3. SOILS

3.1 SOIL DEVELOPMENT

Soil is defined as the upper weathered portion of the earth's crust and serves as a habitat for plants and animals. Soils are a product of the environment and are the result of climate, vegetation, organisms and topography acting on geologic deposits (soil parent material) over time. Due to the interaction of these factors, which can vary with time and from place to place, soils are different from each other. The differences may be small or large and depend upon the magnitude of the factors involved, particularly those of climate and parent material and upon the length of time the factors had been active. Climate directly influences the type of vegetation (organic matter) and the manner in which it is added to the soil. The overall climate of an area determines the microorganism activity, decomposition of organic matter, and the rates of additions to or removal of weathering products from the soils.

The resultant soil differs from the original geologic material from which it was formed in various physical, chemical, mineralogical, biological and morphological properties.

Most soils in this study area have developed under semi-arid climatic conditions in a grassland or dry forest type of environment. The area has low rainfall and high summer temperatures that result in high potential rates of water loss from both soil and plant. This restricts tree growth, limits soil leaching and leads to the accumulation of products from decomposed grasses in the topsoil. These organic matter enriched soils (Chernozems) have formed on a variety of soil parent materials in the Okanagan and Similkameen Valleys.

The grassland soils extend at higher elevations into the dry lower forest zone where the vegetation is composed of Ponderosa pine and Douglas-fir. In these areas the thinner soil surface layer has less organic matter and subsoil colours are generally light brown (Brunisolic soils).

Other soils are characterized by having finer textures and with them translocated clay as a dominant process (Luvisolic soils). Over a long time, clay moves from an upper to a lower soil layer where it eventually may accumulate to such an extent that root and water penetration may be inhibited.

Wet soils (Gleysolic soils) occur throughout the area wherever water is retained in the soil for long periods. They are found on a wide variety of soil parent materials and typically occupy poorly drained to undrained flat or depressional positions in the landscape. Young soils (Regosolic soils) without horizon differentiation are found on some well and rapidly drained portions of floodplains as well as on other steep embankments.

3.2 GLACIATION

The entire area, except some of the highest peaks in the Cascade Range, was covered by ice during at least four separate glaciations. Ice began to accumulate with the onset of each period of glaciation in colder mountainous areas of high precipitation. In these places the accumulated snow was gradually converted into ice. The mountain ranges where early glaciation occurred were the Coast Mountains in the west, the Skeena Mountains in the north and the Monashee Mountains in the east. Later, as glaciation progressed, the ice advanced into valleys and onto the Interior Plateau where the flowing action of glaciers rounded off hills by weight and abrasion. Eventually, a large proportion of British Columbia was covered by a thick ice sheet.

The latest deglaciation commenced about 15,000 years ago with a gradual change to a warmer climate. As the main Okanagan glacier lobe retreated from the toe of the glacier (terminal moraine) in northern Washington State, valley glaciers receded by melting. Ridges and summits then emerged in the highlands due to the lowering of the ice surface. Tributary valley glaciers melted more rapidly than the main Okanagan valley glacier lobe. Some valley and upland areas were free of ice by about 12,000 years ago and were covered with a material orginally eroded from the pre-glacial land surface. This material deposited directly by glacier ice without later modification or sorting by glacial meltwater is known as glacial till.

The main Okanagan Valley glacier, being fed from mountainous areas outside of the Okanagan, was active after much of the highlands had become clear of ice. Ice confined rivers and lakes formed against the Okanagan glacier as large flows of glacial meltwater continued to enter the main valley from the highlands. The glacial meltwaters tended to sort the materials from each other primarily by water velocity. Faster moving water courses deposited coarse sands, gravels, cobbles and stones as crudely bedded glaciofluvial deposits. Slower moving watercourses deposited sands, silts and clays on the former terraces and floodplains. Silts and clays settled out in ice dammed glacial lakes as glaciolacustrine deposits.

Later, when all the glacier ice had melted and the landscape had dried up, wind erosion and re-deposition of sands and silts occurred in sparsely vegetated areas. Extensive areas of wind transported (eolian) materials are found on the wide floodplains and on some glacial tills.

The force of gravity continually affects all materials and plays a dominant role on steeper terrain. All materials that have moved to their present position by direct gravity induced movement are called colluvium. The colluvial materials may either accumulate as shallow or deep deposits on slopes.

Postglacial deposits such as floodplains of rivers and gravelly and sandy fans are deposits of present day streams. Recent fluvial (floodplain) deposits, composed of a variety of water sorted materials, are found along present water courses, while fans have developed where mountain creeks emerge onto level ground. Other deposits of recent times are bogs and swamps. These latter are primarily of organic origin and have generally accumulated in depressions with high water tables.

3.3 SOIL PARENT MATERIALS

3.3.1 Clay and Silt (glaciolacustrine) Sediments

These sediments are widespread throughout the central and northern parts of the study area. They dominantly occur on either side of Skaha and Okanagan Lakes where they are prevalent from Penticton to Naramata, near Westbank, Boucherie Mountain and near Okanagan Mission. These deposits also occur in the Bottom Creek area (locally known as Glenmore Valley), from Rutland to Ellison, and near the lower Similkameen valley.

