2.4 AUTUMN FREEZE RISK

Autumn freezes are a very important factor with respect to grape growing in the Okanagan and Similkameen Valleys. A temperature of -1°C at vine height will kill actively growing grape leaves. Leaf kill prevents further accumulations of sugar within the grapes and delays the maturing of the grapevines making them more susceptible to winter cold.

Paroschy and Meiering (1978) determined that a recuperative period of three to four weeks is required between the time when grapes mature and the first autumn freeze of -1°C. These authors found that over-cropping and late shoot growth delays the accumulation and concentration of protective tissue in the vines.

Several freeze risk research studies have been completed throughout the world in areas where spring and autumn freezes have caused damage to crops. Van Eimern (1968) discussed an extensive freeze risk mapping program in Germany. Bootsma (1976) in an analysis in the hilly terrain of Prince Edward Island used mobile temperature traverses and both short and long term weather stations to determine the clear night temperature regime. This enabled Bootsma to estimate the dates when the 50% (average) and 20% freeze risk occurs in spring and autumn for localities throughout Prince Edward Island. In British Columbia, Davis (1978) completed a spring freeze risk analysis for tree fruits in the Okanagan and Similkameen Valleys and Chilton (1980) assessed spring freeze risk for fruits, vegetables and Douglas-fir seed orchard trees grown on the Saanich Peninsula of Vancouver Island.

Autumn freezes affect the grape crop in the Okanagan and Similkameen Valleys much more than late spring freezes. Denby and Vielvoye (1974) observed that the 1972 grape crop was very badly damaged by early autumn freezes particularly in the Oliver to Osoyoos area. The vines that were most affected by the low temperatures of September 17 to 25, 1972 were in areas where air drainage was poorest. The autumn freezes observed in many of the low lying areas resulted in an early loss of foliage. This prevented vines from reaching full dormancy since the manufacture and translocation of carbohydrates was inhibited. The grapevines were not hardy and severe winter damage occurred as a result of a cold arctic outbreak on December 6 to 8, 1972. The observed winter damage was accentuated by the tendency for some growers to overcrop their vines. Overcropping delays harvest since the greater the crop, the greater the number of degree days required for the crop to ripen.

Early autumn freezes in October of 1981 and 1982 were observed to end the growing season for grapes in many low lying freeze prone localities. As a result, grapes grown in these areas did not attain sufficient sugars to be suitable for wine production. The determination of the probability of autumn freezes is extremely important to the production of grapes in the Okanagan and Similkameen Valleys.

2.4.1 Methodology For Autumn Freeze Risk Analysis

Data for the freeze risk analysis were obtained from a network of weather stations operated by the Federal and Provincial Ministries of Environment and Provincial Ministry of Agriculture and Food. Five base stations were also established specifically to support the Grape Atlas project.

Temperature data were collected on clear calm nights in autumn at various locations throughout the Okanagan and Similkameen Valleys using a rapid response thermometer attached to a vehicle and set to a height of 1.5 meters above ground level. A similar mobile temperature technique has been used very successfully elsewhere to discern the pattern of minimum temperatures to be expected on clear calm nights (Harrison, 1967; Lomas, 1967; Bootsma, 1976; Davis, 1978; Chilton, 1980). Temperatures were recorded at frequent intervals throughout the most critical regions of the study area.

A most valuable aid in delineating the temperature patterns on clear autumn nights was the thermal imagery data collected on the morning of October 25, 1981 by Mars Aerial Remote Sensing Ltd. using a Daedolus DS 1230 scanner mounted in a jet aircraft operated by Canada Centre for Remote Sensing. The patterns on the 1:50 000 scale thermal imagery show the cooler surface temperature areas as lighter tones and the warmer surface temperatures as darker tones.

Considerable information was also obtained by observing the extent of freeze damage to grapevines during the 1981 and 1982 autumns. Phenological observations such as these help to delineate minimum temperature patterns especially in regions where little or no other climate information exists. Finally, although the autumn temperature regime differs somewhat from spring patterns, the spring freeze risk maps for tree fruits helped to delineate warm and cold areas throughout the region.

The spring frost risk, mobile temperature and thermal imagery data were used in mapping the average temperature difference from a permanent weather station that can be expected on clear calm nights. October 10 has been chosen as the most relevant date upon which to assess the freeze risk for grapes throughout the Okanagan and Similkameen Valleys. After this date, only a very few heat units are accumulated making it of little benefit to retain grapes on the vine. Apart from this consideration, grapes must be off the vines well before a severe autumn freeze to permit the vines to recover and prepare for the winter. The grape leaves must remain on the vines for three to four weeks after harvest to permit the accumulation of carbohydrate reserves in the storage tissue. The accumulation of carbohydrates is responsible for the grapevines becoming winter hardy (Paroschy and Meiering, 1978).

The large area encompassed by the Grape Atlas necessitated that the Autumn Freeze Risk analysis be divided into four subregion:

1) the Similkameen Valley, the Richter Pass to Keremeos, with Keremeos as the long-term base station;
2) South Okanagan - the U.S. Border to Okanagan Falls with Oliver as the long-term base station;
3) South-Central Okanagan - Okanagan Falls to Peachland with Penticton Airport as the long-term base station; and,
4) Central Okanagan-Peachland to Okanagan Centre with Kelowna Airport as the long-term base station.

Sufficient data were collected at both the short-term weather stations and the mobile temperature measuring points to achieve a standard error of estimate of the temperature deviations from the long-term station of less than 0.5°C for all of these subregions except for a few localities in the Similkameen Valley. Van Eimern (1968) suggested that the standard error should not exceed 0.5°C if maps are produced using 1°C intervals. Most clear nights during autumn in the Similkameen Valley are windy and mild, making it difficult to isolate those few nights that have a potential for an autumn freeze. The Similkameen Valley was mapped using two nights of data, accordingly, caution should be used in interpreting the autumn temperature results in this subregion.

Analysis of all of the temperature data permits the mapping of isotherms. These temperature deviation lines represent the expected temperature difference of a site from the appropriate long-term base station. The autumn freeze risk can then be estimated by determining the percentage of years that a temperature of -1°C or lower has occurred at that site on or before October 10. Statistics were calculated initially for the period of record at each base station. All areas represented by an isotherm of 0°C are assumed to have the same temperature and therefore the same freeze risk as the base station on clear calm autumn nights.

The freeze risk along all other isotherms is calculated by adding the value of the isotherm to the daily minimum temperatures at the appropriate base station. For example, the freeze risk along the +2°C isotherm would be calculated by adding 2°C to each daily minimum temperature at the base station and calculating the percentage of years in which the temperature would be -1°C or lower on a specific date. The temperature at the base station would have to drop to -3°C before the temperature along the +2°C isotherm fell to -1°C.

The classification for degree of freeze risk was derived as follows:

Class	Freeze Risk	Frequency of Damaging Freezes
1	0 to 10%	0 to 1 yrs. in 10 yrs.
2	10 to 30%	1 to 3 yrs. in 10 yrs.
3	30 to 50%	3 to 5 yrs. in 10 yrs.
4	50%+	more than 5 yrs. in 10 yrs.

2.4.2 The Pattern of Autumn Freeze Risk

The Similkameen Valley, often windy and mild on autumn nights where it is clear, calm and cold elsewhere, has nights when freezes do occur, particularly in the lowest areas of the valley. The area near valley bottom, from the U.S. Border to Cawston has greater than a 50% Freeze risk. The region north of Olalla also has a 50% or greater freeze risk on October 10. West of Cawston, the narrow valley is more exposed to west winds resulting in milder temperatures and a decrease in freeze risk to less than 30% throughout most of the area. The lands above approximately 400 meters (1310 ft) throughout the Similkameen Valley have less than a 10% freeze risk.

The low lying areas from Frank to Richter Lakes have lower nighttime temperatures and more than a 50% chance of a -1°C freeze on or before October 10. Upslope, most of the remaining area has a higher temperature, and the freeze risk rating improves to 30 to 50% or Class 3.

It is evident from the South Okanagan maps that the valley sides are warmer by as much as 5°C. The highest freeze risk (over 50%) exists in the kettle-pocket area southwest of Osoyoos, in the low lying area south of Oliver and near White and Mahoney Lakes.

A 30 to 50% freeze risk as of October 10 is evident throughout the remainder of valley bottom areas from Osoyoos Lake to Inkameep Provincial Park and from north of Vaseux Lake to Okanagan Falls. A second region of 30 to 50% risk covers the large area to the west of the Okanagan Valley in the Park Rill Creek and Mahoney Lake area. Small pockets of this freeze risk class are evident east and west of Osoyoos Lake, in the lowest area of Inkameep Creek Valley and in the protected low hollows of Tugulnuit Lake.

