BC

Ministry of Environment

Soils of Southeast Vancouver Island Duncan-Nanaimo Area

MOE Technical Report 15



ISSN 0821-0942

© Government of British Columbia
Custodian for this document is BC Ministry of Agriculture and Food

TRAFFORD

This book was published "on-demand" in cooperation with Trafford Publishing.
On-demand publishing is a unique process and service of making a book available for retail sale to the public taking advantage of on-demand manufacturing and Internet web marketing. **On-demand publishing** includes promotions, retail sales, manufacturing, order fulfilment, accounting and collecting royalties on behalf of the author.

Suite 6E - 2333 Government St., Victoria, BC, Canada V8T 4P4

Phone	250-383-6864	Toll-free	1-888-232-4444 (Canada & US)
Fax	250-383-6804	E-mail	sales@trafford.com
Web site	www.trafford.com	TRAFFORD PUBLISHING IS A DIVISION OF TRAFFORD HOLDINGS LTD.	

Trafford catalogue #98-0009 URL: www.trafford.com/robots/98-0009.html

10 9 8 7 6 5 4 3 2

Ministry of Environment
Ministry of Agriculture and Food

SOILS OF SOUTHEAST VANCOUVER ISLAND
DUNCAN-NANAIMO AREA

MOE Technical Report 15

J.R.Jungen, P.Ag., P.Sanborn, P.J.Christie, P.Ag.
SURVEYS AND RESOURCE MAPPING BRANCH

Victoria, B.C.
June 1985

Canadian Cataloguing in Publication Data

Jungen, J. R. (John Rudy), 1940-
Soils of southeast Vancouver Island, Duncan-Nanaimo area

(MOE technical report, ISSN 0821-0942 ; 15)

Co-published by the Ministry of Agriculture and Food.
Bibliography: p.
ISBN 0-7718-8478-8

1. Soils - British Columbia - Duncan Region. 2. Soils - British Columbia - Nanaimo Region. I. Sanborn, Paul Thomas, 1955- . II. Christie, P. J. (Philip James), 1952- . III. British Columbia. Ministry of Environment. IV. British Columbia. Ministry of Agriculture and Food. V. Title. VI. Series.

S599.1.B7J86 1985 631.4'7'71134 C85-092154-6

© Copyright 1985. B.C. Ministry of Environment
First Printing 1985.

PREFACE

Soils of Southeast Vancouver Island, Duncan - Nanaimo Area was initiated through special Treasury Board funding and administered by the Ministry of Agriculture and Food. Surveys and Resource Mapping Branch, Ministry of Environment provided supervision, correlation, laboratory and cartographic services. The objectives included mapping soils and agriculture capability at a scale of 1:20 000 for regional and municipal planning, Agriculture Land Reserve fine tuning, corridor development and resource planning, assessment and management.

This report contains detailed information on the soil resources of part of southeastern Vancouver Island and describes the results of a detailed soil survey of the coastal plain from Nanoose Bay to Shawnigan Lake. The report also contains a general description of the area with information on history and present land use, geology, surficial deposits, climate and native vegetation.

The high priority given by the Agricultural Land Commission and the Ministry of Agriculture and Food provided strong impetus for the project.

This report contains detailed information on the soil resources of the coastal plain from Nanoose Bay to Shawnigan Lake. The report also contains a general description of the area with information on physiography, surficial deposits, climate and vegetation.

A total of 19 soils maps at a scale of 1:20 000 make up the survey area. Other available derivative maps include:

1. Land Capability for Agriculture
2. Agricultural Soil Management Groups
3. Surface Soil Erosion Potential
4. Irrigation Water Requirement
5. Soil Constraints for Septic Tank Effluent Absorption

The following derivative maps can be produced for special requests:

1. Soil Drainage
2. Soil Suitability for Raspberries
3. Soil Sensitivity for Acidification
4. Soils Susceptible to Inundation and/or High Water Tables

Additional copies of this publication are available from:

MAPS - BC
B.C. MINISTRY OF ENVIRONMENT
553 SUPERIOR ST.
VICTORIA B.C.
V8V 1X5

Telephone (604) 387-1441
Telex MAPS - BC 049-7135

Cost:

Technical Report ... $4.00
Maps (each) $2.50

SUMMARY

Thirty-seven individual soils are identified in the map area. In addition, twenty-two phases and/or variants of these soils were established. Soil names taken from the original soil survey (Day, 1959) were used where applicable.

The soils found within the map area are mainly classified in the Brunisolic Soil Order although soils of the Podzolic Order are also common where wetter moisture regimes occur. The area is considered a Brunisolic to Podzolic soil transition zone. Soils of the Organic, Regosolic, Gleysolic, and to very minor extent, Luvisolic orders also occur.

The map area consists of about 76 500 ha. Of this total, bedrock occupies 2730 ha, miscellaneous land types occupy 7590 ha and various water bodies encompass 1900 ha.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge all those who assisted in the field mapping and report compilation; in particular A. Burdett, T. Hilborn, T. Ovanin and P. Philp.

V. Osborne and staff, Soils Laboratory, Ministry of Environment, Kelowna provided the physical and chemical analysis. L. Houston, M. Botting and staff, Thematic Mapping Unit, Surveys and Resource Mapping Branch, Ministry of Environment, Victoria, and D. Bush, Ministry of Agriculture and Food, Kelowna, supplied the cartography. Special recognition to B. Webb for word processing of the manuscript.

A. Green, Agriculture Canada, Vancouver, is specially acknowledged for field correlation between this survey and the concurrent Gulf Islands survey.

The positive guidance provided by the editorial committee under the chairmanship of B. Loule is greatly appreciated.

TABLE OF CONTENTS

	Page
PREFACE	iii
SUMMARY	v
ACKNOWLEGEMENTS	vii
TABLE OF CONTENTS	ix
LIST OF FIGURES	xi
LIST OF PLATES	xii
LIST OF TABLES	xiii
HOW TO USE THE SOIL REPORT	1
INTRODUCTION	3
CHAPTER ONE GENERAL DESCRIPTION OF THE AREA	5
1.1 Location	5
1.2 History and Present Land-Use	5
1.3 Physiography	6
1.4 Geology	8
1.5 Pleistocene History and Surficial Deposits	8
1.6 Climate	13
1.7 Native Vegetation	14
CHAPTER TWO SOIL CLASSIFICATION AND MAPPING METHODOLOGY	15
2.1 Soil Classification	15
2.2 Field Procedures and Map Compilation	20
2.3 Soil Legend Development	21
CHAPTER THREE GUIDELINES FOR SOIL DESCRIPTIONS	23
3.1 Introduction	23
3.2 Guidelines to Soil Descriptions	23
3.2.1 Landscape Picture and General Comments	23
3.2.2 Soil Landscape Cross-Section	23
3.2.3 Landscape Characteristics	23
3.2.4 Typical Soil Profile	25
3.2.5 Soil Characteristics	25
3.2.5.1 Soil Physical Properties	31
3.2.5.2 Soil Chemical Properties	33
3.2.6 Soil Phases and Variants	39
3.2.7 Inferred Soil Properties	40
CHAPTER FOUR SOIL DESCRIPTIONS	45
4.1 Introduction	45
Arrowsmith (AR) Soils	46
Beddis (BD) Soils	49
Bellhouse (BH) Soils	52
Bowser (BO) Soils	55
Brigantine (BE) Soils	58
Cassidy (CA) Soils	61

TABLE OF CONTENTS (CONTINUED)

	Page
Chemainus (CH) Soils	64
Comiaken (CN) Soils	67
Corydon (CR) Soils	70
Cowichan (CO) Soils	73
Crofton (CF) Soils	76
Dashwood (DW) Soils	79
Deerholme (DE) Soils	82
Denman Island (DA) Soils	85
Dougan (DN) Soils	88
Fairbridge (FB) Soils	91
Flewett (FT) Soils	94
Galiano (GA) Soils	97
Hillbank (HT) Soils	100
Hollings (HO) Soils	103
Kaptara (KP) Soils	106
Koksilah (KH) Soils	109
Kulleet (KT) Soils	112
Maple Bay (MY) Soils	115
Metchosin (MT) Soils	118
Mexicana (ME) Soils	121
Mill Bay (MB) Soils	124
Parksville (PA) Soils	127
Qualicum (QU) Soils	130
Quennell (QL) Soils	133
Quinsam (QN) Soils	136
Royston (RN) Soils	139
Rumsley (RY) Soils	142
Salalakim (SL) Soils	145
Saturna (ST) Soils	148
Shawnigan (SH) Soils	151
Tolmie (TL) Soils	154
Miscellaneous Land Types	157
SELECTED BIBLIOGRAPHY	165
GLOSSARY OF TERMS	169
APPENDIX A CLIMATE DATA	187

LIST OF FIGURES

Figures		Page
1.1	Location of the Map Area	5
1.2	Physiography	7
3.1	Soil Texture	29
3.2	Erosion Hazard of Soils	44
4.1	Mean Monthly Temperatures and Precipitation for Four Selected Stations	188

LIST OF PLATES

Plates		Page
1.1	Physiography of the Map Area	6
1.2	Example of Morainal Parent Material	10
1.3	Example of Marine Parent Material	10
1.4	Example of Fluvial Parent Material	11
1.5	Example of Colluvial Parent Material	12
1.6	Example of Organic Parent Material	12
4.1	Arrowsmith Soil Landscape	46
4.2	Beddis Soil Landscape	49
4.3	Bellhouse Soil Landscape	52
4.4	Bowser Soil Landscape	55
4.5	Brigantine Soil Landscape	58
4.6	Cassidy Soil Landscape	61
4.7	Chemainus Soil Landscape	64
4.8	Comiaken Soil Landscape	67
4.9	Corydon Soil Landscape	70
4.10	Cowichan Soil Landscape	73
4.11	Crofton Soil Landscape	76
4.12	Dashwood Soil Landscape	79
4.13	Deerholme Soil Landscape	82
4.14	Denman Island Soil Landscape	85
4.15	Dougan Soil Landscape	88
4.16	Fairbridge Soil Landscape	91
4.17	Flewett Soil Landscape	94
4.18	Galiano Soil Landscape	97
4.19	Hillbank Soil Landscape	100
4.20	Hollings Soil Landscape	103
4.21	Kaptara Soil Landscape	106
4.22	Koksilah Soil Landscape	109
4.23	Kulleet Soil Landscape	112
4.24	Maple Bay Soil Landscape	115
4.25	Metchosin Soil Landscape	118
4.26	Mexicana Soil Landscape	121
4.27	Mill Bay Soil Landscape	124
4.28	Parksville Soil Landscape	127
4.29	Qualicum Soil Landscape	130
4.30	Quennell Soil Landscape	133
4.31	Quinsam Soil Landscape	136
4.32	Royston Soil Landscape	139
4.33	Rumsley Soil Landscape	142
4.34	Salalakim Soil Landscape	145
4.35	Saturna Soil Landscape	148
4.36	Shawnigan Soil Landscape	151
4.37	Tolmie Soil Landscape	154

LIST OF TABLES

Tables		Page
2.1	Relationship Between Named Soils, Soil Orders, Great Groups, Subgroups, and Parent Material	19
2.2	Relationship Between Soils Identified in Day et al. 1959 and the Current Soil Survey	22
3.1	Terrain Classification Symbols	24
3.2	Coarse Fragment Classes	26
3.3	Generalized Relationship Between Bulk Density and Soil Texture	32
3.4	Approximate Available Water Storage Capacity of Selected Soil Textures	32
3.5	Soil Reaction (pH)	34
3.6	Conductivity (Salinity)	35
3.7	Cation Exchange Capacity Classes	36
3.8	Description of Soil Phase	39
3.9	Description of Soil Variants	40
3.10	Characteristics of the Unified Classification	41
3.11	Classification of Soils and Soil Aggregate Mixtures in the AASHO System	42
4.1	Brief Synopsis of the Soils	159
4.2	Temperature and Precipitation Means for Selected Stations	187
4.3	Frost Free Days for Selected Stations	187

HOW TO USE THE SOIL MAPS AND REPORT

Soil descriptions including general comments, landscape cross-sectional diagrams, landscape characteristics, photographs, typical profiles, and soil characteristics form the major part of this report. The map legend relates these soils to the maps which are published separately.

The mapping is at a detailed level of intensity (survey intensity level 2) and is intended to guide planners and land users in making decisions at the level of individual land parcels and farm units. For detailed projects on any given site, more intensive field studies would be needed.

General information about the study area and its environmental characteristics is provided in Chapter 1, "General Description of the Area".

Chapter 2 explains the procedures used in collecting the information used to compile the report and maps.

Chapter 3 provides guidelines used for the soil descriptions given in Chapter 4.

Chapter 4 contains the descriptions of soils identified in the study area.

Detailed soil profile descriptions for the map area stored in the British Columbia Soil Information System (BCSIS) and soil and agriculture capability maps are available from:

MAPS-B.C.
Ministry of Environment
Parliament Buildings
Victoria, British Columbia
V8V 1X4

INTRODUCTION

The initial soil survey of the east coast of Vancouver Island was completed in 1959 (Day, 1959). A reconnaissance biophysical soil survey for all of Vancouver Island, begun in the mid-1970's, did not resurvey the coastal plain, but rather incorporated the earlier information. These small scale surveys, while valuable for broad scale planning, were not designed to meet present day requirements for solving complex land use problems. Some of these requirements are: (i) accurate agricultural capability ratings for updating or fine tuning the Agriculture Land Reserves; (ii) municipal and regional district planning; (iii) detailed technical soil information for the Ministries of Agriculture and Food, Environment, Municipal Affairs, and the British Columbia Assessment Authority.

To meet these needs a survey of te Duncan-Nanaimo area at a scale of 1:20 000 was initiated. Field work for the project was conducted during the summers of 1980, 1981, by a team of soil surveyors. Land classification was carried out in accordance with the Terrain Classification System (E.L.U.C. Secretariat, 1976), Canadian System of Soil Classification, 1978, and provisional edition of Land Capability Classification for Agriculture in British Columbia, 1983. Further details of methodology are discussed in Chapter 2.

Soils of Duncan - Nanaimo Map Area includes the coastal plain as well as isolated hills and lower slopes of adjacent mountains. The map area encompasses 76,500 ha and is bounded by Georgia Strait on the east, and the steep mountainous terrain of the Vancouver Island Mountains on the west (Figure 1.2).

Preliminary soil and agriculture capability maps (scale 1:15 840) were produced at the end of each field season. Final soil and agricultural capability maps are available at a scale of 1:20 000. Field information was collected on standardized soil description forms, as outlined in Describing Ecosystems in the Field (Resource Analysis Branch, 1980). This information, along with laboratory analyses are entered in the British Columbia Soil Information System (BCSIS).

The report is divided into four chapters. Chapter One contains general information relevant to the area and describes briefly the geology, parent materials, climate, and vegetation of the surveyed area. Chapter Two provides information on soil classification, field procedures and soil legend development. Chapter Three provides the guidelines and parameters used for describing the individual soils while Chapter Four presents the descriptions of the individual soils.

CHAPTER ONE
GENERAL DESCRIPTION OF THE AREA

1.1 LOCATION

The map area consists of approximately 76 500 ha along the southeastern coast of Vancouver Island (Figure 1.1). From the southern end of Shawnigan Lake (49° 35'N) to Nanoose Harbour (49° 15'N), the study area extends approximately 60 km with a variable width of 2 to 10 km. The area consists of part of the Nanaimo Lowlands and is bounded on the west by Vancouver Island Mountains and on the east by the Strait of Georgia.

