Slocan Valley Water Quantity and Quality Monitoring Program

Report for Year 4
December 1, 1999 - October 30, 2000

Presented by the Winlaw Watershed Committee

Summary

The Slocan Valley Water Monitoring program was established in 1996 with funding from Forest Renewal B.C and in partnership with the Ministry of Environment. Funds are directed through Slocan Forest Products to the Winlaw Watershed Committee that sponsors the program. The objectives of the program are to obtain baseline data on water quantity and quality on selected creeks in the Slocan Valley, to develop stream flow measurement technique and increase community awareness of the creeks and watershed field conditions and to establish a working relation between government, community and the forest licensee as a basis for forest management.

To date, the program has completed four years of flow, sediment, turbidity, and conductivity data collection on eleven creeks and three years of macro invertebrates, nutrients, and low level metals on four creeks. In addition, total and fecal coliform tests were done on 5 - 9 creeks over three years. A review of the last four years shows 1997 as a record high flow year. Years 1998 and 1999 were moderate to high peak flow. And unusual fall flood event brought some creeks to spring high flow levels in 1999.

Spring 2000 was also a moderate flow year. As in the two previous years the spring of 2000 was cool and snow melt water was released gradually. The peak flows for the year were recorded on April 28th for the lower valley creeks and Hasty creek. The upper valley creeks peaked in early to mid May except for Cadden . High water was marked by the blowout of the Cadden weir and washout of Winlaw's Popoff dam.

Year 2000 was also a low sediment year for all the creeks except for Bartlett. At 223 mg/l, Bartlett's peak sediment continues to be higher than all the other creeks.
Conductivity and Temperature readings for the study creeks followed similar trends noted in years 1 - 3 report findings **(1)**.

On seven creeks, one set of five samples were collected over 30 days and tested for Fecal Coliforms. Presumptive tests for the presence of E.. coli were also performed. Findings indicate that presumptive E.coli can occur in natural surface waters and in creeks that consistently show Fecal counts, 50% of the organisms isolated are presumptive positive for E.coli.

Slocan Valley Water Quality and Quantity Year 4 Report
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1.0 Introduction

1.1 Background

This report documents the fourth year of a 5 year study to characterize water quality & quantity on 11 creeks in the Slocan Valley [1]. The program was initiated in 1994 on a volunteer basis by local residents concerned about industrial logging in their watersheds. In 1996 funding was secured from Forest Renewal B.C. to expand the program to include sediment and discharge.

In addition, the program serves the goal of the Ministry of Environment to develop water quality criteria. These criteria focus on coliform, fecal coliform, low level metals and benthic invertebrate analyses as well as sediment and discharge.

Residents who live near creek gauge sites are employed to read gauges, take temperature, record weather observations and collect samples. Testing of water samples for turbidity, suspended sediment and conductivity is done at Passmore Laboratory ltd. A trained person from the laboratory collects coliform, low level metals and phosphorus samples. Metals and phosphorus samples are sent to ASL Analytical Laboratory ltd. in Vancouver. The physical tests - suspended sediment, turbidity and conductivity as well as coliform and fecal coliform tests are done locally at Passmore Laboratory ltd. in the Slocan Valley. Benthic invertebrate samples were collected by Local Residents. Analyses for benthics organisms was done locally at Aquatic Resources Ltd. in Nelson. Their report is submitted under separate cover.

1.2 Objectives: The Year Four Report

The purpose of this report is to present data and findings in a way that will assist in understanding the hydrology, physical and biological processes that operate in the watersheds studied. The field work, data collection and write up is done by community members who receive guidance from technical experts.

1.0 Introduction

1.2 Objectives cont'

Specifically, the objectives of this study as stated in the year one report and comments regarding year four are given below:

a. To obtain baseline data on water quantity, temperature and quality on selected creeks in the Slocan Valley for the purpose of characterizing current conditions.

Ideally, five years of data should be collected prior to disturbance. Road building and logging began in Harris, Bartlett & Bonanza watersheds during 1997 -1998. Operations wound down in New Denver Flats in 1999 but continued in Bonanza. Cutting continues in Lemon. Road building and cutting began in Hasty Creek in January, 2,000. Cutting occurred in the Airy Creek watershed adjacent to Skaha creek.

b. To develop stream flow measurement technique and community awareness of the creeks and watershed field conditions.

c. To establish a working relation between government, community and the forest licensee as a basis for forest management.

A good working relationship has been established with Ministry of Environment and data compiled from the first and second years was given to all interested parties including Ministries of Environment, Forestry, Local Citizens, Fisheries Biologists, Engineering Consultants and Slocan Forest Products Ltd.

1.3 Acknowledgments

The Winlaw Watershed Committee is grateful to the community members who work so hard make this program successful. Their names are listed below:

Denyse LaCroix	Chris Churchill	Bill Horswill
Vira Depretto	Shemmaho	Kuris Raits
Eric Faulks	Chris Cowern	Lesley Mayfield
Joe Matthews	Ricardo Hubbs	Peter Wood
Norm Matthews	April Russell	Rita Corcoran
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Jennifer Yeow	John Fearing	Ben Sopow

In addition to the office and field workers we are thankful to Forest Renewal B.C. for providing funds and the Ministry of Environment for providing technical direction. Assistance from the following Nelson and Slocan Valley based professionals is greatly appreciated:

Darcy Quamme, Invertebrate Biologist
Tony Yeow, MSc. Analytical Chemist

2.0 Overview of Watersheds

Please see the year 1 report for information about the Slocan Valley and Appendix sections 9.2 - 9.4 of that report for information about gauge stations.
The following table lists some of the physical characteristics of each of the watersheds in the Slocan Valley where the study creeks originate:

2.2 Table 1. Summary of Watersheds

Creek	Area Sq. km	Aspect	Max. Elevation meters	Elev. meters	% Gradient at Gauge Site*	Stream Type at Gauge Site	Gauge Type
Small							
Elliot	2.0	SW	1750	730	15+	SP	weir
Jerome	2.9	SE	1800	740	15+	SP	weir
Harris	4.7	W	N/A	690	15	SP	weir
McFayden	5.0	SE	2100	600	15+	SP	weir
Bartlett	5.7	W	2000	645	15-20	SP	weir
Hasty	6.1	W	2000	940	3	CP	meter
Cadden	6.7	W	1800	720	14	SP	weir
Large							
Winlaw	40.7	W	1700	665	3	RP	meter
Airy	58.0	N	2600	490	2	RP	meter
Lemon	178.0	W	2200	590	2.5	CP	WSC
Bonanza	N/A	S	2200**	570	2	RP	meter

*Gradient at gauge site only
** Uncertain elevation
SP = Step - Pool
CP = Cascade - Pool
RP= Riffle - Pool
N/A = not available
WSC = Water Survey Canada

2.3 Geological Discussion of Watersheds

Reason dictates that a relation exists between bedrock Geology, watershed soil type and water quality. For example, the tendency for a creek to pass sediment or become turbid would relate to composition of surrounding soils and the composition of soils would reflect bedrock geology.

