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COLDSTREAM AND VASEUX CREEK WATERSHEDS:

ANALYSIS OF CHANNEL STABILITY AND SEDIMENT SOURCES

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AQUATIC STUDIES BRANCH

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ABSTRACT

Channel stability and suspended sediment sources were evaluated in the Coldstream and Vaseux (Vaseaux) Creek watersheds of the Okanagan Basin of British Columbia. Suspended sediment grab samples were taken at a number of stations throughout the watersheds at regular intervals during 1980. A comparison of sediment concentrations and yields at the various stations showed that the main source of sediments in both watersheds was from failing banks and degrading beds along the lower and middle reaches of the mainstem stream channels.

The sediment sources in the Coldstream watershed coincided with reaches in which the channel stability was classified as poor by both the U.S. Forest Service and Aquatic Studies Branch channel stability evaluation procedures. Channel stability in the main source area of Vaseux Creek was classified as fair. The reach which is the main source of sediments in Vaseux Creek has frequent valley wall failure scars, and was affected by massive scour and sediment deposition during a flood in 1942.

There was an order of magnitude difference in suspended sediment concentrations at all flows between the Coldstream and Vaseux Creek watersheds as measured near gauging stations in the lower reaches. This difference reflects the difference between the generally poor-rated channel of lower Coldstream and the generally fair-rated channel of Vaseux Creek.

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CONTENTS

CONTENTS (Continued)

FIGURES

FIGURES | PAGE

MAPS

MAPS | PAGE

PLATES

TABLES

1. INTRODUCTION

The overall purpose of the Coldstream and Vaseux Creek studies was to document sources of sediment and areas of erosion in tributary watersheds of the Okanagan Basin (Figure 1). The requesting agency, the Okanagan Basin Implementation Board, is attempting to reduce sediment and nutrient loadings to the main Okanagan Valley lakes. Aquatic inventory had two main objectives:

1) to provide an aquatic data base from which interpretations of fish distribution and habitats, and channel properties could be derived
2) to document sediment sources and stability status of stream reaches in the two study watersheds.

The results of the surveys are presented in the form of maps (reduced versions appear in map pocket in back cover), an erosion impact matrix, and this report. The mapping scale is 1:20 000 as it was felt that the standard reconnaissance scale for Aquatic Inventory mapping (1:50 000) would provide insufficient detail for the objectives of the study.

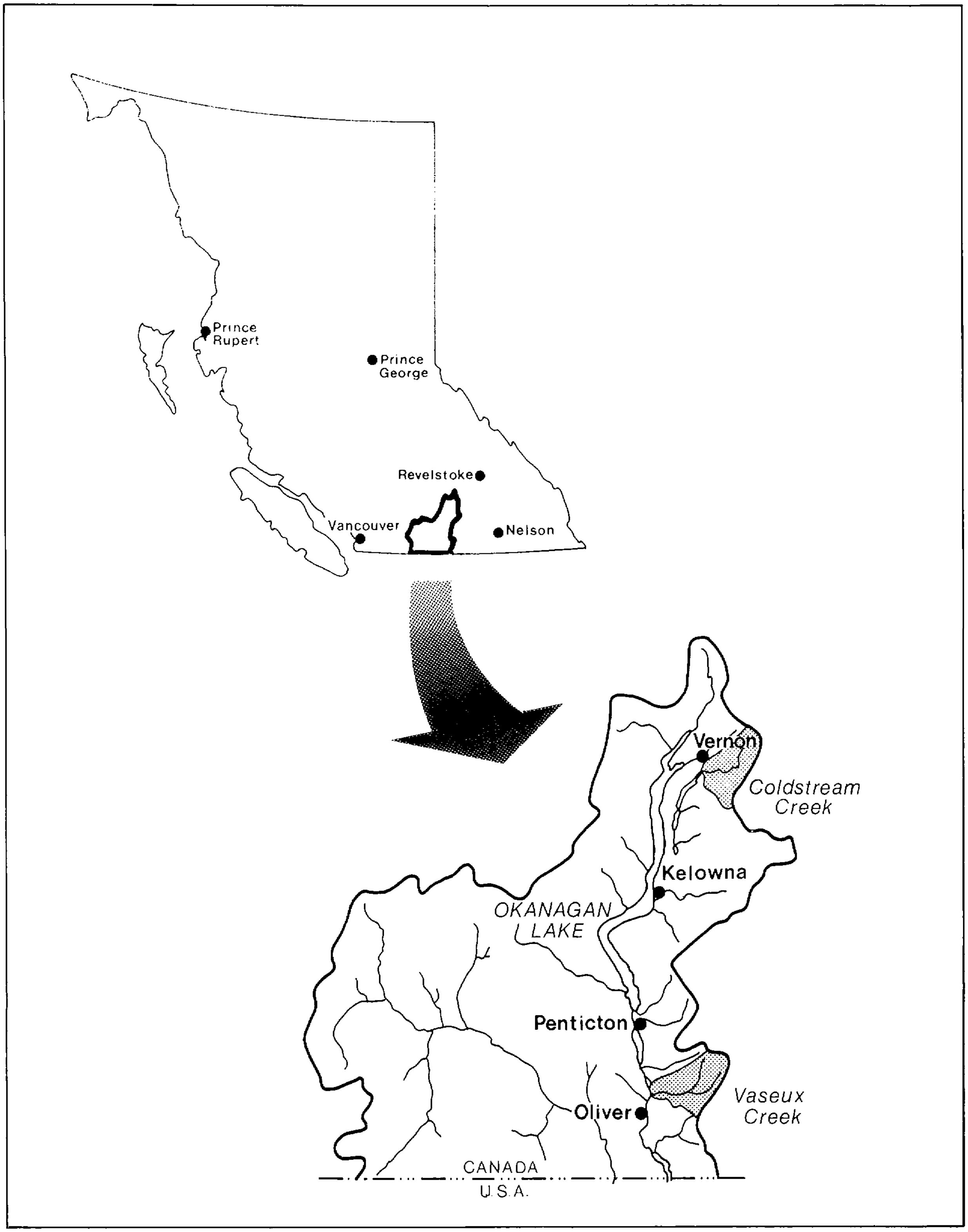

Figure 1 Key Map of the Okanagan Region Within B.C.

2. DESCRIPTION OF STUDY AREAS

2.1 COLDSTREAM CREEK

The Coldstream watershed consists of five upland basins draining an easterly fringe of the Thompson Plateau and the southern edge of the Shuswap Highlands into a broad central valley in the northern Okanagan Basin. Local physiography differs substantially between the upper Coldstream basin, draining south from the Shuswap Highlands, and the upper watersheds of the four main tributaries, draining north from the Thompson Highlands. The upper Coldstream basin has a ridge and valley topography with moderate relief and no lakes, whereas the characteristic topography of the southern upland basins is a low relief plateau with numerous lakes and wetlands. The median elevations of the upland drainages range from 960 to 1390 m, relatively low amongst Okanagan Basin tributaries.

Precipitation in the Coldstream basin increases with elevation, with a north easterly regional gradient. Annual amounts range from 390 mm at Vernon Coldstream Ranch to 650 mm in the Highlands at the head of the upper Coldstream basin. More than half the annual precipitation falls as snow above 1200 m.

The annual streamflow regime of the Coldstream is highly seasonal, with a snowmelt freshet from April to June peaking in May, followed by a groundwater baseflow regime from July to March. The snowmelt freshet occurs early (mean date May 9), and the basin has a low peakflow yield per unit area (34.4 $L/s/km^2$ from the upper Coldstream basin). The upper Coldstream basin appears to have a higher peakflow yield than the four basins on the south side of the Coldstream Valley, even though the latter have a higher median elevation. The higher unit area discharges from the upper Coldstream watershed are likely due to the faster runoff from the steeper topography, unattenuated by lake storage, and the greater snowpack accumulations resulting from the northeasterly increase in precipitation.

Interactions between surface and groundwater flow in the Coldstream valley are locally significant in the streamflow and sediment regimes of the lower Coldstream Creek. There is no surface flow from late summer to early spring on the fluvial fans which debouch into the Coldstream Valley from each of the upland basins. Below these fans, on the other hand, mainstem Coldstream Creek (below Reach 7.1), is essentially a groundwater fed stream during the same period.

The mainstem Coldstream channel (reaches 1 to 7) is characterized by relatively low gradients (0.5 - 1.5%) and fine textured bank and bed materials (Table 1).

TABLE 1

COLDSTREAM AND VASEUX CREEK CHANNEL CHARACTERISTICS

Watershed	Reach No.	Stream Order (Horton)	Average Gradient (%)	Average Channel Width (m)	Bed Material Average % Larges (>64 mm)	Bed Material D_{90} (mm)
Coldstream	1-7	3	1.0	6	10	70
Vaseux	1-4	4	5	13*	60*	450*

* Excludes Reach 3 (bedrock canyon).

Rainbow trout inhabit the mainstem of Coldstream Creek as far upstream as sampling occurred, 21.4 km from the mouth. A large population is believed to exist as many fish were captured at most locations with little effort.

The rainbow population is resident year-round in the stream, while below the pond at Coldstream Ranch, rainbow *(Salmo gairdneri)* and kokanee *(Oncorhynchus nerka)* migrating up from Kalamalka Lake also occur in the stream. The dam at the outlet of this settling pond (Plate 1) is believed to form a barrier to the upstream passage of fish. Coarse fish were also present in the lower reaches of Coldstream Creek but were not captured upstream from the dam.

The section below the dam serves as an extremely important area for spawning fish, especially Kokanee migrating up from Kalamalka Lake.

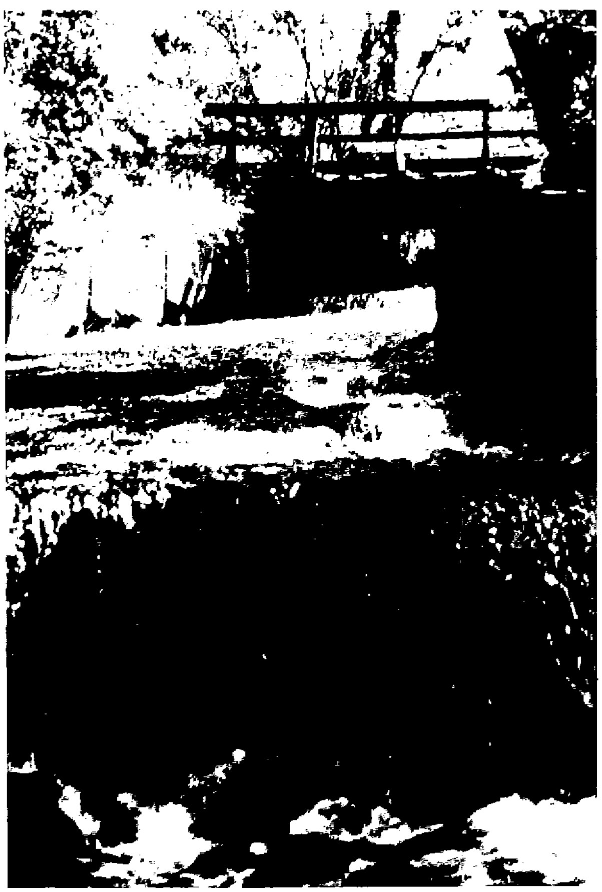

Plate 1 Obstruction Below Settling Pond on Coldstream Creek

2.2 VASEUX CREEK

The Vaseux Creek basin consists of several upland watersheds draining a portion of the Okanagan Highlands into a narrow, deeply entrenched central valley, debouching into the main Okanagan Valley across a large fluvial fan south of Okanagan Falls. The median elevation of the upland basins is over 1600 m, some 200 to 600 m higher than the Coldstream. The upland watersheds have a rather uniform, low relief plateau topography with many wetlands but few lakes.