Moderate overnight temperatures and a lower freeze risk occurs around most of Osoyoos Lake, along the Inkameep Creek Valley, upslope from the Okanagan River south of Inkameep Provincial Park and in the higher areas north of Vaseux Lake. The elevated and steeply sloped lands throughout the region and areas adjacent to Vaseux Lake have less than 10% freeze risk, a consequence of moderate overnight temperatures.

The coldest localities in the south-central Okanagan area are in the vicinity of Prather Lake, Penticton Airport and the valley occupied by McLean Creek just east of Okanagan Falls. Within the Summerland area and a similar area north of a low lying pocket south of Giant's Head are included within the Class 4 or greater than 50% freeze risk zone. Apart from these areas, the remainder of the region tends to fall into Classes 1 and 3. Small pockets of land from Okanagan Falls to Kaleden experience some cold air pooling with a 30 to 50% freeze risk. Within this class are major portions of the Garnett and Prairie Valleys near Summerland. Small pockets of this class are evident near Penticton Airport, just to the northeast of Penticton near Munson Mountian, and above a major frost pocket within the McLean Creek Valley. The remainder of the region has less than a 30% risk. Included in this warmer zone is most of land around Skaha Lake and east and west aspects around Okanagan lake. Large portions of the area surrounding these two lakes have an autumn freeze risk of less than 10% providing a favorable Class 1 environment.

The central Okanagan has extensive areas of high freeze risk in the Kelowna to Winfield area. Included within this zone are the large valley bottom area from the mouth of Mission Creek northward to Wood Lake, large level lands of East Kelowna behind the front benches and most of the Glenmore Valley. The west side of Okanagan Lake has the highest freeze risk, Class 4, in low lying areas in the Trepanier Creek Valley near Peachland and a low area near Westbank. A 30 to 50% freeze risk occurs on sites just above the Trepanier Creek and Westbank frost pocket and in a large area from Kelowna to Winfield. The warmer sloped lands and areas next to Okanagan Lake have a 10 to 30% risk of freeze on or before October 10 throughout most of Peachland, Okanagan Mission, Mt. Boucherie, the benches of Belgo and Rutland and in the area north of Kelowna along Okanagan Lake. The most steeply sloped localities in the vicinity of Peachland and Okanagan Mountain Provincial Park have less than a 10% risk.

Table 16
Autumn Freeze Risk

DIFFERENCE FROM BASE STATION ISOTHERMS	SEPT. 15	SEPT. 20	SEPT. 25	SEPT. 30	OCT. 5	OCT. 10	OCT. 15	OCT. 20	OCT. 25	OCT. 30	NOV. 4	NOV. 9	NOV. 14	NOV. 19	NOV. 24	NOV. 29
SIMILKAMEEN VALLEY - RICHTER PASS TO KEREMEOS BASE STATION: KEREMEOS LATITUDE: 49° 12'N LONGTITUDE: 119° 47'W ELEVATION: 430 METRES (1410 ft)																
-2°C	0	0	4.5	4.5	22.7	50.0	68.2	86.4	100	100	100	100	100	100	100	100
-1°C	0	0	4.5	4.5	9.1	22.7	40.9	63.6	86.4	95.5	100	100	100	100	100	100
0°C	0	0	4.5	4.5	9.1	9.1	22.7	31.8	54.5	68.2	81.8	95.5	95.5	100	100	100
+1°C	0	0	0	0	0	0	0	9.1	18.2	36.4	50.0	72.7	81.8	100	100	100
+2°C	0	0	0	0	0	0	0	0	4.5	36.4	45.5	63.6	72.7	86.4	100	100
+3°C	0	0	0	0	0	0	0	0	4.5	13.6	27.3	45.5	59.1	72.7	95.5	100
SOUTH OKANAGAN - THE U. S. BORDER TO OKANAGAN FALLS BASE STATION: OLIVER LATITUDE:49° 10'N LONGTITUDE: 119° 33'W ELEVATION: 305 METRES (1000 ft)																
0°C	3.2	12.9	19.4	25.8	51.6	64.5	80.6	93.5	96.8	100	100	100	100	100	100	100
+1°C	3.2	3.2	9.7	12.9	29.0	38.7	61.3	83.9	96.8	100	100	100	100	100	100	100
+2°C	3.2	3.2	9.7	9.7	25.8	32.3	54.8	77.4	93.5	93.5	96.8	100	100	100	100	100
+3°C	0	0	3.2	3.2	9.7	12.9	22.6	48.4	71.0	77.4	93.5	96.8	96.8	96.8	100	100
+4°C	0	0	0	0	0	3.2	12.9	35.5	54.8	64.5	87.1	96.8	96.8	96.8	100	100
+5°C	0	0	0	0	0	0	6.5	12.9	29.0	45.2	71.0	87.1	90.3	93.5	96.8	100
SOUTH OKANAGAN - OKANAGAN FALLS TO PEACHLAND BASE STATION: PENTICTON AIRPORT LATITUDE 49° 28'N LONGTITUDE: 119° 36'W ELEVATION: 342 METRES (1122 ft)																
DIFFERENCE FROM BASE STATION ISOTHERMS	SEPT. 15	SEPT. 20	SEPT. 25	SEPT. 30	OCT. 5	OCT. 10	OCT. 15	OCT. 20	OCT. 25	OCT. 30	NOV. 4	NOV. 9	NOV. 14	NOV. 19	NOV. 24	NOV. 29
-1°C	6.3	15.6	31.3	37.5	62.5	71.9	81.3	100	100	100	100	100	100	100	100	100
0°C	0	6.3	15.6	18.8	28.1	50.0	68.8	87.5	93.8	96.9	100	100	100	100	100	100
+1°C	0	3.1	9.4	12.5	15.6	28.1	40.6	59.4	81.3	87.5	100	100	100	100	100	100
+2°C	0	0	6.3	9.4	12.5	12.5	28.1	50.0	65.6	78.1	90.6	96.9	96.9	96.9	100	100
+3°C	0	0	3.1	3.1	3.1	3.1	12.5	25.0	43.8	62.5	71.9	87.5	96.9	96.9	100	100
+4°C	0	0	0	0	0	0	6.3	9.4	15.6	37.5	46.9	71.9	87.5	93.8	100	100
CENTRAL OKANAGAN - PEACHLAND TO OKANAGAN CENTRE BASE STATION: KELOWNA AIRPORT LATITUDE:49° 57'N LONGTITUDE:119° 23'W ELEVATION:471 METRES (1368 ft)																
0°C	16.1	32.3	45.2	61.3	80.6	90.3	90.3	100	100	100	100	100	100	100	100	100
+1°C	6.5	19.4	29.0	35.5	54.8	67.7	80.6	96.8	96.8	96.8	100	100	100	100	100	100
+2°C	3.2	9.7	16.1	19.4	35.5	48.4	67.7	83.9	96.8	96.8	100	100	100	100	100	100
+3°C	3.2	6.5	6.5	12.9	22.6	32.3	41.9	61.3	77.4	83.9	96.8	100	100	100	100	100
+4°C	3.2	3.2	3.2	6.5	12.9	16.1	22.6	32.3	64.5	71.0	93.5	96.8	100	100	100	100
+5°C	0	0	0	0	6.5	12.9	16.1	25.8	48.4	58.1	80.6	90.3	93.5	93.5	100	100

The Autumn Freeze Risk Maps are derived from October 10th Freeze Risk appearing in the Table. The figures within the table represent the percentage chance of having a -1°C freeze on or before the dates indicated.

The Freeze Risk Analysis for Kelowna Airport was extended using Kelowna CDA as a Base station. This was done by estimating the clear autumn night temperature difference between the two stations and applying that difference to the Kelowna CDA climate data. This procedure permitted the freeze risk analysis to be calculated based upon a longer data record.

2.4.2.1 Freeze Risks for Other Autumn Dates

Table 16 has been produced to enable a grower to assess the percentage chance of -1°C autumn freezes in five day intervals from September 15 to November 29.

This information will allow a grower who is attempting to increase the sugar content of the crop to estimate the additional risk involved in harvesting later in the autumn. The frequency table should also help a grower to decide whether to plant early or late maturing grape varieties. The following example will help to clarify the use of the freeze risk table. In the south end of the valley near Oliver, when is the most appropriate time to harvest a grape crop? The +2°C isotherm, representing the average clear calm autumn night temperature difference between the site of interest and the base station, in this case Oliver, passes near the example vineyard. The mapped value corresponds to the October 10 date on the freeze risk table. A delay of ten days to October 20 increases the freeze risk from 32.3% to 77.4%. Ten days earlier on September 30, the freeze risk decreases appreciably to 9.7%.

Areas of transition between the base stations require careful extrapolation. For example, the area near Okanagan Lake Provincial Park, between Peachland and Summerland is more than 5°C warmer than Kelowna Airport but less than 3°C warmer than Penticton Airport. The freeze risk on October 15 in such an area would be less than 16.1% but greater than 12.5%.