The sediments are generally composed of stone and gravel-free, moderately and well sorted fine sand, silt and clay. Thin layers of fine sands and silts are common among these deposits south of Peachland and in the lower Similkameen valley while near Westbank, in the Glenmore valley and near Rutland and Ellison the sediments are more commonly mixtures of silt and clay.

Natural subsurface erosion (piping) by ground and irrigation water is common in these sediments along lakeshore bluffs. Frequently the soil surface collapses and results in formation of small steep sided ravines. The individual sinkholes often coalesce and form deeply entrenched gullies.

3.3.2 Meltwater (glaciofluvial) Deposits

These stony, gravelly and/or sandy deposits are widespread and occur throughout the study area on lower valley sides, terraces, and on rolling terrain. Deposition occurred by glacial meltwater streams and resulted in textures that range from well sorted layered gravels and sands to poorly sorted sands, gravels and cobbles. Extensive deposits of sandy veneers over gravels occur at Osoyoos, west of Penticton, higher lying areas west of Summerland, near Peachland, Westbank, large areas in East Kelowna and Rutland as well as in the upland area west of the Kelowna airport.

Deep well sorted sand deposits occur on either side of Osoyoos Lake and north to Oliver, south of McIntyre bluff, near Okanagan Falls to Kaleden and in small pockets from Okanagan Mission to Ellison.

The sands and gravels are porous and permeable and are generally characterized by arid conditions. Ground and irrigation water flow is rapid through these coarse textured deposits mainly because of their typical loose and noncohesive nature.

3.3.3 Unsorted (glacial till) Deposits

Unsorted glacial till deposits, also known as boulder clay, include materials eroded from pre-glacial sediments as well as from rocks that were re-deposited under glacial ice. Glacial till is a non sorted, massive mixture of various shapes, particle sizes and rock types set in a matrix of clay, silt and sand. By comparison with other deposits, unweathered till is relatively compact, highly consolidated, sticks together (cohesive) and is hard when dry. Typically, these deposits are found at higher elevations within the study area where they were least influenced by post glacial meltwater sorting, erosion and deposition.

Soils on till parent materials are found in pockets near Okanagan Falls, at higher elevations above Naramata, Summerland and Westbank, and along the upper benches east and north of Rutland.

The till is usually weathered to a depth of about 1 m and this results in a surface layer of loose non-compact soil. Often a windblown (eolian) capping of sandy or loamy material ranging in thickness from 10 to 30 cm is also present on the surface.

3.3.4 Recent Stream (fluvial) Deposits

These deposits are similar to those of glaciofluvial origin except that erosion and deposition of material has occurred by non-glacial water. The typical deposits are floodplains (alluvium) and stream deposited fans.

3.3.4.1 Recent Floodplain Deposits

Recent floodplains are areas of flat, gently undulating or gently sloping valley bottom land composed of stream deposited gravel, sand or silt. Floodplains are subject to flooding (inundation) during spring run off.

The main floodplain deposits occur on the Similkameen River floodplain from the Ashnola River to the International boundary, on the Okanagan River floodplain between Osoyoos and Okanagan Lakes, and on the Eneas Creek floodplain near Summerland (locally known as Great Valley).

3.3.4.2 Stream Deposited Fans

Fluvial fans are accumulations of gravels and sands with minor amounts of silts and clays. In plan view these deposits are shaped like a fan. They are located along slope breaks where mountain streams enter wide relatively flat valleys. Decrease in slope together with broadening and shallowing of the main stream channel causes soil materials to settle (sediment deposition) and result in the development of small stream channels across the fan. Large fans consist of layered (stratified) and sorted gravels, sands and finer textured materials. The deposits are coarsest at the top (apex) of the fan and become gradually finer towards the fan toe where sands and silts usually occur. The slope of a fan declines from the apex to the toe.

Good examples of stream deposited fans from south to north in the Okanagan valley are those formed by Inkameep, Testalinda, Hestor, Vaseaux, Shuttleworth, Ellis, Shingle, Trout, Penticton, Powers, McDougall, Mission, Sawmill and Scottie creeks.

Many fans that enter the Similkameen River floodplain emerge from steep mountainous terrain and are therefore very bouldery, cobbly and coarse textured at the top.

3.3.5 Windblown (eolian) Deposits

Windblown deposits result from the transport and redeposition of sand and silt by wind action. In the southern Okanagan Valley the eolian process is believed to have started at the close of the glacial period when the exposed material was dry and bare of vegetation. Most windblown deposits occur in the southern Okanagan Valley where they originated from the sandy glaciofluvial deposits.

3.3.6 Organic Deposits

Organic deposits result from accumulation and decay of vegetative matter. Within the study area these deposits occur in and around some depressions with high water tables and in old cut off meander channels (oxbows) on floodplains. Relatively minor areas of organic deposits occur near Oliver, Summerland, Okanagan Mission and near the Kelowna airport.

3.3.7 Colluvial Deposits and Bedrock

Most colluvial materials in the study area have settled by gravity and are of a moderately coarse gravelly texture. The deposits are generally loose, non-compact, porous and permeable. The pore spaces between coarse rock fragments are largely filled with finer materials. Colluvial deposits are generally associated with the bedrock from which they have formed. The deposit depth is usually less than one meter to bedrock except for colluvial fans. Shallow colluvial deposits overlying bedrock are scattered throughout the Okanagan Valley. Major occurrences are located near Kaleden, Summerland, Naramata, Trepanier and west of the Kelowna airport.

