MEAGER MOUTAIN GEOTHERMAL PROJECT
STATUS OF ENVIRONMENTAL STUDIES
BASELINE DATA COLLECTION PROGRAM

Prepared for

B.C. Hydro & Power Authority

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Vancouver, British Columbia V6B 4T6

by

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In Association with

VTN Consolidated Inc.

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THE STUDY TEAM

This report was compiled by Reid, Crowther & Partners Limited and VTN Consolidated Inc. The expertise of this study team combined the environmental, economic and design experience of VTN staff on geothermal projects in the U.S.A. and Central America with the experience of Reid, Crowther & Partners on a variety of environmental and design studies throughout western Canada.

Reid, Crowther & Partners managed the environmental program and carried out the air quality and water quality studies under the expert advise of VTN Consolidated Inc.. VTN Consolidated also carried out the slope stability studies.

The key personnel included Graham Seagel and Carolyn E. Trindle with guidance from the B.C. Hydro project engineer Josef J. Stauder.

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SECTION 1
SUMMARY

This report is a compilation of environmental inventory data collected during the summer of 1979 from the Meager Mountain geothermal project area. The environmental inventory constitutes one element of the exploration program to determine the feasibility of developing a geothermal resource in the Meager Creek and Lillooet River valleys in southwest British Columbia.

The Meager Mountain geothermal project is a cooperative program involving the B.C. Hydro and Power Authority, Department of Energy, Mines and Resources of the Federal Government and the Provincial Ministry of Energy, Mines and Petroleum Resources. The program has been directed by B.C. Hydro while the Department of Energy, Mines and Resources has carried out independent studies closely coordinated with the project.

Located 160 km north of Vancouver, the geothermal project area is set near the Meager Mountain volcanic complex in the Coastal Mountains of south western British Columbia. Indications to date are that Meager Creek and the upper Lillooet River valley may overlie two separate geothermal reservoirs.

The 1979 environmental studies for the Meager Mountain geothermal project were undertaken to provide preliminary data in the establishment of an environmental baseline for the project, for two purposes, as outlined below.

1) Environmental data was required during the exploration phase because of naturally occurring slope instabilities and hydrogen sulphide releases to the atmosphere. As a result studies of slope stability and H_2S emissions were initiated.

2) Should a resource be proven, there would be a need to establish a long term data base in order to enable environmental assessments of future geothermal development in the study area. This would be particularly relevant in the case of hydrology, meteorology, water quality and air quality. Hence, a baseline inventory of these aspects was initiated in the 1979 study.

The report outlines the methods used in the field and presents the data gathered, with the exception of the meteorological data which was not compiled at the time of writing.

Intensive field studies were carried out from June 18 to September 19, 1979 with additional data collection in November and December 1979. Principal study constraints were limited access in rugged high relief country, no information of resource characteristics, no power source (other than at the B.C. Hydro Camp) and lack of environmental data for the study area.

The findings of the 1979 environmental studies are preliminary at this time, and should be combined with further inventories in order to properly describe baseline conditions in the study area.

The results to date 1) verify the natural occurrence of H_2S in the study area, particularly in Job Creek, 2) showed high total sulphation levels in Job Creek, 3) identify areas of slope instability of varying types and levels of concern and 4) show various physical-chemical characteristics of the surface waters at five sites for three sample periods in June, August and December 1979. Various incidental observations have also been presented in the report, based on casual observations of wildlife, vegetation, fisheries and recreation.

SECTION 2
INTRODUCTION

2.1 GENERAL

This report is a compilation of environmental inventory data collected during the summer of 1979 from the Meager Mountain geothermal project area. The environmental inventory constitutes one element of the exploration program being undertaken by B.C. Hydro & Power Authority to determine the feasibility of developing a geothermal resource in the Meager Creek and Lillooet River valleys in southwest British Columbia. Official authorization to proceed with the environmental study was provided by B.C. Hydro on June 1, 1979 by Purchase Order 947-200. Collection of environmental data commenced on June 18, 1979 and continued throughout the summer until September 19, 1979. Additional field visits were undertaken in early November and mid December.

2.2 PURPOSE OF STUDY

The 1979 environmental studies for the Meager Mountain geothermal project were undertaken in order to provide baseline information for two purposes, as outlined below.

1) Environmental data were required during the exploration phase to assess naturally occurring slope instabilities and hydrogen sulphide releases to the atmosphere. As a result studies of slope stability and H_2S were initiated.

2) There would be a need, should a resource be proven, to obtain long term information in order to enable environmental assessments of future geothermal development

in the study area. This would be particularly relevant in the case of hydrology, meteorology, water quality and air quality. Hence, a baseline inventory of these aspects was initiated in the 1979 study.

The studies carried out comprise the initial investigations in establishing a baseline which, as further data becomes available, would permit a valid characterization of ambient conditions in the study area and, ultimately, the evaluation of impacts related to a geothermal development in the Meager Mountain area.

2.3 GENERAL SETTING

Located 160 km north of Vancouver, the geothermal project area is set near the Meager Mountain volcanic complex in the Coastal Mountains of south western British Columbia (Figure 1). Meager Creek and the upper Lillooet River valley appear to overlie two separate geothermal reservoirs.

Generally, the study area (Figure 1) is characterized by steep rugged topography ranging from 450 m to 2600 m in elevation. The mountain tops above 2000 ~ are frequently glaciated, while the lower slopes show evidence of earlier more extensive glaciation with glacial outwash, valley trains and colluvium. Valley slopes are frequently subject to instabilities with avalanches and slides.

In alpine regions, meadows of alpine tundra flank the glaciers. The steep walled valleys support subalpine and coastal coniferous forests with dense alder thickets in the slide areas. Commercial stands of timber are present and clear cut lots extend up the valley for 13 km along Meager Creek and 4 km along the Lillooet Valley above Meager Creek confluence (Section 4).

Meager Creek and the Lillooet River are glacial in origin with snow and ice melt, rainfall and groundwater discharges contributing to the flow. The major streams are generally very turbid and can be subject to rapid and dramatic diurnal variations in flow due to melt water input. The stream channels are generally entrenched with large boulder substrates and waterfalls through steep gradients, or braided over extensive coarse gravel flood plains which have lower gradients.

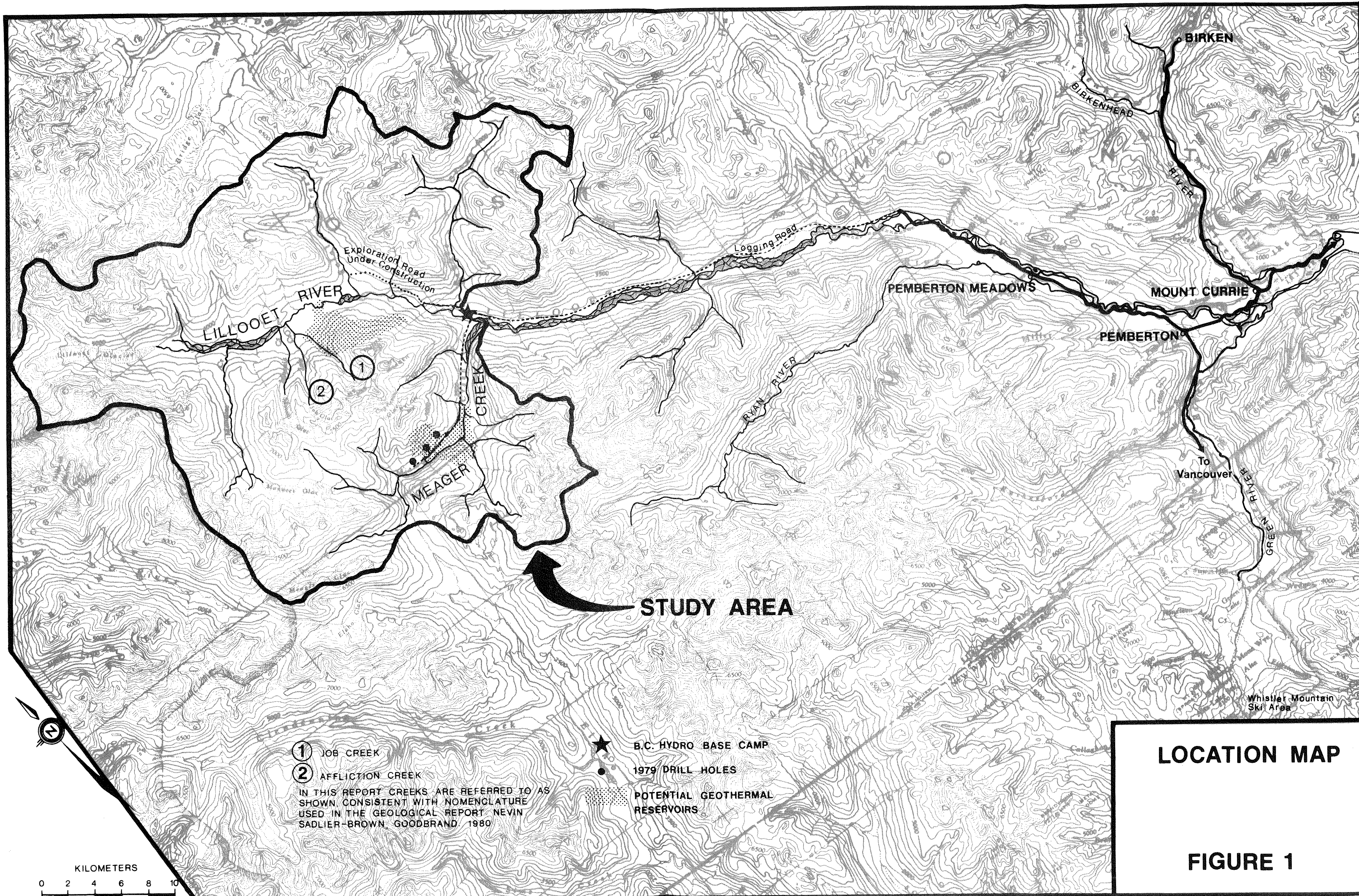
The nearest settlement is approximately 40 km south in the Lillooet River valley near Pemberton Meadows, where the forest industry and agriculture are the main commercial activities. The community of Pemberton is approximately 10 km further south. Within the study area logging is the primary activity, with some mineral exploration and recreation activity. Further background information on the Pemberton area is found in Pemberton - The History of a Settlement[10].

Access within the study area is via private logging roads for 12 km along the Meager Creek valley, and 10 km along the Lillooet River valley from near the confluence of the two streams.

Examples of the study area setting are shown in Plates 1, 2 and 3, Appendix A.

2.4 PROJECT DESCRIPTION

The Meager Mountain geothermal project is a cooperative program involving B.C. Hydro and Power Authority, the Department of Energy, Mines and Resources of the Federal Government and the Provincial Ministry of Energy, Mines and Petroleum Resources.



LOCATION MAP

FIGURE 1

The exploration program has been directed by B.C. Hydro while the Department of Energy, Mines and Resources have also carried out independent studies closely coordinated with the project. The firm of Nevin Sadlier-Brown Goodbrand Ltd. (NSBG) have been the prime consultant involved in the exploration work.

Previous exploration work, which began in 1973, involved geological mapping, geochemistry, geophysical surveys and shallow drilling. This work identified two potential geothermal reservoirs, as shown on Figure 1.

During 1979 the exploration work involved geophysical surveys on the north side of the Meager Mountain complex, along the Lillooet River valley. In addition, a drilling program was carried out on the south side in the Meager Creek valley at approximate locations shown in Figure 1. Additional activities included the establishment of a camp and start of construction of an access road to the north side of the complex. A comprehensive report on the 1979 exploration and drilling activities is being prepared by NSBG.

The environmental program began in 1978 with preparation of an Environmental Reconnaissance report which provided an insight to the types of environmental concerns which could arise from such a project based on experiences elsewhere in the world.

2.5 APPROACH AND SCOPE OF STUDY

Three principle factors affected the approach and scope of this study:

1) A review of existing and available information contained in the Environmental Reconnaissance Report[9] showed that little data exist which is pertinent to the designated areas of inquiry for this study.

2) To date a geothermal resource has not been proven, thus specific project facilities, including location of the production wells, piping and power plants, cannot be defined to permit detailed environmental assessment at this time.

3) The study area is rugged and surface access difficult, necessitating careful assessment of field logistics.

In view of these factors the environmental parameters chosen for study reflect the preliminary nature of the study. Consideration was given to future environmental assessment of a possible geothermal project in the Meager Mountain area, in part based on experiences at other geothermal project sites outside Canada.

Due to the lack of prior information, the unproven nature of the resource and the rugged conditions, a degree of caution was exercised with respect to siting of sample points. Hence, no permanent structures were established. It was anticipated that the experience and information from this study would enable establishment of the most appropriate sample stations in the future.

To facilitate the various manual readings and equipment inspections, one member of the study team was located in the field for the duration of the field progam. Periodically various specialists visited the study area to establish sample sites, collect samples or maintain equipment.

The principal study period extended from June 18, 1979 to September 19, 1979 and work concentrated on slope stability, meteorology, air quality and water quality. The presence of a study team member in the field for this period of time enabled the collection of various incidental items of information which are presented in section 4 under the heading of "Other Findings". This information does not represent the results of any formal study of the wildlife, vegetation, fish, or recreation. However, the inclusion of such information may assist planning any future studies in these disciplines.

The approach and scope of the primary study disciplines are briefly discussed below.

Meteorology - Baseline monitoring of meteorologic conditions in the study area was undertaken to assess the capacity of the atmosphere to disperse possible air borne contaminants. Should geothermal development proceed in the Meager Creek area, long term meteorological records would be important for impact assessment studies.

The program involved monitoring of wind speed and temperature at various sites which were selected based on initial expectations of vertical and horizontal wind patterns. At selected sites rainfall was recorded.

Due to the difficult ground access into the Lillooet River valley beyond Pebble Creek, the 1979 work was restricted to Meager Creek valley and the B.C. Hydro base camp.

Since no meteorological information existed for the study area, it was anticipated that the data from this program would enable modification and refinement of meteorologic study in subsequent years. The meteorologic program for 1979 is therefore preliminary in nature, aimed at future evaluation of any potential air quality impacts once a resource is proven and its characteristics known.

Air Quality - Baseline monitoring of air quality parameters was undertaken because it would be important to establish ambient conditions prior to project development, provide design data, to enable impact assessment and to design long term monitoring. However, natural emissions of hydrogen sulphide already occur in the study area, and this parameter has been of some concern in other geothermal projects, such as the Geysers in California. The preliminary program for 1979 concentrated on an initial study of the natural occurrence of H_2S and levels of total sulphation in the study area, with the primary objective of delineating possible problem areas for field exploration drilling crews.

In addition to H_2S and total sulphation, an attempt was made to monitor particulate matter originating from logging operations and travel on gravel roads.

Constraints on the work involved limited access and lack of a reliable power supply. Hence, to permit a general characterization of air quality in the study area equipment was selected which was inexpensive, easily transported and installed, and did not require a power source.

It was expected that sufficient information would be available at the end of the 1979 program to refine the siting and equipment selection with a view to longer term data needs.

Water Quality - Baseline monitoring of water quality was undertaken to initiate a physico-chemical background profile of surface waters in the area. This profile, once complete, could be used in future studies to assess the implications of a potential geothermal project in the study area.

The study involved three sample periods (beginning in June 1979) at five sites. The sites were distributed above and below the potential geothermal reservoir areas in Meager Creek and Lillooet River valleys. The samples were analysed for a variety of physico-chemical parameters.

In addition, water level data was obtained at two easily accessible sites to permit correlation of results to streamflow characteristics.

The main constraint to establishing monitoring points was the nature of the river channels. This factor and the difficult access particularly influenced selection of the water level monitoring points which were limited to two locations.

Slope Stability - This study was carried out because various forms of naturally occurring slope instabilities are evident in the study area. The work involved a brief field reconnaissance and aerial photographic interpretation of areas adjacent to access, exploration and potential geothermal reservoirs.

The study findings will provide a basis for future considerations concerning project development and similar related studies. In addition, it will assist exploration personnel to avoid critical areas.

The findings of this work (prepared by VTN Consolidated, Inc.) are contained in a separate report and summarized herein.

Other Findings - During the course of the field program the environmental study personnel and the exploration staff made various casual and miscellaneous observations. The observations were recorded and are presented herein simply as background information to assist with future study planning.

This information was recorded because there are very little existing data for the area. The main observations were of wildlife, fish, recreation and vegetation. It is emphasized, however, that the data are the result of informal observation.

In addition, a land use map was prepared based on an initial interpretation of the 1964 aerial photography and updated using September 1979 air photography.

SECTION 3
PHYSICAL SYSTEMS

3.1 METEOROLOGY

3.1.1 INTRODUCTION

Several years data would be required to sufficiently document baseline conditions and assess the effects of a geothermal project in the study area. The 1979 data collection program was intended to initiate this documentation and provide insights to study design for longer term needs. The 1979 meteorological study is preliminary in nature with the study rationale oriented to the purpose and scope outlined in Section 1.

Two valley bottom stations were established for monitoring temperature, precipitation, wind speed and wind direction in the Meager Creek valley and the Lillooet River valley within the study area. Three additional stations were established in the Meager Creek valley to record wind speed and direction and temperature gradients in the valley.

The field monitoring program was designed and run by the staff of the Civil and Environmental Engineering Department (C.E.E.D.) of B.C. Hydro, under the direction of J. Emslie.

3.1.2 METHODOLOGY

3.1.2.1 Instrumentation

The instruments used are listed by station in Table 1.

TABLE 1: Meteorological stations and instrumentation in the Meager Creek and Lillooet River valleys, 1979.

STATION	LOCATION	INSTRUMENTATION
1	Meager Creek valley bottom, 562.4 m elev., in logging clear cut near high bluff on north side.	Cassella Model T9154 hygrothermograph, Weather Measure Model WS-755, Fischer & Porter Model 35B 1559 recording precipitation gauge.
2	Meager Creek valley, 679.7 m elev., in logging clear cut.	Cassella Model T9154 hygrothermograph.
3	Meager Creek valley, 1310.6 m elev., on bench in avalanche slope.	Cassella Model T9154 hygrothermograph.
4	Meager Creek valley, 1720.6 m elev., on rocky knoll at tree line.	Cassella Model T9154 hygrothermograph, Weather Measure Model WS-755.
Base Camp	Lillooet River valley, 432.8 m elev., in large logging clear cut, adjacent to camp.	Maximum and minimum thermometers, Meteorological Service of Canada Standard Copper Rain Gauge, Cassella Model T9154 hygrothermograph.

The climatological station at the base camp included maximum and minimum thermometers housed in a Stevenson screen and a standard copper rain gauge set in the ground in a cleared area. Records were kept using Atmospheric Environment Service charts and forms.

The Weather Measure units were installed on 3 m (10 ft.) towers and recorded temperature, relative humidity, wind direction and wind speed (Plate 5, Appendix A).

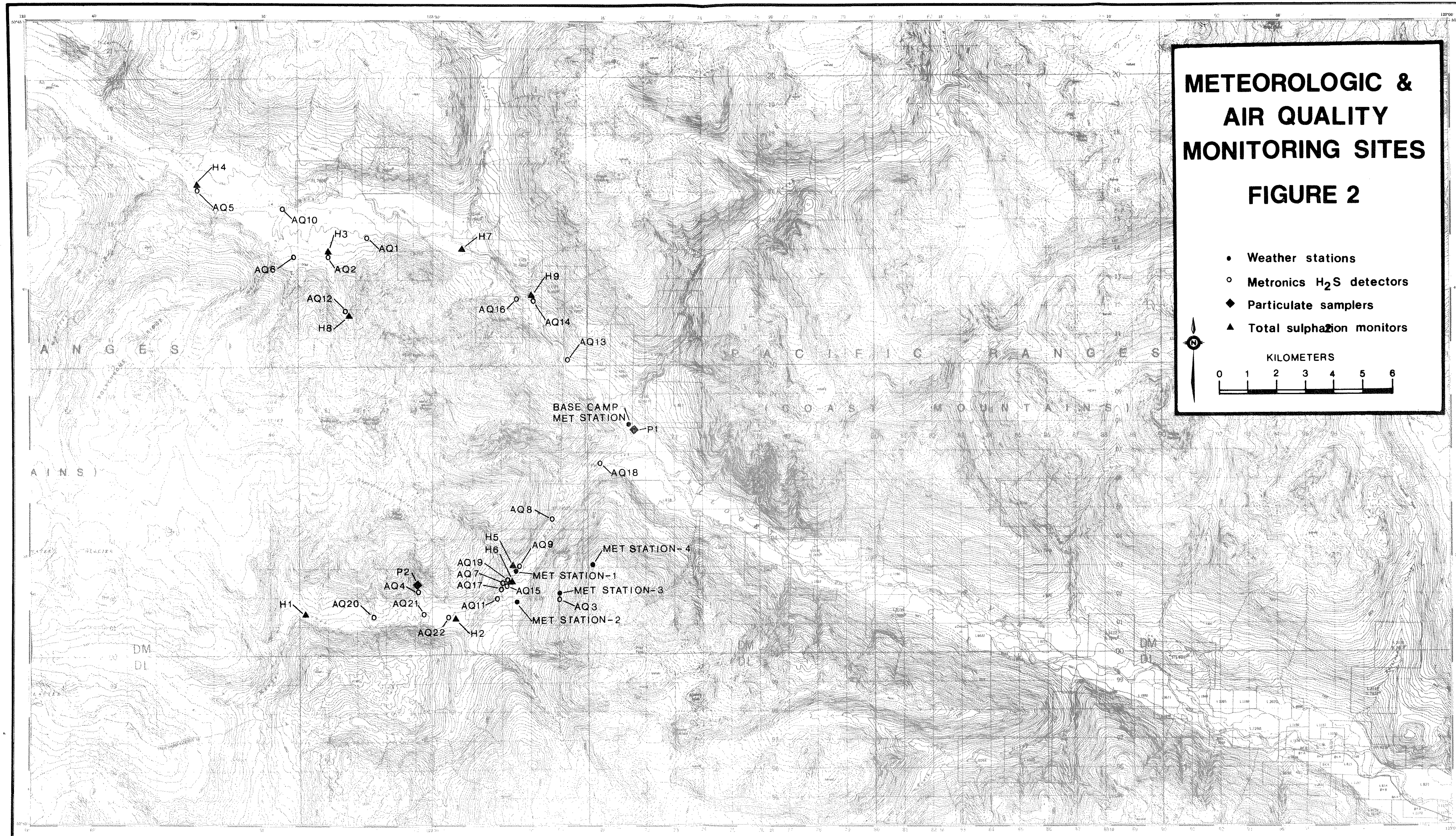
The Cassella hygrothermographs were housed in Stevenson screens levelled on tree stumps approximately 1 m above ground surface. They recorded temperature and relative humidity.

3.1.2.2 Station Locations

The location of meteorological monitoring stations are shown in Figure 2.

Site selection in the Meager Creek valley was most difficult due to the rugged and heavily wooded nature of the valley sides, thus making access by helicopter limited and very difficult. Four sites were selected and equipped as shown in Table 1. The four screens were, roughly, in line along the south side of the valley, and received approximately equal daily exposure to sunlight.

Station 3 was suspect from the outset; being on an avalanche track it was in the natural path of cold air drainage from the permanent snowfield on the ridge above. Even though the screen was positioned as high as possible on a mound of rubble at the base, the data from the instrument show that they are not compatible with those of the other three sites except through mid-day. Time and financial constraints prohibited clearing a



METEOROLOGIC & AIR QUALITY MONITORING SITES

FIGURE 2

suitable site and helicopter landing pad on any of the more desirable locations at that elevation.

At the base camp, instruments were set up on a rise approximately 80 m east of the trailers. The site is located within a large clear cut area with the nearest trees over 300 away.

3.1.2.3 Procedures

Meteorological data collection included daily operation of the manual climatological station at the base camp and regular servicing, chart replacement and calibration of recording instruments throughout the study area.

At the base camp station, maximum and minimum thermometers were read and reset, and precipitation measured manually at 0600 hours and 2000 hours each day from July 3 to September 26. Readings were taken and results logged according to Atmospheric Environment Service of Canada procedures.

The Cassella hygrothermographs were inspected on a weekly basis. Charts were changed, timers were reset and differences in hygrothermograph temperatures relative to concurrent sling readings were noted. The Weather Measure units and the Fischer and Porter precipitation gauge were inspected every second week and serviced as required.

All readings and charts were returned to the offices of C.E.E.D. of B.C. Hydro for data compilation.

3.1.3 RESULTS

At the time of writing the data had not been fully compiled or charts transcribed. Consequently results cannot be properly presented at this time. The 1979 results will be presented in conjunction with 1980 data to provide a preliminary description of the baseline meteorological conditions of the study area.

3.2 AIR QUALITY

3.2.1 INTRODUCTION

The 1979 air quality study focused upon the ambient hydrogen sulphide (H_2S) levels of the study area. While other gaseous emissions may be associated with development of a geothermal resource in the area, the known natural occurrence of H_2S, lack of existing air quality data and potentially toxic nature of H_2S were the primary reasons for this approach. In addition, H_2S releases have occurred in association with other geothermal developments, notably the Geysers in California.

As a first step toward establishing the ambient levels of H_2S in the study area and identifying the source areas, the 1979 study utilized widespread distribution of monitors in order to establish presence or absence of H_2S. The main areas of interest were Job Creek, where H_2S is frequently evident (by odor), Meager and Pebble Hot Springs, and the two potential geothermal reservoir areas.

3.2.2 METHODOLOGY

3.2.2.1 Instrumentation

Three types of monitors were used in the study as noted below:

Hydrogen Sulphide - H_2S strips - manufactured and analysed by Western Industrial Laboratories Limited, and supplied by Western Research and Development Limited.

- Metronics Colortec cards - chemically treated pads which, when exposed to H_2S, change color in proportion to dosage. Supplied by Metronics Assoc. Inc. of Santa Clara, California.

Total Sulphation - Henry Plates - manufactured and analysed by Western Industrial Laboratories Limited, and supplied by Western Research and Development Limited.

Particulates - Model 2000H Hi-Vol by General Metal Works. Supplied, installed and analysed by C.E.E.D. of B.C. Hydro.

The Metronics Colortec cards were housed in polyurethane tubes, suspended vertically with a cap on top and open at the bottom.

The H_2S strips and Henry Plates were housed in wooden louvred boxes containing one of each type of detector (Plate 4, Appendix A). This system is commonly used on a continuous basis in Alberta around facilities such as oil refineries (pers. comm. L. Bergoray, Alberta Environment). It is an economic method which Alberta Environment officials use to identify the requirement for more specific and specialized monitoring to investigate a problem. Generally, this need arises when values of 0.5 and 0.1 mg/100 sq.cm/day of SO_3 equivalent are attained for total sulphation and H_2S respectively (pers. comm. L. Bergoray). This value is the result of much experience with the use of equipment and is not theoretically derived.

These monitors for H_2S and total sulphation were selected because they are readily portable, cost effective and do not require a power source.

3.2.2.2 Station Locations

The siting of monitors is shown in Figure 2, and reflects the main areas of interest as well as the expected dominant up or down valley wind movements. The Hi-Vol particulate samplers required a power source and were of necessity located at the drilling rig and at the base camp.

The H_2S monitoring sites were identified following a brief aerial reconnaissance. Within the general siting objectives noted previously, individual sites were located so that they could be reasonably accessible on the ground or approached using a helicopter in more inaccessible areas.

At each site an attempt to gain maximum exposure to air movement was considered. Monitor housings were usually affixed to limbs of trees which limited exposure on at least one side, or occassionally they were located at ground level if treed sites were excessively sheltered. A summary of each station location is given in Appendix B.

3.2.2.3 Procedures

The H_2S and total sulphation monitors were set up June 18 and 19, 1979 and operated continuously until early September 1979. The H_2S strips and Henry Plates were changed at approximately thirty day intervals to give 3 sample periods. Each sample, upon removal from the shelter, was labelled, sealed in polyurethane bags, and sent to the laboratory for analyses.

The Metronics Colortec cards were initially left out for 30 days as no prior data on H_2S levels was available. Periodic inspections were made and if changes in color were evident the card was replaced. The need for such changes was most evident in and near Job Creek (inaccessible on the ground), where attempts were made to shorten the exposure interval. During installation and removal dates, times and color codes were noted on each card, which was then sealed in a bag and returned to the office. Several monitoring units were relocated after the first month, if no H_2S was recorded, in order to obtain information at other sites.

Whenever possible monitors were checked to ensure that they had not been disturbed. Only twice were shelters disturbed, once near Manatee Creek (Station #H4) and once in Job Creek (Station #H8) where it is suspected that animals knocked the units out of place.

The Hi-Vol samplers were installed in late August 1979 and operated over a period of four weeks. At the drill site near Angel Creek (hole #1 in 1979) the instrument was located approximately 30 m from the rig, 5 m above ground on the up-slope side. Power supply permitted only intermittent operation resulting in a sample duration of four hours. At the base camp the second Hi-Vol was located on top of one of the trailers. Continuous power supply permitted a regular monitoring schedule of 24 hour samples every three days.

3.2.3 RESULTS

The data acquired during the 1979 field monitoring program for H_2S, total sulphation and particulates is presented in Tables 2, 3, 4 and 5.

Table 2: Hydrogen sulphide concentrations using Metronics cards, Meager Creek, 1979.