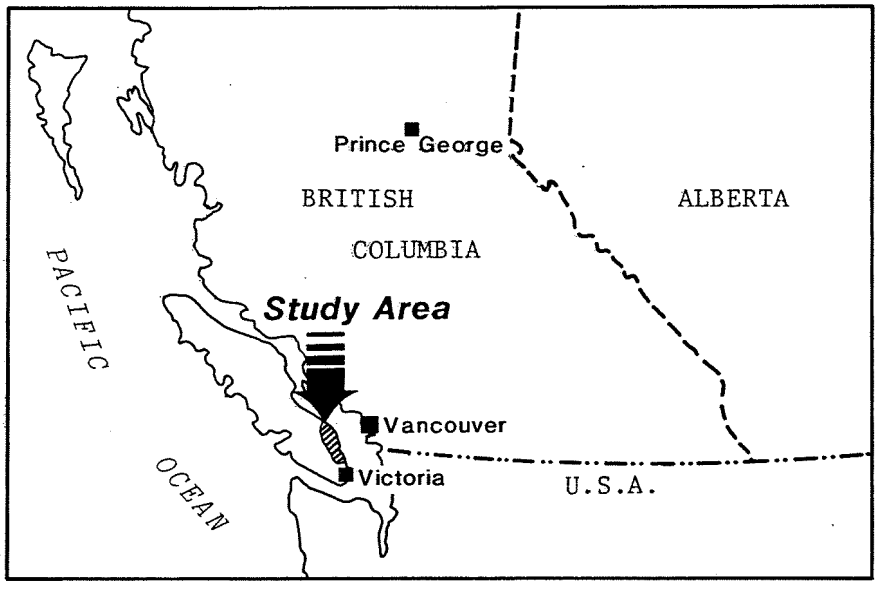


Figure 1.1 Location of the map area.

1.2 HISTORY AND PRESENT LAND USE

Nonaboriginal settlement in the survey area began during the mid-1800's. The main center developed at Nanaimo which is presently the largest city on Vancouver Island north of Victoria. It was established by the Hudson's Bay Company in 1851 to allow exploitation of the local coal resources and became a major center of coal production during the late 19th and early 20th centuries. Expansion of the industry continued between 1901 and 1921, with operations at Ladysmith. Several small settlements in the Nanaimo area were coal mining centers: East Wellington, South Wellington, Extension and Cassidy (Howatson, 1979). Peak coal production was reached in 1922, with the industry declining during the 1930's and most mines ceasing production by the early 1950's. The Duncan area near Cowichan Bay was settled in the 1860's and developed as an agricultural center. The discovery of copper and zinc deposits on nearby Mt. Sicker led to active mining (1897-1907), including construction of a narrow gauge railroad to a smelter at Crofton on Osborn Bay.

The forest industry began at Chemainus in 1862 and was further expanded by the construction of the Esquimalt and Nanaimo (E & N) Railroad in 1886. Virtually all of the study area has been logged at least once, and small scale timber harvesting from second growth forests is occurring on

privately-owned lands. The large forest industry facilities at Nanaimo, Chemainus and Cowichan Bay receive their current timber supplies from elsewhere on the coast.

Present-day agricultural activities are dominated by livestock and dairy production. As a result, the largest proportion of agricultural land is used for pasture and forage crops. The largest concentration of dairy farms is in the area from Mill Bay to just north of Duncan. Vegetables and small fruits for local sale are grown on the floodplain of the Chemainus River and on the Cowichan River delta.

The map area includes most of the Cowichan Valley Regional District and part of the Regional District of Nanaimo. The estimated population is 115,000, of which over half live in the Nanaimo area. The area is serviced with a good network of paved roads and streets. Scheduled ferry service to the mainland and the Gulf Islands is available from Nanaimo. The Nanaimo Municipal Airport provides air travel facilities.

1.3 PHYSIOGRAPHY

The study area lies within the Nanaimo Lowland (Figure 1.2), a narrow coastal plain bounded by the Georgia Depression to the east and the Vancouver Island Ranges to the west (Holland, 1978).



Plate 1.1 Physiography of the map area.

The Lowland is characterized by a series of generally low, northwest trending bedrock ridges, with narrow intervening valleys created by differential erosion of softer rock types. This pattern is particularly evident in the areas east of Highway 1 between Nanaimo and Ladysmith. The Lowland is mostly overlain by various kinds of unconsolidated geologic deposits. Fine marine sediment covers large areas below 100 m asl, particularly in the Duncan area. Morainal deposits (glacial till) form the main material on the undulating and rolling landscapes above 100 m while gravelly fluvial, fluvioglacial and marine deposits are common along rivers, streams and seaward slopes.

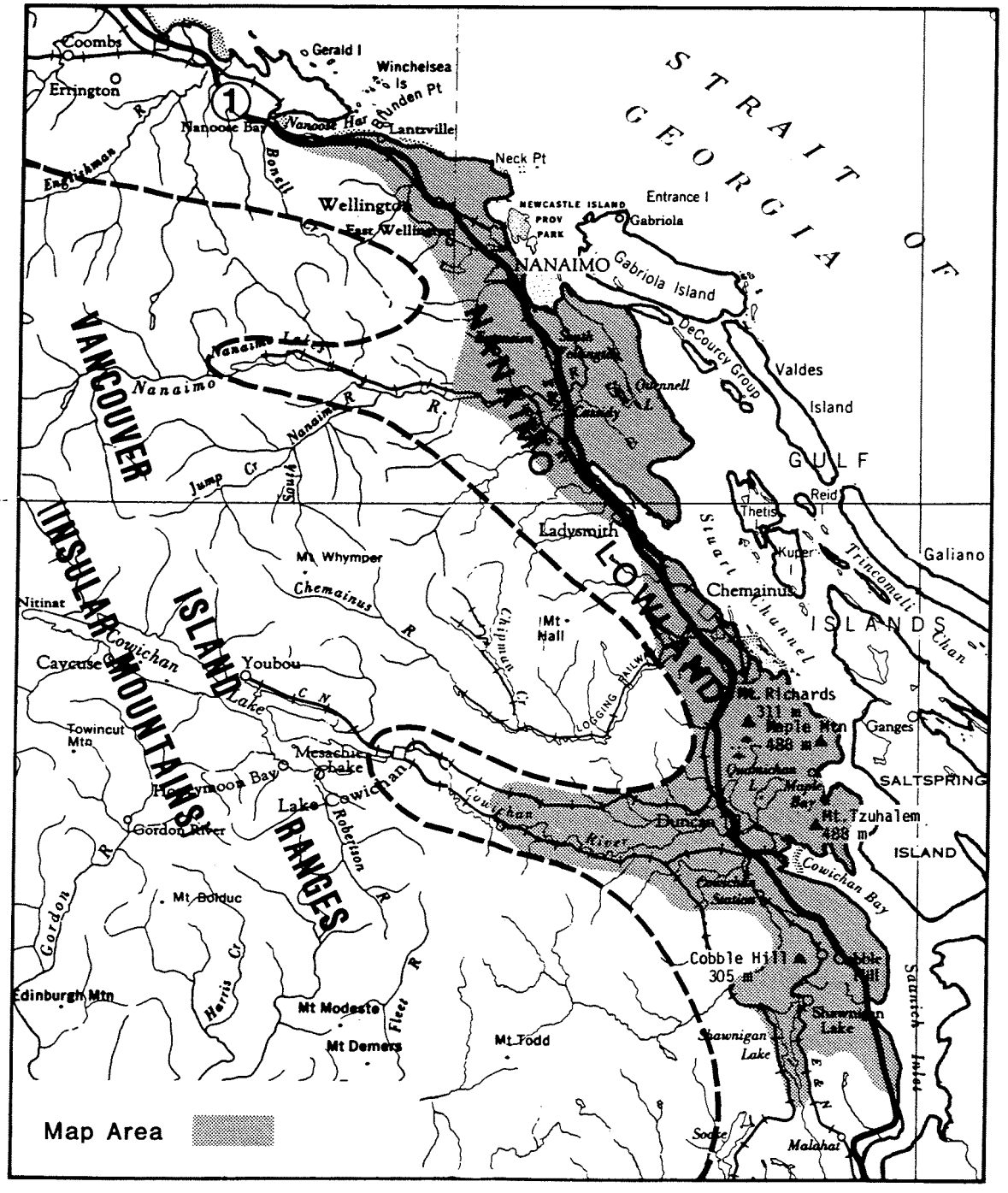


Figure 1.2 Physiography.

Most of the map area lies below 150 m asl. Notable high points are the Woodley Ranges (217 m) east of Ladysmith, Mt. Richards (311 m), Maple Mountain (488 m), Mt. Tzuhalem (488 m) and Cobble Hill (305 m) in the Duncan area.

The principal rivers draining the map area are the Cowichan, Chemainus and Nanaimo Rivers, all of which have extensive floodplains, deltas and estuaries along their lower reaches.

1.4 GEOLOGY

The study area falls almost exclusively within the Nanaimo Lowland (Holland, 1978) physiographic area. The Nanaimo Lowlands are largely underlain by Upper Cretaceous sedimentary rocks of the Nanaimo Group and differential erosion has resulted in the present day ridge and swale topography. The ridges are underlain by hard sandstone and conglomerate, and the valleys are underlain by softer shale and siltstone. Occasional outcroppings of intrusive and extrusive bedrock also occur, particularly on the southern and western boundary of the map area.

1.5 PLEISTOCENE HISTORY AND SURFICIAL DEPOSITS

(A) Glacial and Post-glacial Events

The landscape of southern Vancouver Island has been considerably modified by glaciation during the Pleistocene epoch. The Fraser glaciation, the most recent of these major glaciations, has resulted in the most extensive surficial deposits. This event began with the advance of glacial ice from the mainland Coast Mountains down the Strait of Georgia. Approximately 18,000 to 19,000 years ago, this ice sheet crossed the southeastern part of Vancouver Island (Alley and Chatwin, 1979).

Prior to the overriding of the study area by the Strait of Georgia ice, an ice tongue originating in the Vancouver Island ranges advanced eastward down the Cowichan Valley (Halstead, 1968). Near Duncan, the ice tongue was controlled by several high points (Mt. Prevost, Mt. Richards, Maple Mountain and Mt. Tzuhalem) and eroded the basins of Somenos and Quamichan lakes in the soft shale bedrock. As the ice tongue advanced between Cobble Hill and Saltspring Island, local ponding occurred at its margin, depositing marine sediments northeast of Cobble Hill. Meltwater flowing from the glacier deposited fluvioglacial gravels along its sides and terminus.

When the Strait of Georgia glacier reached the study area, the Cowichan ice tongue was overridden and incorporated in the larger ice sheet. Many of the earlier deposits were either removed or reworked. Downwasting and retreat of the ice followed. At that time (13-12,000 BP), the sea level was approximately 90 m higher in the Duncan area (Mathews et al, 1970) than at present. Meltwater from the ice tongue built a series of ice-contact deltas south of Duncan. These deposits, resting on glacial till, were subsequently covered by marine deposits.

With glacial retreat, uplift of the land occurred rapidly and a sea level near to that of the present was reached about 12,000 years BP (Clague, 1975). Another brief submergence occurred along eastern Vancouver Island, climaxing about 11,500 years BP, followed by rapid emergence. As a result, marine deposits accumulated along the coastal region up to an elevation of approximately 100 m.

Post-glacial erosion has entrenched numerous creeks and rivers draining the map area and large deltas have formed in the Strait of Georgia from the Nanaimo, Chemainus and Cowichan Rivers.

(B) Surficial Deposits

Virtually all soils in the map area are developed in unconsolidated surficial deposits (soil parent materials). Five major genetic types of soil parent materials occur in the study area: morainal, marine, fluvial, colluvial, and organic. These materials are defined according to the Terrain Classification System (E.L.U.C., 1978) and are briefly described in the following paragraphs.

(i) Morainal (till) materials are deposited directly from glaciers and usually are poorly sorted and have little or no bedding (Plate 1.2) and are compacted. These deposits commonly occur above 100 m elevation throughout the study area. Below 100 m, the till is often covered by marine deposits. Two types of till are found in the map area. The more common type is coarser textured (silty sand or sand) and contains 40 to 70% coarse fragments. A finer textured till (sandy fines) is associated with shale and siltstone bedrock, principally in the Cedar and Mt. Prevost areas.

(ii) Marine sediments cover significant areas within the map area and were deposited during the periods of marine submergence after deglaciation. These deposits occur most frequently between Cobble Hill and Crofton below 100 m asl.

Fine textured marine deposits (sandy silt to clayey silt) are the most common (Plate 1.3) and blanket a considerable area south and west of Duncan. The material is very hard when dry and has a low hydraulic conductivity. Perched water tables often occur during the wet winter months, particularly in depressional sites, resulting in saturated soils. At depth, black manganese stains and bedding are sometimes evident.

Coarse textured marine deposits (sand, gravelly sand) originated as beaches or coastal sand bars prior to isostatic rebound. These materials, usually occurring in small, discontinuous deposits, vary in texture, both vertically and laterally and tend to occur on east-facing slopes where exposure to wave action was greatest. They may overlie or grade laterally into finer marine deposits.

Other deposits have also been modified by marine submergence. For example, morainal deposits occurring below the limit of marine submergance sometimes have a surface lag deposit of gravel and cobbles which has been concentrated by wave action.

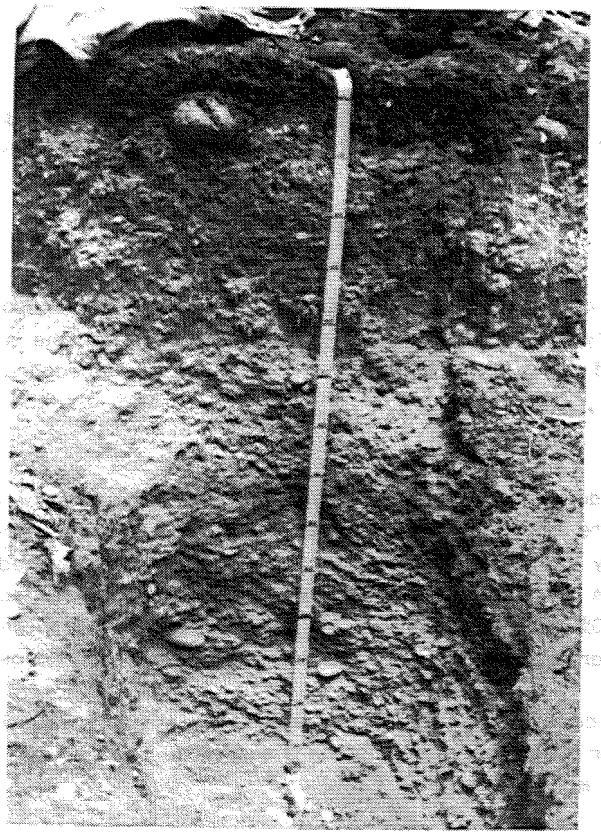


Plate 1.2 Example of moraina1 parent material.



Plate 1.3 Example of marine parent material.

(iii) Fluvial materials have been deposited by flowing water (Plate 1.4). In the map area, many such materials were deposited by glacial meltwaters and are designated as fluvioglacial. Coarse textured fluvioglacial sediments (sand to sandy gravel) have a variety of surface expressions, in the form of old terraces, estuaries and deltas. The deltas are usually found at or below the limit of marine submergence and have characteristic foreset and topset bedding. Finer textured fluvioglacial materials (sandy silt to silty sand) are not common and occur only as a veneer or blanket over coarser textured deltaic deposits.