2.4.3 Microclimates Not Covered By Mapping

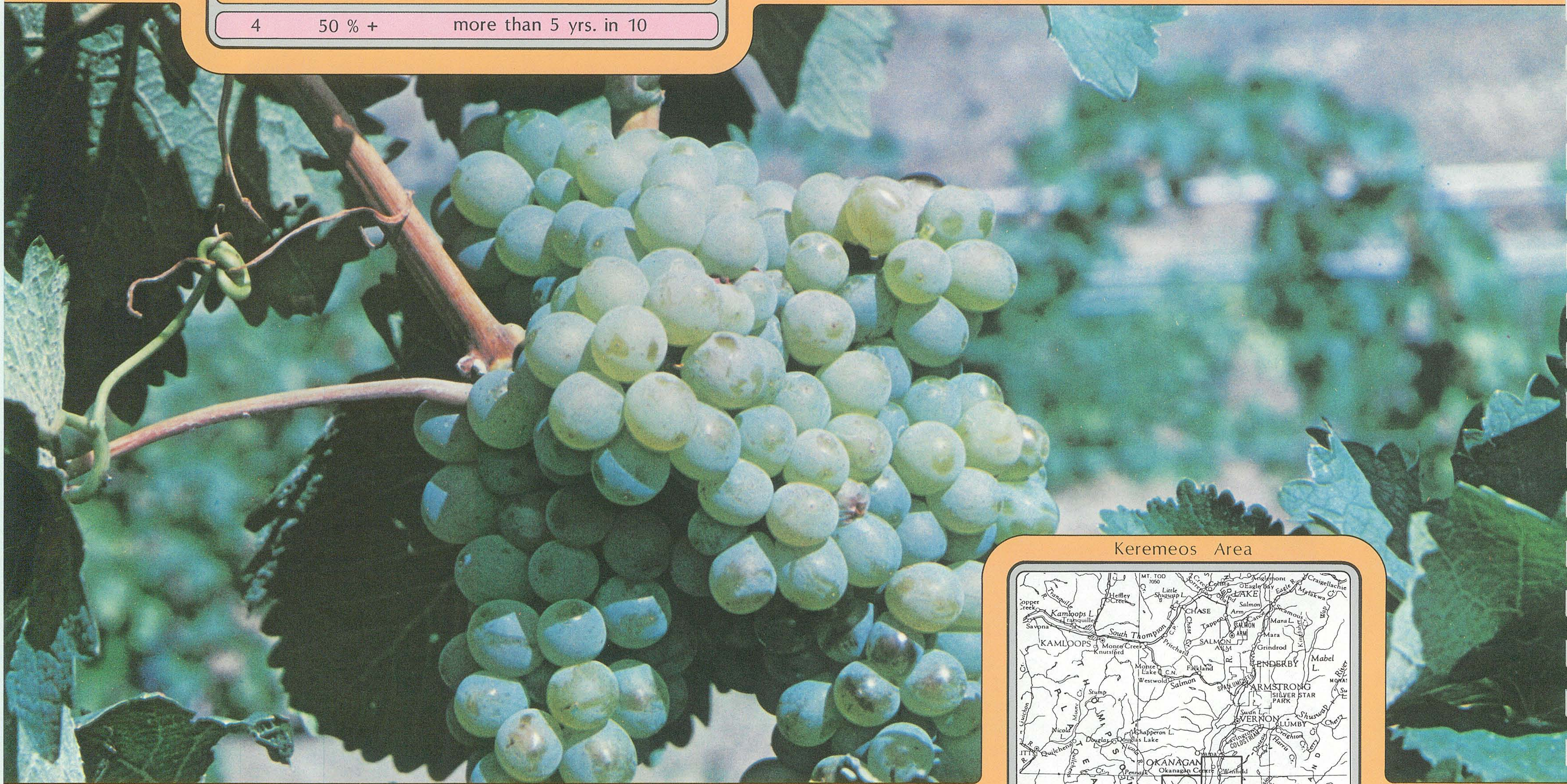
The scale of mapping within the Grape Atlas does not permit small microclimatic areas such as ravines and depressions to be mapped adequately. Subtle changes in the landscape can result in significant differences in minimum temperatures and the associated freeze risk. A brief discussion of some of these microclimates will illustrate the importance of considering these very small areas when selecting potential vineyard areas. Depressional land surfaces must be regarded as less favourable in that on calm nights heavier, cooler air accumulates in these areas. A small depression such as this can result in a significant lowering of temperature and an increase in freeze risk.

Frost pockets can also be created by road embankments, windbreaks, or ledges which dam the flow of air, thereby lowering temperatures and increasing freeze risk. Davis (1977) examined the feasibility of using wind machines for frost protection in the Okanagan Valley. He found that the spring freeze risk of certain frost prone microclimates could be adequately reduced using this method.

Some areas are also much warmer than expected. This is caused by downslope winds on clear autumn nights. These cold winds are the result of heavier air flowing downslope due to gravity. This flow of air mixes with warmer air above and warms these sloping lands. Some of the areas where these moderating local winds occur are in the Belgo region near Mission Creek in Kelowna, much of the region near Peachland, and at the west end of the Prince Valley near Summerland.

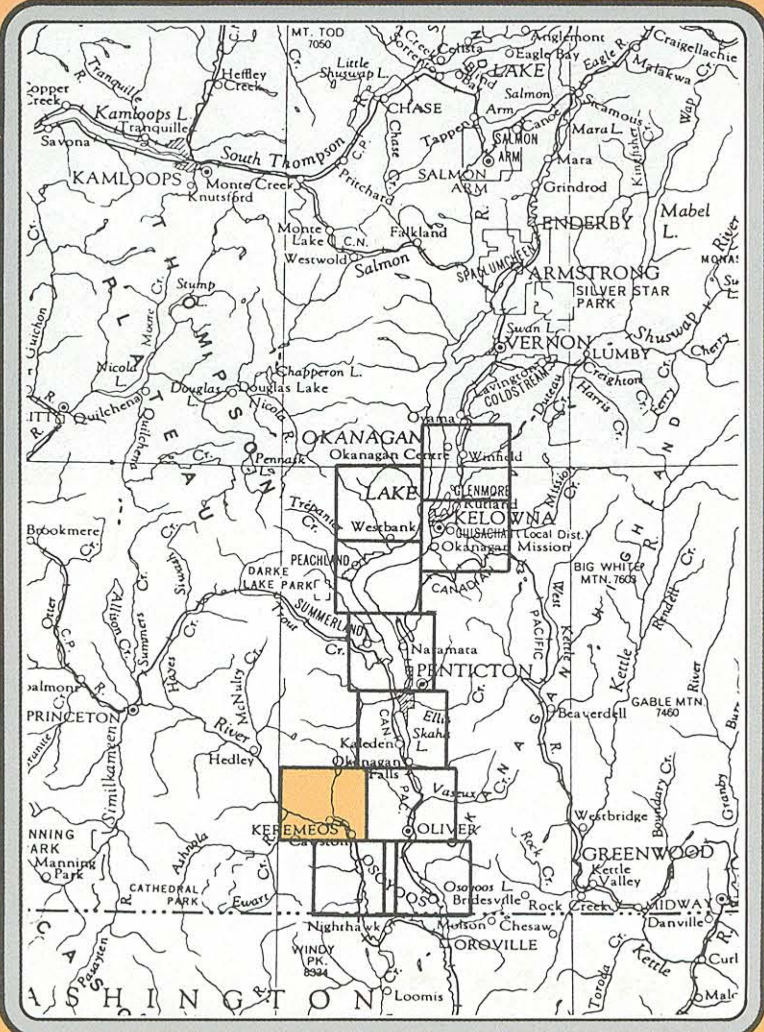
Class	Freeze Risk	Frequency of Damaging Freezes
1	0 - 10 %	0 to 1 yrs. in 10 yrs.
2	10 - 30 %	1 to 3 yrs. in 10 yrs.
3	30 - 50 %	3 to 5 yrs. in 10 yrs.
4	50 % +	more than 5 yrs. in 10