Few studies have been done to investigate these relations on creeks in the West Kootenays. Some initial observations were made by Peter Jordan, a researcher with Ministry of Forests. His findings [4] indicated that there is no clear trend towards higher turbidity per given amount of sediment in watersheds with fine textured soils as compared to watersheds with coarser soils.

In addition, he could not correlate sediment yield to specific sources but rather concluded that "most watershed have numerous small of diffuse sources".

Most water sampling in this paper has concentrated on watersheds in the Nelson Region where the terrain is under laid by granitic rock with coarse soil. The Slocan Valley watershed geology is more varied and a brief description of the geology, terrain and observations on the factors that may affect sediment transfer in the study watersheds is given.

All the geological classifications in the following sections are derived from the survey maps provided by the BC Ministry of Energy and Mines at the following website:

http://webmap.ei.gov.bc.ca/minpot/map/pdac.MWF

The soil classifications and their geological relations are from Jungen [5]. For the present discussion the geological terms are included only to emphasize that there is some relation, albeit complex, between geology, soil and the watershed parameters measured by this program.

Upper Valley Watersheds - Cadden, Bonanza, Grizzly, Harris, Bartlett, Hasty

Bedrock geologic formation for this area is call the "Slocan Group" It consists of slate, argillite, limestone, conglomerate and tuff from the Triassic period. This dark colored rock is predominant in all the above creek beds and in their suspended solids. The soils for this region are known to be silty and clayey [5]. For this reason, they are more likely to produce sediment during rain/snow melt events.

Because of its large size, Bonanza's watershed includes other geologic formations including the granite and gneiss of the Valhalla complex . Bonanza's sediment pattern is largely determined by inputs from tributaries like Cadden and Grizzly. Its discharge is moderated by its lake source.

Cadden, Harris and Bartlett are entirely within the Slocan Group formation and include limestone which contributes to high conductivities. All three creeks show characteristic dark, fine clayey sediment A comparison of these three creeks shows that Cadden is the quickest to show a rise in turbidity.

Harris and Bartlett remain clear after lesser rain and rain on snow events. The main sediment flow occurs during spring at high water. Occasionally, Bartlett also access's reserve sediment at high water and levels jump dramatically.

The Hasty Creek watershed has complex geology which includes formations from the Slocan Group and Nelson Batholith. Coarse granite with sandy soil is observed as well as glacial till. A review of the main Hasty Channel reveals in-filling by this coarse granite sand. Dark fine sediment that is light weight and organic likely comes from the wetlands.

Hasty's sediment release is more varied than Bartlett or Harris. Occasional surges of sediment can come down with rain events at any time of year. However, this likely reflects Hasty's complex nature rather than its geology.

Lower Valley Creeks - Lemon, Elliot, Jerome, Winlaw

Geologically, different formations are seen in the lower valley watersheds. Elliot and Winlaw are in the Nelson Batholith. This rock consists of non porphyrite granite and senite. Soils are coarse and sandy. Elliot is an exception, notable for its fine sediment that results in increased turbidity during rain events. Functioning large and small woody debris contains a lot of the sediment, and acts as a filter which results in very clean water for consumptive use.

Winlaw transports a lot of the coarser sediment typical of its geology as bedload. This results in an active, shifting channel.

Jerome and McFayden watersheds are contained in the Valhalla Complex formation. Rocks here are gneiss and grandiorite and quartz monzonite. Soils are also coarse and sandy with little clay.

Both these creeks transport most of their load of sediment during spring and do not respond quickly with increased sediment during rain events.

The Valhalla Complex is also seen in Airy Watershed at lower elevations. The higher levels contain rock from the Nelson Batholith.

A review of the yearly peak sediment level in each of the creeks for four years of the study indicates that higher sediment levels are observed from the Slocan Group watersheds. This trend is more pronounced in high flow years. See FIGURE 1, page 10. However, in periods other than heavy flow, sediment levels are similar.

3.0 Methodology

3.1 Sample Collection and Analytical Tests

Gauge readings and water samples were collected daily during spring run-off events and major rainfall events. These "grab samples" are collected in accordance with methods outlined in Stednick [2] and tested for Suspended Sediment, Conductivity and Turbidity.
After spring, sample collection was reduced to 2 per month unless a rain event occurred.
Please see the Gauge Reading and Sample Collection Schedule , page 14 .
Spring runoff and heavy rainfall events are critical because they coincide with the main sediment transfer for the year. Gauge readings are continued on average at 3 per week all year .

One sample for low level metals, Total phosphorus, Nitrate, Nitrite and Dissolved and Total Aluminum was collected during Fall on Bonanza and Winlaw. Five samples for Fecal Coliform and presumptive E.coli bacteria were collected over one month during late summer and early fall on Harris, Bartlett, Hasty, Elliot, Jerome, Winlaw and Airy Creeks
Five Benthic Invertebrate and Periphyton samples were collected once in the fall on Bonanza, and Winlaw. These creeks were selected because of their fisheries value and

human consumptive use Sample collection for the benthic invertebrates began next to the gauge station and individual samples were collected across the creek.

All test procedures remained as per the year 2 and analyses were done in accordance with the standard methods outlined in [3] .

3.2 Rainfall Data

Rainfall measurements for March through June 2000 have been incorporated into the data sheets for all creeks. This was done because of the importance of rainfall in interpreting sediment and discharge data. Rainfall measurements from New Denver weather station was obtained from Environment Canada Atmospheric Environment Service. The New Denver rain data was inserted into the data sheets for Cadden, Bonanza, Harris, Bartlett and Hasty Creeks.

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Rain data from the newly relocated Passmore/Vallican stations has been inserted into data sheets for Elliot, Jerome, Winlaw, and Airy Creeks. These two weather stations are manually operated.

