Draft

THE SOIL SURVEY

ENVIRONMENTAL INVESTIGATIONS

PROPOSED HIGH ROSS RESERVOIR IN CANADA

CITY OF SEATTLE
DEPARTMENT OF LIGHTING

F.F. SLANEY & COMPANY LIMITED
VANCOUVER, B.C.

Rcd w/Slaney ltr 2-28-72

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PREFACE

THE SOIL SURVEY AND OTHER ENVIRONMENTAL STUDIES

1.1 SCOPE OF ENVIRONMENTAL STUDIES

The soil study is an integral part of a comprehensive study on the environmental consequences of the High Ross Dam Project proposed by Seattle City Light on the Skagit River System in Canada and the United States. Application for approval of the project has been submitted to the Federal Power Commission for their consideration.

Some of the environmental studies are totally Canadian; others totally American. Most of the major studies are combined or co-operative Canadian-American studies. Canadian studies are designed to provide the Federal Power Commission with the basic data required to understand the environmental consequences in Canada of the proposed High Ross Project.

Studies and reports that are related to or co-ordinated with the soil study in Canada include the following:

1.1.1 Wildlife Studies: Lower Skagit Valley in Canada

1. Climate
2. Soils
3. Vegetation
4. Deer
5. Small Mammals
6. Game Birds
7. Songbirds

8. Large Carnivorous and Furbearing Mammals (with anecdotal information on Amphibians, Reptiles and Insects).
9. Habitat Development and Enhancement.

1.1.2 Fisheries Studies

10. The Aquatic Environment, Fishes and Fishery, Ross Lake and the Canadian Skagit River.

1.1.3 Recreation Studies

11. Recreation: Present and Future, Lower Skagit Valley in Canada

1.1.4 Miscellaneous

12. Relocation of Public Road
13. Shoreline Stability Study of Ross Lake Reservoir (Canada)
14. Estimated Cost of Clearing Proposed Ross Reservoir Site in Canada.

Other similar studies have been undertaken in Washington State by teams of American scientists.

1.1.5 Other Reports

Several other reports, submissions and environmental newsletters concerning the Lower Skagit Valley and the Proposed High Ross Reservoir in Canada have been published over the past two years.

Environmental publications include the following titles:

1. "Skagit Valley and Ross Lake Reservoir in Canada"
2. "Environmental and Development Programs - Skagit Valley and Ross Lake Reservoir in Canada"
   (submission to the Washington State Ecological Commission)
3. "Environmental Investigations, Skagit Valley in Canada and indications of Consequences from Raising the Level of Ross Lake"
   (Memorandum to the International Joint Commission)
4. "Supplementary Data Requested Concerning Ecological and Environmental Consequences in Canada of Raising the Level of Ross Lake"
   (Memorandum to the International Joint Commission)
5. "The Canadian Skagit"
   (Environmental newsletter, Volumes 1 to 7 as of February 1, 1972).

1.2 SKAGIT RIVER WATERSHED AND HIGH ROSS RESERVOIR SITE IN CANADA

1.2.1 The Skagit River Watershed in Canada

The Skagit River drains an area of over 380 square miles in Canada. The main Skagit Valley in Canada extends from the United States-Canadian border some 24 miles to the Hope-Princeton Highway and then turns eastward for some 10 miles as an increasingly steeper and narrower valley.

The floor of the Skagit Valley in Canada is approximately 1575 feet in elevation at the International Border and the valley sides rise to over 7000 feet at the peaks of the larger mountains.

1.2.2 The Proposed High Ross Reservoir Site

The Proposed High Ross Reservoir would attain a full pool level of 1725 feet and would extend about seven miles further into the Skagit Valley to inundate an additional 4300 acres of land. The total area of High Ross Reservoir at full pond would be about 5200 acres.

The Proposed High Ross Reservoir Site represents about two percent of the Skagit River Watershed in Canada. The environmental consequences of the Proposed Reservoir Site would be confined primarily to the lowlands of the Lower Skagit Valley which includes a total area of about 19,000 acres or eight percent of the watershed.

Therefore, except for the studies of fish that are found in Ross Lake and the upper tributaries of the Skagit River and monitoring of the migrating herd of deer that utilize parts of the reservoir site for a period in the spring, the detailed environmental studies were confined mostly to a Two Part Study Area comprising "Part A" ; the Proposed Reservoir Site of 5200 acres and "Part B"; the adjacent lowlands that would be indirectly affected, an area of some 13,800 acres.

The environmental effects of the Proposed High Ross Project on the remaining 92 percent of the Skagit River drainage in Canada is considered negligible.

In this report, the Lower Skagit Valley refers to the part of the Skagit Valley in Canada below 3000 feet in elevation and for a distance of about 12 miles north of the Canadian-United States border. This area coincides with the region of the Skagit Valley that is accessible by gravel and dirt roads and is utilized primarily for forestry, unorganized recreation, and as an access route by Americans intent on camping and fishing on Ross Lake on the United States side of the border.

The upper part of the Skagit Valley is accessible by paved highway and utilized primarily as a transportation corridor (the Hope-Princeton Highway) and as an area of organized recreation within Manning Park where camping and fishing but no hunting is allowed. The Hope Slide and the Silvertip Mountain Ski Resort are also part of the recreation and tourism aspects of the Upper Skagit Valley region.

The alpine regions of the Skagit River Watershed are used primarily for such recreational pursuits as hiking and wilderness camping. These areas are generally over 4500 feet in elevation and would not be affected by raising the level of Ross Lake to elevation 1725 feet.

1.3 SCHEDULE OF STUDIES

Environmental studies commenced in Canada during April, 1970. The initial work was to delineate the boundary of the Proposed Reservoir Site and to inventory the forest cover and define the lands and water bodies that would be affected by the project. An overview of the animal and human activities in the area was obtained during the spring and summer, and plans were formulated for the intensive environmental surveys that commenced in the fall of 1970.

During 1971, the intensive studies of the flora and fauna of the Lower Skagit Valley were continued on a large scale and the basic elements of environment were documented.

PREFACE

Supplementary studies are continuing into 1972 to improve the data concerning certain elements of deer habitat use and fish migration patterns. Also specific habitat improvement and enhancement sites set-up during 1970 are being monitored and manipulated to obtain specific data on the most efficient and economical ways of developing and improving habitats for the benefit of both man and wildlife.

A scheduled radio tagging program for monitoring the movements of deer is a first for British Columbia and should yield more sophisticated information than has been available for analyzing the habits of deer. The results of the supplementary studies are scheduled to be ready for the anticipated Federal Power Commission Hearings.

At this stage of the environmental studies, the knowledge amassed about the Skagit Valley in Canada far exceeds the data base of any other such project in British Columbia and possibly Canada.

If permission to proceed with the High Ross Project is granted, Seattle City Light intends to follow-up the pertinent environmental studies to fully document the before and after effects of the Proposed High Ross Reservoir for future reference of those concerned with other similar developments.

PART 1

THE SOIL SURVEY

1.1 PURPOSE OF SURVEY

The soil survey was designed to provide base data on the productive capacity of the two part study area. The soils are a primary element in understanding the successions of plant communities and the wildlife populations that are evolving in the Valley.

The proposed High Ross Reservoir would alter the resource base of the lower Skagit Valley and the feasibility of mitigating possible reductions in flora or fauna or enhancing or creating certain desirable biotic communities is partially a function of the soil resources.