Scale 1:50 000

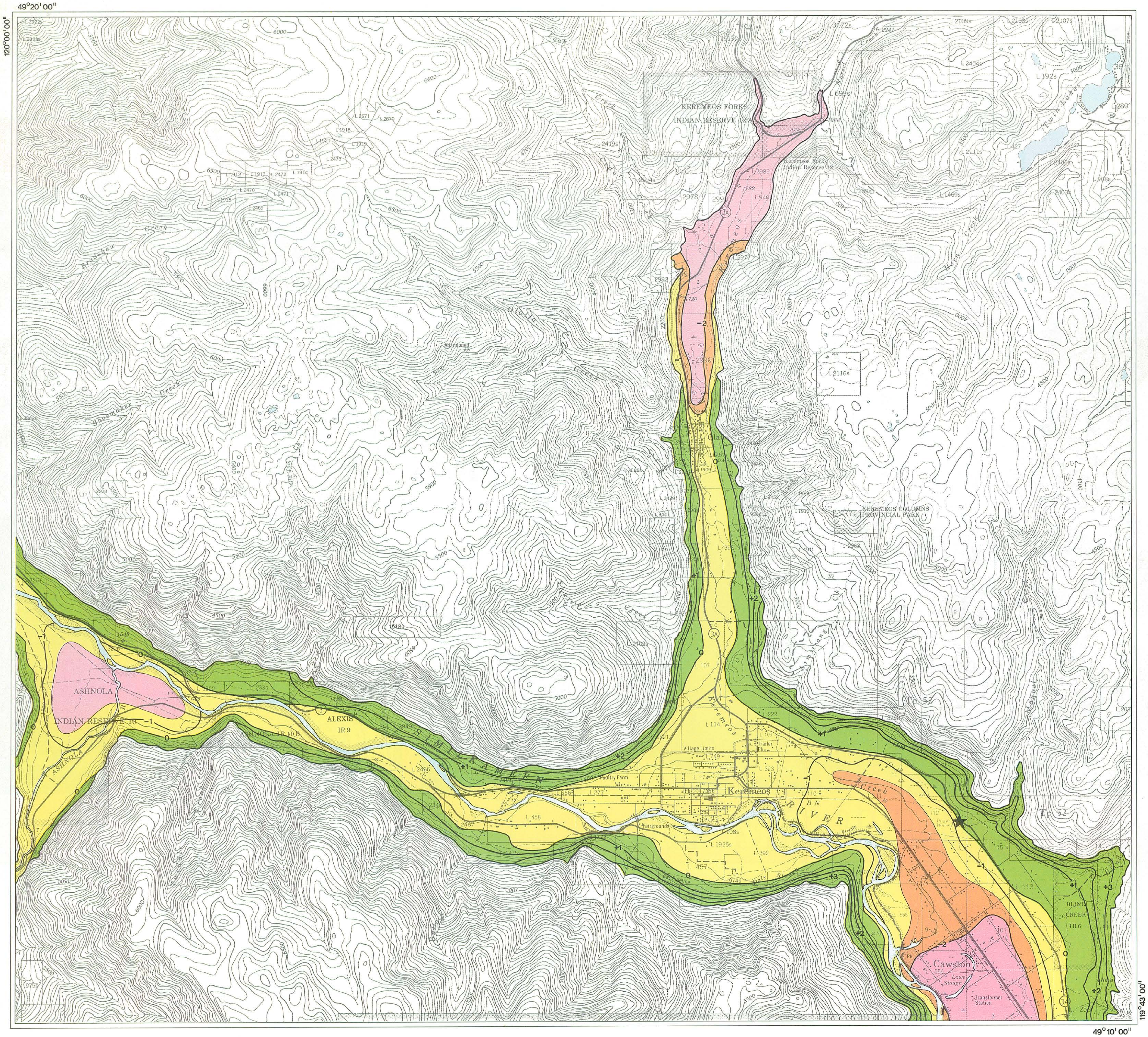


AUTUMN FREEZE RISK

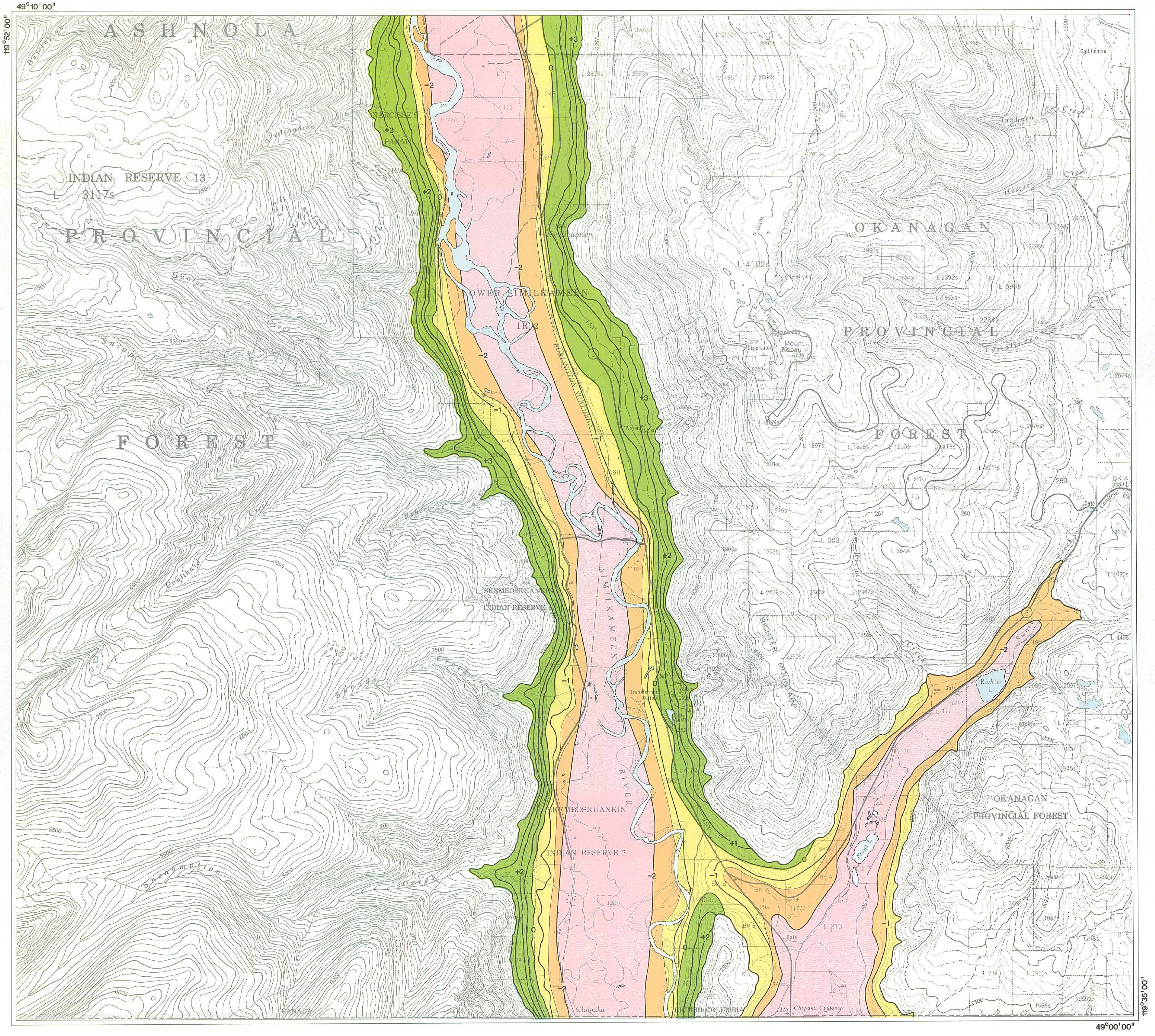
Keremeos Area

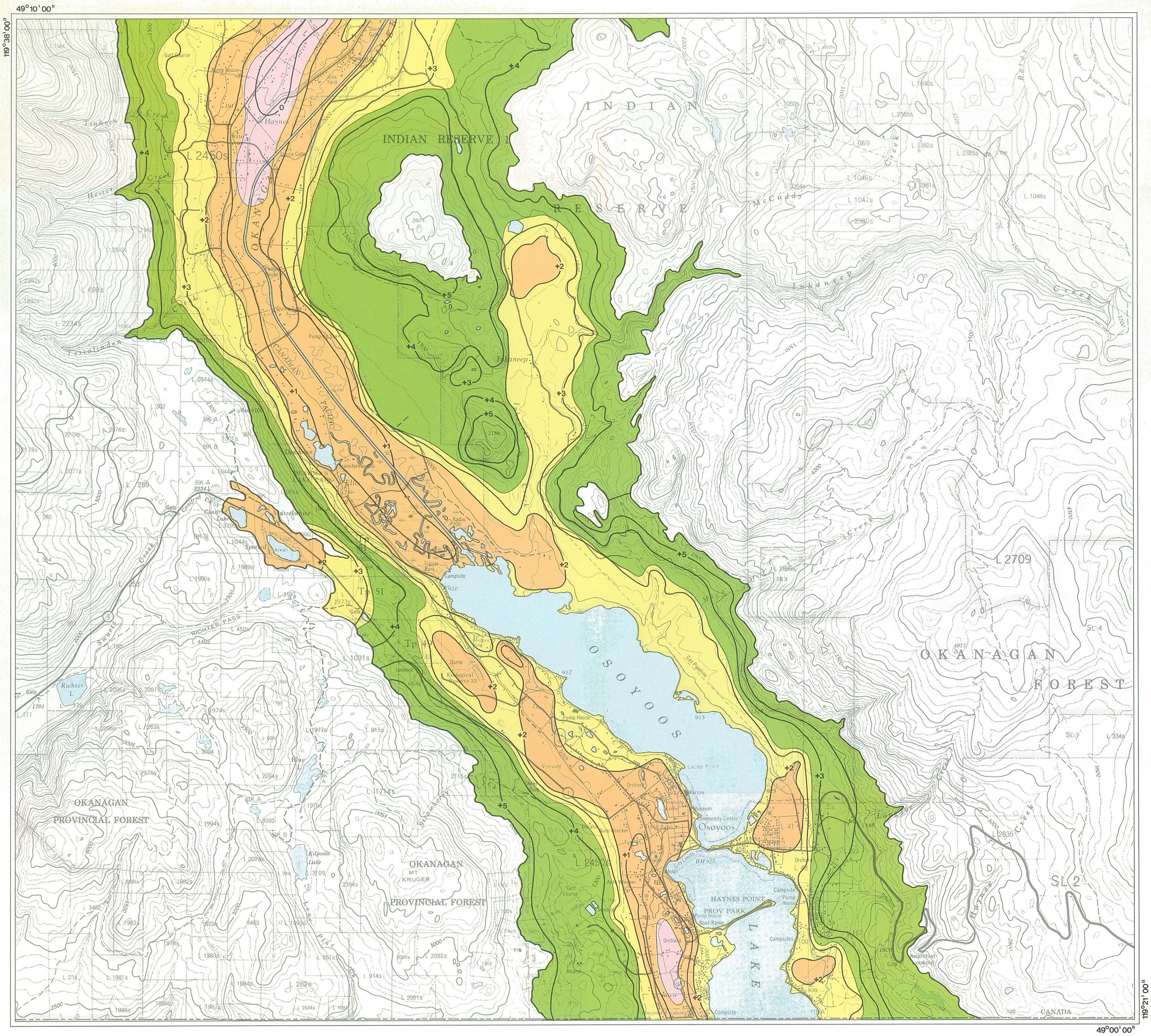


Location Map



49°20'00"
120°00'00"
KEREMEOS FORKS
INDIAN RESERVE 12A
Keremeos Forks
Indian Reserve 12
KEREMEOS COLUMNS
PROVINCIAL PARK
Olalla
ASHNOLA
INDIAN RESERVE 10
ALEXIS
IR 9
SIMILKAMEEN
RIVER
Village Limits
Poultry Farm
Trailer
Keremeos
Fairgrounds
Cawston
Lowe Slough
Transformer Station
BLIND
CREEK
IR 6
Tp 52
49°10'00"
119°43'00"


49°10'00"
119°52'00"
ASHNOLA
PROVINCIAL
FOREST
INDIAN RESERVE 13
L 3117s
NARCISSE'S FARM
LOWER SIMILKAMEEN
IR 2
SIMILKAMEEN
RIVER
BURLINGTON NORTHERN
SKEMEOSKUANKIN
INDIAN RESERVE 8
