PROVINCE OF BRITISH COLUMBIA
MINISTRY OF ENVIRONMENT

SOILS AND SOIL EROSION RATINGS OF THE COLDSTREAM AND VASEUX CREEK WATERSHEDS

Transmittal Document

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ABSTRACT

A soil survey was conducted in the Coldstream and Vaseux Creek watersheds for the purpose of identifying existing and potential areas of erosion.

Part I of the report describes the area encompassed by the Coldstream Creek watershed and the soils located within its boundaries. The Coldstream study area is located east of Vernon and covers 20 700 ha. Soil checks were predominantly made along the many roads in the area, although a few traverses were made by foot. A total of 38 sites and soil forms were completed. Twenty-nine different soils and 5 land types were distinguished and briefly described.

The area and soils of Vaseux Creek watershed are described in Part II of the report. The Vaseux Creek watershed is located southwest of Okanagan Falls and covers 29 900 ha. Soil checks were occasionally made by foot traverses with the majority made along the roads. A total of 16 site and soil forms were described for this area. Forty-two soils and 4 land types were described and mapped.

Part III of the report describes how the soil erosion ratings were determined using the Universal Soil Loss Equation. Six soil erosion maps were produced based on various land-use activities.

PREFACE

Early in 1980, the Okanagan Water Implementation Board requested that the Terrestrial Studies and Aquatic Branches conduct a physical resource survey of the Coldstream and Vaseux watersheds in the Okanagan system. The purpose of the survey was to identify existing and potential areas of erosion which are or could contribute to sources of sediment and nutrient loading, especially phosphorous, entering into Okanagan and Kalamalka lakes.

To meet the objectives requested, the Terrestrial Studies Branch conducted a soil and terrain survey of the two watersheds and produced (1) a terrain map; (2) a soils map; (3) six erosion maps and; (4) this working report. The Aquatics Studies Branch conducted a stream reach inventory and produced (1) an aquatic biophysical map; (2) a stream channel stability evaluation map and; (3) a separate report - Hawthorn, S. & E. Karanka. 1982. Analysis of Channel Stability and Sediment Sources in Coldstream and Vaseux Creek Watersheds.

TABLE OF CONTENTS

	Page
ABSTRACT	iii
PREFACE	v
TABLE OF CONTENTS	vii
LIST OF FIGURES	ix
LIST OF TABLES	xi
PART I COLDSTREAM WATERSHED	
1. GENERAL DESCRIPTION OF THE AREA	1
1.1 Location	1
1.2 Physiography	2
2. METHODS	3
2.1 Field Methods	3
2.2 Mapping Methods	4
3. CHARACTERISTICS OF THE SOILS OF THE STUDY AREA	7
3.1 Soils of Colluvial Origin	7
3.2 Soils of Fluvial Origin	8
3.3 Soils of Glaciolacustrine Origin	9
3.4 Soils of Morainal Origin	10
3.5 Soils of Organic Origin	11
3.6 Bedrock Areas	11
PART II VASEUX WATERSHED	
4. GENERAL DESCRIPTION OF THE AREA	13
4.1 Location	13
4.2 Physiography	14

TABLE OF CONTENTS (CONTINUED)

	Page
5. METHODS	15
5.1 Field Methods	15
5.2 Mapping Methods	16
6. CHARACTERISTICS OF THE SOILS OF THE STUDY AREA	19
6.1 Soils of Colluvial Origin	19
6.2 Soils of Fluvial Origin	20
6.3 Soils of Glaciolacustrine Origin	21
6.4 Soils of Morainal Origin	22
6.5 Soils of Organic Origin	22
6.6 Bedrock Areas	23

PART III SOIL EROSION RATINGS

7. INTRODUCTION	25
7.1 Development of the Soil Erosion Ratings	25
7.2 Rainfall Factor	26
7.3 Erodibility Factor	29
7.4 Slope Length and Slope Steepness Factor	37
7.5 Cropping Management Factor	40
7.6 Erosion Control Practice Factor	41
7.7 Soil Erosion Ratings	41
7.8 Climate and Geomorphi Processes	42
REFERENCES	51

LIST OF FIGURES

Figure		Page
1	Location of the Coldstream Creek watershed	1
2	Location of the Vaseux Creek watershed	13
3	Relationship between the 6 hour rainfall intensity and rainfall factor for type II	28
4	Soil erodibility nomography	34
5	Example of Strahler thermohyet diagram	43
6	Morphoclimatic diagrams showing relationships between climate and prevailing weathering and erosional processes	44
7	Thermohyet diagrams of monthly average precipitation and temperature for Penticton and Coldstream	47
8	Thermohyet diagrams of monthly average precipitation and temperature for Chute Lake and McCulloch	48

LIST OF TABLES

Table		Page
1	Soil Legend for the Coldstream Creek Watershed	5
2	Soil Legend for the Vaseux Creek Watershed	17
3	Rainfall Factors for the Coldstream Vaseux Creek Watersheds	27
4	Average Organic Matter Content in Some Okanagan Soils	30
5	Soil Erodibility Factors for Average Soil Textures	31
6	Soil Erodibility Factors Derived from Field Data	35
7	Soil Erodibility Factors for Coldstream and Vaseux Creek Soils	36
8	Slope Effect Table (Topographic Factor LS)	38
9	Slope Adjustment Chart	39
10	Cropping Management Factors for Coldstream and Vaseux Creek Soils	40
11	Factors for Erosion Control Practices	41
12	Soil Erosion Ratings	42
13	Relationships Between Various Geomorphic Processes and Climate	45
14	Climatic Stations Showing the Months When the Different Degrees of Weathering and Erosion Occur	49

PART I
COLDSTREAM WATERSHED

1. GENERAL DESCRIPTION OF THE AREA

1.1 LOCATION

The Coldstream Watershed (Figure 1) is located east of Vernon in the Coldstream Valley and covers 20 700 ha. It encompasses the upper reaches of Coldstream Creek and its tributaries and their associated highlands.

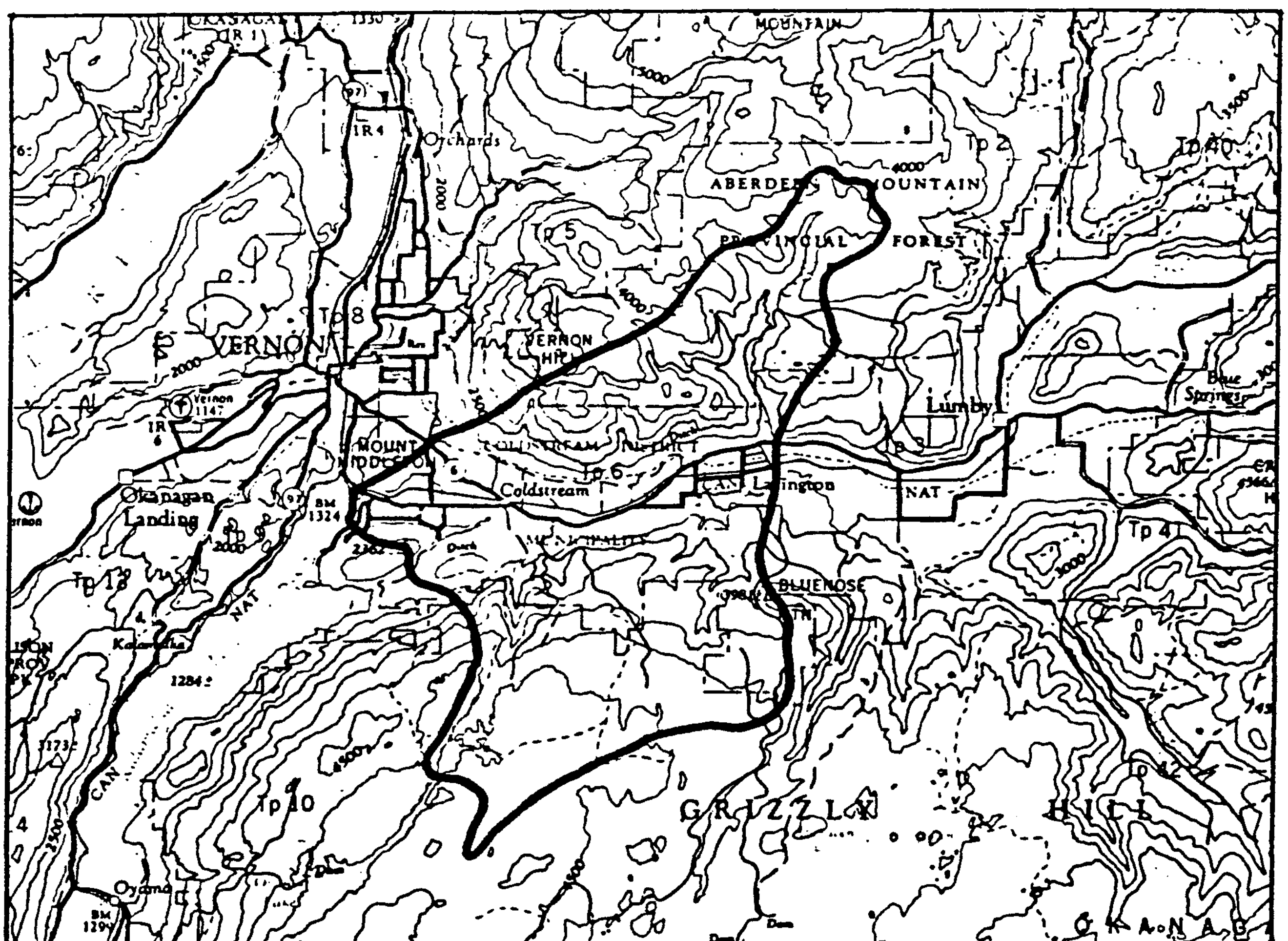


Figure 1. Location of the Coldstream watershed

The land in the Coldstream Valley is primarily used for agricultural endeavors as well as being occupied by sawmilling and industrial plants. As with most streams in the Okanagan, the Coldstream Creek and many of its tributaries are used for domestic water purposes. Logging occurs at the higher elevations of the watershed on both sides of the Coldstream Valley. Cattle grazing is prevalent throughout most of the area. Many of the lakes located in the watershed, as well as being used for water storage, are used for camping and fishing.

1.2 PHYSIOGRAPHY

The Coldstream watershed occurs in two physiographic regions separated by the Coldstream Valley. To the north, the area occurs in the Shuswap Highlands physiographic region (Holland, 1964) and to the south, the Thompson Plateau. Elevations range from a low to 390 m at the mouth of the Coldstream Creek at Kalamalka Lake to about 1525 m near King Edward and Bear Lakes and 1645 m near the Silver Star ski hill.

According to Jones (1960), the study area is underlain two major bedrock groupings - acidic and basic bedrock. The acidic bedrock includes granitoid gneiss, augen gneiss and mica - sillimanite - garnet schist while the basic bedrock consists of basalfic and andesitic lava, argillite and limestone. The topography of the northern portion of the study area consists of steeply sloping terrain and is quite hilly. The soil mantle overlying bedrock is generally quite thin and usually does not exceed 10 m. The Coldstream Valley area consists of gently sloping terrain and generally the soil mantle is quite deep and most probably extends downward for over 50 m. The southern part of the study area is characterized by a steeply sloping sidehill culminated by a rolling plateau area. The soil mantle is quite thin with many bedrock exposures evident.

2. METHODS

2.1 FIELD METHODS

Prior to the commencement of the field work, preliminary assessment of the landscape and access was undertaken on 1:15 000 scale aerial photographs exposed in 1974. The landscape was separated into segments by stereoscopically exmaining the aerial photographs and delineating the various types of terrain or surficial materials. These delineations were refined on the bases of inferred soil texture, soil genesis and slope. The bedrock geology (Jones, 1960) was used to aid in estimating some of the soil characteristics such as texture, soil reaction, carbonate content and soil development. The physiographic map of Holland (1964) was used to divide the report area into its respective physiographic regions and the vegetation zones were used to place the delineated units into their respective forest zones and subzones.

The field survey was conductd during the 1980 summer field season with about 20 700 ha being field checked. The soils of the Coldstream Valley agricultural area were previously surveyed and reported on by Sprout and Kelley (1960) and their information was used in this study. Their inventory was at a survey intensity level 2 (MSWG, 1981) where the field traverses were by foot and by surface vehicle and many of the soil boundaries and all the soil delineations were checked in the field. The upland areas, newly surveyed for this study, were mapped at an intensity level 3 where a few traverses were by foot and the remainder by surface vehicle. Many of the soil delineations and some of the soil boundaries were checked in the field. The actual map units identified in the field were checked against those pretyped, and mapping lines and symbols were adjusted as necessary. Initially, many stops were made to check the soils and vegetation but as familiarity with the terrain characteristics increased, the number of examinations or spot checks was reduced. The information from the spot checks was put directly on the photograph in the form of a terrain symbol, texture, soil classification or other identifying characteristics. Checks, in which the site was described in more detail, were recorded on site and soil description forms and were identified by a number on the photograph and subsequently on the map. At 38 check points, site and soil description forms were completed according to the Manual for Describing Ecosystems in the Field (RAB, 1980) with parent material, soil horizons, depth, drainage, slope, elevation, rockiness, aspect and other characteristics described and noted. Twenty-one of these check points were along the lower reaches of the Coldstream Creek and coincided with the aquatics investigation sites. Many of the terms used are defined in the Gossary of Terms in Soil Science (Canada Department of Agriculture, 1976). Soil samples were taken from selected profiles and a particle size analysis (texture) was performed on the fraction less than 2 mm.