3.4 IMPORTANT SOIL PROPERTIES

Soils possess properties that have either been inherited from the parent material or are the result of the soil processes (additions, losses, translocations and transformations) via the soil forming factors. Some of the important soil properties are as follows.

3.4.1 Soil Texture

Soil texture refers to the combination of mineral particle sizes in the soil. A soil can be coarse, medium or fine textured; each is dependent upon the combination of the individual mineral particle sizes which are grouped into four particle sizes as follows:

(1) gravel, size 2 mm to 80 mm, generally rounded and loosely compacted;
(2) sand, size 0.05 mm to 2 mm, subrounded primarily quartz or feldspar minerals;
(3) silt, size 0.002 mm to 0.05 mm, rounded and not sticky when moist or wet; and,
(4) clay, size <0.002 mm, flat secondary minerals, sticky and plastic when wet or moist.

Most soils are mixtures of these four particle sizes and in addition, some also contain organic matter.

Individual soil texture classes are placed into five main soil textural groups. Common properties related to each group are found in Table 19.

Table 19
Main Characteristics of Soil Textural Groups

TEXTURAL GROUP	SOIL TEXTURES	CHARACTERISTICS
Coarse	gravels (G), sand (S), loamy sand (LS)	generally single grained loose and very friable when moist, loose and soft when dry; many large pores; very low water holding capacity; and rapid perviousness; loose sands tend to wind blow; good bearing strength and trafficability when moist
Moderately Coarse	sandy loam (SL)	very friable when moist, moderate to low water holding capacity; good trafficability and bearing strength when moist
Medium	loam (L), silt loam, (SiL), silt (Si)	friable when moist; slightly sticky and plastic when wet; many medium to small pores; high water holding capacity; moderately good trafficability and bearing strength when moist
Moderately Fine	clay loam (CL), silty clay loam (SiCL), sandy clay loam (SCL)	hard to very hard when dry; sticky and plastic when wet; friable to firm when moist; high proportion of small pores; high water holding capacity; poor trafficability when wet
Fine	silty clay (SiC), sandy clay (SC), clay (C) heavy clay (HC)	very hard when dry; very sticky and plastic when wet; firm when moist; many small pores; moderately high water holding capacity; very poor trafficability when wet

In the soil texture triangle, pure sand (S), silt (Si) and clay (C) soils are shown near the triangle corners while soil textures of loam (L) or clay loam (CL) near the centre have various amounts of each.

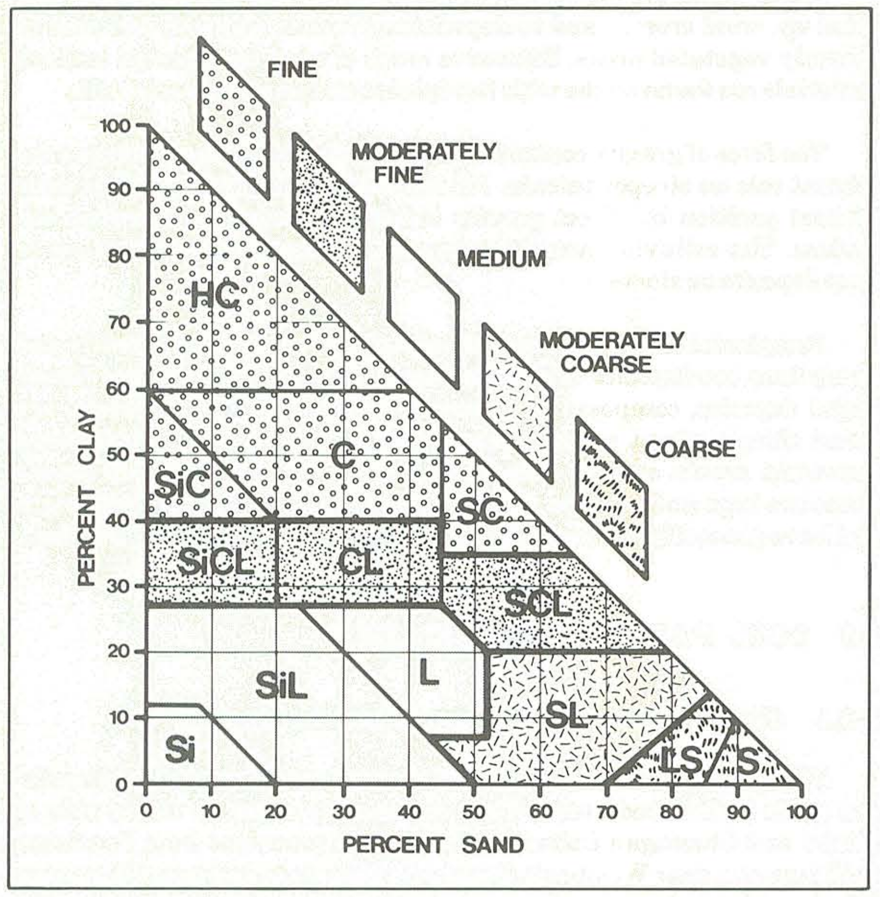

Figure 5 . The Composition of Textural Groups. Percentage of clay and sand in the main textural classes of soils; the remainder of each class in silt

Pure sand, silt or clay textured soils have certain less than desirable properties. In pure sands, for example, large pore spaces are present between individual sand particles. Through these macropore spaces water percolates readily downward so that little is retained for plant growth. Silt and clay soils have small pore spaces that result in a higher water holding capacity. Soils high in clay, however, tend to waterlog, have limited air space and together with other undesirable characteristics may form a less than optimum environment for plant roots.