Deposits of contemporary rivers and creeks also have a wide range of textures, varying from sandy silt to gravelly sand. Floodplains, low lying fluvial terraces, fans and active deltas are characteristic landforms of recent fluvial origin. Generally finer textures (sandy silt, silty sand) occur in the surface sediments of currently active deltas and estuaries (e.g. Cowichan River delta).



Plate 1.4 Example of fluvial parent material.

(iv) Colluvial deposits result from mass wastage and have reached their present position by gravity-induced movement (e.g. rockfalls, soil creep) (Plate 1.5). Such deposits are found only in the steepest parts of the map area and are of minor significance. Colluvium may occur in association with morainal deposits, however colluvium can usually be distinquished by a predominance of angular coarse fragments.



Plate 1.5 Example of colluvial parent material.

(v) Organic materials result from the accumulation and decay of vegetative growth (Plate 1.6). Most organic deposits in the study area resulted from vegetative succession which caused infilling of shallow lake basins (e.g. Dougan Lake, Somenos Lake) and vary greatly in depth. Generally, the organic materials are at an intermediate stage of decomposition. The most common botanical origin of the organic material is from sedges, rushes and reeds, with aquatic peats of algal and animal origin occurring above the mineral contact. Domed islands of bog peat (Sphagnum moss) often occur on the predominantly sedge-derived organic deposits.

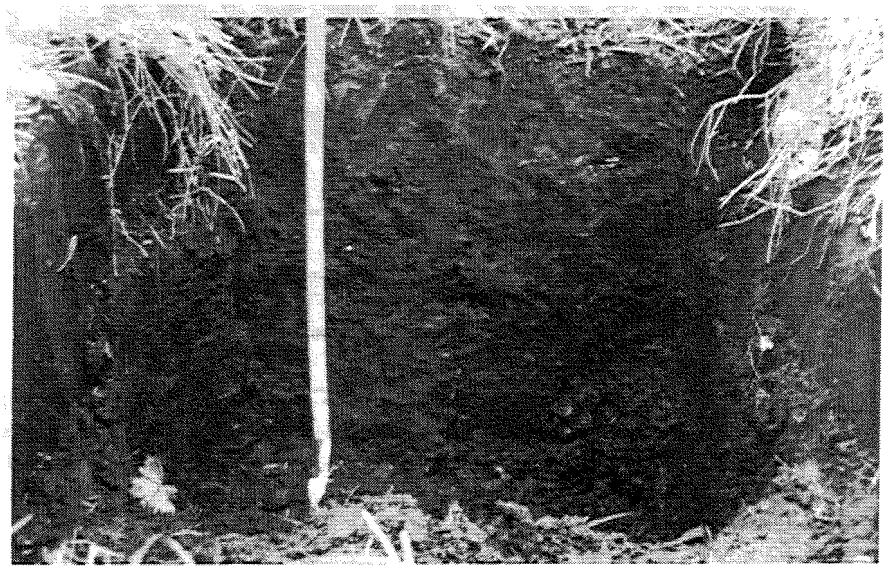


Plate 1.6 Example of organic parent material.

1.6 CLIMATE

A distinct climatic zone characterized by cool wet winters and mild, dry summers occurs over the southeastern lowlands of Vancouver Island, The Gulf Islands in the Strait of Georgia, and the Fraser River Estuary (Shaefer, 1978). While the Pacific Ocean plays the dominant role in determining the climates of the province (Shaefer, 1978), orographic effects are of prime importance in controlling precipitation distribution (Tuller, 1979). This is especially true for the climate of southeast Vancouver Island Lowlands where the climate is affected by the close proximity of the Pacific Ocean, Olympic Peninsula and Vancouver Island Mountains.

During the winter the climate is controlled by moist maritime air masses originating in the north Pacific and flowing onto Vancouver Island. This easterly flow brings the frequent cyclonic storms responsible for the cloud and rain that dominate the area during the winter. Peak precipitation occurs in December and January (Figure 4.1); 80 to 85% of the mean annual precipitation falls during the period October through April. January mean daily air temperatures are about 2°C to 4°C. Given the prolonged periods of cloud cover and cool temperatures, little energy is available to the vegetation for evapotranspiration. This results in a climatic moisture surplus (precipitation minus potential evapotranspiration) for the period October through April, and consequently at the onset of the growing season most of the soils are either saturated, or at field capacity.

Occasionally during winter, intense high pressure ridges build over British Columbia, block the easterly flow, and allow out-flow of cold Arctic air from the major inlets of the mainland o spill onto Vancouver Island, bringing snow and freezing temperatures. Freezing temperatures do not persist for long however, for with the return of the moist maritime westerlies, temperatures rise above 0°C.

Unlike the cloudy, wet winters, the summers are mild and dry. A weak easterly flow during summer allows the North Pacific high pressure cell to influence southwestern British Columbia, bringing warm, dry and cloudless weather to the area. In particular, the months of July and August are dominated by high pressure systems, resulting in mean monthly precipitation of only 22 mm and mean maximum temperatures of 25°C.

During May through September, empirically estimated potential evapotranspiration is 461 mm at Duncan (Baier and Robertson, 1965), while precipitation is 157 mm. This results in an estimated climatic moisture deficit of 304 mm during the growing season. Therefore, in an average growing season, droughty conditions are experienced on most moderately well to rapidly drained soils. The resulting moisture stress is most evident during July and August.

Topographic changes and proximity to the Strait of Georgia are the major influences on mesoscale climatic variation within the map area. Precipitation increases westwardly and also with increasing elevation. Lake Cowichan, at 163 m asl and approximately 35 km from the Strait of Georgia, receives approximately 75% more precipitation than Duncan which is located at 10 m asl and only 7 km from the Strait of Georgia. The average annual precipitation at Duncan is 1042 mm. The temperature regime of the map area is fairly uniform, (Figure 4.1), with minor variations mainly attributable to the moderating influence of the Strait of Georgia.

The west and southeast coasts of Vancouver Island have the longest freeze-free periods in Canada (Tuller, 1979). East coastal locations such as Cowichan Bay and Departure Bay may expect over 200 frost-free days from mid April to mid-November, while inland locations such as Duncan and Nanaimo airport may expect a frost free period of approximately 160 days from May to October.

The long freeze-free periods of the area result in substantial accumulations of seasonal growing degree days (GDD) (Table 4.3). These GDD may be misleading for agricultural crop growth and adjustment using a more suitable thermal criterion is necessary (Colligado, 1978). Since the GDD are mostly accumulated from temperatures at the lower end of the scale (near the base temperature of 5°C), they should not be considered as Effective Growing Degree Days (EGDD) (Colligado, 1978). Effective Growing Degree Days determined for the Duncan area are 1158, based on the period 1941-1970 while the number of GDD for the same period are 1878.

Given the long freeze-free period, abundant sunshine of approximately 1800 hrs at Cowichan Bay and Namaimo Airport (Yorke, 1972), and warm summer temperatures, the southeast coastal plain of Vancouver Island has a very favorable climate for agriculture. Low precipitation during summer is the major climatic limitation. However, provided that water is available for irrigation, the area has a high climatic capability for agriculture.

1.7 NATIVE VEGETATION

Almost all of the map area lies within the Coastal Grand Fir - Western Red Cedar Zone of southeastern Vancouver Island (Harcombe, 1982). This zone has a climatic climax forest of grand fir (Abies grandis) and western red cedar (Thuja plicata) on mesic sites. Coast Douglas-fir (Pseudotsuga menziesii var. menziesii) is a persistent early successional species, dominating most second-growth stands, and may be a climax species on drier sites. Shrubs, such as salal (Gaultheria shallon) and Oregon grape (Mahonia nervosa), are abundant.

In the driest part of this zone which lies within a few km of the coast, particularly on coarse textured soils or where bedrock is close to the surface, open grassy areas occur with occasional stands of Pacific madrone (Arbutus menziesii) and Garry oak (Quercus garryana). More moist sites such as floodplains and creek valleys are often dominated by deciduous species, notably bigleaf maple (Acer macrophyllum), red alder (Alnus rubra), and black cottonwood (Populus balsamifera subsp. trichocarpa). Characteristic herb species on such sites include western sword fern (Polystichum munitum) and skunk cabbage (Lysichitum americanum).

The western boundary of the study area coincides with a transition to the Coastal Western Hemlock Zone. Although coast Douglas-fir dominates during early succession and on drier sites, western hemlock (Tsuga heterophylla) is the climatic climax species within this zone.

CHAPTER 2
SOIL CLASSIFICATION AND MAPPING METHODOLOGY

2.1 SOIL CLASSIFICATION

Soil is the naturally occurring unconsolidated mineral or organic material at the earth's surface which is able to support plant growth. The type of soil at a given location is the result of climate, organisms and topography acting on the parent material over time. Soils display a continuum of properties, reflecting the variation of these soil-forming factors.

Each soil is a three-dimensional, naturally occurring body having length, width and depth. The objective of a soil survey is to identify the different kinds of soil, to separate or classify them by means of a classification system and to delineate their areal distribution on a map. Soils are classified on morphological characteristics observed in a vertical section (soil profile) and on the physical and chemical characteristics obtained by analysis of samples taken from representative basic soil units (pedons). Individual soil profiles are grouped (classified) according to categories of the soil classification employed. The resultant groups are then delineated on a soil map by boundaries which encompass areas of soil in the same group. The kinds of morphologic characteristics considered are discussed in the following section dealing with field methods.

During the process of developing a legend two taxonomic entities were used for naming soils; the soil family and the soil series. A soil family is a taxonomic entity within which from one to large number of series may be established. A soil series is a conceptual class that consists of a group of related pedons that have similar kinds and arrangements of horizons whose color, texture, structure, and consistance, thickness, reaction, and composition fall within a narrow range. Soil series names are usually place names occurring in the locality where the series is orginally classified. The series however is not restricted to that locality.

Because of the complexity of soil characteristics within fluvial terrain units it was not always possible to separately delineate individual soil series. Therefore, the soil family was also used as a category for mapping.

Some soils are so intermixed that it was not possible to describe them using one soil name. In these cases, the map unit is a complex of two or three individual soils. In all such cases, the intermingling of the series and/or families is too intricate to be separated at the map scale used.

In addition to the soil series and families, phases, variants, and several miscellaneous land types are also recognized. The miscellaneous land types consist of non-soil areas and include coastal beaches, eroded scarps, recent alluvium, rock outcrop and man-made land.

Soil phases are variations within a soil series or other hierarchial category due to differences in stoniness, topography, depth of profile or other features which effect land use.

Soil variants are employed when differing soils are identified but occupy such small areas that definition of a new soil is not warranted. These are usually classified as a variant of the established soil series or family which has most characteristics in common with the variant.

The first level of generalization above the soil series is the soil family. A soil family consists of a group of related soil series which fall within a range of differentiating criteria that is broader than that for soil series. The differentiating criteria include particle size distribution, drainage, permeability reaction and consistence as well as others that have implications for land use.

The next level of generalization is the soil subgroup. A soil subgroup consists of a group of soils which have defined common soil horizons which reflect the environmental conditions under which the soils developed. Soil subgroups may be grouped into soil great groups. Soil great groups consist of soils which have major soil horizons in common which reflect the strengh of the dominant soil forming process or processes. The broadest level of generalization is the soil order. A soil order is composed of groups of soils that have developed under broadly similar environmental conditions as expressed by the presence or absence of major, diagnostic soil horizons.

Soil classifications seek to group (similar soils) in order to organize our knowledge of soils and enable prediction of their behaviour. In The System of Soil Classification for Canada (1978), soil groupings are based on properties that indicate a similar mode of origin. The soil order is the highest level of generalization in this system. Of the nine orders, five occur in the study area:

(1) Soils of the humid forested regions containing significant amounts of amorphorus aluminum, iron, and/or organic matter (Podzolic order);
(2) Soils with weakly developed horizons (Brunisolic order);
(3) Young soils with little or no horizon development (Regosolic order);
(4) Soils which are influenced by periodic or long-term water saturation (Gleysolic order); and,
(5) Soils developed primarily from plant residues (Organic order).

Each soil order is subdivided into two to four Great Soil Groups according to the differing strengths of dominant soil-forming processes. Further subdivision into Soil Subgroups is on the basis of the kind and arrangement of soil horizons.

The following paragraphs generally describes the soil orders occurring in the map area, along with the great soil groups and soil subgroups within each soil order. (Also see Table 2.1).

Brunisolic Order

Brunisolic soils are the dominant soil order in the map area, occurring on virtually all parent materials. These soils have drainage classes ranging from imperfectly to rapidly drained, reflecting both topographic position and parent material texture. Soils of the Brunisolic order have sufficient development to exclude them from the Regosolic order, but they lack the degree or kind of horizon development specified for soils of other orders. Their B horizons have insufficient accumulation of Fe, and Al, and organic matter to qualify as Podzolic B horizons.

Two Brunisolic great groups are represented in the map area: Dystric and Sombric. Both are acidic and the latter has a dark, organic matter-enriched surface (Ah) horizon 10 cm or more in thickness. Such Ah horizons may form naturally under grassy, open forests or under long term cultivation.

Three subgroups occur in both great groups. Duric Dystric and Duric Sombric Brunisol soils contain cemented (duric) subsoil horizons and occur mostly on coarse textured glacial till and some fluvioglacial deposits. Gleyed Dystric and Gleyed Sombric Brunisols are imperfectly drained, contain subsurface mottling and are most common on medium textured parent materials with a seasonally perched water table. In some areas small amounts of clay has accumulated in the lower B horizon by illuviation. Orthic Dystric and Orthic Sombric Brunisols occur on moderately well to rapidly drained parent materials.

Gleysolic Order

Gleysolic soils develop in the presence of excessive moisture that results in permanent or periodic reducing conditions. As a result, the gleyed subsoil is bluish-gray to greenish-gray and reddish-brown mottles usually occur in the profile. These soils occur where the watertable is high because of proximity to bodies of water (e.g. floodplains) or in depressional sites, or on materials with low hydraulic conductivity.

Humic Gleysol, Luvic Gleysol, and Gleysol great groups occur in the map area. Humic Gleysols are usually found in depressional sites on medium to fine textured parent materials. Organic matter accumulates in the Ah horizon and occasionally a surface veneer of peat is found. Luvic Gleysols are associated with Humic Gleysol soils but differ by having substantial clay accummulation in the B horizon. Two subgroups of the Gleysol Great Group are significant. The Orthic Gleysols have a mottled and gleyed B horizon, but lack a dark surface horizon. These soils are usually found on fine marine deposits and differ from the Gleyed Dystric Brunisols only in the decreased depth to distinct or prominent mottling. Rego Gleysols occur only on active floodplains or estuaries where continuing sedimentation restricts soil development to a juvenile stage.

Podzolic Order

Podzolic soils have acidic, yellowish red, illuvial B horizons in which amorphous material composed of humified organic matter combined with aluminum (Al) and iron (Fe) has accumulated. Formation of podzolic soils is promoted by cool temperatures, high precipitation, and coniferous vegetation which produces acidic organic matter accumulations on the soil surface.

In general, Podzolic soils occur along the western edge of the map area at higher elevations. In practice, Podzolic soils are difficult to distinguish in the field from Brunisolic soils for both have similar colour. Some profiles tentatively designated as Brunisolic have, after chemical analysis, met the requirements of the Podzolic Order because of high levels of extractable Al which has no effect on soil colour.