Each rain reading represents 24 hours. New Denver readings are taken at 8:00AM. Passmore/Vallican measurements are taken at 7:45 and 16:45. The two readings are added to give a total for 24 hours. All data from the above stations for 1999 - 2000 is unverified.

3.0 Methodology cont

3.3 Data Input

The following is the list of inputs given in the Creek Data Sheets found in Appendix 1. Not included in these sheets are the phosphorus, nitrate, nitrite, periphyton (chlorophyll A) and benthic invertebrate analyses. A review of these parameters and their relation to Flow, Sediment, Conductivity and Coliform Bacteria is submitted by Aquatic Resources Limited as part of this report but under separate cover.

1. Information obtained by the readers that includes date, time, weather, air and water temperatures, gauge readings and initials of reader

2. Events related to metering and weir maintenance. E.g. dates the weirs were inspected and cleaned, dates when inspections/work was done by the Metering Team.

3. Flow data obtained from metering the creeks or weir readings.

4. Passmore Laboratory test results for Suspended Sediment, Conductivity, Turbidity, Total and Fecal Coliforms

5. Rainfall from New Denver or Passmore/Vallican Stations (March - June)

6. Coliform and Fecal Coliform Test Results

7. Quality Control as follows:

   a. External duplicate tests

   c. Results From Canadian Assoc. of Environmental Laboratories Check Samples

3.4 Sampling Schedule

For all 11 creeks

Date	Field Work & Analytical Tests
July 1 - March 30	Read gauges 2 - 3 times/week
July 1 - March 30	Collect 2 samples/month for Sediment/Turbidity/SC*
April 1 - March 30	Record weather conditions/air and water temperatures for each reading as above
April 1 - June 30	Read gauges 3 - 7 times/week depending on condition of creek
April 1 - June 30	Collect 0 - 7 samples/week to total 30samples/creek for Sediment/Turbidity/SC

* SC : Specific conductance or conductivity

Date	Field Work & Analytical Tests
August 15 - Sept 15	Collect 5 samples for Total/Fecal Coliforms (weekly over 30 days)
Sept - Oct 15	Collect 1 sample for Low Level Metals, Nitrogen, Nitrate/Nitrite, Total Phosphorus/Dissolved AL,Cu

April 1 - March 30	Record weather conditions/air and water temperatures for each reading as above
September	Collect Benthos

Creek	Stratified Sample Regime and Benthos
Bonanza	Low Level Metals/Nutrients/ Benthos
Winlaw	Low Level Metals/Nutrients/ Benthos/ Fecal Coli/E.coli
Harris	Fecal Coli/ E.coli
Bartlett	Fecal Coli/ E.coli
Hasty	Fecal Coli/ E.coli
Elliot	Fecal Coli/ E.coli
Jerome	Fecal Coli/ E.coli
Airy	Fecal Coli/ E.coli

3.0 Methodology

3.5 The Metering of Creeks

Overview

It was empirically established in year 1 and 2 that the general log log relation between gauge height and discharge gave the best fit to all the measured flow data. Thus

$y = AX^B$ Where Y = discharge

X = gauge height

A = first creek constant

B = second creek constant

It was also noted in the first 2 years that there was a distinct tendency for the stage discharge curve to shift leftwards and upwards with time, implying a gradual “filling-in” of the creek channel by sediment.

Because of this yearly shift, it was decided that the most accurate stage discharge curve to use would be the most current one. Thus, in effect, the stage discharge curves would be updated on a year by year basis.

Creek by Creek Analysis

Bonanza Creek had 5 readings in 2000, from May 8/00 to Feb 20/01, and the following relation was obtained:

A = 13.4448

B = 2.7307

n = 5

r = 0.9984

The 2000 curve did shift slightly back in, implying that the channel was now no longer "filling in" as occurred in 1999, but was now losing sediment, ie., beginning to clean itself out again. See Figure 1 in Appendix, page 164.

Grizzly Creek, a small tributary of Bonanza was metered from May 2 to June 8 with 4 readings. The following relation was obtained:

A = 2.9276

B = 3.0255

n = 4

r = 0.8429

The high variability of the readings (r=0.8429) was again due to the movement of sediment in the creek. Like Bonanza, Grizzly is losing sediment. See Figure 2 in Appendix, page 165.
It is interesting to note that this effect in 2000 is opposite to 1999 where there was a "filling in " or aggrading of both creeks with sediment. Because of the high variability of the 2000 curve, it was decided to combine all nine readings from the 2 years to obtain a better overall curve for Grizzly. Thus :

A = 4.5388

B = 4.0023

n = 9

r = 0.9482

The Cadden Creek weir finally broke in the week of 4/21/00. It had been bowed for about 2 years and leaking slightly and it finally went after a heavy rain (19.8 mm) on 4/15/00. The new 3 ft weir was not installed until low water at 9/26/00. Meanwhile a gauge was installed at the old weir site on 5/2/00 and Cadden was metered 3 times to obtain the following relation:

A = 375.446

B = 4.5236

n = 3

r = 0.9903

The above values were used to determine flow during the freshet of 2000.

Hasty Creek had 6 readings in 2000 from May 2/00 to Feb 20/01 and the following relation was obtained:

A = 16.7218

B = 5.5813

n = 6

r = 0.9990

A comparison of 1999 and 2000 (Figure 3 in Appendix, pg166) shows that Hasty aggraded significantly in 2000, continuing the trend of the previous year, with the curve moving upwards and leftwards. This “filling in” effect was also visually observed.

3.5 The Metering of Creeks cont.’

Winlaw Creek again showed great unpredictability in 2000, as it has for every year since the program began. This year the Popoff dam, which served as the main control for the metering reach, began to disintegrate after heavy rain on 4/22/00.By 4/27/00, there was a change in control indicated by a sudden drop in the gauge reading (0.520 to 0.416). By 4/28/00, one log of the Popoff dam was gone, after 33 mm of rain in 24 hours. The dam continued to disintegrate while the stream bed continued to stabilize during high water from 4/27/00 to 5/24/00. By 5/24/00 the creek appeared to have stabilized again, as shown by the new curve:

UP TO APRIL 27	APRIL 27 to MAY 24	AFTER MAY 24
A = 45.8730	A = 16.5782	A = 41.6488
B = 3.7504	B = 1.6626	B = 2.2914
n = 9	n = 3	n = 3
r = 0.9828	r = 0.9995	r = 0.9863

Also see Figure 4 in the Appendix, page 167.