Loam textured soils are not characterized by any of their three separate components. The gritty properties of sand, the stickiness of clay or the smooth feel of silt do not dominate in loams. Loamy soils are most productive and versatile due to their intermediate textural properties. They have good water holding capacity, a good reservoir of nutrients as well as good aeration and soil thermal properties. Loam textured soils require less specific management in terms of maintaining productivity or workability than either sandy or clayey soils.

3.4.2 Coarse Fragments

Coarse fragments refer to all gravels, cobbles and stones that are larger than 2 mm in diameter. Most soils, excluding silty and clayey glaciolacustrine sediments and organic deposits, contain coarse fragments in various proportions. Typically, meltwater stream terrace deposits as well as some upper stream deposited fans and colluvium contain the most coarse fragments in the soil (% by volume).

3.4.3 Topography (slope) and its Effect on Soil Drainage and Groundwater

Topography and drainage are closely related to soil formation. Topography refers to features of the surface of the land, such as differences in relief or height, direction, steepness, frequency of slopes and the comparative roughness of the surface. The various combinations of these features form the landscape pattern. Typical slope ranges for the particular soil parent materials are found in table 28. Drainage, on the other hand, refers to conditions of water movement both over the surface of the land and within the soil where it is affected by soil texture and type of parent material.

Very coarse textured soils (gravels and sands) take in water readily, but retain only a small amount; any excess water is lost by drainage out of the soil. At the other extreme are fine textured (clayey) soils that take in water slowly but retain a high proportion. Any soil may be rapidly, well, moderately well, imperfectly or poorly drained depending upon water movement away from the soil (e.g. their position in the landscape). For example: internal water movement (drainage) may be slowed down to such an extent on some clay soils that excessive accumulation results in formation of lakes and ponds in depressions. As most air spaces within the soil are taken up by water, there is little oxygen left for respiration by plant roots.

Grape plants are particularly susceptible to restricted drainage conditions. Imperfectly and poorly drained soils usually have finer textures with resulting poor aeration and higher levels of lime and dissolved salts. All these factors lead to insufficient root development and plant growth, poor nutrient uptake, yellowing of vines (chlorosis) and other physiological disorders.

Some imperfectly drained soils with medium textures may be suited for vineyard production if proper rootstocks and adequate surface and subsurface drainage is provided.

Well to rapidly drained soils provide a better rooting medium for most crops especially for grapes than do wet poorly drained soils. Generally, these soils also show conditions of low salinity and lack of groundwater and with adequate aeration they favour good root development.

Excess water is generally rare in well and rapidly drained soils, while in imperfectly, poorly or in very poorly drained soils an excess of soil water is usually present.

Groundwater is either due to seepage, poor soil drainage due to texture (perched water table) or an accumulation in topographic depressions. A fluctuating groundwater table is often present in imperfectly drained soils that may show adequate drainage during the greater part of the year (growing season).

3.4.4 Available Water Storage Capacity (AWSC)

The capacity of a soil to store water depends upon the particle size composition of the soil (texture) and the soil particle arrangement (structure). It is also dependent upon organic matter and content of coarse fragments.

The available water in soils is generally considered as that held between field capacity and the wilting coefficient. Irrigation research indicates that for optimum crop growth, water should be applied when from 50 to 65% of the available water has been consumed (Irrigation Design Manual for Farm Systems in British Columbia, 1983 Revision). The water storage properties of a soil are sometimes inferred from soil texture (Table 20).

Table 20
AWSC Values for Soil Textures in the Okanagan and Similkameen Valleys

TEXTURE CLASS	AWSC* mm/cm of soil	RELATIVE AWSC RATING
gravel	0.2 - 0.6	very low
sand	0.8	very low
loamy sand	1.0	low
sandy loam	1.2	moderate
loam	1.7	moderate
silt loam	2.1	high
clay loam	2.0	high
clay	2.0	high
organic	2.5	very high

*AWSC values are given for the less than 2 mm size fraction only. For gravelly soils with coarse fragments, the AWSC values are correspondingly reduced.

3.4.5 Soil Perviousness

Soil perviousness is a generalized estimate of the potential of a soil to transmit water internally. It is dependent on such soil characteristics as structure, texture, porosity, cracks, organic matter content and shrink-swell properties. Perviousness applies to the whole soil and is closely related to permeability, percolation, and infiltration rates.

The three classes of perviousness are:

1. Rapidly pervious: the capacity to transmit water vertically is so great that the soil will remain wet for no more than a few hours after thoroughly wetting.

2. Moderately pervious: the capacity to transmit water vertically is great enough that the soil will remain saturated for no more than a few days after thorough wetting.

3. Slowly pervious: the potential to transmit water vertically is so slow that the soil will remain saturated for periods of a week or more after thorough wetting.