As in the Coldstream basin, precipitation increases with elevation, with an easterly regional gradient. Annual amounts range from 300 mm at Oliver to 560 mm at Carmi, some 25 km to the northeast of the Vaseux watershed. Seasonal distribution of precipitation is similar to Coldstream, with a significant increase in snowfall and snowpack accumulations above 1500 m.

The annual streamflow regime of Vaseux Creek is similar to Coldstream, with snowmelt freshet period from April to June and groundwater flow period from July to March. Because of the higher basin elevations, the runoff peak occurs 2 weeks later on average than the Coldstream (May 24), while the mean unit area peakflows are 2 to 3 times greater (64.9 L/s/km2 at the lower Vaseux Creek station and 110.8 L/s/km2 at the upper station).

Groundwater fed flows in the fall and winter period (from August to March) vary from 0.7 to 1.6 L/s/km2 at both upper and lower gauging stations, about 75% of the corresponding yield per unit area in the lower Coldstream Valley.

The mainstem Vaseux channel is characterized by relatively high gradients (4-5%) with coarse textured bank and bed materials (Table 1).

A substantial fishery resource exists in the Vaseux Creek basin. With very few exceptions Rainbow trout were found at all the points sampled. Exceptions included Dutton Creek (no water in lower reaches) and some of the small tributaries to McIntyre Creek where gradients or substrate were unsuitable or where insufficient flows existed. The trout are probably resident as it is extremely unlikely that they could migrate up from the Okanagan River due to the bedrock falls in the canyon reach of Vaseux Creek. Solco Creek, especially, contained large numbers of trout wherever sampling occurred. Rainbow were the only fish captured upstream from the irrigation canal crossing (Plate 2) at the lower end of Vaseux Creek; this possibly acts as a selective barrier to prevent upstream migration of coarse fish species.

Plate 2 Vaseux Creek at Canal Crossing

3. METHODOLOGY

The study involved three inventory components:
1) detailed aquatic biophysical stream inventory
2) suspended sediment sampling
3) channel stability and sedimentation analyses.

Field work for components 1) and 3) was conducted concurrently at various times between May and September 1980. Suspended sediment sampling (component 2) was initiated in March, 1980 and continued until late November, 1980.

3.1 AQUATIC BIOPHYSICAL INVENTORY

The aquatic biophysical inventory was undertaken to provide a data base from which various interpretations of fish distributions and habitat, and channel properties could be derived. This followed the standard methodology used by the Aquatic Studies Branch, although applied with considerably greater sampling density than usual. A comprehensive description of the methodology has been published by the Ministry of Environment (Chamberlin, 1980a & b; and Belford and Chamberlin, 1980). Basically, stream channels are divided into sections (reaches) with relatively homogenous characteristics. Preliminary reaches are identified on air photos prior to field survey. These are checked and described with helicopter flights, ground observations from road access points, or walking along the stream. Reach boundaries may thus be added, eliminated or modified. Coldstream Creek was surveyed by helicopter with checks at road access points, and by walking the lower reaches. Vaseux Creek was surveyed mainly by helicopter, as road access points were relatively infrequent and walking transects were not practical.

Representative points were established throughout the watersheds and described for a variety of parameters, including fish, riparian vegetation, bank and bed materials, and channel hydraulic geometry. The information was mapped (Maps 1 and 2) and added to the provincial computerized Aquatic Data Base. Examples of the reach, point and fish data cards can be found in Appendix 2. The point sampling design on lower Coldstream Creek was very dense, to describe, with replicates, the habitat types within each subreach.

3.2 SUSPENDED SEDIMENT

Suspended sediment grab samples were collected approximately every 30 days except during freshet (April - May) when an attempt was made to sample every two weeks. The samples were collected to ascertain levels of suspended sediment throughout the watershed at specific times, and to document seasonal changes in concentration. Water samples were collected in 500 mL plastic bottles dipped by hand into the stream just below the water surface. Prior to collection, 1 mL of .45 g/L $CuSO_4$ solution had been added to each bottle to inhibit algae growth in the sample. Samples were analyzed at the Ministry of Environment Soils Lab in Kelowna (analysis method is described in Appendix 1). It should be noted that water quality samples were also collected at several sites in the two watersheds by the Waste Management Branch of the B.C. Ministry of Environment and analyzed by the Ministry's Environmental Laboratory in Vancouver.

Suspended sediment rating curves were prepared from the 1980 grab samples and Water Survey of Canada discharge data.

Table 2 summarizes the dates and results for samples that were collected throughout the 1980 field season. Results are also summarized in Figures 3, 4, 8 and 9. Sample sites, located at principle road crossings for ease of access, are shown on the Aquatic Biophysical Maps (Maps 1 and 2).

TABLE 2

SUSPENDED SEDIMENT DATA FOR 1980

SAMPLING LOCATIONS	SAMPLING DATES												
Coldstream Watershed	March 13	April 15	April 24	May 8	May 14		June 10	July 4	Aug. 1	Aug. 29	Sept. 25	Oct. 28	Nov. 28
Coldstream Creek # 1	11.6 (mg/L)	4.79	110.5	23.06	23.64		84.27	6.20	2.22	6.93	8.04	2.16	7.92
Coldstream Creek # 2	16.4	10.0	107.47	-	-		-	-	4.90	5.88	-	-	-
Coldstream Creek # 3	14.02	2.16	-	14.55	20.20		80.96	5.20	2.97	2.86	4.36	16.36	6.67
Coldstream Creek # 4	5.15	1.4	65.98	14.00	-		66.0	3.64	1.0	3.53	31.31	14.46	7.76
Coldstream Creek # 5	23.84	4.54	100.6	19.18	1.2		74.8	4.2	1.4	2.57	8.45	1.6	5.21
Coldstream Creek # 6	2.83	1.6	89.07	15.35	-		62.75	7.07	2.31	1.77	1.36	8.0	9.80
Coldstream Creek # 7	Dry	Dry	7.14	3.06	2.2		11.29	2.38	11.96	Dry	2.6	Dry	-
Coldstream Creek # 8	Snowed In	1.01	4.21	3.43	1.63		7.06	3.37	5.2	4.51	8.57	1.43	2.22
Deer Creek # 1	Snowed In	12.45	49.26	3.4	-		2.6	4.8	4.75	2.69	2.45	1.02	3.64
Brewer Creek # 1	-	Dry	84.17	5.1	-		11.46	Dry	Dry	Dry	Dry	Dry	Dry
Craster Creek # 1	-	Dry	33.67	5.4	-		10.19	2.18	Dry	Dry	Dry	Dry	Dry
Vaseux Watershed		April 14			May 13	May 26	June 9	July 3	July 31	Aug. 27	Sept. 24		Nov. 27
Vaseux Creek # 3		7.27			6.87	17.03	124.12	3.92	1.01	2.40	0.58		1.63
Vaseux Creek # 2		16.84			13.27	7.88	132.67	2.45	0.78	2.55	-		-
Vaseux Creek # 4		Snowed In			6.80	7.40	162.14	1.63	0.78	1.57	2.6		0.98
Vaseux Creek # 1		1.41			2.65	5.25	33.74	0.40	2.5	1.04	5.25		3.33
Dutton Creek # 1		3.88			-	-	-	-	-	-	-		-
Solco Creek # 2		Snowed In			3.96	3.80	17.35	4.75	0.59	2.80	1.43		0.59
Solco Creek # 1		2.22			1.60	2.80	11.75	1.00	0.77	3.50	2.22		3.11
Solco Creek # 3		Snowed In			1.22	3.27	3.40	3.27	1.96	5.40	0.4		15.25
Venner Creek # 1		30.0			7.27	3.40	8.13	5.86	16.47	22.25	34.89		3.0
Underdown Creek # 1		Snowed In			2.20	13.06	31.02	2.35	1.0	1.21	1.98		1.00
McIntyre Creek # 1		Snowed In			2.00	1.82	9.79	0.60	0.99	8.82	2.04		0.81

3.3 CHANNEL STABILITY ANALYSIS

Four methods were used to analyze channel stability. These were: a) the U.S.F.S. channel stability rating method, b) a U.S.F.S. derivative method for use in the helicopter surveys, c) a method developed for using the Aquatic Systems Inventory data base, d) comparative interpretation of aerial photos taken a number of years apart. The first three methods were used in Coldstream Creek. In Vaseux Creek, all four methods were used.

3.3.1 THE U.S.F.S. METHOD

The U.S. Forest Service method of channel stability evaluation (Pfankuch, 1975) as it was used in Oregon's 208 Project (Rickert et al., 1978) was implemented in the Coldstream and Vaseux Basin studies. This methodology was developed to systematize measurements and evaluations of the resistive capacity of small to medium sized stream channels to the detachment of bed and bank materials.

At each ground sampling point 15 channel stability indicators are evaluated. The indicators quantify factors which are thought to affect channel stability locally along the channel, such as bank texture, bank vegetation density, channel debris amount and stability, bed material texture and bed material compaction. Also evaluated is evidence of channel instability, notably the degree of bank failure and recent movement of bed material. The indicators are organized into three groups: upper banks (infrequently affected by flowing water), lower banks (frequently affected by flowing water at moderate to "bank-full" stage) and the bed (underwater at low flows). An example of a completed channel stability evaluation form can be found in Appendix 2.

Each indicator is assigned a weight reflecting the relative contribution of factors affecting channel stability and is rated for the degree to which they are present at the sampling location. There are four possible ratings for each indicator (excellent, good, fair, poor) which are assigned values of 1, 2, 3, and 4. After each stability indicator has been rated, the ratings are totalled giving an overall score to the channel. Because "excellent" stability ratings have a low assigned value, the lower the score, the better the estimated stability of the channel.

The methodology is best suited for analysis of 2nd to 4th order stream channels, (Coldstream Creek is a third order channel, while Vaseux Creek is 4th order based on 1:50 000 topographic map base).

3.3.2 DERIVATIVE METHOD FOR HELICOPTER SURVEYS

As ground-based stream inventories are time and labour intensive an experimental application of this procedure to helicopter overflight observations was attempted. An examination of the U.S.F.S. rating methodology suggested that only 7 of the 15 stability indicators could be evaluated from a low-level, low-speed overflight. The remaining eight channel attributes were simply too small to be visible from the air, or likely to be hidden by riparian vegetation.

The seven indicators rated from the air retained approximately the same overall weighting between the three main channel components (upper banks, lower banks, bottom). These factors also accounted for about two-thirds of the weighting of the overall evaluation score. Thus, if each of these factors could be adequately evaluated from the air, then the total helicopter-based score could be converted to a reasonably equivalent ground-based score if multiplied by 1.5.