STATION		DATE IN	DATE OUT	COLOUR GRADE	HOURS IN	CONC. (ppm)
NO.	LOCATION					
AQ20	No Good Cr.	July 15	July 30	0	362	0
		July 30	Aug. 11	0	291	0
		Aug. 11	Aug. 31	0	478	0
		Aug. 31	Sept. 16	0	386	0
AQ21	Nr. Angel Cr.	Aug. 9	Aug. 30	0	531	0
		Aug. 30	Sept. 16	0	386	0
AQ22	Nr. Branch 30	Aug. 18	Aug. 31	0	307	0
		Aug. 31	Sept. 16	0	384	0
AQ4	Nr. Angel Cr. @ Drill Site #1-1979	July 26	Aug. 8	0	420	0
		Aug. 8	Aug. 31	0	478	0
		Aug. 31	Sept. 16	0	387	0
AQ9	Nr. A Frame	July 17	July 21	0	97	0
		July 21	July 26	0	120	0
		July 26	Aug. 7	0	288	0
		Aug. 7	Aug. 11	0	84	0
		Aug. 11	Aug. 31	0	476	0
		Aug. 31	Sept. 16	T*	387	<0.0001
AQ8	East of A Frame	July 29	Aug. 8	0	240	0
		Aug. 8	Aug. 11	0	73	0
		Aug. 11	Aug. 31	0	478	0
		Aug. 31	Sept. 11	0	264	0
AQ3	At Weather Station #3	July 15	July 20	0	117	0
		July 20	July 26	0	144	0
		July 26	Aug. 7	0	288	0
AQ18	Nr. Mouth of Meager Creek	July 16	July 21	0	117	0
		July 21	July 27	0	144	0
		July 27	Aug. 8	0	288	0
		July 8	Aug. 11	0	73	0
		Aug. 11	Aug. 31	0	478	0
		Aug. 31	Sept. 16	0	389	0

*T = Trace

Table 2: continued

STATION		DATE IN	DATE OUT	COLOUR GRADE	HOURS IN	CONC. (ppm)
NO.	LOCATION					
AQ15	At Meager Hot Sprs.	July 15	July 21	0	114	0
		July 21	July 27	0	144	0
		July 27	Aug. 8	0	288	0
		Aug. 8	Aug. 11	T*	75	0.0004
		Aug. 11	Aug. 31	0	477	0
		Aug. 31	Sept. 16	0	386	0
AQ17	Above Meager Hot Springs	July 16	July 21	0	114	0
		July 21	July 27	0	144	0
		July 27	Aug. 8	0	288	0
		Aug. 8	Aug. 11	0	73	0
AQ19	Below Meager Hot Springs	July 16	July 21	T*	114	0.0003
		July 21	July 27	0	144	0
		July 27	Aug. 8	0	288	0
		Aug. 8	Aug. 11	0	75	0
		Aug. 11	Aug. 31	0	477	0
		Aug. 31	Sept. 16	0	386	0
AQ7	Nr. Meager Hot Springs	July 16	July 21	T*	114	0.0003
		July 21	July 27	0	144	0
		July 27	Aug. 8	0	288	0
		Aug. 8	Aug. 11	0	75	0
		Aug. 11	Aug. 31	0	477	0
		Aug. 31	Sept. 16	0	386	0
AQ11	Top of Boulder Field Nr. Meager Hot Sprs.	July 29	Aug. 8	0	240	0
		Aug. 8	Aug. 11	0	71	0
		Aug. 11	Aug. 31	0	477	0
		Aug. 31	Sept. 16	0	386	0

*T = Trace

Table 3: Hydrogen sulphide concentrations using Metronics cards, Lillooet River Basin, 1979.

STATION		DATE IN	DATE OUT	COLOUR GRADE	HOURS IN	CONC. (ppm)
NO.	LOCATION					
AQ5	Nr. Lillooet River @ Manatee Cr.	July 15	Aug. 15	0	743	0
		Aug. 15	Aug. 30	0	360	0
AQ6	Nr. Lillooet River @ Affliction Cr.	July 15	Aug. 7	0	548	0
		Aug. 7	Aug. 20	T*	312	<0.0001
		Aug. 20	Aug. 30	T*	242	0.0001
		Aug. 30	Sept. 6	0	166	0
		Sept. 6	Sept. 12	0.5	146	0.0005
AQ2	Nr. Lillooet River on Job Cr.	July 15	July 26	3.0	261	0.0036
		July 26	Aug. 7	+4.5	290	015
		Aug. 7	Aug. 15	+4.5	193	>0.0224
		Aug. 15	Aug. 20	+4.5	117	>0.037
		Aug. 20	Aug. 30	+4.5	240	>0.018
		Aug. 30	Sept. 6	+4.5	165	>0.0262
		Sept. 6	Sept. 12	+4.5	144	>0.030
AQ10	Lillooet River @ Job Cr. confluence.	July 15	Aug. 7	0	548	0
		Aug. 7	Aug. 15	0	197	0
		Aug. 15	Aug. 30	0	359	0
		Aug. 30	Sept. 12	T	312	<0.0001
AQ12	Job Cr. Nr. Glacier	July 15	July 26	+4.5	260	>0.0167
		July 26	Aug. 7	+4.5	290	>0.0149
		Aug. 7	Aug. 15	+4.5	193	>0.0224
		Aug. 15	Aug. 20	Damaged	-	
AQ1	Nr. Lillooet R. east of Job Cr.	July 15	Aug. 7	1.0	552	0.0002
		Aug. 7	Aug. 20	2.5	308	0.0018
		Aug. 20	Aug. 30	1.5	241	0.0008
		Aug. 30	Sept. 6	0.5	165	0.0004
		Sept. 6	Sept. 12	1.0	144	0.0008
AQ16	Nr. Lillooet R. falls on Falls Cr.	July 21	Aug. 7	0	409	0
		Aug. 7	Aug. 20	T*	305	<0.0001
		Aug. 20	Aug. 30	0	243	0
		Aug. 30	Sept. 12	0	312	0

*T = Trace

Table 3: continued

STATION		DATE IN	DATE OUT	COLOUR GRADE	HOURS IN	CONC. (ppm)
NO.	LOCATION					
AQ14	Lillooet River below Pebble Cr. Hot Sprs.	July 15	Aug. 7	0	547	0
		Aug. 7	Aug. 20	T*	313	<0.0001
		Aug. 20	Aug. 30	0	239	0
		Aug. 30	Sept. 12	0	312	0
AQ13	Nr. Lillooet River below road cut.	July 17	July 28	0	266	0
		July 28	Aug. 7	T*	261	0.0001
		Aug. 7	Aug. 28	T*	511	<0.0001

*T = Trace

Table 4: Hydrogen sulphide/Total sulphation for 1979

* Units = SO_3 equivalent mg/day/100 sq.cm

STATION		DATE IN	DATE OUT	TOTAL* SULPHATION	H_2S*
NO.	LOCATION				
H4	Nr. Lillooet River @ Manatee Cr. (AQ5)	July 15	Aug. 7	0.037	N.D.
		Aug. 7	Aug. 30	0.016	0.007
H3	Job Cr. Nr. AQ2	July 15	Aug. 7	0.200	0.019
		Aug. 7	Aug. 30	0.277	0.063
		Aug. 30	Sept. 12	0.442	0.134
H8	Job Cr. Nr. glacier	July 15	Aug. 7	1.506	0.967
		Aug. 7	Aug. 30	4.397	0.688
		Aug. 30	Sept. 12	4.903	0.266
H7	Lillooet River above confluence with Salal Cr.	July 15	Aug. 7	0.046	N.D.**
		Aug. 7	Aug. 30	0.038	0.011
		Sept. 12	Sept. 12	0.086	0.018
H9	Below Pebble Hot Springs (Nr. AQ14)	Aug. 30	Sept. 12	0.161	0.037
H1	Meager Cr. @ toe of Devastation Slide	July 15	Aug. 7	0.016	0.011
		Aug. 7	Aug. 30	0.098	0.013
		Aug. 30	Sept. 12	0.184	0.010
H2	Km. 10 Nr. Meager North Main Rd.	July 16	Aug. 8	0.018	0.004
		Aug. 8	Aug. 31	0.016	0.011
		Aug. 31	Sept. 16	0.072	Nil
H5	Nr. A Frame (AQ9) and weather station	July 16	Aug. 8	0.053	0.005
		Aug. 8	Aug. 31	0.016	0.013
		Aug. 31	Sept. 16	0.032	0.032
H6	Below Meager Hot Springs (Nr. AQ19)	July 16	Aug. 8	0.029	N.D.**
		Aug. 8	Aug. 31	0.024	Nil
		Aug. 31	Sept. 16	0.084	0.011

**N.D. = No Data

Table 5: Results for Hi-Vol particulate samplers, August and September 1979, from B.C. Hydro and Power Authority

PRE-SET EXPLOSURE DATES		DUST COLLECTED (mg/m^3)	
FROM 12:00 A.M.	TO 12:00 A.M.	BASE CAMP (P1)	DRILL SITE (P2)
Aug. 25/79	Aug. 26/79	23.2	-
Aug. 28/79	Aug. 29/79	56.3	28.7
Aug. 31/79	Sept. 1/79	22.3	-
Sept. 3/79	Sept. 4/79	3.68	-
Sept. 5/79	Sept. 6/79	-	7.78
Sept. 6/79	Sept. 7/79	4.95	-
Sept. 8/79	Sept. 9/79	-	8.66
Sept. 9/79	Sept. 10/79	5.12	-
Sept. 12/79	Sept. 13/79	10.8	14.0
Sept. 15/79	Sept. 16/79	29.1	-
Sept. 17/79	Sept. 18/79	-	8.47
Sept. 18/79	Sept. 19/79	19.0	-

These results are insufficient to properly describe the ambient conditions in the study area, especially without the meteorological data. However, the high levels of H_2S and total sulphation observed in Job Creek valley indicate that specific and more detailed investigation is required. In addition, while the Metronics Colortec cards did not always detect H_2S levels, the H_2S strips did so at all sites at least once. This suggests a low ambient level of H_2S throughout the main valleys in the study area.

The particulate levels recorded are indicators of the local conditions at the respective sites. However, none of the dust loadings exceeded P.C.B. standards of either the Level A value for the ambient air quality guidelines for the one year geometric mean (60 mg/m^3) or the maximum 24 hours (150 mg/m^3).

For reference purposes the relevant federal and provincial guidelines are presented in Table 6.

3.2.4 DISCUSSION

The results of the 1979 air quality study are insufficient to properly describe existing conditions attributable to the parameters monitored. However, certain factors emerge.

In an overall context, if the ambient H_2S levels result from sources directly or indirectly associated with any potential geothermal resource in the study area, then exploration or production hole drilling should be equipped to properly safeguard exploration personnel from H_2S released by this activity and to prevent uncontrolled release of H_2S to the atmosphere. This is especially relevant to possible project activities in Job Creek valley.

Table 6: A summary of ambient air quality guidelines and levels for H_2S and SO_2

A. BRITISH COLUMBIA (Source: P.C.B., 1975)

PARAMETER	REFERENCE PERIOD*	LEVEL (ppm)		
		A	B	C
SO_2	1 hour	0.17	0.34	0.34**
	24 hours	0.06	0.10	0.14
	1 year	0.01	0.02	0.03
H_2S	1 hour	0.01	0.02	0.03
	24 hours	0.0025	0.0037	0.005

* Average values over these periods. For petroleum and chemical industries these are maximum values (except for ** which is 0.5 in B.C.)

B. FEDERAL CANADIAN (Source: Environment Canada News Release, 1976)

PARAMETER	REFERENCE PERIOD*	LEVEL (ppm)		
		Max. Desired Level	Max. Accept. Level	Max.Tolerable Level
SO_2	1 hour	0.17	0.34	-
	24 hours	0.06	0.11	0.31
	1 year	0.01	0.02	-
H_2	1 hour		0.01	-
	24 hours		0.0031	
	Not Specified	0.0006		

* Average values over these periods.

In Job Creek where the highest H_2S and total sulphation levels were recorded, further study should be considered to better delineate not only ambient levels but worker safety (due to natural conditions).

The Colortec cards recorded one incident of a five day average of greater than 0.037 ppm in Job Creek. This is higher than the British Columbia guidelines at any of levels A, B or C for 24 hours or one hour[1] (Table 6). During this period, the one hour concentrations may have been considerably higher.

It is also worth noting that the total sulphation levels for Job Creek (ca. 4.9 mg/100 sq.cm/day SO_3 equivalent) were high compared to results near facilities monitored by similar equipment in Alberta where values of 2.0 are normally considered high (pers. comm. L. Bergoray). However, no significant effects on vegetation were noted. Lichens of unknown species were observed at various locations on the valley floor of Job Creek. Certain species of lichens are early indicators of SO_2 presence.

Monitors along the Lillooet River valley up and downstream of Job Creek suggest that the levels of H_2S and total sulphation in Job Creek disperse quickly in the main Lillooet River valley.

The H_2S strips and Henry Plates, while yielding data with atypical units, may continue to provide long term information on changes and trends in H_2S emissions.

3.3 SLOPE STABILITY

This portion of the 1979 environmental program has been compiled as a separate report[2]. However, a summary of the study is included below. Maps were prepared but are not reproduced herein.

3.3.1 INTRODUCTION

The objective of this element of work was to indicate areas where future geothermal exploration and development activities would be constrained by geologic hazards, namely failing slopes. To accomplish these objectives the Meager Mountain geothermal exploration area was divided into three study areas: Meager Creek, Job Creek and Lillooet River.

Certain geologic parameters were then compiled and evaluated according to their effect on slope stability, and these parameters were presented on a matrix in order to evaluate six surficial units and three generalized bedrock units. Each of these nine units was then assessed by twelve parameters which may render a particular geologic unit more or less stable. This information was then compiled and presented on a matrix. At the lower margin of the matrix, each geologic unit was assigned a letter from A (best) to F (worst) to indicate relative stability. Some received a variable rating (such as B to C), depending upon local site conditions, especially slope angle and vegetation cover.

A terrain rating map was subsequently derived by combining geologic information with the information presented on the matrix to show overall slope stability. The terrain rating map shows that two areas may be equally rated, but for different geologic reasons, such as occurs with talus chutes and unaltered volcanic rocks. The former is a known landslide area, while the latter has a potential for landsliding. Both are rated "C to D" for overall suitability.

3.3.2 METHODOLOGY

The investigations involved ground and aerial field reconnaissance, aerial photo interpretation, review of published and unpublished literature, and conversations with appropriate persons familiar with the area and issues under investigation.

The Meager Creek Study area was mapped for slope angle and surficial material in greater detail than were the Job Creek and Lillooet River areas.

During field reconnaissance, a Brunton compass was used to determine slope angles, stream gradients and dips and strikes of rock units. Surficial material was examined using a hand lens, acid (to test for carbonate content), a pocket knife to test hardness, and a rock pick.

Aerial reconnaissance was done using a helicopter and still photography. Stereo aerial photographic interpretation was done in-house using a stereoscope and 1964 air photographs (Government of British Columbia).

Study Areas

Of the three designated study areas, the Meager Creek study area was emphasized because;

1) the south geothermal reservoir (Meager Creek) was the area of greatest exploration and development activities,
2) initial surface exploration in the area was complete,
3) three of the five drill holes proposed for 1979 were located there, and
4) the area was readily accessible by road.

The Job Creek study area was identified as the secondary area of investigation because;

1) it was the secondary area of geothermal surface exploration activities,
2) there had been preliminary surface exploration in the area, and
3) it includes a pumice bluff that was of concern during locaton of the north access road along the Lillooet River.

In the Lillooet River study area, the analysis was concentrated along the proposed road alignment parallel to the river. The primary interest was slope stability related to potential access routes leading to the Job Creek area.

3.3.3 RESULTS

3.3.3.1 Meager Creek Study Area

Areas of Primary Concern

Units described by P.B. Read[3] as being unstable or potential slide units are areas that are the primary slide units. The unit above Devastation Slide was rated the worst, although other areas underlain by the same acid tuff breccia unit are also slide-prone. No matter what the triggering mechanism is, another rock slide in this area could result in a Devastation-type slide due to the highly weathered and altered condition of the volcanic units, plus the presence of glacial ice. The Devastation slide of 1975 resulted from a retreating glacier and the consequent removal of support from the underlying weak volcanic units.

Hill 5321 (referred to on maps available in the separate report) is an active slide area. Blocks of the basement complex could slide into Meager Creek and possibly dam the creek, creating a possibility of flooding down Meager Creek with the breaching of the dam.

Areas of Secondary Concern

Areas of secondary concern include Boundary, No Good, Hot Spring, Angel, and Capricorn creeks, and portions of Meager Main logging road. Areas susceptible to occasional avalanches and/or rock slides include Boundary, No Good and Hot Spring creeks. The bridge access to No Good Creek was constructed from a tank car body about three metres in diameter, the conduit being smaller than the width of the stream. During the week of September 9-14, 1979, there was a series of slides on No Good Creek. The amount of material transported was enough to block the culvert, splash over the constructed roadway, and accumulate on the upstream side of the culvert. In addition to being of inadequate size, the life of the structure is limited, as it was not constructed to hold a large mass of material.

The boulder field located southwest of Meager Creek Hot Springs is not unstable, but comprises boulders one to two metres in diameter. The Angel Creek area has a large avalanche chute that crosses the Meager North Main logging road between the 10 and 11 km markers. Capricorn Creek bridge is subject to breaching due to periodic large river flows and large quantities of material on a steep slope. The source of material is a large moraine and constant rockfalls which occur about 2.5 km upstream.

A typical section of road access across Meager Creek Main logging road has a total road width of 5.2 metres, which includes two metres of unstable outside roadbed, for an effective load width of about 3.2 metres. The road was not engineered to specifications that would allow it to withstand years of use, and in places it is only wide enough for a single logging truck. Sections of the roads are subject to constant slumping from loose colluvium, fluvioglacial deposits and old alluvium.

3.3.3.2 Job Creek Study Area

The pumice exposed in the cut slope appears to be steeper than its normal angle of repose. This, plus its moderate shear strength but very low cohesion, makes it subject to continual landsliding. There is serious ground water seepage in the lower centre of the slope, and the Lillooet River is actively eroding the base. This erosion induces some blocks to actually float away down the river, as the pumice has a very low unit weight. The potential for landslide is enhanced by the characteristics of the river gravels, which consist of well-rounded cobbles unsuitable for rip-rap or erosion protection. In addition, snow avalanches occur on the talus cone each winter, carrying rock debris and logs over the edge of the cliff.

Talus slopes in the study area are extensive, providing corridors for snow avalanches in the winter, as evidenced by broken trees and patches of snow in June at elevations of 760 metres. These talus chutes overlap stable fluvioglacial deposits rated "A" because of low slope angle. The stability of the talus is "D" due to rockfall hazards, slope angle and avalanche possibilities in the winter.

Job Creek has fluvioglacial deposits in its creek bed. They rate "C" due to the high angle basement complex material that forms the canyon walls. Perched above creek level is a deposit of fluvioglacial material overlain by volcanic material. The stability of this fluvioglacial material would require further study, if exploration efforts were to continue up the canyon.

On the west bank above Affliction Creek is a unit of weak porphyritic basalt. If exploration efforts confirm the extent of the reservoir to include Affliction Creek, further investigation of this unit is recommended.

3.3.3.3 Lillooet River Study Area

Major concerns focus on the access corridor to the Job Creek study area. The projected road crosses sections of old landslide and lahar deposits from the Plinth Assemblage. The corridor also cuts a highly-jointed section of basement complex rocks. Major jointing dips at a 60° angle and would be hazardous if a sufficient amount of material were not removed.

3.3.4 DISCUSSION

3.3.4.1 Meager Creek Study Area

The Meager Creek study area is generally favourable for geothermal exploration activities on the colluvium-covered areas, and on some of the talus areas.

Areas that would be unsafe for intermediate and deep hole drilling operations are discussed in detail in the slope stability study prepared by VTN. Considerable engineering work would be needed to successfully conduct exploration activities in these areas.

3.3.4.2 Job Creek Study Area

Fluvioglacial deposits cover most of this area, between the NSBG camp utilitized in summer 1979 and Job Creek. The most stable areas would be those just north and west of the pumice slope area. Here, slope angles are minimal (3° to 6°), the forest area is fairly stable, and there has been no logging disturbance other than the surficial geothermal exploration efforts.

3.4 WATER QUALITY

3.4.1 INTRODUCTION

The purpose of the water quality work was to initiate physico-chemical investigations of surface waters in the study area which could be applied to future studies of geothermal development in the Meager Mountain area.

Several factors influenced the scope and nature of the water quality program.

1) Existing chemical data for surface waters in the study area were limited to a few measurements of stream parameters taken in the course of geochemical investigations by Nevin, Sadlier-Brown, Goodbrand Ltd.[4][8] and Hammerstrom & Brown[6]. These data are provided in Appendix C, Tables C-1, C-2 and C-3.

2) The study area is mountainous and access into the upper stream basins is limited.

3) The streams in the study area exhibit extreme seasonal fluctuation and there are few sampling locations which

would provide reliable baseline data over an extended period of time.

4) There were no hydrologic data for the study area and very few sites which readily lend themselves to hydrologic monitoring.

Accordingly, a water sampling program was designed and implemented to initiate a monitoring program for the surface waters which would provide the necessary long term data required should geothermal development proceed. Concurrent hydrologic observations were conducted so that water quality results could be interpreted in relation to flow as well as seasonal factors.

To insure validity of results, considerable care was taken to adopt methods and use instrumentation which would have the precision and accuracy to reliably assess levels of chemical constituents in the surface waters. In addition, an analytical laboratory was used which had a standard in-house quality assurance program. The laboratory analyses were carried out by Beak Consultant Ltd. who demonstrated reliable intralaboratory quality control procedures such as systematic use of replicate or known samples to verify results, determination of precision and accuracy of test procedures, verification of a working standard curve and participation in interlaboratory performance evaluation programs.

3.4.2 METHODOLOGY

3.4.2.1 Instrumentation

Field water quality measurements were made with a Horiba Water Checker Model U7 which measures pH, temperature, dissolved oxygen, conductivity and turbidity. This instrument was selected because of its accuracy and repeatability of results, rapid response time, readability, ease of calibration and practical design for field use. The specifications for the Horiba U7 are given in Table C-4, Appendix C.

Replicate measurements of certain parameters were made using a Beckman Model RA-2A Conductivity Meter, a Hach Portable Dissolved Oxygen Meter Model 16046 with temperature read out, and a Fisher general laboratory mercury thermometer (range -20 to 110°C). Specifications for the conductivity and dissolved oxygen meters are provided in Tables C-5 and C-6, Appendix C.

Alkalinity determinations were made using a Bausch and Lomb Spectrokit for alkalinity as calcium carbonate. The kit employed a titration reaction where one drop of the titration solution (H_2SO_4) was equal to 20 mg/l $CaCO_3$.

Hydrologic observations for 1979 were primarily intended to permit interpretation of water quality results in relation to flow. However, due to channel and flow conditions, 1979 hydrologic measurements were limited to manual readings from staff gauges installed at two readily accessible sites (section 3.4.2.2). The staff gauge at site MC-100 on Meager Creek consisted of a wooden lathe attached to a log bridge abutment, with vinyl tape attached and a 3/8 inch clear tube with cork dust to act as a crest gauge. A similar, free standing arrangement was established at LC-100 on the Lillooet River, with an auxiliary gauge (lathe and tape) anchored to a tree. Periodic near bank flow velocity measurements were taken using a Price AA Current Meter with rating limits of .25 to 8.0 F.P.S.

3.4.2.2 Station Locations

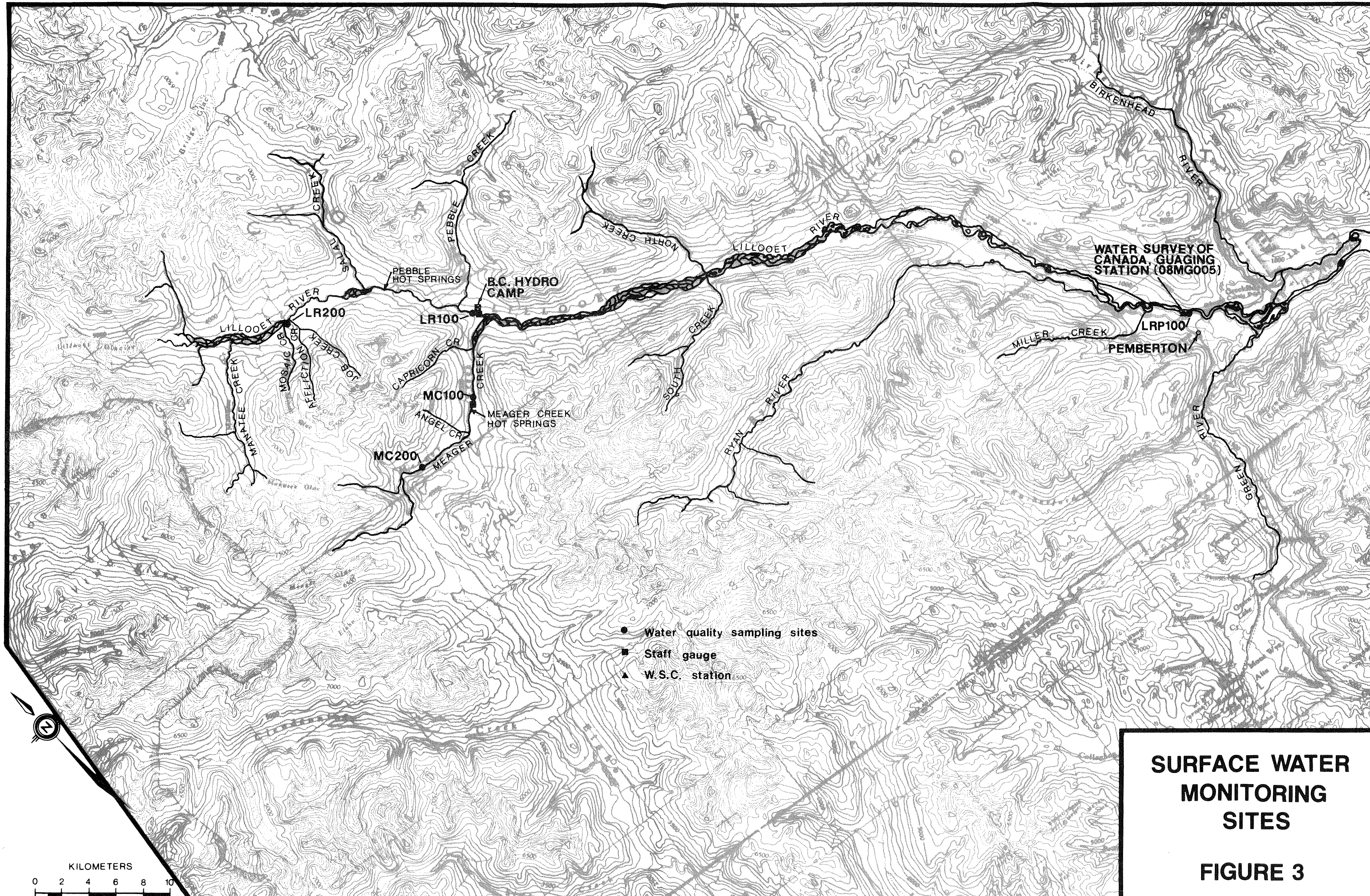
Five sites were selected for water quality sampling as shown on Figure 3. Staff gauges to measure water levels were installed at LR-100 and MC-100. Site LRP-100 is adjacent to an existing Water Survey of Canada stream gauging station (08MG005). The major criteria for site selection were location on a single channel, in a stable and straight reach of the stream which could be used to obtain stable reliable results over time, location within the study area to provide useful long term monitoring points in the advent of geothermal power development (eg. during plant operation) and accessibility. Schematics for each site showing water sampling points and stream gauges are provided in Figures 4, 5, 6, 7, and 8. Rationale for individual sampling site locations are as follows;

LR-100 - at the lower end of possible geothermal reservoir identified by resistivity surveys, adjacent to B.C. Hydro construction camp. Readily accessible for frequent monitoring. A possible better site was located during the study for streamflow monitoring approximately 1 km upstream.

LR-200 - near the upper boundary of a possible geothermal reservoir in the Lillooet valley.

LRP-100 - within the settlement of Pemberton adjacent to the Water Survey of Canada stream gauging station (08MG005). Could serve as an indicator of any downstream effects in the vicinity of human habitation and known anadromous fish habitat.