3.4.6 Soil Temperature

Part of the sun's radiation that reaches the soil is absorbed into the soil surface as heat while the other part is reflected back. Heat transfer from atmosphere to soil is proportionally greater in darker than in lighter coloured soils and explains why darker coloured soils heat up faster than lighter coloured soils. The thermal conductivity and heat capacity are lower for organic than for mineral soils and lower for drier than moister soils. Moist, relatively compacted soils have a high thermal conductivity. They conduct surface heat deep into subsoil layers. In dry, loosely compacted porous soils, however, the thermal conductivity is lower. Their soil surfaces rapidly warm up but as heat transfer to deeper layers is much reduced, a large amount is radiated back to the surrounding air and growing plants.

Topographic conditions also affect the temperature of the soil. This is particularly noticeable when slope orientation (aspect) is considered. Slopes with north and northeast facing aspects are cooler and moister than slopes with south and southwest aspects. In the Okanagan this is shown by a more vigorous tree growth and ground vegetation on northern slopes due mostly to a higher moisture status in the relatively cooler soils. In contrast south and southwest slopes are composed of predominantly darker coloured, warmer grassland soils. The differences in relative soil temperature affect the evapotranspiration, soil microorganism activity and degree of weathering.

Grapevines tend to grow better on relatively porous soils than on fine textured moister and more compacted soils. The warming of moist soils requires a larger amount of energy than for drier soils despite their higher thermal conductivities. In the springtime, moister soils may have characteristically lower temperatures that could retard vine growth. Once these moist soils have reached a higher temperature, their cooling rates are slower and thus they hold the heat for a longer time. Overall moist fine textured soils are relatively cold soils as their warming up is much slower (Table 21).

Table 21
Relative Soil Temperatures Classes

Soil Properties	Relative Soil Temperature Class
well and rapidly drained with moderate amounts of coarse fragments;	warm
well drained medium textured soils;	medium
imperfectly drained groundwater soils (gleyed mineral soils);	cool
poorly drained groundwater soils (gleysols);	cold
organic soils	very cold

The most suitable soils for grape growing are usually dark coloured, south facing and have a medium texture with a moderate proportion of coarse fragments. A vegetation or mulch covered surface is also beneficial as it slows down soil cooling at night during active growth and retards frost penetration in the winter.

The heat energy absorbed by the soil during the daytime often radiates back into the vineyard at night. This heat energy flow favours vine growth development during the spring and also favours ripeness of grapes particularly during frosty nights in the early fall. For this to occur, the soil surface must be moist and more compacted as a dry loose aerated layer has an insulating effect and retards heat flow back into the atmosphere (vineyard).

3.4.7 Soil Water and Soil Aeration

In a productive soil, both air and water must be present in the right proportion. When water is added to the soil by precipitation or irrigation, it first displaces soil air and with it the oxygen in the large pores. Later during drainage this water moves downward and vital oxygen rich air again fills these pores. A soil with its pore spaces full of water for long periods or where groundwater reaches the surface is waterlogged (poorly drained), relatively non aerated, lacks oxygen for plant respiration and other biological activities in the root zone, and is generally unfavourable for normal vine growth. In contrast a soil that contains much air and very little water (such as a sandy or gravelly very coarse textured soil) can also be unfavourable to plant growth (Table 22).

Table 22
Soil Aeration vs Soil Drainage

Soil Properties	Relative Soil Aeration
Rapidly drained soils with large pore spaces and many coarse fragments.	High
Well drained soils with medium textures and moderate amounts of coarse fragments.	Medium
Poorly drained soils with dominant dull colours (gleysols) and very few large pores.	Low

A soil with adequate crop growth potential is well aerated, well drained, has a high available water storage capacity and has medium textures with moderate amounts of coarse fragments.

3.4.8 Restrictions to Root Development

Normal rooting depth for grapes extends to over 1.3 m (4 ft) on deep uniformly porous, friable and fertile soils with the majority of roots located in the upper 50 cm (2 ft) depth. Nutrients in the soil have to be absorbed by the plant roots. It follows that a deep and non-restrictive rooting depth is beneficial for grape plant growth and proper nutrient uptake.

Some of the root restrictions that may occur in soils are: bedrock, watertable, accumulations of salt and lime, compaction of soil, and a textural change to a much finer texture in the subsoil.

3.4.9 Soil Reaction (pH)

Soil pH or reaction denotes conditions of acidity or alkalinity in the solution surrounding the soil particles (Table 23). In an acid reaction (pH <7), acidic (H+) constituents prevail while in an alkaline constituents (OH-) are dominant. When acid and alkaline constituents are in equal concentration the reaction is said to be neutral. Most agricultural crops grow best near neutral pH. Problems in crop growth occur on soils that have either very low or very high pH values (below pH 5 or above 8.5). In the Okanagan and Similkameen study areas, pH values for most soils range from about 6 to 8 in the upper soil while subsoil (deeper than 1 metre) pH values generally range from 7.5 to 8.5. These higher pH values are most commonly found in medium and fine textured calcareous glaciolacustrine subsoils (soil groups 3, 4, 5, 9 in Section 7.5). Strongly alkaline (pH >8.5) conditions tend to reduce availability of most nutrients with other side effects.