3.3.3 AQUATIC BIOPHYSICAL CHANNEL STABILITY EVALUATION

Because of the many similarities between the data gathered for the Aquatic Biophysical Inventory, and the indicators evaluated in the U.S.F.S. channel stability ratings, a model was developed to estimate channel stability ratings from the standard aquatic inventory data (Karanka, in prep.). The calibration of these ratings required a high density of ground sampling hence this experimental methodology was applied only to the mainstem Coldstream data.

3.3.4 COMPARATIVE AIR PHOTO INTERPRETATION

In the Vaseux Creek watershed, it was possible to apply a fourth method of channel stability evaluation, using aerial photography combined with limited ground truthing. The method consists of a comparison of historic channel widths at specific locations at the various times of aerial photography. This was done by establishing transects on the air photos and measuring widths with a measuring magnifier. These measurements are converted to actual channel widths with conversion factors determined by the scale of the aerial photos.

The technique was not applicable to the Coldstream study because the channel is for the most part not visible on aerial photography due to a dense riparian vegetation canopy.

3.4 EVALUATION OF SEDIMENT YIELD

The aquatic inventory and channel stability evaluations undertaken for the Coldstream and Vaseux Creek studies fulfilled in part, the requirements of a methodology developed by the United States Forest Service and Environmental Protection Agency (EPA) for evaluating total potential sediment yield from non-point sources such as forest harvesting (USEPA, 1980).

The EPA procedure summarized in Appendix 3, consists of 21 evaluative steps requiring the collection of 19 data types. The suspended sediment sampling and aquatic biophysical surveys conducted during the 1980 field season, together with the Water Survey of Canada stream gauging satisfy 10 of the 19 data requirements. Seven of the remaining data types are not available for either Coldstream or Vaseux Creek and are not routinely surveyed in any current B.C. watershed inventory procedure. The Aquatic Biophysical inventory fulfils step numbers 1 and 18 of the EPA methodology. Step 3 of the procedure is the determination of suspended sediment rating curves which can be fulfilled from 1980 suspended sediment data and Water Survey of Canada stream gauging data. Step 20 of the procedure can also be completed from the existing data base, while steps 7 to 17, 19, and 21 cannot be done presently due to the lack of requisite data.

As a supplement to the detailed methodology outlined in Appendix 3, the U.S. Forest Service has also developed regional correlations between suspended sediment rating curves and channel stability ratings (USEPA, 1980). While this cannot yet be done in British Columbia because of the lack of required inventory data, the Coldstream and Vaseux Creek studies are a beginning towards this ultimate objective of regional analysis.

4. RESULTS AND INTERPRETATIONS

4.1 COLDSTREAM CREEK

4.1.1 AQUATIC BIOPHYSICAL INVENTORY

The Aquatic Biophysical Inventory gathered basic biological and physical information about the Coldstream system. This information is summarized in Map 1.

The raw data from all points and reaches in the watershed are available as a computer printout from the Aquatic Studies Branch office in Victoria.

These data were used to evaluate channel stability using a rating methodology similar to the U.S.F.S. rating system (see Section 4.1.3), and to summarize fisheries resources and channel characteristics discussed in section 2.1.

4.1.2 SUSPENDED SEDIMENT

From the data presented in Table 2 it would appear that two major peaks in suspended sediment concentrations occurred in 1980 - in the latter part of April and again in early June. Data collected over the past few years by the Waste Management Branch indicate that only one major peak, coincident with the stream hydrograph peak in May, is common for Coldstream Creek. A comparison of the 1980 hydrograph with the average hydrograph for the period 1971-79 (Figure 2) shows that 1980 was not an "average" year, with peak flows in April and June instead of the normal single peak in May. Thus the two peaks in suspended sediment concentrations reflect the abnormal runoff characteristics of 1980.

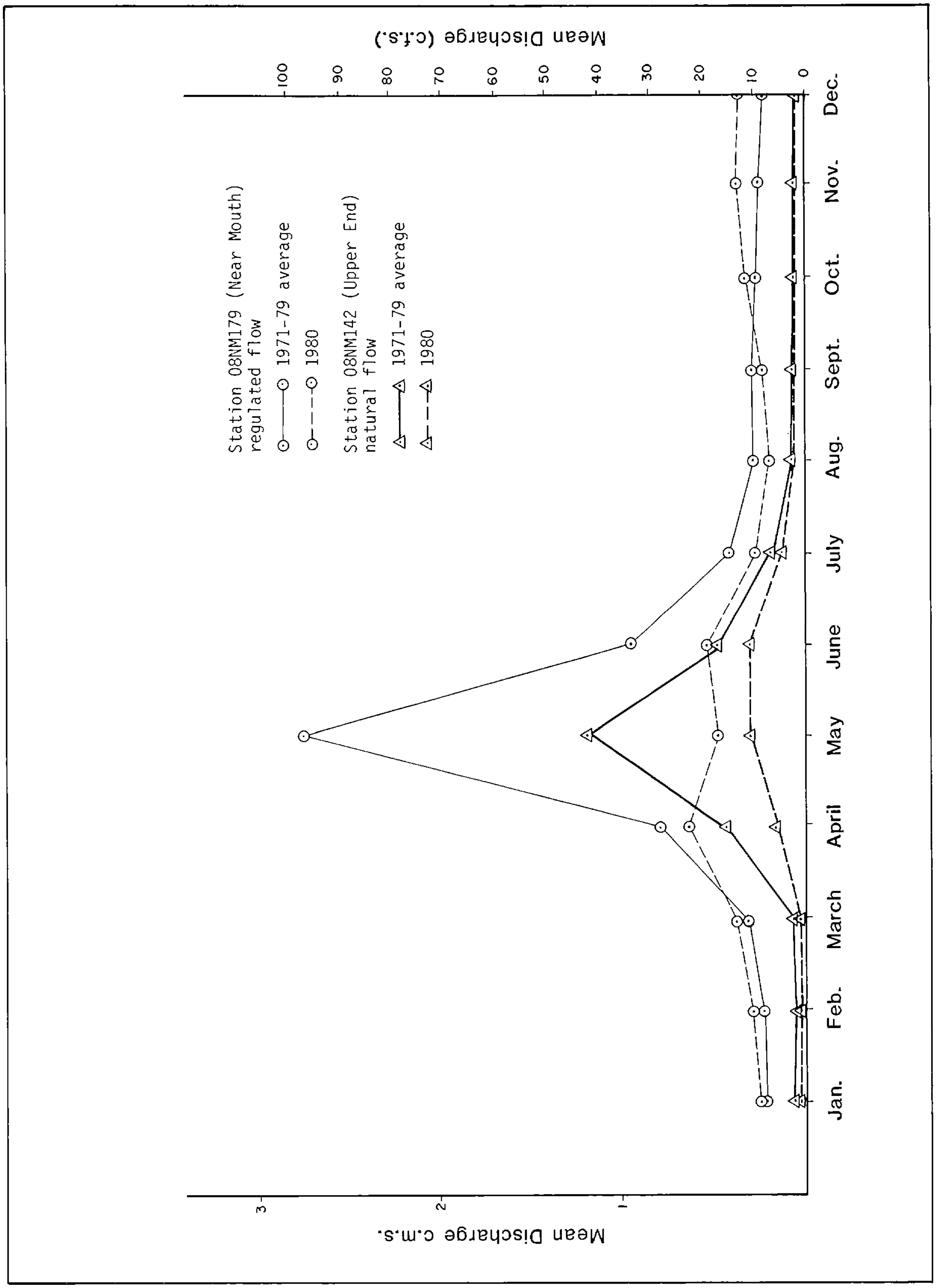

Figure 2 Coldstream Creek Hydrographs

Figure 3 illustrates suspended sediment concentrations for five sampling dates for stations throughout the lower Coldstream Creek valley. For a given date concentrations generally increased in a downstream direction. Sampling locations are indicated with their approximate distance upstream from the mouth. Also indicated in Figure 3 are the stream reaches of the lower Coldstream. The drop in concentrations between points 4 and 5 in April can partly be explained, we believe, by the existence of the pond (Plate 3) in this section of the creek which probably acts as a "settling pond". It should be noted that point 4 is located 1.5 km downstream from the pond and hence indicates suspended sediment loadings from the reach immediately below the pond as well as the pond itself. From August through the end of November, results (Table 2) indicate that suspended sediments increased downstream from points 5 to 4 - apparently the pond did not alleviate this problem at this time of the year. The available data do not explain this apparent anomaly but it is likely that it was caused by increased local sedimentation along the reach below the pond.

The relative location of tributary confluences are indicated by arrows on Figure 3. The peak suspended sediment concentration in 1980 is also shown for each creek. Brewer and Craster Creeks contained flowing water only from late April through early July and were dry for the rest of the sampling period. Suspended sediment concentrations in the three tributaries sampled were lower than concentrations in the mainstem Coldstream throughout the sampling period.