On 8/21/00, while the program was temporarily canceled, the staff gauge , which was located on the left bank, was discovered to be out of the water, a direct result of the loss of the dam in the spring. Unfortunately a new gauge was not installed on the right bank until 9/28/00 and gauge readings were not started again till 10/10/00. See pictures of new gauge on Winlaw creek right bank, page

Airy Creek had 6 readings for 1999, from April 27th to Sept 6 and the following relation was obtained:

A = 25.6822

B = 2.4699

n = 6

r = 0.9994

The differences between the 2 years were small at flows less than 5 m3/sec but became significant at higher flows. At 10 m3/sec, Airy appears to be aggrading, ie depositing sediment. See Figure 5 in the Appendix, page 168.

Benchmarks were checked and found to be stable for all five creeks.

4.0 Results and Discussion

4.01 Approach and Charts

The data collected by readers, technical experts and analytical test results collected to date represents the total inputs of information about each creek.

The following descriptive summaries and charts can be considered outputs. The purpose of these outputs is to identify meaningful relations that characterize the creeks.

Relations likely to be helpful in this regard are:

1. Monthly mean discharge and number of readings
   Chart 1 represents the mean monthly discharge for each creek. The values are based on gauge readings taken by the readers throughout the year. The number of readings "n" varies throughout the year with numerous readings in spring and few in winter.

2. Discharge in relation to time.
   Chart 2 is the 4 year hydrograph for the creek, from 1996 to 2000.

3. Flow, sediment and rain in relation to each other
   Charts 3 for all the creeks represents sediment and rainfall in relation to discharge for the period March to October, 2000. This time period encompasses the spring run-off and hence the time when most sediment transfer occurs. Rain data was entered every day from March to June and gauge readings were taken every 3 days and when samples were collected.

Daily readings were not taken and are not represented between July and March; *hence, this time period is compressed.*

4. Flow, turbidity and rain in relation to each other.
   Chart 4 is very similar to Chart 3 and often confirms it.

5. Flow and conductivity or ionic content of water over time
   Charts 5 show conductivity in relation to discharge for the year 2000.

6. Air and water temperature over time
   Charts 6 show the relation between air and water temperature for the year 2000.

4.02 Freshet Summary

The 1999 - 2000 winter snow pack in the Kootenays was average with a Snow Water Equivalent of 96% of normal as of June 1st. This level was the result of a late, slow spring rather than high snow levels. Precipitation during June was normal and two brief "hot spells" near the beginning and end of the month melted much of the remaining snow slowly and safely. The first half of July was again wetter than usual, but by that time the remaining snow pack was relatively small.

When rains did raise rivers, the snowmelt had fallen off and streams never rose above spring averages. The above information was obtained from Ministry of Environment Lands and Parks Web site for Columbia Basin Snow Survey Measurement :

www.elp.gov.bc.ca/wat/snow

4.0 Results and Discussion

4.03 Summary of Maximum & Minimum Values, Table 2, page 20.

The following table summarize maximum and minimum values for discharge, sediment, and conductivity for 2000. In instances where low entries are noted for more than one day, the value nearest the spring high flow is recorded as the minimum value.

Comments Regarding Results and Discussion

The following observations are based on review of the data obtained by methods described above. As stated in the summary, the nature of the creeks and parameters studied are extremely variable. And gauge readings and sampling frequency is limited. Hence, the values and observations reported represent the closest approximation of the actual maximum or minimum for an event. And, on some creeks, because events can happen so quickly, the entire real event could actually have been missed.

4.1 Cadden Creek

Cadden's geographic formation (see map page) has a classical branching shape. It is a 3rd order creek and the watershed is characterized by steep slopes with few flat benches where sediment can accumulate; hence it lacks sediment storage capacity in the upper levels.

Sediment is stored in the lower reach where abundant mobile material causes the channel to in - fill and shift. In places, water flows under accumulated sediment. Cadden's Turbidity level rises quickly after rain events. Turbidity also falls quickly and, for the most part, the water is very clean and acceptable for human consumption. See Cadden Chart 4, pg 23 .

The hydrograph (see Cadden Chart 2,p 22) was altered because of the blow out of the Cadden weir on April 23rd , 2000 at the beginning of spring freshet. This event occurred with heavy rains and a sudden rise in water level. The old Cadden weir had been installed by Water Survey Canada and was in need of replacement for the last 4 years. It was badly bowed. A gauge was installed on May 2nd and readings continued until the end of June when the program was temporarily discontinued. Cadden was metered 3 times between May 2nd and June 30th and discharge measurements were used to calibrate gauge readings during this time.
A new weir was installed on October 2nd.,2000.

Spring 2000 was not an exceptionally high flow year for Cadden. At a peak flow of 0.526 m3/sec on May 5th, the hydrograph shows 2000 as higher than 1997 which was a record high discharge year. This likely reflects low readings on the old Cadden weir during 1997 - 1999.

Three peak flows were noted in 2000. The high for the year on May 5th was earlier than neighboring Harris and Bartlett. A second, lesser peak was recorded on May 23rd.
Low water was reported on February 19th @ 0.02m3/sec. This is the same as low flow in 1998.

A large rise in sediment (70.8mg/l) with no corresponding rise in discharge was noted on December 12, 1999. See Chart 3, pg 23. Cadden's highest sediment reading (84.0mg/l) for the year occurred on April 28th. This level is in line with previous years sediment levels at the same flow.

This maximum sediment flux event was also reported on Bonanza, Bartlett ,Grizzly, Elliot, Jerome and Winlaw on the same day. See Maximum & Minimum Table, pg 20 .

In previous years a sharp drop in Cadden's Conductivity was noted at high water i.e. the conductivity range in 1998 was 106uS/cm.. This year, Conductivity readings only dropped by 81 uS/cm. The lower range likely reflects lower flow levels. See Chart 5, pg 24.

Historically, Cadden's air and water temperatures have shown a close relation. This trend continued in 2000 and likely reflects Cadden's mainly surface flow. See Chart 6, pg 24 .

