of samples	51	33	109	109	109	110	111	109
BOW RIVER, Ronalane								
Mean	399	235	13.9	46.5	15.6	166.6	1.5	0.45
Minimum	286	180	4.9	29.8	10.3	115	0.3	0.18
Maximum	536	294	27.5	65	20.6	234	10.4	0.86
Number of samples	51	34	111	111	111	111	111	111
BOW RIVER, Carseland								
Mean	373	212	9.3	46.2	13.8	166.1	0.6	0.31
Minimum	275	148	3.4	33.2	10	121	0.3	0.12
Maximum	487	282	38.3	59.8	17.6	199	14.3	1.33
Number of samples	51	34	111	111	111	111	111	111
OLDMAN RIVER, Lethbridge								
Mean	373	215	14.4	41.6	15.5	182.8	1.8	0.48
Minimum	175	143	3.8	15.6	4.9	58	0.3	0.16
Maximum	582	302	29.7	60.2	23	283	12.3	0.94
Number of samples	234	79	235	235	235	235	235	235
SOUTH SASKATCHEWAN RIVER, Medicine Hat[3]								
Mean	397	236	17.6	44.7	16.9	174.9	1.4	0.57
Minimum	308	185	7.8	34.6	13.2	138	0.3	0.26
Maximum	463	297	24.7	65.8	20.6	224	9.4	0.83
Number of samples	15	15	15	15	15	15	15	15

(1) Alberta Environment. 2000. Water quality database (WDS). Water Quality Section, Water Sciences Branch, Alberta Environment, Edmonton, Alberta.

(2) Electrical conductivity measured in lab, except for South Saskatchewan River water samples for which EC was measured in the field. dS m^{-1} = µS m^{-1}/1000.

(3) Samples taken starting January 1998.

Table I-2. Mean water quality of irrigation reservoirs from monthly records, April to November (1973 to 1977)(1).

Reservoir	EC ($dS\ m^{-1}$)	SAR	Ca +Mg	Na	HCO_3	SO_4
			($mmol_c\ L^{-1}$)			
Chin	0.39	0.38	2.8	0.45	2.5	0.9
Sauder	0.40	0.51	2.8	0.6	2.4	1.0
Taber	0.67	1.36	3.9	1.9	2.8	3.0
Seven Persons	0.52	0.95	3.2	1.2	2.7	1.7
Murray	0.50	0.80	3.1	1.0	2.9	1.2
Grassy Lake	0.51	0.78	3.3	1.0	2.8	1.5
Horsefly	0.80	2.22	3.9	3.1	2.5	4.5
Bullshead	0.52	0.95	3.2	1.2	2.8	1.6
Fincastle	0.50	0.88	3.1	1.1	2.6	1.6

(1) Graveland, D.N. 1978. Water quality of nine irrigation reservoirs in the St. Mary irrigation project. Alberta Environment, Technical Development Branch.

Appendix II. Basic Soil Ratings for Brown, Dark Brown, and Black Soils in Southern Alberta

The soil profile, geological deposit, and texture ratings for soil series in Appendix II were obtained using Table 3.5, 3.6, and 3.8, respectively, except for soil series of the Solonetzic order. The basic soil rating (B.S.R.) for soils series of the Solonetzic order only was obtained using: Table II-1 to obtain an initial soil profile (P) rating; Table II-2 to obtain the surface texture (T) rating; and Table 3.6 to rate the geological deposit (G). Soil salinity and sodicity of Solonetzic soils can vary considerably, and depending on site-specific salinity and sodicity may be rated irrigable or nonirrigable, according to the standards for the classification of land for irrigation (AAFRD 2004). The soil profile, geological deposit, and texture ratings for these Solonetzic soils can be adjusted using Tables 3.5, 3.6, and 3.8 when site-specific soil chemistry and field data are obtained during a Level I, II, III, or IV intensity of investigation. The B.S.R. ratings can then be modified for soil chemistry, salinity profile, and depth to a water table using Table 3.9 (note 4), Table 3.10, and Table 3.11. The modified soil rating could result in an irrigable rating for Solonetzic soils having an SAR less than 12 in the B horizon, provided all other criteria for salinity and sodicity, depth to a water table, and net downward water movement are met. The B.S.R. ratings in Table II-3 are intended for use with Level V intensity of investigation using soil survey maps and other data on file.