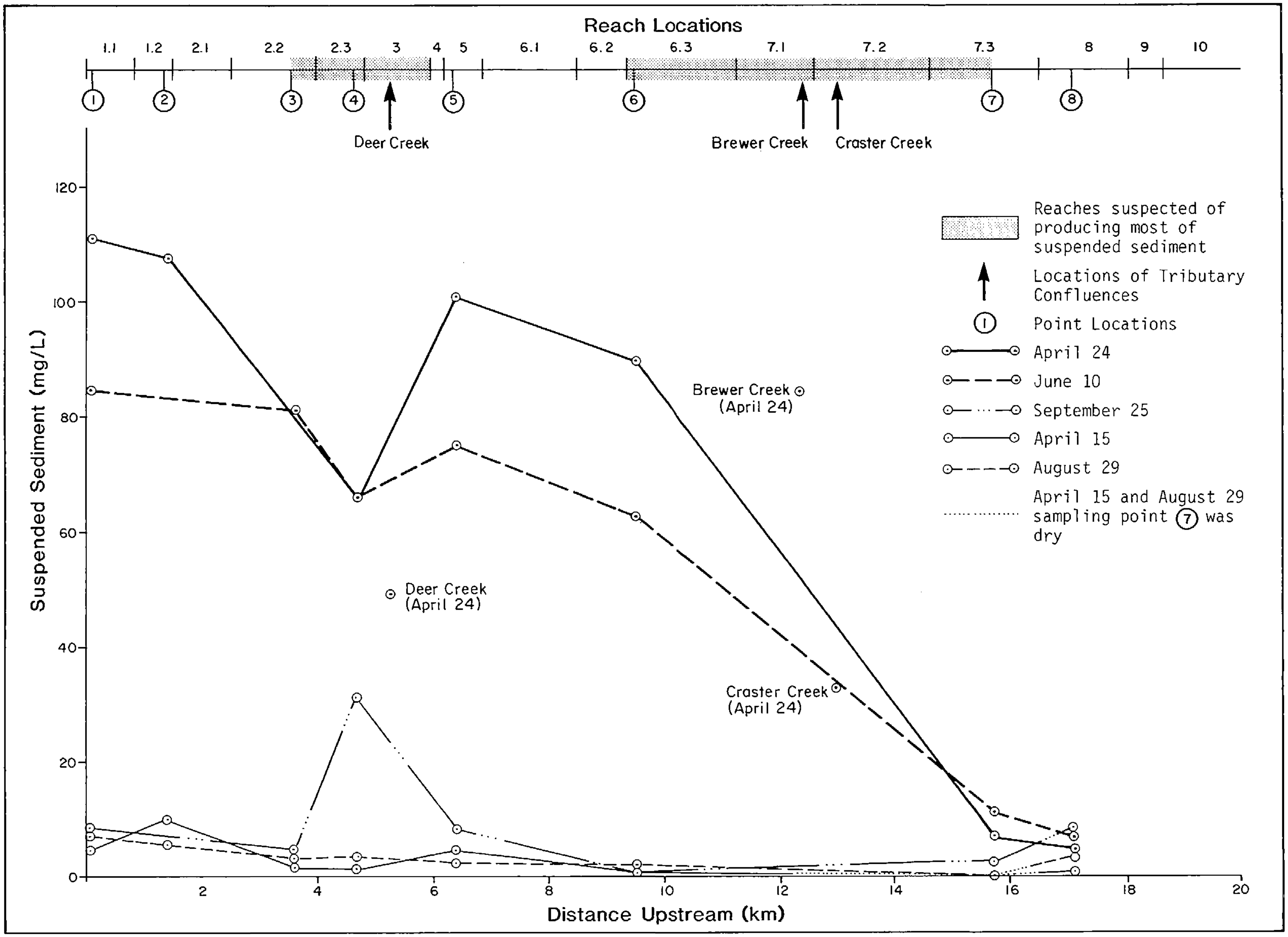

Figure 3 Coldstream Creek Suspended Sediment Concentrations

The sampling location for Deer Creek (Map 1) was well above the valley of Coldstream and hence the results may not reflect its contribution at the confluence. At all times except freshet, however, its contribution would be minimal. Even at freshet the relatively lower sediment concentration of Deer Creek aided in reducing the sediment concentrations at station 4 relative to station 5, and the clarity of Deer Creek water in late summer and fall was observed to be very good.

Plate 3 Settling Pond on Coldstream Creek

To determine the source areas of sediments, overall suspended sediment loadings at several key sampling stations were calculated from the measured concentrations and the stream discharge estimated at the time of sampling, (Table 3). At all stations more than 90% of the total loadings occurred on the one or two days when samples were taken during the freshet.

Figure 4 simply reinforces the ideas that suspended sediment concentrations in Coldstream Creek are low except for the freshet period. The contribution of that part of the watershed upstream of the valley bottom (i.e. reflected at station 7) is minimal year-round. Only 5% of the loadings at station 6 on Coldstream originated from the upper basin as measured at station 7. Upper Deer Creek contributed a similar minimal loading to Coldstream as measured at point 4.

Most of the sediment loadings thus appear to originate along the mainstem Coldstream channel with a lesser source in the fans of Brewer and Craster Creeks.

Suspended sediment rating curves for Coldstream Creek were prepared separately from both the 1980 ASB data and earlier Waste Management Branch data, using samples from stations located below the Deer C. confluence, referenced to stream discharges at the Water Survey of Canada gauging station above the Kalavista Diversion. Both sets of data yielded similar rating curves. The curve derived from ASB data is shown in Figure 11.

A short summary of the role of suspended sediment in the stream channel environment can be found in Appendix 4.

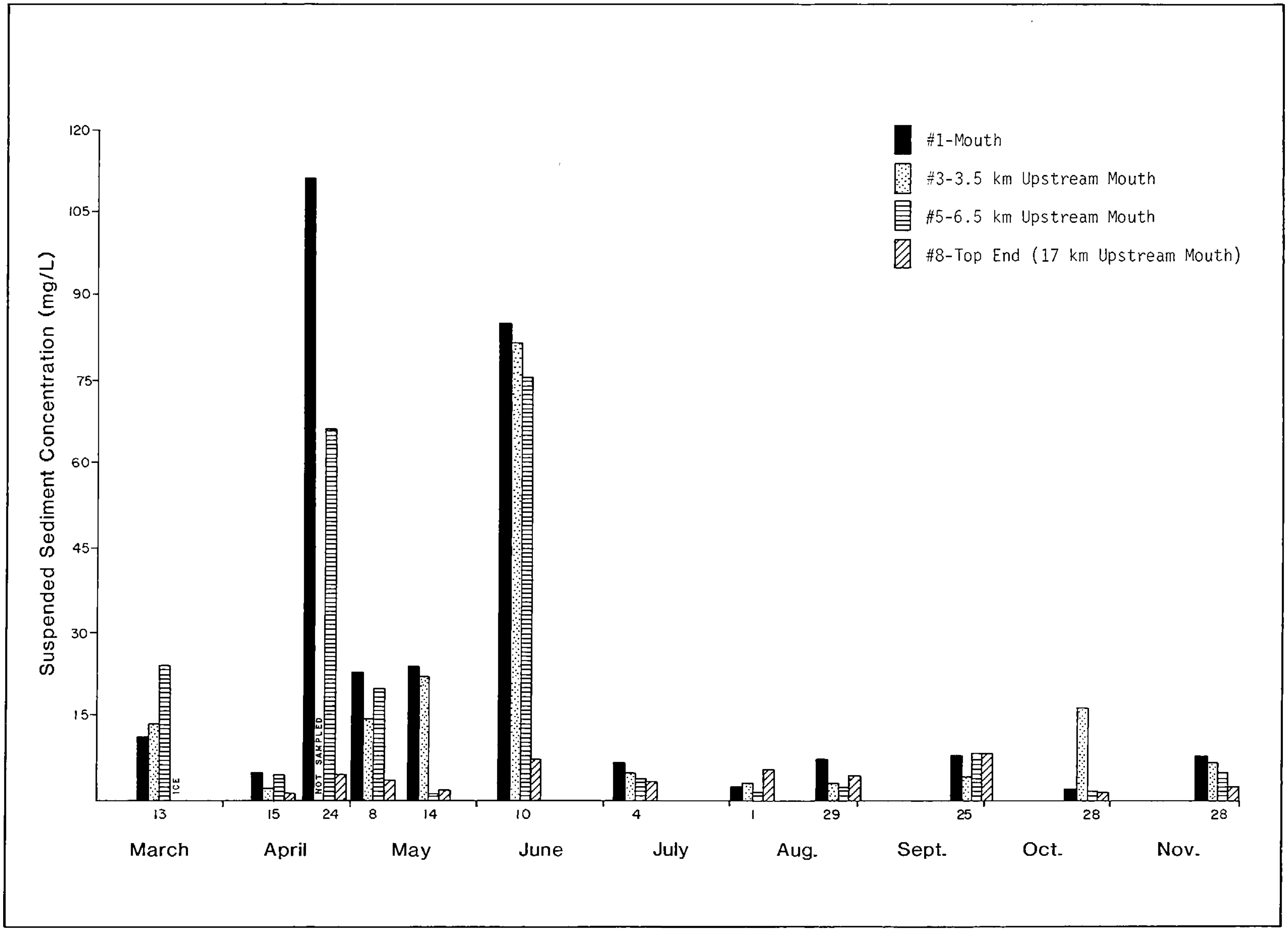

Figure 4 Suspended Sediment Concentrations in Coldstream Creek

TABLE 3

SUSPENDED SEDIMENT LOADINGS FOR 1980

SAMPLING LOCATIONS	DATE LOADING IN TONNES PER DAY												
Coldstream Watershed	March 13	April 15	April 24	May 8	May 14		June 10	July 4	Aug. 1	Aug. 29	Sept. 25	Oct. 28	Nov. 28	TOTAL
Coldstream Creek # 3	.5	.04	15.2	.7			5.5	.2	.04	.06	.1	.3		22.6
Coldstream Creek # 4	.2	.04	11.4	.8			4.1	.1	.01	.09	.9	.2		17.9
Coldstream Creek # 6			9.7	1.4			4.2	.2	.03		.04			15.6
Coldstream Creek # 7	Dry	Dry	.2	.1			.5	.02	.01	Dry	.01	Dry		.8
Deer Creek # 1	Snowed In		(1.1)	.01			.03	.02	.09	.01	T	T		1.3
Brewer Creek # 1		Dry	4.1	.03			.1	Dry	Dry	Dry	Dry	Dry		4.3
Craster Creek # 1		Dry	1.4	.07			.2	Dry	Dry	Dry	Dry	Dry		1.7
Vaseux Watershed		April 14			May 13	May 26	June 9	July 3	July 31	Aug. 27	Sept. 24		Nov. 27	
Vaseux Creek # 1					.4	.5	7.7	.02	.02	.01	.03			8.7
Vaseux Creek # 4		Snowed In			4.6	3.1	217	.2	.02	.06	.08			225.0
Solco Creek # 2		Snowed In			1.5	.9	7.7	.3	.01	.02	.02			10.3
Underdown Creek # 1					.4	2.2	12.2	.09	.01	.01	.03			14.9
McIntyre Creek # 1					.3	.4	2.9	.02	.01	.1	.02			3.7

4.1.3 CHANNEL STABILITY EVALUATION

U.S. Forest Service Ratings

The breaks in rating categories (Figure 5) between good, fair and poor were modified from the original to reflect different conditions of the Okanagan valley. The U.S.F.S. forms suggest that a score of over 115 indicated a poor rating but this study indicated that reaches scoring 103 and over either showed active or impending failures and should be flagged as such. It is interesting to note that Oregon's 208 Non-Point Source Assessment Project also adjusted their ratings and ended up with the breaks between fair and poor at 102 and between good and fair at 79. Our good-fair break was also at 79.

A split within the fair category was added purely to give some indication of the sensitivity of the site as one overall "fair" rating covered such a wide range.

The distribution of U.S.F.S. point scores (Figure 5) would seem to indicate that, as so many totalled 103 and over, many areas in the watershed are actively eroding or in danger of doing so; in fact 37% of the points sampled in this basin were in the poor rating.

Figure 6 illustrates point score and hence stream reach stability ratings versus distance upstream from the mouth. This clearly indicates why reaches 2.1, 2.3, 3, 6.2, 6.3, 7.1, 7.2 and 9 (see Map 3) are rated as poor.