4.0 Results and Discussion cont.'
4.2 Bonanza Creek

As noted in previous years, Bonanza is the most important fish spawning creek in the Slocan Valley Watershed. Kokanee and Rainbow are the two main varieties of fish that spawn in the fall and spring. Last year, over 20,000 Kokanee fish were counted by local residents working with a biologist. This year between 5,000 to 10,000 Kokanee were counted. The count in the Grizzly Creek Channel that was gauged in 1999 was 86. This was over twice as many fish as last year in Grizzly.[6]

Local residents are concerned that reduction in forest cover and impacts from road building could alter water temperature patterns and contribute to sediment load on Bonanza's spawning channels.

Logging continued on Bonanza's west slope in 2000 with the completion of road branch 5200 and 3 new cut blocks. In addition to Slocan Forest Products operations, 10 one Hectare Clear Cuts were completed under Ministries Small Business Development Program. These are located just outside Hill near Highway 6. In addition, cutting continues on Summit Face near Summit lake[7].

Hydrometric Summary

Bonanza Creek began to rise at the beginning of April and experienced its first major peak on April 21st. Historically, Bonanza shows 3 - 4 peaks during the spring season. In 2000, 3 peaks were seen. See Chart 2, pg 26. The high for the year was recorded on May 21st when water levels reached 9.661m3/sec. This compares with 1998 when levels reached 8.03 m3/sec. The high flow was accompanied by 2 days of rain and moderate temperatures. The lowest reading for the year was recorded on October 14th with water levels at 1.116m3/sec.

In previous years, the major flux of sediment came during or just before the first major peak flow event. In 2000, sediment levels peaked at 59.4mg/l on April 28th just *after* the first peak event.

This volume of sediment is in line with levels seen in 1998 at similar discharge. Sediment again rose with the high flow in May, but did not revisit levels in April. See Chart 3, page 27.

Historically, Bonanza has shown a tight relation between sediment and turbidity. That trend continued in 2000. Compare Charts 3 and 4, page 27.

Last year, Bonanza's Conductivity ranged 50uS/cm. In 2000 the range was 36uS/cm. The lower range likely reflects a lower flow year. The cyclic drop does follow the pattern seen in previous years e.g. a drop in conductivity in spring and rise in the fall. See Chart 5, page 28 .

Minimum Conductivity levels at 116uS/cm were recorded on May 21^{st}, the same day as high flow.

4.0 Results and Discussion cont.

4.3 Bonanza and Grizzly Creeks

The peak discharge for Grizzly Creek (Bonanza Tributary) at 0.588m3/sec was recorded on April 28^{th}. In 1999 the peak flow was over 1.6m3/sec and accompanying sediment levels reached 374mg/l. This years high sediment was recorded at 80.4mg/l on April 4^{th}. Grizzly water levels again rose during mid June. See Grizzly Chart 1, page 30..

Grizzly shows a good correlation between Sediment and Turbidity Compare Charts 1 & 2, page 30. .

Historically, Bonanza water temperatures correlate closely to air temperatures. In 2000 this trend continued. See Chart 6, page 28 .

However, in mid July Bonanza's water temperatures did not rise above 15 degrees C. This tendency to remain cool in summer is likely due to influx of cool water from Grizzly. See Chart 4, page 31. Grizzly's water temperatures do not rise above 11 degrees C and trend down at the end of July. See Chart 3, page 31.

4.4 Harris Creek

Harris is a small, second order creek that originates on the west slope of Idaho Peak. It flows sub surface down the slope and resurfaces on new Denver Flats. It is located on the Harris Ranch between Silverton and New Denver.

In 2000 Forestry operations continued on the Flats and two cut blocks were performed in the Harris Creek watershed adjacent to the creek. New Denver Logging operations are now completed for this pass.[7] .

Three peak events were recorded for Harris in 2000.See Chart 2, page 32. The high for the year was recorded on May 22^{nd} at 0.237m3/sec as compared to 0.180 in 1998 and 0.177 m3/sec in 99.

The high came the day after a rain (9.4mm) and a week of mild temperatures.
The low for the year was recorded on August 26th when levels dropped to 0.004m3/sec.
Discharge levels dropped quickly after the 3rd peak was recorded on June 6th. Flows went from 0.104ms/sec to 0.009 on August 7th. Very little rain was recorded during this time.

Maximum sediment levels at 57.0mg/l were recorded on May 22nd. This volume is in line with levels seen at equivalent flows in 1998 when peak sediment was 76.2mg/l. See Chart 3, page 33.

Generally, turbidity corresponded very closely with sediment. Compare Charts 3 & 4, page 33. However, one high turbidity/low sediment was recorded on April 14th. The reader commented that the water at weir had a greenish color.

Conductivity levels showed a characteristic drop in spring and rise in fall and winter. See Chart 5, page 34. A range of 78uS/cm between high and low conductivity in 2000 for the year compares with 89uS/cm in 1989, a year with similar discharge level.

The relation between air and water is similar to Bartlett. See Chart 6, page 34. Both have a tendency to remain cool with warm air temperatures. This likely reflects their subsurface flow at higher elevations.

4.5 Bartlett Creek

Bartlett is the neighbor watershed to Harris. Its three main channels extend up the south west slope of Idaho Peak. One of these channels drains into New Denver Flats, the second skirts the south edge of the flats and the third flows directly from Idaho Peak. Two small streams exit the two terraces below New Denver Flats and also flow into Bartlett. Bartlett is a 6th order creek

Bartlett's discharge pattern for 2000 and the comparison with Harris follows a trend that is seen in previous years. See Charts 2 for Harris, page 32 and Bartlett, page 36 . That trend is Bartlett's higher discharge levels in fall and winter, and rise to about the same level as Harris in spring. This pattern reflects Bartlett's larger storage capacity.

The peak discharge for the year was recorded on April 28th at 0.166m3/sec. Low flow was recorded on September 26th at 0.020m3/sec. Year 2000 low water was the lowest recorded to date for this study. July was omitted from the Monthly Mean Chart because the program was suspended during this time, page 36.

The maximum sediment reading at 223 mg/l was taken on April 28th.See Chart 3, page 37 . This value is in line with readings in 1999 when flow levels were slightly higher, but significantly higher than the sediment in 1998 when water levels were almost the same. These high sediment readings may reflect a "threshold" for stored sediment access. When water levels reach a critical point, reservoirs of sediment from old slides or bank side storage sites are mobilized.

As with Harris, Bartlett shows a strong relation between turbidity and sediment. Compare Charts 3 & 4 , page 37.