2.2 MAPPING METHODS

Upon completion of pretyping the aerial photographys, field checking, sampling and laboratory analyses, and adjusting the pretyped lines where necessary, the terrain maps were developed. The map unit boundaries from the aerial photographs were transferred to 1:20 000 scale map bases and the polygons (map delineations) were symbolled according to the terrain legend (ELUCS, 1976). Almost 100% of the map delineations in the Coldstream Valley agricultural area and about 35% of the upland soil map delineations had at least one ground field check. Although all map delineations were determined by air photo interpretation and extrapolation, the relative distictness and homogeneity of the terrain allowed for an estimated mapping reliability of over 70% throughout the map area.

Using the terrain maps as a base, the soil maps were produced following the construction of a soils legend (Table 1) which separated the various surficial deposits (soil parent materials) predominantly by vegetation zone, underlying bedrock, soil profile development, soil texture and soil drainage.

TABLE 1: SOIL LEGEND FOR THE COLDSTREAM CREEK WATERSHED

Soil Type	Parent Material	Texture (<2 mm)	Coarse Fragments (<2 mm)	Soil Drainage	Dominant* Soil Development	Vegetation** Zone
C1	colluvium	sandy loam	30-50%	well	O.DYB li	DI SAeS-alF:a,c
C2	colluvium	sandy loam	30-50%	well	O.EB li	DI ID:a
C3	colluvium	loam	20-40%	well	BR.GL	DI ID:a
C4	colluvium	loam over sandy loam	30-50%	well	O.EB li	DI ID:a
C5	colluvium	loam over sandy loam	30-50%	well	O.EB li-O.DG-li	DI ID: a,b
C6	colluvium	loam over sandy loam	30-50%	well	O.BL li	DI ID:b
C7	colluvium	sandy loam	30-50%	well	O.EB li-O.DG-li	DI ID:a,b
C8	colluvium	sandy loam	20-50%	well	O.BL li	DI ID:b
C9	colluvium	sandy loam	30-50%	well	O.DYB li	DI SAeS-alF:a,c
F1	fluvioglacial	sandy loam over sand	50-90%	rapidly	O.DYB	DI ID:a
F2	fluvial (floodplain)	sandy loam	20-50%	moderately well	CU.R	DI ID:a
F3	fluvioglacial	sandy loam over sand	0-90%	rapidly	O.EB	DI ID:b
F4	fluvioglacial	sandy loam over sand	0-90%	rapidly	O.BL	DI ID:b
F5	fluvial (fan)	sandy loam	20-40%	well	O.BL	DI ID:b
F6	fluvial (fan)	loam	0-10%	moderately well	O.BL	DI ID:b
F7	fluvial (fan)	loam	0-10%	imperfectly	GL.BL	DI ID:b
F8	fluvial (floodplain)	loam over sand	20-40%	moderately well	O.R	DI ID:b
F9	fluvial (terrace)	silt loam over sand	30-50%	well	O.BL	DI ID:b
L1	glaciolacustrine	clay loam	0%	moderately well	O.BL	DI ID:b
L2	glaciolacustrine	clay loam	0%	imperfectly	GL.BL	DI ID:b
L3	glaciolacustrine	clay loam	0%	moderately well	CA.BL	DI ID:b
M1	morainal	silt loam over loam	20-50%	moderately well	BR.GL	DI SAeS-alF:a,c
M2	morainal	silt loam over loam	20-50%	imperfectly	GLBR.GL	DI SAeS-alF:a,c
M3	morainal	silt loam over loam	20-40%	moderately well	BR.GL	DI ID:a
M4	morainal	silt loam over loam	20-40%	imperfectly	GLBR.GL	DI ID:a
M5	morainal	loam	20-40%	well	O.GL-O.DG	DI ID:a,b
M6	morainal	loam	20-40%	well	O.BL	DI ID:b
O1	organic	derived from mosses		very poorly	TY.M	DI ID:a
O2	organic	derived from mosses		very poorly	TY.M	DI SAeS-alF:a,c
Land Type						
A1	fluvioglacial (gravel pits)	sand	50-90%	rapidly		DI ID:b
R1	bedrock	granitoid gneiss				DI SAeS-alF:a,c and ID:a,b
R2	bedrock	granitoid gneiss				DI ID:b
R3	bedrock	volcanic flow				DI ID:b
R4	talus	volcanic flow	100%			DI SAeS-alF:a,c and ID:a,b
R5	bedrock	volcanic flow				DI SAeS-alF:a,c and ID:a,b

*Dominant Soil Development

O.DYB	-	Orthic Dystric Brunisol
O.DYB li	-	Orthic Dystric Brunisol-lithic phase
O.EB	-	Orthic Eutric Brunisol
O.DB li	-	Orthic Eutric Brunisol-lithic phase
O.BL	-	Orthic Black
O.BL li		Orthic Black-lithic phase
CA.BL	-	Calcareous Black
GL.BL	-	Gleyed Black
O.DG	-	Orthic Dark Gray
O.DG li	-	Orthic Dark Gray-lithic phase
O.GL	-	Orthic Gray Luvisol
BR.GL	-	Brunisolic Gray Luvisol
GLBR.GL	-	Gleyed Brunisolic Gray Luvisol
TY.M	-	Typic Mesisol
O.R	-	Orthic Regosol
CU.R	-	Cumulic Regosol

**Vegetation Zone

DI SAeS-alF:a	Dry Interior Region; Subalpine Engelmann spruce - alpine fir zone: lodgepole pine subzone
DI SAeS-alF:c	Dry Interior Region; Subalpine spruce - alpine fir zone: Rocky Mountain Douglas-fir - lodgepole pine subzone
DI ID:a	Dry Interior Region; Interior Rocky Mountain Douglas-fir zone: lodgepole pine subzone
DI ID:b	Dry Interior Region; Interior Rocky Mountain Douglas-fir zone: ponderosa pine subzone

3. CHARACTERISTICS OF THE SOILS OF THE STUDY AREA

To characterize the study are, the soils were separated according to the surficial geologic materials from which they were derived. These materials are variable both in their composition and distribution. Their aerial distribution is shown on both the Terrain and Soil maps for the Coldstream watershed.

Generally, the soils developed from the acidic bedrock are moderately coarse to coarse textured whereas the soils developed for the basic bedrock are usually medium to moderately fine textured. The area had been blanketed with a layer of medium textured windblown deposits (loess and volcanic ash). These deposits are still present in the higher elevational areas having flatter topogrpahy but have been eroded away in the steeper areas.

3.1 SOILS OF COLLUVIAL ORIGIN

Soils of colluvial origin occupy a significant portion of the study area outside of the Coldstream Valley agricultural area. They are composed of materials which have undergone downslope movement and have reached their present position due to gravity. Generally, they consist of massive, nonsorted to poorly sorted materials which range in particle size from clay to boulders and are related to the underlying or up-slope materials from which they are derived.

The colluvial materials from which these soils have developed are predominantly derived from the underlying bedrock. Soils C1, C2, C7 and C8 are derived from or associated with areas of acidic bedrock and generally have a gravelly sandy loam texture. Soils C4, C5, C6 and C9 are derived from or associated with areas of basic bedrock and generally have a gravelly loam solum texture overlying a gravelly sandy loam substrata (parent material) texture. These soils are generally shallow and are less than one metre thick to the to the underlying bedrock. C3 soils have developed in deeper colluvial deposits and are located in an area that had previously slumped. As most of these colluvial soils are located in areas prone to erosion, they now show little evidence of having any windblown deposits in their surface horizons.

C1 and C9 soils occur in well forested areas dominantly covered by Engelmann spruce, alpine fir, lodgepole pine and occassionally Douglas-fir. C2, C3 and C4 soils also occur in well forested areas, but the dominant tree species are Douglas-fir, lodgepole pine and western larch. C5 and C7 soils occur in parkland areas that have both open forests of trembling aspen, ponderosa pine and/or Douglas-fir and edaphic grassland areas. C6 and C8 soils occur in edaphic grassland areas.

These colluvial soils are generally well drained and usually have high to moderate infiltration and percolation rates. They are also moderately pervious although this decreases abruptly at the contact with the underlying bedrock.

3.2 SOILS OF FLUVIAL ORIGIN

Soils of fluvial origin are composed of materials transported and deposited by streams and are commonly well sorted. Depending on the type and size of stream and its gradient, the deposits vary in texture, ranging from gravels to silts.

The fluvial deposits in the study area have been subdivided into three categories based on their texture and mode of deposition.

Soils developed in fluvioglacial deposits in the study area generally consist of a sandy loam solum texture grading to a very gravelly sand and/or sand substrata texture. Surface cobbles and stones are abundant in places where the overlay is thin. F1 soils occur in well forested areas along the stream channels of the upper reaches of the Coldstream Creek and its tributaries. F3 soils generally occur in open forested areas along the Coldstream valley sides and lower reaches of Coldstream Creek. F4 soils generally occur in edaphic grassland areas and are cultivated. Soils designated as A1 have been distributed and are presently being used as gravel pits or as industrial sites.

These glaciofluvial soils are generally rapidly drained and usually have high infiltration and perculation rates and are rapidly pervious.

Soils developed in fluvial fan deposits have, at the fan apex areas, gravelly sandy loam textures in which surface gravels and cobbles are abundant (F5) and grade downslope into F6 and F7 soils which are generally free of coarse fragments and have a loam texture. These soils are located in the Coldstream agricultural area and are cultivated or used for pastures.

These fluvial fan soils vary in soil drainage from well (F5) to moderately well (F6) to imperfectly drained (F7). They have moderate infiltration and percolation rates and are moderately pervious.

Soils developed in fluvial floodplain deposits are located along the margins of the present day streams. These soils vary from gravelly sandy loam textures (F2) in the upper stream reaches where steeper gradients occur to silt loam or loam surface textures grading to gravelly sand at depth (F8 and F9) in the lower stream reaches with low gradients. These soils, under normal conditions, are usually moderately well drained but do have high or fluctuating water tables and are subject to occassional flooding. They are generally rapidly to moderately pervious.

3.3 SOILS OF GLACIOLACUSTRINE ORIGIN

Soils of glaciolacustrine origin consist of sediments that have settled from suspension in bodies of standing fresh water or that have collected at their margins through wave action. The sediments usually consist of stratified sand, silt and clay deposited in former lake beds or moderately to well sorted sand and coarser materials that are beach and other littoral sediments along the margins of former glacial lakes.

Soils developed in glaciolacustrine sediments have a substrata that is stratified and often varved. The texture varies from clay loam at the surface to stratified silts and fine sands at depth. These soils are in the Coldstream agricultural area and are usually under cultivation.

These soils become very compact and hard when dry and very sticky when wet. Surface water infiltation is moderately slow and internal percolation rates are very slow. They are slowly pervious and moderately well drained (L1 and L3). A feature of the clays is to swell or expand on wetting and to shrink and crack on drying. In some areas where seepage from higher areas accumulate, the L2 soils are imperfeclty drained.

3.4 SOILS OF MORAINAL ORIGIN

Soils of morainal origin occupy a significant portion of the study area, mainly at the higher elevations. Morainal deposits (often called glacial till) consist of materials transported and deposited by glaciers. They generally consist of well-compacted substrata materials that are non-stratified and contain a heterogeneous mixture of particle sizes (ranging from gravel to boulders) in a matrix of sand, silt and clay.

The soils developed in morainal materials have a loam texture containing a variable amount of gravel, cobbles and boulders. The upland soils M1, M2, M3 and M4 also have a silt loam solum that was derived from eolian sediments. M1 and M2 soils occur in well forested areas dominantly covered by Engelmann spruce, alpine fir, lodgepole pine and occassionally Douglas-fir. M3 and M4 soils also occur in well forested areas, but the dominant tree species are Douglas-fir, lodgepole pine and western larch. The M5 soils occur in parkland areas that have both open forests of trembling aspen, ponderosa pine and/or Douglas-fir and edaphic grassland areas. M_6 soils occur in edaphic grassland areas.

These morainal soils are compact, calcareous and hard (when dry) below depths of about one-half to one metre. Moisture infiltration through the surface is moderate while percolation rates decrease in the compact substrata. These soils are well (M5 and M6) or moderately well (M1 and M3) drained and are moderately pervious in the solum and slowly pervious in the substrata.. In some areas where seepage or surface water accumulates, the M2 and M4 soils are imperfeclty drained.

3.5 SOILS OF ORGANIC ORIGIN

Soils of organic origin occupy small and scattered areas mainly up on the plateau south of Coldstream valley. They are composed of materials resulting from vegetative growth, decay and accumulation in and around closed basins or gentle slopes, where the rate of accumulation exceeds that of decay. Generally, they consist of peat, unstratified and locally containing minor amounts of marl and inorganic detritus.

Soils developed in organic materials are very poorly drained and composed mainly of organic materials at an intermediate stage of decomposition. 01 soils occur in open wetland areas surrounded by dense stands of Douglas-fir, lodgepole pine and western larch. 02 soils also occur in open wetland areas but are surrounded by dense stands of Engelmann spruce, alpine fir and lodgepole pine.

3.6 BEDROCK AREAS

Areas of bedrock outcrop or rock covered by less than 10 cm of soil or organic material are most prevalent south of the Coldstream Valley. The bedrock in R1 and R2 areas is predominantly composed of granitoid gneiss, augen gneiss and mica-sillimanite-garnet schist whereas R3, R4 and R5 areas are composed mainly of basaltic and andesitic lava and argillite and to a lesser extent limestone. R4 areas are rubbly-blocky talus areas located below basalt cliffs and are generally treeless. Bedrock R1 and R5 areas are well forested whereas R2 and R5 areas are located in the grasslands.