Table 23
Ranges of Soil pH

pH Values	Reaction Class Terminology
<4.5	Extremely acid
4.6 - 5.0	Very strongly acid
5.1 - 5.5	Strongly acid
5.6 - 6.0	Medium acid
6.1 - 6.5	Slightly acid
6.6 - 7.3	Neutral
7.4 - 7.8	Mildly alkaline
7.9 - 8.4	Moderately alkaline
>8.5	Strongly alkaline

In regions of low rainfall such as are found in the Okanagan and Similkameen Valleys, calcium and other bases have not been fully leached out of the soil and consequently are present in the subsoils. This generally results in relatively moderate to high levels of calcareousness in subsoils of glaciolacustrine, glacial till, glaciofluvial and colluvial parent materials.

3.4.10 Soil Nutrients and Cation Exchange Capacity

The quantity of elements with a positive charge (cations) that a soil can hold and use in an exchange process is called the Cation Exchange Capacity (CEC). Cation exchange is an important process to soil fertility as the retention of exchangeable cations minimizes nutrient losses due to percolating waters. The exchangeable cations are generally available for plant uptake. As the soil's CEC holds the mineral nutrients required by the growing plant, a high CEC in a soil is a desirable feature. The total CEC is a useful indicator of the relative amount of colloidal material (clay and organic matter) and is usually associated with moisture holding capacity and potential fertility of the soil.

Coarse textured soils such as sands, loamy sands, and gravelly loamy sands have very low CEC as compared with organic matter rich fine textured soils (Table 24).

Table 24
Cation Exchange Capacity and
Class Equivalents

CLASS	CATION EXCHANGE CAPACITY (milli-equiv./100 g)
Very Low	<5
Low	5 - 10
Medium	10 - 20
High	20 - 50
Very High	50 - 150 (only for organic soils)

The cation exchange capacity is based on the fine (<2 mm) fraction (excluding coarse fragments) of the soil.

3.4.11 Soil Salinity

Soil salinity refers to the presence of soluble (easily dissolved) salts in the soil in amounts that may adversely affect plant growth. Most well drained coarse textured soils in the study area are generally free of salts. Weakly to moderately saline conditions are found in subsoils of medium, moderately fine and fine textured glaciolacustrine silty and clayey sediments. In all poorly drained mineral soils as well as on seepage sites, salinity may be light to severe.

Saline conditions are usually expressed in terms of electrical conductivity - a measure of the electrical current flowing through a soil water extract. In the presence of a high concentration of soluble salts, high values for conductivity are obtained. The results of conductivity measurements are usually expressed by numbers representing the conductivity (mS/cm). The salinity classses in Table 25 are only a general guide for saline conditions; critical limits for plant growth may vary with the type of soil and salt, the depth to salts in the soil, the nature of the seasonal rainfall and other factors.

Grapes generally show a low tolerance (sensitive) to saline soils. Depending upon the variety, grape plants usually show saline induced physiological disorders at soil conductivities greater than 3 mS/cm in the upper one metre of soil.

Table 25
Soil Salinity Classes

Salinity Classes	Conductivity (mS/cm)	Plant Growth Conditions
non saline	0	no salinity effects on plant or soil
very weakly saline	0 - 2	salinity effects generally negligible; grape plant growth generally not affected
weakly saline	2 - 4	yields and growth of very sensitive crops such as grapes are somewhat restricted
moderately saline	4 - 8	yields and growth of many plants restricted; not suited for grapes
strongly saline	8 - 16	only salt tolerant crops grow and yield satisfactorily; not suited for grapes

3.5 SOIL GROUPS

For purposes of this atlas, soils in the Okanagan and Similkameen valleys have been grouped into fourteen soil management groups based mainly on parent material, texture, coarse fragments, drainage and topography. Other detailed soil characteristics are presented in Table 26. Each management group is characterized by similar soil limitations for grape production that require similar management input for success.