Table II-1. Ratings for the soil profile factor for Solonetzic soil series[(1)].

Soil order, great group or subgroup, and characteristics	Rating index
Solonetzic soils[(2)]	
Solonetz, very hard and/or massive Bn	30
Alkaline Solonetz	20
Solodized Solonetz, ≥ 15 cm to Bnt	40
Solodized Solonetz, < 15 cm to Bnt	30
Solod, ≥ 15 cm to Bnt	60
Solod, < 15 cm to Bnt	50
Gleyed[(3)]	30

(1) Alberta Agriculture. 1990. Standards for the classification of land for irrigation in the province of Alberta. Alberta Agriculture, Lethbridge, Alberta.

(2) Solonetzic soils - Solonetzic soils are downgraded and given a low priority for irrigated agriculture for the following reasons:

a) Hard, compact, structural Bnt horizon resulting from a low calcium to sodium ratio which causes dispersion of clay particles and inhibition of water, air and root penetration.
b) High salt content of parent material, and often the solum, resulting in crop stress due to high osmotic pressure and increased potential for salinization of the root zone.
c) Tillage problems associated with the soil being extremely hard when dry and sticky when wet.
d) Extreme variability of soils in areas where Solonetzic soils occur, making management of soil and water very difficult.
e) Adverse effects on nutrient uptake, especially nitrogen and to a lesser extent, phosphorus. Low fertility associated with eroded pits.

(3) Gleyed soils - Because drainage limitations are variable and can be corrected, adjustments can be made to the rating, depending on the severity of the limitation, and ease with which it can be corrected. Drainage is considered a changeable soil characteristic.

Table II-2. Ratings of surface soil texture for Solonetzic soil series[1].

Texture class	Rating index
With normal textural gradients:	
Loam, silt loam, very fine sandy loam	100
Fine sandy loam	90
Clay loam, silty clay loam, sandy clay loam	80
Sandy loam	70
Coarse sandy loam, silty clay, sandy clay	60
Loamy sand, clay	50
Loamy coarse sand, heavy clay	40
Sand	30
Gravel	20
With abrupt textural change[2, 3] to finer subsoils within 50 cm:	
change of 1 class, reduce surface texture rating by 10 units;	
change of 2 classes, reduce surface texture rating by 20 units;	
change of 3 classes, reduce surface texture rating by 30 units.	

(1) Alberta Agriculture. 1990. Standards for the classification of land for irrigation in the province of Alberta. Alberta Agriculture, Lethbridge, Alberta.

(2) The abrupt textural change that occurs at the "B" horizon of Solonetzic soils is not rated under profile or geological deposit, and is therefore rated under texture. This reduction applies only to Solonetzic soils and not to abrupt textural changes due to materials change.

(3) When reductions are necessary due to abrupt textural changes, use the textural classes outlined in note 4 under G factor (Table 3.6).

Table II-3. Basic soil rating (B.S.R.) for some dominant and co-dominant soil series in the brown, dark brown, and black soil zones of southern Alberta.