All Podzolic soils in the map area belong to the Humo-Ferric Great Group which is characterized by a Bf horizon in which Fe and Al, but little organic matter have accumulated. Distinct eluvial (Ae) horizons are not common in Podzolic soils in the study area, apparently because organic matter and Fe and Al released by weathering mask their appearance. Well defined Ae horizons occur mainly on coarse, rapidly drained fluvioglacial materials and seldom on glacial till.

The most common Podzolic subgroup is Duric Humo-Ferric Podzol, characterized by a strongly cemented to indurated (duric) horizon below the Bf horizon. Duric horizons resemble the under-

lying parent material in colour and are most common on glacial till (Plate 1.2). The cementing agents are believed to be Al, Fe, and Si (McKeague & Sprout, 1975). Three other Podzolic subgroups occur in the study area. These are Orthic Humo-Ferric Podzols which are well drained, without a duric horizon, Sombric Humo-Ferric Podzols which have dark, organic matter-enriched A horizon and have developed under open, grassy forests, and Gleyed Humo-Ferric Podzols which are imperfectly to poorly drained and have mottling in the subsoil.

Regosolic Order

Regosolic soils exist wherever active deposition or erosion interrupt soil development. These conditions occur on active floodplains or on steep, eroding slopes. Regosolic soils on recent fluvial deposits are of much greater extent and have a wide range of textures (silt loam to very gravelly sand). The largest areas of Regosolic soils are on the floodplains and deltas of the Nanaimo, Chemainus, and Cowichan Rivers.

Both Regosolic great groups occur in the map area. Humic Regosols have an organic matter enriched Ah horizon; Regosols do not. Four subgroups are recognized in both great groups. These are Orthic Regosols which depict the central characteristics of the order and great groups, Cumulic (formed by repeated additions of fresh sediment), Gleyed (imperfectly drained) and Gleyed Cumulic.

Organic Order

Organic soils are the least extensive of the five orders found in the map area. These soils occur in poorly or very poorly drained depressions where organic matter accumulates faster than it can decompose. Most of these Organic soils are at an intermediate or advanced degree of decomposition and respectively belong to the Mesisol and Humisol great groups.

Table 2.1
Relationship Between Named Soils, Soil Orders, Great Groups, Subgroups, and Parent Material

ORDER	GREAT GROUP	DOMINANT SUBGROUP	PARENT MATERIAL	SOIL NAME	(Symbol)
Brunisolic	Dystric Brunisol	Orthic	marine, fluvial	Beddis	(BD)
Brunisolic	Dystric Brunisol	Orthic	fluvial	Chemainus	(CH)
Brunisolic	Dystric Brunisol	Orthic	marine	Dougan	(DN)
Brunisolic	Dystric Brunisol	Orthic	fluvial	Flewett	(FT)
Brunisolic	Dystric Brunisol	Orthic	morainal over bedrock	Galiano	(GA)
Brunisolic	Dystric Brunisol	Orthic	morainal over fluvial	Hollings	(HO)
Brunisolic	Dystric Brunisol	Orthic	marine	Hillbank	(HT)
Brunisolic	Dystric Brunisol	Orthic	morainal	Mexicana	(ME)
Brunisolic	Dystric Brunisol	Orthic	marine over bedrock	Maple Bay	(MY)
Brunisolic	Dystric Brunisol	Orthic	fluvial, marine	Qualicum	(QL)
Brunisolic	Dystric Brunisol	Orthic	morainal, colluvial over bedrock	Rumsley	(RY)
Brunisolic	Dystric Brunisol	Orthic	morainal, colluvial over bedrock	Salalakim	(SL)
Brunisolic	Dystric Brunisol	Orthic	morainal, colluvial over bedrock	Saturna	(ST)
Brunisolic	Dystric Brunisol	Duric	marine, fluvial over morainal	Dashwood	(DW)
Brunisolic	Dystric Brunisol	Duric	marine over morainal	Mill Bay	(MB)
Brunisolic	Dystric Brunisol	Duric	morainal	Shawnigan	(SH)
Brunisolic	Dystric Brunisol	Duric	marine, fluvial over morainal	Deerholme	(DE)
Brunisolic	Dystric Brunisol	Gleyed	marine, fluvial	Brigantine	(BE)
Brunisolic	Dystric Brunisol	Gleyed Eluviated	marine	Fairbridge	(FB)
Brunisolic	Dystric Brunisol	Gleyed	marine	Kulleet	(KT)
Brunisolic	Dystric Brunisol	Gleyed	morainal	Royston	(RN)
Gleysolic	Humic Gleysol	Orthic	marine, fluvial	Denman Island	(DA)
Gleysolic	Humic Gleysol	Orthic	morainal	Koksilah	(KH)
Gleysolic	Humic Gleysol	Orthic	fluvial, marine	Kaptara	(KP)
Gleysolic	Humic Gleysol	Orthic	marine	Parksville	(PA)
Gleysolic	Humic Gleysol	Orthic	marine	Tolmie	(TL)
Gleysolic	Luvic Gleysol	Humic	marine	Cowichan	(CO)
Gleysolic	Humic Gleysol	Rego	fluvial	Crofton	(CF)
Gleysolic	Humic Gleysol	Rego	fluvial	Corydon	(CR)
Organic	Mesisol	Typic	organic	Arrowsmith	(AR)
Organic	Humisol	Typic	organic	Metchosin	(MT)
Podzolic	Humo-Ferric Podzol	Orthic	fluvial	Quennell	(QL)

Table 2.1 (Continued)

ORDER	GREAT GROUP	DOMINANT SUBGROUP	PARENT MATERIAL	SOIL NAME	(Symbol)
Podzolic	Humo-Ferric Podzol	Duric	morainal	Quinsam	(QN)
Podzolic	Humo-Ferric Podzol	Sombric	morainal, colluvial over bedrock	Bellhouse	(BH)
Podzolic	Humo-Ferric Podzol	Gleyed	marine	Bowser	(BO)
Regosolic	Regosol	Cumulic	fluvial	Cassidy	(CA)
Regosolic	Regosol	Cumulic	fluvial	Comiaken	(CN)

2.2 FIELD PROCEDURES AND MAP COMPILATION

The intensity of the survey is Level 2, according to the guidelines of the Mapping Systems Working Group (1981). The publication map scale of 1:20 000 is typical for a survey at this intensity level. Field work involved at least one soil inspection in over 90% of map delineations, with boundaries frequently checked in open country, or less frequently in forested areas. Boundary delineation was determined by aerial photograph interpretation, using landform characteristics, variation in slopes, tone and vegetation patterns. Ground truthing was used to improve accuracy of delineations on the pretyped aerial photographs and to determine boundaries that were not discernible through stereoscopic examination. Soil boundaries and thematic information were compiled on 1:15 000 and 1:20 000 scale aerial photographs.

Field observations recorded at inspection sites included: site position, terrain type, elevation, soil horizons and thickness, texture, drainage, coarse fragment content, and agriculture capability rating. Standardization of site information was made possible by using site and soil description forms as outlined in Describing Ecosystems in the Field (Resource Analysis Branch, 1980). Approximately 4800 inspections at this level of detail were conducted. Eighty representative soil profiles were described in detail and sampled for laboratory analysis. All these descriptions, along with supporting analytical data, are stored on computer file (British Columbia Soil Information System) and are available on request from the Surveys and Resource Mapping Branch, Ministry of Environment.

At all inspection sites, the agricultural capability rating was determined, according to methodology in Land Capability Classification For Agriculture in British Columbia, Draft Technical Paper (Kenk and Cotic, 1982). Soil and landscape observations made between inspection sites on foot traverses were also used in deriving agricultural capability ratings for individual map delineations.

Soil inspection pits were dug with a shovel, usually to a depth of 100 cm. In materials with few coarse fragments a hand auger was often used. To enable more consistent estimates of coarse fragment content, a 2 mm mesh sieve was used to separate gravel and cobbles from the finer fraction. For organic soils, a specialized peat auger was used so that the entire control section (160 cm) could be observed.

A number of practical problems, some of which are peculiar to the study area, influenced the rate of progress and accuracy of the mapping. First, the inherent complexity of the soil landscape was particularly great below the limit of marine submergence. Abrupt and unpredictable changes in soil texture occur as a result of past marine sedimentation and wave action and are not easily identified on aerial photographs. Second, although road access was generally good, dense forest cover in some areas caused uncertainties in accurately plotting inspection site locations and delineating boundaries. Third, the highly fragmented pattern of land use and property sizes influenced the rate of progress. In order to assist the rate of mapping progress, parcels of less than two hectares were usually not visited unless an inferred soil boundary crossing the parcel required checking.

After completion of field mapping, delineations were transferred from the working aerial photographs to a 1:20 000 scale base map. Boundaries appearing on the soil maps were deleted on the corresponding agricultural capability maps if the ratings of adjacent soil polygons were the same.

2.3 SOIL LEGEND DEVELOPMENT

Soils occur in intricate patterns across the landscapes. Each piece of the pattern, with a unique set of soil properties represents a mappable entity. This entity, which may consist of one or more soils, is presented on a soils map as a soil mapping individual. Each unique soil is discussed in an accompaning soil report. Prior to the survey it is not possible to determine the exact soil property ranges that will be used to define and delineate a particular soil (Mapping System Working Group 1981). This must be left to the correlator and surveyors as they gain more data during the soil survey. This process is known as soil legend development.

The initial information used for developing the legend was obtained from "Soil Survey of Southwest Vancouver Island and Gulf Islands, British Columbia" (Day et al., 1959), (mapping scale 1:63 360), and report "Soil Resources of Southern Vancouver Island" (in progress), (mapping scale 1:50 000).

These surveys provided sufficient information on groups of related soils and their associated landscape characteristics to develop a preliminary working legend. As the survey progressed repetitive types of soil sequences on similiar parent materials were observed and described.

In total, thirty seven soils, each with unique combinations of properties and which differed significantly with respect to their physical behavior and chemical composition, were identified and described in detail.

Specifically, the soils differ with respect to one or more of the following characteristics: genetic material, texture, drainage, classification, and type of bedrock if it occurs at depths less than one metre. Each soil is given a local geographical name - that name represents a soil with a unique set of properties. Whenever possible, previously established names were used (Table 2.2). For example, Soil Survey Report No. 6 (Day et al., 1959), which used a 1:63 360 mapping scale, described the Shawnigan soils as having a relatively wide range of soil properties, suitable for that scale of mapping. This soil survey report, which uses a 1:20 000 mapping scale identified four separate groups of soil within the original Shawnigan soil. Each new soil has sufficient differentiating characteristics and interpretive differences to warrant separation and each can be delineated at the new larger map scale.

Since the main objective of the soil maps is to provide as much interpretive value as possible, an "uncontrolled soil legend" was perceived to best provide that flexibility. This type of legend allows the soil surveyor the opportunity to describe each soil mapping individual in as much useful detail as required and also allows additions of new soils, if warranted.

Table 2.2
Relationships Between Soils Identified in Day et al. 1959 and Current Soil Survey

Soil Name (1959 Survey)	Current Soil Names*
Arrowsmith	Arrowsmith
Bowser	Brigantine, Bowser, Denman Island
Cassidy	Cassidy
Chemainus	Chemainus, Crofton, Corydon, Comiaken, Flewett
Cowichan	Cowichan
Dashwood	Dashwood
Fairbridge	Fairbridge, Hillbank, Mill Bay, Maple Bay, Dougan, Kulleet
Metchosin	Metchosin
Kye	Beddis, Deerholme
Parksville	Parksville
Qualicum	Qualicum, Quennell, Kaptura
Quinsam	Quinsam, Koksilah
Royston	Royston
Shawnigan	Shawnigan, Mexicana, Koksilah, Hollings
Tolmie	Tolmie
Unnamed, shallow to bedrock soils	Bellhouse, Saturna, Salalakim, Rumsley, Galiano

*Many of the soils identified by Day et al. 1959 are more narrowly defined by the current survey. The original Bowser soil, for example, has been subdivided into three unique soils which are named Brigantine, Denman Island and Bowser. The name Bowser has been retained in the current survey for continuity but the soil it now identifies has limits on its characteristics than are more restrictive than those originally defined by Day et al. 1959.

CHAPTER THREE
GUIDELINES FOR SOIL DESCRIPTIONS

3.1 INTRODUCTION

The guidelines provided in this chapter describe in detail the criteria and parameters used for describing the soils in Chapter 4.

3.2 GUIDELINES TO SOIL DESCRIPTIONS

3.2.1 Landscape Picture and General Comments

Where available, landscape photographs are used to illustrate a typical setting in which each soil occurs. The general comments include a description of the main soil characteristics, topography, drainage, parent materials, and the typical location of the soil in the landscape. Also included are brief comments on the soils suitability (or limitations) for agricultural, urban and other uses.

3.2.2 Soil Landscape Cross Section

These diagrams depict the usual landscape position of each soil in relation to other soils and parent materials. The symbols used for the latter are described in Table 3.1 and are extracted from Terrain Classification System, Environment and Land Use Committee Secretariat, 1976.

3.2.3 Landscape Characteristics

Parent Material - defined according to the Terrain Classification System (E.L.U.C., 1976).

Topography - given as a description of slope classes as defined in Canadian System of Soil Classification, 1978. The classes are defined as follows:

Description	Percent slope
depressional or nearly level	0 to 0.5
very gently sloping or gently undulating	0.5 to 2
gently sloping or undulating	2+ to 5
moderately sloping or gently rolling	5+ to 9
strongly sloping or moderately rolling	9+ to 15
steeply sloping or strongly rolling	15+ to 30
very steeply sloping or hilly	30+ to 60
extremely sloping or very hilly	over 60

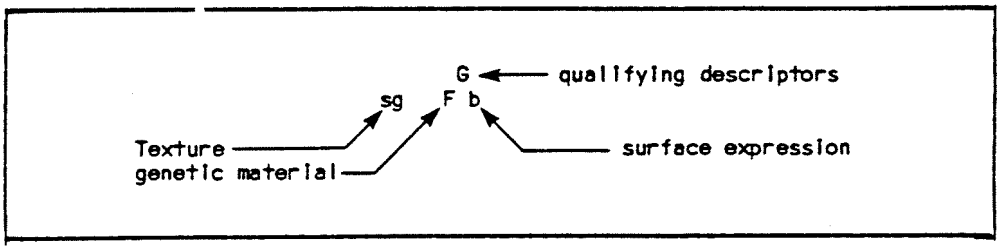
Elevation Range - given in meters above sea level.

Aspect - typical orientation of slopes on which the soil occurs.

Flood Hazard - described according to classes (no hazard, rare, may be expected, frequent, and frequent and irregular) as defined in Describing Ecosystems in the Field, R.A.B., 1980.

Table 3.1
Terrain Classification

Explanation of Letter Notation



Texture

Letter Symbol	Name
b	bouldery
k	cobbly
p	pebbly
s	sandy
s	silty
c	clayey
a	blocky
r	rubbly
g	gravelly
f	fine
m	mesic
h	humic

Genetic Material

Letter Symbol	Name
A	anthropogenic
C	colluvial
E	eolian
F	fluvial
L	lacustrine
M	morainal
O	organic
R	bedrock
W	marine
U	undifferentiated

Surface Expression

Letter Symbol	Name
b	blanket
f	fan
h	hummocky
l	level
m	subdued
v	ridged
s	steep
t	terraced
v	veneer

Qualifying Descriptors

Letter Symbol	Name
G	glacial
B	bog
F	fen
S	swamp

Flooding relates to river and stream overflow and not surface accumulation via high water-tables, seepage, and runoff. They are referred to as ponding and are not considered in this assessment.