PART II
VASEUX WATERSHED

4. GENERAL DESCRIPTION OF THE AREA

4.1 LOCATION

The Vaseux watershed (Figure 2) is located southeast of Okanagan Falls and covers 29 900 ha. The area is primarily forested with logging the primary industry. Some recreation also occurs in the form of fishing at some of the lakes and streams and skiing at Mount Baldy. Cattle grazing also occurs throughout the forested area as well as on the open slopes. Minor amounts of cultivation occur at the lower elevations in the main Okanagan valley.

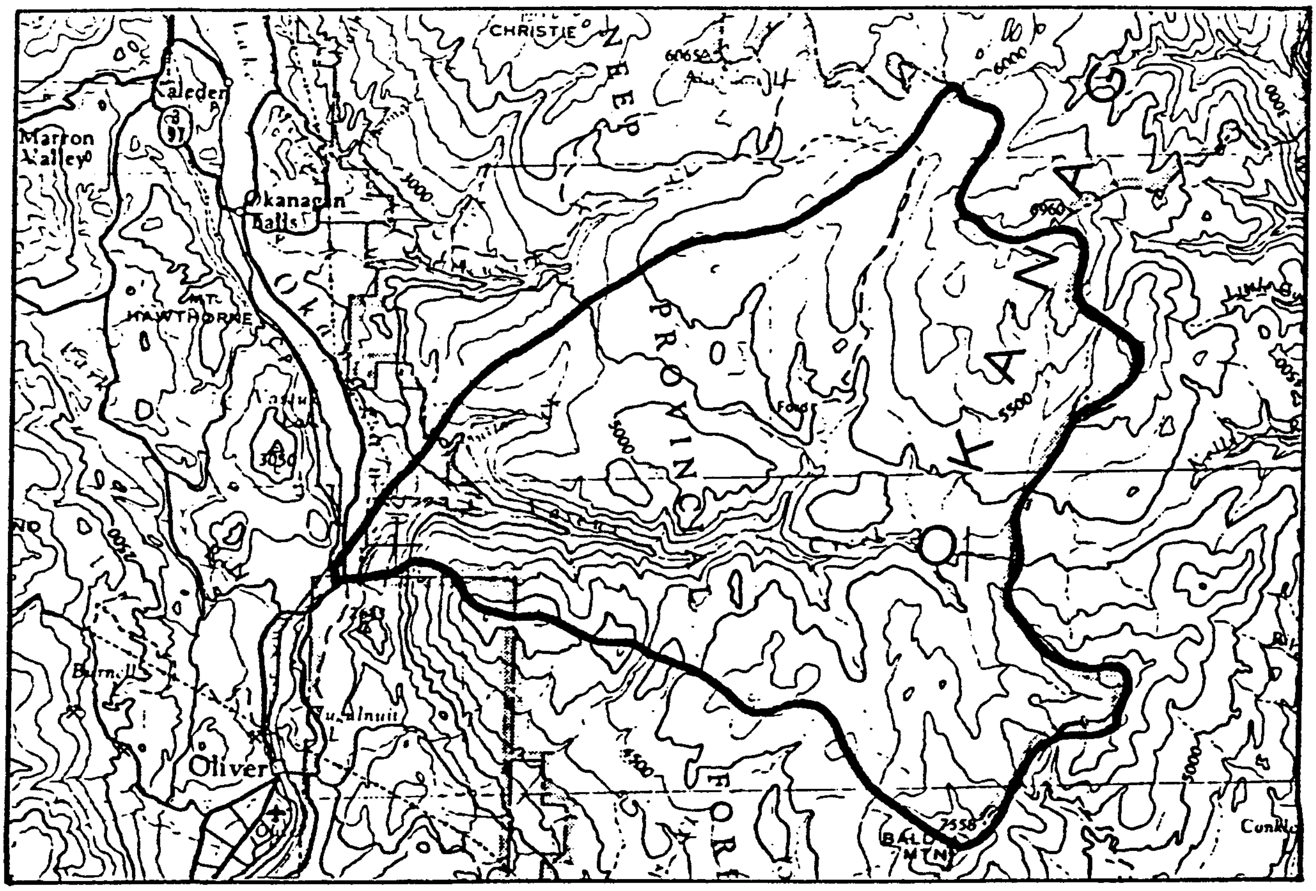


Figure 2. Location of the Vaseux watershed.

4.2 PHYSIOGRAPHY

The Vaseux watershed is located in the Okangan Highlands with elevations ranging from a low of 330 m at the mouth of Vaseux Creek to a high of 2300 m at the top of Mount Baldy.

According to Little (1961) the bedrock of the study area is primarily composed of granite, granodiorite and granitoid gneiss and to a lesser extent andesite and conglomerate. The topography of the study area consists of hilly terrain dissected by the deeply, entrenched gorge created by Vaseux Creek. The soil mantle for the study area is generally quite thin with bedrock exposures mainly occcurring in the higher subalpine areas and along the Vaseux Creek gorge.

5. METHODS

5.1 FIELD METHODS

Prior to the commencement of the field work, preliminary assessment of the landscape and access was undertaken on 1:15 000 scale aerial photographs exposed in 1974. The landscape was separated into segments by stereoscopically examining the aerial photographs and delineating the various types of terrain or surficial materials. These delineations were refined on the bases of inferred soil texture, soil gneiss and slope. The bedrock geology (Little, 1961) was used to aid in estimating some of the soil characteristics such as texture, soil reaction, carbonate content and soil development. The physiographic map of Holland (1964) was used to identify the physiographic region in which the study area occurred and the vegetation zones were used to place the delineated units into their respective forest zones and subzones.

The field survey was conducted during the 1980 summer field season with about 29 000 ha being field checked. The soils of the lower Vaseux Creek fan area were surveyed and reported on by Wittneben (in progress). These soils were surveyed at an intensity level 1 (MSWG, 1981) where the field traverses were by foot and surface vehicle and many of the soil boundaries and all the soil delineations were checked in the field. The upland areas, newly surveyed for this study, were surveyed at an intensity level 3 where a few traverses were by foot and the remainder by surface vehicle. Many of the soil delineations and some of the soil boundaries were checked in the field. The actual map units identified in the field were checked against those pretyped, and mapping lines and symbols were adjusted as necessary. Initially, many stops were made to check the soils and vegetation but as familiarity with the terrain characteristics increased, the number of examinations or spot checks was reduced. The information from the spot checks was put directly on the photograph in the form of terrain symbol, texture, soil classification or other identifying characteristics. Checks, in which the site was described in more detail, were recorded on site and soil description forms and were identified by a number on the photograph and subsequently on the map.

At 16 check points, site and soil description forms were completed according to the Manual for Describing Ecosystems in the Field (RAB, 1980) with parent material, soil horizons, depth, drainage, slope, elevation, rockiness, aspect and other characteristics described and noted. Many of the terms used are defined in the Glossary of Terms in Soil Science (Canada Department of Agriculture, 1976). Soil samples were taken from selected profiles and a particle size analysis (texture) was performed on the fraction less than 2 mm.

5.2 MAPPING METHODS

Upon completion of pretyping the aerial photographys, field checking, sampling and laboratory analyses, and adjusting the pretyped lines where necessary, the terrain maps were developed. The map unit boundaries from the aerial photographs were transferred to 1:20 000 scale map bases, and the polygons (map delineations) were symbolled according to the terrain legend (ELUCS, 1976). Almost 100% of the map delineations in the lower Vaseux Creek fan area and about 27% of the upland soil map delineations had at least one ground field check. Although all map delineations were determined by air photo interpretation and extrapolation, the relative distinctness and homogeneity of the terrain allowed for an estimated mapping reliability of about 70% in the map area.

Using the terrain maps as a base, the soil maps were produced following the construction of a soils legend (Table 2) which separated the various surficial deposits (soil parent materials) predominantly by vegetation zone, underlying bedrock, soil profile development, soil texture and soil drainage.

TABLE 2: SOIL LEGEND FOR THE VASEUX CREEK WATERSHED

Soil Type	Parent Material	Texture (<2 mm)	Coarse Fragments (<2 mm)	Soil Drainage	Dominant* Soil Development	Vegetation** Zone
C1	colluvium	sandy loam	30-50%	well	SM.HFP II	DI At
C2	colluvium	sandy loam	30-50%	well	O.HFP II	DI SAeS-alF:a
C3	colluvium	sandy loam	30-50%	well	O.BL II-O.HFP II	DI SAeS-alF:a
C4	colluvium	sandy loam	30-50%	well	O.DYB II	DI SAeS-alF:a,c
C5	colluvium	sandy loam	30-50%	well	O.BL II-O.DYB II	II SAeS-alF:a,c
C6	colluvium	sandy loam	30-50%	well	E.EB II	DI ID:a
C7	colluvium	sandy loam	20-40%	well	E.EB	DI ID:a
C8	colluvium	sandy loam	30-50%	well	E.EB II-O.DG II	DI ID:a
C9	colluvium	sandy loam	30-50%	well	E.EB II	DI ID:b
C10	colluvium	sandy loam	20-40%	well	E.EB	DI ID:b
C11	colluvium	sandy loam	30-50%	well	E.EB II-O.DG II	DI ID:b
C12	colluvium	sandy loam	30-50%	well	O.BL II	DI ID:b
F1	fluvial (floodplain)	sandy loam over sand	30-50%	moderately well	O.R	DI SAeS-alF:a,c
F2	fluvioglacial	sandy loam over sand	50-90%	rapidly	O.HFP	DI SAeS-alF:a
F3	fluvioglacial	sandy loam over silt loam, fine sandy loam or sand	0-10%	moderately well	O.HFP	DI SAeS-alF:a
F4	fluvioglacial	sandy loam over sand	50-90%	rapidly	O.DYB	DI SAeS-alF:a,c
F5	fluvioglacial	sandy loam over sand	50-90%	imperfectly	GL.DYB	DI SAeS-alF:a,c
F6	fluvioglacial	sandy loam over silt loam, fine sandy loam or sand	0-10%	moderately well	O.DYB	DI SAeS-alF:a,c
F7	fluvial (floodplain)	sandy loam over sand	30-50%	moderately well	O.R	DI ID:a
F8	fluvial (fan, delta, terrace)	sandy loam over sand	50-90%	rapidly	O.DYB	DI ID:a
F9	fluvioglacial	sandy loam over sand	0-90%	rapidly	O.DYB	DI ID:a
F10	fluvial (floodplain)	sandy loam over sand	50-90%	rapidly	O.R	DI ID:b
F11	fluvial (braided floodplain)	sand	70-90%	rapidly	O.R	DI ID:b
F12	fluvial (fan)	sandy loam	50-90%	well	O.R	DI ID:b
F13	fluvial (fan)	sandy loam over sand	20-50%	well	O.B	DI ID:b
F14	fluvioglacial	sandy loam over sand	20-50%	rapidly	E.EB	DI ID:b
F15	fluvioglacial	sandy loam over sand	50-90%	rapidly	E.EB-O.DG	DI ID:b
F16	fluvioglacial	loam over sand	50-90%	rapidly	R.B	DI ID:b
L1	glaciolacustrine (beach ridges)	sandy loam over sand	50-90%	rapidly	O.DYB	DI SAeS-alF:a,c
M1	morainal	sandy loam	20-40%	moderately well	O.HFP	DI SAeS-alF:a
M2	morainal	sandy loam	20-40%	imperfectly	GL.HFP	DI SAeS-alF:a
M3	morainal	sandy loam	20-40%	well	O.BL-O.HFP	DI SAeS-alF:a
M4	morainal	sandy loam	20-40%	moderately well	BR.GL	DI SAeS-alF:a,c
M5	morainal	sandy loam	20-40%	imperfectly	GLBR.GL	DI SAeS-alF:a,c
M6	morainal	sandy loam	20-40%	well	BR.GL	DI ID:a
M7	morainal	sandy loam	20-40%	imperfectly	GLBR.GL	DI ID:a
M8	morainal	sandy loam	20-40%	well	O.GL-O.DG	DI ID:a
M9	morainal	sandy loam	20-40%	well	E.EB	DI ID:b
M10	morainal	sandy loam	20-40%	well	O.GL-O.DG	DI ID:b
M11	morainal	sandy loam	20-40%	well	O.BL	DI ID:b
O1	organic			very poorly	TY.M	DI SAeS-alF:a,c
O2	organic			very poorly	TY.M	DI ID:a
Land Type						
R1	bedrock					DI SAeS-alF:a,c
R2	talus					DI SAeS-alF:a,
R3	bedrock		100%			DI ID:a,b
R4	talus		100%			DI ID:a,b

*Dominant Soil Development

- O.DYB - Orthic Dystric Brunisol
- O.DYB-II - Orthic Dystric Brunisol-lithic phase
- GL.DYB - Gleyed Dystric Brunisol
- E.EB - Eluviated Eutric Brunisol
- E.EB-II - Eluviated Eutric Brunisol-lithic phase
- O.GL - Orthic Gray Luvisol
- BR.GL - Brunisol Gray Luvisol
- GLBR.GL - Gleyed Brunisolic Gray Luvisol
- O.B - Orthic Brown
- R.B - Rego Brown
- O.BL - Orthic Black
- O.BL-II - Orthic Black - lithic phase
- O.DG - Orthic Dark Gray
- O.DG-II - Orthic Dark Gray - lithic phase
- O.HFP - Orthic Humo-Ferric Podzol
- O.HFP-II - Orthic Humo-Ferric Podzol-lithic phase
- GL.HFP - Gleyed Humo-Ferric Podzol
- SM.HFP-II - Sombric Humo-Ferric Podzol-lithic phase
- TY.M - Typic Mesisol
- O.R - Orthic Regosol

**Vegetation Zone

- DI AT - Dry Interior Region; Subalpine Engelmann spruce - alpine fir zone: lodgepole pine subzone
- DI SAeS-alF:c - Dry Interior Region; Subalpine Engelmann spruce - alpine fir zone: Rocky Mountain Douglas-fir - lodgepole pine subzone
- DI ID:a - Dry Interior Region; Interior Rocky Mountain Douglas-fir zone: lodgepole pine subzone
- DI ID:b - Dry Interior Region; Interior Rocky Mountain Douglas-fir zone: ponderosa pine subzone

6. CHARACTERISTICS OF THE SOILS OF THE STUDY AREA

To characterize the study area, the soils were separated according to the surficial geologic materials from which they were derived. These materials are variable both in their composition and distribution. Their aerial distribution is shown on both the Terrain and Soil maps for the Vaseux watershed.