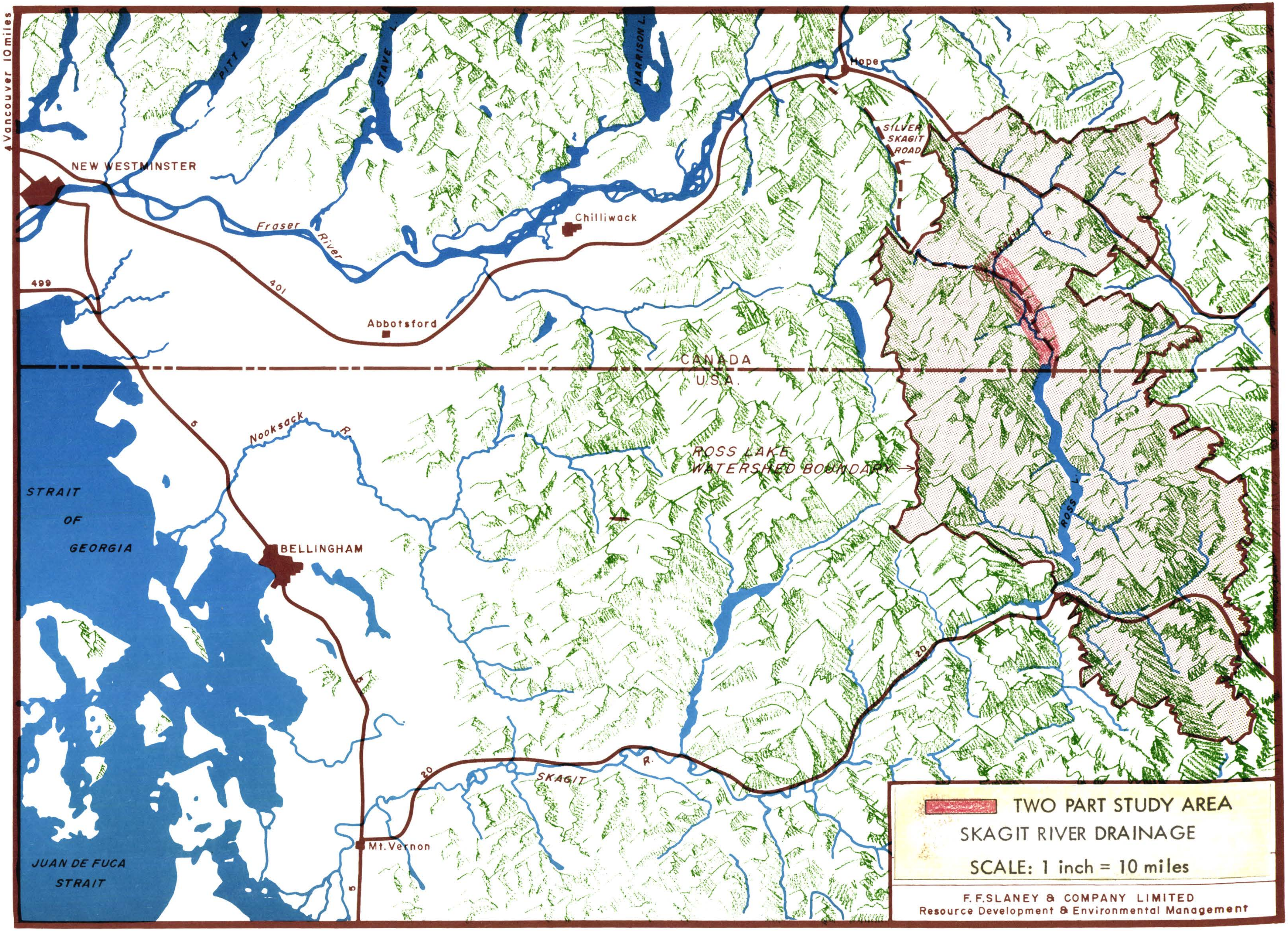
1.2 PHYSIOGRAPHY

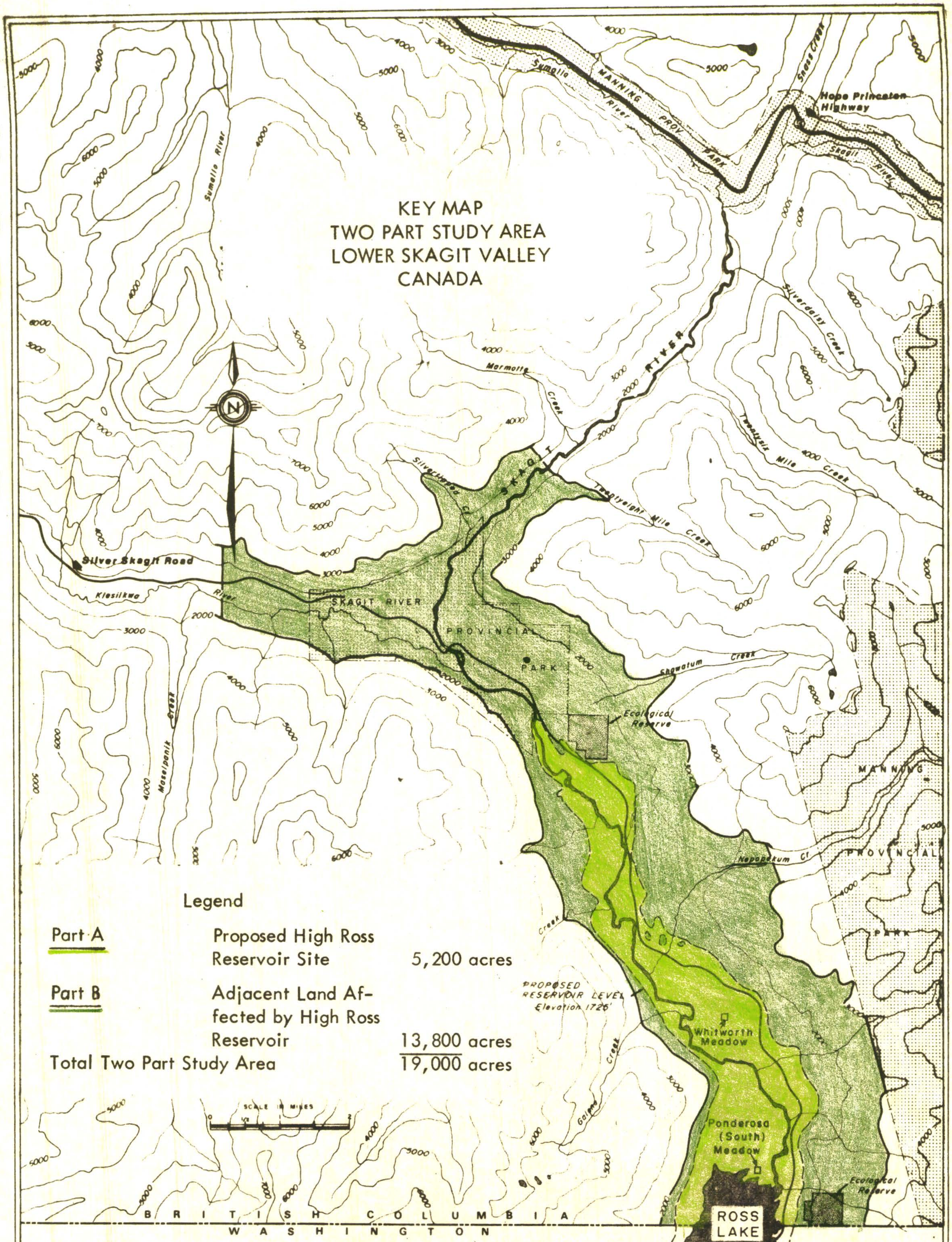
The two part study area surveyed was designed to include the proposed High Ross Reservoir site and the adjacent lands that would be affected indirectly by increasing the size of Ross Reservoir. The total area surveyed and mapped in Canada is about 19,000 acres or 30 square miles.

The lands in Part "A" (5200 acres - The Proposed Reservoir Site) lie between elevations 1602.5 and 1725 feet. The adjacent lands, Part "B" (13,800 acres) of the study area, lie above elevation 1725 feet and below elevation 3000 feet. See Key Maps.

1.3 VEGETATION

The valley supports a mosaic of coastal forest types with intrusions of interior-type plant communities. The well-drained sites generally support stands of poor quality Douglas fir and pines. The sites with adequate moisture support mixed stands of cedar, Douglas fir, balsam and hemlock as well as deciduous species. The wetter sites generally support stands of cottonwood, birch, willow, crabapple and other deciduous species.


Vancouver 10 miles
NEW WESTMINSTER
PITT L.
STAVE L.
HARRISON L.
Hope
SILVER SKAGIT ROAD
Fraser River
Chilliwack
Abbotsford
499
401
CANADA
U.S.A.
Nooksack R.
ROSS LAKE WATERSHED BOUNDARY
ROSS L.
STRAIT OF GEORGIA
BELLINGHAM
5
20
SKAGIT R.
Mt. Vernon
JUAN DE FUCA STRAIT
TWO PART STUDY AREA
SKAGIT RIVER DRAINAGE
SCALE: 1 inch = 10 miles
F. F. SLANEY & COMPANY LIMITED
Resource Development & Environmental Management


KEY MAP
TWO PART STUDY AREA
LOWER SKAGIT VALLEY
CANADA
Legend
Part A
Proposed High Ross Reservoir Site
5,200 acres
Part B
Adjacent Land Affected by High Ross Reservoir
13,800 acres
Total Two Part Study Area
19,000 acres
MANNING PROV. PARK
Hope Princeton Highway
Sumallo River
Skagit River
Silver Skagit Road
Klesilkwa River
SKAGIT RIVER PROVINCIAL PARK
Silverdaisy Creek
Twentysix Mile Creek
Twentyeight Mile Creek
Shawatum Creek
Marmotte Creek
Maselpanik Creek
Nepopekum Cr
Ecological Reserve
PROPOSED RESERVOIR LEVEL Elevation 1725'
Whitworth Meadow
Ponderosa (South) Meadow
Galene Creek
MANNING PROVINCIAL PARK
SCALE IN MILES
BRITISH COLUMBIA
WASHINGTON
ROSS LAKE

Over the past 25 years, the valley floor has been logged and relogged. Current logging operations within the study area are mostly confined to cutting cottonwood and salvaging dead and down western red cedar.

Evidence of past forest fires is widespread and most of the forest stands in the valley are less than 100 years old. Remnants of pasture lands from abandoned ranches are found within the proposed Reservoir Site.

1.4 CLIMATE

Climatic records were derived from a weather station located near the center of the proposed reservoir site for the period 1939 to 1955, in combination with data from three hygrothermographs established in the valley in October, 1970.

The vegetative period is the period during which the mean monthly temperature is at or above 42°F. The vegetative period is about five months with a variation of 15 days between the north and south end. The vegetative period is an indication of the growing period available for normal agricultural crops. Many native plants and shrubs, particularly the alpine species, thrive at temperatures below 42° F.

1.5 DRAINAGE

Soils on most of the alluvial fans and outwash terraces are gravelly and well drained. Silt soils in abandoned river channels are usually poorly drained. The steep hillsides are mostly thinly mantled bedrock. Surface water which flows down the rocky side slopes usually percolates through the deep gravel soils of the valley bottom before reaching the river. Nepopekum Creek and the Klesilkwa River are the only tributaries within the study area that sustain a year round flow across the valley floor.

1.6 GEOLOGY

The formations known as the Hozomeen group were formed during a period of northwest trending, folding and faulting. This was associated with the development of the Custer gneiss in the late Paleozoic or early Mesozoic periods. An activity in the Miocene period produced the Chilliwack batholith intrusion.

The bedrock foundation within the two part study area is mostly chert and argillite with greenstone and tonalite. See Appendix 102.

1.7 SURFICIAL GEOLOGY

Glacial and alluvial actions have produced three distinct formations: kettled outwash gravel terraces, alluvial fans, and alluvial river deposits.