Table 26
Physical and Chemical Characteristics of Soil Groups

SOIL GROUP	SOIL PARENT MATERIAL	SOIL TEXTURE AND GRAVELLY MODIFYER		COARSE FRAGMENTS (%)		SLOPE (%)	DRAINAGE CLASS	GROUNDWATER	AVAILABLE WATER STORAGE CAPACITY	SOIL PERVIOUSNESS	RELATIVE SOIL TEMPERATURE	RELATIVE SOIL AERATION	RESTRICTIONS TO ROOT DEVELOPMENT	pH (Reaction)		RELATIVE CALCAREOUSNESS		CATION EXCHANGE CAPACITY	SALINITY	
		0-100 cm	>100 cm	0-100 cm	>100 cm									0-100 cm	>100 cm	0-100 cm	>100 cm	0-100 cm	0-100 cm	>100 cm
1	Fluvial fans (surface stoniness: 0%)	medium, gravelly medium	gravelly medium or gravelly mod. coarse	0-40	20-50	1-15	well	absent	moderate to high	moderate	medium	medium	none	6.6-7.8	6.6-7.8	nil	slight to moderate	high	non saline	non or very weakly saline
2	Fluvial fans (surface stoniness: 0-3%)	gravelly mod. coarse	gravelly mod. coarse gravelly coarse	20-75	40-90	5-30	well to rapid	absent	moderate to low	moderate	medium to warm	medium to high	none	6.6-7.8	7.4-8.4	nil to slight	slight to moderate	low	non saline	non or very weakly saline
3	Glacial till	medium	medium, gravelly mod. coarse, gravelly medium	5-20	15-50	10-30	well	absent	moderate	moderate	medium	medium	none	6.6-7.8	7.4-7.8	nil to slight	moderate	medium to low	non saline	very weakly saline
4	Glaciolacustrine	medium, moderately fine, moderately coarse	medium, moderately fine	0-2	0	2-9	well	absent	high	moderate	medium	medium	none to slight (compaction, salinity)	6.1-7.8	7.4-8.4	nil to slight	moderate	medium to low	non or very weakly saline	weakly or moderately saline
5	Glaciofluvial over glaciolacustrine	gravelly coarse gravelly mod. coarse	medium, moderately fine	20-60	0	5-30	well	absent	low to moderate	rapid to moderate	medium to warm	high	none	6.1-7.8	7.4-8.4	nil	moderate	medium to low	non saline	very weakly saline
6	Glaciofluvial, Fluvial fan, Recent fluvial	mod. coarse, coarse mod. coarse, coarse mod. coarse, coarse	coarse, gravelly coarse coarse, gravelly coarse coarse, gravelly coarse	0-10	0-30	2-30	well to rapid	absent	low	rapid	medium to warm	high	none	6.1-7.8	6.6-8.4	nil to slight	nil to slight	low	non saline	non saline
7	Glaciofluvial (stoniness: 3-50%), Fluvial fan (stoniness: 3-50%), Recent fluvial	gravelly mod. coarse gravelly mod. coarse gravelly coarse	gravelly coarse gravelly coarse gravelly coarse	20-60	50-90	2-30	rapid	absent	very low to low	rapid	warm	high	none to slight lime accum. pans	6.1-7.3	7.9-8.4	nil to slight	slight to moderate	low	non saline	non saline
8	Colluvium veneer over bedrock	gravelly mod. coarse	(bedrock)	20-60	-	15-70	rapid	absent	low to moderate	rapid	medium to warm	high	severe (bedrock)	6.6-7.8	7.9-8.4	nil to slight	slight to moderate	medium	non saline	non saline
9	Glaciolacustrine	fine, mod. fine	moderately fine, fine	0	0	2-9	mod. well	absent	moderate to high	slow	medium to cool	low to medium	slight (structure)	6.1-7.8	7.9-8.4	nil to slight	slight to moderate	high	non or very weakly saline	very weakly or weakly saline
10	Fluvial fan, Recent fluvial	mod. coarse, gravelly mod. coarse, medium	gravelly coarse, coarse moderately coarse	10-30 0-10	10-30 0-20	0-5	imperfect	mod. high (50-150 cm)	low to moderate	moderate to rapid	cool to cold	low to medium	slight to mod. (seasonal water table)	6.1-8.4	5.6-8.4	nil to slight		medium to low	non or very weakly saline	very weakly or weakly saline
11	Glaciofluvial, Fluvial fan, Recent fluvial, Glaciolacustrine	gravelly mod. coarse medium, gravelly mod. coarse medium, mod. fine fine, mod. fine	gravelly mod. coarse gravelly mod. coarse medium, gravelly medium mod. fine, medium	0-20	0-50	0-2	poor	high (20-100 cm)	moderate to high	slow	cold to very cold	low	severe (water table salinity lime)	6.6-8.4	6.1-7.8	nil to slight	moderate to high	medium to high	weakly or moderately saline	weakly or moderately saline (variable)
12	Organic	well and semi-well decomposed	semi-well and undecomposed	0	0	0-2	very poor	high (variable)	very high	-	cold to very cold	low	severe (water table)	6.1-7.3	5.6-6.0	slight	nil to slight	very high	very weakly saline	non or very weakly saline
13	non-suitable areas (steep slopes, beach, rock)	variable	variable	variable	variable	0-70	variable	variable	variable	variable	medium	variable	variable	-	-	-	-	-	-	-
14	Major built up areas	variable	variable	variable	variable	0-9	variable	variable	variable	variable	variable	variable	variable	-	-	-	-	-	-	-

Brief characteristics for each soil group are as follows:

Soil Group 1 - consists of well drained soils that developed on medium to moderately fine textured stream deposited fan materials. Subsoil textures are commonly gravelly sandy loam, gravelly silt loam or silt loam. Their cation exchange capacities in the upper soil are high and they occur on less than 15% slopes. The amount of coarse fragments in the upper soil is less than 20%.

Soil Group 2 - consists of well to rapidly drained soils that developed on medium to moderately coarse textured stream deposited fluvial fan materials. The amount of coarse fragments is usually greater than 20%. They occur on 5-30% slopes.

Soil Group 3 - consists of well drained soils developed on medium to moderately coarse textured unsorted till deposits. They occur on slopes ranging from 10 to 30%.

Soil Group 4 - consists of well drained medium textured soils developed on medium to moderately fine textured glaciolacustrine sediments. These soils are weakly to moderately saline at depths deeper than 1 m (3 ft). Slopes range from 2 to 9%.

Soil Group 5 - consists of well drained soils developed on veneers of coarse textured meltwater stream deposits overlying moderately fine textured silty and clayey sediments. These soils are weakly saline at depths deeper than 1 m (3 ft) and occur on slopes ranging from 5 to 30%.