6.1 SOILS OF COLLUVIAL ORIGIN

Soils of colluvial origin occupy a significant portion of the study area and are found in combination with rock outcrops. They are composed of materials which have undergone downslope movement and have reached their present position due to gravity. Generally, they consist of massive, non-sorted to poorly sorted materials which range in particle size from clay to boulders and are related to the underlying or up-slope materials from which they are derived.

Soils developed in colluvial materials, which have been derived from or associated with areas of granite, granodiorite and granitoid gneiss and to a lesser extent andesite and conglomerate bedrock, generally consist of a gravelly sandy loam texture and are generally less than one metre thick overlying bedrock. C1 soils occur in meadow areas of the alpine tundra. C2 and C4 soils occur in well forested areas dominantly covered by Engelmann spruce, alpine fir, lodgepole pine and occassionally Douglas-fir. C3 and C5 soils occur on steep, south and west facing subalpine slopes that for historical reasons are now partially non-treed and are grass covered. C6 soils occur in well forested areas with the dominant tree species being Douglas-fir and lodgepole pine. C9 soils occur in lower elevation, open forests of Douglas-fir and ponderosa pine. C7 and C10 soils have developed in deeper colluvial deposits and are the deep counterparts of the shallow C6 and C9 soils. As with C3 and C5 soils, C8 and C11 soils occur in parkland areas that have both open forests and edaphic open grassland areas. C12 soils occur in edaphic grassland areas.

These colluvial soils are generally well drained and usually have high to moderate infiltration and percolation rates. They are also moderately pervious although this decreases abruptly at the contact with the underlying bedrock.

6.2 SOILS OF FLUVIAL ORIGIN

Soils of fluvial origin are composed of materials transported and deposited by streams and are commonly well sorted. Depending on the type and size of stream and its gradient, the deposits vary in texture, ranging from gravels to silts.

The fluvial deposits in the study area have been subdivided into three categories based on their texture and mode of deposition.

Soils developed in fluvioglacial deposits generally consist of a sandy loam solum texture grading to a very gravelly sand and/or sand substrata texture. Surface cobbles and stones are abundant where the overlay is thin. F2, F4 and F5 soils occur in well forested areas dominated by Engelmann spruce, alpine fir, lodgepole pine and occassionally Douglas-fir. F3 and F6 soils also occur in the subalpine but have a substrata consisting of silt loam, fine sandy loam or sand textured ponded materials. F9 soils occur in well forested areas covered mainly by Douglas-fir and lodgepole pine. F14, F15 and F16 soils occur in areas that grade from open forests of Douglas-fir and ponderosa pine (F14) to parkland areas (F15) to grasslands (F16).

These fluvioglacial deposits are predominantly rapidly drained. Exceptions are the F3 and F6 soils, which are located along McIntyre Creek and along Vaseux Creek above the point where McIntyre Creek joins Vaseux Creek, and are moderately well drained and the F5 soils which are located along the present stream channels and are imperfectly drained. Generally the fluvioglacial soils have a high infiltration rate, a high to moderate preculation rate and are rapidly to moderately pervious.

Soils developed in fluvial fan deposits consist of very gravelly sandy loam textures in which surface gravels and cobbles are abundant (F8 and F12) and grade into areas where the gravelly soils have a sandy loam overlay.

These fluvial fan soils vary from rapidly to well drained, are rapidly pervious and have rapid infiltration and percolation rates.

Soils developed in fluvial floodplain deposits are located along the margins of the present day streams. They generally have sandy loam surface textures grading to gravelly sand substrata textures (F1, F7 and F10) except for the braided stream F11 soils which have very gravelly sand textures and an abundance of surface gravels and cobbles.

These soils, under normal conditions, are usually rapidly to moderately well drained but do have high or fluctuating watertables and are subject to annual flooding. They are rapidly pervious.

6.3 SOILS OF GLACIOLACUSTRINE ORIGIN

Soils of glaciolacustrine origin consist of sediments that have settled from suspension in bodies of standing fresh water or that have collected at their margins through wave action. The sediments usually consist of stratified sand, silt and clay deposited in former lake beds or moderately to well sorted sand and coarser materials that are beach and other littoral sediments along the margins of former glacial lakes.

Soils interpreted to have developed in glaciolacustrine beach sediments are located on the hillside on the west side of Solco Creek. These L1 soils consist of a band of three parallel ridges, each successively lower in elevation than its predecessor. They are composed mainly of sand with varying amounts of gravel. The soils are rapidly pervious and have rapid surface infiltration and downward percolation rates. They are usually rapidly drained.

6.4 SOILS OF MORAINAL ORIGIN

Soils of morainal origin occupy a significant portion of the study area. Morainal deposits (often called glacial till) consist of materials transported and deposited by glaciers. They generally consist of well-compacted substrata materials that are non-stratified and contain a heterogeneous mixture of particle sizes (ranging from gravel to boulders) in a matrix of sand, silt and clay.

The soils developed in morainal materials have a sandy loam texture containing a variable amount of gravel, cobbles and boulders. The high elevation soils M1, M2, M3, M4 and M5 occur in well forested areas of Engelmann spruce, alpine fir, lodgepole pine and occassionally Douglas-fir. The mid-elevation soils M6, M7 and M8 occur in well forested areas dominated by Douglas-fir and lodgepole pine. The low elevation morainal soils, M9, M10 and M11, occur in areas that grade from open forests of Douglas-fir and ponderosa pine (M9) to parkland areas (M10) to grasslands (M11). As with their colluvial counterparts, M3, M8 and M10 soils occur in parkland areas where a portion of the area is treed and the remainder is edaphic grasslands.

These morainal soils are compact and hard (when dry) below depth of about one-half to one metre. Moisture infiltration through the surface is moderate while percolation rates decrease in the compact substrata. These soils are well (M3, M6, M8, M9, M10 and M11) drained or moderately well (M1 and M5) drained and are moderately pervious. In some areas where seepage or surface water accumulates, the M2, M5 and M7 soils are imperfectly drained.

6.5 SOILS OF ORGANIC ORIGIN

Soils of organic origin usually occupy areas along the present stream channels. They are composed of materials resulting from vegetative growth, decay and accumulation in and around closed basins or gentle slopes, where the rate of accumulation exceeds that of decay. Generally, they consist of peat, unstratified and locally containing minor amounts of marl and inorganic detritus.

Soils developed in organic materials are very poorly drained and composed mainly of organic materials at an intermediate stage of decomposition. O1 soils occur in open wetland areas surrounded by dense stands of Engelmann spruce, alpine fir and lodgepole pine. O2 soils also occur in open wetland areas but are surrounded by dense stands of Douglas-fir and lodgepole pine.

6.6 BEDROCK AREAS

The bedrock in the Vaseux Creek watershed is predominantly acidic and composed of granite, granodiorite and granitoid gneiss; small areas of andesite and conglomerate also occur. These areas of bedrock outcrop or rock covered by less than 10 cm of soil or organic material are most prrominant along the side-hills of the main Okanagan valley and in the Vaseux gorge area. R2 and R4 areas are rubbly-blocky talus areas located below exposed bedrock cliffs and are generally treeless. Bedrock R1 areas occur in high elevation areas and R3 areas in mid and low elevation areas.

PART III
SOIL EROSION RATINGS

7. INTRODUCTION

With concerns of decreased water quality in the Okanagan Lake system due to the addition of sediment and nutrients. This study was conducted to identify existing and potential areas of erosion for various land-use activities. The procedure followed in reaching this objective was to map the terrain and soils of the Coldstream and Vaseux watersheds and then to apply the Universal Soil Loss Equation to each of the mapped soil polygons, taking into account the various land-use activities.

The Universal Soil Loss Equation (U.S.D.A., S.C.S. 1976) was used as a guideline in obtaining the erosion factors for the Coldstream and Vaseux areas. The land-use activity erosional impact groupings were based on the information presented by Brown III, et al (1979). Interpretation of the climatic data as to when the various types of weathering and erosional factors are most prevalent was taken from Rickert et al. (1978).

7.1 DEVELOPMENT OF THE SOIL EROSION RATINGS

The estimation of the soil erosion ratings for the various soils in the study areas for various land-use activities are based on the Universal Soil Loss Equation where A=RKLSCP. From the equation A is the predicted annual soil loss in tons per acre, R is the rainfall factor, K is the soil erodibility factor, LS is the slope length and steepness factor, C is the cover or cropping factor and P is the erosion control practice factor. The following descriptions explain how the factors were developed for the Coldstream and Vaseux study areas.

7.2 RAINFALL FACTOR

The rainfall factor (R) is expressed as a rainfall erosion index value and can be defined as the erosive force of the rainfall. It reflects the turbulence of runoff to dislodge and transport soil particles. The rainfall factor is supposed to be based on the rainfall from a maximum 6 hour intensity storm. As this type of information was not available for this study, the 24 hour rainfall intensity was used. The 24 hour rainfall intensities for each month for Penticton Airport, Vernon Coldstream Ranch, Chute Lake and McCulloch, which are the closest and most representative weather stations representing various elevations, are recorded in Table 3. For each monthly rainfall intensity a rainfall factor was obtained from the graph in Figure 3. The rainfall factor for each month was totalled for the year and then averaged. As a result, the valley bottoms represented by the ponderosa pine vegetation subzone of the Interior Rocky Mountain Douglas-fir zone was assigned a rainfall factor of 30, the valley sides represented by the lodgepole pine subzone of the Interior Rocky Mountain Douglas-fir zone, was assigned 35 and the high elevation plateau represented by the Subalpine Engelmann spruce - alpine fir zone was assigned a factor of 40.

TABLE 3: RAINFALL FACTORS FOR COLDSTREAM AND VASEUX CREEK WATERSHEDS

	PENTICTON		COLDSTREAM		CHUTE LAKE		McCULLOCH	
Month	24-Hour Rainfall (inches)	Rainfall Factor	24-Hour Rainfall (inches)	Rainfall Factor	24-Hour Rainfall (inches)	Rainfall Factor	24-Hour Rainfall (inches)	Rainfall Factor
January	0.62	10.0	0.70	12.5	0.50	7.5	0.32	4.5
February	0.73	13.0	1.23	41.5	0.51	7.5	0.31	3.5
March	0.54	8.5	0.72	13.0	1.32	49.0	1.01	26.0
April	1.08	30.0	0.89	19.5	1.12	33.0	1.21	40.0
May	1.17	36.5	1.18	38.0	1.56	72.5	1.14	34.5
June	1.32	49.0	1.57	73.5	1.17	36.5	2.28	164.5
July	1.49	66.0	1.17	36.5	1.17	36.5	1.66	83.0
August	0.87	18.5	1.24	41.5	1.02	26.0	1.09	31.0
September	0.75	14.0	1.40	57.0	1.35	52.0	1.19	38.5
October	1.75	93.5	0.81	16.0	1.73	91.5	0.99	25.0
November	0.76	14.0	0.72	13.0	0.76	14.5	0.58	9.0
December	0.49	7.5	0.73	13.0	0.50	7.5	0.45	6.5
Total		360.0		375.0		434.0		466.0
Average		30.0		31.2		36.2		38.8