The kettled outwash gravel terraces lie above the present floodplain. These older formations occur mostly in the northern portion of the study area. This material was formed from the outwash of old large glacier-fed rivers and is characterized by large boulders, cobbles and gravel deposits. Prominant depressions, "Kettle Holes", were formed from the melting of large fragments of ice deposited in the outwash.

Prominent alluvial fans have been formed by most of the tributaries. St. Alice Creek and Nepopekum Creek have produced the largest and most complex fans. Material in the alluvial fans varies from coarse gravel to sandy silt.

Alluvial river deposits form the present floodplains. The basic deposits are coarse gravels overlain with a relatively thin surface layer of silts and organic material. This is the dominant material within the proposed reservoir site and in the Klesilkwa drainage.

Talus deposits of large angular fragments usually mantle the contact between the steep sidehills and the valley floor.

The mountain sides enclosing the valley have shallow residual soils overlaying igneous and metamorphic bed rock.

PART 2

DESCRIPTION OF SOILS

2.1 FORMATION

Soils are formed by the action of climate, water, fire, vegetation, and animal life on parent material over a period of time. The soils of the study area in the Skagit Valley are mostly young and poorly developed. A map of the surficial geology of the study area shows the distribution of the parent materials. With the exception of the rocky side hills and talus slopes, the soils have developed from alluvial or glacial deposits.

2.2 SOIL MAPPING AND SAMPLING

Field surveys were made during the summer and fall of 1971.

The soil descriptions and classifications are as recommended for a level and reconnaissance survey, as outlined in Publication No. 1264, "Guidelines for Bio-physical Land Classification", Department of Fisheries and Forestry, Ottawa, 1969, for classification of forest lands and associated wildlife.

The soils survey was facilitated by other studies undertaken in the valley. The most useful base was the surficial geology report by Thurber Consultants Limited, November 1970. A Canada Land Inventory Map of the land soil units of the Skagit Valley in Canada was also utilized.

The forest cover cruise map prepared by B. C. Forest Service, the biogeo-climatic classifications of vegetation cover, and the wildlife habitat map prepared for the major animal species of the valley were also utilized. Aerial photographs were also utilized to help define soil type boundaries.

The soils were systematically studied in test pits, road cuts, river banks, gravel pits and cleared lands.

The arrangement, thickness, colour, texture, reaction and structure of the soil horizons were recorded. Representative samples of each soil type were collected for laboratory analysis.

Stones were described in terms of abundance, size, type, shape and orientation. The size, abundance and distribution of roots were recorded in each pit.

2.3 CLASSIFICATION OF SOILS

Based on the system of soil classification for Canada, soils are any unconsolidated mineral or organic layer thicker than four inches on the earth's surface. Soils were classified according to parent material, morphology, drainage conditions, relief, and texture of the soil surface.

Further classification was carried out by designating each sample to an order and great soil group which are of the same genetic type and have similar kinds of horizons, color, morphology and chemical characteristics.

The orders and great soil groups represented in the Skagit Valley are:

2.3.1 Luvisolic Order

Luvisols are well-or imperfectly-drained soils that have developed under mixed coniferous or deciduous forests in cool climates. The parent material is neutral to alkaline. Soils have eluvial (Ae) horizons and illuvial textural B horizons.

The Gray Luvial (Wooded) - Great Group is represented by a Bisequa Gray Luvial (wooded) soil, the Shawatum and Silver Tip.

2.3.2 Podzolic Order

Podzols are well-or imperfectly-drained soils that have developed under coniferous or mixed forests in cool or temperate climates and on acid parent materials.

These soils have organic surface horizons and podzolic B horizons in which the characteristic accumulation products are organic matter combined with Fe and Al.

The Humo-Ferric Podzol Great Group is represented by a Orthic Humo-Ferric Podzol, in the northeast complex, and a Mini Humo-Ferric Podzol, Klesilkwa and Nepopekum soil series.

2.3.3 Brunisolic Order

These soils have brown-colored soils indicative of good to imperfect drainage or of good to moderate oxidizing conditions, and have developed under forest or forest and grass conditions. They may have organic surface horizons and Ah horizons. All have a brownish Bm but none have a Bt (textural) or a podzolic B horizon.

The Eutric Brunisol Great Group
These are Brunisolic soils that under virgin conditions have organic surface horizons. The Ah horizon is less than two inches under forest communities. They may be weakly expressed (Aej) or strongly expressed (Ae) eluvial horizons. The parent material is usually calcareous.

The Eutric Brunisol Great Group is represented by an Orthic Eutric Brunisol, Ponderosa soil series, and a Degraded Eutric Brunisol, St. Alice soil series.

2.3.4 Regosolic Order

These are well-and imperfectly-drained soils with good to moderate oxidizing conditions, having horizon development too weak to meet the requirements of soils in any other order.

The Regosol Great Group is the only great group of the Regosolic order and is represented by a Cumulic Regosol, the International and Witworth soil series.

See Appendix 201 for definitions of soil terminology.

2.4 DESCRIPTIONS OF SOILS BY SERIES

A description of each soil is presented on the following pages.

See Soil Series Map on Appendix 104. Cross section views of soils in the valley are shown in Appendix 105.

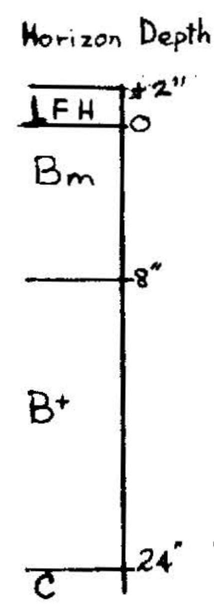
2.4.1 Shawatum - Bisequa Gray Luvisol

This association is found on an alluvial fan which overlies an outwash gravel terrace. It is moderately-well-drained soil vegetated with Douglas fir. There has been logging activity on about 60 percent of the area.

Agricultural Capability $\ ^{C}5_{P}$

Horizon	Thickness (Inches)	Description of Horizon
LFH	(1-2)	Reddish brown, needles and woodchips
Bm	(6-8)	Yellowish brown, silt, pH 6.3, 2.2% organic matter
B+	(14-18)	Strong brown, silt, pH 6.6, some cobbles present
C		Coarse outwash material

REPRESENTATIVE SOIL PROFILE



2.4.2 Silver Tip – Bisequa Gray Luvisol

This association is found on steep areas of bare or thinly mantled bedrock in the Upper Skagit, and in the moisture receiving sites in the Northeast complex. They are well-to moderately-well-drained sites characterized by Douglas fir-cedar.

Agricultural capability T
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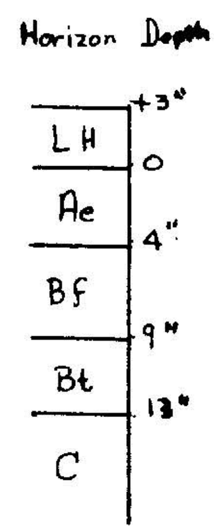
Horizon	Thickness Inches	Description of Horizon
LH	(2-3)	Very dark gray, leaves, twigs and roots
Ae	(2-5)	Gray, sandy loam, pH 4.1, 2.8% organic matter
Bf	(1-6)	Yellowish brown, sandy loam, pH 5.2
Bt	(3-6)	Light yellowish brown, sandy loam, pH 5.2
C		Very pale brown, sandy loam with some gravel and cobbles, pH 5.4

REPRESENTATIVE SOIL PROFILE



2.4.3 Klesilkwa - Mini. Humo-Ferric Podzol

This soil association is found on outwash gravel terraces which are composed of gravels, cobbles and boulders. The development is generally shallow. Strongest development occurs in the soils near the Nepopekum Creek. The soil is well drained and the dominant vegetation found in this type is Douglas-fir-cedar with some hemlock. There has been little human activity other than salvage logging in these sites.

Agricultural Capability C
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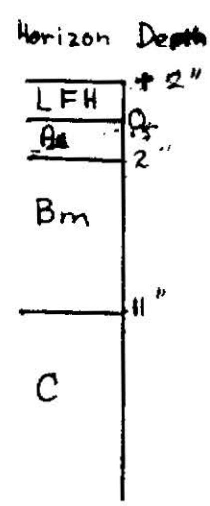
Horizon	Thickness Inches	Description of Horizon
LFH	(1-2)	Moss and needles, few fire roots
Ae	(0-2)	Brown, sandy loam, pH 5.5 discontinuous
Bf	(8-10)	Light yellowish brown, sandy loam, pH 5.9
C		Gray, sand and outwash gravels, pH 5.6

REPRESENTATIVE SOIL PROFILE



2.4.4 Nepopekum – Mini Humo-Ferric Podzol

This soil is found on the finer-textured alluvial and eroded alluvial fans, and usually has concretions present in the B horizon. This association includes a flat phase of two to five percent and sloping phase of five to 30 percent. It is moderately to imperfectly drained and vegetated with Douglas fir, lodgepole pine and cottonwood.

Agricultural Capability C
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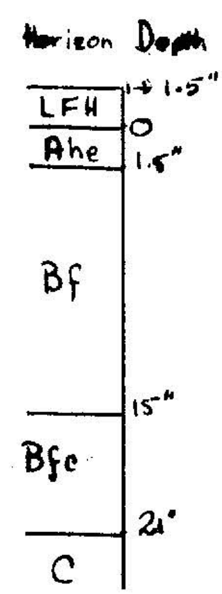
Horizon	Thickness Inches	Description of Horizon
LFH	(.5-1.5)	Dark brown, leaves, twigs, bark
Ahe	(1-2)	Yellowish brown, loam, pH 5.2, (3.7% organic matter)
Bf	(2-13)	Yellowish brown, sandy loam, pH 5.8
Bfcc	(3-9)	Strong brown, sandy loam, pH 5.5 numerous concretions, 2-5mm egg shaped
C		Dark brown, sand, mixed sand and gravels with cobbles present, hardpans found in certain phases pH 5.5

REPRESENTATIVE SOIL PROFILE



2.4.5 Ponderosa – Orthic Eutric Brunisol

This soil group is found in two areas, Ponderosa Meadow (Lot 222) and Witworth Ranch (Lot 221), which were used for agrarian purposes from about 1902 to 1929. Both sites are flat and the parent material is reworked alluvial granular deposits. These are well-drained areas vegetated by grasses, forbs, shrubs and scattered trees.