INDIAN RESERVE 7
OKANAGAN
PROVINCIAL
FOREST
Mount Kobau
Observatory
RICHTER MOUNTAINS
Richter L.
OKANAGAN
PROVINCIAL FOREST
Golf Course
Chopaka
Chopaka Customs
CANADA
BRITISH COLUMBIA
119°35'00"
49°00'00"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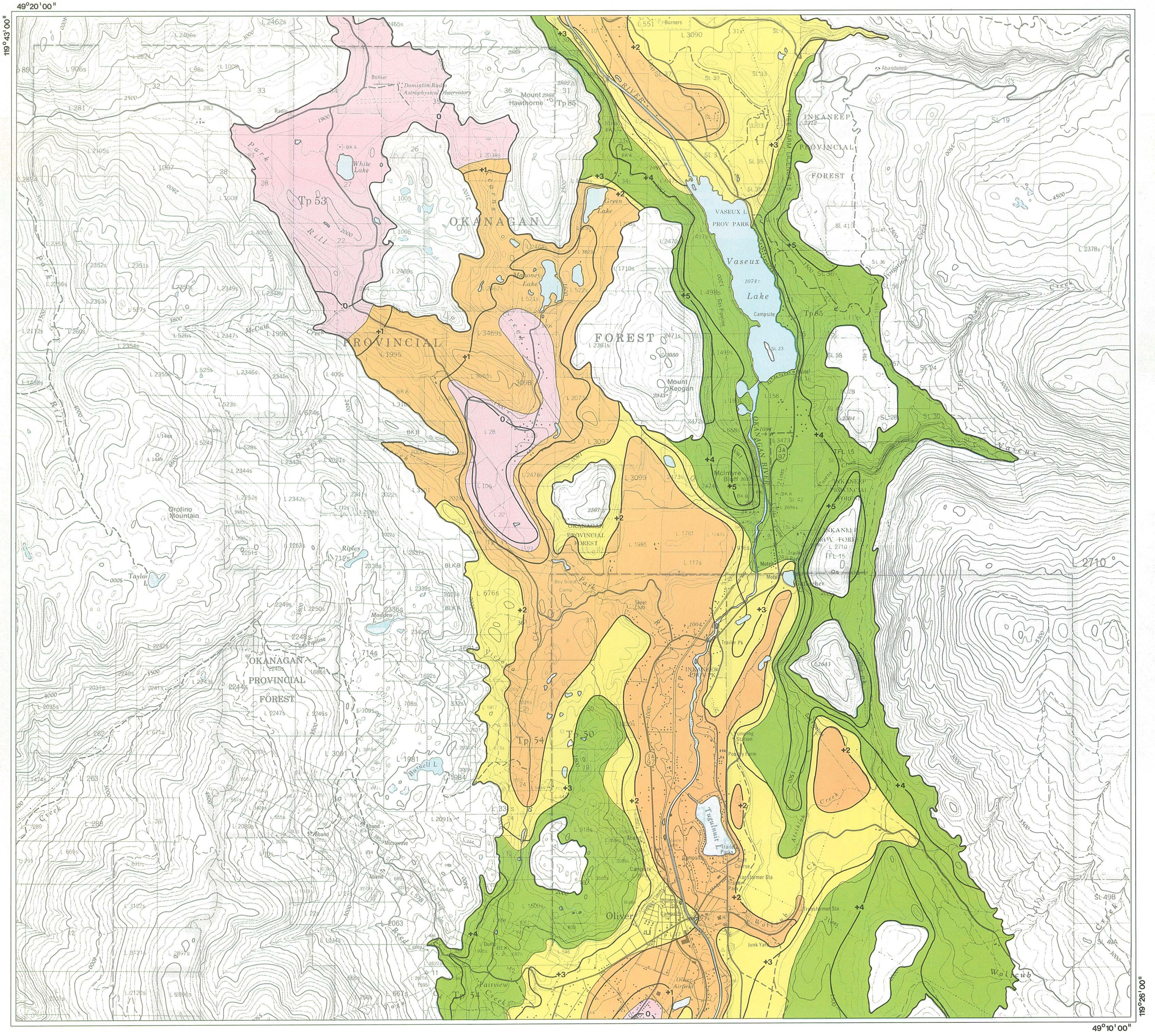
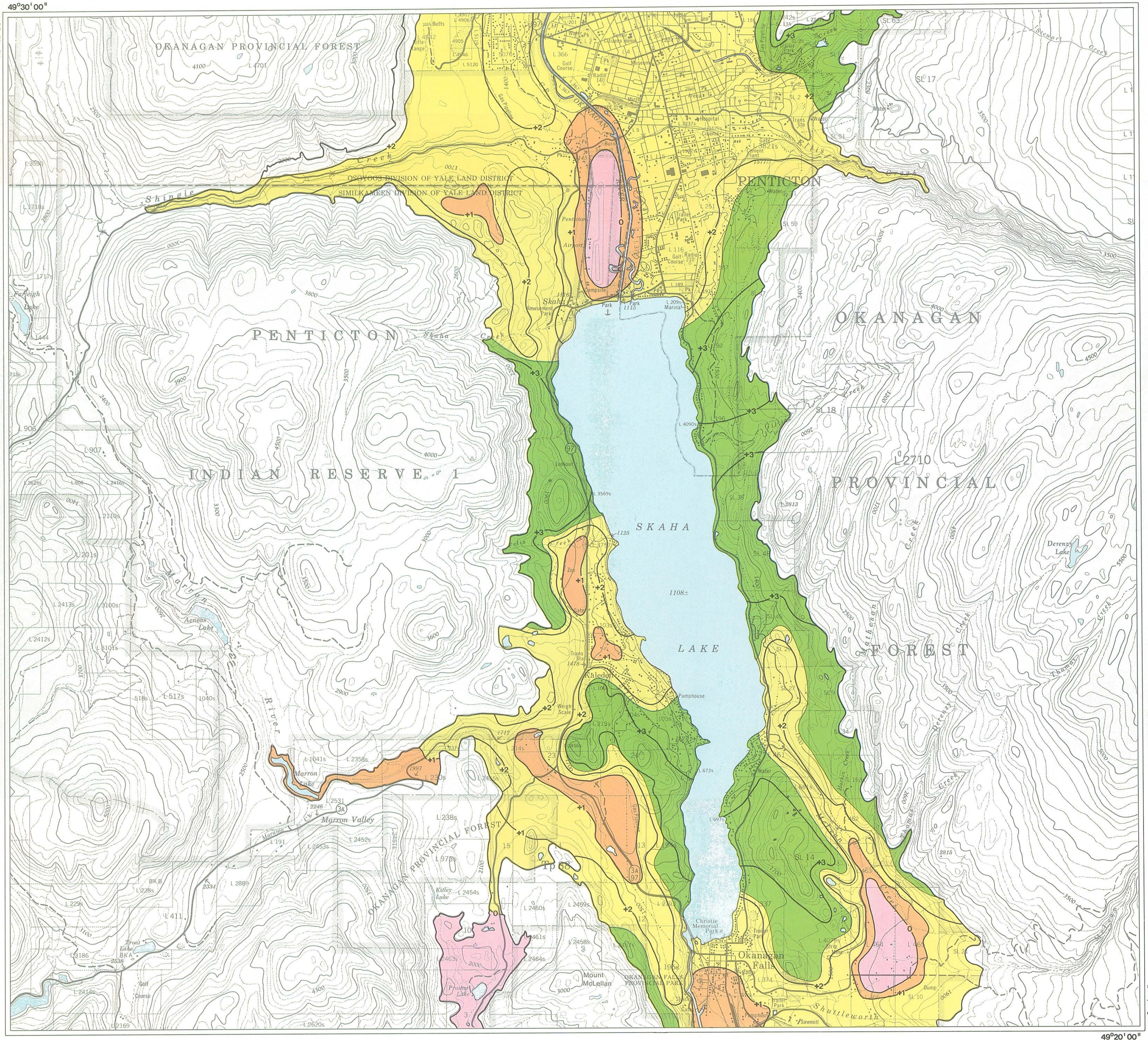
INDIAN RESERVE 1
INDIAN
RESERVE 1
OKANAGAN
CANADIAN PACIFIC
L 2450s
Tinhorn Creek
Hester Creek
Testalinden
Inkaneep
Inkaneep Creek
McCuddy
L 2709
OKANAGAN FOREST
OSOYOOS
LAKE
Osoyoos
Lacey Point
HAYNES POINT
PROV PARK
RICHTER PASS
Richter L.
OKANAGAN
PROVINCIAL FOREST
OKANAGAN
MT KRUGER
PROVINCIAL FOREST
Kilpoola Lake
SL 2
CANADA
49°00'00"
119°21'00"