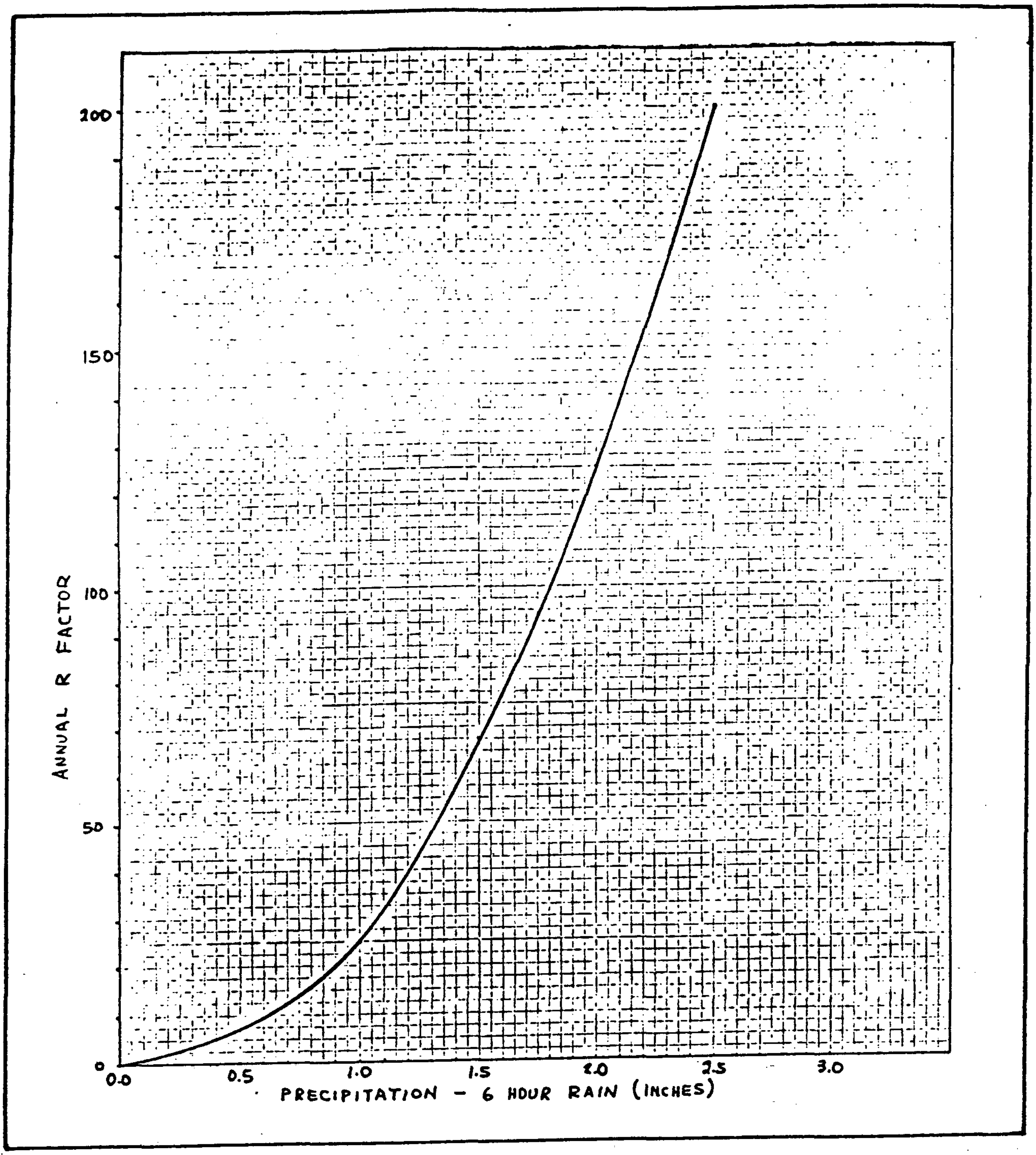


Figure 3. Relationship between the 6-hour rainfall intensity and rainfall factor for type II.

7.3 ERODIBILITY FACTOR

The soil erodibility factor (K) is a measure of the rate at which a soil will erode. The soil factors considered are the percent silt and very fine sand, percent organic matter, soil structure and soil permeability. During the field survey the textures of the soil horizons were estimated by hand texturing and in many cases verified by laboratory analysis. Organic matter content was also determined by laboratory analysis.

The organic matter content in soils analyzed from the study areas and other soil surveys conducted in the Okanagan were studied and the average percentage was noted for the surface and substratum soil layers of the various soil developments (Table 4). Table 5 was developed to assist in estimating the soil erodibility factor for soils not sampled. The percentage of silt and sand was taken from mid-point of each textural class located on the textural triangle chart. The soil structure and permeability was estimated for each organic matter percentage. The soil erodibility factor was then estimated from the soil erodibility nomograph (Figure 4). Table 6 shows the percent silt, sand/and organic matter determined by laboratory analysis of soils sampled in the Coldstream and Vaseux areas. The soil structure and permeability were estimated in the field. The soil erodibility factor was determined using the soil erodibility nomography.

The soils of the Coldstream and Vaseux watershed were assigned a soil erodibility factor by adveraging the factors from Table 6 for the various soils. Soils not checked in the field were assigned soil erodibility factors by using Table 5 in combination with the factors derived from field data. Table 7 shows the soil erodibility factors for the surface layers and substratum of the various soils in the Coldstream and Vaseux watersheds.

TABLE 4: AVERAGE ORGANIC MATTER CONTENT IN SOME OKANAGAN SOILS

Soil Development	Percent Organic Matter		
	Surface Layer	Subsoil Layer	Substratum Layer
Sombric Humo-Ferric Podzol	19	8	2
Orthic Black	8	3	1
Gleyed Black	8	3	1
Orthic Humo-Ferric Podzol	5	4	0
Gleyed Humo-Ferric Podzol	5	4	0
Gleyed Brunisolic Gray Luvisol	5	2	0
Brunisolic Gray Luvisol	4	2	0
Orthic Dystric Brunisol	4	2	0
Gleyed Dystric Brunisol	4	2	0
Orthic Brown	3	2	1
Rego Brown	3	2	1
Orthic Dark Brown	3	2	1
Orthic Dark Gray	3	2	1
Orthic Eutric Brunisol	3	1	0
Eluviated Eutric Brunisol	3	1	0
Orthic Gray Luvisol	3	1	0
Orthic Regosol	1	1	0
Cumulic Regosol	1	1	0

TABLE 5: SOIL ERODIBILITY FACTORS FOR AVERAGE SOIL TEXTURES

Soil Texture	Percent Silt	Percent Sand	Percent Organic Matter	Soil* Structure	Perme-ability**	Soil Erodibility Factor K
clay	20	20	8	3	4	0.09
	20	20	7	3	4	0.09
	20	20	6	3	4	0.09
	20	20	5	3	4	0.10
	20	20	4	3	4	0.10
	20	20	3	4	5	0.14
	20	20	2	4	5	0.15
	20	20	1	4	5	0.16
	20	20	0	4	5	0.17
silty clay	47	7	8	3	4	0.09
	47	7	7	3	4	0.10
	47	7	6	3	4	0.12
	47	7	5	3	4	0.14
	47	7	4	3	4	0.16
	47	7	3	4	5	0.24
	47	7	2	4	5	0.27
	47	7	1	4	5	0.30
	47	7	0	4	5	0.33
sandy clay	5	51	8	3	3	0.07
	5	51	7	3	3	0.07
	5	51	6	3	3	0.07
	5	51	5	3	3	0.07
	5	51	4	3	3	0.07
	5	51	3	4	4	0.10
	5	51	2	4	4	0.10
	5	51	1	4	4	0.10
	5	51	0	4	4	0.10
silty clay loam	56	10	8	3	3	0.08
	56	10	7	3	3	0.10
	56	10	6	3	3	0.13
	56	10	5	3	3	0.17
	56	10	4	3	3	0.20
	56	10	3	4	4	0.30
	56	10	2	4	4	0.34
	56	10	1	4	4	0.38
	56	10	0	4	4	0.41

TABLE 5: (CONTINUED)

Soil Texture	Percent Silt	Percent Sand	Percent Organic Matter	Soil* Structure	Perme-ability**	Soil Erodibility Factor K
clay loam	35	32	8	3	3	0.07
	35	32	7	3	3	0.08
	35	32	6	3	3	0.09
	35	32	5	3	3	0.10
	35	32	4	3	3	0.13
	35	32	3	4	4	0.21
	35	32	2	4	4	0.23
	35	32	1	4	4	0.26
	35	32	0	4	4	0.28
sandy clay loam	15	60	8	3	3	0.07
	15	60	7	3	3	0.07
	15	60	6	3	3	0.07
	15	60	5	3	3	0.07
	15	60	4	3	3	0.08
	15	60	3	4	3	0.08
	15	60	2	4	3	0.09
	15	60	1	4	3	0.10
	15	60	0	4	3	0.11
silt	87	6	8	3	3	0.12
	87	6	7	3	3	0.19
	87	6	6	3	3	0.24
	87	6	5	3	3	0.32
	87	6	4	3	3	0.38
	87	6	3	4	3	0.49
	87	6	2	4	3	0.55
	87	6	1	4	3	0.61
	87	6	0	4	3	0.68
silt loam	65	22	8	3	3	0.10
	65	22	7	3	3	0.16
	65	22	6	3	3	0.21
	65	22	5	3	3	0.27
	65	22	4	3	3	0.32
	65	22	3	4	3	0.41
	65	22	2	4	3	0.47
	65	22	1	4	3	0.52
	65	22	0	4	3	0.58

TABLE 5: (CONTINUED)

Soil Texture	Percent Silt	Percent Sand	Percent Organic Matter	Soil* Structure	Perme-ability**	Soil Erodibility Factor K
loam	42	42	8	3	3	0.07
	42	42	7	3	3	0.09
	42	42	6	3	3	0.12
	42	42	5	3	3	0.16
	42	42	4	3	3	0.20
	42	42	3	4	3	0.26
	42	42	2	4	3	0.31
	42	42	1	4	3	0.34
	42	42	0	4	3	0.37
sandy loam	25	65	8	3	2	0.04
	25	65	7	3	2	0.05
	25	65	6	3	2	0.06
	25	65	5	3	2	0.08
	25	65	4	3	2	0.10
	25	65	3	4	2	0.15
	25	65	2	4	2	0.18
	25	65	1	4	2	0.20
	25	65	0	4	2	0.22
loamy sand	10	83	8	3	1	0.02
	10	83	7	3	1	0.02
	10	83	6	3	1	0.02
	10	83	5	3	1	0.02
	10	83	4	3	1	0.03
	10	83	3	3	1	0.03
	10	83	2	3	1	0.04
	10	83	1	3	1	0.04
	10	83	0	3	1	0.05
sand	6	92	8	3	1	0.02
	6	92	7	3	1	0.02
	6	92	6	3	1	0.02
	6	92	5	3	1	0.02
	6	92	4	3	1	0.02
	6	92	3	3	1	0.02
	6	92	2	3	1	0.03
	6	92	1	3	1	0.03
	6	92	0	3	1	0.03

*Soil Structure
1 very fine granular
2 fine granular
3 moderate or coarse granular
4 blocky, platy or massive

**Permeability
1 rapid
2 moderate to rapid
3 moderate
4 slow to moderate
5 slow
6 very slow

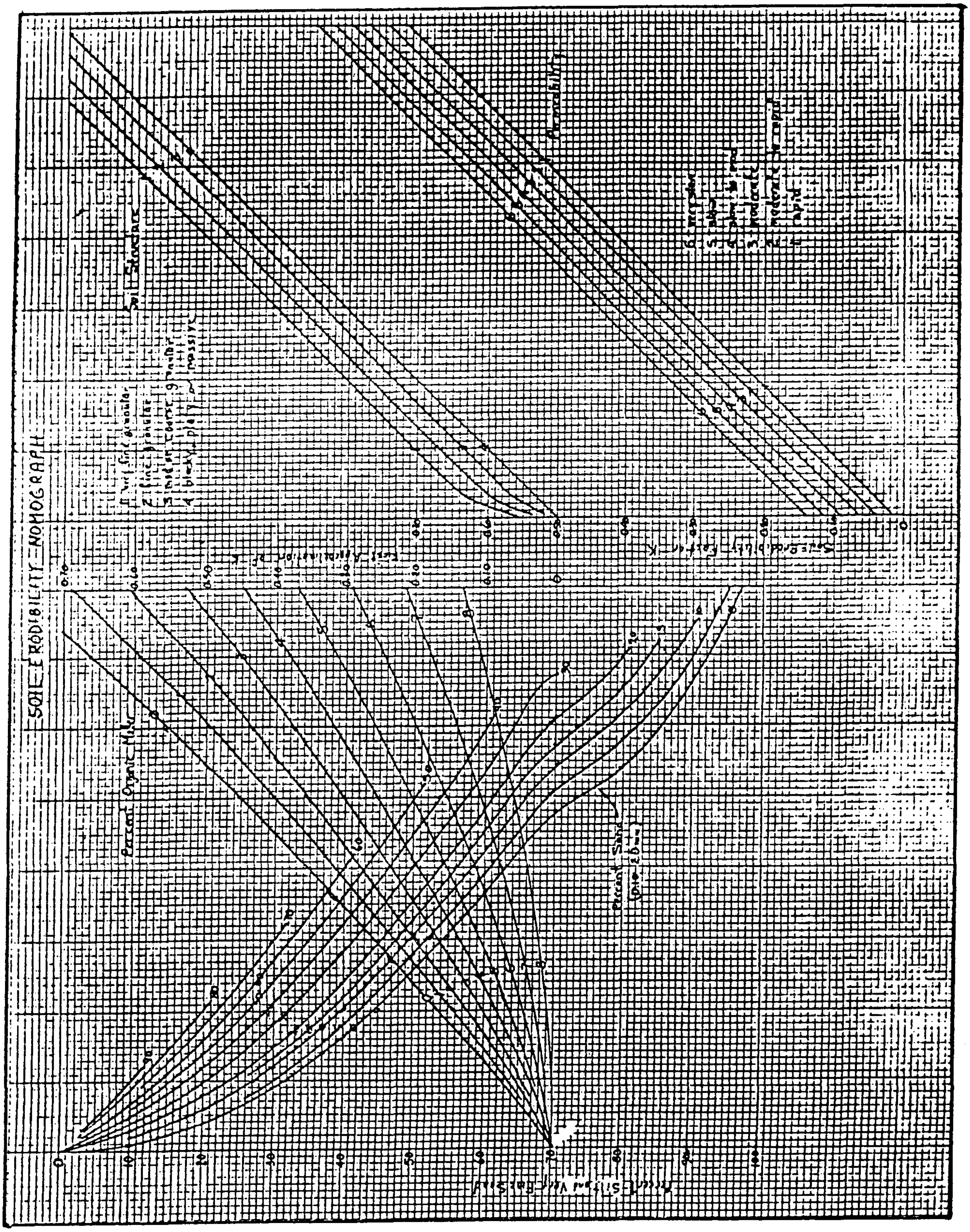


Figure 4. Soil erodibility momograph.