Agricultural Capability C
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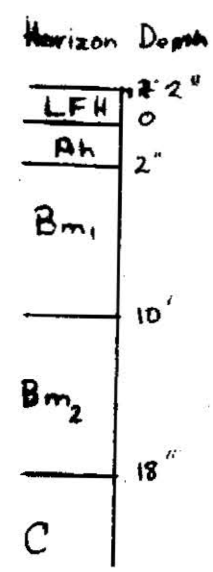
Horizon	Thickness Inches	Description of Horizon
LFH	(1-2)	Grass, roots and leaves
Ah	(1-2)	Dark brown, sandy loam, pH 5.2, 11.8% organic matter
Bm_1	(6-11)	Light olive brown, loamy sand pH 5.7
Bm_2	(3-8)	Dark yellowish brown, sandy loam, pH 5.6, more compact than Bm_1
C		Mixed water worked gravels with some cobbles pH 5.6

REPRESENTATIVE SOIL PROFILE



2.4.6 St. Alice - Degraded Eutric Brunisol

This soil association is found on reworked alluvial ~~granular~~ deposits ~~and con-~~tains a shallow dry phase and a deeper wetter phase which occurs close to the present Skagit River. These soils are well-to imperfectly-drained and are vegetated by Douglas fir and lodgepole pine on the dry phase and by stands of cottonwood along with cedar-cottonwood mixtures on the wet sites. About 70 percent of this unit has been selectively or clear cut logged. The area in the St. Alice Creek drainage is densely vegetated with rhododendron.

Agricultural Capability C
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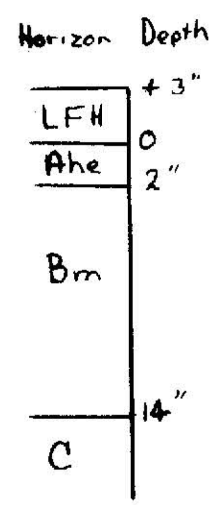
Horizon	Thickness Inches	Description of Horizon
LFH	(2-3)	Needles and twigs
Ahe	(.5-2.5)	Brown, sandy loam, pH 5.3, (7.8% organic matter)
Bm	(8-13)	Dark yellowish brown, loamy sand, pH 5.8
C		Brown sand, pH 5.6 mixed gravels and cobbles.

REPRESENTATIVE SOIL PROFILE



2.4.7 International - Cumulic Regosol

This association is found on streams with steep gradients which are characterized by coarse materials and periodic but not annual flooding. The flooding adds new layers of coarse material which buries accumulated humic material. It is

rapidly drained and vegetated by Douglas fir-cedar-cottonwood. There has been clear cut logging activity on the St. Alice Creek area of this association.

Agricultural Capability C

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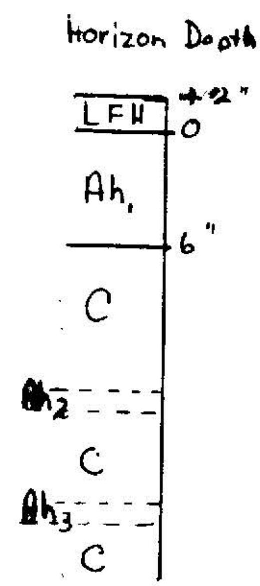
Horizon	Thickness Inches	Description of Horizon
LFH	(1-2)	Very dark grayish brown, leaves, twigs and roots
Ah_1	(4-6)	Pale brown, sandy loam, pH 5.6, 6.0% organic matter
C		Light brownish gray, layering of silts, sands and gravels with intermittent Ah horizons.

REPRESENTATIVE SOIL PROFILE



2.4.8 Witworth – Cumulic Regosol

This association is found on flat areas or active flood plains beside the river or in old creek beds which still receive moisture in the spring but are not flowing creeks. The series is characterized by thick silt layers with buried organic layers. The soils are imperfectly to poorly drained and support stands of cottonwood and thickets of deciduous shrubs. Selective logging was active during 1971.

Agricultural Capability C
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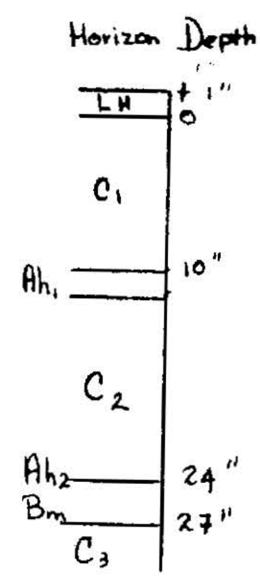
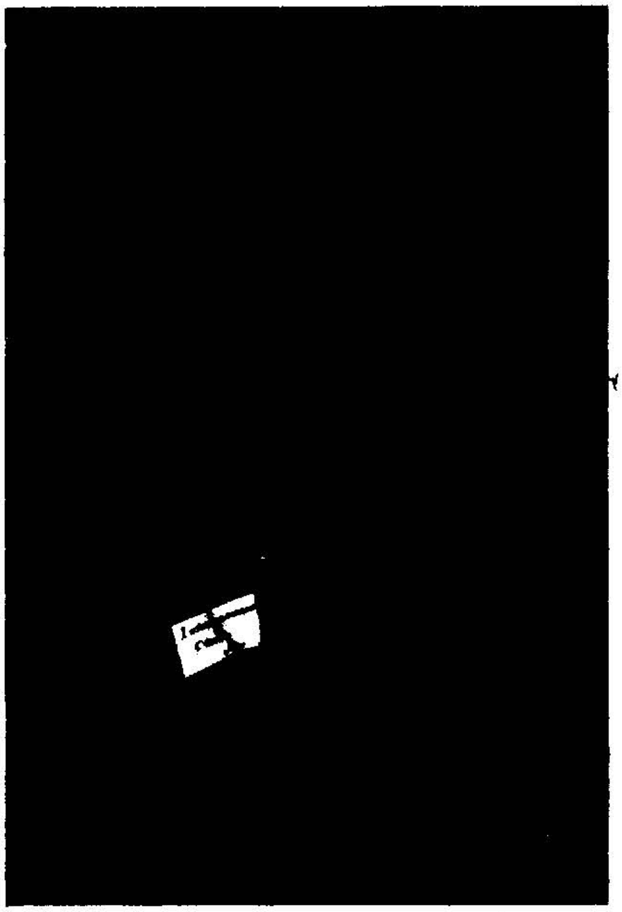
Horizon	Thickness Inches	Description of Horizon
LH	(0-1)	Deciduous leaves
C_1	(8-12)	Pale brown, silt, pH 6.3
Ah_1	(2-4)	Compact layer of humic material
C_2	(8-10)	Pale brown, silt, pH 6.3
Ah_2	(1-2)	Compact layer of humic material
Bm	(2-4)	Dark brown, silt pH 6.0, (2% organic matter)
C_3		Light yellowish brown, loam, pH 6.1