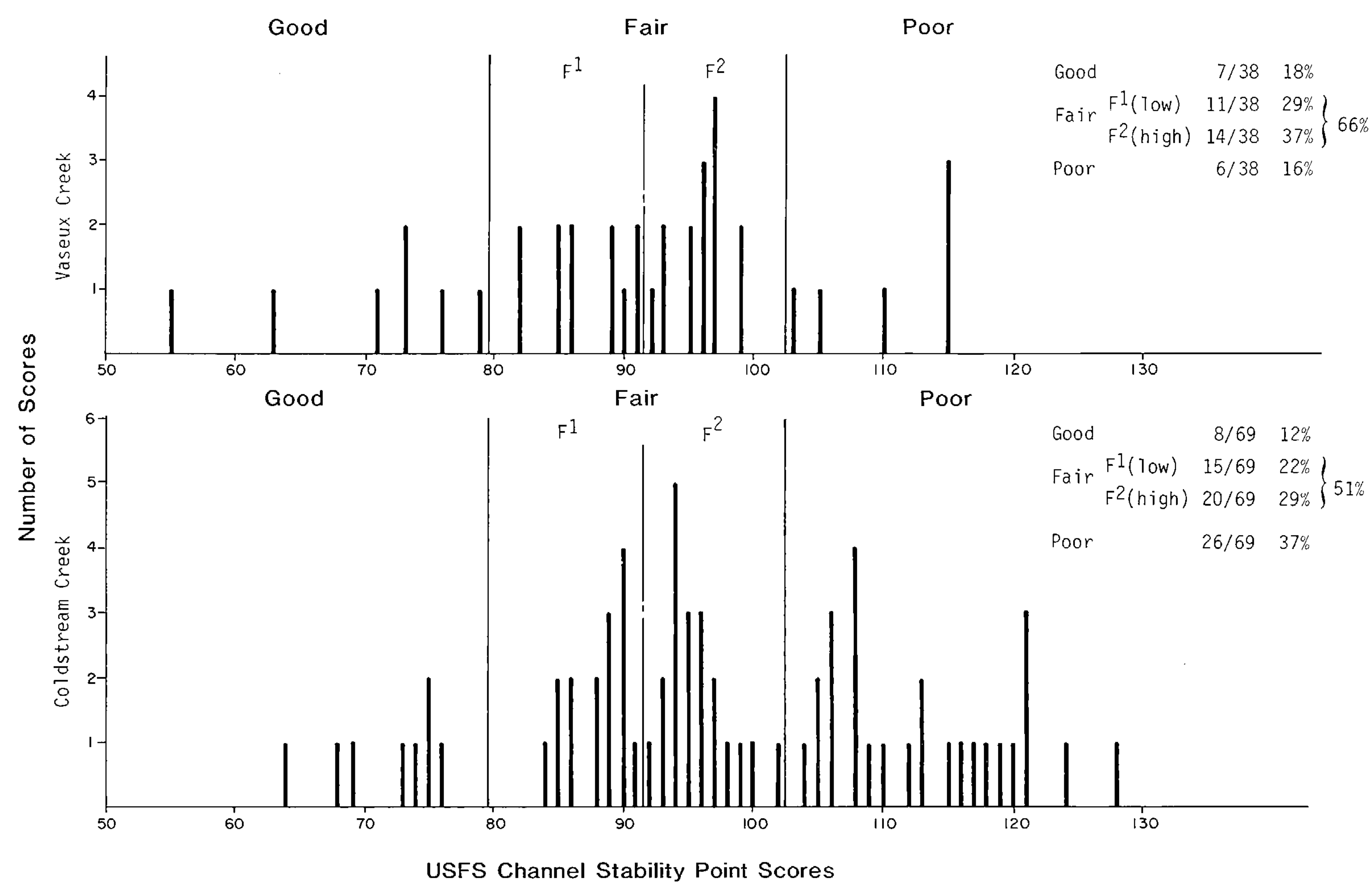

Figure 5 Frequency Distribution of Channel Stability Point Scores

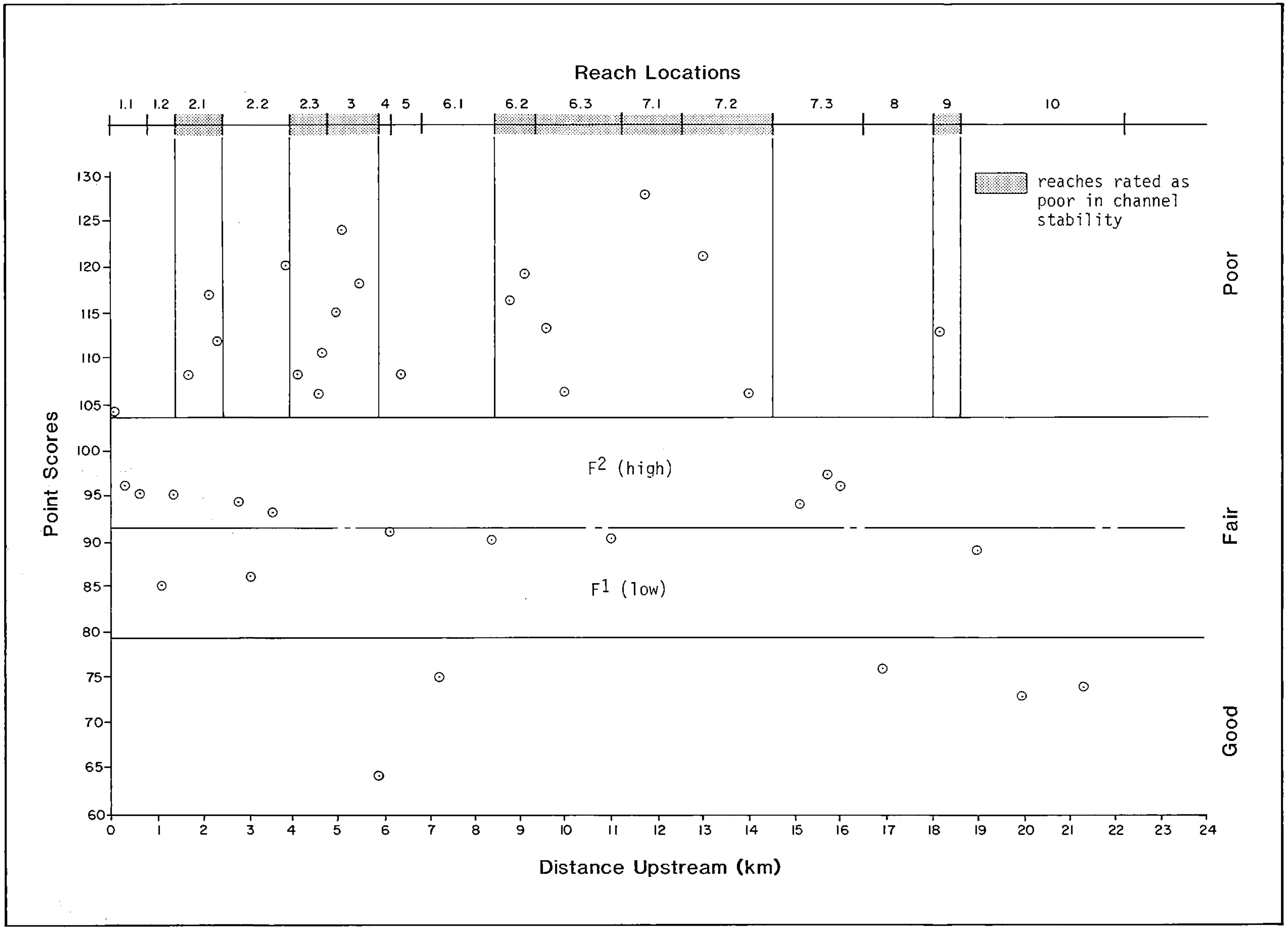

Figure 6 Mainstem Coldstream Creek Location of Point Stability Scores and Reach Ratings

The stream reaches at the bottom ends of Deer, Brewer and Craster Creeks (see Map 3) were also rated as poor (Plate 4).

An attempt was made on Map 3 to indicate whether the bed, the banks or a combination of both contributed most to the overall poor stability rating score. Plate 5 shows a typical "poor" rated reach of lower Coldstream Creek with actively eroding banks composed of fine textured materials. By contrast Plate 6 illustrates a very stable channel environment.

The U.S.F.S. channel stability evaluations were analyzed for differences between "poor" rated and "fair" or "good" rated reaches. Most of the differences in scores between the two groups of reaches are due to the degree of bank erosion or bed material scouring and deposition present.

Plate 4 Lower End of Craster Creek
(Coldstream Watershed)

Plate 5 Lower Coldstream Creek

Plate 6 Upper Coldstream Creek

Helicopter Observations

The attempt to rate stability from helicopter observations was only partially successful due to poor visibility caused by shadows and dense crown closure along most of the small stream channels. The reaches identified from the air were very general, and variability within reaches could not be separated as in the ground survey. The observations did, however, reinforce the results obtained from ground samples.

Aquatic System Data Analysis

Channel stability ratings from Aquatic Systems data using the experimental methodology developed for the Coldstream inventory have a correlation of -0.83 with the U.S.F.S. ratings (Figure 7). The strong negative correlation is due to the way in which the rating is developed from the Aquatic Data Base: higher scores indicated greater stability, the opposite of the U.S.F.S. procedure.

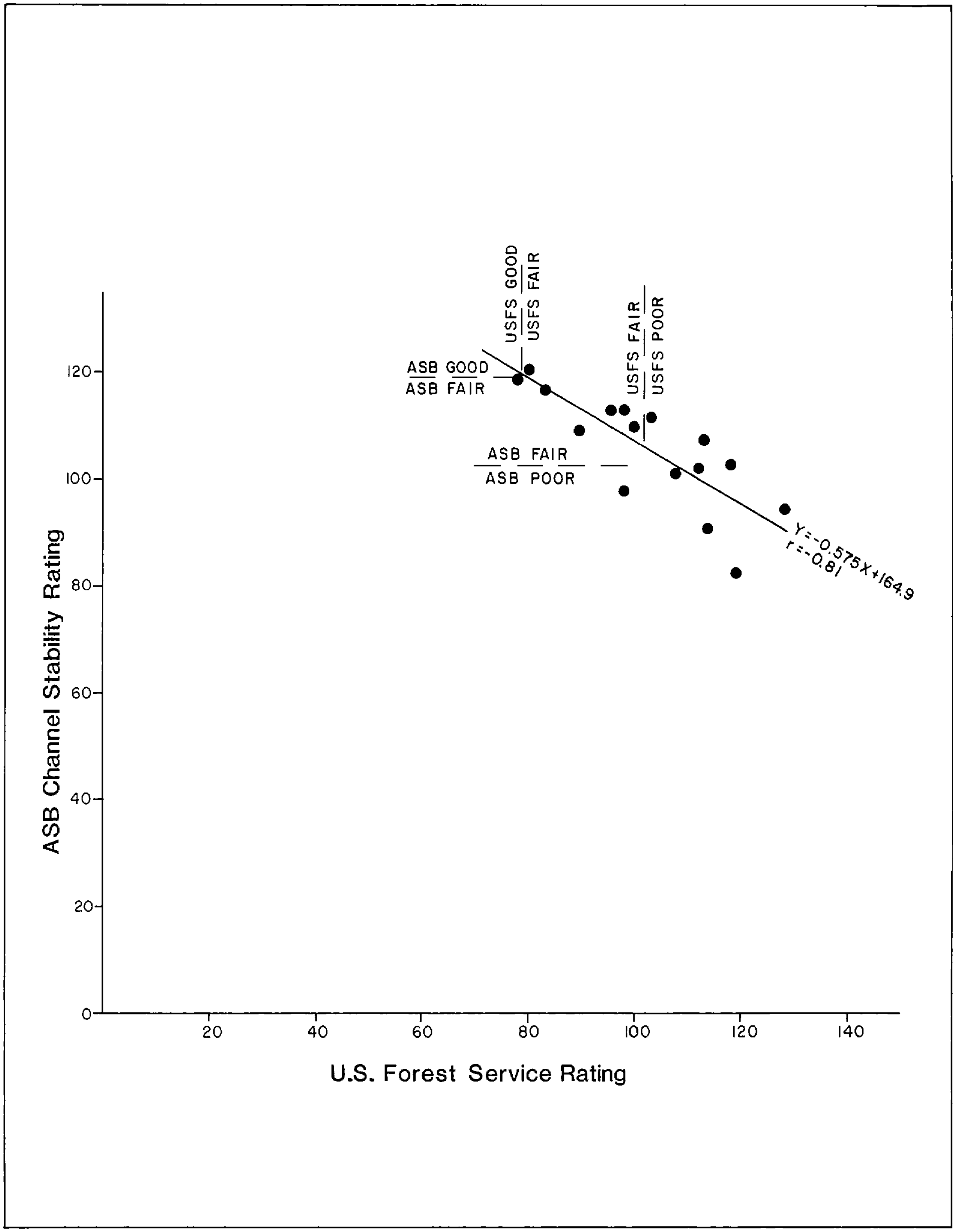

Figure 7 Correlation of U.S. Forest Service and Aquatic Studies Branch Channel Stability Ratings (Coldstream Creek)

4.2 VASEUX CREEK

4.2.1 AQUATIC BIOPHYSICAL INVENTORY

The Aquatic Inventory data for the Vaseux Creek watershed are summarized in Map 2, while the raw data are available as a computer printout from the Aquatic Studies Branch.