MC-100 - downstream of possible geothermal reservoir in the Meager Creek valley and downstream of main vent of



LILLOOET RIVER
LR200
SALAL CREEK
PEBBLE CREEK
PEBBLE HOT SPRINGS
B.C. HYDRO CAMP
LR100
NORTH CREEK
LILLOOET RIVER
BIRKENHEAD RIVER
WATER SURVEY OF CANADA, GUAGING STATION (08MG005)
LRP100
PEMBERTON
MILLER CREEK
MOSAIC CR
AFFLICTION CR
JOB CREEK
CAPRICORN CR
CREEK
MC100
MEAGER CREEK HOT SPRINGS
ANGEL CR
MC200
MEAGER
MANATEE CREEK
SOUTH CREEK
RYAN RIVER
GREEN RIVER
Water quality sampling sites
Staff gauge
W.S.C. station
KILOMETERS
0 2 4 6 8 10
N
SURFACE WATER MONITORING SITES
FIGURE 3

FIGURE 4

SCHEMATIC PLAN FOR STATION

LRP100

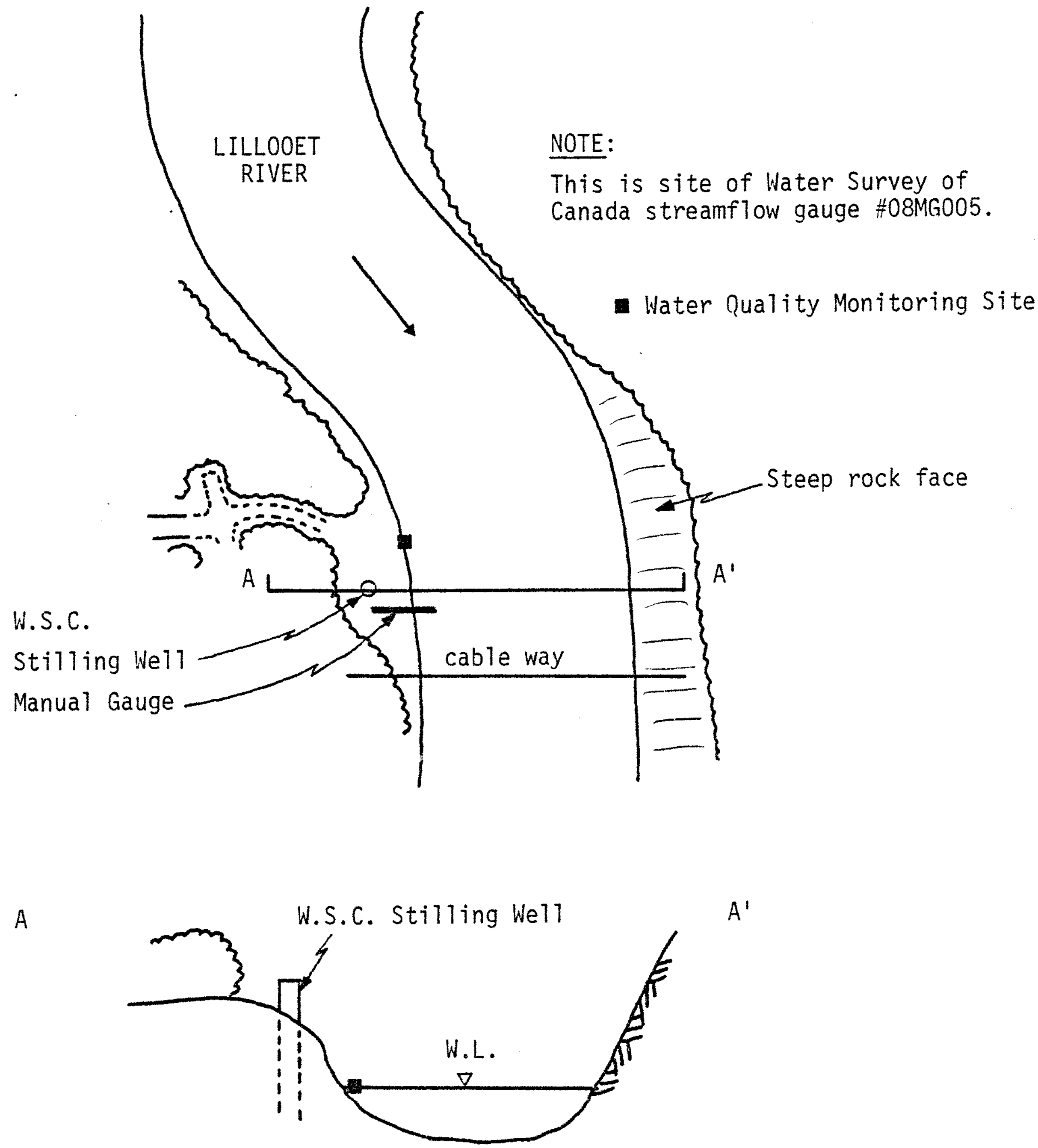


FIGURE 5

SCHEMATIC PLAN AND SECTION

FOR STATION LR100

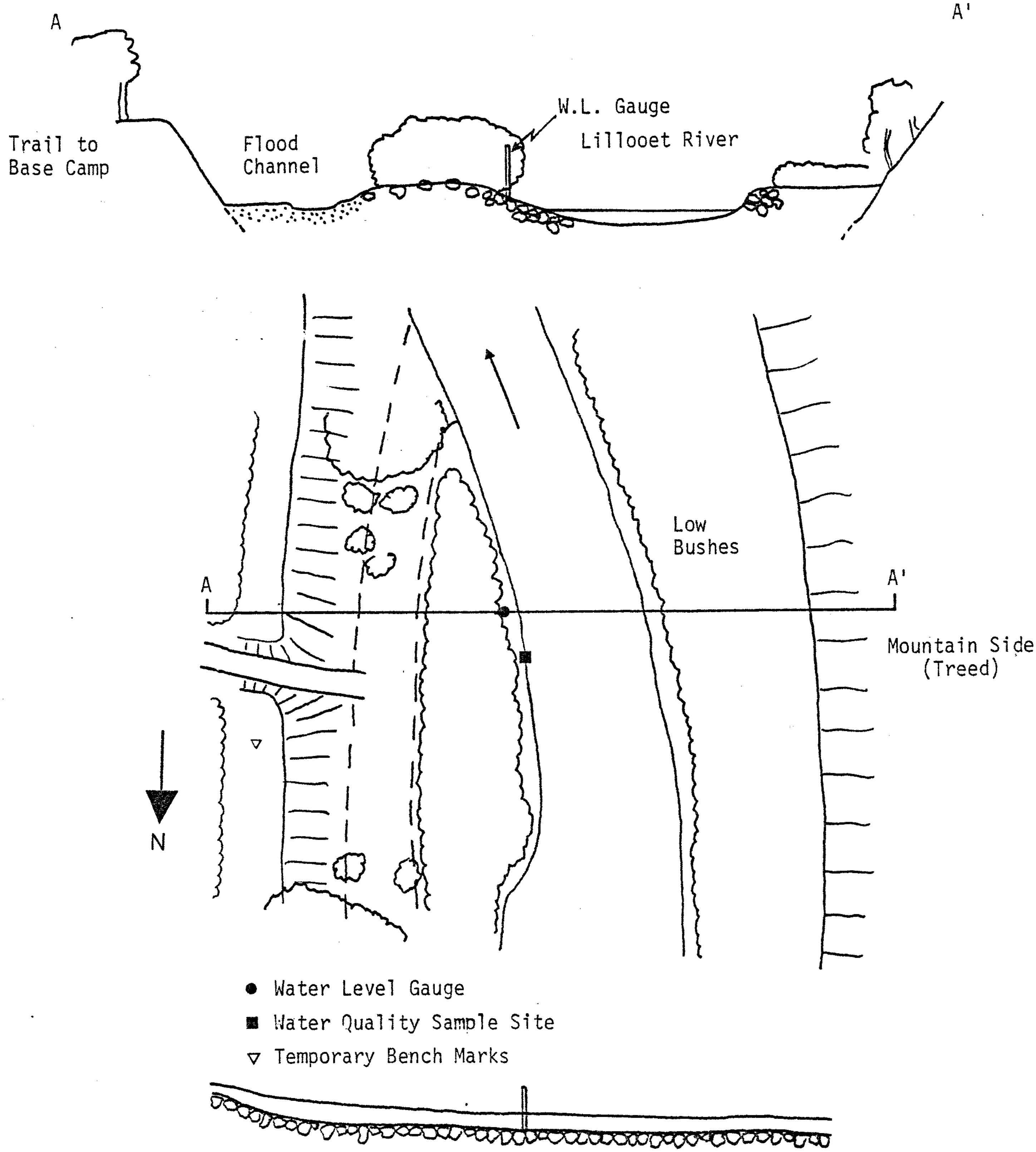


FIGURE 6

SCHEMATIC PLAN AND SECTION

FOR STATION LR200

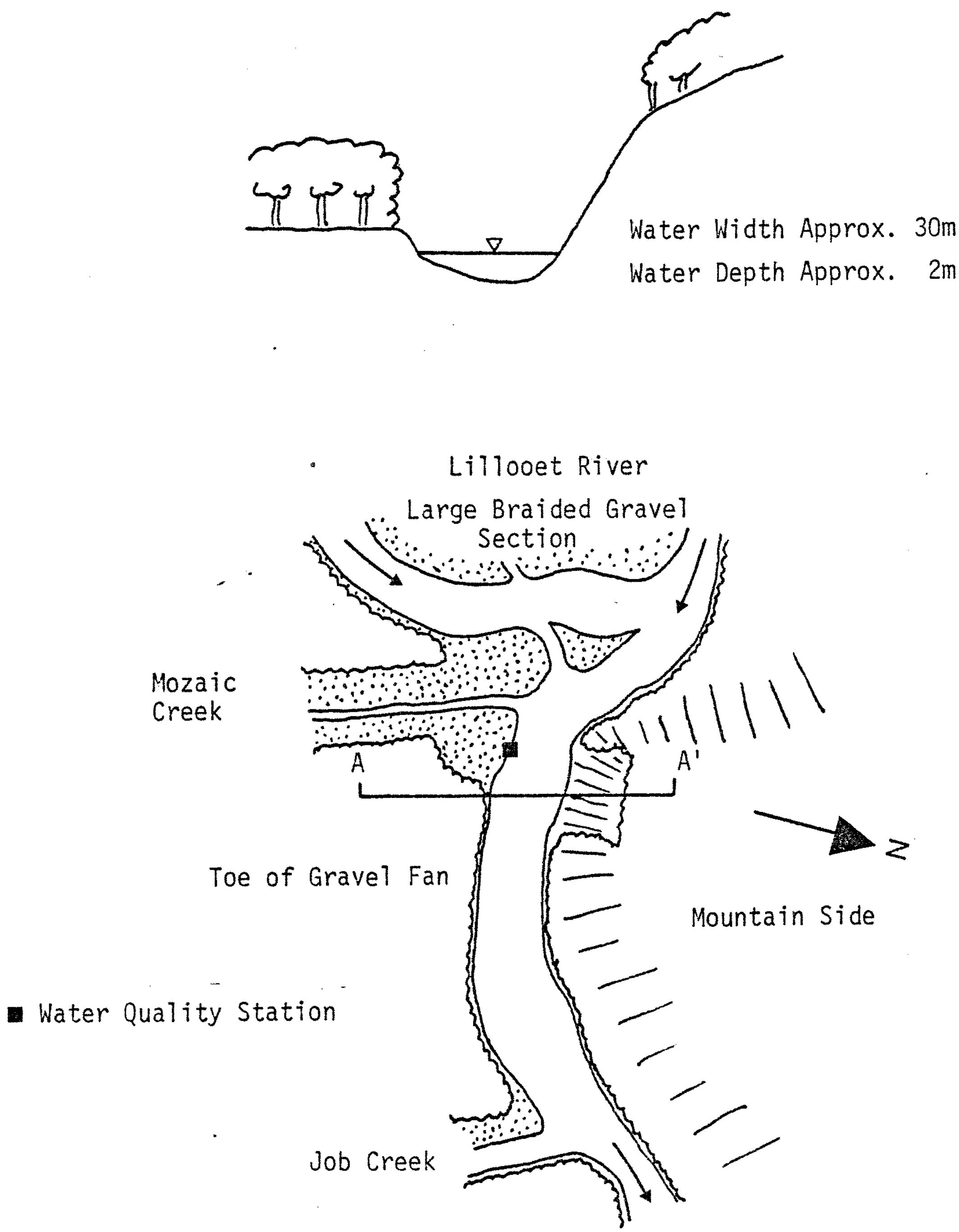


FIGURE 7

SCHEMATIC PLAN AND SECTION
FOR STATION MC100

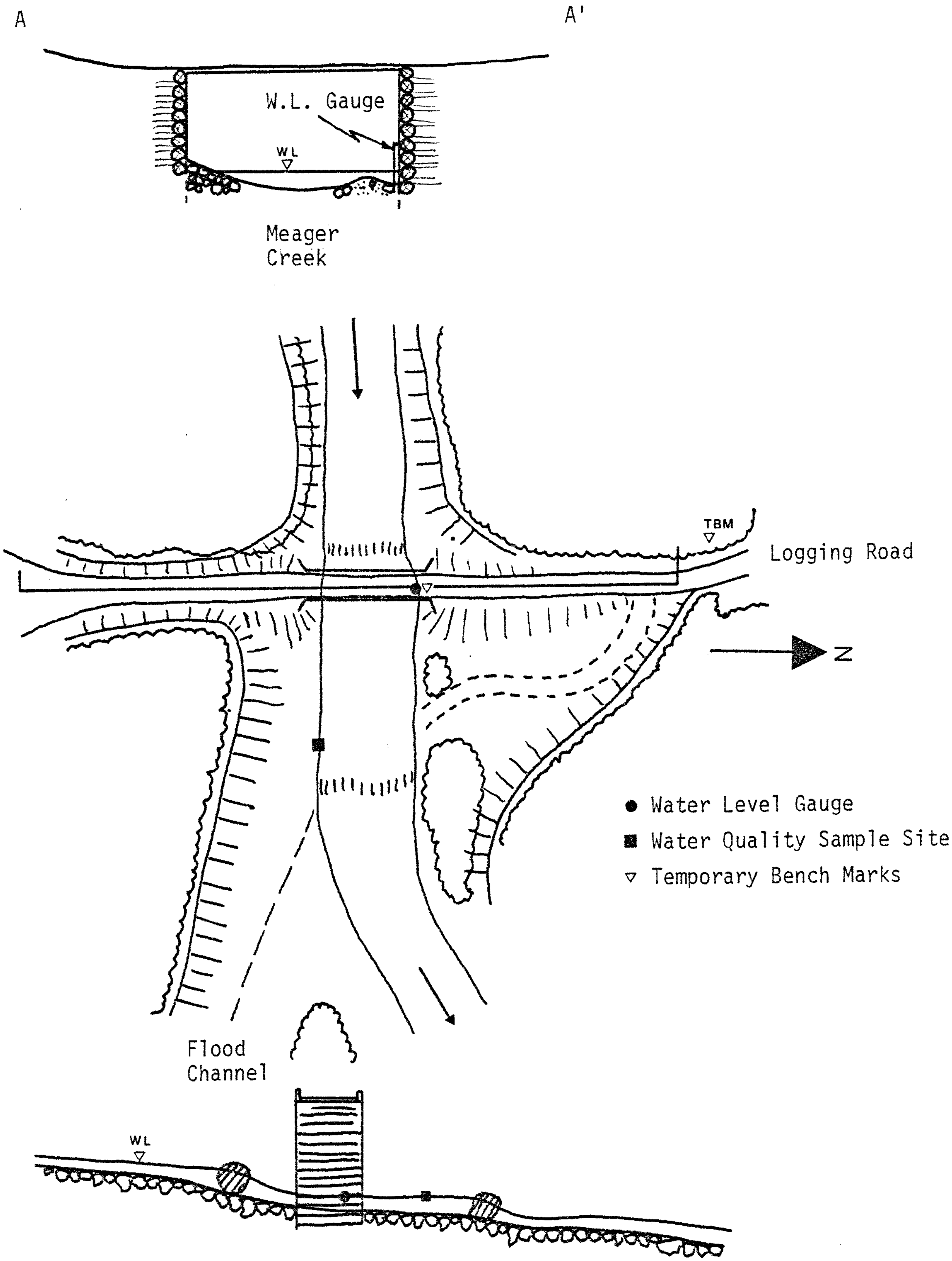
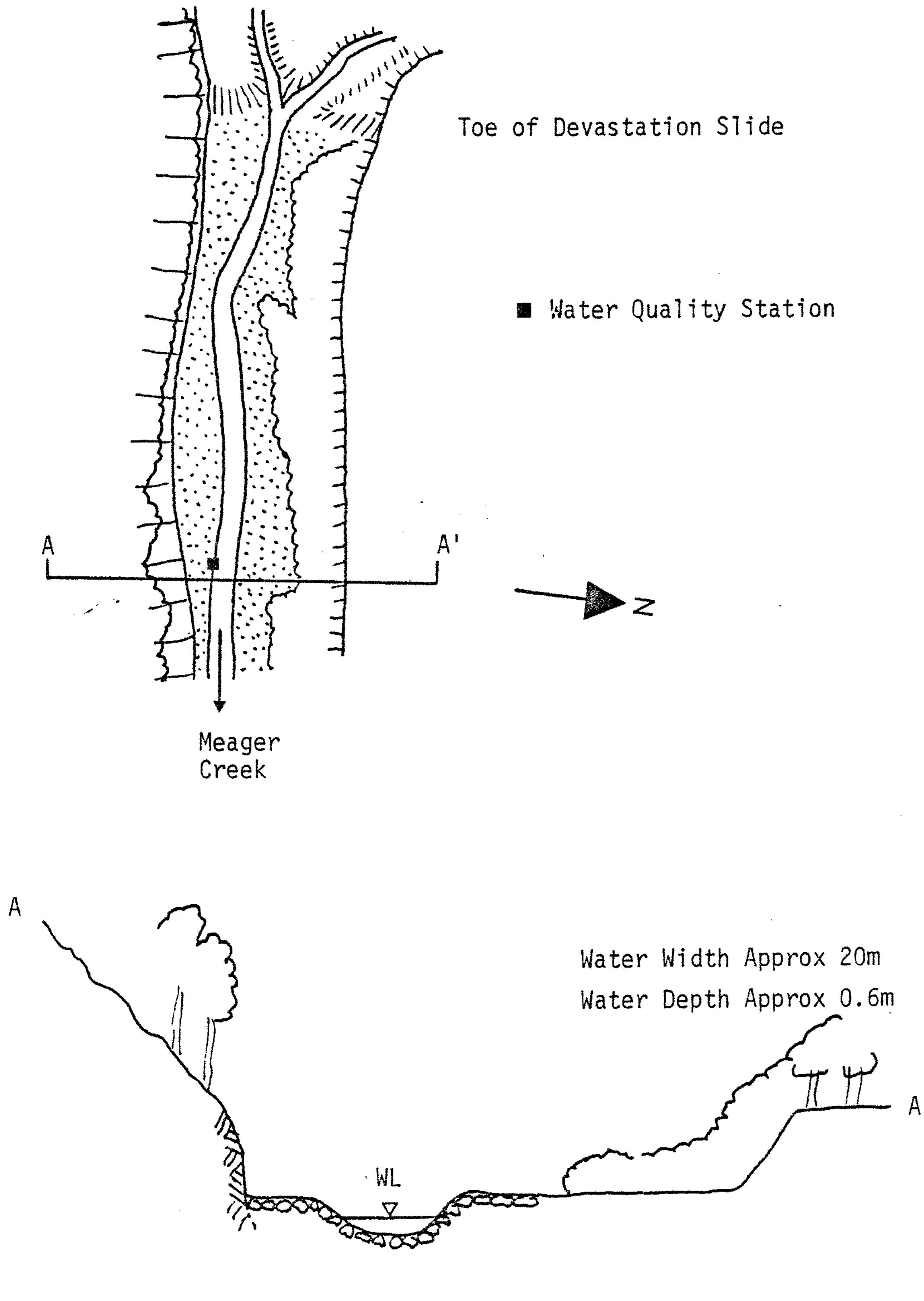


FIGURE 8

SCHEMATIC PLAN AND SECTION

FOR STATION MC200



Meager Creek hot springs. Readily accessible by road to permit frequent monitoring.

MC-200 - near the possible upper boundary of geothermal reservoir in the Meager Creek valley.

3.4.2.3 Procedures

The water quality sampling program consisted of two components: field water quality in which seven parameters were measured at each site at approximately two week intervals from June 19 to September 20 and on single occasions in November and December; and lab water quality in which three sets of water samples representing different seasonal conditions were collected from each site and sent to the lab for analysis of a comprehensive array of chemical and physical constituents. Field water quality measurements were taken in conjunction with the water samples for lab analysis (Plate 6, Appendix A).

The field water quality parameters measured and instruments used at each site are shown in Table 7.

The pH, dissolved oxygen and turbidity probes of the Horiba U7 were calibrated at the start of each day that the unit was used. The Hach Dissolved Oxygen Meter was air calibrated on site on each occasion it was used. Barometric pressure required for calibration of the oxygen meter was read from a Thommen Pocket Altimeter Barometer. Measurements were taken at each sample site, one to two meters from the bank in persistent uniform flow approximately two thirds of a meter deep. Care was taken to minimize influence on the water regime while taking the measurement. Local flow anomalies such as back eddies or extreme turbulence were avoided. Results for field measurements were recorded on standard data forms (Figure C-1, Appendix C).

TABLE 7: Field water quality parameters and instrumentation, Meager Creek Project, 1979.

PARAMETER	INSTRUMENT USED
Air Temperature (°C)	Mercury thermometer
Water Temperature (	U7 Mercury thermometer Hach Dissolved Oxygen Meter
pH	Horiba U7
Conductance (micromhos/cm)	Horiba U7 Beckman Conductivity Meter
Dissolved Oxygen (mg/l)	Horiba U7 Hach Dissolved Oxygen Meter
Turbidity (Formazin turbidity units)	Horiba U7
Alkalinity (mg/l $CaCO_3$)	Bausch & Lomb Spectrokit

In the course of taking biweekly field water measurements, additional field readings were taken in other areas of interest as time and logistics permitted. Field parameters for Job Creek were measured on six occasions to develop a baseline profile prior to possible future exploration activities in Job valley. Field parameters for Angel creek were measured on eight occasions to provide a baseline in the event of changes due to exploration activities underway in the valley during the 1979 field season. A series of additional field measurements were taken at MC-100 and LR-100 to determine possible diurnal variations in water quality.

Lab water quality samples were collected at each of the five water quality sites on June 19 and 20, August 15 and 16 and December 9 and 10. The schedule sought to obtain flow samples representing average, high and low flow conditions respectively. Water quality parameters which were analysed in the lab are shown in Table 8.

Samples were collected in new, acid washed, glass, polyethylene or Nalgene bottles. Some samples were collected directly into the sample bottles while those to be analysed for dissolved ions and trace elements were collected in a 2.4 litre Cogstadt filter barrel with nylon bolts. The water was pressure filtered through .45 u filter paper into the sample bottles. Samples for coliform counts were taken in sterilized, pre-packaged containers.

Beak Consultants Ltd. provided an array of sample bottles for each site which were colour coded according to the preservative and/or filtration required. Upon collection of samples, bottles were labelled with the following information:

TABLE 8: Methods, detection limits and precision for water quality analyses conducted during this study

PARAMETER	METHOD	PRESERVATION TECHNIQUE	CONTACT TIME	MINIMUM DETECTABLE LIMITS	PRECISION
PHYSICAL-CHEMICAL PARAMETERS					
pH @ 25°C	Meter	Cool to 4°C	6 hours	-	0.02
Suspended Solids	Gravimetric	Cool to 4°C	7 days	1 mg/l	5%
TDS @ 180°C	Gravimetric	Cool to 4°C	24 hours	1 mg/l	5%
TDS (sum of constituents)	-	-	-	-	-
Colour (in platinum cobalt units)	Colorimetric	Cool to 4°C	24 hours	5 C.U.	10 C.U.
Alkalinity	Titration	Cool to 4°C	24 hours	0.5 mg/l	1 mg/l
Tannins & Lignins	Colorimetric	Cool to 4°C	24 hours	0.1 mg/l	10%
Dissolved Calcuim	AA	5 ml/l conc. HNO_3	7 days	0.02 mg/l	0.04 mg/l
Dissolved Magnesium	AA	5 ml/l conc. HNO_3	7 days	0.003 mg/l	0.006 mg/l
Dissolved Sodium	AA	5 ml/l conc. HNO_3	7 days	0.003 mg/l	0.006 mg/l
Dissolved Potassium	AA	5 ml/l conc. HNO_3	7 days	0.01 mg/l	0.02 mg/l
Dissolved Chloride	Colorimetric	Filter - cool to 4°C	7 days	0.02 mg/l	0.04 mg/l
Dissolved Fluoride	Dist-Colorimetric	Filter - cool to 4°C	7 days	0.1 mg/l	2.4%
Dissolved Sulfate	Turbidimetric	Filter - cool to 4°C	7 days	1 mg/l	1.2%
Dissolved Silica	Colorimetric	Filter - cool to 4°C	7 days	0.04 mg/l	3%
Specific Conductance @ 25°C micromhos/cm	Meter	-	24 hours	1.5 umhos/cm	-
NUTRIENT PARAMETERS					
Total Kjeldahl Nitrogen (ORG-N AND NH_3-N)	Dist-Colorimetric	2 ml/l conc. H_2SO_4; cool to 4°C	24 hours	0.01 mg/l	4.58%
Total Nitrate (NO_3-N)	Colorimetric	2 ml/l 2% $HgCl_2$; cool to 4°C	24 hours	0.02 mg/l	2.11%
Total Nitrite (NO_2-N)	Colorimetric	2 ml/l 2% $HgCl_2$; cool to 4°C	24 hours	0.001 mg/l	0.030 mg/l
Total Phosphate (T-PO_4^{3-})	Colorimetric	Cool to 4°C	24 hours	0.003 mg/l	10%
Dissolved Ortho-Phosphate (O-PO_4^{3-})	Colorimetric	Filter - cool to 4°C	24 hours	0.003 mg/l	10%
ORGANIC PARAMETERS					
Total Organic Carbon	TOC Analyzer	2 ml/l conc. HCl; cool to 4°C	24 hours	0.5 mg/l	0.25 mg/l
Oil & Grease	Exn-Gravimetric	2 ml/l conc. H_2SO_4; cool to 4°C	24 hours	1 mg/l	2 mg/l
TRACE ELEMENTS (DISSOLVED PHASE)					
Arsenic	Colorimetric	Filter	6 months	0.005 mg/l	10%
Cadmium	AA	Filter; 5 ml/l conc. HNO_3	6 months	0.01 mg/l	0.02 mg/l
Chromium	Colorimetric	Filter; 5 ml/l conc. HNO_3	6 months	0.005 mg/l	0.010 mg/l
Copper	AA	Filter; 5 ml/l conc. HNO_3	6 months	0.04 mg/l	0.08 mg/l
Iron	AA	Filter; 5 ml/l conc. HNO_3	6 months	0.06 mg/l	0.12 mg/l
Lead	AA	Filter; 5 ml/l conc. HNO_3	6 months	0.11 mg/l	0.22 mg/l
Manganese	AA	Filter; 5 ml/l conc. HNO_3	6 months	0.02 mg/l	0.04 mg/l
Mercury	Flameless AA	Filter; 50 ml/l conc. HNO_3;	6 months		
		5 ml/l 10% $K_2Cr_2O_7$	1 month	0.25 ug/l	0.50 ug/l
Molybdenum	AA	Filter	6 months	0.02 mg/l	0.04 mg/l
Nickel	AA	Filter; 5 ml/l conc. HNO_3	6 months	0.06 mg/l	0.12 mg/l
Selenium	Colorimetric	Filter	6 months	0.003 mg/l	5%
Zinc	AA	Filter; 5 ml/l conc. HNO_3	6 months	0.009 mg/l	0.018 mg/l
MICROBIOLOGICAL PARAMETERS					
Total Coliform	MF	Cool to 4°C	30 hours	1/100 ml	-
Fecal Coliform	MF	Cool to 4°C	30 hours	1/100 ml	-

Station:	__________	Sample No.:	__________
Date:	__________	Time:	__________
Collected By:	__________	Witnessed By:	__________
Filtered:	__________	Non-filtered:	__________

During sample collection care was taken to minimize the risk of contaminating samples and to choose sampling points which would provide comparable results for all sampling occasions. A field blank sample was prepared using distilled/deionized water from Beak's laboratory.

Sample bottles were immediately packed in ice chests for transport to the laboratory within 48 hours of sample collection.

The preservation techniques, specific analytical methods, minimum detection limits and precision/accuracy for each parameter analysed are presented on Table 8. Atomic absorption spectrophotometry analysis was carried out using a Varian Techtron Model AA-5 atomic absorption spectrophotometer. Total organic carbon was determined using a Beckman Model 915A Total Organic Carbon Analyser. Duplicate analyses were conducted on each sample run and duplicate samples were taken at one site on each sampling occasion.

Hydrologic readings were taken from staff gauges on Meager Creek and the Lillooet River. A single staff gauge was installed at MC-100, directly onto the bridge abutment. Two gauges were installed at the Lillooet River site, one directly in the stream channel and a back up gauge on the stream bank. Depending on stage conditions, readings were taken either directly from the gauge (three readings were taken to calculate an average value), and/or taken with a hand level reading onto the gauge. From July 3 to September 19, readings were generally taken once a day in the late afternoon. Before and after that time, readings were taken sporadically as feasible. Several estimates of flow velocity and near-shore flow measurements with the Price AA meter were made througout the period of record.

3.4.3 RESULTS

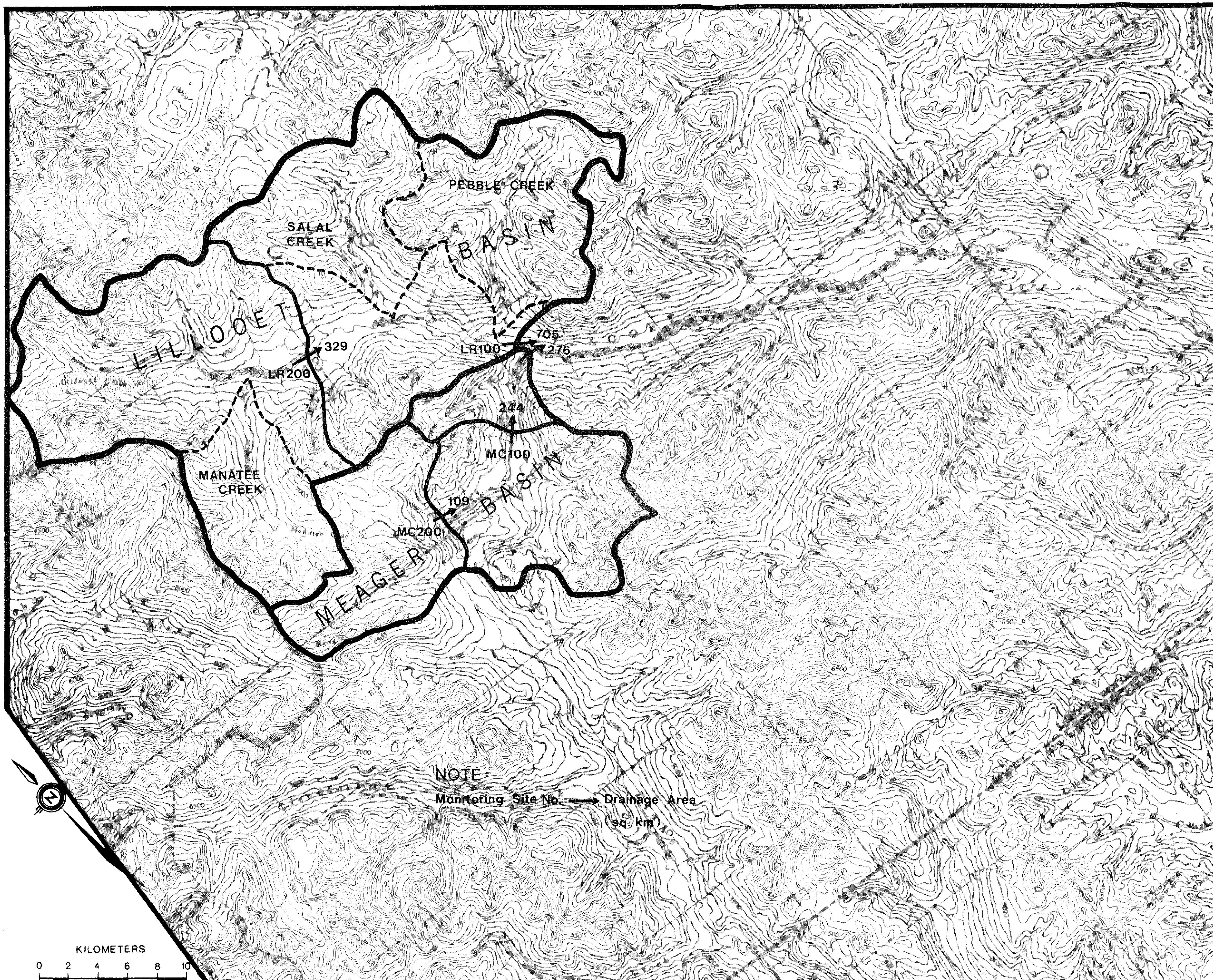
Tabulated results of the field and lab water quality analyses are presented in Appendix C. Results for hydrologic observations are presented in Appendix D. Drainage basins for the streams studied are shown in Figure 9. The following discussion compares results for Meager Creek and the Lillooet River, within the primary study area and at Pemberton, for various times during the sampling period.

3.4.3.1 Meager Creek

Water Temperature, Air Temperature and Dissolved Oxygen

The results of the field water quality analysis for Meager Creek are provided in Table C-7, Appendix C. A general tendency for water temperatures to reflect concurrent air temperatures was masked to varying degrees depending on the time of day the measurement was made and the amount of glacial meltwater which contributed to the flow. For example, the maximum air temperature for the period of record (28°C on July 3) did not concur with the maximum water temperature (10.1°C on September 6) due to the large input of glacial meltwater and consequent depression of water temperature.

Water temperature measurements for Meager Creek ranged from a minimum of 0.1°C at MC-200 (December 11, 1045 hrs) to a maximum of 10.1°C at MC-100 (September 6, 1930 hrs). Mean water



DRAINAGE AREAS

FIGURE 9

temperatures for the period of observations were 5.67°C at MC-200 and 6.8°C at MC-100. Concurrent air temperatures ranged from 28°C at MC-100 on July 3 at 1523 hrs to -4°C at MC-100 on December 10 at 1505 hrs. Mean air temperatures for the upper and lower Meager Creek sites were 16.7°C and 17.3°C respectively.

Figure 10 illustrates the relationship between air and water temperatures and dissolved oxygen concentrations in Meager Creek for the time period indicated. Dissolved oxygen concentrations were near saturation or supersaturated at both sites on all sampling occasions. This was probably due to the extreme turbulence (or eddy currents) of the stream flow for most of its course and the presence of high waterfalls in the upper watershed. Concentrations ranged from 14.9 mg/l dissolved oxygen at 8.8°C (MC-100, July 3) to 10.2 mg/l dissolved oxygen at 9.4°C (MC-200, September 6).