The range for conductivity at 120uS/cm is in line with 1999. See Chart 5 for Bartlett, page .This range relates to the mineral content of the water and its dilution in spring is higher in Bartlett than other creeks in the study area.

Bartlett and Harris water temperatures rarely rise above 9 degrees C even during periods of warm air temperatures. See Chart 6, page 38 . This trend likely reflects their high mountain and/or subsurface origin.

4.6 Hasty Creek

The Hasty Creek Watershed is located south east of Silverton. Hasty Creek is a 3rd order creek that flows into a wetland. Here it meets numerous other streams, forms ponds and small rivlets before meeting a diverted channel that drains the Vevey watershed.

Numerous studies have documented the sensitive nature of the hydrology in the wetlands and questioned the wisdom of road construction and logging operations in this controversial watershed. Logging operations commenced in the winter of 2000 and continued in the fall and winter of 2001. Road 200 that cuts across the numerous streams above the wetland has been clear and partially constructed. The bridge across Hasty above the wetlands was built. Six small cut blocks with 30 - 40% retention have been completed.[7]

Hasty's discharge pattern for 2000 was similar in volume to 1998 when at least 6 peaks were documented. High water was recorded on April 28th at a peak flow of 0.966m3/sec. This was the earliest high recorded in 4 years of the study. The high for the year came during a period of cool rainy weather. Other peaks were noted on May 21st and June 6th when temperatures were elevated. In total, 3 major and 4 minor peaks were noted. See Hasty Chart 2, page 40.

In previous years, the yearly high sediment reading came at or just before high discharge. This year, the peak sediment reading was recorded during the second major peak flow on May 21st at 23.4mg/l.See Chart 3, page 41. This volume is in line with previous years flows and sediment.

Although historically, Hasty has a close relation between turbidity and sediment, (compare charts 3 & 4, page 41) a number of readings taken between April 27th and May 1st showed higher than normal turbidity for volume of sediment. Unusually high sediment *and* turbidity readings were observed on Sept. 17th, Sept. 30th and October 5, 2000. Gauge readings taken at the same time did not indicate increased flow. In addition, some of the samples also had significantly lowered conductivity. In fact, the conductivity level reported on October 5th at 48.5uS/cm dropped to spring freshet peak flow levels recorded on April 28th. That reading was 47.2uS/cm.

Aside from the anomalies cited above, Hasty conductivity follows a characteristic pattern of dips in conductivity with surges in flow and generally lower readings in spring. See Chart 5, page 42 .

Historically, Hasty's water temperatures are low because of the high elevation of the gauge, Hasty has had a close relation between air and water and that trend continued in 2000. See Chart 6, page 42. It is interesting to note that water temperature stays above air from fall through winter to May. At the beginning of May air rises above water.

4.7 Elliot Creek

Elliot is a 4th order creek that has 2 main channels and flows down the west slope of Slocan Ridge in Appledale. Neighboring watersheds include Christian on the South and Anderson on the north. The watershed is characterized by steep rock (talus) slopes, and a confined channel where water flows subsurface above the gauge. As one ascends, Elliot alternates between surface and subsurface flow and a rock cascade. The upper reaches of the creek flow on the surface. Here, large and small woody debris and vegetative material is abundant.

Elliot is remarkable for its uniform yearly flow range. As illustrated in chart 2, the peak spring flow between the highest year of the study - 1997 @ 0.131ms/sec and the lowest year - 1999 at 0.102 m3/sec is only 0.029 m3/sec. See Chart 2, page 44, and Chart 7, page 47.

Unlike other valley creeks, the peak flow for year 2000 was higher than both 1998 and 1999. At 0.122m3/sec on April 28th , the timing for high water reading was the same as 1997 and within approximately one week of 1998 and 1999. This consistent flow pattern likely reflects Elliot's well functioning water storage system e.g. woody debris and absorbent soils.
Four discharge peaks were observed between March 15th and June 20th. Low water was reported on Oct. 31st.

Elliot's high sediment reading for the year was reported on the same day as high flow. However, high sediment samples were also noted on Jan. 27th (12.6mg/l), Sept. 13th (14.1mg/l), Sept 29th (19.8mg/l) and Oct. 29th (18mg/l). These increases did not coincide with a rise in flow. Also of interest is the tendency for higher sediment levels to occur in fall and winter. Also at times when no significant increase in flow is noted. See Elliot Chart 3, page 45 .

Unlike other valley creeks, Elliot sediment does not show a strong relation to Turbidity. As noted in previous years and illustrated on Chart 4, page 45. Turbidity has a stronger relation to flow.

The relation between discharge and conductivity does follow the seasonal pattern seen in other creeks. See Chart 5, page 46 . In fact, at 120.4 uS/cm, Elliot's Conductivity range is one of the highest of all in the study. This reflects a strong dilution effect in spring - possibly from surface run - off. A sudden drop in Conductivity readings from 208uS/cm on Sept 30th to 131uS/cm on Oct. 15th may reflect dry conditions and a shift to groundwater sources.

The historic relation between air and water for Elliot is not close and this trend continued in 2000. See Chart 6, page 46. Again, subsurface flow may account for cooler water.

4.8 Jerome Creek

Jerome is a 1st order creek who's headwaters originate on the top and northeast side of Perry's ridge. As noted on the Jerome map, (page 161 in Appendix) , the single channel is confined to a steep canyon. There are no significant tributaries.

Jerome has a large alluvial fan that extends far below the limit of the surface creek. Subsurface flow here supplies wells for downstream residents. The weir is located at the break between the fan and the steep slope above.

Remarkably close high flow levels have characterized the last three years 1998 - 2000. See Chart 2, page 49. Year 2000 peak flow @ 275m3/sec on April 28th was between 1998 and 1999 in terms of volume.

The timing was in line with all the lower valley creeks except Airy. The high coincided with heavy rain and occurred a week after warm temperatures were noted. High flow was the 4th peak of the season and 2 more rises were recorded. Water levels dropped abruptly at the end of June and the low for the year was recorded on Oct. 25 @ 0.008m3/sec. This level is the same as last year's low reading.

The peak sediment level at 50.4mg/l was also recorded on April 28th. See Chart 3, page 50. This volume is in line with previous years. Jerome's peak sediment levels range from 15 to 50 over the 4 years of the study. These values are low when compared to other creeks in the study.