4.2.2 SUSPENDED SEDIMENT

The 1980 results (Table 1) indicate that only one major peak occurred in the year. Figures 8 and 9 illustrate sediment results obtained in Vaseux Creek and in Solco Creek, respectively. Hydrographs derived from Water Survey of Canada data (Figure 10) indicate that peak flows in 1980 were lower than the average for the period 1970-79 but that the overall run-off timing differed very little, thus our suspended sediment results probably reflect a "normal" seasonal situation. Figure 8 indicates that sediment levels in the latter half of the year were very low. As anticipated, points 2 and 4 (Figure 8 and Map 2) showed elevated sediment levels as they are downstream from the river reaches where much evidence of valley wall instability exists.

Although an increase in sediment levels from point 4 to point 2 was evident, it was less than expected from the number of valley wall failure scars. Actual failure occurrences may be infrequent, occurring episodically in years with wetter than normal soil conditions or in years with unusually high flows with active undercutting of the banks at points of slope failure. The resulting failure scars, on the other hand, persist because vegetation is re-established very slowly on oversteepened slopes above coarse textured materials in the semi-arid Okanagan climate.

Figure 9 presents some puzzling results. It is not known why the levels of suspended sediment in Venner Creek showed a consistent increase each month from early July through the end of September.

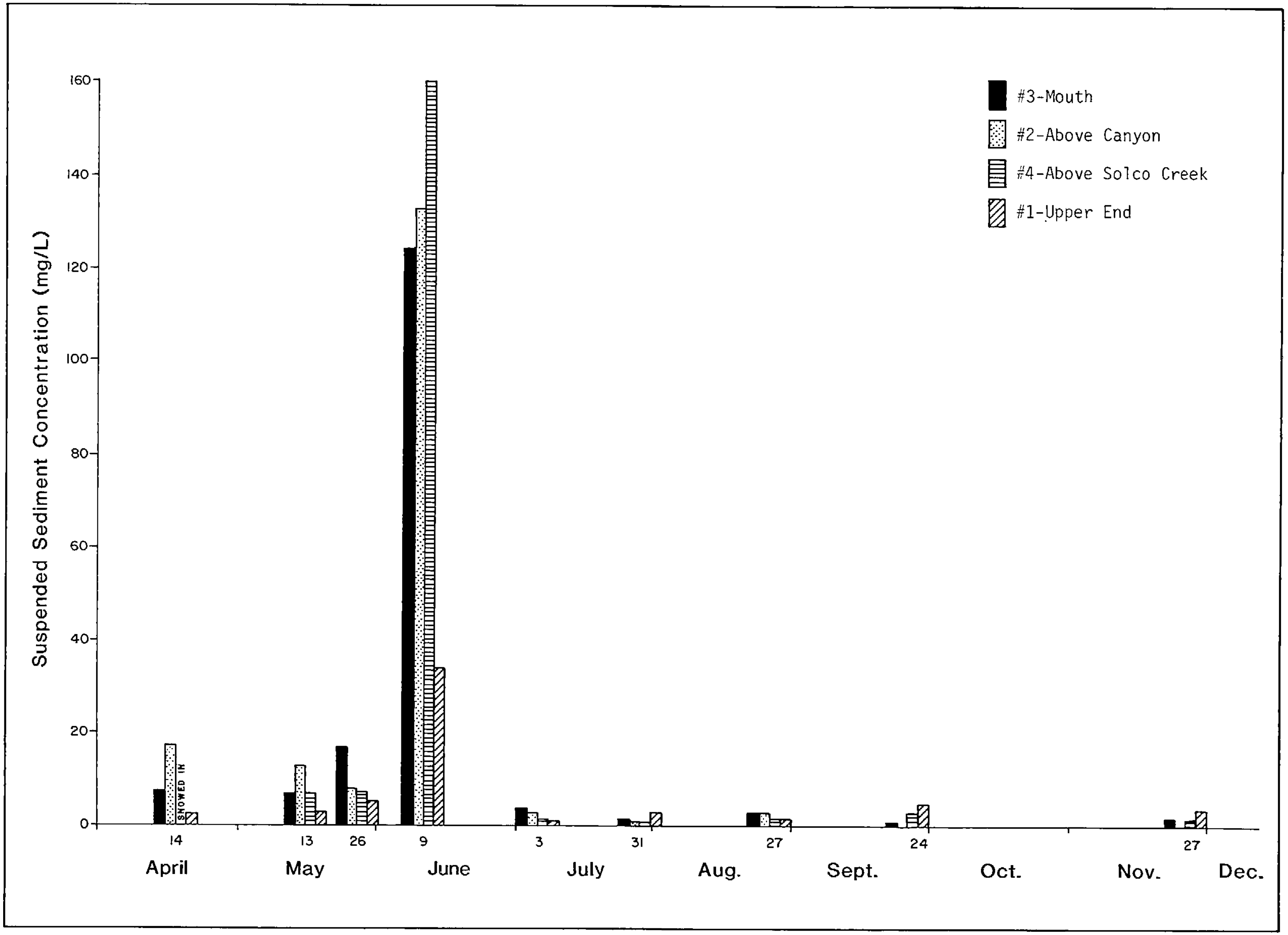

Figure 8 Suspended Sediment Concentrations in Vaseux Creek

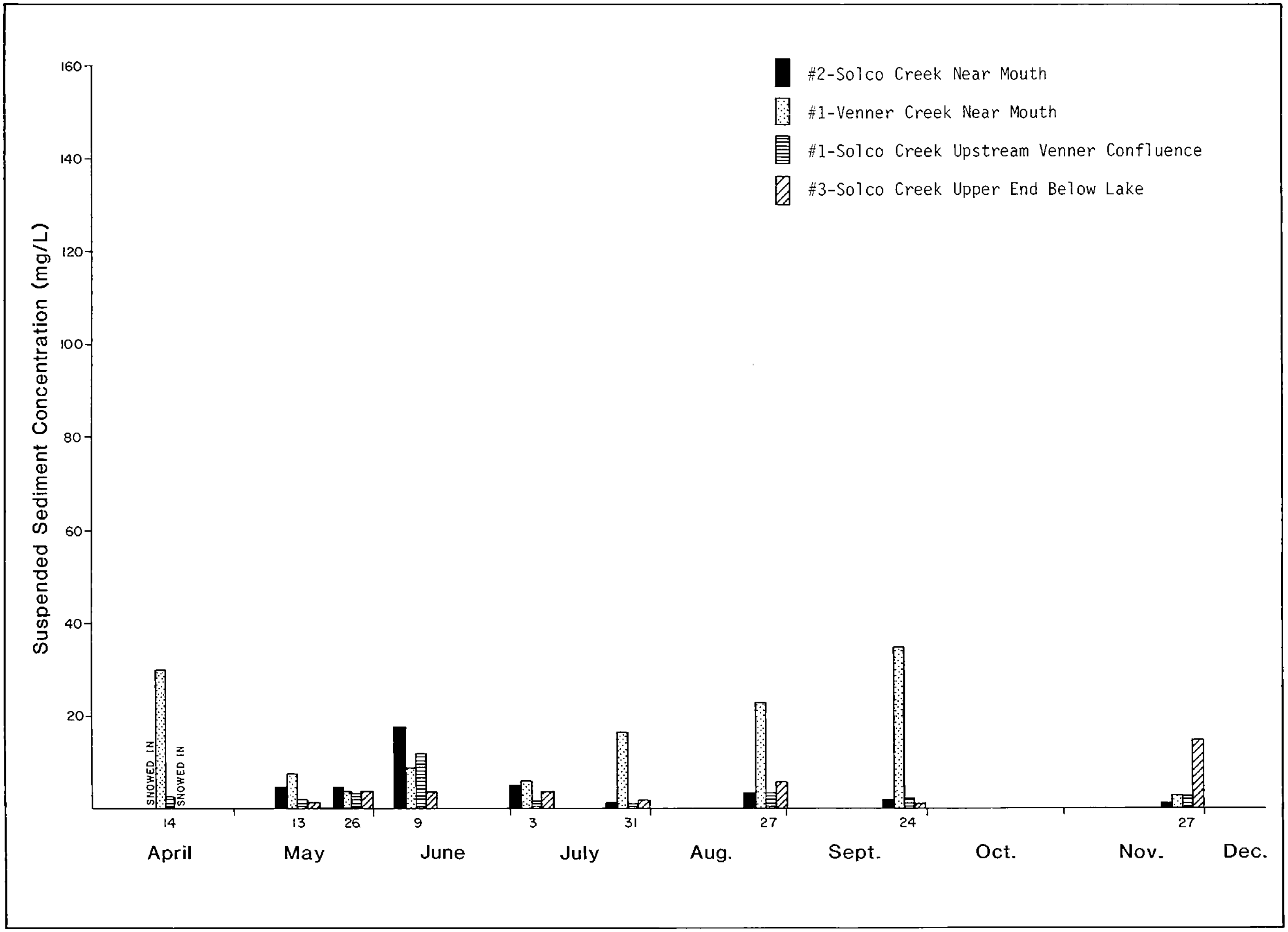

Figure 9 Suspended Sediment Concentrations in the Solco Creek Watershed

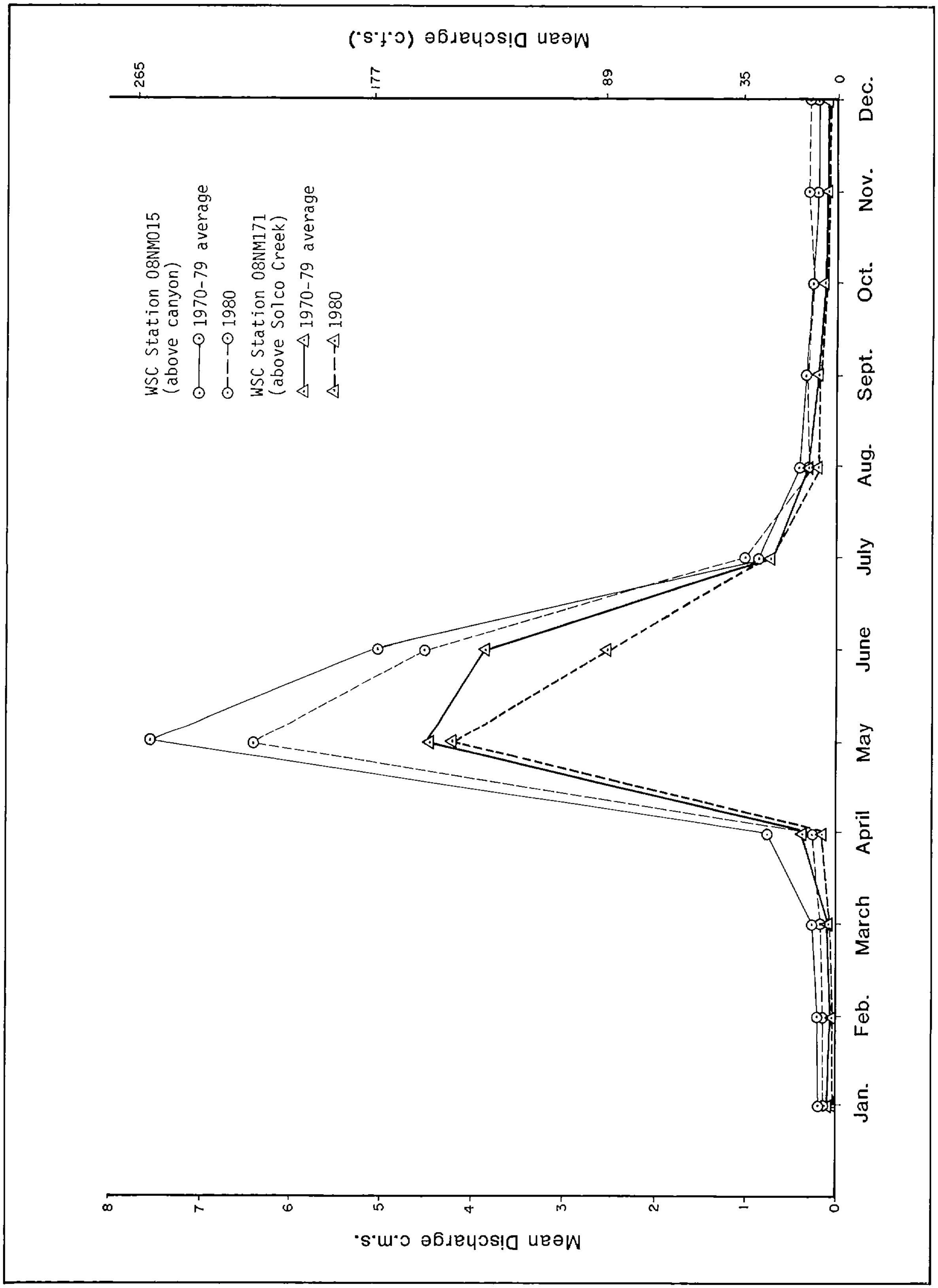

Figure 10 Vaseux Creek Hydrographs

Water levels decreased throughout the summer, sampling did not take place during storm events, the road crossing upstream from the sampling point (100 m) did not show signs of deteriorating in this period and the slumping bank just downstream from the sampling location would not have affected the water quality. The only possible suggestions are that logging truck traffic spread dust particles on to the creek or that cattle caused increased sediment levels. However, both occurred in an area of the creek where numerous beaver ponds and small swamps were present which would normally cause much of the sediment load to settle out. The elevated sediment level at station Solco # 3 in November was unexpected as it is in an area of swampland immediately below Solco Lake. It is possible that in cutting through the ice cover on the creek the bottom was disturbed or material was added to the creek resulting in the high suspended sediment concentration. It may be noted that abnormally high fall and winter suspended sediment concentrations have been sampled from time to time on other interior streams at Water Survey of Canada sediment sampling stations.

Suspended sediment loadings at key mainstem and tributary sampling sites show that the tributary creeks in the watershed contribute only 15% of the sediment measured at Point 4 of Vaseux Creek. Although Venner Creek carries significant concentrations of suspended material in late summer and fall, most of this material does not reach Vaseux Creek as noted in the levels at Solco #2 (Table 1) located well downstream from the Venner-Solco confluence.

Most of the suspended sediment (85%), we conclude, is being picked up by Vaseux Creek itself in its middle reaches (reaches 4 and 5 - see Map 4).