Turbidity, Suspended Solids and Flow

Values recorded for turbidity show a direct relationship to flow (Figure 10). Variations in flow were primarily attributable to glacial meltwater and precipitation. Increasing flows during warm days, due to ice melt in the head-waters, were attended by rock-flour from the glaciers and a high suspended sediment load. Turbidity values for Meager Creek ranged from high of 730 Formazin turbidity units (F.T.U.) at MC-100 on July 6 to low of 2 F.T.U. at the same site on November 3.

Results of the lab analysis for suspended solids reflect a similar trend (Tables C-8 and C-9, Appendix C), ranging from a winter low of 6 mg/l at MC-100 (December 10) to a high during the summer of 692 mg/l at MC-200 (August 15).

FIGURE 10: Field water quality results for temperature, dissolved oxygen, turbidity, flow and specific conductance in Meager Creek, 1979

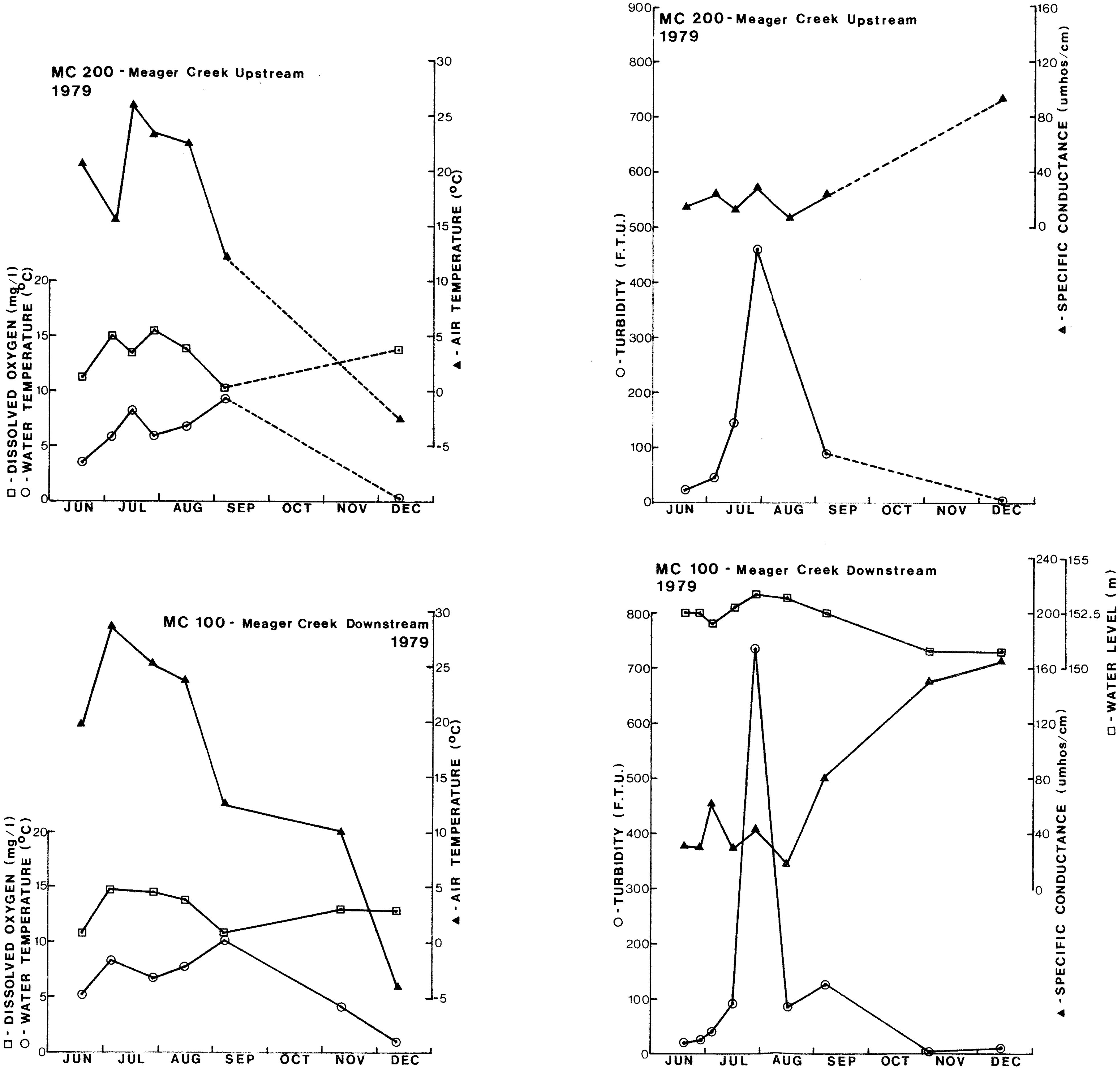


FIGURE 10

Alkalinity and pH

pH values for both sites on Meager Creek were near neutral but tended to be slightly basic for the majority of measurements. The field values for pH ranged from 6.6 at MC-100 on June 19 to 8.3 at MC-200 on August 15. Lab results for pH were also within this range and consistently on the basic side of neutral.

The pH of natural waters influences the speciation of inorganic carbon, primarily H_2CO_3, HCO_3, CO_3 and indirectly the dissolution of CO_2. These in turn influence akalinity which represents the acid neutralizing capacity of an aqueous system.

The dominant component of alkalinity at pH values indicated would be the bicarbonate ion (HCO_3). Alkalinity values were low for the period of record (Tables C-8 and C-9, Appendix C), ranging from 17 mg/l as $CaCO_3$ at MC-100 on August 16 to 52 mg/l as $CaCO_3$ at MC-100 on December 10.

The pH values measured in the stream are a reflection of the following generalized reaction scheme for carbon metabolism:

$$mCO_2 + mH_2O \underset{\text{Photosynthesis}}{\overset{\text{Respiration}}{\rule{3cm}{0.4pt}}} (CH_2O)m + O_2$$

That is respiratory activities of the aquatic biota contribute carbon dioxide to water which is measured as acidity. The lowest (more acidic) values obtained for pH in the course of field measurements tended to be measured early in the day. This trend was also noted in some results for the diurnal series of measurements (Table C-21) although there are exceptions. Respiratory process of aquatic organisms during the night may contribute to lower pH values noted for some morning measurements. The observed variation of pH over time would suggest that Meager Creek has a moderately low acid buffering capacity. This observation is consistent with low results obtained for alkalinity.

Total Dissolved Solids and Conductance

Results for total dissolved solids (TDS) are given as both the total concentrations measured at 180°C and the calculated sums of dissolved constituents analysed (Tables C-8 and C-9, Appendix C). The consistently lower values for TDS as the sum of constituents indicates the presence of dissolved substances which were not analysed as individual constituents. The lowest concentration of TDS analysed was 43 mg/l at MC-200 on June 19 and the highest was 127 mg/l at MC-100 on December 10. Total dissolved solids as sums of constituents also show higher values for the winter sample.

Lab results for specific conductance range from low (39.2 umhos/cm, MC-200, August 15) to moderate (21.2 umhos/cm, MC-100, December 10). Field results are given for the Horiba U7 and periodic duplicate measurements made with the Beckman RA-2A Conductivity meter. Generally duplicate measurements are within acceptable range of one another and the lab analysis results. Occasional discrepancies may be due to instrumentation problems and questionable values have been excluded from this presentation. However, all data is presented for examination in Tables C-7, Appendix C. The relationship between conductance, flow and turbidity is shown in Figure 10.

The results show that specific conductance varies directly with total dissolved solids, showing an increase during the winter sampling period. Conductance and total dissolved solids vary inversely with turbidity and suspended solids, the latter showing a decrease during the December sampling period. In winter the main components of river flow are spring water and groundwater recharge which have relatively high concentrations of dissolved solids hence high conductance. During high flow events this water is diluted with ice melt or rain water which is relatively low in dissolved solids, therefore conductance is decreased. Consistently higher values for conductance at MC-200 probably reflects the input of dissolved solids from the hot springs upstream of this site.

Proportionality coefficients were calculated relating TDS and specific conductance as follows:

$$\emptyset \text{ (Proportionality Coefficient)} = \frac{\text{TDS}}{\text{Conductance}}$$

The results are shown in Table 9.

TABLE 9: Proportionality coefficients for conductance and TDS at Meager Creek water quality sites, 1979.

	Ø June 19	Ø August 15-16	Ø December 10-11
MC-200	.8	1.48	.65
MC-100	.7, .6	1.13	.6

Ion Concentrations

Results for specific ion concentrations are given in Table C-8 and C-9. There is a shift in dominance of certain anions and cations between the upper (MC-200) and lower (MC-100) Meager

Creek sites. Cation concentrations at MC-200 on all sampling occasions showed the following order of dominance:

Ca>Na>Mg>K

At MC-100 the same order of dominance was seen in the June 19 water sample, however, in subsequent samples, the order changed as follows:

Na>Ca>Mg = K (August 16, 1415 hrs)
Na>Ca>Mg>K (December 10, 1505 hrs)

The order of anion concentrations at MC-200 was consistent throughout the period of observation, namely:

$SO_4>SiO_4>Cl>F$

At MC-100 the order of dominance shifted but was consistent for all samples as follows:

$SO_4>Cl>SiO_2>F$

The increased dominance of sodium and chloride ions at MC-100 probably reflects the influence of the Meager Creek hot springs which discharge to Meager Creek about .5 km upstream of MC-100. Hammerstrom and Brown[3], noted the dominance of sodium and chloride ions in Meager Creek hot springs water as compared to Meager Creek waters where calcium and sulphate were the predominant cation and anion respectively. It is interesting to note that this influence was not evident in the June sample but appeared in August when meltwater flow was even greater and would tend to dilute hot spring ion concentrations. This apparent anomaly may be due to the mixing characteristics of spring waters in Meager Creek. It is possible that the August sample was taken from a near-shore zone where spring water had not been thoroughly mixed with the receiving stream water, whereas the June sample was taken from a point in the stream where spring and stream water were more completely mixed. Although an attempt was made to take samples from comparable points at the sample site, the extent of the mixing zone could vary with time depending on the amount and turbulence of flow, water temperature differences, etc.

Nutrients and Organics

Nutrient levels in Meager Creek were low throughout the period of record (Tables C-8 and C-9). The relative increase in phosphate in the August sample may be due to increased productivity at that time and may reflect the presence of phosphate which is lightly adsorbed on the suspended solids phase. There does not appear to be any man-induced sources of phosphate in Meager Creek as indicated by the very low ortho-phosphate concentrations. The apparent increase in nitrates in December may be due to the masking effect of glacial runoff during the summer months. It is also possible that the high turbidity and scouring of the substrate associated with glacial runoff inhibits photosynthesis, hence cycling of nutrients in the aquatic system.

Total organic carbon (TOC) was low during the period of observation. Apparent increases in December may be a function of lower flows rather than actual increases in TOC levels. Oil and grease were not detectable in Meager Creek. Tannins and lignins were generally below the limits of detection.

Interestingly, results for true colour which reflect the presence of organic molecules in the water reveal a trend of higher values during high flows, possibly due to flushing of organic soils and surface runoff during flood events. Values range from a low of 5 in December at both sites, to 20 at MC-200 and 15 at MC-100 for the high flow sample in August.

Trace Metals

Concentration of the trace metals arsenic, cadmium, copper, lead, mercury, molybdenum, nickel and selenium were all below the lower limits of detection in Meager Creek for the period of observation. Iron concentrations were low ranging from .02 mg/l at MC-100 (August 10) to .06 mg/l at MC-200 (December 11). Manganese levels were also low ranging from less than .01 mg/l at MC-100 (June 19) to .04 mg/l at MC-200 (December 11). Results for zinc were low (.005 mg/l, MC-100, December 10) to moderate (.059 mg/l, MC-200, December 11). Chromium was detected once at .02 mg/l on a duplicate sample from MC-100 (June 19).

Bacteria

Total and fecal coliform bacteria counts were slightly higher at MC-100 than MC-200 but results for both sites were very low throughout the period of record.

3.4.3.2 Lillooet River

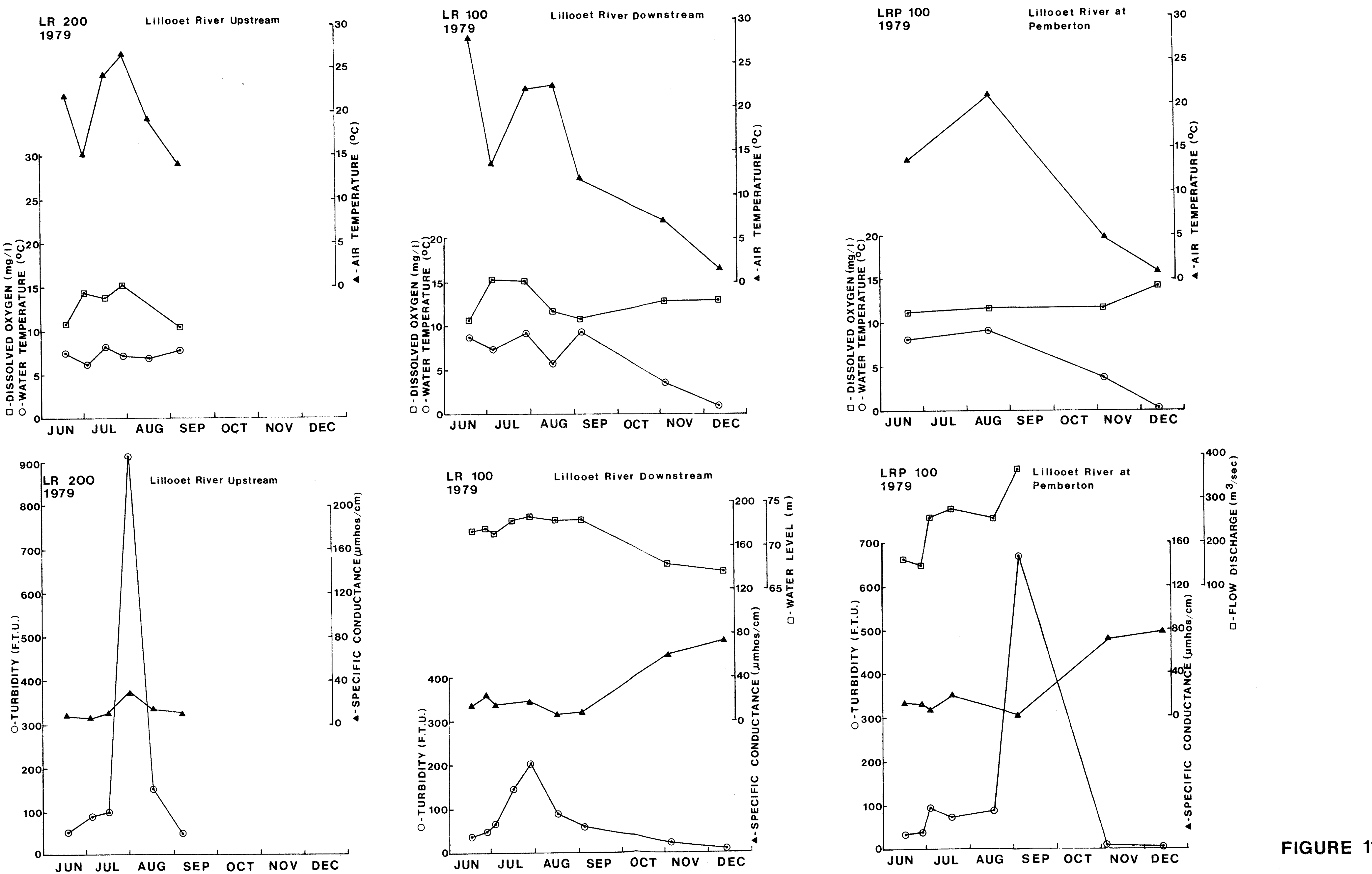
Water Temperature, Air Temperature and Dissolved Oxygen

The results of field water quality measurements for the Lillooet River are provided in Table C-10, Appendix C. As in Meager Creek, water temperatures in the upper Lillooet River (LR-100, LR-200) were influenced by air temperature and glacial meltwater input. The tendency for water to reflect air temperatures was masked on warm days when water temperatures would be decreased by the influx of glacial meltwater. In the lower Lillooet (LRP-100), further from the overriding influence of glacial runoff, water temperatures varied directly with air temperatures. The temperature range measured at LRP-100 was from 0.3°C on December 12 at 1130 hrs to 12.4°C on both June 26 at 1735 hrs and July 17 at 1625 hrs. In the primary study area temperatures ranged from 0.8°C at LR-100 on December 10 at 1130 hrs to 10.5°C at LR-100 on July 16 at 1545 hrs. Average temperatures in the Lillooet for the period of observation were 7.25°C at LR-200, 6.95°C at LR-100 and 8.02°C at LRP-100. Note that the mean temperature for LR-200 does not include a winter temperature value. Water temperatures in the Lillooet are comparable to those of Meager Creek.

Air temperature measurements in the Lillooet valley ranged from 1.5°C (LR-100, December 10) to 29°C (LR-100, July 16) in the upper watershed and from 1.0°C (December 12) to 33.5°C (July 17) at LRP-100 in the lower watershed. Mean air temperatures for the period of record were 20.06°C, 18.04°C and 15.9°C at LR-200, LR-100 and LRP-100 respectively. Note that the mean air temperature at LR-200 does not include a winter value.

Figure 11 shows the relationship between air and water temperatures and dissolved oxygen in the Lillooet River for the times indicated. The Lillooet River was supersaturated with dissolved oxygen at all sites on all sample occasions. Concentrations ranged from 10.4 mg/l dissolved oxygen at 7.8°C (LR-200 , June 9) to 15.4 mg/l at 7.3°C (LR-100, July 4) in the upper watershed and from 11.6 mg/l dissolved oxygen at 3.85°C (December 12) to 11.8 mg/l at 9.2°C (August 16) in the Lillooet River at Pemberton. The comparable high saturation values in both the upper Lillooet and Meager Creeks are likely due to the colder water temperatures, very turbulent flows and water falls in the upper watershed. Warmer water temperatures, less

FIGURE 11: Field water quality results for temperature, dissolved oxygen, turbidity, flow and specific conductance in the Lillooet River, 1979



turbulence and exsolution of the dissolved gases account for lower dissolved oxygen concentrations at LRP-100.

Turbidity, Suspended Solids and Flow

Figure 11 shows the relationships between flow, turbidity and conductance measurements for the Lillooet River. Results for turbidity were very low to very high and changed as a direct function of flow as was the case in Meager Creek. In the primary study area turbidity ranged from 11 F.T.U. at LR-100 on December 10, 1130 hrs to 918 F.T.U. at LR-200 on July 26, 1340 hrs. At Pemberton values ranged from 3 F.T.U. on December 12, 1130 hrs to 670 F.T.U. on September 3, 1500 hrs.

Suspended solids results reflected the same trend varying from a winter low of 4 mg/l (LR-100, December 10) to a summer high of 319 mg/l (LR-200, August 15) in the upper Lillooet and from 7 mg/l (December 12) to 264 mg/l (August 15) in the river at Pemberton. From the data collected, the Lillooet River and Meager Creek appear similar in terms of turbidity and suspended solids.

Alkalinity and pH

The results of field and lab measurements of pH are presented in Appendix C on Table C-10 and Tables C-11, C-12 and C-13 respectively. Field results for the upper Lillooet range from 5.9 at LR-100 on June 26 to 8.3 at both LR-100 and LR-200 on August 15 and 16 respectively. Lab results for this area range from 7.0 at LR-200 (August 15) to 7.7 at LR-100 (December 10). The data show a tendency for waters of the upper Lillooet to be slightly less basic than the waters of Meager Creek. Field pH values for LRP-100 vary from 5.6 (July 9) to 8.1 (September 1); lab results vary from 7.3 (August 15) to 7.5 (December 12).

Results for alkalinity were low at all sites on the Lillooet throughout the period of observations suggesting a low acid buffering capacity (Tables C-11, C-12 and C13, Appendix C). The lowest value was 6.8 mg/l as $CaCO_3$ for LR-200 on August 15. The highest value for the upper watershed was 33 mg/l as $CaCO_3$ at LR-100 on December 10. The range for LRP-100 was 11 mg/l as $CaCO_3$ on August 15 to 38 mg/l as $CaCO_3$ on December 12. These results are generally lower than those for Meager Creek though both streams show an increasing trend during the winter. This increase may be explained by the reduced flow of glacial meltwater and consequent low ion dilution factor.

Total Dissolved Solids and Conductance

The results for TDS measured and calculated are given in Tables C-11, C-12 and C-13, Appendix C. As in Meager Creek, persistent lower values for TDS as sum of constituents indicates the presence of dissolved substances not analysed as individual constituents. The low value for measured TDS in the upper watershed was 26 mg/l at LR-200 (June 19); the high value was 83 mg/l at LR-100 (December 10). These results were lower than those for Meager Creek. At Pemberton values ranged from 38 mg/l on June 19 to 81 mg/l on December 12. TDS as sum of constituents shows the trend of increasing values for the winter sample.

As in Meager Creek specific conductance at all sites on the Lillooet varies directly as TDS and inversely as turbidity and suspended solids (Figure 11). Lab data for conductance ranged from 17.3 umhos/cm at LR-200 on August 15, to 120 umhos/cm at LR-100 on December 10. These values are generally lower than those for Meager Creek. Conductance at LRP-100 ranged from 29.7 umhos/cm on August 15 to 122 umhos/cm on December 12. As in Meager Creek, conductance at all sites on the Lillooet show an increase in December.

Proportionality coefficients for the Lillooet River sites are given in Table 10.

TABLE 10: Proportionality coefficients for conductance and TDS at Lillooet River water quality sites, 1979.

	Ø June	Ø August	Ø December
LR-200	.63	1.96	.65/.69
LR-100	.76	1.68/1.79	.66
LRP-100	.8	1.38	.66

Ion Concentrations

Results for specific ion concentrations are given in Tables C-11, C-12 and C-13, Appendix C. There is a shift in dominance of certain cations between the two upper Lillooet River sites. During the June and August sampling occasions the order of dominance at LR-200 persisted as follows:

Ca>K>Na>Mg.

At LR-100 sodium became more predominant in the following order of magnitude:

Ca>Na>K>Mg.

The concentrations of potassium and magnesium at LR-100 were close but exchanged positions in the order of dominance for the December sample. At LRP-100 the total concentrations for each cation were lower but the order of dominance persisted, namely:

Ca>Na>K>Mg (June, August)
Ca>Na>Mg>K (December)

The order of anion concentrations persisted at all sites on the Lillooet River throughout the period of record, namely:

$SO_4 > SiO_2 > Cl > F$

The gap between sulphate and silica concentrations narrowed at the two downstream sites and on one occasion (August 15) at LRP-100 the concentration of silica equaled that of sulphate. The increase in concentration of sodium, potassium and silica probably reflects the influence of waters from springs such as Pebble hot springs, approximately 3 km upstream of LR-100. Hammerston and Brown[1] found that these springs had high concentrations of sodium, potassium and silica relative to the receiving waters of the Lillooet River. Again, as in Meager Creek, the ion concentrations were much higher during the low flow period in December.

Nutrients and Organics

Nutrient levels at all sites on the Lillooet River were low and showed similar trends to results for Meager Creek. TOC was also low and oil and grease and tannins and lignins were consistently below the lower limits of detection.

As in Meager Creek, results for true colour in the Lillooet were lowest in December with less than 5 colour units at LR-100 (December 10) and 5 colour units at LRP-100 (December 12). The highest recorded values were 20 units at LR-200 on June 19 and the same at LRP-100, also on June 19.

Trace Metals

The trace metals arsenic, cadmium, copper, lead, molybdenum, nickle and selenium were all below the limits of detection.

Chromium was detected once at .04 mg/l at LR-100 on December 11. Iron concentrations were low ranging from .02 mg/l at LR-100 (August 16) to .21 mg/l at LRP-100 (December 12). Zinc occurred in low to moderate concentrations, that is, .008 mg/l at LR-100 (August 16) to .23 mg/l at LRP-100 (June 19). Mercury was detected once at a concentration of .0015 mg/l at LRP-100 on August 15. The result may reflect contamination during the collection or analysis of the sample or it may indicate a source of anthropogenic water pollution from the settled area upstream of Pemberton. However, it is not possible to draw conclusions on the basis of a single measurement.

Bacteria

Total and fecal coliform numbers were low in the upper Lillooet River. There was a slight increase in numbers at LRP-100 with counts ranging from 4 total coliforms/100 ml and 2 fecal coliforms/100 ml on December 12 to 23 total coliforms/100 ml and 7.8 fecal coliforms/100 ml on June 19. The increased numbers in June may indicate the influence of runoff from pasture land upstream of Pemberton.

3.4.4 DISCUSSION

In summary the surface water quality characteristics indicate a pristine aquatic environment influenced by the geologic environment and natural biogeochemical cycles. The major factors affecting water quality in the area appear to be the input of spring water, particularly large hot spring streams in both the Meager Creek and upper Lillooet valleys, and contributions of meltwater flow from the glaciated headwater regions. The springs contribute relatively high concentrations of dissolved substances, with resultant higher conductance and their effect is most evident during the low flow months of fall and winter. During summer, high air temperatures induce melting in the headwaters and attendant flooding of streams with meltwater. These floods are low in dissolved substances and dilute ion concentrations in the streams. They also carry a very high suspended sediment load. The very high dissolved oxygen levels observed, particularly during the summer months are due to water falls in the upper basins and extreme turbulence induced by steep gradients and high flows over large boulder substrates.

The surface waters of the study area can be characterized as slightly basic with apparent low acid buffering capacity. Nutrient and organic levels are generally very low and most trace metals persistently below the lower limits of detection. Bacteria levels are also very low indicating clean waters.

An early spring sample would complete a quarterly sampling program representing seasonal conditions. Based on the trends established by this baseline work analysis of specific water quality parameters may be relaxed or sustained in future water quality investigations.

SECTION 4
OTHER FINDINGS*

4.1 VEGETATION

4.1.1 INTRODUCTION

As the vegetation component of the reconnaissance level studies was not a priority, field observations were made in conjunction with data collection for the principle study components discussed in section 3. Hence, this section provides a descriptive inventory of gross vegetation types.

More detailed work would be required to complete maps of vegetation types as a basis for future wildlife studies (i.e. habitat analysis). These baseline maps could also be used to identify potential impacts of a project development on the flora of the area (i.e. change in species composition or effect on species).

A more comprehensive knowledge of existing vegetation patterns would be desirable to enable assessment of existing effects on vegetation due to logging operations in the area and due to natural emissions of sulphur compounds (H_2S and SO_2).

4.1.2 METHODOLOGY

The criteria for distinguishing between vegetation types were the change in the dominant species or a change in the species

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* The information presented in this section results from casual observations made during the course of work discussed in Section 2.

composition which characterized a particular plant community. Vegetation types were classified by grouping plant communities of similar species, structural composition, and environmental influences. The descriptive inventory of gross vegetation types was based on information from:

1) forest cover maps (British Columbia Forest Service). Meager 92-J-11-d, 92-J-12-a, Lillooet and Pebble Creek 92-J-11-e, Lillooet and Job Creek 92-J-12-h;
2) Resource Map Folio Meager Creek, Vancouver Forest District - SOO PSYU;
3) B.C. Government aerial photographs, July 1965; and
4) several field checks in conjunction with sampling for air and water quality studies.

Vegetation sample plots were located in major vegetation types along the Meager Creek valley. Greater attention was directed to the valley bottom of this drainage because of the present drilling activity in the area. Only the major vegetation types were sampled in the area of potential development due to time constraints. Within each sample plot (20 m x 20 m) notes on species composition and coverage (Domin-Krajina coverage scale) were taken. Observations of browsed species were also noted.

The following points are emphasized as limitations to the discussion of results;

1) boundaries between gross vegetation types are necessarily arbitrary where broad transition areas (ecotones) exist,
2) difficulties in establishing the current extent of logging from outdated air photo coverage.
3) data obtained during field reconnaissance studies of the area were limited to lower elevations of the stream

valleys of the area, hence limited data are available of the alpine and sub-alpine areas, and

4) field sampling effort was concentrated in the Meager Creek valley due to ease of access.

4.1.3 RESULTS

The vegetation in the study area falls basically into three zones: alpine (elevations above 1370m to 1830m); sub-alpine forest (mountain hemlock parkland subzone); and coniferous forest (mountain hemlock forest subzone, coastal western hemlock wet subzone, coastal western hemlock dry subzone, interior hemlock wet subzone and interior Douglas fir subzone). Within the broad category of coniferous forest, complex patterns of conifers, deciduous tree species, and shrub thickets occur. Slope stability, soil conditions and fire history are important influences on the specific composition of the forested areas.

Dominant forest species at lower elevations (300m to 915m) include Douglas fir, western hemlock, and western red cedar. These species are present in varying frequencies depending on the vegetation type in which they occur. Vegetation types on well drained soils at these elevations are often characterized with a few individuals of western white pine. At higher elevations (upper Meager Creek valley beyond No Good Creek and upper Lillooet valley above the falls), balsam fir becomes a dominant species of the forest canopy. Other tree species which become major components of the forest cover at elevations between 915m and 1370m are mountain hemlock and yellow cedar.

Above the coniferous forest zone the sub-alpine parkland forest zone exists with remnant mountain hemlock, balsam fir and sub-alpine fir. With increasing elevation alpine flora takes over. The sub-alpine forest cover disintegrates into krummholz form and tree islands.

The forest cover in both drainages is considered mature to over mature. Many stands are composed of trees over 200 years (e.g. plot #3 past No Good Creek). Hemlock in this stand are over mature and suffering from heart rot. The forest cover above the falls on the Lillooet River is characterized by balsam fir, western hemlock and western white pine with many dead spurs and dead branches covered with arboreal lichens *(Usnea sp.)*.

In a few places in the study area fires have disturbed the climax vegetation. For example, at approximately mile 24 the dominant forest cover is lodgepole pine, a fire successional species.

Common understory shrubs include huckleberry, false box, mock azalea, devil's club, vine maple, Sitka alder, elderberry and either young or stunted individuals of various coniferous species. The abundance varies between vegetation types. On the dry, well drained soils huckleberry and false box are abundant. The wetter sites are characterized by devil's club, elderberry, false azalea and yew. At lower elevations with damp soils, the understory is lush and dense (i.e. western red cedar-devil's club association at km 4 on Meager Road). For species composition of the gross vegetation types refer to Appendix E.

Riparian vegetation along Meager Creek, the Lillooet River and major tributary streams is usually Sitka alder and willow thickets. If the banks do not rise steeply from the water, cottonwood and red alder often colonize the area immediately behind the shrubby banks. In wide floodplain areas this deciduous woodland is extensive enough to be considered a vegetation type. Refer to plot #4, Meager Creek in Appendix E.