Soil series	Symbol	SCA[1]	Subgroup	Profile rating (P)	Geological deposit description	Geological deposit rating (G)	Surface texture	Texture rating (T)	B.S.R.	Remarks
Academy	ADY	6	O.BL	100	Till	90	SiCL	80	72	
Acadia Valley	ACV	1	O.V	100	Very fine textured water-laid sediments	100	HC	40	40	
Altario	ALT	4	R.DB	70	Till	90	L	100	63	
Antelope	ATP	1	O.R		Very coarse wind or water sediments		S			Nonirrigable due to coarse texture.
Antonio	ANO	1	O.B	100	Coarse-textured sediments/till	70	SL	70	49	
Ardenode	ARE	6	O.BL		Very coarse wind or water sediments		S			Nonirrigable due to coarse texture.
Arrowwood	AWD	3	DB.SO	60	Moderately fine-textured water sediments	90	SiL	90	49	Possibility of salinity if irrigated.
Beauvais	BVA	8	O.DG	100	Till	90	L	100	90	
Beazer	BZR	5	O.BL	100	Till	90	L	100	90	
Bingville	BVL	1	O.B	100	Moderately coarse wind or water sediments	100	SL	70	70	
Blackfoot	BFT	5	O.BL	100	Medium-textured/gravelly coarse	40	L	100	40	
Bow Valley	BOV	6	O.BL		Gravelly coarse-textured material		L			Nonirrigable: gravelly deposits within 50 cm of surface.
Brocket	BKE	3	R.DB	70	Fine textured water-laid sediments	100	CL	80	56	
Brownfield	BFD	4	DB.SO	60	Till	80	L	90	43	Possibility of salinity if irrigated.
Bullhorn	BUL	5	E.BL	90	Moderately fine-textured water sediments	100	CL	80	72	
Bullpound	BLP	1	B.SZ	30	Moderately fine-textured water sediments	90	L	90	24	Possibility of salinity if irrigated.
Bunton	BUT	1	O.B	100	Medium-textured wind and water sediments	70	L	100	70	
Cardston	CTN	5	O.BL	90	Fine textured water laid sediments	100	C	50	45	
Carmangay	CMY	3	O.DB	100	Coarse textured/medium- or moderately fine textured non-till	80	LS	50	40	
Carway	CRW	8	O.BL	100	Moderately coarse wind or water sediments	100	SL	70	70	
Cavendish	CVD	1	O.B	100	Very coarse wind or water sediments	100	LS-S	40	40	
Cecil	CCL	1	SZ.B	70	Till	90	SCL	80	50	
Chin	CHN	1	O.B	90	Medium-textured wind and water sediments	100	L	100	90	
Chinz	CHZ	1	SZ.B	70	Medium-textured wind and water sediments	100	SiL	100	70	
Chokio	CIO	3	CA.DB	80	Moderately fine-textured water sediments	100	L	100	80	
Clarinda	CLR	1	R.B	70	Till	90	L	100	63	
Coaldale	CLD	3	O.DB	90	Fine textured water-laid sediments	100	CL	80	72	
Coronation	CNN	4	O.DB	100	Moderately fine-textured water sediments	80	L	100	80	
Cowley	CWY	5	CA.BL	80	Fine textured water-laid sediments	100	SiC	60	48	
Cradduck	CRD	3	O.DB	100	Till	90	L	100	90	
Cranford	CFD	1	O.B	100	Medium-textured sediments/till	80	SiL	100	80	
Crowfoot	CFT	3	O.DB	90	Medium-textured/gravelly coarse-textured sediments	60	L	100	54	
Crowlodge	CGE	5	BL.SO	60	Fine textured water-laid sediments	90	C	50	27	Possibility of salinity if irrigated.