Vegetation - describes broadly some of the most typical native trees, shrubs and grasses. Mention is made of whether the soils are mostly in their native state or are cultivated.

3.2.4 Typical Soil Profile

A generalized soil profile diagram is provided for each soil, with major horizons indicated and briefly described according to CanSIS, 1978 and C.S.S.C., 1978.

3.2.5 Soil Characteristics

These tables summarize data obtained from field observations and laboratory analyses. Data for physical and chemical properties are presented as unweighted means, along with the range of values measured and the number of samples analysed. The laboratory data are usually from the analyses of two or more representative profiles, often supplemented by additional samples from selected soil horizons or depths. If laboratory data are unavailable, estimated values are usually provided. Definitions for the soil characteristics described are as follows:

Depth to Bedrock - this term refers to the estimated average depth to solid bedrock. Where bedrock is greater than 100 cm from the surface the symbol N/A (non applicable) is used.

Humus Form - this indicates the type of humus form that most commonly occurs under natural conditions defined as follows (R.A.B., 1980).

MOR - A nonzoogenous forest humus form distinguished by a matted F layer and an organic H layer with a sharp delineation from the A horizon. It is generally acid, has a high organic carbon content of 52% or more, and a high C:N ratio of 25 to 35, or sometimes higher. Various subgroups can be recognized by the morphology, and chemical and biological properties. Commonly occurs in coniferous forests.

MODER - A zoogenous forest humus form made up of plant remains partly disintegrated by the soil fauna (F layer), but not matted as in raw humus. It is transitional to a zone of spherical or cylindrical microejections of arthropods that are permeated by loose mineral particles in its lower part and often throughout. Although incorporation of organic matter is intense, it is shallow, because none of the organisms concerned with moder formation have important burrowing activity. The mixing of organic and mineral particles is purely mechanical. Organic carbon content under the F layer varies from 23% to 29%, but may exceed 35%. The C:N ratio is 20 to 25 and sometimes lower. Various subgroups can be recognized by their morphology and chemical characteristics.

MULL - A zoogenous forest humus form consisting of an intimate mixture of well-humified organic matter and mineral soil that makes a gradual transition to the horizon underneath. It is distinguished by its crumb or granular structure. Due to the activity of the burrowing microfauna (mostly earthworms), partly decomposed organic debris does not accumulate as a distinct layer (F layer) as in mor and

moder. The organic matter content is 5 to 20% and the C:N ratio is 10 to 15. Various subgroups can be distinguished by the morphology and chemical characteristics.

Solum Depth - the total thickness of upper horizons in which soil forming processes are active and in which most plant roots occur. It usually consists of A and B horizons.

Depth to, Thickness, and Type of Restricting Layer - the depth of soil to a root restricting layer; the thickness of the restricting layer; type of restricting layer includes cemented or other layers acting as barriers to plant roots (for example, duric horizons, Bt horizons, or compacted glacial till).

Rooting Depth - depth of soil available for plant rooting.

Coarse Fragment Class - a measure by volume of the content of coarse fragments 2.5 cm in diameter or greater in the upper 25 cm of mineral soil. These classes indicate the abundance of coarse gravels, cobbles and stones present. These are considered a hindrance to cultivation, decrease available water holding capacity and decrease the volume of soil available for rooting and nutrient uptake. Fine gravels <2.5 cm in diameter are not included. The classes are defined in Table 3.2.

Table 3.2
Coarse Fragment Classes

Class	Description
0	Coarse fragments greater than 2.5 cm in diameter are essentially absent.
1	Coarse fragments offer a only slight hinderance to cultivation. The total content of coarse fragments greater than 2.5 cm in diameter is less than 10% and/or the content of cobbles and stones is less than 1%.
2	Coarse fragments cause a significant interference with cultivation. The total content of coarse fragments greater than 2.5 cm in diameter varies from 11 to 20% and/or the content of cobbles and stones varies from 2 to 5%.
3	Coarse fragments are a serious handicap to cultivation. The total content of coarse fragments greater than 2.5 cm in diameter varies from 21 to 40% and/or the content of cobbles and stones varies from 6 to 15%.
4	Coarse fragments prevent cultivation until considerable picking has been done. The total content of coarse fragments greater than 2.5 cm in diameter varies from 41 to 60% and/or the content of cobbles and stones varies from 16 to 30%.
5	The abundance of coarse fragments makes impractical the application of improvement practices. The total content of coarse fragments is greater than 60% and/or the content of cobbles and stones is greater than 30%.

Depth to and Type of Watertable - the depth to the upper zone of free water as indicated by matrix colours of low chroma or distint to prominent mottles of high chroma. Watertables are described according to their persistence, i.e. seasonal (usually during winter) or year-round, and their origin, i.e. whether perched (resulting from an underlying impermeable layer) or apparent (representing the true surface of the unconfined groundwater). For some soils the presence of a water table is unknown since soil pits were generally only dug about 1 m deep. In these cases the watertables are described as >1 m deep and of unknown type.

Soil perviousness - Soil perviousness refers to the soils ability to transmit water internally, and is inferred from soil characteristics such as structure, texture, porosity, cracks, organic matter content, and shrink-swell properties. It is closely related to measures of permeability, percolation rate, and infiltration rate, but these are reserved for actual measurements using standard techniques. Perviousness applies to the whole soil profile. Because of this, it is determined by the least permeable layer in the soil "control section". It is important to distinguish between soil drainage and perviousness. For example, a rapidly pervious soil could be receiving excessive seepage and thus be poorly drained. Three perviousness classes are defined (from Resource Analysis Branch, 1980):

a. 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 thorough wetting. The horizons and soils have large and continuous or connecting pores and cracks that do not close with wetting.

b. 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 saturation. Most moderately pervious soils hold relatively large amounts of water against the force of gravity, and are considered to have good physical structure for rooting and supplying water to plants. Soil horizons may be single grained, granular, blocky, weakly platy or massive (but porous if continuous conducting pores or cracks are present which do not close with wetting).

c. Slowly pervious - The potential to transmit water vertically is so slow that the horizon or the soil will remain saturated for periods of a week or more after thorough wetting. The soil may be massive, blocky or platy, but connecting pores that conduct water when the soil is wet are few, and cracks or spaces among peds that may be present when the soil is dry, close with wetting. Even in positions accessible to plant roots, roots are usually few or absent and if present, they are localized along cracks when the soil is wet.

Soil Drainage - Defined in terms of (i) the actual moisture content in excess of field moisture capacity, and (ii) the extent of the period during which such excess water is present in the plant-root zone. It is recognized that permeability, level of groundwater, and seepage are factors affecting moisture status. However, because these are not easily observed or measured in the field, they cannot be used generally as criteria for drainage classes.

Soil profile morphology, particularly mottling and gleying, normally, but not always, reflects soil drainage. Topographic position and vegetation as well as other soil characteristics, are useful field criteria for assessing soil drainage classes.

The definitions of the soil drainage classes are underlined. As a guide to surveyors, additional comments under each class indicate some of the pertinent soil morphological features that are commonly, but not necessarily found.

a. Rapidly drained - The soil moisture content seldom exceeds field capacity in any horizon except immediately after water additions. Soils are free from any evidence of gleying or mottling throughout the profile. Rapidly drained soils often occur on steep slopes.

b. Well drained - The soil moisture content does not normally exceed field capacity in a horizon (except possibly the C) for a significant part of the year. Soils are usually free from mottling in the upper 1 m, but may be mottled below this depth.

c. Moderately well drained - The soil moisture in excess of field capacity remains for a small but significant period of the year. Soils are often faintly mottled in the lower B and C horizons or below a depth of 0.7 m. The Ae horizon, if present, may be faintly mottled in fine-textured soils and in medium-textured soils that have a slowly permeable layer below the A and B horizons. In grassland soils the B and C horizons may be only faintly mottled and the A horizon may be relatively thick and dark.

d. Imperfectly drained - The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year. Soils are often distinctly mottled in the B and C horizons; the Ae horizon, if present, may be mottled. The matrix generally has a lower chroma than in the well drained soil on similar parent material. Soils are generally gleyed subgroups of mineral soil orders.

e. Poorly drained - The soil moisture in excess of field capacity remains in all horizons for a large part of the year. The soils are usually strongly gleyed. Except in high chroma parent materials, the B, if present, and upper C horizons usually have matrix chromas of 3 or less; prominent mottling may occur throughout. Soils are generally in the Gleysolic or Organic order.

f. Very poorly drained - Free water remains at or within 30 cm of the surface most of the year. The soils are usually strongly gleyed. Subsurface horizons usually are of low chroma and yellowish to blueish hues. Mottling may be present within 30 cm or at depth in the profile. Soils are generally in the Gleysolic or Organic order; mineral soils are usually a peaty phase.

Depth to Salts - The depth to saline horizons indicated by electrical conductivity measurements. Soil is usually considered saline when electrical conductivity is 4 mS/cm or higher.

Soil Texture - Soil texture is an important physical property and is defined in terms of the size distribution of primary mineral particles (2 mm diameter or less) as determined by sieve and sedimentation analysis, or field estimation. Particle size separates consist of clay (<0.002 mm), silt (0.002-0.05 mm) and sand (0.05-2.0 mm). The texture classes are illustrated in Figure 3.1.

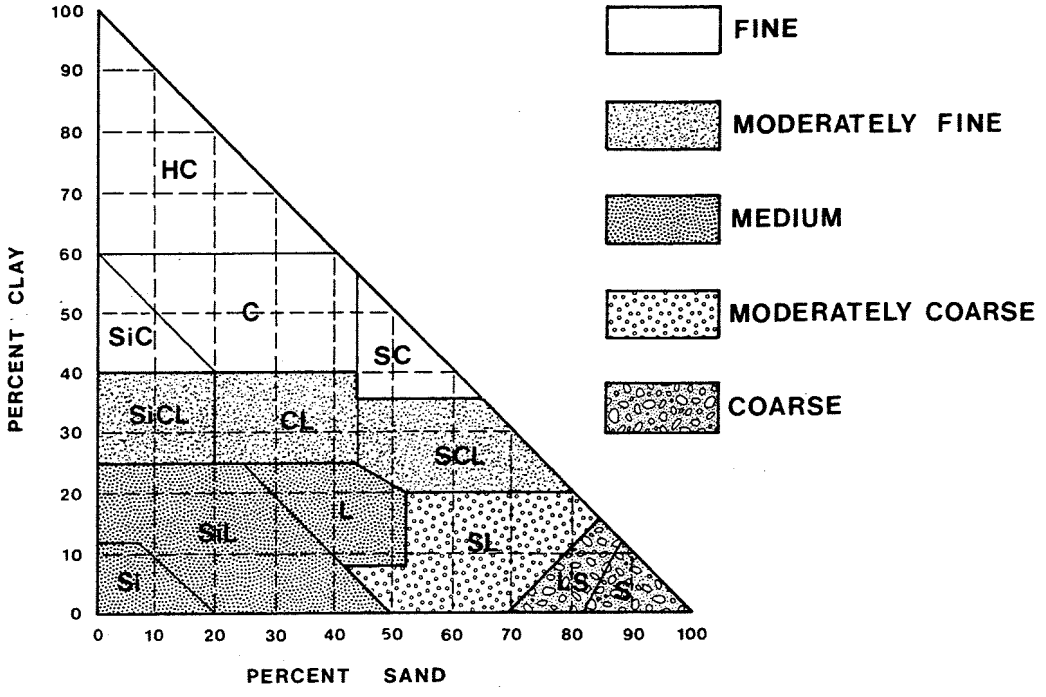


Figure 3.1 Soil texture classes. Percentages of clay and sand in the main textural classes of soil; the remainder of each class is silt.

The relative proportions of the particle size separates for various soil textures is as shown in Figure 3.1. Texture classes can be modified by the prefix "gravelly", if 20 to 50% gravels by volume or "very gravelly" if gravels occupy 50 to 90% of the soil volume, with gravels defined as the coarse fragments less than 7.5 cm in diameter. Sand, loamy sand, and sandy loam textures can be further subdivided on the basis of the proportions of the various sand separates present.

The limits of the various textural classes and subclasses are:

Sand - Sand is a soil material that contains 85% or more sand; the percentage of silt plus 1.5 times the percentage of clay does not exceed 15.

coarse sand - Coarse sand is a soil material that contains 25% or more very coarse and coarse sand, and less than 50% any other one grade of sand.

medium sand - Medium sand is a soil material that contains 25% or more very coarse, coarse, and medium sand, and less than 50% fine or very fine sand.

fine sand - Fine sand is a soil material that contains 50% or more fine sand or less than 25% very coarse, coarse, and medium sand and less than 50% very fine sand.

very fine sand - Very fine sand is a soil material that contains 50% or more very fine sand.

Loamy Sand - Loamy sand is a soil material that contains at the upper limit 85 to 90% sand, and the percentage of silt plus 1.5 times the percentage of clay is not less than 15; at the lower limit it contains not less than 70 to 85% sand, and the percentage of silt plus twice the percentage of clay does not exceed 30.

loamy coarse sand - Loamy coarse sand is a soil material that contains 25% or more very coarse and coarse sand and less than 50% any other one grade of sand.

loamy (medium) sand - Loamy sand is a soil material that contains 25% or more very coarse, coarse, and medium sand and less than 50% fine or very fine sand.

loamy fine sand - Loamy fine sand is a soil material that contains 50% or more fine sand or less than 25% very coarse, coarse, and medium sand and less than 50% very fine sand.

loamy very fine sand - Loamy very fine sand is a soil material that contains 50% or more very fine sand.

Sandy Loam - Sandy loam is a soil material that contains either 20% or less clay, with a percentage of silt plus twice the percentage of clay that exceeds 30, and 52% or more sand; or less than 7% clay, less than 50% silt, and between 43% and 52% sand.

coarse sandy loam - Coarse sandy loam is a soil material that contains 25% or more very coarse and coarse sand and less than 50% any other one grade of sand.

sandy loam (medium) - Sandy loam consists of 30% or more very coarse, coarse and medium sand, but less than 25% very coarse sand, and less than 30% very fine or fine sand.

fine sandy loam - Fine sandy loam is a soil material that contains 30% or more fine sand and less than 30% very fine sand or between 15 and 30% very coarse, coarse and medium sand.

very fine sandy loam - Very fine sandy loam is a soil material that contains 30% or more very fine sand or more than 40% fine and very fine sand, at least half of which is very fine sand, and less than 15% 15% very coarse, coarse, and medium sand.

Loam - Loam is a soil material that contains 7 to 27% clay, 28 to 50% silt, and less than 52% sand.

Silt loam - Silt loam is a soil material that contains 50% or more silt and 12 to 27% clay, or 50 to 80% silt and less than 12% clay.

Sandy clay loam - Sandy clay loam is a soil material that contains 20 to 35% clay, less than 28% silt, and 45% or more sand.

Clay loam - Clay loam is a soil material that contains 27 to 40% clay and 20 to 45% sand.

Silty clay loam - Silty clay loam is a soil material that contains 27 to 40% clay and less than 20% sand.

Sandy clay - Sandy clay is a soil material that contains 35% or more clay and 45% or more sand.

Silty clay - Silty clay is a soil material that contains 40% or more clay and 40% or more silt.

Clay - Clay is a soil material that contains 40% or more clay, less than 45% sand, and less than 40% silt.

Heavy clay - Heavy clay is a soil material that contains more than 60% clay.

3.2.5.1 Soil Physical Properties

These properties relate to the mechanical behavior of the soil. The physical data is presented as simple, unweighted means, along with the range of values found and the number of samples analysed for each property.