The other major deciduous vegetation type are the snowslide areas which maintain unforested paths on steep hillsides. These areas are densely vegetated with predominantly Sitka alder and willows. Other species include red osier dogwood, elderberry, vine maple and the odd stunted conifer.

The vegetation is similar on the gravel bars of the braided areas of both the Lillooet River and Meager Creek. Those gravel/sand bar areas that are not frequently inundated are characterized by a moss/lichen mat. Lupines and some grass species characterize the herb layer. On the gravel bars in the upper Lillooet River near Manatee Creek and Job Creek, yellow flowered avens is the dominant ground cover. Cottonwood, alder and willow are sparsely distributed on the gravel bars. In the fall, the cottonwood located on gravel bars were the first to change colour. In more stable gravel bar areas coniferous species have established themselves. However, most conifer specimens were either young or stunted because of adverse conditions.

The Meager Creek hot springs are also located on a gravel outwash area. The main difference between the hot springs area and other gravel bars is that the water courses draining through it are "hot" and the area is relatively snow free during the winter. The flora around the hot springs is similar to that of other gravel bar associations and not exotic to the area. Semi-aquatics such as *Mimulus sp.* and sedges vegetate the periphery of the hotpools and water courses. An apparent stress condition is evident with the coniferous species established on the hot spring gravel bar. The coniferous species are either stunted or young. Douglas fir specimens have a yellow tinge to their needles and both Douglas fir and western white pine produced many cones (possibly stress cones) when only 2m-3m high. Since this area is relatively snow free during the winter and warmer than the surrounding area due to the hot springs, the stress condition may be caused by a high rate of evapotranspiration. Refer to Appendix E for a generalized list of species characteristic of gravel bars and hot springs in the study area.

Along Job Creek the pungent odour of H_2S gas was evident particularly in the upper reaches (approximately 1065m elevation). From brief observations, there were no noticeable lesions or signs of chlorotic distortion to the leaves of the surrounding vegetation. There was also no apparent difference in the species composition or species vigor of individual species between the vegetation association in Job Creek and similar associations in comparable areas without noticeable H_2S/SO_2 emissions (eg., Affliction Creek). However, the sulphur content of the plant tissue in the upper Job Creek area may be significantly high, but would only be detectable upon chemical analysis. Case and Krouse state: "It is apparent that the reproductive tissues of at least some vascular plants may be adversely influenced by sulphur emissions (SO_2) without producing visible foliar injury". [7] Refer to section 3 for a discussion of total sulphation rates in the vicinity of Job Creek.

Browsed species were noted during field investigations. The most heavily browsed species appeared to be red osier dogwood. Other shrubs browsed include huckleberry, mountain ash and some herbs. Some browsing on grasses was also evident.

Black bears took advantage of abundant huckleberries and saskatoon berries during July and August. When in season dense huckleberry understory of the woodlands around the B.C. Hydro camp provided excellent forage for black bears.

To provide a more comprehensive background on the vegetation in the study area, maps on the vegetation types should be completed utilizing recent air photo coverage (1979). Other helpful studies would include a chemical analysis of the plant tissues of various species in the upper Job Creek area. This could be done to determine total sulphur content, in conjunction with air quality studies. Also, trunk bore samples taken from the coniferous species in the hot spring area would determine whether the trees are stunted or young.

4.2 WILDLIFE

4.2.1 INTRODUCTION

Detailed wildlife studies were not conducted at this stage of exploration. However in the course of carrying out prescribed studies a conscientious effort was made to record all wildlife sightings in the study area. Since many of the sightings were reported by persons not trained as wildlife biologists, the species list is by no means definitive or even necessarily wholly accurate. However, it does give an idea of the predominant species in the area and may assist in defining direction of further study.

4.2.2 METHODOLOGY

All reported wildlife sightings from early June to late September were recorded together with the date, time, location and behaviour of the animal at the time of the observation. Sightings were reported by B.C. Hydro; Nevin, Sadlier-Brown, Goodbrand (N.S.B.G.); and Reid, Crowther & Partners personnel working out of the B.C. Hydro construction camp in the study area. Wildlife observations of helicopter pilots, loggers, Fish and Wildlife Branch officers, trappers and others transient in the area, were also recorded. Where possible, wildlife sightings were then located and marked on a map.

4.2.3 RESULTS

The distribution of species observed is shown on Figure 12.

4.2.4 DISCUSSION

Because the wildlife sightings were incidental to other activities of the observers they reflect the areas of most intense human use rather than the distribution of wildlife per se. Thus sightings are concentrated along road corridors and at camps and drill sites.

Black-tail deer and black bear are prevalent throughout those portions of the study area experiencing intense human use and were frequently sighted. Deer, primarily doe and fawns, were especially prevalent in the Meager Creek valley above 4 km. Within the Lillooet valley there was a relatively high concentration of sightings (doe and fawns) between mile 7* (11.3 km) and 9 (14.5 km) and later in the summer, several bucks were observed in the vicinity of the B.C. Hydro camp.

Bear were seen mainly in the Lillooet River valley, especially between 7 (11.3 km) and 14 (22.5 km) mile in the lower valley and around the B.C. Hydro base camp and the N.S.B.G. exploration camp in the upper valley. There were two periods of concentrated bear activity at the B.C. Hydro base camp.

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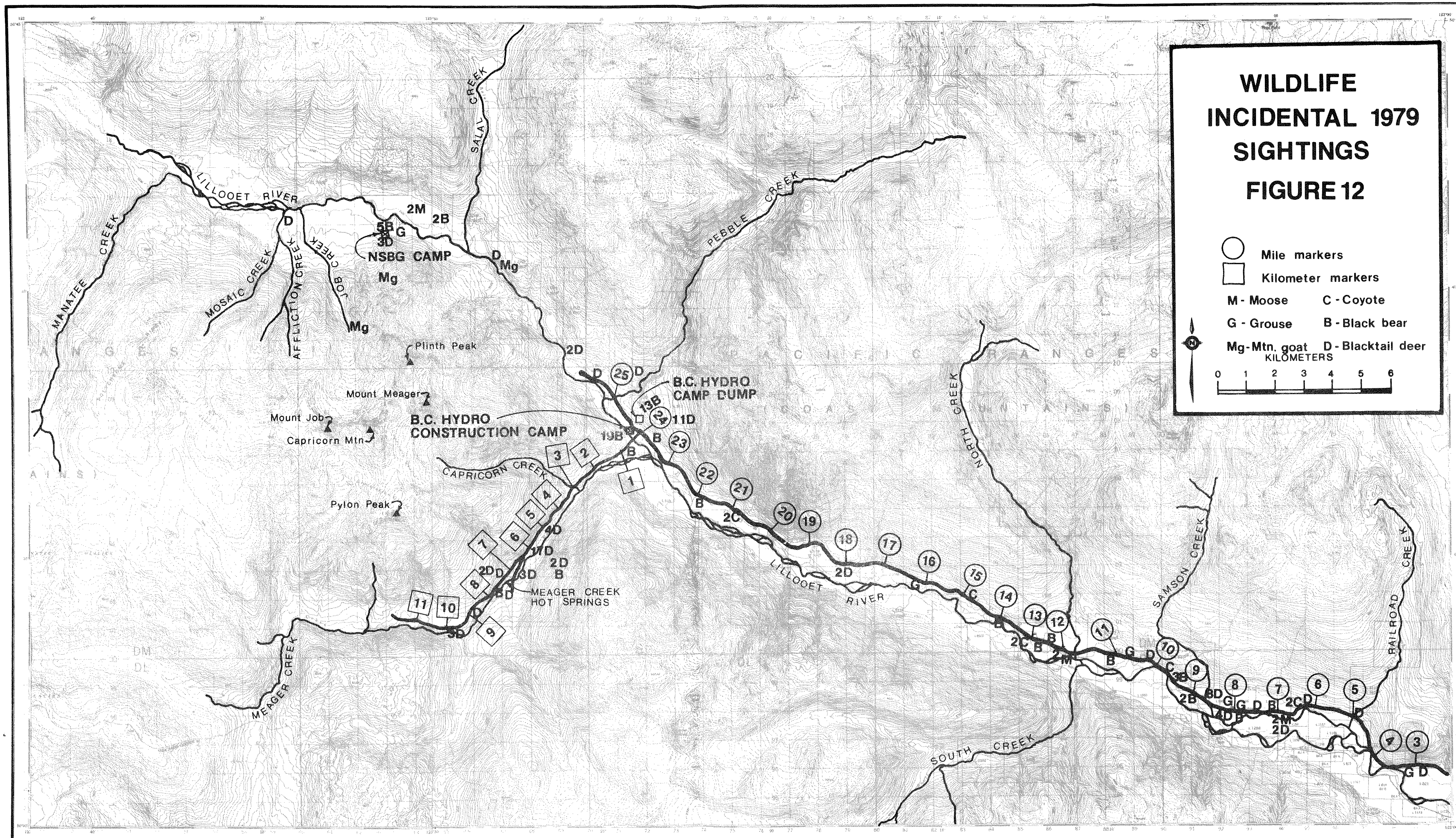
* Use of mile numbers for landmarks refers to mileage signs posted along road by logging companies.



WILDLIFE
INCIDENTAL 1979
SIGHTINGS
FIGURE 12
Mile markers
Kilometer markers
M - Moose
C - Coyote
G - Grouse
B - Black bear
Mg - Mtn. goat
D - Blacktail deer
KILOMETERS
0 1 2 3 4 5 6
LILLOOET RIVER
MANATEE CREEK
MOSAIC CREEK
AFFLICTION CREEK
JOB CREEK
SALAL CREEK
PEBBLE CREEK
NSBG CAMP
Plinth Peak
Mount Meager
Mount Job
Capricorn Mtn
Pylon Peak
B.C. HYDRO CONSTRUCTION CAMP
B.C. HYDRO CAMP DUMP
CAPRICORN CREEK
MEAGER CREEK HOT SPRINGS
MEAGER CREEK
NORTH CREEK
SAMSON CREEK
RAILROAD CREEK
SOUTH CREEK
LILLOOET RIVER

One, between July 26 and August 10, concurred with the peak of the berry season. At this time the bears were commonly seen feeding in the abundant huckleberry patches in the logged area around the camp. They were also attracted into the camp area by garbage and the smell of food from the cook house. Bears reappeared in the area of the base camp between September 8 and September 19 and were obviously attracted by the cook house and the garbage dump. Bear sightings were rare in the Meager Creek valley with only two observations on a slide slope above the Angel Creek drill site and a single sighting on the avalanche slope at meteorological Station 3.

Moose, moutain goat and grizzly bear are also present in the study area though very infrequently observed. The few sightings of grizzly bear and mountain goat this summer were confined to the upper Lillooet valley, specifically the upper valleys of tributaries such as Pebble and Salal Creeks.

N.S.B.G. personnel working in the upper Lillooet valley in June noted evidence of moose in the area (tracks, pellets) but did not see any. Also in June, Eldon Talbot, the local helicopter pilot, observed two moose in the meadow area above the Lillooet River falls. The only other report of moose was a cow and calf at 12 mile (19.3 km) in the lower valley during the week of June 18.

Squirrels and chipmunks were ubiquitious and so numerous that no attempt was made to keep a record of their occurrence. Sightings of coyote were fairly frequent in localized areas of the Lillooet valley and seemed to extend further up the valley as summer progressed. Pika were observed on a rocky slope on the Meager North Main Road at 8 km. There were also several unconfirmed sightings of mink at the Meager Creek bridge in the Meager Creek valley.

Kestrels were commonly observed hunting in or over clear cut areas throughout the study area. Grouse (species unknown) were frequently seen on the Lillooet valley road up to 17 (27.4 km) mile. Canada geese were observed in backwater channels of the lower Lillooet and there were two reports of great blue heron in the Lillooet valley near the camp and at Pebble Creek confluence.

4.3 FISHERIES

4.3.1 INTRODUCTION

Only limited fisheries data are available for the Lillooet River and Meager Creek within the study area. Coho and sockeye salmon may use Meager Creek but this has not been confirmed. South Creek, a tributary of Meager Creek, is known to support rainbow and/or steelhead trout and Dolly Varden char but population numbers are unknown.

The Lillooet River, and various tributaries nearer Pemberton, are known to support chinook, coho and sockeye salmon and steelhead and sea-run cutthroat trout (pers. comm. W.J. Schouwenburg, n.d.). However, the population numbers and distribution in the upper watershed are unknown. The International Pacific Salmon Fisheries Commission (pers. comm. I.P.S.F.C. letter dated December 11, 1978) had indicated that the Birkenhead River and the Lillooet River near Pemberton support significant runs of anadromous fish. Sockeye escapement to the Lillooet River above Lillooet Lake for the twelve year period 1966-77 is given in Table 11. Approximately 99 percent of this production is supplied by spawning in the Birkenhead River from 2 (3.2 km) to 14 (25.5 km) miles above Lillooet Lake. The remainder is contributed along the Lillooet system including the Green River, Miller Creek, Ryan River,

Table 11: Sockeye salmon escapement, commercial catch and Indian food fishery catch for Lillooet and Birkenhead Rivers in the period 1966-1977.

YEAR	ESCAPEMENT		COMMERCIAL CATCH			INDIAN FISHERY ADULTS & JACKS
	ADULTS	JACKS	ADULTS	JACKS	ALL	
1966	20,116	61,018	80,778	37,365	118,143	5,648
1967	39,876	18,160	248,536	22,864	271,400	7,236
1968	58,104	25,803	235,860	3,579	239,439	7,200
1969	37,382	27,145	169,181	22,095	191,276	4,279
1970	30,656	42,104	143,774	15,540	159,314	6,610
1971	24,629	8,043	434,860	17,143	452,003	6,813
1972	54,722	58,802	226,074	14,883	240,957	5,319
1973	56,735	82,668	432,676	37,627	470,303	7,308
1974	119,814	53,906	652,333	30,160	682,493	24,064
1975p	61,581	31,392	303,987	47,737	351,724	11,479
1976p	77,465	30,816	383,118	15,577	398,695	14,335
1977p	23,845	19,294	231,230	34,285	265,515	20,400
Mean	50,410	38,263	295,201	24,905	320,106	10,058

p = Preliminary estimates of commercial and Indian food fishery catches.
Source: International Pacific Salmon Fisheries Commission, communication dated December 11, 1978.

Railroad Creek, Samson Creek and Twenty-five Mile Creek. Samson and Railroad creeks are believed to contain the primary sockeye spawning habitat in the upper Lillooet. Portions of the mainstem Lillooet between Mount Currie and Meager Creek may provide suitable salmon spawning habitat but this has not been confirmed. All the progeny of Birkenhead and Lillooet River spawners migrate through Lillooet Lake and a large proportion of these reside in the lake for 12 months.

4.3.2 METHODS

Any reports of fish observed or caught in the study area were recorded along with date, location and other pertinent information. In addition, the Environmental and Socio-Economic Services Department (E.S.S.D.) of B.C. Hydro conducted a brief electrofishing survey of several streams in the area. Smith-Root and Coffelt electroshockers were used and netted fish were preserved and transported to the Vancouver lab for identification.

4.3.3 RESULTS

At the end of July, fish were observed in a small unnamed stream west of the B.C. Hydro camp. The stream located between 25 (40.25 km) and 26 (41.9 km) mile on the logging road, is spring fed and flows down a steep, logged slope to the Lillooet River. Two fish were caught (3.5 (8.9 cm) and 6 (15.24 cm) inches in length), identified as cutthroat trout and aged at four years in the B.C. Hydro lab. It is suspected that this is a resident population of stunted fish. Migration in from the Lillooet River seems unlikely due to the extremely steep stream gradient and a stream course which is in sections choked with logging debris.

The results of the brief fisheries survey conducted by E.S.S.D. in September are summarized in Table 12 below.

In this survey, sampling effort was minimal, since no more than 500 seconds of electroshocking time was spent in any one sampling occasion. Electrofishing efficiency was hampered in the Lillooet River and Meager Creek owing to fast flowing conditions and high turbidity.

The only other observation of fish this season was a report of several adult coho salmon at the mouth of Samson Creek during the last week of September.

4.4 RECREATION

4.4.1 INTRODUCTION

Improved access via private logging and exploration roads and increased publicity ("Hotsprings of Western Canada"[8] and publicized accounts of geothermal exploration in the area) has resulted in increased recreational activity in the upper Lillooet River basin including the study area. The coastal mountain environment provides ample opportunity for both consumptive (hunting, fishing) and nonconsumptive (sightseeing, hiking, mountaineering, camping) recreational activities. The hot springs within the study area are emerging as a popular attraction to recreationists, as evidenced by this year's provision of rudimentary visitor facilities at the springs by the B.C. Forest Service. The recreational use of the study area was noted during the field program to provide a basis from which future studies could be planned to assess existing and potential interactions of recreation with other resource uses in the area.

Table 12: Results of electrofishing survey conducted in Meager Creek geothermal area, September 12, 13 and 14, 1979.

DATE	LOCATION	OBSERVATION
79 09 12	*Unnamed creek 1 km west of Pebble Creek.	Observed 4-5 cutthroat trout up to 15cm in length, none captured.
79 09 12	**Unnamed creek between 22 and 23 mile on logging road.	Observed 2 fish, approx. 10cm in length, none captured.
79 09 13	Meager Creek at 2 km.	Captured 3 sculpins, (<u>Cottus asper</u>) 125mm in length.
79 09 13	Lillooet River at 24 mile bridge.	Observed 1 fish, probably sculpin, none captured.
79 09 13	Unnamed creek between 22 and 23 mile on logging road.	Captured 2 juvenile coho salmon (59mm); observed 4 juvenile salmonids.
79 09 14	Unnamed creek between 22 and 23 mile on logging road.	Captured 2 juvenile coho (53 and 75mm) and 1 juvenile cutthroat (43mm); observed 12 more juvenile salmonids.
79 09 14	Unnamed creek 1 km west of Pebble Creek.	Captured 1 cutthroat (100 mm); observed 2 more.

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* The unnamed creek referred to is the same spring fed creek west of the Hydro camp where cutthroat trout were observed and captured at the end of July.

** This unnamed creek, downstream of the camp, crossed the logging road between 22 and 23 mile and entered the Lillooet River just downstream of the Meager Creek confluence. Sampling was conducted on a .5 km section between the logging road and Lillooet River. The stream was clear and shallow (.15 - 1 m in depth) with a substrate composed of gravel bars in riffle areas and soft organic mud in slow flowing reaches. The substrate is stained a rust red colour possibly due to ferrous precipitates.

4.4.2 METHODOLOGY

Casual observations by personnel associated with the geothermal exploration program and of others frequenting the study area were recorded during the 1979 field season. Observations were made on an opportunistic basis, usually during the course of other work in the area, and therefore should not be interpreted as a comprehensive or formal account of recreational activity. However, the records provide a qualitative insight to 1979 summer recreational use patterns in the study area and may be useful to provide direction for further study.

4.4.3 RESULTS

Observations of recreational use in the study area are summarized in Appendix F. The main uses noted during the 1979 field season included day and overnight use of the Meager Creek hot springs area, car camping and back packing throughout the study area, mountaineering in the high country by some organized groups, sightseeing in the general area and hunting throughout the area.

Most people involved in day use activities, including sightseeing and visiting the hot pools (picnicing and dipping etc.), came from the Pemberton area. Overnight campers and backpackers usually came from further afield, primarily the lower mainland. One group, however, came from as far away as Cambridge, England. Groups from the base camp made fairly persistent use of the hot springs area. Recreationists in the study area were either in small parties of 3-4 individuals or visiting the area though organized groups such as the B.C. Mountaineering Club, the Alpine Club and the Boy Scouts.

Most activity was noted in the vicinity of the hot springs though other areas received relatively consistent use. The broad floodplain at 2 km on Meager Creek was a popular campsite. Backpackers, particularly group expeditions, gravitated toward the glaciated headwater areas. There was a notable increase in use on holiday weekends (August 1 and September 1 weekends) and an increase in fall due to the influx of hunters.

During the period of observations it was noted that the Meager Creek hot springs area experienced some deterioration as a result of increased recreational use. Despite the provision of garbage cans by the B.C. Forest Service, garbage was left on the river bank campsites. The fragile moss-lichen plant communities on the gravel bars adjacent to the hot springs and sedge borders along the hot spring drainages were severely trampled by campers and day users of the hotspring area.

4.5 LAND USE MAP

4.5.1 INTRODUCTION

A preliminary land use map was initially prepared to assist the slope stability study which formed a part of the 1979 program. Such a map would be useful during a project design stage and also assist future environmental evaluations. For these reasons the preliminary land use map is included herein, thereby assisting future project planning.

4.5.2 METHODOLOGY

The land use information was based on interpretation of 1964 Government of British Columbia aerial photographs of the area. Logged areas and road locations were taken from September 1979 B.C. Hydro aerial photography.

The information taken from the aerial photographs was supplemented by field observations of ground conditions.

All information was plotted at a scale of 1:20,000 on topographic maps prepared specifically for the geothermal project.

4.5.2 RESULTS

The preliminary land use map is presented in Figure 13 (inside back cover), and shows that the principle land disturbance has resulted from logging activities, including road building. Other activities include recreation and geothermal exploration.

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APPENDIX A

PHOTOGRAPHIC PLATES FOR MEAGER CREEK GEOTHERMAL STUDY AREA, 1979

1. Lillooet River below Manatee Creek looking east, June, 1979.

2. Job Creek, July 1979.

3. Meager Creek valley below No Good Creek looking north-east, July, 1979.

4. H_2S strip and Henry Plate monitoring site, Meager Creek Hot Springs, July, 1979.

5. Weather Measure, Meteorological Station 4, July, 1979.

6. Water sample filtering apparatus, MC-100, June, 1979.

1. Lillooet River below Manatee Creek looking east, June, 1977.

2. Job Creek, July, 1979.

3. Meager Creek valley below No Good Creek looking north-east, July, 1979.

4. H_2S strip & Henry Plate monitoring site, Meager Creek Hot Springs July, 1979.

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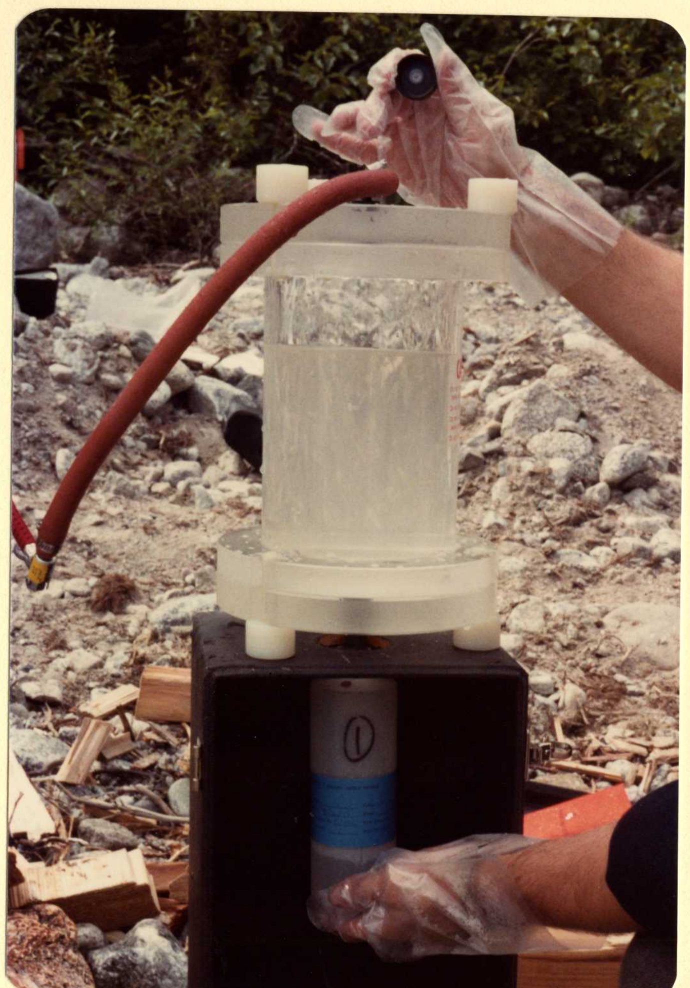

6. Water sample filtering apparatus, MC-100, June, 1979.

APPENDIX B

BRIEF DESCRIPTION OF AIR QUALITY MONITORING SITES

A) Metronics Colortec H_2S Detectors

B) Total Sulphation and Henry Plate Monitors

APPENDIX B

BRIEF DESCRIPTION OF AIR QUALITY MONITORING SITES

A) METRONICS COLORTEC H_2S DETECTORS

AQ1 3 m above ground on bare dead tree trunk near toe of sparsely vegetated rock slide, on north facing slope. Good exposure. Elev. 780 m.

AQ2 2 m above ground on bush limb, 300 m north of Job Creek valley. Good exposure. 100 m south of H3. Elev. 840 m.

AQ3 2 m above ground on bare limb of bush on rocky knoll in middle of avalanche slope near Meteorology station #3. Good exposure. Elev. 1311 m.

AQ4 3 m above ground on west side of tall cedar tree trunk, facing access road and drill site #1 (1979). Poor valley exposure; collects valley side down draft past rig. Elev. 855 m.

AQ5 2 m above ground on trunk of cottonwood tree in small stand on island in Lillooet River. Adjacent to H4. Fair exposure. Elev. 780 m.

AQ6 3 m above ground on bare dead trunk of tree in middle of wide open gravel area. Good exposure. Elev. 850 m.

AQ7 2 m above ground on limb of sapling adjacent to Meager Creek right bank, approx. 70 m north of main pool of Meager Hot Springs in narrow valley. Fair exposure to east, poor to north, south and west. Elev. 610 m.

AQ 8 — 2 m above ground on tree stump in logged area or north side of Meager Creek below logging road. Good exposure to west. Elev. 550 m.

AQ 9 — 2 m above ground on tower at meteorology station #1, and near H5. Good exposure. Elev. 562 m.

AQ 10 — 1-1/2 m above ground on limb of bush in open gravel area on left side of Lillooet River. Fair exposure. Elev. 732 m.

AQ 11 — 2 m above ground on trunk of tree in partial clearing on rock slide . Exposed to down slope air movements; sheltered from main valley winds by surrounding trees. Elev. 670 m.

AQ 12 — 3 m above ground on limb of bush on east side of Job Creek. Thick bush to east, exposed to up and down valley winds. 100 m down valley from H8. Elev. 1100 m.

AQ 13 — 3 m above ground on limb of sapling on left bank of Lillooet River, below rock cut, near road. Valley norrow, fair exposure to down valley winds. Elev. 482 m.

AQ 14 — 1 m above rocks and 4 m above Lillooet River in very narrow canyon bottom. 300 m downstream from Pebble Hot Springs. Fair exposure for winds in canyon. Elev. 490 m.

AQ 15 — 4 m above ground on limb of sapling, located above one of the streams emanating from the Meager Hot Springs. Elev. 615 m.

AQ 16 — 1 m above ground on top limb of low bush at the lip of waterfall overlooking Lillooet River falls and the canyon. Good exposure to down slope winds in narrow defile. Elev. 540 m.

AQ 17 Similar to AQ 11, on limb of cedar tree , lower down boulder field just above Meager Hot Springs. Elev. 640 m.

AQ 18 3 m above ground on top limb of alder exposed to large open braided gravel river bed at mouth of Meager Creek. North side of valley with roots and tall trees 50 m away. Elev. 450 m.

AQ 19 2 m above ground near pool on east end of Meager Hot Springs. Located on limb of small tree. Fair exposure to winds along narrow valley. 25 m below H6. Elev. 600 m.

AQ 20 2 m above ground on bare trunk of small isolated tree at west side of logged area over-looking 30 m deep canyon of No Good Creek. Good exposure to north, south and east, fair to west. Elev. 855 m.

AQ 21 3 m above ground near Angel Creek, on limb of alder. Poor exposure to north, fair to south, east and west. Elev. 825 m.

AQ 22 3 m above ground on post in centre of large logged area, near H2. Good exposure. Elev. 763 m.

B) TOTAL SULPHATION & HENRY PLATE MONITORS

H1 On boulder at ground level just above toe of Devastation Slide. Good exposure with nearest trees 150 m away, though limited exposure to south by mountain side which rises up 200 m away. Elev. 840 m.

H2 1 m above ground in centre of large tree stump, in centre of large clearing. Good exposure. Near AQ 22. Elev. 762 m.

H3 2 m above ground on trunk of tree, 100 m north of AQ 2. Good exposure to south, east and west. Poor exposure to north. Elev. 830 m.

H4 Adjacent to AQ 5.

H5 5 m SW of meteorology station #1, 1 m above ground on tree stump. Fair exposure, limited by bluff 30 m away to the north. Elev. 560 m.

H6 2 m above ground in alder tree, 150 m down valley of main hot pool at Meager Hotsprings. Fair exposure to west and north. Elev. 605 m.

H7 2 m above ground in cottonwood tree trunk 100 m from left bank of Lillooet River above Salal Creek. Fair exposure to north, east and west. Elev. 760 m.

H8 On top of 3 m high ridge of boulders in centre of narrow Job Creek valley; Job Creek to the west. Good exposure. Elev. 1135 m.

H9 On large rock on left bank of Lillooet River, 60 m upstream of AQ 14. Good exposure to down valley winds. Elev. 495 m.

APPENDIX C
WATER QUALTIY DATA

Table

Figure

TABLE C-1

TEMPERATURE AND MAJOR ION COMPOSITION OF MEAGER CREEK

Sample Location	Temp. (°C)	SiO_2 (ppm)	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
Water near hotspring 79-D	4	8.3	1.4	0.7	7.8	2
Water near main vent	4	9.4	5	1.1	6.8	1.8

Source: Nevin, Sadlier-Brown, Goodbrand Ltd. (5).

TABLE C-2

PHYSICO-CHEMICAL COMPOSITION OF AFFLICATION CREEK
(October 1976)

QUANTITATIVE	(PPM)
T (°C)	0.0
pH (units)	6.38
SiO2	22.0
Na	7.9
K	2.9
Ca	26.0
Mg	6.0
HCO3	41.0
CO3	-0.1
SO4	44.0
Cl	0.3
STANDARDIZED SEMI-QUANTITATIVE ANALYSIS	
Sb	- *
As	-
Ba	40
Be	-
Bi	-
Bo	-
Cd	-
Cr	-
Co	-
Cu	2
Ga	-
Ge	-
Fe	1000
Pb	10
Mn	300
Mo	-
Ni	-
Nb	-
Ag	0
Sr	40
Ta	n.d.
Te	-
Th	-
Sn	140
Ti	20
V	-
Zn	-
Zr	-

'n.d.' stands for no determination
* '-' below detection limit
Note: Affliction Creek is referred to as Job Creek in the present study.
Source: Nevin, Sadlier-Brown, Goodbrand Ltd. (4)

TABLE C-3A: Sample numbers, collection dates & locations of water samples from Meager Creek geothermal area.