Soil series	Symbol	SCA[1]	Subgroup	Profile rating (P)	Geological deposit description	Geological deposit rating (G)	Surface texture	Texture rating (T)	B.S.R.	Remarks
Current Lake	CUR	4	DB.SS	40	Moderately fine-textured water sediments	90	L	90	32	Possibility of salinity if irrigated.
Del Bonita	DLB	5	O.BL	100	Medium-textured wind and water sediments	100	L	100	100	
Delacour	DEL	6	O.BL	100	Till	90	SiL	100	90	
Delia	DLA	4	O.DB	100	Till/softrock	20	L	100	20	
Delmas	DMS	2	O.DB		Gravelly coarse-textured material		L			Nonirrigable: gravelly deposits within 50 cm of surface.
Dempster	DPT	2	O.BL	100	Coarse-textured softrock	20	L	100	20	
Diamond	DIM	3	R.DB	70	Medium-textured wind and water sediments	100	L	100	70	
Dishpan	DHP	1	R.G,sa		Moderately fine-textured water sediments		L			Nonirrigable due to salinity.
Dolcy	DCY	4	O.DB	100	Coarse-textured/till	70	SL	70	49	
Drumheller	DMH	4	O.HV	100	Very fine textured water-laid sediments	100	HC	40	40	
Duchess	DHS	1	B.SS	30	Medium-textured sediments/till	70	SiL	100	21	Possibility of salinity if irrigated.
Dunvargan	DVG	8	O.BL	100	Till	90	L	100	90	
East Bow	EBO	6	R.BL	70	Medium-textured sediments/till	80	SiL	100	56	
Edgerton	ERT	4	O.R		Very coarse wind or water sediments		S			Nonirrigable due to coarse texture.
Elkwater	EKW	2	O.BL	100	Till	90	L	100	90	
Etzikom	EZM	1	O.R		Gravelly coarse-textured material		LS			Nonirrigable: gravelly deposits within 50 cm of surface.
Expanse	EXP	1	CA.B	80	Medium-textured wind and water sediments	100	L	100	80	
Fenner	FNR	4	DB.SS	40	Coarse-textured sediments/till	70	LS	50	14	Possibility of salinity if irrigated.
Fish Creek	FSH	8	O.BL	100	Fine textured water-laid sediments	100	SiC	60	60	
Flagstaff	FST	4	SZ.DB	70	Till	90	L	100	63	
Foremost	FMT	1	O.B	90	Till	90	L	100	81	
Fork	FOR	2	O.DB	100	Coarse-textured/medium- or moderately fine textured non-till	80	SL	70	56	
Gem	GEM	1	B.SO	50	Medium-textured sediments/till	80	SiL	90	36	Possibility of salinity if irrigated.
Gleddies	GLS	1	R.G,sa		Fine textured water-laid sediments		SiCL			Nonirrigable due to salinity.
Gopher	GPH	1	B.SS	40	Coarse-textured sediments/till	70	SL	70	20	Possibility of salinity if irrigated.
Grudge	GRG	2	DB.SS	30	Till	80	SiC	60	14	Possibility of salinity if irrigated.
Halkirk	HKR	4	DB.SS	40	Till	80	L	90	29	Possibility of salinity if irrigated.
Halliday	HDY	1	B.SO	60	Till	80	SiL	90	43	Possibility of salinity if irrigated.
Hanalta	HAN	4	O.BL	100	Till	90	L	100	90	
Happy Valley	HPV	6	R.BL	70	Moderately coarse wind or water sediments	100	SL	70	49	
Hatfield	HFD	8	O.BL	100	Till/softrock	20	SCL	80	16	
Heartbreak	HRK	2	O.DB	100	Very coarse wind or water sediments	100	LS-S	40	40	
Hegson	HEG	2	O.DB	100	Till	100	C	50	50	
Helmsdale	HMS	1	R.B	70	Till	90	L	100	63	
Hemaruka	HUK	1	B.SS	30	Till	80	L	90	22	Possibility of salinity if irrigated.
Highwood	HIW	6	R.BL	70	Very coarse wind or water sediments	100	L	100	70	

Soil series	Symbol	SCA[1]	Subgroup	Profile rating (P)	Geological deposit description	Geological deposit rating (G)	Surface texture	Texture rating (T)	B.S.R.	Remarks
Hillmer	HLM	5	O.BL	100	Medium-textured wind and water sediments	100	CL	80	80	
Houcher	HCH	4	R.DB		Very coarse wind or water sediments		S			Nonirrigable due to coarse texture.
Hughenden	HND	4	O.DB	100	Till	90	L	100	90	
Idamay	IMY	3	DB.SZ	30	Moderately fine-textured water sediments	90	SiL	90	24	Possibility of salinity if irrigated.
Illingworth	IWT	1	O.G	60	Moderately fine-textured water sediments	100	L	100	60	Nonirrigable due to poor drainage. Ratings apply when drainage is provided.
Islands	INS	1	R.G	50	Very coarse wind or water sediments	100	LS	50	25	
Joanto	JAT	5	R.HG	50	Fine textured water-laid sediments	100	CL	80	40	Nonirrigable due to poor drainage. Ratings apply when drainage is provided.
Kangaroo	KGO	1	O.B		Gravelly coarse-textured material		SL			Nonirrigable: gravelly deposits within 50 cm of surface.
Karlsbad	KBD	1	B.SO	50	Moderately fine-textured water sediments	80	SiL	90	36	Possibility of salinity if irrigated. BSR may be modified by soil chemistry
Kathyrn	KYN	6	GL.BL	70	Medium-textured sediments/till	90	SiL	100	63	
Kehol	KHO	3	DB.SS	40	Moderately fine-textured water sediments	90	L	90	32	Possibility of salinity if irrigated.
Kessler	KSR	3	O.DB	100	Moderately coarse wind or water sediments	100	SL	70	70	
Kirkcaldy	KRK	3	DB.SO	60	Medium-textured sediments/till	80	SiL	90	43	Possibility of salinity if irrigated.
Kirkchamp	KCH	3	SZ.DB	70	Medium textured non-till/fine or very fine textured non-till	70	L	100	49	
Kirriemuir	KUR	4	O.DB	90	Till	90	L	100	81	
Kitsim	KTM	1	O.G,sa		Till		CL			Nonirrigable due to salinity.
Klemengurt	KGT	5	BL.SZ	30	Fine textured water-laid sediments	90	SiC	60	16	Possibility of salinity if irrigated.
Knight	KNT	5	O.BL	100	Moderately coarse wind or water sediments	40	SL	70	28	
Kyiscap	KCP	3	O.R,sa		Moderately fine-textured water sediments		SL			Nonirrigable due to salinity.
Lakesend	LSD	3	DB.SS	40	Medium-textured sediments/till	80	L	90	29	Possibility of salinity if irrigated.
Lanfine	LFE	4	E.DB	90	Till	90	L	100	81	
Leithead	LHD	4	DB.SS	40	Moderately coarse wind or water sediments	90	SL	70	25	Possibility of salinity if irrigated.
Lethbridge	LET	3	O.DB	100	Medium-textured wind and water sediments	100	L	100	100	
Lilydale	LLD	3	O.B,sa		Medium-textured wind and water sediments		SiL			Nonirrigable due to salinity.
Lonely Valley	LVY	5	O.BL	100	Moderately coarse wind or water sediments	70	L	100	70	
Lundbreck	LNB	8	O.BL		Gravelly coarse-textured material		SL			Nonirrigable: gravelly deposits within 50 cm of surface.
Lupen	LUP	2	O.DB	100	Medium-textured sediments/till	80	CL	80	64	
Lyalta	LTA	6	O.BL	100	Moderately fine-textured water sediments	100	L	100	100	
Macleod	MAC	3	CA.DB		Gravelly coarse-textured material		L			Nonirrigable: gravelly deposits within 50 cm of surface.
Magrath	MGT	3	O.DB	100	Fine textured water-laid sediments	100	CL	80	80	
Maleb	MAB	1	O.B	90	Till	90	L	100	81	
Mami	MAM	5	BL.SZ	30	Till	80	CL	70	17	Possibility of salinity if irrigated.
Marmaduke	MMD	2	O.DB	100	Medium-textured sediments/gravelly coarse sediments	40	L	100	40	
Masinasin	MSN	1	O.B	90	Till	90	L	100	81	