A composite suspended sediment rating curve for Vaseux Creek was derived from data at point Nos. 2, 3, and 4, referenced to daily discharge data at both Water Survey of Canada gauging stations (Figure 11). The rating curve from Waste Management sediment samples had slightly lower concentrations at a given flow.

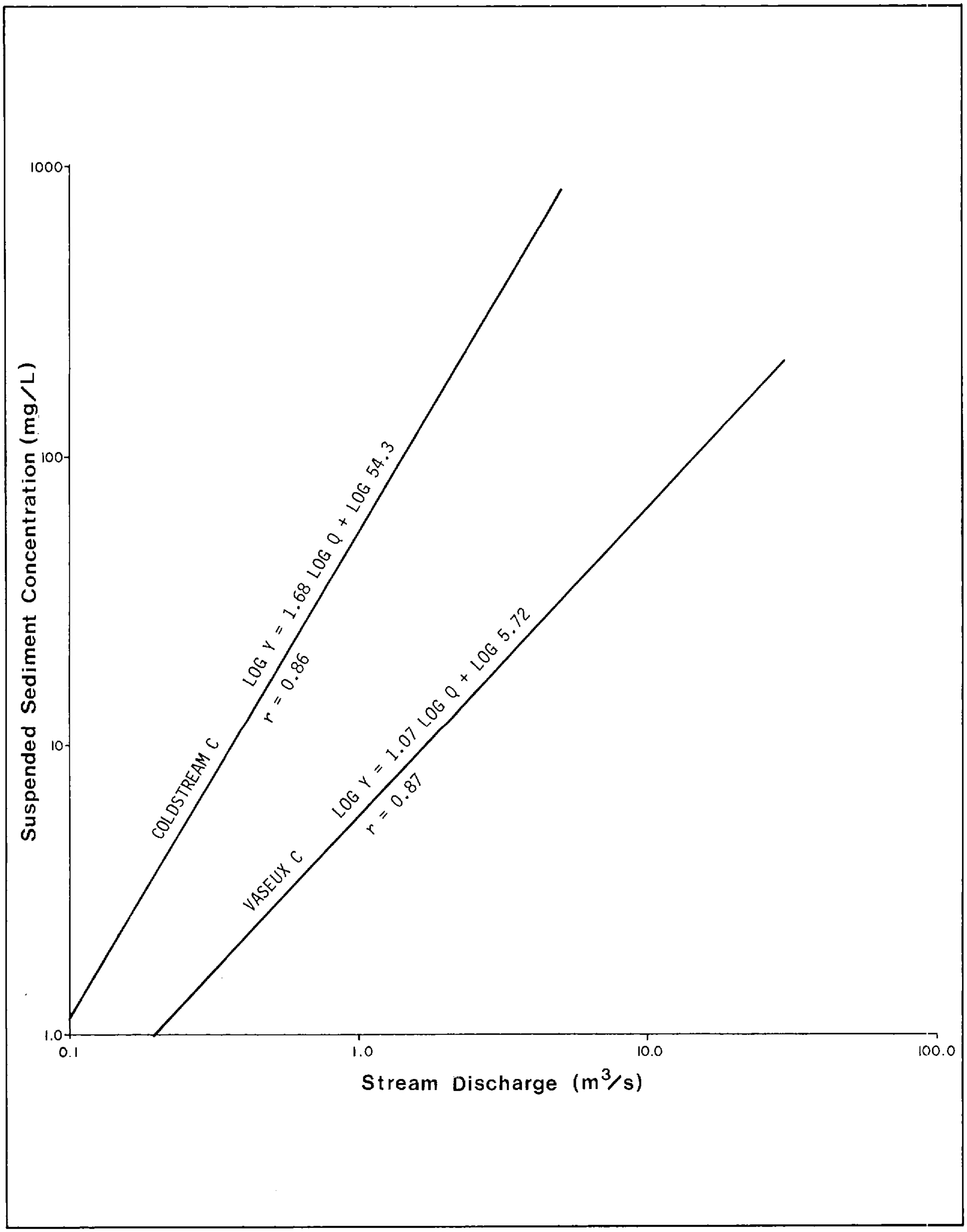

Figure 11 Suspended Sediment Rating Curves for Coldstream and Vaseux Creeks

4.2.3 CHANNEL STABILITY EVALUATION

U.S.F.S. Ratings

The same breaks in rating categories were followed for Vaseux as were made for the Coldstream watershed. However due to the low density of sample points the split in the fair category and the reason (bed, banks or combination of both) for the poor rating were not mapped.

Compared to Coldstream Creek it would appear (Figure 5) that a much more even distribution of channel stability point scores exists. Only 6 out of the 38 points sampled (16%) were found to be in the poor class and this was reflected in the reach ratings where only six reaches were classified as having poor stability. Plate 7 shows a "poor"-rated section of upper Vaseux Creek while the canyon (Reach 3), illustrated in Plate 8 was rated as being very stable.

The middle reaches of Vaseux Creek, where channel stability was rated as fair (Map 4), produced most of the suspended sediment reflected in measurements at the mouth. This apparent anomaly is due to the presence of large areas of slumping in this area especially on the north side of the valley (Plate 9). These failures almost all occur on the valley wall, which is a very minor component of the U.S.F.S. channel stability rating process.

Plate 7 Upper Vaseux Creek

Plate 8 Canyon on Vaseux Creek

Plate 9 Middle Reach of Vaseux Creek

Aerial Photography Analysis

Aerial photographs taken in 1938, 1951, and 1974 were analyzed to determine whether changes in channel width, pattern, or location have occurred in the recent past along the mainstem of Vaseux Creek. It was immediately apparent that a major change had occurred between 1938 and 1951 (Plate 10). During this period, the average channel width has tripled from the Vaseux Creek Canyon upstream to the junction of McIntyre Creek (Reach 4). The area of floodplain affected was approximately 40 ha. The channel itself avulsed (changed location) at several places.

Since 1951, the channel has been relatively stable, with only minor changes in location and pattern, mainly at meander bends, while many of the gravel bars created between 1938 and 1951 have slowly revegetated.

Field inspection of the floodplain at four locations suggested that a major flood had occurred about 30 to 40 years ago, based on probable ages of trees re-establishing on the gravel bars created between the 1938 and 1951 photography. These gravel bars are typical lobate deposits and levees which are formed on coarse bedload channels during the receding stage of a major flood as the stream loses its ability to move the material entrained during the maximum flow.

The deposits were undoubtedly formed by the 1942 flood, described graphically in the *Penticton Herald* of May 28, 1942, and more objectively by the Joint Board of Engineers (1946).

Although scanty, hydrometric data from the south Okanagan area suggest that the maximum daily flow of the 1942 flood may have been 60 m^3/sec at the lower Vaseux Creek gauging station, 50% greater than any subsequent flows, including the 1948 and 1972 floods. The return period of such a flow is a minimum of 50 years. A detailed analysis of the 1942 flood is in preparation (Karanka, in prep.).