Permeability - is a measure of downward rate of water movement through a saturated soil. Since laboratory determinations of permeability were not performed, estimates were made based on the following soil characteristics and guidelines. The soil characteristics were mainly texture and to a lesser degree, soil structure, organic matter, coarse fragment content, porosity, and bulk density.

Very Slow - The soil has very little if any water transmission. Generally fine-textured soils dominate. Permeability is less than 0.125 cm/hr.

Slow - The soil has very little water transmission. Generally moderately fine-textured soils such as clay loams and silty clay loams dominate. Permeability is 0.125 cm/hr to 2.5 cm/hr.

Moderate - There is good water transmission. Generally medium-textured soils such as loams and silt loams dominate. Permeability is 2.5 cm/hr to 12.5 cm/hr.

Rapid - The soil water transmission is too great for optimum growth. Generally moderately coarse-textured soils such as sandy loams and gravelly loams dominate. Permeability is 12.5 cm/hr to 25 cm/hr.

Very Rapid - Excessive water transmission throughout the soil. Porous, coarse-textured soils such as sands and gravels dominate. Permeability is greater than 25 cm/hr.

Bulk Density - Bulk density is the mass of a unit volume of dry soil and includes both pores and soil solids. Bulk density depends largely on texture, structure and degree of compaction. Generally, with higher bulk densities there is less pore space and development of structure. The addition of organic matter enhances soil structure development and decreases bulk density while compacting soils by traffic or tillage increases bulk density. For most soils, surface layers are likely to be less compact than subsoil layers.

Table 3.3 shows the approximate relationship between bulk density and soil texture. The type of taxonomic soil development, organic matter content and presence of coarse fragments can greatly change this relationship. For example, a loamy sand Bf horizon may have a bulk density much lower than 1.5-1.6 g/cm^3 due to well developed structure while if a large amount of coarse fragments are present, the bulk density will likely be substantially higher.

Table 3.3
Generalized Relationship Between Bulk Density and Soil Texture

Bulk Density	Soil Texture	Class
0.1-0.4 g/cm^3	peat	very low
<1.1 g/cm^3	heavy clay, clay	very low
1.1-1.2 g/cm^3	silty clay, clay, sandy clay	low
1.2-1.3 g/cm^3	clay loam, silty clay loam, sandy clay	moderately low
1.3-1.4 g/cm^3	loam, sandy clay loam, silt loam, silt	medium
1.4-1.5 g/cm^3	fine sandy loam, loam	medium high
1.5-1.6 g/cm^3	sandy loam, loamy sand	high
>1.6 g/cm^3	sand	very high

Available Water Storage Capacity (AWSC) - AWSC represents the amount of water which can be extracted from the soil by plants or is available for plant use. Quantitatively, it is the depth of water held in the soil between field capacity (1/3 atmosphere) and permanent wilting point (15 atmospheres) and is expressed in cm/m.

Table 3.4
Approximate Available Water Storage Capacity of Selected Soil Textures

Approximate AWSC (cm H_2O/m of soil)	Soil Texture*	Class
2.5 4.5	"pea" gravel very gravelly sand	very low
8.3 10.0	sand loamy sand	low
12.5 14.2 17.5	sandy loam fine sandy loam loam	moderate
20.0 20.0 20.8 22.0	clay loam clay silt loam organic	high

*Soil textures contain no gravels or other coarse fragments except where indicated. There presence will proportionately reduce the above AWSC values.

Type of Organic Material - The term applies to soils in the Organic Order. Three types of organic material are recognized based on the degree of decomposition: fibric (relatively undecomposed, with readily identifiable plant fragments); mesic (intermediate stage of decomposition); and, humic (advanced stage of decomposition).

Rubbed Fiber Content - This is a measure for determining the degree of decomposition of organic material. Fibric organic material contains more than 40% fiber, mesic material contains between 10 and 40% fiber and humic material contains less than 10% (McKeague, 1976).

von Post Scale - This empirical rating is a field assessment of the degree of organic material decomposition on a scale of 1 to 10: fibric (1 to 4), mesic (5 or 6), and humic (7 or greater) (The Canadian System of Soil Classification, 1978).

Pyrophosphate Index - This color test provides another measure of organic material decomposition: fibric (>5), mesic (3 to 5), and humic (<3) (The Canadian System of Soil Classification, 1978).

Coarse Fragments - These are soil particles greater than 2 mm in diameter. They are separated into two classes: those between 2 mm and 7.5 cm diameter are considered as gravels and those greater than 7.5 cm diameter are considered as cobbles and stones. Data given are average values based on visual estimates of relative volumes based on field sievings.

Percent Passing Sieves - This analysis refers to the percent of soil or gravel material which passes through specified sieve sizes and is used to determine Unified engineering soil classification system. No. 4 sieves have mesh openings of 4.76 mm meshes while No. 40 sieves have openings of 0.42 mm. Material passing the No. 200 sieve (0.074 mm mesh openings) is considered to be all silt and clay.

Percent Sand - as determined by particle size analysis.

Percent Clay - as determined by particle size analysis.

3.2.5.2 Soil Chemical Properties

The data presented are intended to give a general indication of the levels and variability of important soil chemical properties. They are suitable for general applications but are not suitable for deriving site specific recommendations such as for fertilizer application.

For determination of optimum fertilizer applications for individual farms or fields, it is advisable to have independent analyses and interpretations conducted, because of the wide variability found within the same soil, the effects of past and present management practices and the type of crop to be grown. The chemical values shown for most soils are based on analyses of undeveloped (forested) conditions. Tillage, crops and fertilizer applications can drastically alter these relationships. Soils under cultivation and cropping tend to become depleted of primary and secondary elements, phosphorous fixation occurs under acid conditions, bases and nitrates tend to be leached, as well as the tendency for acidification to occur as an on-going process. Minor elements such as boron, manganese, copper, zinc, molybdenom, and selenium have not been included in the standard chemical analyses carried out on the soils of the map area.

The chemical data are presented as simple unweighted means, along with the range of values found and the number of samples analysed for each property.

Soil Reaction (pH)

Soil reaction or pH is expressed in values from zero to 14. A value of seven indicates neutrality; decreasing values below seven indicate increasing acidity, while increasing values above seven indicate increasing alkalinity.

Soil pH was measured by two methods. The first utilized a glass electode in a 1:1 soil-water suspension for mineral soil samples and a 1:5 suspension for organic soil samples. The second method employed a 0.01M $CaCl_2$ solution instead of water. This latter method reduces the effect of varying concentrations of salts and approaches the pH of the soil solution under actual field conditions. Values by this method are usually about 0.5 pH unit less than in water determinations.

Plants vary in their ability to grow at different pH values. Nutrient availability to various plants at different pH values may vary significantly. In general, depending upon the type of crop to be grown, soils with pH (H_2O) values between 5.5 and 6.0 normally require slight amounts of lime whereas soils with pH (H_2O) values between 5.0 and 5.5 require moderate amounts of lime, and soils with values between 4.5 and 5.0 may require high amounts of lime. The actual amounts of lime required are best determined by a lime requirement test.

The pH of surface and subsurface horizons of southeastern Vancouver Island soils is affected largely by the regional climate, soil mineralogy, especially aluminum content, texture, soil water relationships, organic matter content and soil management. The reaction classes of soil parent materials in the survey area are generally slightly or medium acid. The surface soil horizons are nearly always medium or strongly acid.

Table 3.5
Soil Reaction (pH)

Reaction Class	pH Values (0.01 M $CaCl_2$)
Extremely Acid	<4.5
Very Strongly Acid	4.6-5.0
Strongly Acid	5.1-5.5
Medium Acid	5.6-6.0
Slightly Acid	6.1-6.5
Neutral	6.6-7.3
Mildly Alkaline	7.4-7.8
Moderately Alkaline	7.9-8.4
Strongly Alkaline	>8.5

Conductivity (Salinity)

Salt content is usually measured on a saturated soil extract and the resultant electrical conductivity is expressed in millisiemens per centimeter (mS/cm). Salinity is not a common problem in the study area, being restricted to areas subject to tidal flooding (modified from U.S.S.L., Riverside, California; U.S.D.A., 1971).

Table 3.6
Conductivity (Salinity)

Salinity Classes	Conductivity (mS/cm)	Plant Growth Conditions
Non saline (NS)	<2	Salinity effects negligible. Soils free of excess salts; plant growth not inhibited.
Very weakly saline (VWS)	2-4	Yields of sensitive crops restricted. Soils have very slight amounts of excess salts; sensitive plants may show growth restrictions.
Weakly saline (WS)	4-8	Yields of many crops restricted. Soils are slightly affected by excess salt; growth of sensitive plants inhibited but some salt tolerant plants may not be.
Moderately saline (MS)	8-16	Most salt-tolerant crops have lower yields. Soils are moderately affected by exccess salt. Plant growth is very inhibited and few crops do well.
Strongly saline (SS)	>16	Only a few very salt tolerant plants survive and show low yields. Soils are strongly affected by excess salt.

Crops and plants differ in their tolerance to salinity. Such crops as wheatgrass, beets and spinach are not only highly tolerant but also react to growth stimulation by salt levels that could be lethal to sensitive plants such as Alsike clover.

Organic Carbon

The amount of organic carbon in soils is a measure of soil organic matter which results from the decomposition and incorporation of leaves, twigs, roots, mosses, seeds and other organic material. The amount of organic matter that accumulates is controlled by vegetation which in turn is related to precipitation, drainage and temperature. The amount of organic matter can vary from less than 1% to almost 100%. In cultivated soils organic matter maintenance is very important as it improves soil fertility and soil structure, promotes resistance to crusting, puddling and erosion, and increases aeration and friability as well as moisture holding capacity and cation exchange capacity. Organic matter content can be estimated by multiplying the percent organic carbon by 1.7.

The organic matter in soils can be maintained by frequent incorporation of green manures, crop residues, barnyard manure or other organic material. This helps to maintain adequate levels of soil fertility for crop production. In general the carbon content of mineral soils is highest at the surface and decreases with depth. Organic soils tend to have organic carbon content that

remains relatively constant throughout the soil profile or increases slightly with increasing depth. Levels of organic carbon of less than 2% are considered low, 2% to 10% moderate, while greater than 10% are high.

Nitrogen

Nitrogen is a major plant nutrient required for growth. Nitrogen is utilized by plants mainly in the nitrate form which is easily lost from the soil by leaching, and in the ammonium form which is somewhat less subject to leaching. Soil organic matter and commercial fertilizers are the major nitrogen sources.

Microorganisms play an important role in the provision of nitrogen to plants. The ammonifying and nitrifying microorganisms convert nitrogen from soil organic matter into forms available for plant uptake. The amount released is influenced by drainage, temperature, C:N ratio of added organic matter. Nitrogen-fixing bacteria, some of which are associated with roots of legumes (e.g. clover, alfalfa), convert atmospheric nitrogen into forms usable by plants.

In their undisturbed condition, forested soils in the study area have high nitrogen levels only in the surface organic layers and the uppermost mineral soil horizon. Nitrogen content decreases rapidly with depth.

For most crops, those soils having total nitrogen levels of greater than 0.40% in the surface 25 cm are not likely to need much nitrogen fertilization for a few years. As most of these values will vary widely from site to site, it is more useful to take individual soil fertility tests when devising a fertilization program. Surface soils with values of less than 0.25% total nitrogen will generally require fertilization.

Cation Exchange Capacity

The ability of soils to hold exchangeable cations is termed the cation exchange capacity which is expressed as milli-equivalents of cations required to balance the negative charge of 100 g of soil at pH 7.0. Exchange sites are mainly supplied by organic matter and clay minerals. Therefore, depending on the organic matter content and the type and amount of clay minerals present, the exchange capacities can range from less than 10 to over 100 milli-equivalents per 100 g of soil. The following values may be used as a guide to the relative levels of the exchange capacities of soils.

Table 3.7
Cation Exchange Capacity Classes

Class	Cation Exchange Capacity (Milli-equivalents/100 g)
Very Low (VL)	less than 5
Low (L)	5 - 10
Medium (M)	10 - 20
High (H)	20 - 60
Very High (VH)	more than 100

High cation exchange capacities generally occur in fine-textured soils and soils with high organic matter contents. Organic soils in the surveyed area have cation exchange capacities in the range of 160-200 milli-equivalents per 100 g, which reflect their very high organic matter content and high potential ability to hold nutrients. For mineral soils, exchange capacities are mostly high in the surface horizon, reflecting high organic matter contents, decreasing to medium and low in the subsoil. Coarse-textured, gravelly subsoils usually have very low cation exchange capacities.

Base saturation is a most important property in soils. It is defined as the percentage of total cation exchange capacity occupied by the basic calcium, magnesium, sodium and potassium cations. Aluminum and hydrogen generally occupy that portion on the exchange complex that is not satisfied by basic cations. The ease with which cations are absorbed by plants is related to the degree of base saturation. For any given soil the availability of basic cations increases with the degree of base saturation. For example, a soil with a base saturation of 80% would provide cations to growing plants far more easily than the same soil with a base saturation of 40% (Tisdale and Nelson 1966). The soils of the surveyed area normally have low base saturation, particularly in the upper strongly weathered horizons.

Exchangeable Cations

Calcium, magnesium, potassium, sodium, hydrogen, aluminum and hydroxyaluminum ions are the most abundant exchangeable cations. Their proportions vary from soil to soil depending on soil characteristics and past management practices. Aluminum and hydrogen ions are very abundant in most soils, but are not measured directly; rather, they are assumed to make up the remainder of the total cation exchange capacity that is not filled by the basic cations. For the soils of the study area, basic cations account for about half of the cation exchange capacity.

Aluminum and hydrogen cations predominate in acid soils while calcium and magnesium are the most common in near neutral soils. Sodic and saline soils may contain various proportions of exchangeable sodium, calcium and magnesium as well as minor amounts of potassium. Exchangeable calcium and magnesium, removed by crops and lost by leaching, are usually replaced by aluminum and this results in a decrease in pH.

(i) Exchangeable Calcium (Ca)

Calcium is the dominant basic cation on the exchange complex. Calcium values of surface horizons in soils in the report area are generally greater than 4 meq/100 g although subsoils often have calcium levels of less than 4 meq/100 g. Generally, the latter are coarse-textured soils with low cation exchange capacities and low organic matter contents. Exchangeable calcium levels below 2.5 meq/100 g are considered low and inadequate for many crops.

(ii) Exchangeable Magnesium (Mg)

Magnesium levels are generally greater than 0.85 meq/100g in most of the A horizons of mineral soils in the survey area. Most subsoils and coarse-textured sands and loamy sands with low organic matter have lower values. Organic soils in the survey area in general have high levels of magnesium, above 1.7 meq/100 g. Soils with high magnesium levels require little or no magnesium fertilization while those with medium to low levels (<0.85 meq/100 g) may show beneficial effects

with increasing amount of magnesium fertilizer. Proper rates of fertilizer applications however, should be determined by individual soil tests and be related to the requirement of the desired crop. (H. Chuah, personal communication).

(iii) Exchangeable Sodium (Na)

Sodium is a relatively loosely held ion on the exchange complex and is readily lost and replaced by other ions in the soil solution. The presence of sodium in large quantities, especially in fine-textured soils, is undesirable because of its detrimental effect on soil structure. Soils containing appreciable exchangeable Na cations tend to become dispersed, are less permeable to water, and have poor tilth. When Na cations occupy more than 10 to 20% of the cation exchange capacity, the soil develops a poor physical condition, especially if the soluble salt content is low. Coarse-textured soils can tolerate a higher exchangeable sodium percentage than fine-textured soils before the physical condition deteriorates. Also, soils having a high organic matter content can tolerate a higher Na cation percentage than those without it.