Soil Group 6 - consists of predominantly rapidly drained soils developed on coarse textured meltwater streams, stream deposited fluvial fans or recent stream deposits. Soils of this group are composed of primarily deep sands that have a low available water holding capacity, low cation exchange capacity and occur on slopes ranging up to 30%.

Soil Group 7 - consists of rapidly drained soils developed on coarse textured meltwater streams, stream deposited fans, or recent stream deposits. Soils are largely composed of gravels, sands and cobbles, have very low water holding and cation exchange capacities and occur on slopes ranging up to 30%.

Soil Group 8 - consists of well to rapidly drained soils developed on shallow moderately coarse textured soil veneer (1.2 m or 3 ft) overlying bedrock. The soils contain a high proportion of angular rock fragments and coarse fragments derived from weathered bedrock. These soils have severe limitations mainly due to the shallowness and proximity of bedrock and steep slopes. The soil, however, may contain minor areas deep enough and free of bedrock for viticultural use. Slopes range from 15 to 70%.

Soil Group 9 - consists of moderately well drained soils developed on moderately fine to fine textured silty and clayey glaciolacustrine sediments. The soils are gravel free, have slow infiltration rates, low aeration and a relative cool soil temperature. They occur on slopes ranging from 2 to 9%.

Soil Group 10 - consists of all imperfectly drained soils regardless of parent material. These soils have either developed on stream deposited fans, recent floodplains or on silty and clayey glaciolacustrine sediments. Soil textures range from sandy loam to clay loam. The soil moisture commonly is in excess of field capacity and remains in subsurface soil horizons for moderately long periods during the year. Slopes range from 0 to 5%.

Soil Group 11 - consists of all poorly drained mineral soils regardless of parent material. These soils occur in slight depressions or on flat topography where they have developed on edges of stream deposited fans, recent floodplains or on silty and clayey glaciolacustrine sediments under the influence of relatively high groundwater tables. Slopes range from 0 to 2%. The soil is waterlogged and water remains in all subsurface soil horizons for a large part of the year. These soils are generally in the Gleysolic order.

Soil Group 12 - consists of very poorly drained soils developed on organic materials. These soils have a permanent high water table and are relatively cold. Organic soils occur in gentle depressions in the landscape. Some organic soils are underlain by calcareous marl layers. Slopes range from 0 to 2%.

Soil Group 13 - consists of non suitable sites for grape growth such as very steep topography, recent beach deposits, bedrock, and gravel pits. Steep escarpments with slopes >30% and eroded gullies of silty or clayey glaciolacustrine sediments are also included.

Soil Group 14 - consists of major built up areas. These include the downtown cores of major cities, towns and villages and some subdivisions and industrial sites.

3.6 SOIL SUITABILITY FOR GRAPES

From the above discussion it follows that well suited soils for grape production will possess many of the following properties: a well to rapid soil drainage; medium to moderately coarse textures in their upper horizons; near neutral pH; moderate to high available water storage capacity; good aeration for nonrestricting root development; a desireable structure; moderate soil perviousness; a medium to high cation exchange capacity; relatively warm soil temperatures; absence of high water table and no saline or strongly calcareous conditions within the upper one metre (3 ft) of soil. These qualities are present in soil groups 1, 2, 3, and 4 and are therefore termed well suited with minimal to no limitations (Table 27).

Table 27
Soil Group and Soil Suitability
for Viticulture

CLASS	SOIL GROUP	SOIL SUITABILITY FOR VITICULTURE
1	1, 2, 3, 4	well suited
2	5, 6, 7 ,9	moderately well suited
3	10, 11	poorly suited
4	8, 12, 13, 14	non suited

The next group in decending order of suitability is that composed of soil groups 5, 6, 7, and 9. These soils are moderately well suited for grape growing as they possess one or more adverse soil characteristics. The main adverse soil characteristic in soil groups 6 and 7 is the coarse sandy or gravelly sandy texture. Under these conditions, despite the increased aeration and relatively higher soil temperature, additional irrigation water has to be applied. The coarse textures imply lower cation exchange capacity in the soil and relatively low soil fertility. Thus the grower has to rely on more frequent and greater fertilization and careful management. Due to the low water holding capacity, higher aeration and deeper frost penetration (if soils lack a ground cover), the soils make freezing and winter kill of vines more likely. Soil groups 5 and 9 on the other hand have clayey soil textures that dry out slowly, are only moderately well drained and have slow infiltration. The potential root development in the latter is moderately impeded and even though the available water storage capacity is high, the soils are relatively cool.

Poorly suited for grape growing are soil groups 10 and 11. These predominantly wet soils in depressions have soil drainages ranging from imperfect to poor. Some of the dryer soils of group 10 may have some potential if rootstocks resistant to wet soil conditions are used. Most of these wet soils have moderate to high levels of salinity and a variable fertility status. The soils are generally cold and warm up slowly. Unless drainage and increased aeration is feasible, group 11 soils should not be used.

Soil groups 8, 12, 13, and 14 are non suited for grape production for a variety of reasons such as steep slope in excess of 30%; shallow soil veneer and bedrock outcrops, gravel pits, and built up areas.