TABLE 6: SOIL ERODIBILITY FACTORS DERIVED FROM FIELD DATA

Number	Horizon	Soil Texture	% Silt	% Sand	% Organic Matter	Soil Structure	Permea-bility	Soil Erodibility Factor K
2604	Ck1	loam	44	45	2	3	3	0.30
2614	Ck	silt loam	57	26	1	4	4	0.46
2616	Ck	loam	48	41	0	4	4	0.47
2619	Bm	silt loam	57	37	4	3	3	0.33
	C	sandy loam	43	52	0	4	2	0.43
2621	Bm	sandy loam	29	68	2	4	1	0.20
2623	Bm1	sandy loam	27	71	2	4	1	0.19
2625	Bm	silt loam	57	35	4	3	3	0.30
	C	loam	45	39	1	4	3	0.36
2702	Bm	silt loam	65	24	4	3	3	0.33
	C	silt loam	61	23	1	4	4	0.42
2703	C	loam	46	43	1	4	3	0.39
2704	C3	silt loam	61	26	0	4	1	0.48
2705	C	sandy loam	34	54	0	4	3	0.32
2706	C2	silt loam	83	1	1	4	3	0.54
2708	Bm	sandy loam	31	66	2	4	2	0.24
2709	Ae2	sandy loam	30	64	1	4	1	0.23
	C	sandy loam	48	49	0	4	3	0.47
2710	C	silt loam	71	24	1	4	3	0.60
2711	C	sandy loam	32	63	0	4	1	0.28
2712	Bm	sandy loam	41	55	2	4	2	0.31
	C	loamy sand	21	77	0	4	1	0.19
2714	Bm1	sandy loam	42	54	4	4	2	0.24
	C	loamy sand	13	83	0	4	2	0.13
2715	C	sandy loam	30	66	0	4	3	0.31
2716	B	sandy loam	47	47	2	4	2	0.34
	C	loam	37	51	1	4	3	0.32
2717	B	silt loam	51	42	4	3	3	0.27
	C	loam	39	50	1	4	3	0.33
2718	Bm	sandy loam	45	51	2	4	3	0.37
	C	loam	41	49	1	4	3	0.35
2719	B	sandy loam	32	60	2	4	3	0.26
	C2	sand	6	92	0	4	1	0.06
2720	Ck	loam	34	50	1	4	3	0.28
2721	Ck	loam	39	50	1	4	3	0.33
1	C	silt	81	16	1	4	3	0.62
2	C	sandy clay loam	6	71	1	4	3	0.09

*Soil Structure
1 very fine granular
2 fine granular
3 moderate or coarse granular
4 blocky, platy or massive

**Permeability
1 rapid
2 moderate to rapid
3 moderate
4 slow to moderate
5 slow
6 very slow

TABLE 7: SOIL ERODIBIILTY FACTORS FOR COLDSTREAM AND VASEUX CREEK SOILS

Coldstream Soil Erodibility Factors		
Soil Type	Surface Layers	Substratum Layer
C1	0.10	0.22
C2	0.10	0.22
C3	0.20	0.37
C4	0.26	0.22
C5	0.19	0.22
C6	0.07	0.22
C7	0.11	0.22
C8	0.04	0.22
C9	0.10	0.22
F10	0.10	0.03
F2	0.20	0.22
F3	0.15	0.03
F4	0.04	0.03
F5	0.04	0.22
F6	0.07	0.37
F7	0.07	0.37
F8	0.34	0.03
F9	0.10	0.03
F10	0.03	0.03
L1	0.07	0.26
L2	0.07	0.26
L3	0.07	0.26
M1	0.30	0.43
M2	0.16	0.43
M3	0.30	0.43
M4	0.16	0.43
M5	0.19	0.43
M6	0.07	0.43
O1	--	--
O2	--	--
Land Type		
A1	0.03	0.03
R1	0.01	--
R2	0.01	--
R3	0.01	--
R4	0.02	--
R5	0.01	--

Vaseux Soil Erodibility Factors		
Soil Type	Surface Layers	Substratum Layer
C1	0.04	0.22
C2	0.15	0.22
C3	0.10	0.22
C4	0.18	0.22
C5	0.15	0.22
C6	0.18	0.22
C7	0.18	0.32
C8	0.14	0.22
C9	0.18	0.22
C10	0.18	0.32
C11	0.14	0.22
C12	0.04	0.22
F1	0.22	0.03
F2	0.15	0.03
F3	0.22	0.52
F4	0.18	0.03
F5	0.10	0.03
F6	0.28	0.52
F7	0.22	0.03
F8	0.15	0.22
F9	0.18	0.03
F10	0.22	0.03
F11	0.03	0.03
F12	0.03	0.03
F13	0.06	0.22
F14	0.18	0.03
F15	0.14	0.03
F16	0.06	0.03
L1	0.15	0.03
M1	0.28	0.32
M2	0.16	0.32
M3	0.18	0.32
M4	0.28	0.32
M5	0.16	0.32
M6	0.28	0.32
M7	0.16	0.32
M8	0.23	0.32
M9	0.28	0.32
M10	0.23	0.32
M11	0.12	0.32
O1	--	--
O2	--	--
Land Type		
R1	0.01	--
R2	0.02	--
R3	0.01	--
R4	0.02	--

7.4 SLOPE LENGTH AND SLOPE STEEPNESS FACTOR

The slope length factor (L) is the ratio of soil loss from a specific slope length. The slope length is defined as the distance from the point of origin of overland flow to either the point where the slope decreases to the extent that deposition begins or the point where runoff enters a well defined channel. The slope steepness factor (S) is the ratio of soil loss from a specific percent slope. The L and S factors are treated in combination and are determined from the following equations:

For slopes <9% $LS = \left(\frac{l}{72.6}\right)^{0.3}\left(\frac{0.43 + 0.30s + 0.043s^2}{6.613}\right)$

For slopes >9% $LS = \left(\frac{l}{72.6}\right)^{0.3}\left(\frac{s}{9}\right)^{1.3}$

l = slope length
s = percent slope

In the Coldstream and Vaseux Creek watersheds, the average slope length was estimated and recorded for each soil unit. The percent slope was obtained from the soils map and was represented by a slope class or range of slope classes. To calculate the LS factor, the mid-point of each slope class was used in the formula and the slope effect table (Table 8) was determined.

To obtain the LS factor for a soil unit having a single slope class, the LS factor was read directly off of Table 8 matching the slope class and the slope length. For example the LS factor for a slope class 6 and slope length 125 feet the LS factor is 4.44. To obtain the LS factor for a soil unit having a range of slope classes Table 8 and Table 9 are used.

TABLE 8: SLOPE EFFECT TABLE (TOPOGRAPHIC FACTOR LS)

SLOPE		SLOPE LENGTH (FEET)																							
Class	Mid %	20	30	40	62.5	80	90	100	125	150	187.5	200	225	250	275	300	312.5	325	350	375	400	425	437.5	475	500
2	1	0.08	0.09	0.10	0.11	0.12	0.12	0.13	0.14	0.15	0.16	0.16	0.16	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.20	0.20	0.20	0.21	0.21
3	4	0.24	0.27	0.29	0.33	0.36	0.37	0.39	0.41	0.93	0.46	0.98	0.49	0.50	0.52	0.53	0.54	0.54	0.56	0.57	0.58	0.59	0.60	0.61	0.62
4	8	0.57	0.65	0.71	0.81	0.87	0.90	0.93	0.99	1.05	1.12	1.14	1.18	1.22	1.26	1.29	1.31	1.32	1.35	1.38	1.41	1.43	1.45	1.98	1.51
5	12	0.99	1.11	1.22	1.39	1.50	1.55	1.60	1.71	1.81	1.93	1.97	2.04	2.10	2.16	2.22	2.25	2.27	2.33	2.38	2.93	2.47	2.49	2.55	2.59
6	25	2.56	2.90	3.16	3.61	3.89	4.03	4.15	4.44	4.69	5.02	5.11	5.30	5.97	5.63	5.78	5.85	5.92	6.05	6.18	6.30	6.41	6.47	6.63	6.73
7	40	4.72	5.33	5.81	6.65	7.16	7.42	7.65	8.18	8.64	9.24	9.42	9.76	10.08	10.37	10.64	10.77	10.90	11.15	11.38	11.60	11.81	11.92	12.21	12.40
8	60	8.00	9.04	9.85	11.56	12.13	12.56	12.97	13.86	14.64	15.66	15.96	16.54	17.07	17.56	18.03	18.25	18.47	18.88	19.28	19.65	20.01	20.19	20.69	21.01
9	85	12.58	14.21	15.49	17.71	19.07	19.76	20.39	21.80	23.03	24.62	25.11	26.01	26.84	27.62	28.35	28.70	29.04	29.69	30.31	30.91	31.47	31.75	32.54	33.05
10	100	15.54	17.55	19.14	21.88	23.56	24.41	25.19	26.93	28.45	30.42	31.01	32.13	33.16	34.12	35.02	35.45	35.87	36.68	37.45	38.18	38.87	39.22	40.20	40.12

SLOPE		SLOPE LENGTH (FEET)																							
Class	Mid %	525	562.5	600	625	650	687.5	700	725	750	800	812.5	875	900	937.5	1000	1062.5	1100	1125	1187.5	1250	1312.5	1375	1437.5	1500
2	1	0.21	0.22	0.22	0.22	0.23	0.23	0.23	0.23	0.24	0.24	0.24	0.25	0.25	0.25	0.26	0.26	0.26	0.27	0.27	0.27	0.28	0.28	0.29	0.29
3	4	0.63	0.64	0.65	0.66	0.67	0.68	0.69	0.69	0.70	0.72	0.72	0.73	0.74	0.75	0.76	0.78	0.79	0.79	0.80	0.72	0.83	0.84	0.85	0.86
4	8	1.53	1.56	1.59	1.61	1.63	1.66	1.67	1.68	1.70	1.73	1.74	1.78	1.80	1.82	1.85	1.89	1.91	1.92	1.95	1.98	2.01	2.04	2.06	2.09
5	12	2.63	2.69	2.74	2.77	2.81	2.85	2.87	2.90	2.93	2.99	3.00	3.07	3.09	3.13	3.19	3.25	3.29	3.31	3.36	3.41	3.46	3.51	3.56	3.61
6	25	6.83	6.98	7.11	7.20	7.28	7.91	7.45	7.53	7.60	7.75	7.79	7.96	8.03	8.13	8.29	8.44	8.53	8.59	8.73	8.86	8.99	9.12	9.24	9.3
7	40	12.59	12.85	13.10	13.26	13.42	13.65	13.72	13.87	14.01	14.28	14.35	14.67	14.80	14.98	15.27	15.55	15.71	15.82	16.08	16.33	16.57	16.80	17.03	17.25
8	60	21.32	21.77	22.19	22.47	22.73	23.12	23.24	23.49	23.73	24.20	24.31	24.85	25.07	25.37	25.87	26.35	26.62	26.80	27.23	27.66	28.07	28.46	28.85	29.22
9	85	33.54	34.24	34.91	35.34	35.75	36.36	36.56	36.94	37.32	38.05	38.23	39.09	39.42	39.91	40.69	41.93	41.88	42.15	42.84	43.50	44.14	44.76	45.37	45.95
10	100	41.42	12.29	43.12	43.65	44.17	44.91	45.16	45.63	46.10	47.00	47.22	48.28	48.69	49.15	50.26	51.18	51.74	52.06	52.92	53.74	54.53	55.30	56.04	56.76

TABLE 9: SLOPE ADJUSTMENT CHART

SEGMENT NUMBER	EQUAL LENGTH SEGMENT FACTORS		
	Number of Slope Classes		
	2	3	4
1	0.81	0.72	0.66
2	1.91	1.05	0.96
3		1.23	1.13
4			1.25

The LS factor is multiplied by the equal length segment factor (Table 9) with the dominant slope class being multiplied by the higher factor. For example, for a soil unit having a slope length of 125 feet and a slope class of 5-7, the LS factors for slope classes 5, 6 and 7 for the slope length of 125 feet are listed as 1.71, 4.44 and 8.18 respectively in Table 8. The equal length segment factors from Table 9 for 3 slope classes are multiplied by the LS factors, the totals of which are added and divided by 3 giving the corrected LS factor of 4.22. The first listed slope class (in this case, slope class 5) is multiplied by the highest equal length segment factor.

EXAMPLE:

slope class	LS value		equal length segment factor	weighted LS
5	1.71	x	1.23	2.1033
6	4.44	x	1.05	4.6620
7	8.18	x	0.72	5.8896
				12.6549
			Corrected LS	4.22

7.5 CROPPING MANAGEMENT FACTOR

The cover or cropping management factor (C) is the ratio of soil loss from land cropped under specified conditions to the corresponding loss from the land in continuous fallow. Using the C factors in U.S.D.A., S.C.S. (1976) as a guideline, the C factors for the Coldsream and Vaseux Creek areas for the soils covered by natural vegetation before any land-use activities had occurred are listed in Table 10. These C factors have been increased to 0.10, 0.30, 0.50 or 0.60 in areas that are eroding naturally. The 0.001 C factor was used in areas that are well forested, mainly high and mid-elevation forests. The 0.003 C factor was used for soils covered by open forests whereas the 0.013 C factor was used in areas covered by both grasslands and treed areas. The 0.028 C factor was used in grassland areas. Therefore, depending on the land-use activity and its affect on the vegetative cover and soil, the cover or cropping management factor varies from 0.01, 0.05, 0.10, 0.20, 0.30, 0.40, 0.60 to 1.00.