Sodium is not considered an essential plant nutrient and becomes toxic to many crops if exchangeable sodium exceeds 25%. In the surveyed area, Na cations are the least abundant exchangeable cations, except in soils affected by tidal flooding.

(iv) Exchangeable Potassium (K)

Exchangeable potassium exists in equilibrium with fixed forms of K in the soil. This equilibrium is disturbed when plants remove the exchangeable form and, to re-establish equilibrium, some fixed potassium is released. The maintenance of an adequate supply depends upon the reserve and rate of release.

Soils with less than 0.15 meq/100 g of exchangeable potassium are considered to have low levels, while values greater than 0.31 meq/100 g are considered high. Generally those soils with high to very high levels of potassium will require little or no potassium fertilization, whereas those with moderate to very low levels will require varying amounts as determined by individual soil tests and crop requirements.

Phosphorus

Phosphorus is a major nutrient element required for plant growth. Since plants can only utilize inorganic forms, the organic forms must be mineralized by microorganisms before plant uptake is possible. The proportion of phosphorus available for plant growth to the total present in the soil at any one time is generally small.

Available phosphorus levels below 10 ppm are low, while values over 40 ppm are considered high. Depending upon the crop to be grown, soils with moderately high to high available phosphorus levels will generally require little or no phosphorus fertilization, whereas those with medium to very low values will require varying amounts as determined by individual soil tests and crop requirements.

Sulfur

Sulfur is a minor but essential element for crop growth. Its content is generally low (<3 ppm) in most Vancouver Island mineral soils, but very high (>20 ppm) in organic soils.

Iron and Aluminum

Iron and aluminum content, as measured by the sodium pyrophosphate extraction technique, provides an important criterion in soil classification. For most of the soil textures in the study area, the Fe+Al content of the B horizon must be equal or greater than 0.6% for the soils to be classified in the Podzolic order. (Additional criteria apply; see: Canada Soil Survey Committee, 1978). Most B horizons in moderately well to rapidly drained soils in this study area have Fe+Al values of 0.4 to 1.0%.

3.2.6 Soil Phases and Variants

In addition to the 37 named soils described for the study area, phases and variants of these soils are also recognized. The complete lists of phase and variant symbols and their description are given below. Those phases and variants recognized for each soil are also indicated in each soil description in Chapter 4.

Soil Phases are variations of a defined soil and occur due to differences in stoniness, topography, depth of profile, depth to bedrock, and other features which affect the soils use and management. They are not sufficiently different from the defined soil to warrant identification of a separate soil. Table 3.8 lists all soil phases used in the report area.

Table 3.8
Description of Soil Phases

Phase Symbol	Description
co	Cobbly. Cobbles and stones occupy more than 20% of the soil volume.
dc	Moderately to strongly cemented horizon (duric) occurring between 100 and 200 cm depth.
g	Gravelly. Between 20 and 50% of the soil volume is occupied by gravels.
l2	Shallow lithic. Bedrock occurs at depths between 50 and 100 cm of the soil surface.
pt	Peaty. 15 to 40 cm of humic or mesic organic material occurs on the surface of the mineral soil.
r	Rubbly and/or blocky. More than 50% of the soil volume is occupied by coarse fragments greater than 25 cm in diameter.
l3	Very shallow lithic. Bedrock occurs at depths between 10 and 50 cm of the soil suface.
vg	Very gravelly. Between 50 and 90% of the soil volume is occupied by gravels.
w	Strongly mottled. Moisture regime of the soil is wetter than the usual conditions as evidenced by prominent mottling within 50 cm of the surface. Seasonal perched water tables present. Landscape position is not typical of Gleysolic soils.
wc	Weakly cemented horizons are present in the subsurface and/or subsoil.

Soil Variants are soils whose properties are believed to be sufficiently different from other known soils to justify identification of a new soil, but occurring over such a small area that definition of a new named soil is not justified. Exceptions were made with some Gleysolic soils (e.g. Koksilah) because of their significance to land use and management. Table 3.9 lists all variants in the report area.

Table 3.9
Description of Soil Variants

Symbol	Description
a	Sufficient Ah is present for the soil to be classified in the Sombric subgroup of the Podzolic or Brunisolic Orders.
id	The soil is imperfectly drained and classified in the Gleyed subgroup of the appropriate soil order.
lo	10 to 50 cm of loam textured material occurs at the soil surface.
mc	Moderately cemented soil horizons are present.
md	Moderately well to well drained, e.g. Orthic Dystric Brunisol instead of Gleyed Dystric Brunisol.
pd	Poorly drained (Gleysolic).
s	Shallow. 50 to 100 cm of surficial deposit overlying another of different origin, or a strongly contrasting change in texture.
so	Terric organic soils (mineral material occurs between 40 and 160 cm of surface).
sp	Sedimentary peat is present in the subsoil.
t	Taxadjuncts are soils that approximate, but do not quite meet the criteria of a taxonomic category. Specific classification given in the soil description section. (Used only for Organic soils in this map area).
vs	Very shallow. 10 to 50 cm of surficial deposit overlying another of different origin, or a strongly contrasting change in texture.

3.2.7 Inferred Soil Properties

The Unified System

The Unified classification system (Asphalt Institute, 1978) (U.S.D.A, 1971) is based on 1) textural characteristics for those soils with a small amount of fines; and 2) on plasticity-compressibility characteristics for soils where fines affect their behaviour. These are shown in Table 3.10.

This classification gives a basis for predicting soil behaviour as an engineering construction material. Eight of the 15 Unified classes are coarse-grained and identified as GW, GP, GM, GC, SW, SP, SM and SC. Fine-grained classes are identified as ML, CL, L, MH, CH and OH. One class of organic soil is identified as Pt. (Asphalt Institute, 1978).

American Association of State Highways Officials (AASHO) System

The AASHO system (Asphalt Institute, 1978) is based on the observed field performance of soils under highway pavement; it is widely used by highway engineers. In this system a soil is placed in one of seven basic group ratings (A-1 to A-7) on the basis of grain size distribution, liquid limit and plasticity index (as shown in Table 3.11). Group A-1 are gravelly soils of high bearing strength and are the best soils for subgrade while groups A-4 to A-7 are the poorest for subgrade. These latter groups are clay soils having low bearing strength when wet.

Table 3.10
Characteristics of the Unified Classification

UNIFIED SYMBOL	MATERIAL CHARACTERISTICS
GW	Well-graded gravels, gravel-sand mixtures, little or no fines
GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
GM	Silty gravels, gravel-sand-silt mixtures
GC	Clayey gravels, gravel-sand-clay mixtures
SW	Well-graded sands, gravelly sands, little or no fines
SP	Poorly-graded sands, gravelly sands, little or no fines
SM	Silty sands, sand-silt mixtures
SC	Clayey sands, sand-clay mixtures
ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
OL	Organic silts and organic silty clays of low plasticity
MP	Inorganic silts, micaceous or diatomateous fine sandy or silty soils, elastic silts
CH	Inorganic clays of high plasticity, fat clays
OH	Organic clays of medium to high plasticity, organic silts
Pt	Peat and other highly organic soils

Table 3.11
Classification of Soils and Soil-Aggregate Mixtures in the ASSHO System

General Classification	Granular Materials (35% or less passing 0.075 mm)							Silt-Clay Materials (More than 35% passing 0.075 mm)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis, Percent Passing											
2.00 mm (No. 10)	50 max	---	---	---	---	---	---	---	---	---	---
0.425 mm (No. 40)	30 max	50 max	51 min	---	---	---	---	---	---	---	---
0.075 mm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of Fraction Passing of 0.425 mm (No. 40)											
Liquid Limit	---		---	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity Index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min
Usual Types of Significant Constituent Materials	Stone Fragments Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Rating as Subgrade	Excellent to Good							Fair to Poor			

Plasticity index of A-7-5 subgroup is equal to or less than LL. minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

Atterberg Limits (Liquid Limit and Plastic Limit)

The engineering properties of soils vary with the amount of water present. Atterberg Limits measure the effect of moisture on the consistence of the material.

Atterberg limits are most commonly applied in the planning of road construction. Generally, soils with high liquid limits, such as clays, have poor engineering properties. A low plasticity index, on the other hand, indicates a granular soil with little or no cohesion or plasticity. Some silts and sandy soils are non-plastic (NP).

The liquid limit is the minimum percentage moisture content at which the soil-water mixture changes from a liquid to a plastic state, and represents the moisture content at which the soil will barely flow under an applied force.

The liquid limit varies widely and values as high as 80 to 100 are not uncommon with values of 40 to 60 more typical for clay soils. For silty soils, values of 25 to 50 can be expected, and are typical for medium to fine textured soils in this study area. The liquid limit test is not applicable for sandy soils; such soils are classified as "non-plastic" (NP).

The plastic limit is the minimum percentage moisture content at which the soil-water mixture changes from a plastic to a semi-solid state. It represents the minimum moisture at which puddling is possible and the maximum moisture content at which the soil is friable. It also generally indicates the point of maximum cohesion in the soil.

The plastic limit of silts and clays will not vary too widely and will range from 5 to 20. Normally, silty soils have the lower plastic limit. Pure sand is "non-plastic" (NP).

The plasticity index is the arithmetic difference between the liquid and plastic limits and indicates the range of moisture content within which a soil material is in a plastic condition. Generally the greater the plasticity index, the greater are the plasticity, compressibility and volumetric change characteristics of the soil.

The plasticity index can be as high as 70 to 80 for very plastic clays. Commonly, clays will have P.I.'s between 20 and 40. The silty materials normally range in P.I. between 10 and 20. In quality evaluation for pavement materials, materials are sometimes restricted to those with a liquid limit of 25 or less and a maximum P.I. of 6, i.e., a predominantly granular material. Plasticity index is an important parameter relating to tilth and workability of soil by tillage implements.

Soil Susceptibility to Water Erosion

Soil erosion by water is a complex process involving six major factors that determine the loss of soil at a particular site. The method used is valid for both exposed subsoils and cultivated surface soils. Erodibility is site specific and involves detachment and soil transport by both rainfall and runoff. To determine erodibility at a site, the soil erodibility factor K is calculated by the soil-erodibility nomograph developed by Wischmeier, Johnson and Cross (1971) which incorporates a number of soil factors such as particle size, organic matter content, struc-

ture, and permeability into a graphic representation. Once calculated, the K factor is used in the Universal Soil Loss Equation to estimate the annual rate of soil loss in tonnes/hectare.

The calculated K values for soils in the study are corrected for coarse fragment content using a method suggested by J. J. Rasmussen (1980). The corrected K values result in more realistic soil loss estimates when the Universal Soil Loss Equation is applied in the field.

Once the K factor is arrived at via the nomograph, it can be used in conjunction with the slope angle of a site to determine the erosional risks for disturbed areas such as construction sites and agricultural land. For this, the erosional hazards graph is used in relating the soil erodibility factor and associated slope angles to determine the susceptibility to erosion on uncovered soils. Thus the erosion hazard can be estimated for most soils within the map area.

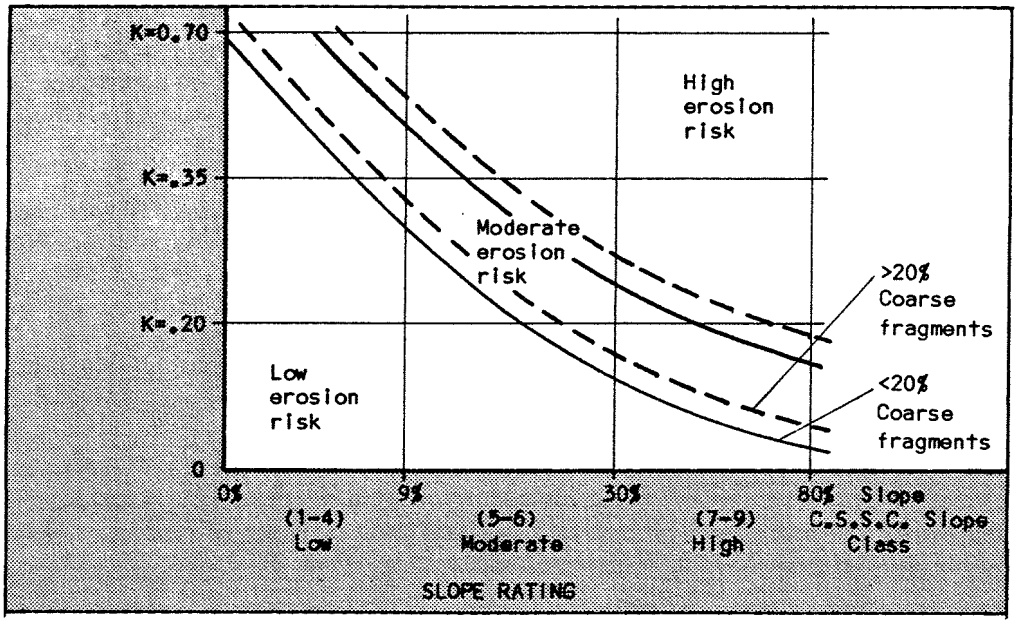


Figure 3.2 Erosion Hazard of Soils (Coen & Holland, 1976).

CHAPTER FOUR
SOIL DESCRIPTIONS

4.1 INTRODUCTION

Chapter Four describes the characterisitics of the thirty-seven individual soils and their phases and variants which are classified in the Duncan-Nanaimo map area. Detailed individual soil profile descriptions and chemical and physical analyses are not included. These are available on request from the British Columbia Soil Information System (Surveys and Resource Mapping Branch, British Columbia Ministry of Environment, Victoria, British Columbia). Summarized physical and chemical data are presented as simple, unweighted means, along with the ranges of values found and the number of samples analysed.

The soils are arranged in alphabetical order and the soil map symbol is indicated in brackets after the soil name. The soil landscape picture indicates a typical landscape in which the soil occurs. The General Comments section includes information on parent materials, topography, soil texture, soil classification, drainage, as well as some comments on land use, agricultural and urban suitability and soil management considerations.

The soil landscape cross-section depicts the physiographic setting, relating the soil with commonly associated soils. The parent material is described according to the terminology of the Terrain Classification System (E.L.U.C., 1976). Table 3.1 should be used for reference.

The generalized soil profile indicates most common depths of major soil horizons. These descriptions should assist map users in identifying the soil in the field.