49°20'00"
119°43'00"
119°26'00"
49°10'00"
OKANAGAN
PROVINCIAL
FOREST
OKANAGAN
PROVINCIAL
FOREST
INKANEEP
PROVINCIAL
FOREST
Vaseux
Lake
VASEUX L.
PROV PARK
Mount Keogan
Mount Hawthorne
Dominion Radio Astrophysical Observatory
White Lake
Green Lake
Mahoney Lake
Tuc-el-nuit
Oliver
Orofino Mountain
Taylor L.
Ripley L.
Madden L.
Burnell L.
Tp 53
Tp 54
Tp 50
Tp 85
Park Rill
McIntyre Bluff
OKANAGAN RIVER
Wolfcub
Fairview
Vaseux
2710

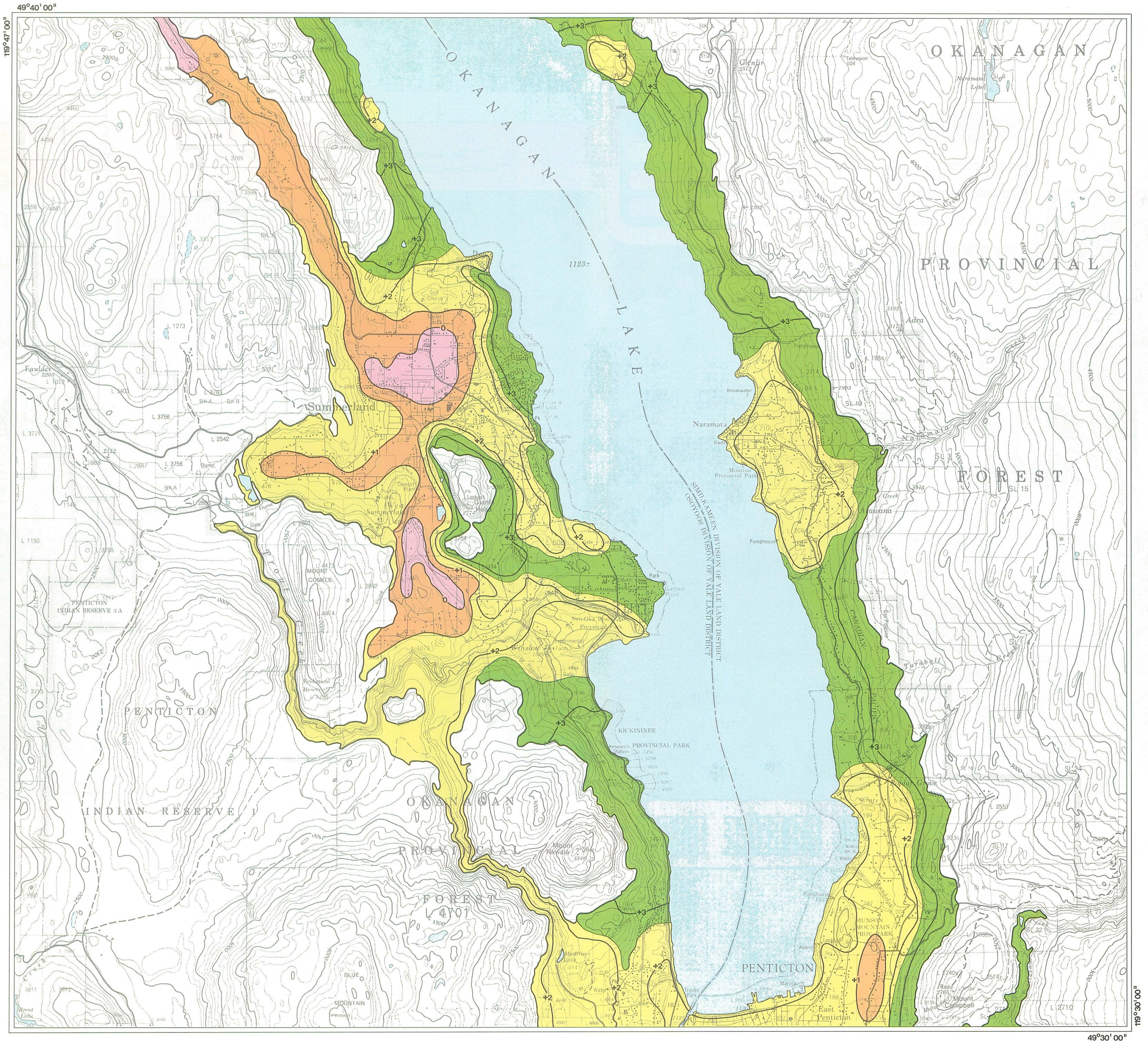
49°30'00"