Jerome's Conductivity range at 81uS/cm compares with previous years and shows the same cyclic pattern i.e. a drop in spring and rise in fall and winter. See Jerome Chart 5, page 51.

Historically, the relation between air and water for Jerome is not close and this trend continued in 2000. See Jerome Chart 6, page 51.

4.9 Winlaw Creek

Winlaw Creek drains a 40.7 square kilometer watershed that originates on the slope of Mount. Eccles to the north and borders the Pedro Creek watershed to the south. Historically the creek is noted for its sudden and dramatic shifts in the channel. This activity is due to the large amount of sediment that comes down in the spring, frequent flood events and especially lack of large woody debris. Although logging did occur in the late 1900's, Winlaw remains one of the largest least undisturbed watersheds in the Slocan Valley. The Winlaw watershed has 11 new sub-basins.

Winlaw had five main peak flow events in 2000 beginning on March 6th through June 9th. See Winlaw Chart 2, page 53. The high flow for the year was recorded on April 28th. The timing of this event was in line with Jerome, Elliot, and Hasty and the earliest recorded in 4 years of study. The event came with 32.8 millimeters of rain over 24 hours after a week of rainy days and cool temperatures. The 28th was also the day that the Poppoff dam began to break. Although the charts show the water levels dropping dramatically during mid June, this reflects lack of readings and the fact that the gauge was out of water between July and September. The low for the year at 0.066 m3/sec was reported on October 10th.

Historically Winlaw's sediment levels have not been as closely linked to flow as Airy and Bonanza. And 2000 saw this trend continue with elevated sediment levels in January.See Chart 3, page 54. The high sediment reading at 51.9 mg/l came on April 28th. This value is in line with historical sediment levels for the level of flow. A strong correlation does exist between sediment and turbidity and this trend continued in 2000. Compare Charts 3 & 4, page 54 .

Historically the cyclic relation between conductivity and flow has not been as close as other valley creeks. See Chart 5, page 55. No dramatic drops or rises in conductivity were reported between mid March and the end of April even though water levels rose dramatically. At 81.3 uS/cm the range for conductivity was in line with previous years.

Winlaw's water temperature has historically been low in relation to rising air temperatures and year 2000 saw this trend continue. See Chart 6, page 55. The highest water temperature was 10 degrees at the end of August.

4.10 Airy Creek

Logging activities were resumed in the Airy creek drainage in year 2000. Approximately 4.5 kilometers of road was built to access two cut blocks (36 hectares) adjacent to Skaha creek. In addition, a 30 hectare block located off the Mainline Airy road was cut. Six hundred meters of road was built to access this block.[8]

The hydrograph for Airy creek is the most comprehensive of all the creeks in the program, especially during the months of April to July, the high flow period. Credit for the excellent coverage of this creek goes to the reader, Kuris Raits. Kuris took daily readings for flow, air, and water during this time. Hence, daily fluctuations in these parameters can be seen. See Airy Chart 6 & 3, pages 59 & 58 .

. Airy showed six distinct discharge peaks during the spring and summer of 2000 and two smaller rises in the fall. The peak flow was reported on June 14th at 13.039 m3/sec. This is very close to 1998 when flow levels reached 13.33 on 5/7. The high for the year was proceeded by rain but warm temperatures were not a major factor. A low flow of 0.162 m3/sec was reported on October 15th. This was the latest reported flow in four years of study.

Airy's discharge pattern is similar to smaller debris flow creeks with sudden rises and drops.
At 21.6 mg/l on June 14th, Airy's peak sediment is in line with 13.8 mg/l seen in 1998 with similar flow levels See Chart 3, page 58. Airy shows a strong relation between flow and sediment documented in previous years. A strong or tight relation also exists between turbidity and sediment.
Compare Charts 3 & 4, page 58. .

Airy shows the lowest conductivity level of all the creeks in the study. It also shows the lowest range in conductivity. See Chart 5, page 59. The cyclic yearly pattern of high conductivity in fall and a rapid drop in the spring can be seen on chart five. It is interesting to note that conductivity drops sharply at the beginning of spring with the first rise in discharge then continues to drop slowly as summer progresses. A gap in readings on chart five reflects a break in the program.

Airy's air and water temperatures are more strongly linked than Winlaw's. Water temperatures rose to 14 degrees C on three occasions at the end of July. See Airy Chart 6, page 59.

4.0 Results and Discussion cont.'

4.11 Total and Fecal Coliforms

Background

Recent updates in MELP water quality objectives have resulted in revisions to standards for Total and Fecal Coliforms. In the past, testing for potability involved both Total and Fecal organisms . However, the Total Coliform test can include organisms that are associated with decaying plant material. These organisms have been considered to be poor indicators of animal or human contamination in natural waters.

Although Fecal Coliforms are not considered good indicators of risk for illness to digestive systems, the specific nature of this test i.e. growth at elevated temperatures does give a more reliable indicator of recent warm blooded animal contamination.

Historically, Fecal Coliforms in food have been associated with high levels of E.coli. In natural surface waters, organisms such as Enterobacter, Klebsiella and Citrobacter can be found in fresh pollution in the absence of E. coli ; hence, the need to confirm for E.coli when Fecal organisms are found.

The above reasons may explain the decision by MELP to specify Fecal Coliforms <u>and</u> E.coli as the best indicators of water potability [9]

Because of lengthy confirmation tests and the variability of the E.coli organism, most water laboratories do not routinely check for E. coli. Historically, the four biochemical tests - Indole production, Methyl Red acidity, Vogues Proskeur and utilization of citrate (collectively called the IMVIC tests) have been recognized as the standard for *partial* or *presumptive (pres.)*

identification for E.coli.

In consultation with MELP, it was determined that this year's testing would include IMVIC tests and that the tests would be performed on organisms that test positive for the presence of Fecal coliforms.

Sampling Regime and Methodology

Last year two sampling sets of five over thirty days were taken, the first in the spring and a second set in the fall. A review of the data indicated generally low counts in the spring due to low water temperature. Higher counts in the fall related to warm water temperatures and/or "flushing" due to rain events.

This year, only one set of 5 samples was collected over 30 days. This set was collected during late summer when water temperatures were high. Collection was done on 7 creeks including Harris, Bartlett, Hasty, Elliot, Jerome, Winlaw and Airy.

As in previous years, an attempt was made to sample strategically e.g. immediately after heavy rain or during warm temperatures. All samples were collected and brought to the lab immediately. They were transported with ice packs in a cooler and put on test the same day.