REPRESENTATIVE SOIL PROFILE



REPRESENTATIVE SOIL PITS IN THE LOWER SKAGIT VALLEY TWO PART STUDY AREA

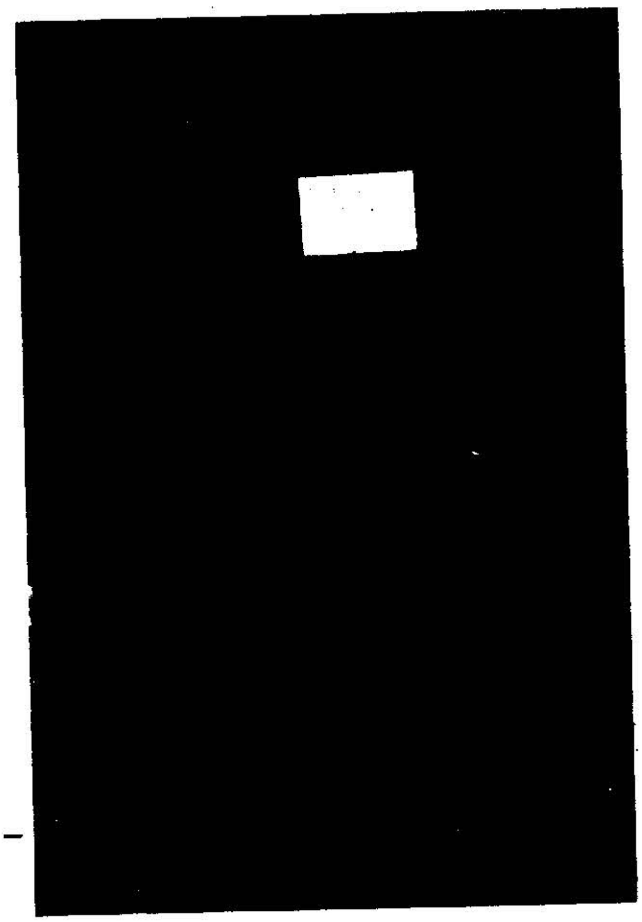


Soil Series: International

Soil Type: Sandy Loam

Soil Group: Cumulic Regosol

Stoniness: Very gravelly

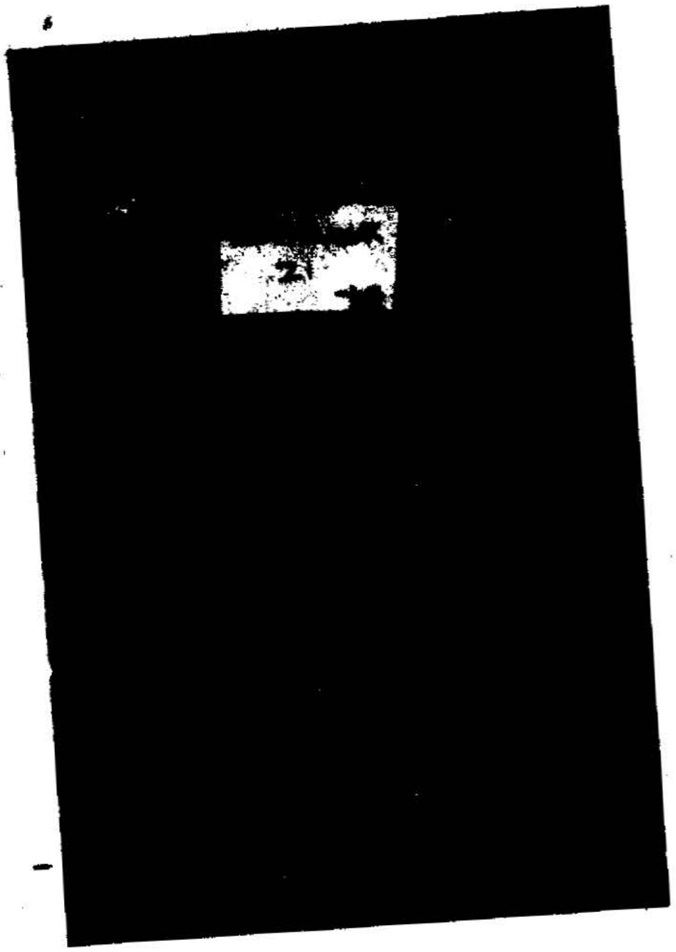


Soil Series: Ponderosa

Soil Type: Sandy Loam

Soil Group: Orthic Eutric Brunisol

Stoniness: Moderately stony

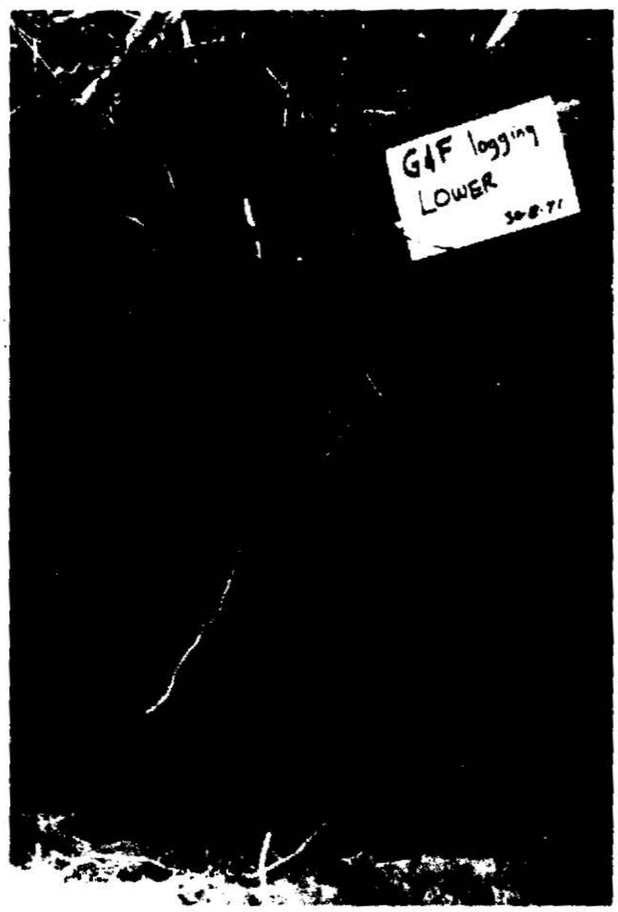


Soil Series: Klesilkwa

Soil Type: Sandy Loam

Soil Group: Mini Humo Ferric Podzol

Stoniness: Exceedingly stony

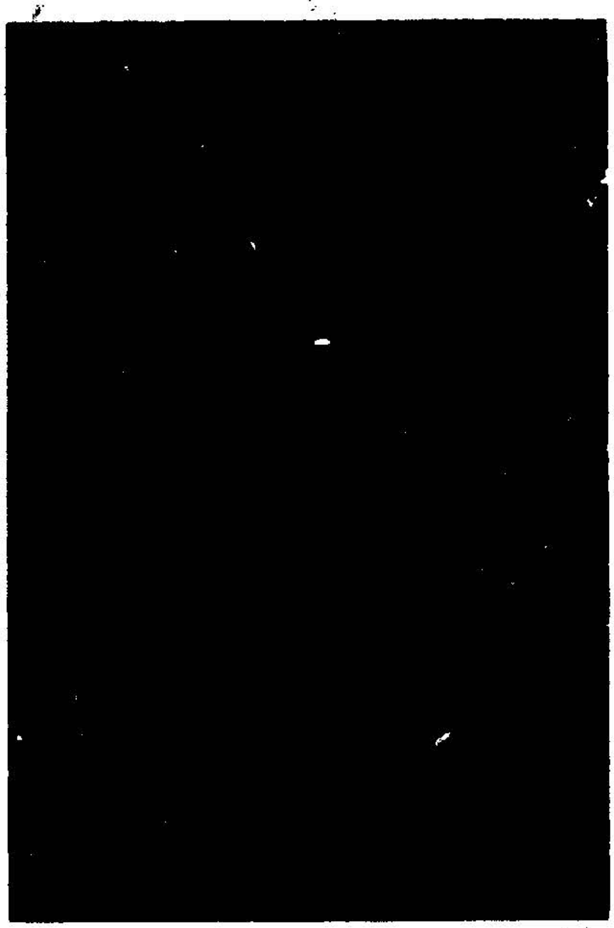


Soil Series: Shawatum

Soil Type: Silt

Soil Group: Bisequa Gray Luvisol

Stoniness: Moderately stony

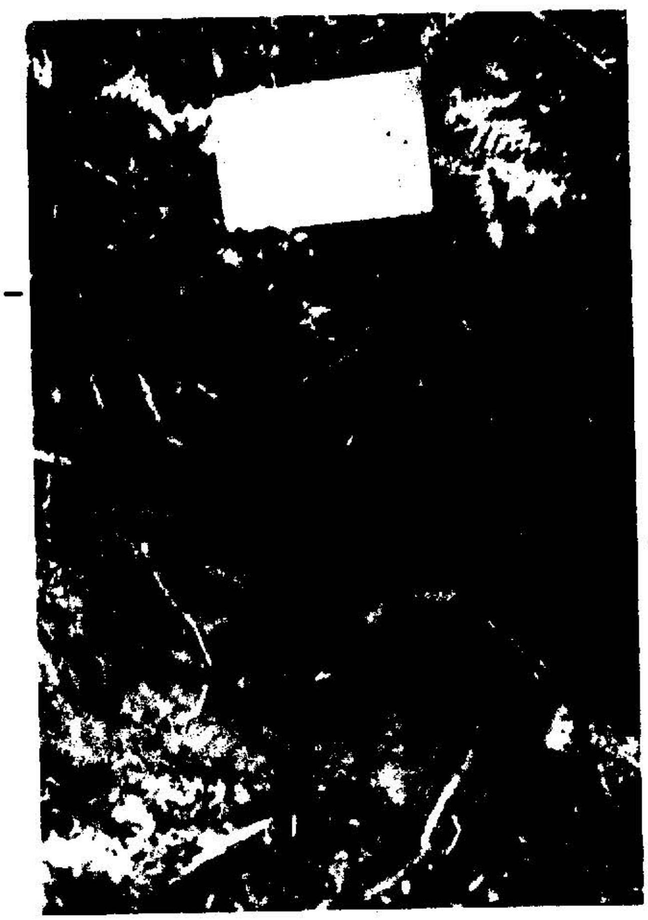


Soil Series: Nepopekum

Soil Type: Sandy Loam

Soil Group: Mini Humo Ferric Podzol

Stoniness: Some gravels



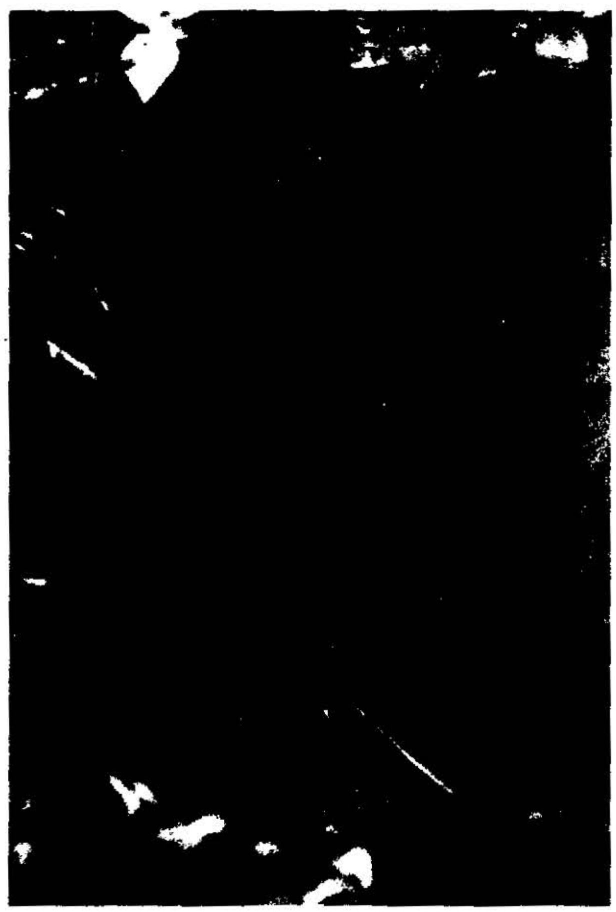
Soil Series: Silver Tip

Soil Type: Sandy Loam

Soil Group: Bisequa Gray Luvisol

Stoniness: Very stony

Talus component of northeast soil complex



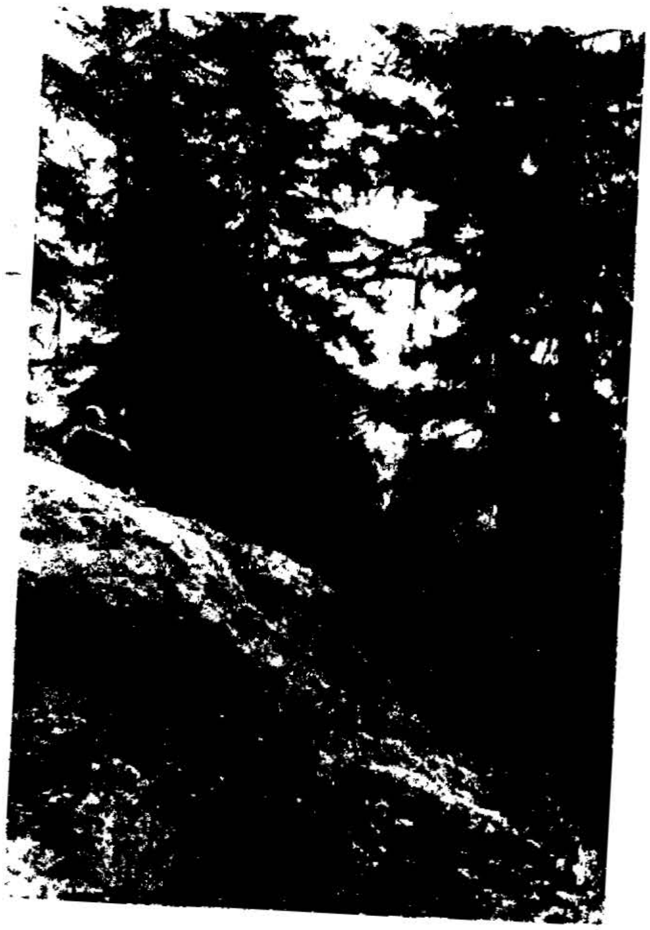
Soil Series: Witworth

Soil Type: Silt

Soil Group: Cumulic Regosol

Stoniness: Slightly stony

Collecting samples of horizons for laboratory analysis



Thinly mantled bed rock in the predominant type of soil complex on the steeper valley slopes

Soil Series: Part of North-east complex

Soil Type: Sandy Loam

Soil Group: Orthic Humo-Ferric Podzol

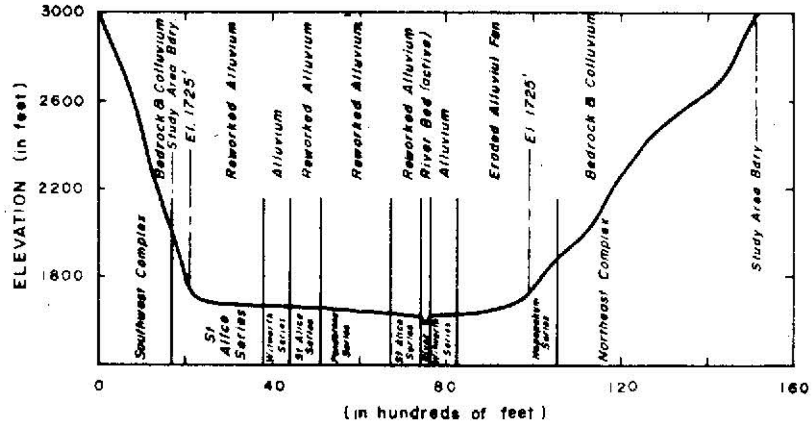
Stoniness: Exceedingly stony

APPENDIX 102

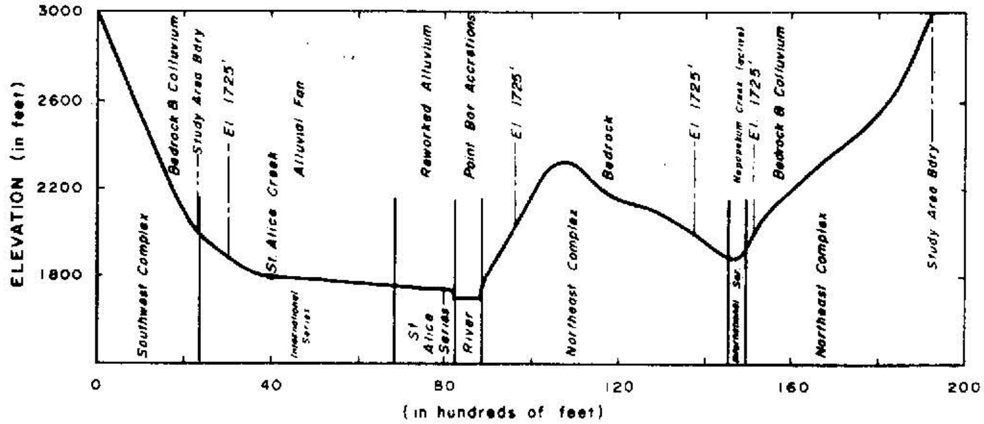
APPENDIX 104

APPENDIX 105

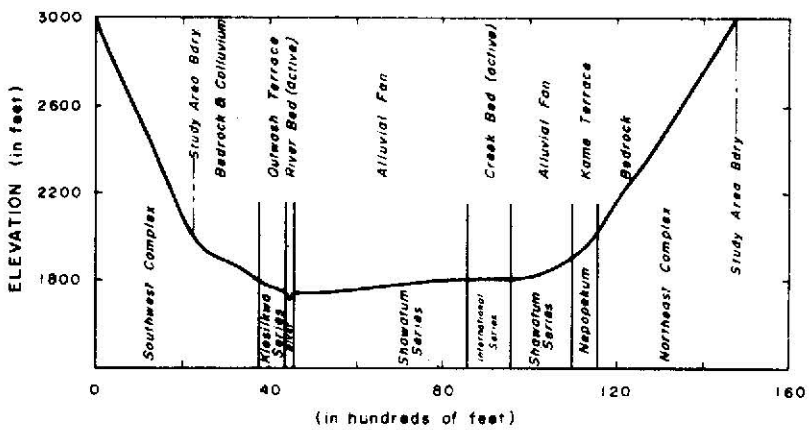
SECTION
A - A1



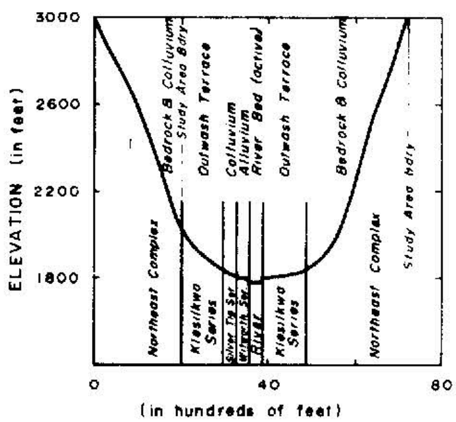
SECTION
B - B1



SECTION
C - C1



SECTION
D - D1



Cross Section of PARENT MATERIALS AND SOILS

Two Part Study Area
Lower Skagit Valley
Canada

APPENDIX 201

APPENDIX 201

DEFINITIONS OF SOIL TERMINOLOGY

Basic soils represented in the two part study area of the Skagit Valley according to the System of Soil Classification for Canada:

Order	Great Group	Subgroup
Luvisolic	Gray Wooded (Gray Luvisol)	Bisequa Gray Wooded