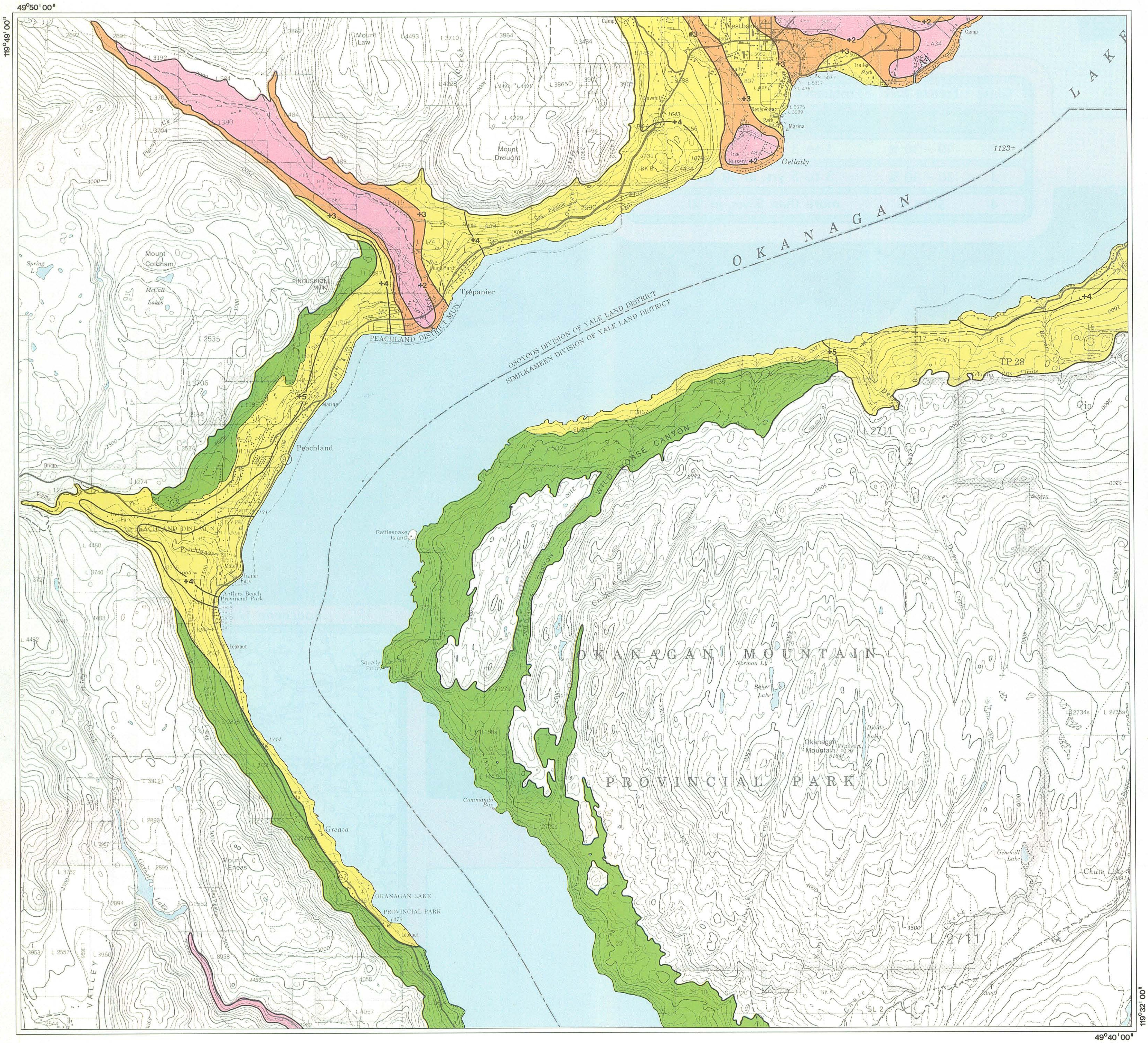
119°45'00"

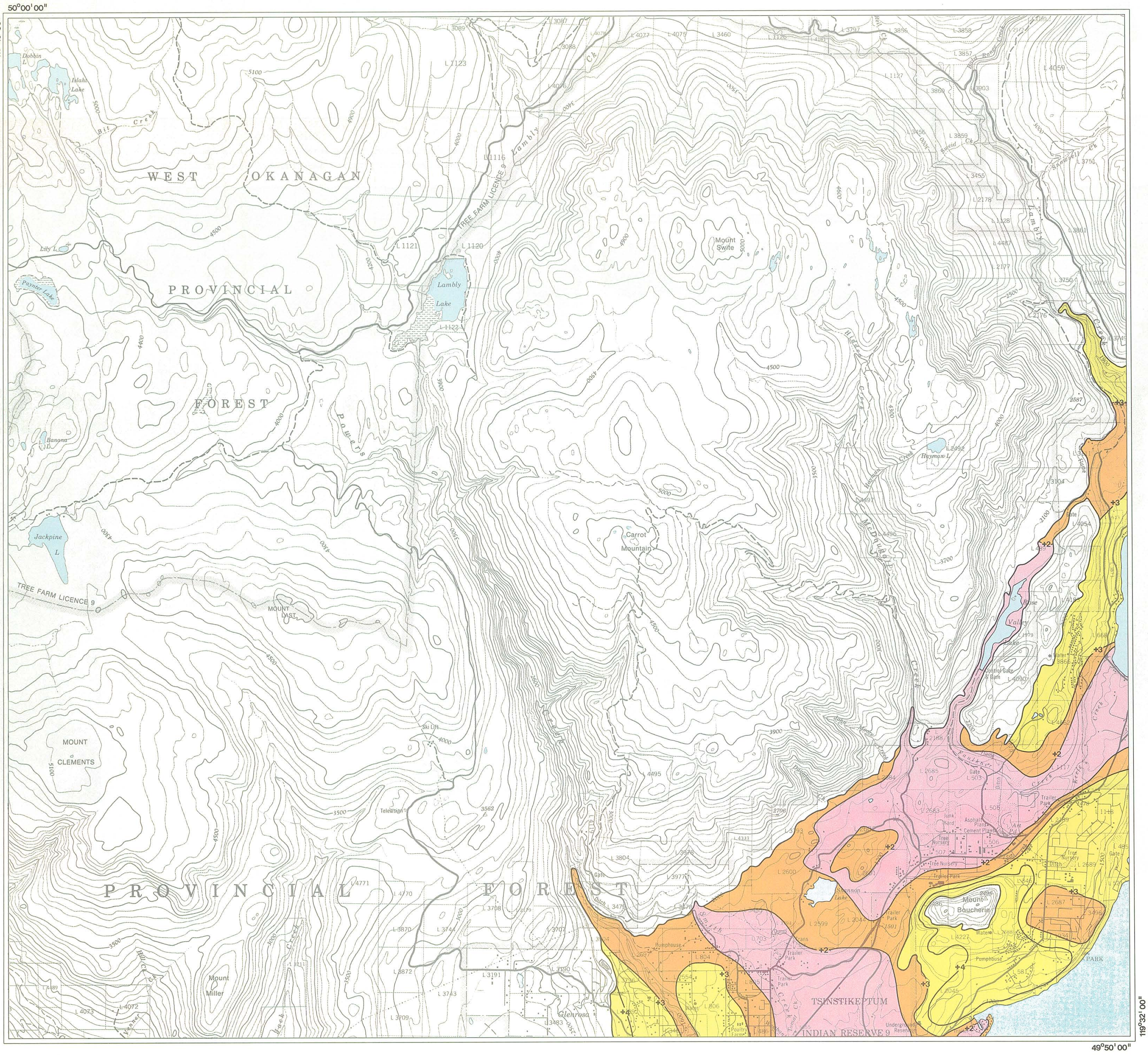


119°28'00"

49°20'00"