TABLE 10: CROPPING MANAGEMENT FACTORS FOR COLDSTREAM AND VASEUX CREEK SOILS

COLDSTREAM - C FACTORS FOR NATURAL CONDITIONS				VASEUX - C FACTORS FOR NATURAL CONDITIONS			
Soil	C Factor	Soil	C Factor	Soil	C Factor	Soil	C Factor
C1	0.001	M1	0.001	C1	0.001	F12	0.003
C2	0.001	M2	0.001	C2	0.001	F13	0.028
C3	0.001	M3	0.001	C3	0.013	F14	0.003
C4	0.001	M4	0.001	C4	0.001	F15	0.013
C5	0.003	M5	0.003	C5	0.013	F16	0.028
C6	0.028	M6	0.008	C6	0.001	L1	0.001
C7	0.003	O1	0.001	C7	0.001	M1	0.001
C8	0.028	O2	0.001	C8	0.013	M2	0.001
C9	0.001	R1	0.001	C9	0.003	M3	0.013
F1	0.001	R2	0.003	C10	0.003	M4	0.001
F2	0.003	R3	0.003	C11	0.013	M5	0.001
F3	0.003	R4	0.001	C12	0.028	M6	0.001
F4	0.028	R5	0.001	F1	0.001	M7	0.001
F5	0.028			F2	0.001	M8	0.013
F6	0.028			F3	0.001	M9	0.003
F7	0.028			F4	0.001	M10	0.013
F8	0.002			F5	0.001	M11	0.028
F9	0.028			F6	0.001	O1	0.001
F10	0.028			F7	0.001	O2	0.001
L1	0.028			F8	0.001	R1	0.001
L2	0.028			F9	0.001	R2	0.001
L3	0.028			F10	0.003	R3	0.003
				F11	0.600	R4	0.003

7.6 EROSION CONTROL PRACTICE FACTOR

The erosion control practice factor (P) is the ratio of soil loss from a specified conservation practice to the soil loss occurring from up-and-down-hill tillage operations, when other conditions remain constant. Table 11 gives the factors for erosion control practices.

TABLE 11: FACTORS FOR EROSION CONTROL PRACTICES

Slope	Up and Down Hill	Cross Slope Farming Without Strips	Contour Farming	Cross Slope Farming With Strips	Contour Strip-cropping
2.0-7.0	1.0	0.75	0.50	0.37	0.25
7.1-12.0	1.0	0.80	0.60	0.60	0.30
12.0-18.0	1.0	0.90	0.80	0.80	0.40
18.1-24.0	1.0	0.95	0.90	0.90	0.45

7.7 SOIL EROSION RATINGS

In order to determine the soil loss from each soil unit the various pertinent land-use activities for the Coldstream and Vaseux areas were considered. The land-use activities were grouped by erosional-impact factors based on the relative tendency of each activity to disrupt the natural vegetation and soil conditions. This information was obtained from Table 7 described in the report by Brown III et al. (1979). Using the erosional-impact rating table in the same report as a guide, the rating system for the Coldstream and Vaseux Creek areas was determined and listed in Table 12.

TABLE 12: SOIL EROSION RATINGS

Rating		Amount of Sediment Moved Tons/Acre/Year	
VL	Very Low	$<10^{-2}$	less than 0.006
L	Low	10^{-2}-10^{-1}	0.006 - 0.50
M	Moderate	10^{0}	0.51 - 5.00
H	High	10^{1}	5.01 - 50.0
VH	Very High	$>10^{1}$	greater than 50.0

The following example shows how a soil unit has its soil erosion rating change under various land-use activities: for example, a M3 soil unit occupying 55.3 ha. and having a slope class of 6-8, the soil erosion rating (A) would be:

		R	K	LS	C	P	A	Rating
natural conditions	(Map 1)	35	0.30	8.01	0.001	1.00	0.084	L
10-year forest regrowth, etc.	(Map 2)	35	0.30	8.01	0.01	1.00	0.84	M
cable logging, etc.	(Map 3)	35	0.30	8.01	0.07	1.00	5.87	H
croplands, etc.	(Map 4)	35	0.30	8.01	0.26	1.00	21.9	H
light construction, etc.	(Map 5)	35	0.30	8.01	0.60	1.00	50.5	VH
heavy construction, etc.	(Map 6)	35	0.43	8.01	1.00	1.00	121	VH

The P value in this case is 1.00 because of the steep slopes but on gentle slopes it could reduce the erosion rating by one-half (see Table 11). The K factor used for heavy construction is for the substratum whereas all other K factors are based on the surface soils.

7.8 CLIMATE AND GEOMORPHIC PROCESSES

In order to have some idea when the erosion can occur the climatic data was evaluated. A graphical analysis of the climatic data and geomorphic thresholds is used to determine the monthly potentials for weathering and erosion.

The technique for classifying climate incorporates the use of the thermohyet diagram developed by Strahler (1969). This diagram (Figure 5) graphically integrates average monthly temperature and precipitation data against a background grid which shows the ranges of these factors for the six climatic zones of arid, semi-arid, equitorial, humid temperature, polar, and glacial (Wilson, 1968). The diagram provides a quick, readily usable technique for analyzing climate, but of equal importance, it can be directly coupled with geomorphic process diagrams modified from the work of Peltier (1950). As shown in Figure 6, the modified Peltier diagrams classify areas in terms of potentials for five broad geomorphic processes which are explained in Table 13.

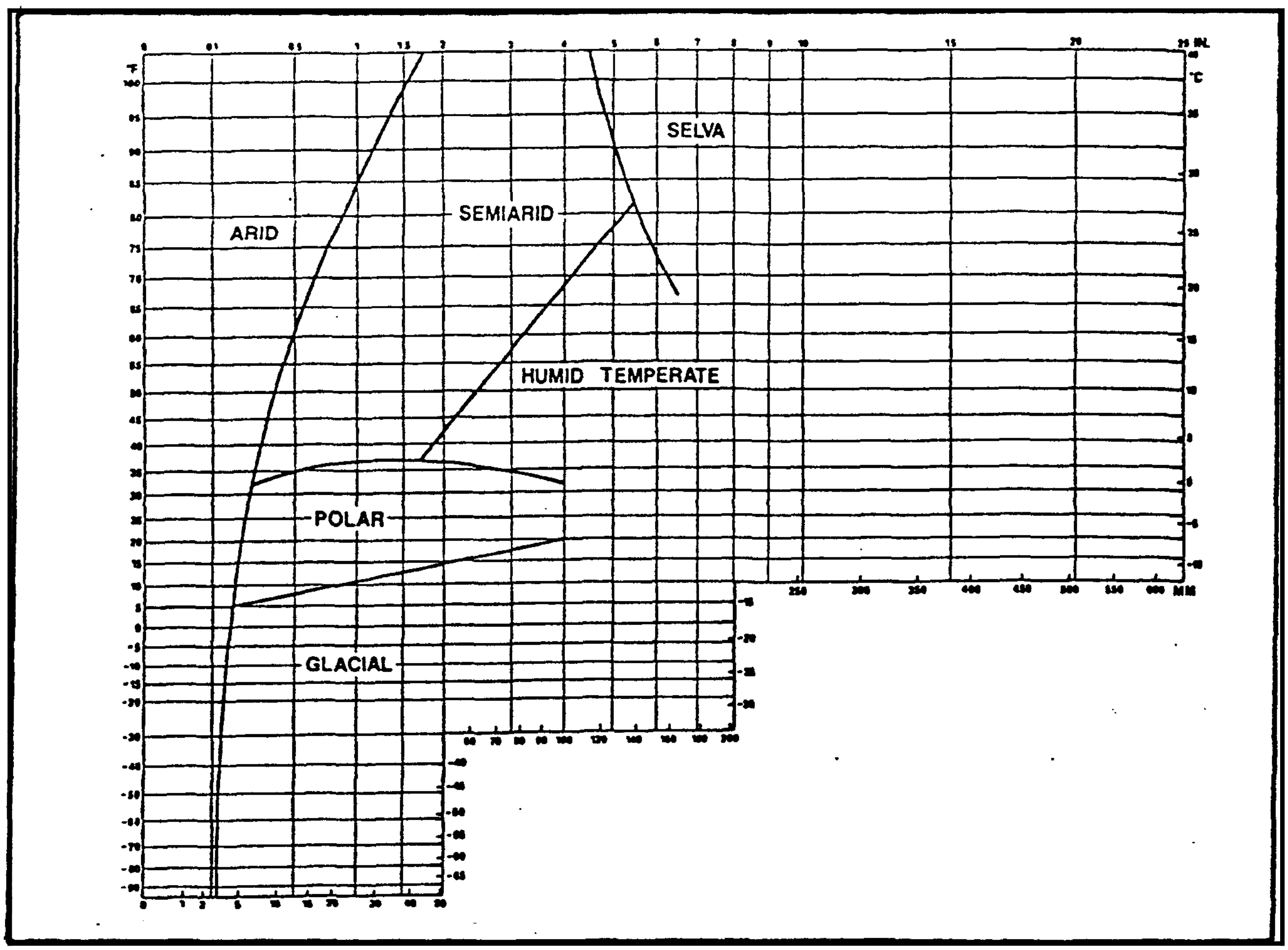


Figure 5. Example of Strahler thermohyet diagram. Diagram uses monthly means of temperature and precipitation throughout the year. The superimposed climatic zonations were proposed by Wilson for differentiating areas of similar climatic regimes. (Diagram adopted from Strahler, 1969; climatic zonation from Wilson, 1968).

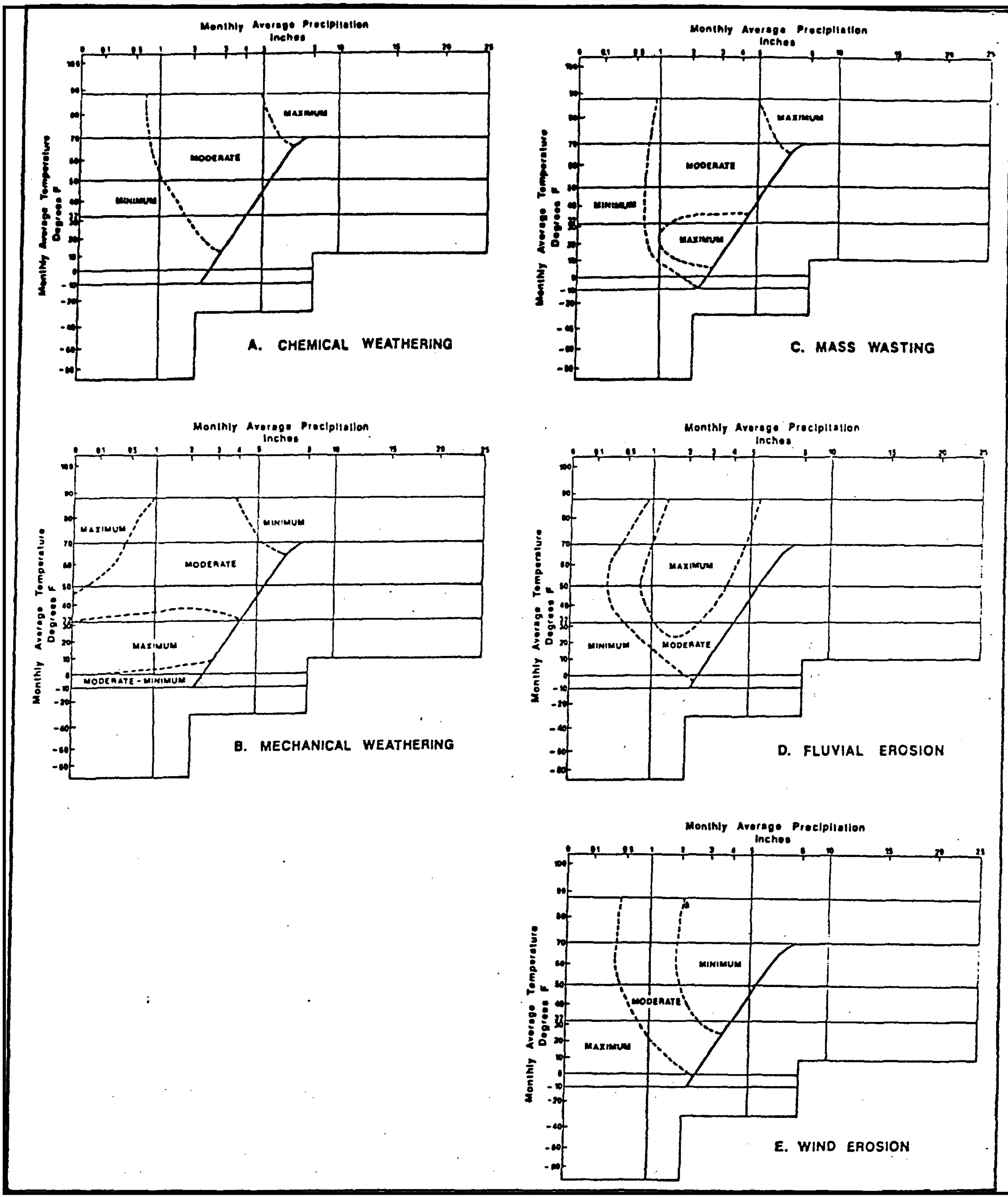


Figure 6. Morphoclimatic diagrams showing relationships between climate and prevailing weathering and erosional processes. Climate defined in terms of monthly average precipitation and temperature. Diagrams modified from Peltier (1950).