Soil series	Symbol	SCA[1]	Subgroup	Profile rating (P)	Geological deposit description	Geological deposit rating (G)	Surface texture	Texture rating (T)	B.S.R.	Remarks
Maycroft	MFT	8	O.BL	100	Moderately fine-textured water sediments	100	CL	80	80	
Mcalpine	MCA	2	DB.SS	40	Till	80	L	90	29	Possibility of salinity if irrigated.
McNab	MCN	1	O.R,sa		Medium-textured wind and water sediments		L			Nonirrigable due to salinity.
Meachin	MHN	1	GL.B	70	Medium-textured wind and water sediments	100	L	100	70	
Metisko	MET	4	O.DB	100	Moderately coarse wind or water sediments	100	SL	70	70	
Michichi	MIC	4	DB.SO	60	Fine textured water-laid sediments	90	CL	80	43	Possibility of salinity if irrigated.
Midnapore	MDP	6	O.BL	100	Moderately coarse wind or water sediments	100	L	100	100	
Migra	MGR	2	O.DB	100	Coarse-textured sediments/till	70	SL	70	49	
Milk River	MKR	1	CU.R	60	Moderately coarse wind or water sediments	70	LS	50	21	
Millicent	MCT	1	SZ.B	70	Fine textured water-laid sediments	100	CL	80	56	
Mokowan	MKN	5	O.R	60	Medium-textured softrock	20	CL	80	10	
Monitor	MTR	4	R.DB	70	Medium-textured wind and water sediments	100	L	100	70	
Neidpath	NDP	1	O.LG	50	Moderately fine-textured water sediments	100	L	100	50	Nonirrigable due to poor drainage. Ratings apply when drainage is provided.
Neutral	NUT	4	R.DB	70	Till	90	L	100	63	
New Dayton	NED	3	O.DB		Gravelly coarse-textured material		SL			Nonirrigable: gravelly deposits within 50 cm of surface.
Ninastoko	NNK	5	BL.SS	40	Till	80	L	90	29	Possibility of salinity if irrigated.
Nine Mile	NEM	3	CA.DB	80	Till	90	CL	80	58	
Oasis	OAS	3	O.DB	100	Medium-textured sediments/coarse-textured sediments	80	L	100	80	
Ockey	OKY	5	O.BL	100	Till/softrock	20	SCL	80	16	
Oldman	ODM	5	R.BL	70	Moderately fine-textured water sediments	100	L	100	70	
Olsen	OSN	3	CA.DB	80	Moderately coarse wind or water sediments	100	L	100	80	
Onnevue	OVE	4	SZ.DB	70	Till	90	SCL	80	50	
Owendale	OWD	5	O.BL	100	Medium-textured softrock	20	L	100	20	
Oxley	OXY	5	BL.SZ	30	Medium-textured softrock	20	SiCL	70	4	Possibility of salinity if irrigated.
Paintearth	PTE	4	O.DB	100	Medium-textured softrock	20	L	100	20	
Parr	PAR	3	DB.SS	40	Till	80	SL	70	22	Possibility of salinity if irrigated.
Parsons	PSO	5	R.BL	70	Till	90	L	100	63	
Patricia	PTA	1	B.SS	30	Fine textured water-laid sediments	90	CL	80	22	Possibility of salinity if irrigated.
Peigan	PGN	5	BL.SS	40	Fine textured water-laid sediments	90	C	50	18	Possibility of salinity if irrigated.
Pemukan	PUN	1	O.B		Gravelly coarse-textured material		SL			Nonirrigable: gravelly deposits within 50 cm of surface.
Pincher	PNR	5	O.BL	100	Fine textured water-laid sediments	100	C	50	50	
Porcupine	PPE	8	O.BL	100	Medium-textured wind and water sediments	90	SL	70	63	
Provost	PRO	4	O.DB	100	Medium-textured sediments/till	80	L	100	80	
Pulteney	PUY	3	O.DB	100	Till	90	CL	80	72	
Purescape	PUR	2	O.DB	100	Till	90	CL	80	72	
Purple Springs	PLS	1	O.B	100	Coarse-textured sediments/till	60	LS	50	30	