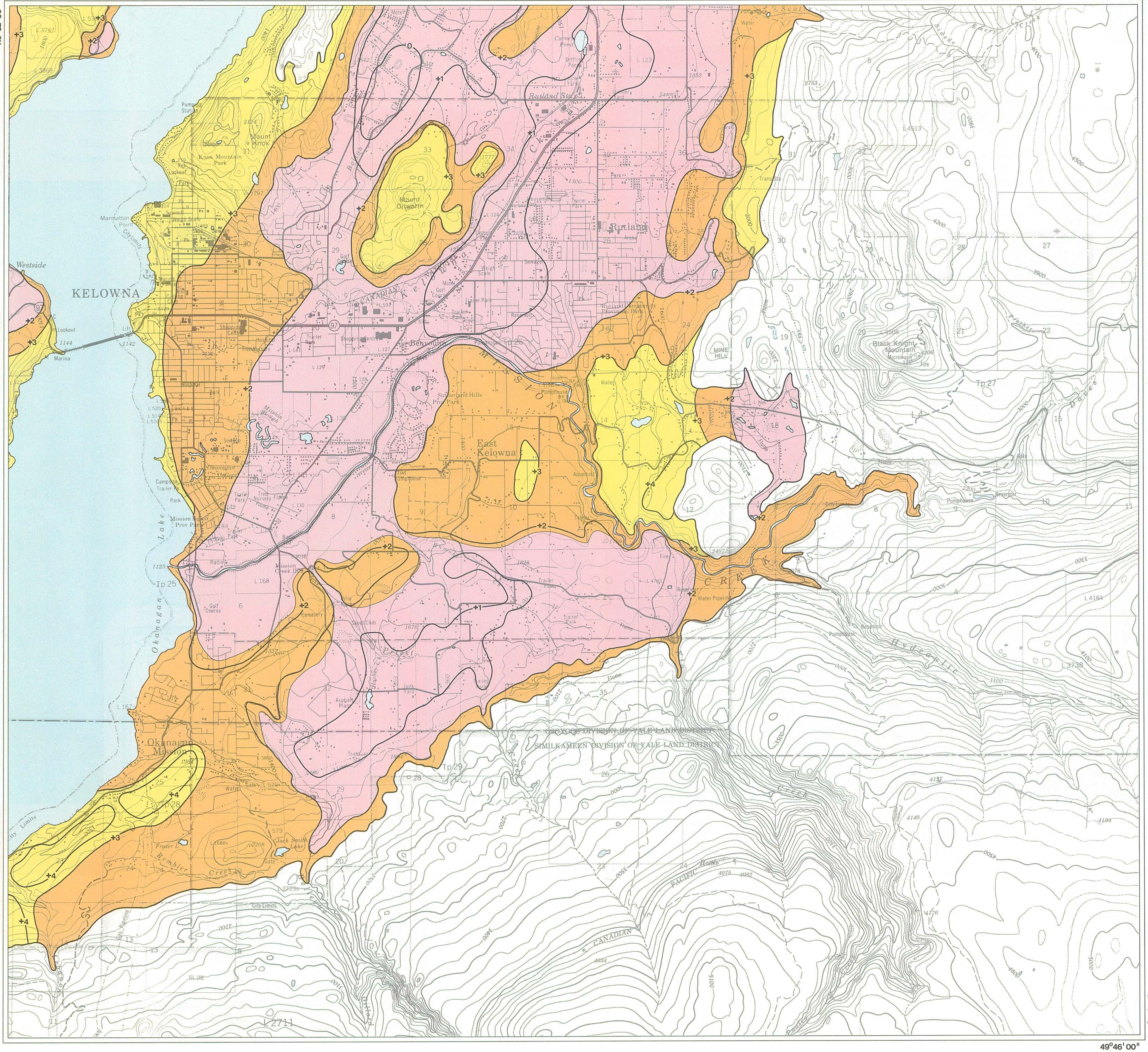

49°40'00"
119°47'00"
49°30'00"
119°30'00"
OKANAGAN LAKE
OKANAGAN PROVINCIAL FOREST
Summerland
Naramata
Glenfir
PENTICTON
East Penticton
PENTICTON INDIAN RESERVE 1
PENTICTON INDIAN RESERVE 3A
KICKININEE PROVINCIAL PARK
SIMILKAMEEN DIVISION OF YALE LAND DISTRICT
OSOYOOS DIVISION OF YALE LAND DISTRICT
MOUNT CONKLE
Mount Nkwala
BLUE MOUNTAIN
Mount Campbell
Faulder
Adra
Winslow
Manitou Provincial Park
MUNSON MOUNTAIN PARK
1123±
+3
+2
+1
0


49°50'00"
119°49'00"
OKANAGAN LAKE
OSOYOOS DIVISION OF YALE LAND DISTRICT
SIMILKAMEEN DIVISION OF YALE LAND DISTRICT
1123±
Westbank
Gellatly
Marina
Mount Law
Mount Drought
Mount Coldham
McCall Lakes
Spring L.
PINCUSHION MTN
Trepanier
PEACHLAND DISTRICT MUN.
PEACHLAND DIST. MUN.
Peachland
Antlers Beach Provincial Park
Lookout
Rattlesnake Island
Squally Point
WILD HORSE CANYON
OKANAGAN MOUNTAIN
PROVINCIAL PARK
Okanagan Mountain
Norman L.
Baker Lake
Commando Bay
Greata
Mount Eneas
OKANAGAN LAKE PROVINCIAL PARK
VALLEY
Gemmill Lake
Chute Lake
TP 28
L 2711
+2
+3
+4
+5
119°32'00"
49°40'00"


50°00'00"
119°49'00"
119°32'00"
49°50'00"
WEST OKANAGAN
PROVINCIAL
FOREST
PROVINCIAL FOREST
TREE FARM LICENCE 9
Dobbin
Islaht Lake
Lily L.
Payntor Lake
Banana L.
Jackpine L
Lambly Lake
Mount Swite
Carrot Mountain
MOUNT LAST
MOUNT CLEMENTS
Mount Miller
Heyman L.
Rose Valley Lake
Shannon Lake
Mount Boucherie
Glenrosa
Ski Lift
Television
TSINSTIKEPTUM
INDIAN RESERVE 9
PARK
Powers
Lambly Ck
McDougall Creek
Smith Creek
Trailer Park
Tree Nursery
Pumphouse
Gate

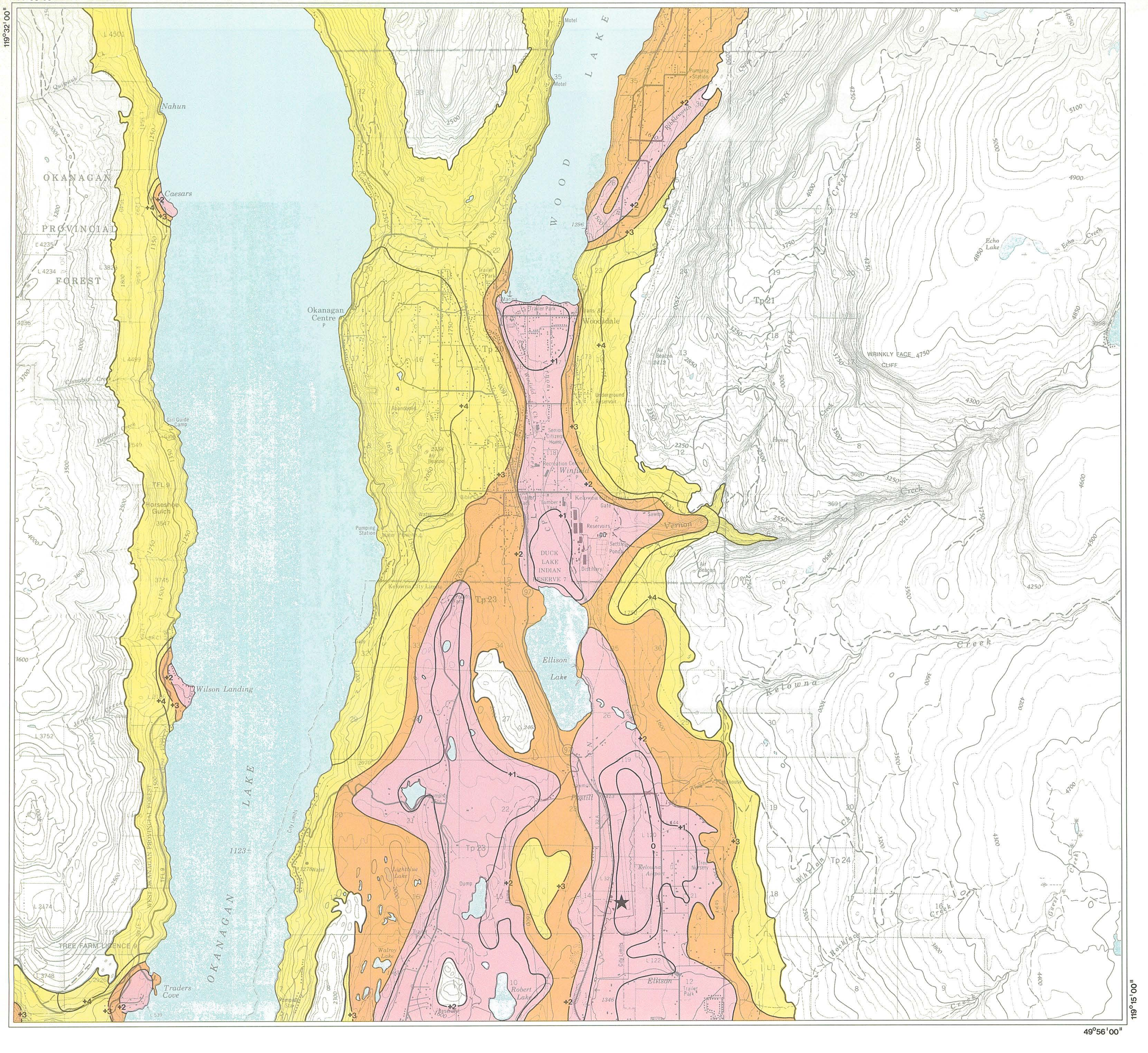
49°56'00"

119°32'00"



119°15'00"

49°46'00"


50°06'00"
119°32'00"
OKANAGAN
PROVINCIAL
FOREST
Nahun
Caesars
Girl Guide Camp
Horseshoe Gulch
Wilson Landing
Traders Cove
TREE FARM LICENCE 9
OKANAGAN LAKE
Okanagan Centre
WOOD LAKE
Woodsdale
Winfield
DUCK LAKE INDIAN RESERVE 7
Ellison Lake
Vernon Creek
Kelowna Creek
Kelowna Airport
Ellison
Robert Lake
Postill
Echo Lake
Echo Creek
WRINKLY FACE CLIFF
Tp 21
Tp 23
Tp 24
119°15'00"
49°56'00"