Podzolic	Humo-Ferric Podzol	Orthic Humo-Ferric Podzol Mini Humo-Ferric Podzol
Brunisolic	Brunisol	Orthic Eutric Brunisol Degraded Eutric Brunisol
Regosolic	Regosol	Cumulic Regosol

Criteria for Identification of Horizons and Layers

All horizons except transition horizons may be vertically subdivided by consecutive arabic numbers placed after the letter designations. The assigned arabic numeral has no meaning except that of vertical subdivision.

Roman numerals are prefixed to horizon designations to indicate unconsolidated lithologic discontinuities in the profile. Roman numeral I is understood for the uppermost material and, therefore, is not written. Subsequent contrasting materials are numbered consecutively in order in which they are encountered downward, that is, II, III.

Master Organic Layers

Organic layers may be found at the surface of the mineral soils, or at any depth beneath the surface in buried soils, or overlying geologic deposits. They contain more than 30% organic matter.

L-F-H - These are organic layers developed under imperfectly to well-drained conditions.

L - This is an organic layer characterized by an accumulation of organic matter in which the original structures are easily discernible.

F - This is an organic layer characterized by an accumulation of partly decomposed organic matter. The original structures in part are difficult to recognize.

H - This is an organic layer characterized by an accumulation of decomposed organic matter in which the original structures are indiscernible.

Master Mineral Horizons and Layers

Mineral horizons are those that contain less organic matter than that specified for organic horizons.

A - This is a mineral horizon or horizons formed at or near the surface in the zone of the removal of materials in solution and suspension, or of maximum in situ-accumulation of organic matter, or both.

- Ah - horizons in which organic matter has accumulated as a result of biological activity
- Ae - horizons that have been eluviated of clay, iron, aluminum, or organic matter, or all of these.