01	2/8/76	thermal seep at creek level 4.7 km upstream from GSC1
02	2/8/76	Meager Creek water adjacent to sample 01
03	2/8/76	thermal seep at creek level 4.4 km upstream from GSC1
04	2/8/76	fresh water from tributary of Meager Creek flowing from Pylon Peak, collected at Drill Camp No.2 (1975)
05	3/8/76	Meager main vent thermal spring adjacent to GSC1
06	3/8/76	thermal water from GSC1
07	1/9/76	thermal seep along Lillooet River bank
08	1/9/76	Lillooet main vent thermal spring on terrace 30 m above river
09	1/9/76	fresh water from stream adjacent to sample 08
10	2/9/76	Lillooet River water from upstream of thermal springs
11	13/11/76	fresh water from the upper reaches of Affliction Creek where it exits from the glacier ice
12	30/11/76	Same as sample 07
13	30/11/76	Same as sample 08
14	30/11/76	Same as sample 09
15	13/11/76	Same as sample 11
16	30/11/76	Same as sample 10
17	30/11/76	Same as sample 06
18	30/11/76	Same as sample 05
19	15/11/76	Lillooet River sample collected between the outlets of Pebble Creek and Meager Creek
20	15/11/76	Lillooet River sample collected 1 km downstream of the outlet of Meager Creek
21	30/11/76	fresh water from tributary entering Meager Creek 180 m upstream of GSC1
22	30/11/76	Meager Creek sample collected adjacent to drill hole 74-H-1

Source: Hammerstrom & Brown (6)

TABLE C-3B: Analysis of samples from the Mt. Meager hot spring area in parts per million concentration.

Sample	Date	Location	pH	T(°C)	SiO_2(r)	Cl	SO_4	HCO_3	Na	K	Mg	Ca	$Mn^{0.01}$	Mn	$Fe^{0.01}$	Fe
01	2/8/76	Meager	6.50	31.4	56.0	133	25	503	165	23.7	15.4	92.0	-	0.45	-	0.45
02	2/8/76	Meager	7.30	4.0	4.0	0.51	26	31	2.4	1.1	2.5	9.3	-	0.10	-	2.40
03	2/8/76	Meager	6.80	30.0	54.0	295	50	260	248	27.0	17.1	83.5	-	0.95	-	0.50
04	2/8/76	Meager	7.50	7.5	11.0	0.37	5	46	2.9	1.1	2.2	7.4	-	0.01	-	0.30
05	3/8/76	Meager	6.40	48.5	80.5	428	65	450	347	44.0	24.8	92.0	-	0.32	-	0.00
06	3/8/76	Meager	6.05	56.0	92.0	466	170	458	377	46.2	34.1	97.0	-	0.65	-	0.15
07	1/9/76	Lillooet	7.70	53.5	40.0	72	315	992	410	13.8	6.6	44.0	-	0.09	-	0.00
08	1/9/76	Lillooet	6.85	59.0	43.0	67	275	992	396	10.2	6.1	42.5	-	0.10	-	0.15
09	1/9/76	Lillooet	7.10	7.0	22.0	0.27	10	23	2.5	1.1	1.1	3.9	-	0.00	-	0.00
10	2/9/76	Lillooet	7.20	5.0	2.0	0.44	15	31	2.0	1.1	2.2	7.0	-	0.05	-	1.45
11	13/11/76	Afflict.	6.20	-1.0	10.0	2.17	50	122	8.0	2.1	10.0	47.0	-	0.53	-	1.85
12	30/11/76	Lillooet	8.00	50.5	44.0	72	340	1068	418	18.9	7.0	39.0	-	0.09	-	0.00
13	30/11/76	Lillooet	6.70	59.0	60.0	71	385	1053	405	18.9	7.0	32.5	-	0.11	-	0.15
14	30/11/76	Lillooet	7.30	6.0	18.0	0.45	3	38	2.0	1.0	0.5	3.3	-	0.00	-	0.00
15	13/11/76	Afflict.	7.80	0.0	8.5	0.61	75	183	8.0	2.0	10.5	47.0	0.40	0.50	-	1.60
16	30/11/76	Lillooet	7.40	0.0	10.0	1.01	39	76	13.5	1.7	3.0	15.7	-	0.04	-	0.30
17	30/11/76	Meager	6.15	56.5	96.0	500	180	686	410	52.0	40.5	105.0	0.50	0.65	-	0.30
18	30/11/76	Meager	6.60	50.0	102.0	500	145	595	390	48.5	31.0	92.0	0.25	0.34	-	0.00
19	15/11/76	Lillooet	7.75	1.3	4.5	0.46	24	46	3.5	1.1	2.5	14.1	-	0.03	-	0.30
20	15/11/76	Lillooet	7.75	2.0	3.0	1.56	25	53	5.5	1.2	3.0	16.3	-	0.02	-	0.25
21	30/11/76	Meager	7.50	-1.0	1.7	<.18	16	nd	2.0	1.5	1.0	15.4	-	0.00	-	0.01
22	30/11/76	Meager	7.50	0.0	1.7	1.38	25	nd	5.5	1.3	4.5	16.9	-	0.00	-	0.15

SiO_2(r) refers to reactive silica
The superscript 0.01 refers to filtration through a 0.01 micron membrane filter
Afflict. refers to samples from Affliction Creek
nd refers to not determined

Source: Hammerstrom & Brown (6)

TABLE C-4: Horiba U-7 Water Quality Checker specifications.

PARAMETER	METHOD OF MEASUREMENT	RANGE OF MEASUREMENT	ACCURACY	TEMPERATURE COMPENSATION
pH	Glass Electrode	0.0 to 14.0 pH	±0.1 pH	Automatic 0 to 40°C
Turbidity	Ratio Turbidometer	0 to 400ppm Suspended Solids	±20ppm	- -
Temperature	Thermistor	0 to 40°C	±0.5°C	- -
Electrolytic Conductivity	4-Electrode Sensor	0 to 99 umhos/cm	±50 umhos/cm	- -
Dissolved Oxygen	Membrane Type Galvanic Cell	0 to 20.0 ppm DO	±1.0ppm	Automatic 0 to 40°C

INDICATOR :	Light emitting diodes, 3 digits with accuracy of ±1 digit.
MEASUREMENT SELECTION :	Rotary Switch
POWER SOURCE:	Rechargeable battery (Nickel-cadmium cell) or line AC.
CONNECTING CABLE :	Standard length-2 metres
WEIGHT :	Instrument - 700g Sensor - 900g
SHIPPING WEIGHT :	Approximately 5 kg

TABLE C-5: Beckman Model RA-2A Conductivity Meter specifications

RANGE:	5-2000 micromhos/cm
ACCURACY:	2% of span
CONDUCTIVITY PROBE:	Model CELVS01, CELVS1 Platinized goldplate nickle rod electrodes
CELL CONSTANT:	0.1 and 1.0
MEASURING CIRCUITS:	400 Hz
POWER SOURCE:	2 flashlight batteries

TABLE C-6: Hach Dissolved Oxygen Meter Model 16046 specifications.

SENSING ELEMENT

Clark-type membrane, covered polarographic probe.

RANGES

0-10 and 0-20 mg/l with standard membrane

0-5 and 0-10 mg/l with high sensitivity membrane

ACCURACY

±1% of full scale at temperature of calibration

TEMPERATURE COMPENSATION

±1% of reading within ±5% of probe temperature

±3% of reading over entire range of probe temperature

PRESSURE COMPENSATION

Effective to 0.5% reading over 100 psi range (230 feet of water)

OPERATING TEMPERATURE RANGE

-2° to 45°C

INSTRUMENT TEMPERATURE STABILITY

±2% of full scale reading over instrument operating temperature range

CALIBRATION

1. Fresh air of known temperature
2. Water sample of known oxygen concentration

RESPONSE TIME

90% of full scale in 10 seconds

SMALLEST SCALE DIVISION

0.02 mg/l on lowest range

READABILITY

0.05 mg/l on lowest range

STORAGE TEMPERATURE RANGE

-2° to 60°C

POWER SUPPLY

Six 1.25V NiCd batteries requiring a 12-hour recharge after every 50 hours of use. Complete with external wall plug converter/charger, 95-135V ac, 50-60Hz.

TABLE C-6: continued

RECORDER OUTPUT

Fixed, 0-100 mV ($\pm$5 mV). Recorder must have minimum input impedance of 50K ohms.

RECORDER OUTPUT RESOLUTION

Better than 1 mV

INDICATING METER

4-1/2" Analog meter with mirrored scale

CASE

Durable black ABS plastic; resistant to impact and chemical attack

DIMENSIONS

14" (35.5 cm) wide, 10-3/4" (27.3 cm) deep and 8-1/2" (21.6 cm) high

WEIGHT

Net Weight: 8.5 lbs. (3.86 kg)

Shipping Weight: 10.5 lbs. (4.76 kg)

WATER QUALITY DATA - 1979 FIELD PROGRAM

NOTE:

As the conductance probe for the Horiba U7 is not temperature compensated to 25°C results were converted according to the following equation:

$$\text{Conductance @ } 25°\text{C} = \frac{\text{C (in situ)}}{\text{I} + \text{K} [\text{T} - 25°\text{C}]}$$

where C = Horiba U7 reading for conductance at T in situ
T = water temperature at the time of the reading
K = 2.4%/°C

Temperature conversion factors for the Beckman Conductivity Meter were established by plotting meter readings for a given solution through a range of temperatures and dividing the meter reading for conductance at 25°C by the value at temperature (T_n). The field results for conductance at temperatures (T_1,T_2...) were mulitplied by the appropriate conversion factors for temperatures (T_1,T_2...) to obtain conductance at 25°C.

TABLE C-7: Results of field water quality measurements in upper (MC-200) and lower (MC-100) Meager Creek, 1979.

SAMPLE NUMBER	DATE	TIME	COLLECTED BY	WITNESSED BY	AIR TEMPERATURE C	WATER TEMPERATURE C				pH			SPECIFIC CONDUCTANCE umho/cm						DISSOLVED OXYGEN mg/l			TURBIDITY F.T.U.				ALKALINITY* mg/l CaCo3
						1*	2*	3*	4*	1	2	7*	1	5*	2	5	6*	5	1	2	4	1	Avg.	2	Avg.	
MC 100-QC-1	79 06 19*	0945	EN	MK	19.7	5.2				6.6			19	36.2					10.8			20-21				60
MC 100-QC-2	79 06 26	1445	EN	GS		9.2				7.3			19	30.5					18.1			25				60
MC 100-QC-3	79 07 03	1523	EN		28	8.8				7.9			38	62.2			75	111.75	14.9			41-45	43			40
MC 100-QC-4	79 07 16	1125	EN	MP	23.8	8.3				7.6			17	28.4			31	46.5	17.4			90-97	94			60
MC-100-QC-5	79 07 26	1035	MP		25	6.7				7.0			25	44.6			30	46.8	14.5			659-819	730			40
MC-100-QC-6	79 08 16*	1300	EN	MP	23.5	7.7	7.5			8.1	7.3		10	17.1	18	31.03	37.5	56.25	13.8	12.4		82-105	87	99-125	111	40
MC-100-QC-7	79 09 06	1930	EN		12.3	10.1				7.7			51.5	80.17					10.9			110-140	130			40
MC-100-QC-8	79 11 03	1700	EN	MP	10.0	4.2		4.6		8.0			77	153.75			139	234.9	13.0			2				
MC-100-QC-9	79 12 10*	1505	MP	EN	-4.0	1.0		1.0		7.8			71	165.09			110	185.9	12.8		12.4	10				60
MC 200-QC-1	79 06 19*	1230	MK	EN	20.5	3.5				6.8			8	16.5					11.3			23				60
MC 200-QC-3	79 07 03	1750	EN		15.5	5.8				8.0			13	24.1			38	61.56	15.0			43-47	45			40
MC 200-QC-4	79 07 15	1602	EN	MP	25.5	8.2				7.8			8	13.5			21.5	32.25	13.5			151-138	144			40
MC 200-QC-5	79 07 26	1245	MP		23.5	5.9				7.8			16	29.5			22.5	36.45	15.5			375-511	460			40
MC 200-QC-6	79 08 15*	1345	EN	MP	22.5	6.8	6.8			8.3	7.3		5	8.9	10	17.76	25	39.0	13.9	13.1		260-286	270	225-245	231	40
MC 200-QC-7	79 09 06	1500	EN		12.1	9.4				8.25			15	23.98					10.2			75-97	90			40
MC 200-QC-9	79 12 11*	1045	EN	MP	-2.5	0.1		0.0		8.0			38	94.43			70	118.4	13.7			6-7	6			60

* 1. Horiba U7 (with stirrer cup)
2. Horiba U7 (with flow-through cup)
3. Fisher general laboratory mercury thermometer
4. Hach Portable Dissolved Oxygen Meter, Model 16046
5. Conductance at 25°C, calculated
6. Beckman Model RA-2A Conductivity Meter
7. Hach Mini pH Meter, Model 17200

Alkalinity - Bausch and Lomb Spectrokit

Dates marked with asterisks indicate occasions when concurrent samples were taken for lab analysis.

TABLE C-8: Results of laboratory water quality analysis for site MC-200, 1979.

PARAMETER	DATE		
	79 06 19 (1230)	79 08 15 (1400)	79 12 11 (1045)
PHYSICAL-CHEMICAL PARAMETERS			
pH (units)	7.5	8.1	7.8
Suspended Solids (105°C)	44	692	7
Total Dissolved Solids (180°C)	43	58	86
Total Dissolved Solids (sum of constituents)	23	12	47
True Colour (units)	5	20	5
Total Alkalinity	19	18	44
Tannins & Lignins	<0.1	<0.1	<0.1
Dissolved Calcium	8.8	3.0	11
Dissolved Magnesium	1.4	0.73	3.3
Dissolved Sodium	1.5	1.0	3.5
Dissolved Potassium	0.68	0.49	1.3
Dissolved Chloride	0.1	0.1	0.3
Dissolved Fluoride	<0.05	<0.05	0.05
Dissolved Sulfate	7	5	18
Specific Conductance (umhos/cm)	53.6	39.2	133
Dissolved Silica	3.7	1.9	10
NUTRIENT PARAMETERS			
Total Kjeldahl Nitrogen	<0.02	0.13	<0.05
Total Nitrate Nitrogen	0.04	0.04	0.07
Total Nitrite Nitrogen	0.007	<0.005	<0.003
Total Phosphate Phosphorus	0.034	0.41	0.016
Dissolved Ortho-Phosphate Phosphorus	0.003	0.008	0.006
ORGANIC PARAMETERS			
Total Organic Carbon	2	<2	6
Oil & Grease	<1	<1	<1
TRACE ELEMENTS			
Dissolved Arsenic	<0.005	<0.005	<0.005
Dissolved Cadmium	<0.005	<0.005	<0.005
Dissolved Chromium	<0.01	<0.01	<0.01
Dissolved Copper	<0.005	<0.005	<0.005
Dissolved Iron	0.04	0.05	0.06
Dissolved Lead	<0.01	<0.01	<0.01
Dissolved Manganese	0.01	0.02	0.04
Dissolved Mercury	<0.00025	<0.00025	<0.00025
Dissolved Molybdenum	<0.05	<0.05	<0.05
Dissolved Nickel	<0.01	<0.01	<0.01
Dissolved Selenium	<0.003	<0.003	<0.003
Dissolved Zinc	0.053	0.024	0.059
MICROBIOLOGICAL PARAMETERS			
Total Coliform (organisms/100 ml)	<2	<2	1.8
Fecal Coliform (organisms/100 ml)	<2	<2	<2.0

TABLE C-9: Results of laboratory water quality analysis for site MC-100, 1979.

PARAMETER	DATE			
	79 06 19 (1100 & 0945)		79 08 16 (1415)	79 12 10 (1505)
PHYSICAL-CHEMICAL PARAMETERS		(duplicate)		
pH (units)	7.4	7.4	7.5	7.4
Suspended Solids (105°C)	36	34	259	6
Total Dissolved Solids (180°C)	56	47	61	127
Total Dissolved Solids (sum of constituents)	35	35	21	86
True Colour (units)	10	10	15	5
Total Alkalinity	21	22	17	52
Tannins & Lignins	<0.1	<0.1	<0.1	0.2
Dissolved Calcium	7.0	7.5	3.6	11
Dissolved Magnesium	1.4	1.4	0.84	3.3
Dissolved Sodium	6.7	6.7	4.1	18
Dissolved Potassium	1.2	1.1	0.84	2.8
Dissolved Chloride	6.4	5.9	3.5	18
Dissolved Fluoride	<0.05	<0.05	<0.05	0.06
Dissolved Sulfate	7	7	5	18
Specific Conductance (umhos/cm)	80.5	81.0	54.0	212
Dissolved Silica	5.6	5.8	3.4	15
NUTRIENT PARAMETERS				
Total Kjeldahl Nitrogen	<0.02	<0.02	<0.02	0.14
Total Nitrate Nitrogen	0.04	0.02	0.02	0.06
Total Nitrite Nitrogen	<0.005	<0.005	<0.005	<0.003
Total Phosphate Phosphorus	0.031	0.029	0.21	0.016
Dissolved Ortho-Phosphate Phosphorus	<0.003	0.003	0.010	0.008
ORGANIC PARAMETERS				
Total Organic Carbon	3	5	<2	6
Oil & Grease	<1	<1	<1	<1
TRACE ELEMENTS				
Dissolved Arsenic	<0.005	<0.005	<0.005	0.008
Dissolved Cadmium	<0.005	<0.005	<0.005	<0.005
Dissolved Chromium	<0.01	0.02	<0.01	<0.01
Dissolved Copper	<0.005	<0.005	<0.005	<0.005
Dissolved Iron	0.05	0.03	0.02	0.03
Dissolved Lead	<0.01	<0.01	<0.01	<0.01
Dissolved Manganese	<0.01	<0.01	0.02	0.02
Dissolved Mercury	<0.00025	<0.00025	<0.00025	<0.00025
Dissolved Molybdenum	<0.05	<0.05	<0.05	<0.05
Dissolved Nickel	<0.01	<0.01	<0.01	<0.01
Dissolved Selenium	<0.003	<0.003	<0.003	<0.003
Dissolved Zinc	0.029	0.029	0.043	0.005
MICROBIOLOGICAL PARAMETERS				
Total Coliform (organisms/100 ml)	13	7.8	6.8	4.5
Fecal Coliform (organisms/100 ml)	2	4.5	2.0	<2.0

TABLE C-10: Results of field water quality measurements at upstream (LR 200) and downstream (LR 100) sites on the Lillooet River within the study area and on the Lillooet River at Pemberton (LRP-100), 1979. Refer to Table C-7 for explanation of asterisks.

SAMPLE NUMBER	DATE	TIME	COLLECTED BY	WITNESSED BY	AIR TEMPERATURE C	WATER TEMPERATURE C				pH			SPECIFIC CONDUCTANCE umho/cm						DISSOLVED OXYGEN mg/l			TURBIDITY F.T.U.				ALKALINITY* mg/l CaCo3
						1*	2*	3*	4*	1	2	7*	1	5*	2	5	6*	5	1	2	4	1	Avg.	2	Avg.	
LR 100-QC-1	79 06 19*	1615	EN	MK	27.8	8.8				7.0			8	13.1					10.7			42				60
LR 100-QC-2	79 06 26	1230	EN	GS	28	7.5				5.9			12	20.7					17			50				60
LR 100-QC-3	79 07 04	1400	EN		13.5	7.3				7.7		7.4-7.6	9	15.7			22	34.32	15.4		12.2	59-64	61			40
LR 100-QC-4	79 07 16	1545	EN	MP	29	10.5				7.3			11	16.9			20	29	17.8			128-158	148			40
LR 100-QC-5	79 07 26	1815	MP		22.1	9.2				7.7			13	18.3			14	20.86	15.1			198-212	205			40
LR 100-QC-6	79 08 16*	0900	MP	EN	22.5	5.6	5.1			8.3	7.8		4	7.48	9	17.23	17	28.22	11.7	10.5		89-101	92	87-114	98	40
LR 100-QC-7	79 09 06	1830	EN		11	9.4				7.8			6	9.59					10.8			40-65	58			40
LR 100-QC-8	79 11 03	1145	EN	MP	7	3.5		3.8		8.2			30	61.98			59	99.71	12.8			22				
LR 100-QC-9	79 12 10*	1130	MP	EN	1.5	0.8		0.5		7.7			32	76.34			65	109.85	13		12.6	10-12	11			40
LR 200-QC-1	79 06 19*	1415	EN	MK	21.8	7.5				7.3			5.5	9.5					10.7			54				60
LR 200-QC-3	79 07 03	1835	EN		15	6.1				8.1			4	7.3			22	33	14.4			87-95	91			60
LR 200-QC-4	79 07 15	1730	EN	MP	24.1	8.2				7.8			7	11.7			15.2	22.8	13.7			95-111	100			40
LR 200-QC-5	79 07 26	1340	MP		26.5	7.1				7.7			19	33.3			12	18	15.2			716-998	918			40
LR 200-QC-6	79 08 15*	1600	EN	MP	19	6.8	6.6			8.3	7.8		8.5	15.1	11	18.73	11.9	17.85	13.1	11.7		148-158	154	149-201	170	40
LR 200-QC-7	79 09 06	1420	EN		14	7.8	7.0			8.15	7.8		6.5	11.07	2.5	4.4			10.4	10.6		41-68	50	250-300	275	40
LRP 100-QC-1	79 06 20*	0930	EN	MK	13.5	8.15				6.95			9.5	15.96			25.1	37.65	11.35			34				60
LRP 100-QC-2	79 06 26	1735	EN	GS		12.45				7.3			9.0	12.87					17.3			38				40
LRP 100-QC-3	79 07 09	1515	EN		21.0	9.5				5.6			6.0	9.24					17.5			92-102	97			40
LRP 100-QC-4	79 07 17	1625	MP		33.5	12.4				7.3			14.0	20.07			22	29.7	15.1			57-78	71			40
LRP 100-QC-6	79 08 16*	1645	EN	MP	21.0	9.2	9.0			7.6	7.5		5.0	8.05	5	8.12	24.5	36.5	11.8	10.7		77-92	85	84-107	93	40
LRP 100-QC-7	79 09 03	1500	EN	SH	16.8	8.6	8.3			8.5	7.9		2.5	4.12	8	13.35			16.3	14.9		641-698	670	632-801	700	40
LRP 100-QC-8	79 11 03	0845	EN	MP	4.8	3.85		4.0		6.5			35.0	71.08			62.5	105.62	11.6			3-5	4			
LRP 100-QC-9	79 12 12*	1130	EN	MP	1.0	0.3		0.0		8.1			32.0	78.56			70	118.3	14.3		13.3	3-4	3			60

TABLE C-11: Results of laboratory water quality analysis for site LR-200, 1979.

PARAMETER	DATE		
	79 06 1[illegible] (1415)	79 08 15 (1615)	No Winter Sample
PHYSICAL-CHEMICAL PARAMETERS			
pH (units)	7.4	7.0	
Suspended Solids (105°C)	52	319	
Total Dissolved Solids (180°C)	26	34	
Total Dissolved Solids (sum of constituents)	21	5	
True Colour (units)	20	15	
Total Alkalinity	12	6.8	
Tannins & Lignins	<0.1	<0.1	
Dissolved Calcium	9.0	1.4	
Dissolved Magnesium	0.56	0.22	
Dissolved Sodium	0.92	0.40	
Dissolved Potassium	0.93	0.51	
Dissolved Chloride	0.2	<0.1	
Dissolved Fluoride	<0.05	<0.05	
Dissolved Sulfate	7	2	
Special Conductance (umhos/cm)	41.2	17.3	
Dissolved Silica	2.7	0.43	
NUTRIENT PARAMETERS			
Total Kjeldahl Nitrogen	<0.02	0.14	
Total Nitrate Nitrogen	0.05	0.03	
Total Nitrite Nitrogen	0.016	<0.005	
Total Phosphate Phosphorus	0.045	0.30	
Dissolved Ortho-Phosphate Phosphorus	<0.003	0.004	
ORGANIC PARAMETERS			
Total Organic Carbon	3	<2	
Oil & Grease	<1	<1	
TRACE ELEMENTS			
Dissolved Arsenic	<0.005	<0.005	
Dissolved Cadmium	<0.005	<0.005	
Dissolved Chromium	<0.01	<0.01	
Dissolved Copper	<0.005	<0.005	
Dissolved Iron	0.03	0.16	
Dissolved Lead	<0.01	<0.01	
Dissolved Manganese	<0.01	0.01	
Dissolved Mercury	<0.00025	<0.00025	
Dissolved Molybdenum	<0.05	<0.05	
Dissolved Nickel	<0.01	<0.01	
Dissolved Selenium	<0.003	<0.003	
Dissolved Zinc	0.029	0.028	
MICROBIOLOGICAL PARAMETERS			
Total Coliform (organisms/100 ml)	<2	<2	
Fecal Coliform (organisms/100 ml)	<2	<2	

TABLE C-12: **Results of laboratory water quality analysis for site LR-100, 1979.**

PARAMETER	DATE				
	79 06 19 (1615)	79 08 16 (0900)		79 12 10 (1130 and 1300)	
PHYSICAL-CHEMICAL PARAMETERS			(duplicate)		
pH (units)	7.3	7.2	7.1	7.7	7.6
Suspended Solids (105°C)	61	210	202	4	5
Total Dissolved Solids (180°C)	36	46	49	81	83
Total Dissolved Solids (sum of constituents)	26	11	10	54	55
True Colour (units)	20	15	15	<5	5
Total Alkalinity	14	9.2	9.1	33	33
Tannins & Lignins	<0.1	<0.1	<0.1	<0.1	<0.1
Dissolved Calcium	9.5	2.4	2.2	9.2	8.8
Dissolved Magnesium	0.73	0.30	0.33	2.0	2.0
Dissolved Sodium	1.5	0.70	0.75	5.7	5.7
Dissolved Potassium	0.83	0.50	0.55	1.5	1.5
Dissolved Chloride	0.2	<0.1	<0.1	1.5	1.5
Dissolved Fluoride	0.05	<0.05	<0.05	0.14	0.13
Dissolved Sulfate	8	5	4	19	20
Specific Conductance (umhos/cm)	47.5	27.4	27.3	118	120
Dissolved Silica	5.4	2.2	1.9	15	15
NUTRIENT PARAMETERS					
Total Kjeldahl Nitrogen	<0.02	0.17	0.08	*	<0.005
Total Nitrate Nitrogen	0.10	0.03	0.03	0.08	0.08
Total Nitrite Nitrogen	<0.005	<0.005	<0.005	<0.003	<0.003
Total Phosphate Phosphorus	0.055	0.21	0.19	0.016	0.014
Dissolved Ortho-Phosphate Phosphorus	<0.003	0.006	0.004	0.006	0.006
ORGANIC PARAMETERS					
Total Organic Carbon	2	<2	<2	3	<2
Oil & Grease	<1	<1	<1	<1	<1
TRACE ELEMENTS					
Dissolved Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005
Dissolved Cadmium	<0.005	<0.005	<0.005	<0.005	<0.005
Dissolved Chromium	<0.01	<0.01	<0.01	0.04	<0.01
Dissolved Copper	<0.005	<0.005	<0.005	<0.005	<0.005
Dissolved Iron	0.07	0.02	0.13	0.05	0.03
Dissolved Lead	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Manganese	0.01	0.02	0.02	0.05	0.05
Dissolved Mercury	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Dissolved Molybdenum	<0.05	<0.05	<0.05	<0.05	<0.05
Dissolved Nickel	<0.01	<0.01	<0.01	<0.01	<0.01
Dissolved Selenium	<0.003	<0.003	<0.003	<0.003	<0.003
Dissolved Zinc	0.13	0.016	0.008	0.015	0.018
MICROBIOLOGICAL PARAMETERS					
Total Coliform (organisms/100 ml)	<2	<2	4.5	<2.0	<2.0
Fecal Coliform (organisms/100 ml)	<2	<2	4.5	<2.0	<2.0

* No result as there were problems with the first run and insufficient sample to redo. ** Field blank subtracted from samples to obtain results.

TABLE C-13: Results of laboratory water quality analysis for site LRP-100, 1979.

PARAMETER	DATE		
	79 06 19 (1415)	79 08 15 (1615)	79 12 12 (1130)
PHYSICAL-CHEMICAL PARAMETERS			
pH (units)	7.4	7.3	7.5
Suspended Solids (105°C)	71	264	7
Total Dissolved Solids (180°C)	38	41	81
Total Dissolved Solids (sum of constituents)	23	11	51
True Colour (units)	20	10	5
Total Alkalinity	15	11	38
Tannins & Lignins	<0.1	<0.1	<0.1
Dissolved Calcium	8.0	3.1	9.4
Dissolved Magnesium	0.79	0.39	2.2
Dissolved Sodium	1.6	0.90	5.0
Dissolved Potassium	0.86	0.64	1.6
Dissolved Chloride	0.7	0.3	3.5
Dissolved Fluoride	<0.05	<0.05	0.007
Dissolved Sulfate	6	3	15
Specific Conductance (umhos/cm)	47.5	29.7	122
Dissolved Silica	4.8	3.1	14
NUTRIENT PARAMETERS			
Total Kjeldahl Nitrogen	<0.02	0.03	*
Total Nitrate Nitrogen	0.08	0.03	0.09
Total Nitrite Nitrogen	0.010	<0.005	<0.003
Total Phosphate Phosphorus	0.055	0.23	0.018
Dissolved Ortho-Phosphate Phosphorus	<0.003	0.005	0.006
ORGANIC PARAMETERS			
Total Organic Carbon	3	<2	4
Oil & Grease	<1	<1	<1
TRACE ELEMENTS			
Dissolved Arsenic	<0.005	<0.005	<0.005
Dissolved Cadmium	<0.005	<0.005	<0.005
Dissolved Chromium	<0.01	<0.01	<0.01
Dissolved Copper	<0.005	<0.005	<0.005
Dissolved Iron	0.04	0.03	0.210
Dissolved Lead	<0.01	<0.01	<0.01
Dissolved Manganese	<0.01	<0.01	0.04
Dissolved Mercury	<0.00025	0.0015	<0.00025
Dissolved Molybdenum	<0.05	<0.05	<0.05
Dissolved Nickel	<0.01	<0.01	<0.01
Dissolved Selenium	<0.003	<0.003	<0.003
Dissolved Zinc	0.23	0.010	0.009
MICROBIOLOGICAL PARAMETERS			
Total Coliform (organisms/100 ml)	23	17.5	4.0
Fecal Coliform (organisms/100 ml)	7.8	6.5	2.0

* No result as there were problems with the first run and insufficient sample to redo.

TABLE C-14: Precision data for lab water quality analysis, July 1979.