Soil series	Symbol	SCA[1]	Subgroup	Profile rating (P)	Geological deposite description	Geological deposit rating (G)	Surface texture	Texture rating (T)	B.S.R.	Remarks
Rainier	RIR	1	O.B	100	Coarse-textured/medium- or moderately fine textured non-till	80	SL	70	56	
Ramillies	RAM	1	O.B	90	Medium-textured sediments/gravelly coarse sediments	60	L	100	54	
Readymade	RDM	3	O.DB	100	Till	90	SiL	100	90	
Ribstone	RIB	4	O.DB	100	Coarse-textured sediments/till	60	LS	50	30	
Rinard	RND	5	O.BL		Gravelly coarse-textured material		L			Nonirrigable: gravelly deposits within 50 cm of surface.
Rockford	RFD	5	O.BL		Gravelly medium-textured water sediments		L			Nonirrigable: gravelly deposits within 50 cm of surface.
Rockyview	RKV	6	O.BL	100	Medium-textured sediments/till	80	SiL	100	80	
Rolling Hills	RHS	1	B.SS	40	Coarse-textured/medium- or moderately fine textured non-till	80	SL	70	22	Possibility of salinity if irrigated.
Rolward	RRD	1	B.SS	40	Coarse-textured/medium- or moderately fine textured non-till	80	SL	70	22	Possibility of salinity if irrigated.
Ronalaine	ROL	1	SZ.B	70	Till	90	CL	80	50	
Rosemary	RMR	1	B.SO	60	Fine textured water-laid sediments	80	CL	80	38	Possibility of salinity if irrigated.
Rush Lake	RLK	2	O.DB	100	Moderately fine-textured water sediments	100	CL	80	80	
Sakalo	SAK	5	O.BL	100	Medium-textured sediments/coarse-textured	80	L	100	80	
Sarcee	SRC	8	O.BL	100	Medium-textured wind and water sediments	100	CL	80	80	
Scollard	SCD	4	O.DB		Gravelly coarse-textured material		SL			Nonirrigable: gravelly deposits within 50 cm of surface.
Scotfield	SFD	1	O.R,sa		Moderately fine-textured water sediments		L			Nonirrigable due to salinity.
Seven Persons	SPS	1	O.B	100	Fine textured water-laid sediments	100	SiC	60	60	
Sexton	SXT	3	O.HR	70	Moderately coarse wind or water sediments	80	SL	70	39	
Shandor	SND	5	O.BL	100	Fine textured water-laid sediments	100	SiC	60	60	
Sharp Hills	SHL	8	R.BL	70	Moderately coarse wind or water sediments	100	L	100	70	
Sloughay	SLY	1	R.HG	50	Moderately fine-textured water sediments	100	SiC	60	30	Nonirrigable due to poor drainage. Ratings apply when drainage is provided.
Sprole	SOL	2	O.DB	100	Till	90	CL	80	72	
Standoff	SOF	5	O.BL	100	Moderately fine-textured water sediments	100	L	100	100	
Steveville	SIL	1	B.SS	30	Till/softrock	20	L	100	6	Possibility of salinity if irrigated.
Stirling	SIG	1	B.SZ	30	Fine textured water-laid sediments	90	SiC	60	16	Possibility of salinity if irrigated.
Sullivan Lake	SUL	4	DB.SS	40	Coarse-textured sediments/till	70	SL	70	20	Possibility of salinity if irrigated.
Sunnynook	SYK	1	B.SS	40	Coarse-textured sediments/till	70	LS	50	14	Possibility of salinity if irrigated.
Taber	TAB	1	O.B	90	Medium-textured sediments/coarse-textured sediments	80	L	100	72	
Tempest	TEP	1	HU.LG	60	Moderately fine-textured water sediments	100	SiCL	80	48	Nonirrigable due to poor drainage. Ratings apply when drainage is provided.
Thelma	THA	2	O.BL	100	Moderately fine-textured water sediments	100	L	100	100	
Three Hills	THH	6	O.BL	100	Very fine textured water-laid sediments	100	HC	40	40	
Thumb	THB	4	O.BL	100	Moderately fine-textured water sediments	100	L	100	100	
Tilley	TIY	1	SZ.B	70	Medium-textured wind and water sediments	100	L	100	70	
Timko	TIK	1	SZ.B	70	Medium-textured sediments/till	80	SiL	100	56	
Torlea	TLA	4	DB.SS	40	Till/softrock	20	SiL	90	7	