B - This is a mineral horizon or horizons characterized by one or more of the following:

1. an enrichment in silicate clay, iron, aluminum, or humus, alone or in combination.

2. a prismatic or columnar structure that exhibits pronounced coatings or stainings and significant amounts of exchangeable Na.

3. an alteration by hydrolysis, reduction, or oxidation to give a change in color or structure from horizons above or below, or both, and so does not meet the requirements of 1 and 2 above.

C - This is a mineral horizon or horizons comparatively unaffected by the pedogenic processes operative in A and B, excepting (i) the process of gleying, and (ii) the accumulation of calcium and magnesium carbonates and more soluble salts.

e - A horizon characterized by the removal of clay, iron, aluminum, or organic matter alone or in combination. When dry, it is higher in color value by 1 or more units than an underlying B horizon. It is used with A (Ae).

f - A horizon enriched with hydrated iron. It usually has a chroma of 3 or more. It is used with B alone (Bf), with B and h (Bfh and Bhf), with B and g (Bfg), and with others. These horizons are differentiated on the basis of organic matter content into:

Bf - less than 5% organic matter
Bfh- 5 to 10% organic matter
Bhf- more than 10% organic matter

g - A horizon characterized by gray colors, or prominent mottling, or both, indicative of permanent or periodic intense reduction.

In some reddish parent materials, matrix colors of reddish hues and high chromas may persist despite long periods of reduction. In these soils, horizons are designated as g if there is gray mottling or if there is marked bleaching on ped faces or along cracks.

Aeg - This horizon must meet the definitions of A, e, and g.

h - A horizon enriched with organic matter. It is used with A along (Ah); or with A and e (Ahe); or with B alone (Bh); or with B and f (Bfh, Bhf).

Ah - When used with A alone, it refers to the accumulation of organic matter and must contain less than 30% organic matter.

Ahe - When used with A and e it refers to an Ah horizon that has been degraded as evidenced, under natural conditions, by streaks and splotches and often by platy structure. It may be overlain by a darker-colored Ah and underlain by a lighter-colored Ae.

Bh - This horizon contains more than 2% organic matter and the ratio of organic matter to oxalate-extractable Fe is 20 or more.

k - Denotes the presence of carbonate, as indicated by visible effervescence when dilute HCl is added. It may be used with any master horizon or combination of master horizon and lowercase suffix. Most often it is used with B and m (Bmk) or C (Ck).

m[3] - A horizon slightly altered by hydrolysis, oxidation, or solution or all three, to give a change in color or structure, or both. This suffix can be used as Bm, Bmgj, Bmk and Bms.

n - A horizon in which the ratio of exchangeable Ca to exchangeable Na is 10 or less. When used with B it must also have the following distinctive morphological characteristics: prismatic or columnar structure, dark coatings on ped surfaces, and hard to very hard consistence when dry.

p - A layer disturbed by man's activities, that is, by cultivation or pasturing or both. It is to be used only with A.

s - A horizon with salts, including gypsum, which may be detected as crystals or veins, as surface crusts of salt crystals, by distressed crop growth, or by the presence of salt-tolerant plants.

sa - A horizon with secondary enrichment of salts more soluble than calcium and magnesium carbonates, where the concentration of salts exceeds that present in the unenriched parent material. The horizon is 4 inches (10 cm) or more thick.

A Bt horizon must be at least 2 inches (5 cm) thick.

In massive soils, the Bt horizon should have oriented clays in some pores and also as bridges between the sand grains.

If peds are present, a Bt horizon shows clay skins on some of the vertical and horizontal ped surfaces and in the fine pores, or shows oriented clays in 1% or more of the cross section.

If a soil shows a lithologic discontinuity between the eluvial horizon and the Bt horizon, or if only a plow layer overlies the Bt horizon, the Bt horizon need show only clay skins in some part, either in some fine pores or on some vertical and horizontal ped surfaces.

x - A horizon of fragipan character. A fragipan is a loamy subsurface horizon of high bulk density. It is very low in organic matter and when dry it has a hard consistence and is seemingly cemented. When moist, it has a moderate to weak brittleness. It has few or many bleached fracture planes and has an overlying friable B horizon.

z - A permanently frozen layer.

SOIL CAPABILITY CLASSIFICATION FOR AGRICULTURE

Capability Classes

Class 1 - Soils in this class have no significant limitations in use for agricultural crops.

Class 2 - Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.

Class 3 - Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices.

Class 4 - Soils in this class have severe limitations that restrict the range of crops or require special conservation practices or both.

Soils in Class 4 have such limitations that they are only suitable for a few crops, the yield for a range of crops is low, or the risk of crop failure is high. The limitations may seriously affect such farm practices as the timing and ease of tillage, planting and harvesting, and the application and maintenance of conservation practices. These soils are low to medium in productivity for a narrow range of crops, but may have a higher productivity for a specially-adapted crop.

Class 5 - Soils in this class have very severe limitations that restrict their capaoility to producing perennial forage crops, and improvement practices are feasible.

Soils in Class 5 have such serious soil, climatic, or other limitations that they are not capable of use for sustained production of annual field crops. However, they may be improved by the use of farm machinery for the production of native or tame species of perennial forage plants. Feasible improvement practices include clearing of bush, cultivation, seeding, fertilizing, and water control.

The limitations in Class 5 include the adverse effects of one or more of the following: severe climate; low water-holding capacity; severe past erosion; steep slopes; very poor drainage; very frequent overflow; severe salinity permitting only salt tolerant forage crops to grow; or stoniness or shallowness to bedrock that make annual cultivation impractical.

Some soils in Class 5 can be used for cultivated field crops provided unusually intensive management is used. Some of the soils in this class are also adapted to special crops such as blueberries, orchard crops, or the like, requiring soil conditions unlike those needed by the common crops. Cultivated field crops may be grown in Class 5 areas where adverse climate is the main limitation still, but crop failures will then occur under average conditions.

Class 6 - Soils in this class are capable only of producing perennial forage crops, and improvement practices are not feasible.

Soils in Class 6 have some natural sustained grazing capacity for farm animals, but have such serious soil, climatic, or other limitations as to make impractical the application of improvement practices that can be carried out in Class 5. Soils may be placed in this class because their physical nature prevents improvement through the use of farm machinery, the soils are not responsive to improvement practices, there is a short grazing season, or stock watering facilities are inadequate. Such improvement as may be effected by seeding and fertilizing by hand or by aerial methods shall not change the classification of these soil areas.

The limitations in Class 6 include the adverse effects of one or more of the following: very severe climate; very low water-holding capacity; very steep slopes, very severely eroded land with gullies too numerous and too deep for working with machinery; severely saline land producing only edible, salt-tolerant, native plants; very frequent overflow allowing less than 10 weeks effective grazing; water on the surface of the soil for most of the year; or stoniness or shallowness to bedrock that makes any cultivation impractical.

Class 7 - Soils in this class have no capability for arable culture or permanent pasture.

The soils or lands in Class 7 have limitations so severe that they are not capable of use for arable culture or permanent pasture. All classified areas (except organic soils) not included in Classes 1 to 6 shall be placed in this class. Bodies of water too small to delineate on the map are included in this class.

Class 7 soils may or may not have a high capability for trees, native fruits, wildlife, and recreation. Hence, no inferences can be made as to the capability of the soils and land types in this class beyond the scope of their capability for agriculture.

C - Adverse climate. This subclass denotes a significant adverse climate for crop production as compared to the "median" climate, which is defined as one with sufficiently high growing-season temperatures to bring field crops to maturity, and with sufficient precipitation to permit crops to be grown each year on the same land without a serious risk of partial or total crop failures.

D - Undesirable soil structure or low permeability or both. This subclass is used for soils difficult to till, or which absorb water very slowly, or in which the depth of the rooting zone is restricted by conditions other than a high water table or consolidated bedrock.

E - Erosion. Subclass E includes soils where damage from erosion is a limitation to agricultural use. Damage is assessed on the loss of productivity and on the difficulties in farming land with gullies.

F - Low fertility. This subclass is made up of soils having low fertility that either is correctable with careful management in the use of fertilizers and soil amendments or is difficult to correct in a feasible way. The limitation may be due to lack of available plant nutrients, high acidity or alkalinity, low exchange capacity, high levels of carbonates, or the presence of toxic compounds.

I - Inundation by streams or lakes. This subclass includes soils subjected to inundation causing crop damage or restricting agricultural use.

M - Moisture limitation. This subclass consists of soils where crops are adversely affected by drouthiness owing to inherent soil characteristics. They are usually soils with low water-holding capacity.

N - Salinity. This subclass includes soils with enough soluble salts to adversely affect crop growth or restrict the range of crops that may be grown. Such soils are not placed higher than Class 3.