PARAMETER	1st VALUE	2nd VALUE	PER CENT DIFFERENCE
<u>PHYSICAL-CHEMICAL PARAMETERS</u>			
pH (units)	7.4	7.4	0
Suspended Solids (105°C)	70	71	1.4
Total Dissolved Solids (180°C)	56	57	1.7
Total Dissolved Solids (sum of constituents)	-	-	-
True Color (units)	5	5	0
Total Alkalinity	21	21	0
Tannins & Lignins	<0.1	<0.1	0
Dissolved Calcium	7.0	7.0	0
Dissolved Magnesium	1.4	1.4	0
Dissolved Sodium	sample run directly		
Dissolved Potassium	sample run directly		
Dissolved Chloride	0.09	0.1	10*
Dissolved Fluoride	0.05	0.05	0
Dissolved Sulfate	6	6	0
Conductivity (μmhos/cm)	80.3	80.6	0.4
Dissolved Silica	5.8	5.7	1.7
<u>NUTRIENT PARAMETERS</u>			
Total Kjeldahl Nitrogen	<0.02	<0.02	0
Total Nitrate Nitrogen	0.05	0.05	0
Total Nitrite Nitrogen	0.015	0.016	6.4
Total Phosphate Phosphorus	0.035	0.033	5.9
Dissolved Ortho-Phosphate Phosphorus	0.003	0.004	29*
<u>ORGANIC PARAMETERS</u>			
Total Organic Carbon	2	3	40*
Oil & Grease	<1	<1	0
<u>TRACE ELEMENTS</u>			
Dissolved Arsenic	<0.005	<0.005	0
Dissolved Cadmium	<0.005	<0.005	0
Dissolved Chromium	<0.01	<0.01	0
Dissolved Copper	<0.005	<0.005	0
Dissolved Iron	0.04	0.04	0
Dissolved Lead	<0.01	<0.01	0
Dissolved Manganese	<0.01	<0.01	0
Dissolved Mercury	<0.00025	<0.00025	0
Dissolved Molybdenum	<0.05	<0.05	0
Dissolved Nickel	<0.01	<0.01	0
Dissolved Selenium	<0.003	<0.003	0
Dissolved Zinc	0.23	0.22	4.4
<u>MICROBIOLOGICAL PARAMETERS</u>			
Total Coliform (organisms/100 ml)	<2	<2	0
Fecal Coliform (organisms/100 ml)	<2	<2	0

* Differences in duplicate values for these parameters are small. Per cent differences appear large because values are close to detection limits.

TABLE C-15: Precision data for lab water quality analysis, September 1979.

PARAMETER	1st VALUE	2nd VALUE	PER CENT DIFFERENCE
PHYSICAL-CHEMICAL PARAMETERS			
pH (units)	7.0	7.0	0
Suspended Solids (105°C)	252	276	9.1*
Total Dissolved Solids (180°C)	40	42	4.9
Total Dissolved Solids (sum of constituents)	-	-	-
True Color (units)	15	15	0
Total Alkalinity	6.6	6.9	4.4
Tannins & Lignins	<0.1	<0.1	0
Dissolved Calcium	3.1	3.1	0
Dissolved Magnesium	0.38	0.39	2.6
Dissolved Sodium	sample run directly		
Dissolved Potassium	sample run directly		
Dissolved Chloride	0.3	0.3	0
Dissolved Fluoride	<0.05	<0.05	0
Dissolved Sulfate	5	5	0
Conductivity (μmhos/cm)	54.0	54.0	0
Dissolved Silica	0.43	0.43	0
NUTRIENT PARAMETERS			
Total Kjeldahl Nitrogen	0.03	0.04	28.6**
Total Nitrate Nitrogen	0.03	0.04	28.6**
Total Nitrite Nitrogen	<0.005	<0.005	0
Total Phosphate Phosphorus	0.29	0.30	3.4
Dissolved Ortho-Phosphate Phosphorus	0.004	0.004	0
ORGANIC PARAMETERS			
Total Organic Carbon	<2	<2	0
Oil & Grease	<1	<1	0
TRACE ELEMENTS			
Dissolved Arsenic	<0.005	<0.005	0
Dissolved Cadmium	<0.005	<0.005	0
Dissolved Chromium	<0.01	<0.01	0
Dissolved Copper	<0.005	<0.005	0
Dissolved Iron	0.13	0.13	0
Dissolved Lead	<0.01	<0.01	0
Dissolved Manganese	0.02	0.02	0
Dissolved Mercury	<0.00025	<0.00025	0
Dissolved Molybdenum	<0.05	<0.05	0
Dissolved Nickel	<0.01	<0.01	0
Dissolved Selenium	<0.003	<0.003	0
Dissolved Zinc	0.008	0.010	22.2**
MICROBIOLOGICAL PARAMETERS			
Total Coliform (organisms/100 ml)	22	13	51.4**
Fecal Coliform (organisms/100 ml)	11.0	2.0	138.5**

* Rapid settling of solids made it difficult to obtain good duplicates.

** Differences in duplicate values for these parameters are small. Per cent differences appear large because values are close to detection limits.

TABLE C-17: Results for field blank analysis, July 1979.

PARAMETER	Field Blank
Dissolved Calcium	7.5
Dissolved Magnesium	1.4
Dissolved Sodium	6.8
Dissolved Potassium	1.1
Dissolved Arsenic	*
Dissolved Cadmium	<0.005
Dissolved Chromium	<0.01
Dissolved Copper	0.008
Dissolved Iron	0.09
Dissolved Lead	<0.01
Dissolved Manganese	0.01
Dissolved Mercury	0.00025
Dissolved Molybdenum	*
Dissolved Nickel	<0.01
Dissolved Selenium	*
Dissolved Zinc	0.037

Values for deionized water used as a reference blank for trace metal analyses were "zero" in all cases except for dissolved zinc which was 0.015 mg/l. However it was not necessary to dilute any of the samples before trace metal analyses were run.

The field blank value for mercury was subtracted from the values for the samples before the sample results were reported. However, for the other metals the field blank values were not subtracted from the values for the samples.

* The field blank was not analyzed for these constituents because of the volume required for the tests. However, in all cases the samples were below the detection limit.

TABLE C-18: Results for field blank analysis, September, 1979.

PARAMETER	Field Blank
Dissolved Calcium	0.16
Dissolved Magnesium	<0.1
Dissolved Sodium	<0.1
Dissolved Potassium	0.03
Dissolved Arsenic	*
Dissolved Cadmium	<0.005
Dissolved Chromium	<0.01
Dissolved Copper	<0.005
Dissolved Iron	0.06
Dissolved Lead	<0.01
Dissolved Manganese	<0.01
Dissolved Mercury	0.0006
Dissolved Molybdenum	*
Dissolved Nickel	<0.01
Dissolved Selenium	*
Dissolved Zinc	<0.005

The field blank value for mercury was subtracted from the values for the samples before the sample results were reported. However, for the other metals the field blank values were not subtracted from the values for the samples.

* The field blank was not analyzed for these constituents because of the volume required for the tests. However, in all cases the samples were below the detection limit.

TABLE C-20: Field water quality data for Job Creek in the upper Lillooet River basin and Angel Creek in the Meager Creek basin, 1979.

SAMPLE NUMBER	DATE	TIME	COLLECTED BY	WITNESSED BY	AIR TEMPERATURE C	WATER TEMPERATURE C 1*	2*	3*	4*	pH 1	2	7*	SPECIAL CONDUCTANCE umho/cm 1	5*	2	5	6*	5	DISSOLVED OXYGEN mg/l 1	2	4	TURBIDITY F.T.U. 1	Avg.	2	Avg.	ALKALINITY* mg/l CaCo3
JOB-1 (QC-1)	79 06 19	1515	EN	MK	20.8	5.1				7.3			77	147.39					11.1			370				
JOB-2 (QC-3)	79 07 03	1915	EN		15.0	3.8				7.8			70	142.79					14.4			350				
JOB-3 (QC-4)	79 07 15	1835	EN	MP	22.5	4.95				8.0			55	106.01			44.9	74.53	13.6			450-701	650			80
JOB-4 (QC-5)	79 07 26	1400	MP		23.0	6.9				8.0			58	102.55			40.0	62.4	14.8			412-599	465			80
JOB-5 (QC-6)	79 08 20	1350	EN		19.4	5.85	5.7			8.1	7.8		27	49.96	32	59.61	62.5	101.25	13.7	11.2		138-201	165	195-501	365	40
JOB-6 (QC-7)	79 09 06	1350	EN		14.9	7.6	6.9			8.2	8.1		81	139.08	50	88.4			11.3	10.7		360-560	490	33-790	500	60
ANGEL-1	79 08 17	1530	EN		16.2	10.3	10.3			7.9	7.7		11	17	18	26.27	39.5	57.27	11.1	10.3		1		158-240	200	40
ANGEL-2	79 08 18	1920	EN	SH	19.8	9.4	9.4			8.0	7.7		11	17.58	17	27.17	37.5	55.87	12.3	11.9		2.5		166-205	175	40
ANGEL-3	79 08 19	1930	EN	SH	20.2	10.2	10.1			7.85	7.5		14	21.71	19	29.58	39.5	57.27	12.5	11.3		5		165-195	170	40
ANGEL-4	79 08 21	1500	EN		32.8	15.9	15.9			7.9	7.6		21	26.87	28.5	36.46			10.6	9.6		1				40
ANGEL-5	79 08 22	1855	EN	SH	17.7	9.7	9.7			7.8	7.7		11	17.38	17	26.86	35.5	51.47	11.9	10.6		2		41		40
ANGEL-6	79 08 23	1950	EN	SH	15.0	9.65	9.6			7.6	7.45		10	15.83	16	25.38	35.5	51.47	12.2	9.3		1.5		335		
ANGEL-7	79 08 25	1530	EN		28.0	13.35	13.35			8.0	7.6		16	22.21	24.5	34.01	42	56.7	10.7	9.4		4.5				
ANGEL-8	79 09 05	1030	EN			7.15	7.2			7.95	7.9		10	17.49	15	26.19			9.9	10.2		24-28	26	190-305	270	

* 1. Horiba U7 (with stirrer cup)
2. Horiba U7 (with flow-through cup)
3. Fisher general laboratory mercury thermometer
4. Hach Portable Dissolved Oxygen Meter, Model 16046
5. Conductance at 25°C, calculated
6. Beckman Model RA-2A Conductivity Meter
7. Hach Mini pH Meter, Model 17200

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TABLE C-21: Results for diurnal series of water quality measurements of Meager Creek at site MC-100, 1979.

SAMPLE NUMBER	DATE	TIME	COLLECTED BY	WITNESSED BY	AIR TEMPERATURE C	WATER TEMPERATURE C 1*	2*	3*	4*	pH 1	2	7*
MC 100-1	79 08 27	1130	EN		21.9	7.9	7.1			7.6	7.5	
MC 100-2	79 08 27	1955	EN		19.2	8.4	8.35			7.3	7.25	
MC 100-3	79 08 28	1030	EN		18	6.5	6.5			7.25	7.1	
MC 100-4	79 08 28	1935	EN	SH	18.1	8.5				7.5		
MC 100-5	79 08 29	1135	EN		21.2	7.15	6.9			6.9	7	
MC 100-6	79 08 29	1925	EN	MM & JI	19	8.7	8.6			7.5	7.4	
MC 100-7	79 09 02	1200	EN		17.4	6.5	6.5			7.8	7.5	
MC 100-8	79 09 02	1945	EN		11.5	6.3	6.2			8	7.55	
MC 100-9	79 09 03	1300	EN		21	7.2	7.45			8.45	8.6	
MC 100-10	79 09 05	0930	EN		11.2	6.0	6.0			7.8	7.5	
MC 100-11	79 09 05	1855	EN	SH	13.5	7.7	7.5			8.2	8	
MC 100-12	79 09 11	1300	EN		22	8.0		8.2		8.1		
MC 100-13	79 09 11	1900	EN	SH	12.5	7.9		8.0		8		
MC 100-14	79 09 13	1910	EN	SH	12.8	8.4		9.0		7.8		
MC 100-15	79 09 14	1845	EN		13.7	8.5		9.0		7.2		
MC 100-16	79 09 15	1100	EN		13.2	7.3		8.0	7.8	7.2		
MC 100-17	79 09 15	2155	EN		13.1	7.2		8.0		7.7		
MC 100-18	79 09 16	1240	EN		22.5	7.5		8.0	8.9	7.4		
MC 100-19	79 09 16	2030	EN	SH	12.2	7.1		7.5		7.3		
MC 100-20	79 09 17	0930	EN		10	5.7		6.2	6.9	7.8		
MC 100-21	79 09 17	2030	EN		14.2	7.5		8.0	8.2	7.8		
MC 100-22	79 09 18	1955	EN		14	7.8			8.0	7.3		
MC 100-23	79 09 19	0945	EN		10.2	6.0		6.7	7.0	7.2		

SAMPLE NUMBER	SPECIAL CONDUCTANCE umho/cm 1	5*	2	5	6*	5	DISSOLVED OXYGEN mg/l 1	2	4	TURBIDITY F.T.U. 1	Avg.	2	Avg.	ALKALINITY* mg/l $CaCo_3$
MC 100-1	17	28.83	21	36.81	44.9	67.35	13.2	13.0		70		270		40
MC 100-2	8	13.3	15	24.98	31.5	47.25	11.45	11.8		265		356-407	375	40
MC 100-3	15	26.98	21.5	37.77	43	69.66	14.7	14.9		71-87	79	282-313	295	40
MC 100-4	10	16.56			32.5	48.75	14.1			245-280	260			40
MC 100-5	10	17.49	21	37.13	55	85.8	12.3	12.5		74-83	79			40
MC 100-6	6	9.85	13	21.44	35	52.15	14.3	14.5		345-381	363	312-391	351	
MC 100-7	2.5	4.5	7.5	13.49	37.5	60.75	11.4	11.25		264-282	273	217-313	265	
MC 100-8	4.5	8.16	1.5	2.73	35	56.7	11.6	11.5		219-258	238	440-620	475	
MC 100-9	18	31.42	13	22.46			9.75	9.05		560-630	595	670-790	750	
MC 100-10	12	22.06	22	40.44			10.8	10.6		564-611	580	531-620	580	
MC 100-11	6.5	11.11	14	24.14			13.3	13.3		230-250	240	300-385	350	
MC 100-12	22	37.16					12.2			30-40	32			
MC 100-13	16.5	27.98					11.25			140-165	150			
MC 100-14	10	16.62					11.2			500-600	560			
MC 100-15	10	16.56					11.3			410-470	430			
MC 100-16	13	22.6					11.85		11.9	170-210	195			
MC 100-17	8	13.97					12.0		10.5	400-450	430			
MC 100-18	17	29.31					12.7		11.7	70-80	75			
MC 100-19	8	14.02					12.1			160-190	168			
MC 100-20	16	29.81					12.5		11.7	65-85	75			
MC 100-21	7.5	12.93					11.6		11.5	220-290	250			
MC 100-22	7	11.92					11.7		12.2	360-440	390			
MC 100-23	10	18.38					12.4		11.7	90-115	100			

* 1. Horiba U7 (with stirrer cup)
2. Horiba U7 (with flow-through cup)
3. Fisher general laboratory mercury thermometer
4. Hach Portable Dissolved Oxygen Meter, Model 16046
5. Conductance at 25°C, calculated
6. Beckman Model RA-2A Conductivity Meter
7. Hach Mini pH Meter, Model 17200

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TABLE C-22: Results for diurnal series of field water measurements of the Lillooet River at site LR-100, 1979.

SAMPLE NUMBER	DATE	TIME	COLLECTED BY	WITNESSED BY	AIR TEMPERATURE C	WATER TEMPERATURE C				pH			SPECIAL CONDUCTANCE umho/cm						DISSOLVED OXYGEN mg/l			TURBIDITY F.T.U.				ALKALINITY* mg/l $CaCo_3$
						1*	2*	3*	4*	1	2	7*	1	5*	2	5	6*	5	1	2	4	1	Avg.	2	Avg.	
LR 100-1	79 08 27	0915	EN		9.9	5.7	5.1			7.65	7.15		5	9.31	11.5	22.01	18	29.88	13.6			93-108	100	111-140	126	20
LR 100-2	79 08 27	1912	EN	SH	14.5	7.85	7.8			7.2	7.3		9	15.3	15	25.54	15.9	23.85	13.0	12.5		325		220		40
LR 100-3	79 08 28	0930	EN		12.8	5.4	5.25			6.8	6.95		6	11.33	14	26.62	18.5	30.71	14.9	15.35		114-119	116	180-207	190	40
LR 100-4	79 08 28	1835	EN	SH	16.2	8.25	8.2			7.2	7.1		10	16.72	15	25.13	17	25.5	15.1	14.5		518-580	565	344-405	375	40
LR 100-5	79 08 29	1100	EN		15	5.7	5.6			6.6	7.05		4.5	8.38	10	18.71	21	34.86	14.3	13.7		83-117	95	225-275	250	40
LR 100-6	79 08 29	1835	EN	MM & JI	20.0	8.6	8.5			6.5	6.5		9	14.84	13	21.52	17	25.33	15.9	15.8		223-261	240	216-281	250	40
LR 100-7	79 09 02	1130	EN		14.6	5.9	5.6			7.7	7.4		1.5	2.77	8.5	15.91	19.9	32.24	12.4	11.95		508-533	520	640-904	778	40
LR 100-8	79 09 02	2015	EN		10.1	5.9	5.6			7.8	7.5		2.5	4.62	5	9.36	75	121.5	11.3	11.85		431-494	460	714-845	780	
LR 100-9	79 09 03	1200	EN		13.4	5.5	5.5			8.4	8.25		6	11.29	3.5	6.58			10.4	9.4		450-550	490	423-568	485	
LR 100-10	79 09 05	0900	EN		11.1	5.45	5.3			7.8	7.55		2.5	4.71	7	13.28			11.6	10.7		295-358	330	217-320	275	
LR 100-11	79 09 05	1920	EN	SH	11.5	7.7	6.9			8.7	8.1		3	5.13	6	10.61			13.7	13.9		108-110	109	120-145	135	
LR 100-12	79 09 11	1100	EN		15	5.5		5.0		8.15			4	7.52					12.8			122-150	139			
LR 100-13	79 09 11	1815	EN	SH	15.3	8.7		8.7		8.2			10	16.43					11.75			100-125	112			
LR 100-14	79 09 13	1840	EN	SH	19.5	8.9		9.5		7.8			7	11.41					11.4			200-270	235			
LR 100-15	79 09 14	1130	EN		17.9	5.7		6.1		6.6			7	13.04					12.2			140-200	160			
LR 100-16	79 09 14	1815	EN		12.5	8.5		9.0		7.7			6.5	10.76					12.4			370-470	420			
LR 100-17	79 09 15	1030	EN		15.8	5.7		5.6	5.2	6.8			6	11.18					12.3		12.1	140-180	150			
LR 100-18	79 09 15	1945	EN		15.1	7.7		8.9	8.3	7.9			6	10.26					11.6		11.9	260-300	275			
LR 100-19	79 09 16	1200	EN		17.5	5.9		5.9	6.9	6.85			6	11.08					12.8		11.5	100-140	125			
LR 100-20	79 09 16	2000	EN	SH	14	6.9		8.0		7.7			6	10.61					12.8			150-200	175			
LR 100-21	79 09 17	1030	EN		12.2	5.6		5.2	6.2	7.85			7	13.1					12.45		12.4	70-100	80			
LR 100-22	79 09 17	1850	EN		16.3	7.95		8.5	9.0	7.8			6	10.16					12.2			150-200	185			
LR 100-23	79 09 18	1915	EN	SH	15.3	7.7		8.2		7.2			7	11.97					12.1		11.9	230-290	260			
LR 100-24	79 09 19	1030	EN		12.1	5.4		5.5	6.0	7.3			5	9.44					12.1		11.9	90-110	95			

* 1. Horiba U7 (with stirrer cup)
2. Horiba U7 (with flow-through cup)
3. Fisher general laboratory mercury thermometer
4. Hach Portable Dissolved Oxygen Meter, Model 16046
5. Conductance at 25°C, calculated
6. Beckman Model RA-2A Conductivity Meter
7. Hach Mini pH Meter, Model 17200
Alkalinity - Bausch and Lomb Spectrokit

FIGURE C-1: Data Form for Field Water Quality Measurements.

WATER QUALITY FIELD DATA

Project ______________________ Date ______________________

Station No. ____________________ Sample No. __________________

Station Location ____

Observer(s) ____________________ Time ______________________

Air Temperature ______________ °C ______________________

Water Temperature ____________ °C ______________________

pH ___________________________ ______________________

Conductance (in situ) _________ ______________________

Dissolved Oxygen ____________ umho ______________________

Turbidity ____________________ mg/l ______________________

Akalinity ____________________ J.T.U. ______________________

______________________________ ______________________

______________________________ ______________________

______________________________ ______________________

______________________________ ______________________

Remarks ____

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APPENDIX D
HYDROLOGIC OBSERVATIONS

Table

Table D-1: Hydrology/water level observations at site MC100, Meager Creek, 1979

DATE 1979	TIME	WATER LEVEL (In Feet)		WSC* DISCHARGE LILLOOET R.	WATER QUALITY	COMMENTS
		OBSERVED	CREST			
JUNE						
18	1545	152.58				Q (est) = 19 cms J = 1.8 m/sec.
19	0930	152.58	153.23	161.972	FWQ-LWQ	
25	0910	152.43	153.23	148.38	FWQ (26)	
	1235	152.58				
JULY						
3	1525	152.08	154.0		FWQ	
4	1510	152.25	152.5	135.638		
5	1650	152.65	152.88	156.026		
6	1700	152.78	153.18	176.414		
7	1515	152.63	153.28	190.289		
8	1510	153.8	154.28	239.277		
9	1910	153.34	154.18	257.399		
10	1930	153.81	154.13	314.317		
11	1820	153.23	154.08	276.372		
12	1930	153.13	153.43	239.56		
13	1900	152.7	153.0	211.81		
14	2120	153.08	153.38	193.404		
15	2100	153.18	153.68	207.562		
16	1130	152.73	-	236.729	FWQ	
17	2025	153.68	-	279.77		
18	2045	153.88	154.08	317.148		
19	2030	153.88	154.18	336.97		
20	0900	152.88	154.18	348.297		
21	1825	153.68	154.38	359.624		
22	1830	153.43	153.68	314.317		
23	1915	153.48	153.58	285.999		
24	2030	153.28	153.58	275.806		
25	1600	153.28	153.38	264.479		
26	1900	153.38	153.58	265.329	FWQ	
27	1605	153.33	153.48	276.372		
28	1100	152.83	153.53	283.168		
29	1630	153.03	153.48	261.647		
30	1535	153.13	153.38	247.772		
31	1915	153.33	153.48	278.921		
AUG.						
1	1635	153.28	153.48	274.956		
2	1530	153.13	153.43	270.426		
3	1645	153.08	153.33	250.887		
4	1645	152.98	153.28	230.499		
5	1615	152.83	153.18	214.075		
6	1420	152.48	152.98	191.705		

* Lillooet R. @ Pemberton - Gauge #08MG005 - Preliminary Data Supplied by W.S.C. - Mean Daily Flows in m^3/S.

Table D-1: continued

DATE 1979	TIME	WATER LEVEL (In Feet)		WSC* DISCHARGE LILLOOET R.	WATER QUALITY	COMMENTS
		OBSERVED	CREST			
AUG.						
7	1900	152.86	-	189.439		
8	1630	153.18	-	197.651		
9	1930	153.39	-	213.792		
10	1530	153.14	153.68	233.047		
11	1920	153.45	153.73	242.109		Boulders moving in bed.
12	1810	153.59	153.83	249.188		
13	1915	153.68	154.18	270.142		
14	1825	153.25	154.13	282.035		
15	2030	153.25	153.78	253.719		
16	1940	153.31	153.73	255.701	FWQ-LWQ	
17	1700	153.25	153.58	232.198		
18	1900	153.19	153.83	228.799		
19	1845	153.23	153.58	223.136		
20	2100	153.55	153.98	237.861		
21	1845	153.78	-	285.999		
22	1920	153.73	154.43	353.96		
23	2035	153.57	154.18	302.989		
24	1900	153.31	153.88	245.045		
25	1915	153.48	153.88	243.241		
26	1910	153.58	153.93	247.489		
27	1130	152.95	-	264.479		
	2015	153.34	154.13			
28	1050	152.85		265.045		
	1945	153.51	154.03			
29	1200	152.71		250.604		
	1945	153.61	154.03			
30	1945	153.28	153.98	246.639		
31	1845	152.98	153.53	210.394		
SEPT.						
1	1945	153.18	153.58	201.333		
2	1200	153.21	154.58	317.148		
	1945	153.84	154.18			
3	1245	153.68	155.98	368.119		Definite change in channel.
4	2000	153.08	153.83	231.915		
5	1000	153.43	153.93	240.693		
	1915	153.25	-			
6	1945	152.48	-	192.271	FWQ	HL
7	1945	152.88	-	153.194		
8	1945	154.05	-	342.633		

* Lillooet R. @ Pemberton - Gauge #08MG005 - Preliminary Data Supplied by W.S.C. - Mean Daily Flows in m^3/S.

Table D-1: continued

DATE 1979	TIME	WATER LEVEL (In Feet)		WSC* DISCHARGE LILLOOET R.	WATER QUALITY	COMMENTS
		OBSERVED	CREST			
SEPT.						
9	1845	152.88	154.48	281.469		
10	-	-	-	168.485		
11	1300	152.18	-	138.752		
	1655	152.48	-			
12	-	-	-	132.806		
13	1910	153.03	-	145.548		
14	1845	153.28	153.58	181.794		
15	1100	152.73	153.53	206.146		
	2155	153.18	153.68			
16	1240	152.68	-	198.501		
	2030	152.98	-			
17	0930	152.48	-	166.786		
	2030	153.2	153.38			
18	1955	153.26	153.48	185.758		
19	0945	152.68	153.53	201.049		
NOV.						
3	1700	150.71				
DEC.						
10	1505	150.72				

* Lillooet R. @ Pemberton - Gauge #08MG005 - Preliminary Data Supplied by W.S.C. - Mean Daily Flows in m^3/S.

Table D-2: Hydrology/water level observations at site LR-100 Lillooet River, 1979

DATE 1979	TIME	WATER LEVEL (In Feet)		WSC* DISCHARGE LILLOOET R.	WATER QUALITY	COMMENTS
		OBSERVED	CREST			
JUNE						
19	1330	71.749		161.9722	FWQ-LWQ	Q (est) = 64 cms J = 1.8 m/sec.
25	1435	72.099		148.38	FWQ (26)	
JULY						
4	1400	71.349	73.75	135.638	FWQ	
5	1815	72.299	72.45	156.026		
6	1715	72.549	72.75	176.414		
7	0815	12.449	73.15	190.289		
8	-	-	-	239.277		
9	1930	73.149	74.00	257.399		
10	2020	73.949	74.05	314.317		
11	1800	73.349	74.05	276.372		
12	1900	72.999	73.60	239.56		
13	1830	72.479	73.30	211.81		
14	2100	72.949	73.25	193.404		
15	2100	73.449	73.75	207.562		
16	0815	72.849	73.75	236.729	FWQ	
	1545	73.349				
	1645	73.549				
17	1130	73.163		279.77		
	2000	74.313				
18	2000	74.363		317.148		
19	1950	74.613		336.97		
20	2010	74.363		348.297		
21	1620	74.013		359.624		
22	1800	73.263		314.317		
23	2000	73.613		285.999		
24	2000	73.413		275.806		
25	2000	73.463		264.479		
26	1815	73.313		265.329	FWQ	
27	1700	73.463		276.372		
28	2000	73.713		283.168		
29	1700	72.963		261.647		
30	1700	73.163		247.772		
31	1950	73.413		278.921		
AUG.						
1	1700	73.213		274.956		
2	1145	72.463		270.426		
	1945	73.113				
3	1900	73.313		250.881		
4	2015	72.913		230.449		

* Lillooet R. @ Pemberton - Gauge #08MG005 - Preliminary Data Supplied by W.S.C. - Mean Daily Flows in m^3/S.

Table D-2: contintued

DATE 1979	TIME	WATER LEVEL (In Feet)		WSC* DISCHARGE LILLOOET R.	WATER QUALITY	COMMENTS
		OBSERVED	CREST			
AUG.						
5	1645	72.163		214.075		
6	1030	71.563		191.705		
7	1955	72.713		189.439		
8	1815	73.113		197.651		
9	2030	73.313		213.792		
10	1600	73.063		233.047		
11	1900	73.013		242.109		
12	1830	72.913		249.188		
13	1850	72.863		270.142		
14	1915	73.063		282.035		
15	2015	73.163		253.719		
16	1300	72.963		255.701	FWQ-LWQ	
17	1830	72.963		232.198		
18	1830	72.663		228.799		
19	1830	72.963		223.136		
20	2015	73.413		237.861		
21	1830	73.363		285.999		
22	1815	73.763		353.96		
23	2100	73.663		302.989		
24	-	-		265.045		
25	1945	73.313		243.241		
26	1830	73.663		247.489		
27	1915	73.463		264.479	FWQ	
28	1830	73.313		265.045	FWQ	
29	1835	73.313		250.604	FWQ	
30	1930	72.963		246.639		
31	1820	72.413		210.394		
SEPT.						
1	1925	72.963		201.333		
2	2015	74.013		317.148	FWQ	
3	1200	73.163		368.119	FWQ	
4	1905	71.713		231.915		
5	0900	72.863		240.693	FWQ	
	1920	72.363			FWQ	
6	1830	71.513		192.271	FWQ	
7	1920	71.713		153.194		
8	1300	73.463		342.633		
	1930	74.263				
9	1100	72.113		281.467		
	1830	71.663				
10	2100	71.213		168.485		

* Lillooet R. @ Pemberton - Gauge #08MG005 - Preliminary Data Supplied by W.S.C. - Mean Daily Flows in m^3/S.

Table D-2: continued

DATE 1979	TIME	WATER LEVEL (In Feet)		WSC* DISCHARGE LILLOOET R.	WATER QUALITY	COMMENTS
		OBSERVED	CREST			
SEPT.						
11	1100	69.713		138.752	FWQ	
	1815	70.713			FWQ	
12	1400	70.363		132.806		
13	1840	72.213		145.548	FWQ	
14	0745	71.863		181.794	FWQ	
	1815	72.813			FWQ	
15	1030	71.863		206.146	FWQ	
	1945	72.863		206.146	FWQ	
16	1200	71.513		198.501	FWQ	
	2000	72.463			FWQ	
17	1030	70.663		166.786	FWQ	
	1850	71.463			FWQ	
18	1915	72.963		185.758	FWQ	
19	1030	72.013		201.049	FWQ	
NOV.						
3	1145	68.763				
DEC.						
12	1130	67.263				

* Lillooet R. @ Pemberton - Gauge #08MG005 - Preliminary Data Supplied by W.S.C. - Mean Daily Flows in m^3/S.