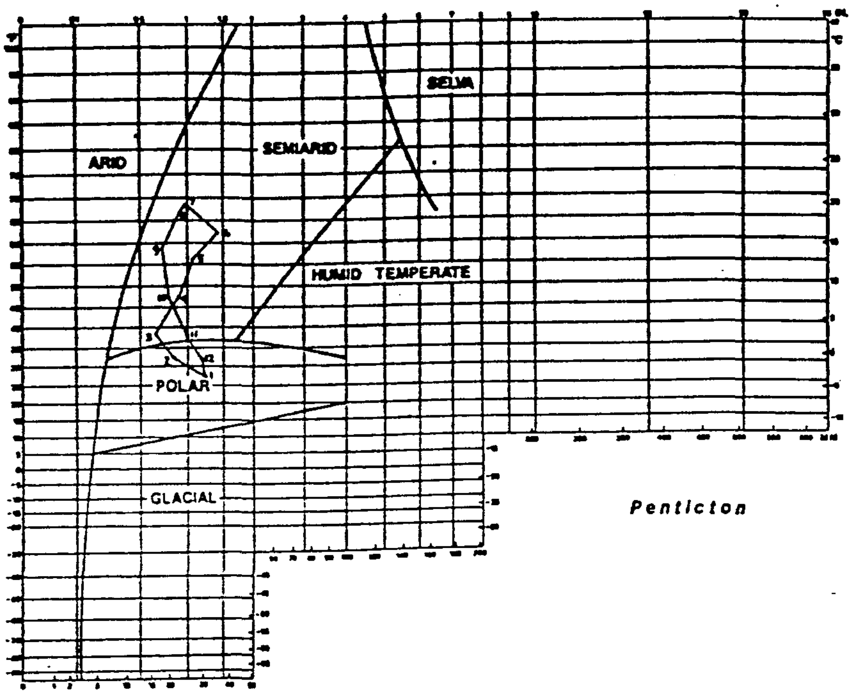
TABLE 13: RELATIONSHIPS BETWEEN VARIOUS GEOMORPHIC PROCESSES AND CLIMATE[1] (as depicted in Figure 6)

PROCESS	DESCRIPTION
Mechanical Weathering	Most intensive mechanical weathering occurs via frost action and is, therefore, prevalent in cool, moderately moist areas subject to multiple freeze-thaw cycles. However, as seen in the upper left corner of Figure 6 - B, intensive mechanical weathering can also occur in hot, dry climates as a result of pore water dessication (even small amounts) and subsequent salt crystal growth. Mechanical weathering is generally less intense where freezing or thawing rarely occur (warm or cold climates) or where rainfall is heavy.
Chemical Weathering	Two major premises are: chemical weathering must involve water as an active or catalytic agent; and the rate of chemical reaction (limestone and quartzite solution being exceptions) increases with increasing temperature. Thus, chemical weathering is most intensive in hot, humid regions and least intensive in arid regions. There is progressive variations between these extremes. The presence of dense vegetation tends to accelerate chemical weathering through the formation of organic acids that attack the rock and soil minerals.
Mass Wasting	Mass movements are favored by the availability of subsurface moisture. Thus, most intensive mass wasting is found in wet climates, particularly those that are either hot or cool. These climates promote intense weathering (either mechanical or chemical) and, hence, promote accumulation of in place weathered debris. These deposits are then prone to downslope mass movement. Concentrated rainstorms promote rapid mass movements such as earthflows and debris avalanches. Gradual soil creep occurs by virture of even, well distributed rains or freezing and thawing that cause expansion and contraction of clay-laden soils.
Fluvial Erosion	Running water is the most important universal erosional agent and is often the most powerful agent even in dry climates. In general, however, the erosional effectiveness of overland flow depends upon the amount of water available. Despite this, climates that produce dense vegetation (e.g. tropic and humid-temperate) do not produce maximum fluvial erosion because vegetation acts to protect the land surface. Hence, most intensive fluvial erosion occurs where runoff is high and vegetation is sparse. Langbein and Schumm (1958) showed that maximum fluvial erosion occurs (U.S. data only) where the mean temperatures is 10°C and average annual precipitation is 380 mm. These conditions would be found in areas of semi-arid or semi-humid climates with possibly some extension into frost climates where vegetation is sparse and seasonal runoff can be high due to melting of snow and ice. The latter climate is found in many mountainous regions of Oregon above altitudes of 5000 ft.
Wind Erosion	Wind action is most effective where vegetation is sparse. Hence, wind erosion is most important in arid regions, both hot and cold. It should be emphasized that in many semi-arid regions, wind erosion may not be as important an erosional agent as thunderstorm-induced fluvial erosion.

[1]For more detailed discussion and definition of terms refer to: Peltier (1950); Leopole, Wilman and Miller (1964); Tricart and Cailleux (1965); Wilson (1968, 1973); Debyshire (1973).

Figures 7 and 8 show the thermohyet shapes for the 4 climatic stations used in the Coldstream - Vaseux study. The thermohyet shapes for Penticton, Coldstream, Chute Lake and McCulloch are overlayed on the morphoclimatic diagrams of Figure 6 resulting in Table 14 showing which months have minimum, moderate or maximum amounts of weathering or erosion.

The major purpose of the Strahler - Peltier diagram overlay procedure is to develope a conceptual tool for systematically examining the climatically controlled tendencies for particular types of erosional processes. For example, thermohyets that are positioned mostly within the "maximum mass wasting" region of Figure 6 may indicate a strong tendency for activity such as soil creep and landsliding; particularly if terrain conditions are susceptible to mass wasting. In another example, suppose a particular area has a thermohyet that falls within the "maximum fluvial erosion" region for another part of the year. This suggests that the area will probably exhibit a wider array of erosional features and problems than those areas whose thermohyets are small in size and enclosed solely within one of the "moderate regions" of Figure 6.



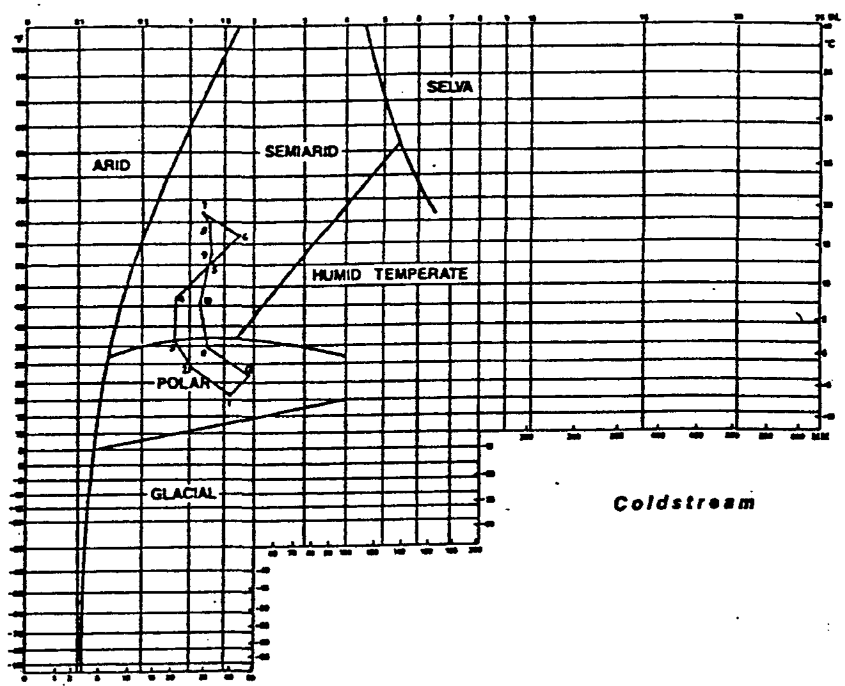


Figure 7. Thermohyet diagrams of monthly average precipitation and temperature for Penticton and Coldstream. Numbered dots indicate month of year.

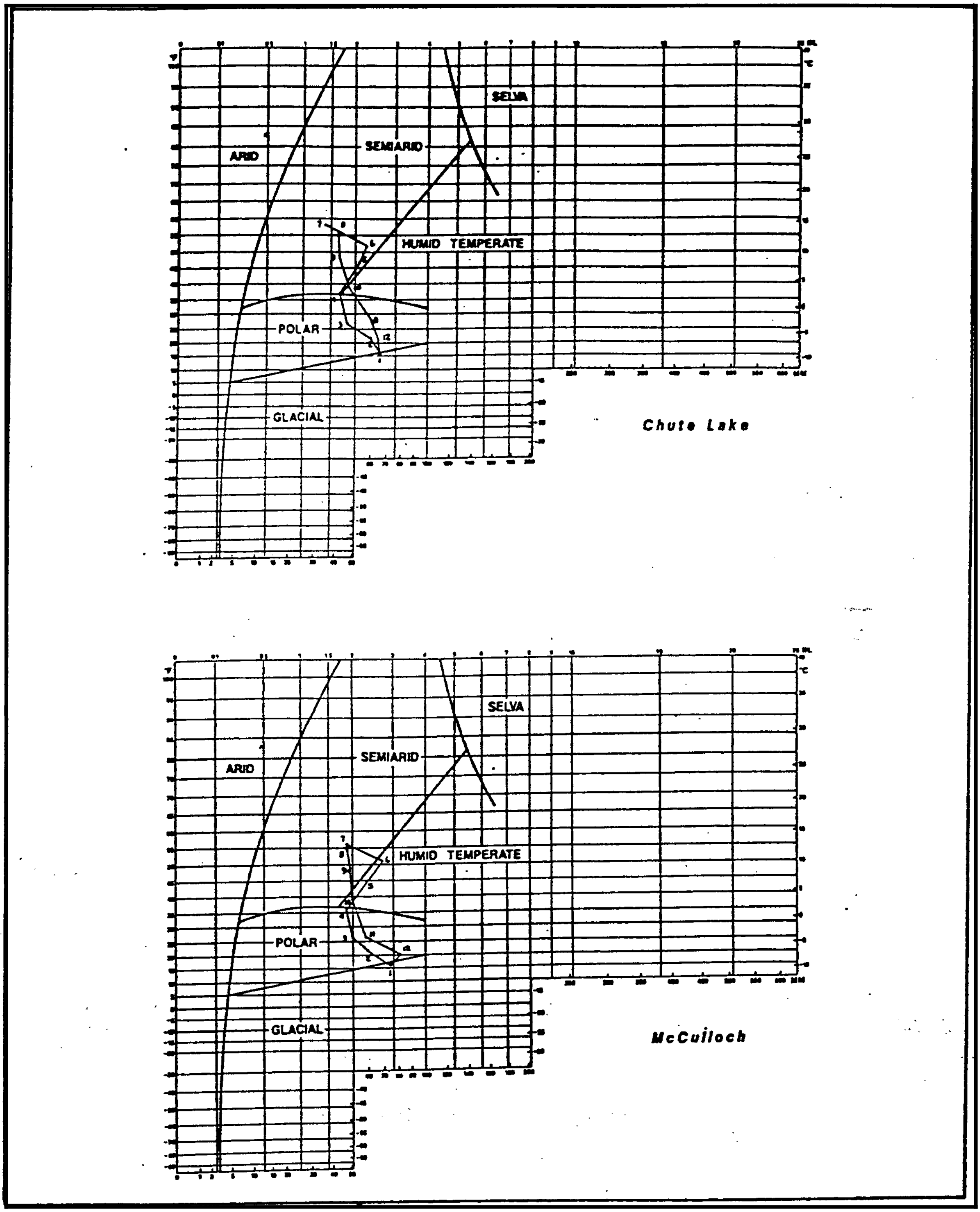


Figure 8. Thermohyet diagrams of monthly average precipitation and temperature for Chute Lake and McCulloch. Numbered dots indicate month of year.

TABLE 14: CLIMATE STATIONS SHOWING THE MONTHS WHEN THE DIFFERENT DEGREES OF WEATHERING AND EROSION OCCUR

PENTICTON AIRPORT			
	Minimum	Moderate	Maximum
Chemical Weathering	1-4, 9-12	5-8	
Fluvial Erosion		1-3, 9	4-8, 10-12
Mass Wasting		2-11	1, 12
Mechanical Weathering		3-11	1, 2, 12
Wind Erosion		1-12	

COLDSTREAM RANCH			
	Minimum	Moderate	Maximum
Chemical Weathering	1-4, 10, 11	5-9, 12	
Fluvial Erosion		1-3	4-12
Mass Wasting		3-10	1, 2, 11, 12
Mechanical Weathering		4-10	1-3, 11, 12
Wind Erosion		1-12	

CHUTE LAKE			
	Minimum	Moderate	Maximum
Chemical Weathering	3	1, 2, 4-12	
Fluvial Erosion		1, 2, 12	3-11
Mass Wasting		5-10	1-4, 11, 12
Mechanical Weathering		5-10	1-4, 11, 12
Wind Erosion	5, 6	1-4, 7-12	

McCULLOCH			
	Minimum	Moderate	Maximum
Chemical Weathering		1-12	
Fluvial Erosion		1, 2, 12	3-11
Mass Wasting		5-10	1-4, 11, 12
Mechanical Weathering		5-10	1-4, 11, 12
Wind Erosion	5-7	1-4, 8-12	

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