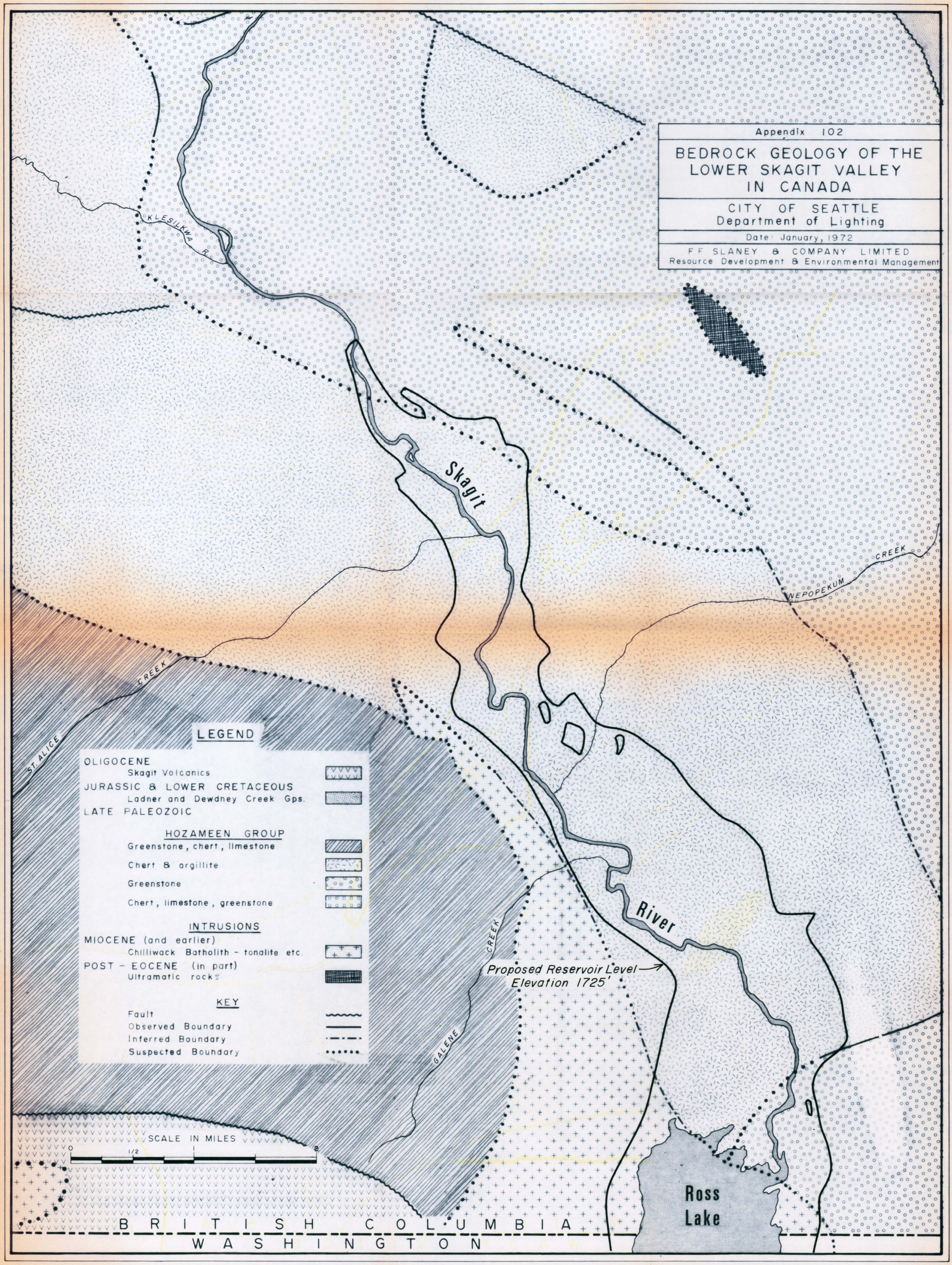
P - Stoniness. This subclass is made up of soils sufficiently stony to significantly hinder tillage, planting, and harvesting operations. Stony soils are usually less productive than comparable non-stony soils.

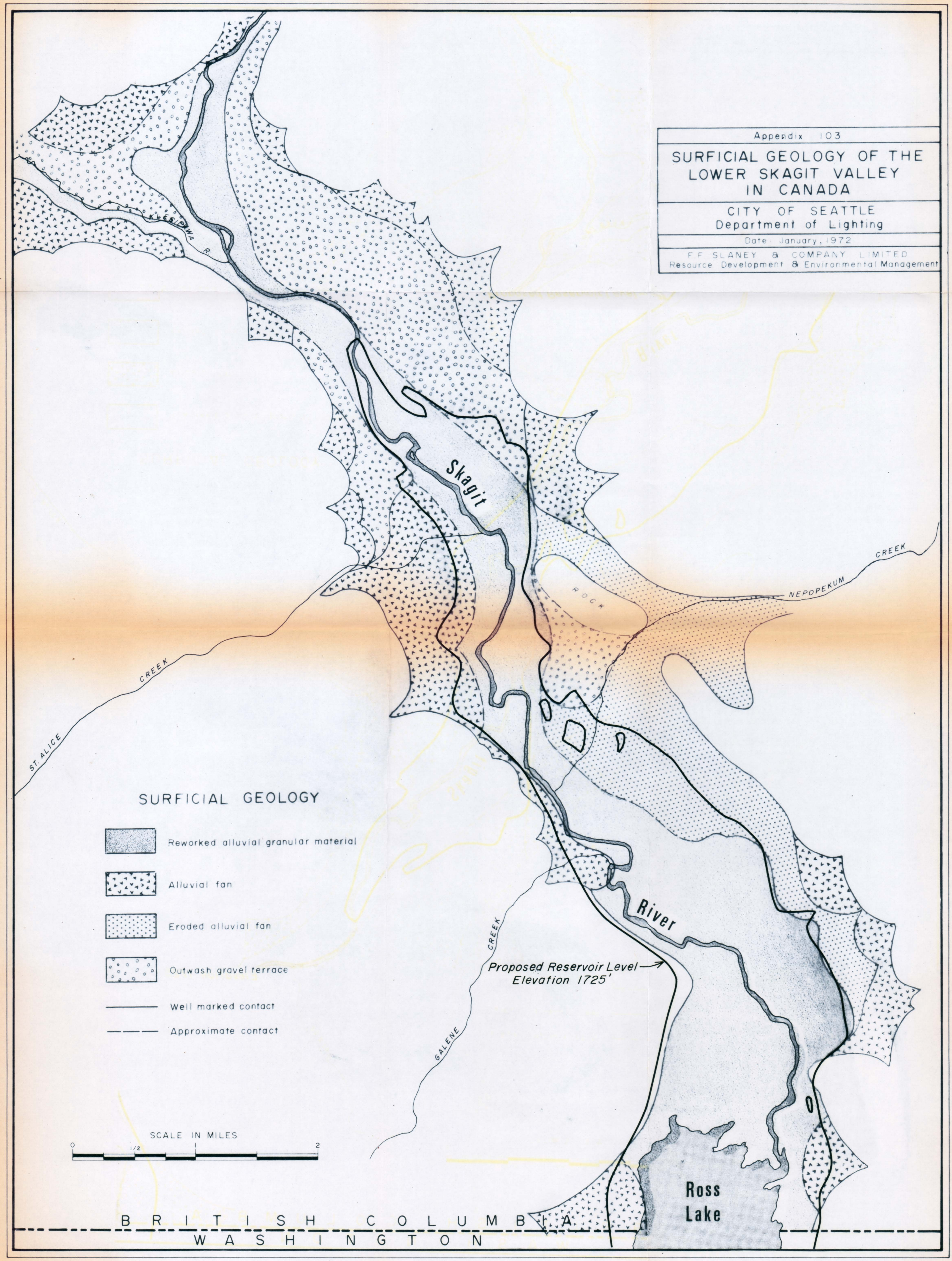
R - Consolidated bedrock. This subclass includes soils where the presence of bedrock near the surface restricts their agricultural use. Consolidated bedrock at depths greather than 3 feet from the surface is not considered as a limitation, except on irrigated lands where a greater depth of soil is desirable.

T - Topography. This subclass is made up of soils where topography is a limitation. Both the percent of slope and the pattern or frequency of slopes in different directions are important factors in increasing the cost of farming over that of smooth land, in decreasing the uniformity of growth and maturity of crops, and in increasing the hazard of water erosion.

W - Excess Water. Subclass W is made up of soils where excess water other than that brought about by inundation is a limitation to their use for agriculture. Excess water may result from inadequate soil drainage, a high water table, or seepage or run-off from surrounding areas.

X - Cumulative minor adverse characteristics. This subclass is made up of soils having a moderate limitation caused by the cumulative effect of two or more adverse characteristics that singly are not serious enough to affect the class rating.


Appendix 102
BEDROCK GEOLOGY OF THE LOWER SKAGIT VALLEY IN CANADA
CITY OF SEATTLE
Department of Lighting
Date: January, 1972
F.F. SLANEY & COMPANY LIMITED
Resource Development & Environmental Management
KLESILKWA R.
Skagit
River
NEPOPEKUM CREEK
ST. ALICE CREEK
GALENE CREEK
Proposed Reservoir Level
Elevation 1725'
Ross Lake
SCALE IN MILES
0
1/2
1
2
BRITISH COLUMBIA
WASHINGTON
LEGEND
OLIGOCENE
Skagit Volcanics
JURASSIC & LOWER CRETACEOUS
Ladner and Dewdney Creek Gps.
LATE PALEOZOIC
HOZAMEEN GROUP
Greenstone, chert, limestone
Chert & argillite
Greenstone
Chert, limestone, greenstone
INTRUSIONS
MIOCENE (and earlier)
Chilliwack Batholith - tonalite etc.
POST - EOCENE (in part)
Ultramatic rocks
KEY
Fault
Observed Boundary
Inferred Boundary
Suspected Boundary



Appendix 103
SURFICIAL GEOLOGY OF THE LOWER SKAGIT VALLEY IN CANADA
CITY OF SEATTLE
Department of Lighting
Date: January, 1972
F.F. SLANEY & COMPANY LIMITED
Resource Development & Environmental Management
SURFICIAL GEOLOGY
Reworked alluvial granular material
Alluvial fan
Eroded alluvial fan
Outwash gravel terrace
Well marked contact
Approximate contact
SCALE IN MILES
0
1/2
1
2
Skagit
River
Proposed Reservoir Level
Elevation 1725'
Ross Lake
KLESILKWA R.
ST. ALICE CREEK
NEPOPEKUM CREEK
ROCK
GALENE CREEK
BRITISH COLUMBIA
WASHINGTON