Tests were performed using methods described in the Standard Methods for the Examination of Water and Wastewater, 17th edition, 1989 published by the American Public Health Assoc. Specifically, sections 9225D for the Membrane Filtration procedure and 9225E 1,2,3,4 for the IMVIC tests.

Due to problems with the Vogues Proskauer test, in some instances the results from this test are not reported.

4.12 Total and Fecal Coliform

Review of Findings 2000 *See Table 3 & 4, page 64 & 65.*

1. In previous years, Harris Creek showed occasional low fecal coliform counts that were accompanied by high sediment readings. In 2000, the counts ranged from 1 - 3 cells/100ml in 3 out of the 5 samples. Sediment levels were not elevated on days near the counts. However, rain was noted on 2 of the 3 days that had counts. A slight rise in water level was also noted at the weir. Regarding the presence of presumptive E.coli (pres.E.coli), five samples were brought through IMVIC testing, 3 were positive.

2. Historically, Bartlett Creek has shown low (0 -1cells /100ml) counts for all seasonal samplings except spring 1998. It has also been lower than Harris and this trend appears to continue in 2000. Only one sample of 5 tested had a count (2 cells per 100ml). This sample, on Aug 21st was taken just after rain and a very slight increase in sediment. Also, a warming trend in air temperatures was noted.
   Harris, the smaller of the two New Denver Flats Creeks surfaces and meanders on the Flats. Bartlett has one channel that originates in the Flats. The second and larger descends as a debris flow channel down the face of Idaho Peak. Surface waters likely pick up organic material and bacteria en route through the Flats. Harris's single channel and longer route through the Flats may explain the higher counts.

3. Hasty Creek has historically shown fecal coliform counts in the range of 2 - 15 cells/100ml in all seasons when testing was done. This year, the first sample in the series of 5 taken August 21st after a rain event and during warm weather was greater than 300cells/100ml for Fecal Coliforms. Residents were warned to boil their water. Because of the high count and overgrowth on the plate, isolation of a pure culture for IMVIC tests was difficult. For this reason, only 2 IMVIC tests were reported and both were negative for pres. E.coli.
   The Hasty Creek gauge is downstream from the confluence of two channels - one that flows through wetland with organic material and a second, larger channel that originates high in the Vevey Watershed. This channel flows briefly through the wetlands, joins the wetlands channel and exits approximately 100 meters above the gauge.

In the interest of determining the origin of the high Fecal Counts, samples were collected from wetland streams on Aug 25 and Sept 6th. In fact, the Hasty - Vevey Stream had higher Fecal counts than the wetlands stream. Also, organisms isolated from warmer water (Aug 21st sampling) showed fewer pres. E.coli positive tests. Hence, further investigative testing is recommended for 2001.

4. Historically, Elliot Creek has had one of the lowest fecal coliform count. Of the 37 samples collected over 3 years, only 5 show fecal counts and all the counts are less than 2cells/100ml. This year, the first 2 samples showed 1 Fecal Coliform count. The August 21st sample was positive for pres. E.coli, the second was negative. As mentioned in previous reports, Elliot flows underground just above the sampling station. Its temperature remains cool, even in mid summer.

5. Historically, Jerome Creek also has shown very low fecal counts. Of the 47 samples collected over 4 years, only 5 have shown fecal coliforms and only one of those had a count higher than 2 cells/100ml.

6. Historically, Winlaw Creek has shown occasional counts above 2 cells/100ml for Fecal Coliforms. This year, the first two samples taken on August 21st and 25th each had 2 Fecal Coliforms per 100ml.

9. Historically, Airy Creek has shown occasional greater than 2/100ml counts of fecal coliforms - usually in the spring after rain events and when water temperatures rise. This year Airy had counts for all samples - 1 to 2 for the first 3 sets, 4 for the fourth and 3 for the fifth. Of the 4 samples checked for pres. E.coli, 2 were positive.

Summary of Fecal Coliforms and presumptive Positive E.coli

A review of the data for Fecal Coliforms and Presumptive E.coli indicates continuation of trends seen in previous years. Namely, 1. Increased counts after rain events. 2. Slightly increased counts with warmer temperatures. 3. Tendency for each creek to have consistently low or high counts i.e each creek has its own normal level of Fecal Coliforms.

Regarding the incidence of presumptive E.coli the following limited observations can be made on the study creeks:

1. Presumptive E.coli can occur in any creek occasionally, normally at low (1-2 cells/100ml) levels.
2. Within a population of Fecal Coliforms and for the creeks that showed higher levels of these organisms (like Harris and Airy), 50% percent of organisms tested were positive for Presumptive E. coli

3. There does not appear to be a correlation between Presumptive E.coli presence and increased water temperature.

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5.0 Quality Control

This year of 2000, instead of doing internal duplicates (technically called “replicates” by the APHA) where the same sample is analyzed twice, two separate samples were taken at the same time at the creek and analyzed separately. This was called an external duplicate(or technically called “duplicate” by the APHA) The results are tabulated in TABLE 5 for the year 2000, page 67.

Also some samples were forwarded to ASL (Analytical Service Laboratory Ltd) as in previous years. These values are also shown in TABLE 5, page 67.

As in previous years, the external quality control program in the form of an inter-laboratory study was done under CAEAL, The Canadian Assoc. of Environmental Analytical Laboratories (CAEAL). Check samples for fecal and total coliform, suspended sediment and conductivity were analyzed at Passmore Laboratory and compared with other Canadian laboratories. The CAEAL scores to date are presented in TABLE 6, page 69 and the full report detailing reference, reported, AD, Z score and points assigned is given in the Appendix in the
year 1999 report.

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Year 4 Report

Appendix

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Legend for Geological Map Units

gn, Pgn, uKgn:	Gneiss and granodiorite - gniess of Vahalla Complex (Cretaceus, early tertiary and older)
PE g:	Quartz monzonite of Valhalla Complex (early Tertiary)
mJn, mJp:	Nelson batholith - grandiorite (Jurassic)
Kg, Kq:	Granite, granodiorite quartz monzonite (Cretaceous)
TrS:	Slocan Group - slate, argillite, limestone (Triassic)
Ije:	Elise formation, Rossland Group (Jurassic) - andesite, basalt

Map is not to any standard scale
Each map sheet is 11.11 km in the N-S direction