ARROWSMITH SOILS (AR)

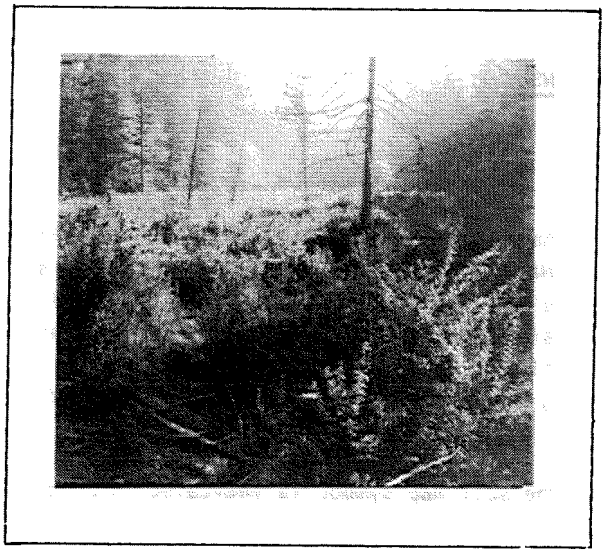


PLATE 4.1: ARROWSMITH SOIL LANDSCAPE

GENERAL COMMENTS

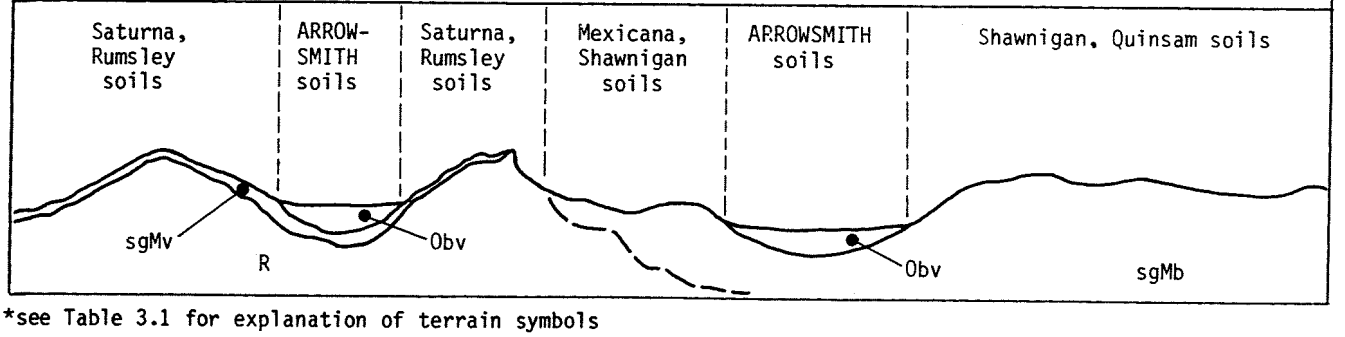
Arrowsmith soils (495 ha) occur in very poorly drained depressional areas throughout the map area. They are level and range in extent from 0.23 to 25 ha with an average map unit size of about 6 ha. The largest occurrence is near the Millstone River southwest of Bowen Park near Nanaimo. These soils have an apparent, year-round water table within 1 m of the soil surface and consist of dominantly mesic organic materials. At depth, normally greater than 160 cm they are generally underlain by sedimentary peat which, in turn, overlays silts and clays.

Arrowsmith soils are at an intermediate stage of decomposition and dominantly have dark brown, mesic material in the middle and bottom tiers. They are classified as **Typic Mesisols**, with minor inclusions of Terric Humic Mesisols.

Arrowsmith soils are considered to be the most desirable organic soils for agricultural use as they have favorable tilth and permeability. Watertables should be maintained at the highest levels which still permit good crop growth and field trafficability. They should be maintained near the soil surface over the winter to prevent undue oxidation and subsidence. Present land use includes vegetable production, forage crops and pasture. Adequate liming and fertilization are required to bring production to full potential.

Arrowsmith soils are severely constrained for urban and related uses by very low bearing strengths and high watertables.

ARROWSMITH SOIL LANDSCAPE CROSS SECTION*



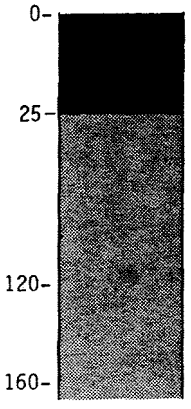
*see Table 3.1 for explanation of terrain symbols

LANDSCAPE CHARACTERISTICS

PARENT MATERIAL	:	organic
TOPOGRAPHY	:	level
ELEVATION RANGE	:	2-300 m asl
ASPECT	:	none
FLOOD HAZARD	:	may be expected
VEGETATION	:	Native vegetation supported by Arrowsmith soils includes a variety of water tolerant plants such as Labrador tea, hard hack, mosses, willow, skunk cabbage, sedges, and reeds as well as some western red cedar and shore pine.

TYPICAL ARROWSMITH SOIL PROFILE

DEPTH (cm)



Op - Black (10YR 2.5/1m), humic organic material; granular, cultivated; very strongly acid.

Oh - Black (10YR 2/1m), humic organic material; very strongly acid.

Om_1 - Dark brown (10YR 3/3m), mesic organic material; very strongly acid.

Om_2 - Dark reddish brown (10YR 3/3m), mesic organic material; strongly acid.

SOIL CHARACTERISTICS

DEPTH TO BEDROCK (cm)	: N/A
HUMUS FORM	: Peatymor
SOLUM DEPTH (cm)	: >160
DEPTH, THICKNESS AND TYPE OF RESTRICTING LAYER (cm)	: no restricting layer
ROOTING DEPTH (cm)	: <160
COARSE FRAGMENT CLASS	: 0
DEPTH TO AND TYPE OF WATERTABLE (cm)	: 25-100; apparent
PERVIOUSNESS	: moderate
SOIL DRAINAGE	: very poor
DEPTH TO SALTS (cm)	: N/A
SOIL TEXTURE	: N/A

SOIL PHYSICAL PROPERTIES	SOIL DEPTHS (cm)					
	No. of Samples	0-40	No. of Samples	40-120	No. of Samples	120-160
BULK DENSITY (g/cm^3)	Est.	(.1-.2)				
AWSC (cm/m)	Est.	20				
TYPE OF ORGANIC MATERIAL		humic		mesic		mesic
RUBBED FIBRE CONTENT %	Est.	(10-40)	Est.	(10-40)	Est.	(10-40)
von POST SCALE		5-6		5-6	Est.	5-6
PYROPHOSPHATE INDEX		3-5		3-5	Est.	3-5

SOIL CHEMICAL PROPERTIES	SOIL DEPTHS (cm)					
	No. of Samples	0-40	No. of Samples	40-120	No. of Samples	120-160
SOIL REACTION 1:1 H_2O	5	5.4 (5.1-5.8)	6	5.5 (5.3-5.7)	3	5.6 (5.3-5.8)
(pH) 1:2 $CaCl_2$	5	5.0 (4.8-5.4)	6	5.3 (5.1-5.5)	3	5.4 (5.1-5.6)
CONDUCTIVITY mS/cm		N/A		N/A		N/A
ORGANIC CARBON (%)	3	43.8 (35.0-50.9)	7	49.7 (33.8-54.5)	3	52.1(48.4-54.8)
NITROGEN (%)	2	1.94 (1.81-2.06)	7	1.98 (1.57-2.44)	3	2.18(1.40-3.16)
EXCHANGE CAPACITY (meq/100g)	2	147.3 (113-181)	7	141 (130-159)	2	147.6(139.2-156.9
EXCHANGEABLE CATIONS - Ca	1	77.0	6	70.6 (48-94)	3	63 (29-81)
(meq./100g) - Mg	1	2.8	6	3.6 (1.8-8.4)	3	5.2 (3.3-7.8)
- Na	1	0.0	6	0.1	3	0.1 (0.1)
- K	1	0.2	5	0.3 (0.2-0.4)	2	0.5 (0.4-0.5)

SOIL PHASES/VARIANTS	
SOIL SYMBOL	SOIL DESCRIPTION
ARso	Shallow organic variant; these soils have less than 160 cm of organic material. They are classified as Terric Mesisol.
ARso,t	Shallow organic variant and taxajunct variant; these soils have less than 160 cm of organic material and contain more than 25 cm of humic organic material. They are classified as Terric Humic Mesisol.
ARt	Taxajunct variant; the solum contains more the 25 cm of humic organic material. They are classified as Humic Mesisol.

INFERRED SOIL PROPERTIES
ARROWSMITH SOILS

SOIL NAME SYMBOL	SOIL DEPTH (cm)	UNIFIED TEXTURE SYMBOL	AASHO TEXTURE SYMBOL	LIQUID LIMIT	PLASTICITY INDEX	SOIL ERODIBILITY K FACTOR
AR	0-160	Pt	-	-	-	-

BEDDIS SOILS (BD)



PLATE 4.2: BEDDIS SOIL LANDSCAPE

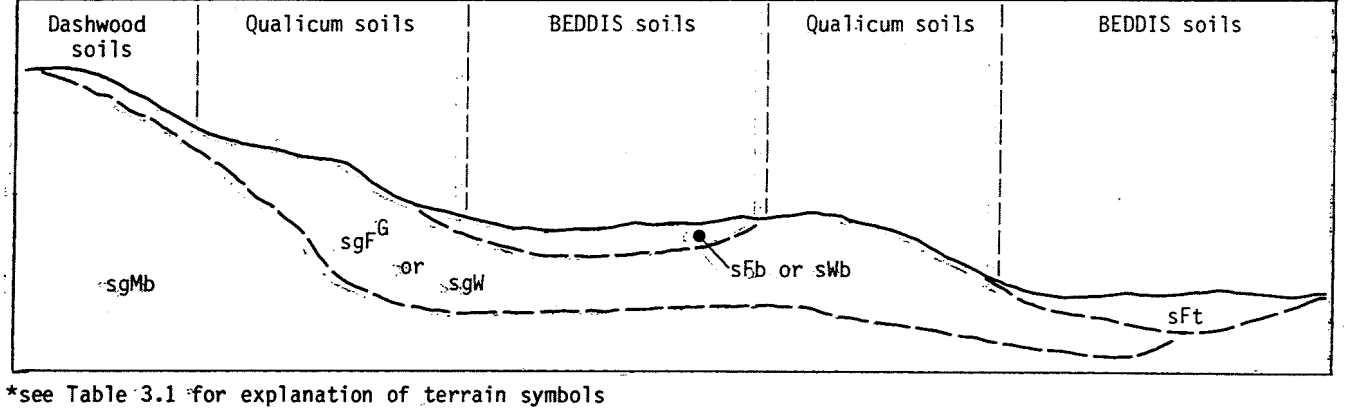
GENERAL COMMENTS

Beddis soils (1090 ha) occur throughout the survey area on nearly level to steep slopes below elevations of about 100 m. Generally they are found on well to rapidly drained sandy fluvial terraces, old post-glacial beaches and other marine deposits.

Beddis soils are stone-free with loamy sand or sandy loam surface horizons. The lower horizons are compact and are loamy sand to sand in texture. They are predominantly **Orthic Dystric Brunisols** although minor components of Orthic Humo-Ferric Podzols also occur.

Agriculturally, Beddis soils are droughty, however, with irrigation and fertilization most crops can be produced. Beddis soils are well suited for forest nursery operations, however, sloping areas are susceptible to erosion. In general, these soils are suitable for urban and related developments.

BEDDIS SOIL LANDSCAPE CROSS SECTION*

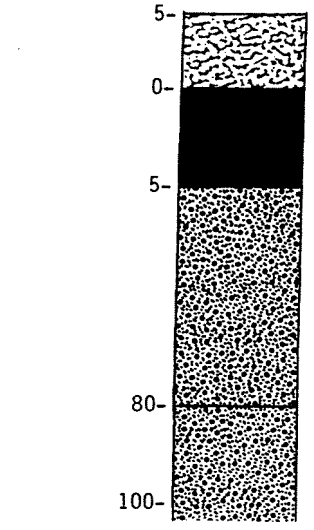


*see Table 3.1 for explanation of terrain symbols

LANDSCAPE CHARACTERISTICS

PARENT MATERIAL	:	sandy fluvial blanket, sandy marine blanket
TOPOGRAPHY	:	0-30%; nearly level to strong slopes
ELEVATION RANGE	:	0-100 m asl
ASPECT	:	all
FLOOD HAZARD	:	rare
VEGETATION	:	The native vegetation is mainly composed of second growth Douglas-fir, western red cedar and grand fir with occasional red alder and maple.

TYPICAL BEDDIS SOIL PROFILE



LF — Loose, non-compact litter over compact fiber; very strongly acid.

Ahe — Reddish yellow (7.5YR 7/6m) sandy loam; moderate, medium granular; very friable; very strongly acid.

Bm — Yellowish brown (10YR 5/6m) loamy sand; moderate, medium subangular blocky breaking to single-grained; very friable; very strongly acid.

BC — Yellowish brown (10YR 5/4m) sandy loam sand to loamy sand; massive breaking to single-grained; friable; medium acid.

SOIL CHARACTERISTICS

DEPTH TO BEDROCK (cm)	:	N/A
HUMUS FORM	:	moder to mull
SOLUM DEPTH (cm)	:	>100
DEPTH, THICKNESS AND TYPE OF RESTRICTING LAYER (cm)	:	no restricting layer
ROOTING DEPTH (cm)	:	>90
COARSE FRAGMENT CLASS	:	0-1
DEPTH TO AND TYPE OF WATERTABLE (cm)	:	N/A
PERVIOUSNESS	:	rapid to moderate
SOIL DRAINAGE	:	rapid to moderately well
DEPTH TO SALTS (cm)	:	N/A
SOIL TEXTURE	:	Loamy sand, sandy loam

SOIL PHYSICAL PROPERTIES	SOIL DEPTHS (cm)			
	No. of Samples	0-50	No. of Samples	50-100
PERMEABILITY (CLASS)		rapid - moderate		rapid - moderate
BULK DENSITY (g/cm^3)	3	1.22 (1.19-1.27)	3	1.73 (1.70-1.78)
AWSC (cm/m)	3	10 (8-12)	3	14.7 (9.6-17.4)
AWSC (Corr. for % CF) (cm/m)	3	9 (7-11)	3	14.0 (9.6-17.2)
% COARSE FRAGMENTS >7.5cm	Est.	0	Est.	0-2
% COARSE FRAGMENTS <7.5cm	Est.	5-20	Est.	0-25
% PASSING # 4	2	92.5 (85.4-99.6)	2	99.7 (99.5-99.8)
% PASSING # 40	2	79.4 (62.0-96.7)	2	97.3 (95.3-99.2)
% PASSING # 200	2	15.4 (13.6-17.1)	2	53.0 (37.9-68.1)
% SAND	17	78.1 (51.0-97.1)	8	74.9 (31.2-97.8)
% CLAY	16	3.2 (1.1-7.1)	8	2.2 (1.0-7.9)

SOIL CHEMICAL PROPERTIES	SOIL DEPTHS (cm)			
	No. of Samples	0-50	No. of Samples	50-100
SOIL REACTION 1:1 H_2O (pH)	14	5.5 (4.4-6.0)	11	5.8 (5.7-6.0)
1:2 $CaCl_2$	30	5.0 (4.0-5.6)	11	5.1 (4.9-5.4)
CONDUCTIVITY mS/cm		N/A		N/A
ORGANIC CARBON (%)	22	1.1 (0.3-2.2)	9	0.4 (0.1-1.0)
NITROGEN (%)	9	0.07 (0.02-1.2)	9	0.02 (0.01-0.05)
EXCHANGE CAPACITY (meq/100g)	8	12.0 (5.7-17.4)	9	6.9 (4.9-9.7)
EXCHANGEABLE CATIONS (meq/100g) - Ca	9	1.0 (0.3-2.1)	9	0.8 (0.2-6.3)
- Mg	9	0.2 (0.1-0.5)	8	0.1 (0.1-0.3)
- Na	9	0.1 (0.1)	8	0.1 (0.1-0.2)
- K	9	0.1 (0.1-0.2)	8	0.1 (0.1-0.1)
PHOSPHORUS (ppm)	3	20 (7.5-34)	3	15 (12-17)
SULFUR (ppm)	9	0.5 (0.1-0.8)	9	2.7 (0.3-7.3)
% IRON	29	0.22 (0.03-0.55)	5	0.07 (0.03-0.10)
% ALUMINUM	29	0.39 (0.12-0.82)	5	0.34 (0.22-0.45)