Soil series	Symbol	SCA[1]	Subgroup	Profile rating (P)	Geological deposit description	Geological deposit rating (G)	Surface texture	Texture rating (T)	B.S.R.	Remarks
Tothill	TTH	2	O.DB	100	Till	90	CL-C	65	58	
Travers	TVS	1	CA.B	80	Till	90	L	100	72	
Twining	TWG	6	SZ.BL	70	Fine textured water-laid sediments	100	CL	80	56	
Van Cleeve	VAC	3	O.DB	100	Till/softrock	20	L	100	20	
Vendisant	VST	1	R.B		Very coarse wind or water sediments		S			Nonirrigable due to coarse texture.
Ventre	VET	1	R.G	50	Moderately fine-textured water sediments	100	L	100	50	Nonirrigable due to poor drainage. Ratings apply when drainage is provided.
Verburg	VEB	3	R.DB	70	Till	90	SiL	100	63	
Verdigris	VGR	1	CU.R	60	Moderately fine-textured water sediments	70	SiL	100	42	
Victor	VTR	4	DB.SZ	30	Moderately fine-textured water sediments	90	SiC	60	16	Possibility of salinity if irrigated.
Wainwright	WWT	4	O.DB	100	Very coarse wind or water sediments	100	SL	70	70	
Walsh	WLH	1	R.G	50	Fine textured water-laid sediments	100	C	50	25	
Wardlow	WDW	1	B.SS	30	Moderately fine-textured water sediments	80	L	90	22	Possibility of salinity if irrigated.
Weston	WTN	3	O.R	60	Fine textured water-laid sediments	100	C	50	30	
Wheiden	WDN	1	O.B	90	Till	100	CL	80	72	
Whitney	WNY	3	O.DB	90	Medium-textured sediments/till	80	SiL	100	72	
Wiese	WES	4	DB.SS	40	Fine textured water-laid sediments	90	L	90	32	Possibility of salinity if irrigated.
Wilda	WID	2	R.DB	70	Till	90	CL	80	50	
Wollim	WOL	3	R.DB		Gravelly coarse sediments/till		L			Nonirrigable: gravelly deposits within 50 cm of surface.
Yarnley	YNY	1	B.SS	40	Very coarse wind or water sediments	90	S	30	11	
Youngstown	YTW	1	B.SS	40	Moderately coarse wind or water sediments	90	SL	70	25	Possibility of salinity if irrigated.

[1] Soil Correlation Area