APPENDIX E
VEGETATION

1. Coverage Scale

2. Vegetation descriptions and species lists for study plots, Meager Creek geothermal area, 1979.

APPENDIX E
COVERAGE SCALE

After Domin-Krajina

+	Solitary
1	Rare, 1-2 individuals
2	Sparse, very scattered
3	0-4% scattered
4	4-10%
5	10-25%
6	25-33%
7	33-50%
8	50-75%
9	75-95%
10	95-100%

PLOT NO: 1 PLOT SIZE: 20 m x 20 m DATE: 1979 07 25

VEGETATION TYPE - Biogeoclimatic Subzone: Interior Western Hemlock Wet Subzone or Interior Douglas Fir Subzone

- Forest Cover Type: HCF (PW) 941-P

ALTITUDE: 1700'

SLOPE GRADIENT: 20°

EXPOSURE: east facing slope

GROUND SURFACE COVERED BY:

Humus	30%
Mineral Soil	40-60%
Decaying Wood	10%
Rock	5%

PHOTO: (2)

COMMENTS:

This vegetation type is a mature stand of hemlock, Douglas fir, and western red cedar. The stand is located on well drained soil on an east facing slope. The understory is moderate and the ground cover composed primarily of a clubmoss mat and some decaying wood. 500' northeast of the plot is a small drainage. The species composition changes slightly to a higher occurence of western red cedar in the tree layer and species more adapted to moist soil conditions in the shrub/herb layer i.e. devil's club, *Actea rubra* etc.

There are numerous small drainages along both sides of Meager Valley. The composition of the gross vegetation types varies slightly at these drainage areas reflecting the moister conditions.

PLOT NO: 1 DATE: 1979 07 25

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Tree Layer - A1 (100'-125')	*Tsuga heterophylla* (western hemlock)	7	
	Pseudotsuga menziesii (Douglas fir)	5	
	Thuja plicata (western red cedar)	5	
Tall Shrub Layer - B1 (10'-25')	*Thuja plicata* (western red cedar)	6	
	Tsuga heterophylla (western hemlock)	5	
	Abies amabilis (amabilis fir)	5	
	Taxus brevifolia (yew)	3	
	Acer glabrum var. douglassi (Douglas maple)	2	
Low Shrub Layer - B2 (1'-5')	*Pachistima myrsinites* (false box)	7	
	Vaccinium membranaceum (huckleberry)	5	
	Amelanchier sp (florida) (saskatoon)	2	
	Sorbus sitchensis (mountain ash) - seedling	1	
Herb Layer - C	*Linnaea borealis* (twin flower)	7	
	Chimaphila umbellata (Pipsissewa)	6	
	Cornus canadensis (bunchberry)	6	
	Clintonia uniflora (Queen's cup)	5	
	Tiarella trifolata (foam flower)	4	
	Pyrola asarifolia var. purpurea (wintergreen)	4	
	Pyrola secunda var. obtusata (one sided wintergreen)	4	
	Goodyera oblongifolia (Rattlesnake plantain)	4	
	Smilacina stellata (soloman seal)	4	

PLOT NO: 2 PLOT SIZE: 20 m x 20 m DATE: 1979 07 27

VEGETATION TYPE - Biogeoclimatic Subzone: Coastal Western Hemlock Wet Subzone with continental influence.

- Forest Cover Type: FCH 941-P

ALTITUDE: 2450'

SLOPE GRADIENT: 10°

EXPOSURE: south-east facing slope

GROUND SURFACE COVERED BY:

Humus	50-60%
Mineral Soil	10%
Decaying Wood	30-50%
Rock	5%

PHOTO: 2

COMMENTS:

This vegetation type is comprised of a mature balsam fir, hemlock and western red cedar tree layer. The understory is moderate with young coniferous species (balsam fir) being predominant numbers of the shrub layers. This stand is located on a southeast facing slope. The substrate has a fairly high percentage of decaying wood on humic material. The floor cover was predominantly a lesser clubmoss/twinflower mat.

Dead spurs were noted, however, no lichen was apparent on either dead (standing) or alive trees.

A small amount of browsing was noted particularly of red osier dogwood.

PLOT NO: 2

DATE: 1979 07 27

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Tree Layer - A1 (100'-125')	*Abies amabilis* (amabilis fir)	6	
	Tsuga heterophylla (western hemlock)	6	
	Tsuga mertensiana (mountain hemlock)	3	
	Thuja plicata (western red cedar)	4	
	Pseudotsuga menziesii (Douglas fir)	4	
	Pinus monticola (western white pine) 3 dead spurs	2	
Tall Shrub Layer - B1 (10'-25')	*Abies amabilis* (amabilis fir)	6	
	Thuja plicata (western red cedar)	5	
	Acer glabrum var. douglassi (Douglas maple)	5	
	Tsuga sp. (Hemlock)	3	
	Alnus Sinuata (sitka alder)	3	
	Sorbus sitchensis (mountain ash)	1	X
Low Shrub Layer - B2 (1'-5')	*Pachistima myrsinites* (false box)	7	
	Vaccinium membranaceum (huckleberry)	7	
	Menziesia ferruginea (false azalea)	5	
	Amelanchier sp. (florida) (saskatoon)	5	
	Abies amabilis (amabilis fir)	4	X*
	Pinus monticola (western white pine)	3	
	Rosa sp. (Rose)	3	
	Cornus stolonifera var. stolonifera (Red osier dogwood)	3	X**

* New shoots nipped off top.
** Quite heavily browsed.

PLOT NO: 2

DATE: 1979 07 27

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Herb Layer - C	*Linnaea borealis* (twinflower)	8	
	Chimaphila umbellata (Pipsissewa)	6	
	Cornus canadensis (bunchberry)	6	
	Clintonia uniflora (Queen's cup)	5	
	Streptopus amplexifolius (twisted stalk)	4	
	Pyrola asarifolia var. purpurea	3	
	Smilacina stellata (soloman seal)	3	
	Adenocaulon bicolor (silver green)	3	
	Woodsia sp. (fern)	3	
	Listera borealis (orchid)	2	
Moss Layer	*Selaginella sp.* (lesser-clubmoss)	10	
	studded leather lichen	4	

PLOT NO: 3 | PLOT SIZE: 20 m x 20 m | DATE: 1979 07 30

VEGETATION TYPE - Biogeoclimatic Subzone: Coastal Western Hemlock Wet Subzone with continental influence.

- Forest Cover Type: HB (C Cy) 941-P

ALTITUDE: 2700'

SLOPE GRADIENT: 5°

EXPOSURE: southerly

GROUND SURFACE COVERED BY:

Humus	25%
Mineral Soil	15%
Decaying Wood	50-60%
Rock	10%

PHOTO: 1

COMMENTS:

This vegetation type is mature to overly mature hemlock and balsam fir. Understory is sparse with either young or stunted balsam fir dominating the shrub layer.

Decaying wood is conspicuous on the floor. Clubmoss provides a dense mat on the ground surface.

There was no evidence of browse in the plot.

Baby toad was observed in the floor cover.

This stand has a southerly exposure and is relatively flat.

PLOT NO: 3 DATE: 1979 07 30

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Tree Layer - A1 (100'-125')	*Tsuga heterophylla* (western hemlock)	8	
	Abies amabilis (amabilis fir)	8	
	Thuja plicata (western red cedar)	3	
Shrub Layer - B1 (1'-5')	*Abies amabilis* (amabilis fir)	5	
	Vaccinium membranaceum (huckleberry)	4	
	Ribes sp. (gooseberry)	4	
	Pachistima myrsinites (false box)	2	
	Oplopanax horridus (devil's club)	+	
Herb Layer - C	*Rubus pedatus* (trailing rubus)	6	
	Chimaphila umbellata (Pipsissewa)	5	
	Abies amabilis (amabilis fir) - seedlings (2"-6")	5	
	Clintonia uniflora (Queen's cup)	4	
	Pyrola asarifolia var. purpurea (wintergreen)	4	
	Pyrola secunda var. obtusata (one-sided wintergreen)	4	
	Goodyera oblongifolia (rattlesnake plantain)	4	
	Corallorhiza (mertensiana) (coral root)	4	
	Tiarella trifolata (foam flower)	4	
	Linnea borealis (twinflower)	4	
	Sorbus sitchensis (mountainn ash) - seedling (1'-2')	3	
	Smilacina stellata (solomon seal)	2	

PLOT NO: 3 DATE: 1979 07 30

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Moss Layer	*Gynocarpium dryopteris* (fern)	2	
	Hypopitys monotropa (pinesap)	2	
	Lycopodium sp. (clubmoss)	8	
	moss on decaying wood	6	
	studded leather lichen	3	

PLOT NO: 4 PLOT SIZE: 20 m x 20 m DATE: 1979 08 02

VEGETATION TYPE - Biogeoclimatic Subzone: Interior Western Hemlock Wet Subzone or/Interior Douglas Fir

- Forest Cover Type: FCH 961 M

ALTITUDE: 1900'

SLOPE GRADIENT: flat

EXPOSURE: southeast

GROUND SURFACE COVERED BY:

Humus	0-5% (leaf litter)
Mineral Soil	20%
Decaying Wood	-%
Rock	80%

PHOTO: 1

COMMENTS:

Deciduous stand composed primarily of cottonwood and red alder approximately 50-60 feet high. Understory - open with some young or stunted conifers.

Substate is rocky, possibly an old river channel bed. Some moss on rocks and leaf litter (very little humic soil). Little evidence of moss skirting base of trees and only small amount of dead wood lying on the ground.

Game trail was noted on slope immediately north of sample plot.

Herb layer sparse.

PLOT NO: 4 DATE: 1979 08 02

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Tree Layer - A1 (50'-60')	*Populus trichocarpa* (cottonwood)	8	
	Alnus rubra (red alder)	4	
Shrub Layer - B1 (3'-15')	*Alnus rubra* (red alder)	5	
	Alnus sinuata (sitka alder)	4	
	Acer circinatum (vine maple)	4	
	Ribes lacustre (gooseberry)	4	
	Rubus pariflorus (thimbleberry)	3	
	Shepherdia canadensis (Buffalo berry)	3	
	Cornus stolonifera var. stolonifera (red osier dogwood)	3	X
	Rubus leucodermis (Black caps)	3	
	Pinus monticola (western white pine)	3*	
	Pseudotsuga menziesii (Douglas fir)	3*	
	Thuja plicata (western red cedar)	3*	
	Abies amabilis (amabilis fir)	3*	
	Populus trichocarpa (cottonwood)	3	
	Vaccinium sp. (huckleberry)	+	
Herb Layer - C	*Lupinus sp.* (Lupine)	3	
	Antennaria sp. (white pussy-toes)	3	
	Adenocaulan bicolor (silver green)	3	
	Pyrola secunda var. obtusata (one sided wintergreen)	2	X
	Chimaphila umbellata (pipsissewa)	3	

* Small trees either stunted or young.

PLOT NO: 4 DATE: 1979 08 02

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
	Smilacina stellata (solomon seal)	2	
	Osmorhiza chilensis (sweet root)	2	
	Galium triflorum (sweet scented bedstraw)	3	
	Epilobium angustifolium (fireweed)	3	
	Sordus sp. (mountain ash)	2	
	Agropyron sp. (wheat grass)	3	X
	Taraxacum sp. (dandelion)	+	
	Polystichum munitum (sword fern)	+	
	Athyrium sp. (lady fern)	+	
	Montia sp. (heart-shaped leaf)	1	
Moss Layer	*Lycopodium sp.* (club moss)	4	
	Selaginella sp. (lesser-club moss)	4	

PLOT NO: B.C.H.P.A. camp along Lillooet PLOT SIZE: DATE: July 1979

VEGETATION TYPE - Biogeoclimatic Subzone: Interior Douglas Fir Subzone

- Forest Cover Type: F(C) 941-P

ALTITUDE: 1450'

SLOPE GRADIENT: flat

EXPOSURE: southwest

GROUND SURFACE COVERED BY:

Humus	30-40%
Mineral Soil	10%
Decaying Wood	30-50%
Rock	5%

PHOTO:

COMMENTS:

This vegetation type is a mature stand characterized by Douglas fir as the predominant tree layer species with a huckleberry understory. The floor cover is a thick mat composed primarily of Lycopodium and other mosses covering decaying wood and other humic material.

Black bears make use of the huckleberries when in season.

Area seems relatively well drained with a fairly high percent of decaying wood on the ground.

PLOT NO: B.C.H.P.A. camp along Lillooet DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Tree Layer - A1 (100'-125')	*Pseudotsuga menziesii* (Douglas fir)	8	
	Tsuga heterophylla (western hemlock)	5	
	Thuja plicata (western red cedar)	4	
	Abies amabilis (amabilis fir)	4	
	Pinus monticola (western white pine)	3	
Shrub Layer - B1 (1'-5')	*Vaccinium membraneceum* (black mountain huckleberry)	9	*
	Vaccinium alaskaense (huckleberry)	4	*
	Amelanchier (florida) (saskatoon berry)	4	*
	Pachistina myrsinites (false box)	3	
	Menziesia ferruginea var. ferruginea (mock azalea)	2	
	Lonicera spp. (honeysuckle)	2	
	Sordus sp. (mountain ash)	1	
	Acer circinatum (vine maple)	1	
Herb Layer - C	*Linnaea borealis* (twinflower)	5	
	Chimaphila umbellata (pipsissewa)	4	
	Clintonia uniflora (Queen's cup)	4	
	Tiarella trifolata (foam flower)	3	
	Goodyera oblongifolia (rattlesnake plantain)	3	
	Cornus canadensis (bunchberry)	3	
	Smilacina stellata (solomon seal)	3	
	Lupinus spp. (lupine)	2	

* Berries eaten by bears in July and August.

PLOT NO: B.C.H.P.A. camp along Lillooet DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Moss Layer	*Lycopodium sp.* (club moss)	9	
	studded leather lichen	4	
	other mosses	4	

PLOT NO: General forest type with damp understory. PLOT SIZE: DATE: July 1979

VEGETATION TYPE - Biogeoclimatic Subzone:

- Forest Cover Type:

ALTITUDE: Approx. 1400'-2800' up Meager Creek (north side)
1400'-2000' up Lillooet (north side)

SLOPE GRADIENT: usually flat to gentle slope

EXPOSURE: southerly to south westerly

GROUND SURFACE COVERED BY:

Humus	50-60%
Mineral Soil	5%
Decaying Wood	30-40%
Rock	<5%

PHOTO: 2

COMMENTS:

Understory characteristic of moist conditions - high water table, ground seepage etc.

This understory is lush and dense.

The tree layer usually reflects the surrounding frost cover type but with a higher percentage of western red cedar.

These damp areas are noted around km 10 and km 4 on the Meager road and approximately km 3.5 on the new road (B.C. Hydro road).

PLOT NO: General forest type with damp understory (approx. 1400'-2800' elevation) DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Tree Layer (100'-125')	*Thuja plicata* (western red cedar)	*	
	Tsuga heterophylla (western hemlock)		
	Abies amabilis (amabilis fir)		
Shrub Layer	*Alnus sinuata* (sitka alder)	**	
	Acer circinatum (vine maple)		
	Sambucus racemosa var. arborescens (red elderberry)		
	Cornus stolonifera var. stolonifera (red osier dogwood)		
	Ribes sp. (gooseberry)		
	Salix sitchensis (willow)		
	Oplopanax horridus (devil's club)		
	Sordus sp. (mountain ash)		
	Salix sp. (willow)		
	Rubus spectabilis (salmonberry)		
Herb Layer	*Polystichum sp.*		
	Pteridium aquilinum pubescens (bracken)		
	Equisetum arvense (horsetail)		
	Lysichitum americanum (skunk cabbage)		
	Streptopus amplexifolius (twisted stalk)		
	Andenocaulon bicolor (silvergreen)		
	Montia cordifolia (leaf miner's lettuce)		
	Tiarella trifoliata (foam flower)		

* Usually dominant - at km 4 almost a pure stand of cedar
- at km 3.5 of new road cedars 9'Ø

** More prevalent in area with open canopy i.e. near Angel Creek

PLOT NO: General forest type with damp understory (approximately 1400'-2000' elevation) DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
	Galium sp. (bedstraw) *Smilacina stellata* (solomon's seal) *Actea rubra* (baneberry) *Epilobium glandulosum var. glandulosum* *Mimulus sp.* (yellow mimulus) *Clintonia uniflora* (Queen's cup) *Aruncus sylvester* (goats beard) *Pyrola sp.* (wintergreen)		

PLOT NO: Stand above hot springs. PLOT SIZE: DATE: July 1979

VEGETATION TYPE - Biogeoclimatic Subzone: Coastal Western Hemlock Wet Subzone with Continental Influence

- Forest Cover Type: HFBC 951-M

ALTITUDE: 2000'

SLOPE GRADIENT: 15°

EXPOSURE: northwest facing slope

GROUND SURFACE COVERED BY:

Humus	10-20%
Mineral Soil	10-20%
Decaying Wood	25-40%
Rock	30% (1'-2'Ø)

PHOTO:

COMMENTS:

The forested area above the hot springs gravel bar area is covered with a mature stand of western red cedar, Douglas fir, western hemlock and balsam fir. The slope above the hot springs has two benches - the second bench bounded by a forestry road. The other side of this road has been logged.

On the lower bench the vegetation has an understory characterized by moist tolerant species - i.e. devil's club. On the slope up to and including the second bench in dryer. The understory is sparser and characterized by species such as false azalea and huckleberry.

PLOT NO: Stand above hot springs DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Tree Layer - A1 (100'-125')	*Thuja plicata* (western red cedar)	6	
	Pseudotsuga menziesii (Douglas fir)	6	
	Tsuga heterophylla (western hemlock)	6	
	Abies amabilis (amabilis fir)	6	
	Pinus monticola (western white pine)	3	
Shrub Layer - B1 (3'-10')	*Menziesia ferruginea* (false azalea)	6	
	Vaccinium membraneceum (black mountain huckleberry)	5	
	Acer circinatum (vine maple)	5	
	Ribes spp. (currant or gooseberry)	3	
	Sordus spp. (mountain ash)	2	
	Abies amabilis (amabilis fir)	3	
	Taxus brevifolia (yew)	3	
	Pachistina myrsinites (false box)	3	
	Oplopanax horridus (devil's club)	6*	
Herb Layer - C	*Tiarella trifoliata* (foam flower)	5	
	Chimaphila umbellata (pipissewa)	6	
	Clintonia uniflora (Queen's cup)	5	
	Actea rubra (baneberry)	2	
	Cornus canadensis (bunchberry)	4	
	Smilacina stellata (solomon's seal)	3	
	Adenocaulon bicolor (silvergreen)	6	
	Linnaea borealis (twinflower)	3	

* On lower bench.

PLOT NO: Stand above hot springs DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
	Polystichum sp.	4	
	Pteridium aquilinum pubescens (bracken)	2	
	Athyrium filix-femina (lady fern)	4	
	Equisetum arvense (horsetail)	3*	
	Streptopus amplexifolius (twisted stalk)	3*	
	Pyrola asarifolia var. purpurea (wintergreen)	3*	
	Galium spp. (bedstraw)	5*	
	Actaea rubra (baneberry)	4*	
	Montia cordifolia (leaf miner's lettuce)	4*	
	Habenaria dilatata var. leucostachys (large orchid)	3*	
	Aruncus sylvester (goats beard)	3*	
	Epilobium sp.	2*	
Moss Layer	*Lycopodium spp.* (club moss)	8	
	studded leather lichen	2	

* Lower level bench; moist soil conditions

PLOT NO: Hot springs area (gravel bar) PLOT SIZE:

DATE: July 1979

VEGETATION TYPE - Biogeoclimatic Subzone:

- Forest Cover Type:

ALTITUDE: 1900'

SLOPE GRADIENT: flat

EXPOSURE: northwest

GROUND SURFACE COVERED BY:

Humus	<5%
Mineral Soil	75-90%
Decaying Wood	<5%
Rock	10-25%

PHOTO: Area subject to change i.e. after rainstorm in August stream diverted course and washed out upper hot pool. See photos. Photos also of possible stress cones.

COMMENTS:

- Hot spring flora not usually exotic or endemic to the area.
- Often find semi-aquatics on waters edge.
- Coniferous trees growing on the gravel bar in the hot spring area seem stunted and the needles have a yellow tinge, especially Douglas firs. Some trees, Douglas fir and western white pine have produced cones when trees are 6'-10' high.

  Possibly stress cones?

  Area fairly snow free in winter and therefore warmer than surrounding area - possibly high rate of evapotranspiration causing stress. Maybe interesting to do increment bores to note age of trees.
- Very sandy and rocky substrate with moss/lichen cover.
- Shrubs and trees are sparsely distributed.
- around water seepages - herbaceous layer lush - especially semi-aquatics - sedges, *Mimulus sp.* etc.
- Area used by people for camping, picnicing, hot pool dipping.
- Deer prints noted and bear scat.

PLOT NO: Hot springs area (gravel bar) DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Tree Layer (10'-25')	*Populus trichocarpa* (cottonwood) *Alnus rubra* (red alder)		
Stunted or Young Trees (5'-10')	*Pinus monticola** (western white pine) *Pseudotsuga menziesii** (Douglas fir) *Tsuga heterophylla* (western hemlock) *Abies amabilis* (amabilis fir) *Thuja plicata* (western red cedar)		
Shrub Layer (3'-8')	*Amelanchier (florida)* (saskatoon) *Shepherdia canadensis* (buffalo berry) *Rubus leucodermis* (black cap) *Arctostaphylos uva ursi* (kinnikinnick) *Cornus stolonifora* (red osier dogwood)		
Herb Layer - C	*Carex sp.* (sedge) *Mimulus spp.* (yellow) *Typha latifolia* (bull rush) *Equisetum arvense* (horsetail) *Equisetum hyemale* (horsetail) *Epilobium glandulosum var. glandulosum* *Epilobium spp.* *Polystichum sp.* *Pteridium aquilinum pubescens* (bracken) *Lupinus spp.* (lupine)		

* Possible stress cones

PLOT NO: Hot springs area (gravel bar) DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
	Fragaria spp. (strawberry)		
	Antennaria spp. (pussy toes)		
	Achillea millefolium (yarrow)		
	Plantago spp. (plantain)		
Moss Layer	dry brown moss		
	grey lichen		

PLOT NO: Bluff area PLOT SIZE: DATE: August 1979
south of New Road, opposite Falls Creek.

VEGETATION TYPE - Biogeoclimatic Subzone:

- Forest Cover Type: FH(C) 841-P

ALTITUDE: 2200'

SLOPE GRADIENT: 5°

EXPOSURE: southwest facing slope

GROUND SURFACE COVERED BY:

Humus	25%
Mineral Soil	15%
Decaying Wood	40-50%
Rock	15%

PHOTO: 1 of fungal community on forest floor

COMMENTS:

The dominant tree species in this stand is western hemlock. The understory is light and sparsely distributed with mock azalea being the characteristic understory shrub. A mossy carpet with a large species of club moss covers a substrate with a lot of rotting timber.

On the bluff overlooking the Lillooet River opposite Falls Creek a concentration of rabbit scats were noted.

PLOT NO: Bluff area south of New Road, opposite Falls Creek

DATE: August 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Tree Layer (90'-100')	*Tsuga heterophila* (western hemlock)	9	
	Abies amabilis (amabilis fir)	4	
	Thuja plicata (western red cedar)	3	
	Pseudotsuga menziesii (Douglas fir)	3	
Shrub Layer (5'-10')	*Menziesia ferruginea* (false azalea)	6	
	Taxus brevifolia (yew)	3	
	Abies amabilis (amabilis fir)	3	
	Ribes sp.	1	
Herb Layer	*Linnaea borealis* (twinflower)	5	
	Chimaphila umbellata (pipsissewa)	4	
	Goodyera oblongifolia (rattlesnake plantain)	3	
	Pyrola sp. (wintergreen)	3	
	Adenocaulon bicolor (silvergreen)	3	
	Clintonia uniflora (Queen's cup)	3	
Moss Layer	moss	9	
	Lycopodium clavatum (club moss)	7	
	fungi - mushrooms - coral like fungus	4	

PLOT NO: Gravel Bar Vegetation   PLOT SIZE: DATE: July 1979

VEGETATION TYPE - Biogeoclimatic Subzone:

- Forest Cover Type:

ALTITUDE:

SLOPE GRADIENT:

EXPOSURE:

GROUND SURFACE COVERED BY:

Humus	%
Mineral Soil	%
Decaying Wood	%
Rock	%

PHOTO:

COMMENTS:

Trees growing on gravel bars along both the Lillooet River and Meager Creek are sparsely distributed with the most common tree species being cottonwood. During the fall the leaves of the cottonwood growing in these areas were the first to change colour. In the more stable floodplain areas which are not frequently inundated, coniferous tree species have established themselves. However, these specimens are short indicating either young trees or stunted individuals tolerating less than ideal habitat requirements. Along some parts of these water courses a dense strip of sitka alder and willow form the riparian vegetation. Examples of this are seen along the Lillooet River near the B.C. Hydro camp and along the banks of upper Job Creek. When these species are located on open gravel areas they usually occur in clumps, sparsely distributed over the area.

In the upper Lillooet near Manatee Creek and on gravel bars in lower Job Creek, the predominant ground cover is yellow flowered avens. Lupines are also a common herb in these associations.

Most of the gravel bars are characterized by a dry moss/grey lichen mat utilizing the sandy substrate.

PLOT NO: Gravel Bar Vegetation DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Tree Layer (10'-20')	*Populous trichocarpa* (cottonwood)		
	Alnus rubra (red alder)		
	Pseudotsuga menziesii (Douglas fir)	*	
	Tsuga heterophila (western hemlock)	*	
	Pinus monticola (western white pine)	*	
	Pinus contorta latifolia (lodgepole pine)	*	
	Thuja plicata (western red cedar)	*	
Shrub Layer (5'-10')	*Alnus sinuata* (sitka alder)		
	Salix sp. (willow)		
	Vaccinium sp. (huckleberry)		
	Rubus parviflorus (thimbleberry)		
Herb Layer	*Dryas drummondii* (yellow flowered avens)		
	Epilobium angustifolium (fireweed)		
	Epilobium sp.		
	Lupinus sp. (lupine)		
	Castileja sp. (paintbrush)		
	Pyrola asarifola var. purpurea (wintergreen)		
	Oxyria digyna (mountain sorrel)		
	Carex sp. (sedge)		
	Achillea millefolium (yarrow)		
	Penstemon sp. (penstemon)		
	Antennaria sp. (white pussy toes)		

* Generally sparse distribution

PLOT NO: Gravel Bar Vegetation DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
Moss Layer	grey lichen dry moss cladina type lichen		

PLOT NO: Subalpine (Weather Station #3 and #4) PLOT SIZE: DATE: July 1979

VEGETATION TYPE - Biogeoclimatic Subzone:

- Forest Cover Type:

ALTITUDE:

SLOPE GRADIENT:

EXPOSURE:

GROUND SURFACE COVERED BY:

Humus	%
Mineral Soil	%
Decaying Wood	%
Rock	%

PHOTO:

COMMENTS:

The most prevalent tree species is *Abies lasiocarpa* (subalpine fir) with some *Abies amabilis* (amabilis fir) mixed. The trees are located in islands and have assumed a krummoholz form.

At Weather Station #4 the substrate is rocky and small depressions are filled with ponds. The ground cover is predominantly a heather mat (both *Cassiope mertensiana* and *Phyllodoce empetriformis*). Other species noted include *Vaccinium myrtillus, Sordus sitchensis* and *Luetkea pectinata*.

Weather Station #3 is located in a depression where the snow recedes late in the season. The vegetation is common to high altitude moist conditions. A lush meadow of sedges (*Carex sp.*) is most common. Other species include: *Arnica latifolia, Erythronium grandiflorum, Ranunculus sp., Anemone occidentalis, Athyrium alpestre americanum, Valeriana sitchensis*, and *Veratrum californicum*.

PLOT NO: Snowslide area (@ 4.0 km on new road) DATE: July 1979

LAYER (HEIGHT)	SPECIES	COVERAGE	BROWSE
	Salix sp. (tree like=20'-25') (willow)		
	Alnus sinuata (sitka alder)		
	Oplopanax horridus (devil's club)		
	Sambucus racemosa var. arborescens (red elderberry)		
	Cornus stolonifera var. stolonifera (red osier dogwood)		
	Sordus sp. (mountain ash)		
	Urtica sp. (stinging nettle)		
	Pteridium aquilinum pubescens (bracken)		
	Polystichum sp.		
	Smilacina stellata (solomon's seal)		
	Pyrola sp. (wintergreen) (heart shaped leaves)		

- very dense thickets of vegetation
- at this point a seepage runs through, therefore moist conditions
- other snowslide areas look to be predominantly sitka alder

APPENDIX F

RECREATION

1. Incidental observations of recreational use of Meager Creek study area, summer, 1979.

APPENDIX F

Incidental observations of recreational use of Meager Creek study area, summer 1979.

MONTH	DAY	NO. OF PARTIES	NO. OF INDIVIDUALS	REMARKS
July	14	2	4	Camped at hot springs.
	17	1	8	At hot springs for the evening from Pemberton.
	20	1	3	Camped at hot springs.
	21	1	3	Day use of hot springs.
		1	30	B.C. Mountaineering Club hiking in headwaters area for 2 weeks.
	22	1	4	At hot springs.
		1	4	En route to hot springs.
	24	1	5	Camped at 2 km on Meager Creek.
	26	1	2	Camped at hot springs from Vancouver.
	27	1	2	Camped at hot springs from Vancouver.
	29	1	7	En route to hot springs.
August	3	6	?	B.C. Mountaineering Club hiking and camping in general area.
	4	3	7	At hot springs-one group from Vancouver.
	5	4	18	Camping and picnicing at hot springs.
		3	?	En route to hot springs.
	8	1	1	Individual hiking into hot springs.
	9	1	10	Expedition from Cambridge, England at B.C. Hydro camp en route to Manatee glacier.
	11	2	9	Two families picnicing at hot springs.
		1	2	En route to hot springs.
		1	?	Camper headed up Lillooet River above B.C. Hydro camp.
	19	?	25-30	Observed in hot springs and during the course of the day.
	21	1	2	Camped at hot springs.
	22	1	2	Camped at hot springs.
	23	1	2	Camped at hot springs.
	26	3	6	Camped at hot springs.
	27	2	7	En route to hot springs.
		1	6	At hot springs for the evening from Pemberton.
	31	1	3	Camped at hot springs.

APPENDIX F: continued

MONTH	DAY	NO. OF PARTIES	NO. OF INDIVIDUALS	REMARKS
September	1	5	11	Camped at hot springs.
		2	4	Camped at 2 km on Meager Creek.
		2	4	Camped under Lillooet River bridge.
	2	6	17	Camped in vicinity of hot springs.
		3	8	En route to hot springs.
		2	4	Camped under Lillooet River bridge.
	3	6	Approx. 14	At hot springs during the day.
		4	14	En route to hot springs on Meager Creek road.
		6	18	On Lillooet River road.
	8	1	1	Camped at hot springs.
	9	Numerous cars on roads in study area including hunters, sightseers, hot springs visitors.		
	13	1	1	Camped at hot springs.
	15	2	2	Camped at hot springs.
	16	2	7	Picnicing at hot springs.
		1	1	Camped at 2 km on Meager Creek road.
November	3	1	15	Boy Scouts camped at hot springs.
		3	?	Hunters on B.C. Hydro exploration road in upper Lillooet.
		3	?	Hunters on Lillooet River logging road.
		1	?	Hunters at 4 k on Meager Creek road.
December	9	Path to the hot springs was packed indicating use since snowfall.		