Air Photo No.: BC 100:017
Approx. Scale: 1:20 500
Date: 1938

Air Photo No.: BC 1243:081
Approx. Scale: 1:20 700
Date: 1951

(approx.)

Plate 10 Comparison of Middle Vaseux Creek, 1938 and 1951 Aerial Photography

5. DISCUSSION

Figure 3 indicates that reaches 2.3, 3, 6.3, 7.1, 7.2 and lower 7.3 of Coldstream Creek (as noted by shading) are producing most of the suspended sediment reflected by the readings at station 1 at the mouth. When Figure 3 and Figure 6 are compared it is readily apparent that the reaches which appear to contribute the most sediment are virtually the same as those with the poorest channel stability rating. These poor-rated reaches have been shaded in both figures to note the similarity. In reaches where it appears sediment is being contributed and is not reflected in a poor rating, (upper 2.2 and lower 7.3) individual point scores are in the poorer end of the fair rating.

It can be concluded that the main source of suspended sediment is the valley bottom through which Coldstream Creek flows in those reaches identified in Figures 3 and 6 by shading.

The differences between suspended sediment rating curves for Vaseux and Coldstream Creeks (Figure 11) correspond with differences in U.S.F.S. stability ratings and reflect the differences in stream regime. Coldstream Creek has a 10 to 20 fold greater sediment production at a given flow than Vaseux Creek, due to the greater mobilization of the fine-textured materials in the banks and channel. Thus the differences in channel stability ratings between the two systems are correlated with differences in suspended sediment production.

Coldstream and Vaseux Creeks display the two most contrasting types of river channel behavior likely to be found in the Okanagan Basin. Lower Coldstream Creek has a relatively low energy regime: the upland basins produce relatively low peakflows for a given unit area which are further attenuated by the groundwater regime in the lower valley. The stream gradient is also rather low. However, the banks and bed material are generally fine-textured (sands and small gravels), hence can be eroded or moved by relatively frequent runoff events. The dimensions of the channel are adjusted to the most recent magnitudes of "frequent" peakflows. This type of channel and hydrologic regime is quite sensitive to changes in climate or land use of the upland basin which increase the frequency of higher intensity peakflow events. Such increases may result in long term channel enlargement, and greater rates of channel migration and bank erosion.

Vaseux Creek by contrast has a much higher energy regime: the basin naturally produces relatively high intensity peakflows. The channel gradient is also rather high. But the key factor is that the banks and bed material are very coarse-textured (Plate 11), and can apparently be moved on a large scale only by infrequent events (greater than a 10 year recurrence interval - Karanka, in prep.).

These infrequent events have a long term impact on the floodplain, which can be identified 50 or more years after the event. In between such events, over periods of 25 to 100 years, the stream channel is essentially stable, becoming gradually entrenched in the flood deposit. This type of channel is relatively insensitive to climate and land use changes because the channel and floodplain forming events are caused by extreme meteorological events which are probably not substantially affected by land use practices.

It should be noted that, while the channel itself may remain relatively stable in spite of general climate or land use changes, suspended sediment concentrations may be increased as a result of increased slope mass movement frequency, headwater gully erosion, or land surface disturbance.

Plate 11   Middle Vaseux Creek

6. CONCLUSIONS

Virtually all of the suspended sediment reflected by the levels at the mouths of Coldstream and Vaseux Creeks is, at present, being contributed by the middle reaches of the mainstem creeks themselves.

In Coldstream Creek this material is coming from the areas where the stream banks are actively failing as well as from the stream bed itself. Rip-rapping the banks has helped somewhat but long sections would still need to be protected. Fences, to prevent cattle from gaining access to the creek, are most important in these unstable areas. Reaches with failing banks are 2.1, 2.3, 3, 6.2, 6.3, 7.1, 7.2, and 9 (Map 3). Developments adjacent to the stream should be closely monitored in these reaches as well as in the lowest reaches of Deer, Brewster and Craster Creeks.

Lower Coldstream Creek is very sensitive to changes in the streamflow regime because of its poor channel stability status. Thus any headwater land use activities should be carefully planned to avoid increases in downstream flows, particularly peakflows. Clearcut openings should be designed to maintain the present status of snowpack accumulations and snowmelt periods.

Little can be done to alleviate the problem in Vaseux Creek as most of the material being transported is eroded from the creek bed, a result of deposition there by past major flood events, or is deposited in the creek from valley wall failures which have been occurring infrequently over a long period of time. Roads should be kept away from the valley side slopes throughout the whole of the middle reaches of Vaseux Creek to prevent aggravation of the valley wall failures.

The lower end of Coldstream Creek serves as an important Kokanee spawning area. Close attention should be paid to this area in order that the spawning gravel is not allowed to become covered in fine sediment smothering the developing eggs and thus drastically reducing the fish populations. The Coldstream kokanee resource and the rainbow trout resource in the Vaseux watershed should be recognized as important values in watershed considerations.

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APPENDIX 1

NON-FILTERABLE RESIDUE LAB PROCEDURES USED BY THE STANDARDS AND DATA UNIT OF THE AQUATIC STUDIES BRANCH

Abstract:

One of the driving forces behind the decision of the ASB to analyse its own samples has been the relative high cost of having large numbers of water quality grab samples transported and clinically analysed. The basically uncomplicated lab procedures as shown, are easily learned and provide "ball park" figures for suspended sediment loads.

NOTE: Any mention of brand name products does not constitute any endorsement of same.

Equipment:

Field - 500 mL plastic bottles (clean)
1 mL nalgene pipets (unbreakable)
$CuSO_4$ in solution -(0.45 g/l)

Lab - 1 oven - Thelco model 15 Drying Oven (temperature range to 150°C) Manufactured by Precision Scientific Co.

1 scales - Mettler H-315 electronic balance. Distributed and serviced by Fisher Scientific Co.

1 Vacuum Pump - Doerr Type S, 1/3 HP 115V.

Filter Paper - Reeve Angel Glass Fibre Filter 934 AH grade
4.25 cm - for low suspended solids samples
9.0 cm - for obvious high suspended solids samples

1 Desiccator - c/w desiccant - (indicating type silica gel preferred) and desiccator plate

2 Parabella stainless steel vacuum funnels 1000 mL size

2 Buchner type funnel filters 9.0 cm size for higher suspended solids

2 Filtering flasks - 1000 mL size

4 Graduated cylinders - 500 mL size in 5 mL graduations, approx. 2 m-vacuum hose (cut into 3 approx. 65 cm sections)

1 Y-shaped polyethylelene tube connectors

6 Drying dishes or plates; tweezers and laboratory spatula

Methodology:

Field preparation of sample: Into each 500 mL grab sample is added 1 mL of the $CuSO_4$ solution.

Lab Preparation and Procedures:

1. Pre-wash all glassware and funnels with a good lab glassware soap such as Sparkleen. Rinse all equipment well with distilled water.
2. Wash filter paper under suction use 100 mL of distilled water for 4.25 cm filter; 150 mL for 9.0 cm paper.
3. Dry filter paper for 30 minutes at 105°C.
4. Desiccate for 10 minutes.
5. Zero balance.
6. Weigh and record weights.
7. Return filter paper to funnel.
8. Shake water sample thoroughly - record water sample number and pertinent information.
9. Pour sample through filter under suction.
10. Rinse lightly, with distilled water, the sides of the funnel to ensure that all of the filtrate is rinsed onto the filter paper (The use of 1-2 mL of distilled water is considered negligable considering residual filtrated sample that remains in the flask and the fact that the filtrate is measured to the nearest 5 mL).
11. Measure filtrate volume (to nearest 5 mL); record volume, discard filtrate.
12. Dry filter and residue for 60 minutes at 105°C.
13. Rinse cylinder, funnel and placement screen with distilled water. Particular attention should be given to the neck and filter screen which may pick-up accumulations of loose glass fibre from the filters or residual residue.
14. Desiccate for 10 minutes.
15. Zero balance.
16. Weigh and record filter paper and residue.
17. Calculate and record.

NB In all cases where the filter paper is to be moved or handled, use the tweezers and/or spatula.

Results:

All results are kept in a lab book in tabular form. Results are made available to the Aquatic project co-ordinator for entry onto ASB point cards. The tabular form is as follows:

Water Sample #	Lab Run	Stream Name and Number	Point #	Date of Sample	Weight of F.P. and Residue	Weight of F.P.	Weight of Residue	Volume of Filtrate	Results (mg/L)	Comments	Field Crew Initials
1	2	3	4	5	6	7	8	9	10	11	12

1. Water sample number, entered from field grab sample bottle.
2. Lab run, code or number (e.g. 1, 1A, B) assigned by lab technician running sample to avoid mixing up results.
3. Stream name and number, gazetted name and ASB watershed code.
4. Point #, assigned in field to avoid confusion when 2 or more samples have been taken on the same river.
5. Date of sample, date of field sample.
6. Weight of filter paper and residue, expressed in mg.
7. Weight of filter paper, "washed" filter paper weight prior to run of sample.
8. Weight of residue, item 6 minus item 7 expressed in mg.
9. Volume of filtrate, filtrate measures to nearest 5 mL.
10. Results, nonfilterable residue; item 8 divided by item 9 expressed in mg/L.
11. Comments, any comments relative to experiment or from sample bottle.
12. Field crew initials, results should be made available for further use by field crew.

APPENDIX 2

EXAMPLES OF AQUATIC STUDIES BRANCH'S POINT, FISH AND REACH CARDS AND THE U.S.F.S. CHANNEL STABILITY RATING FORM

STREAM CHANNEL STABILITY

System No. ____________ System Name ____________

Reach No. ______ Point No. ____ Distance Upstream (KM) ______.____

NTS Map ________ Date ______ (YR MO DAY) Agency ____ Surveyors ____/____/____

Section	Key #	EXCELLENT		GOOD		FAIR		POOR		Key #
Upper Banks	1	Bank slope gradient <30%.	(2)	Bank slope gradient 30-40%.	(4)	Bank slope gradient 40-60%.	(6)	Bank slope gradient 60%+.	(8)	1
	2	No evidence of past or any potential for future mass wasting into channel.	(3)	Infrequent and/or very small. Mostly healed over. Low future potential.	(6)	Moderate frequency & size, with some raw spots eroded by water during high flows.	(9)	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	(12)	2
	3	Essentially absent from immediate channel area.	(2)	Present but mostly small twigs and limbs.	(4)	Present, volume and size are both increasing.	(6)	Moderate to heavy amounts, predominantly larger sizes.	(8)	3
	4	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	(3)	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	(6)	50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	(9)	<50% density plus fewer species & less vigor indicate poor, discontinuous, and shallow root mass.	(12)	4
Lower Banks	5	Ample for present plus some increases. Peak flows contained. W/D ratio <7.	(1)	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.	(2)	Barely contains present peaks. Occassional overbank floods. W/D ratio 15 to 25.	(3)	Inadequate. Overbank flows common. W/D ratio > 25.	(4)	5
	6	65%+ with large, angular boulders 12"+ numerous.	(2)	40 to 65%, mostly small boulders to cobbles 6-12".	(4)	20 to 40%, with most in the 3-6" diameter class.	(6)	< 20% rock fragments of gravel sizes, 1-3" or less.	(8)	6
	7	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	(2)	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	(4)	Moderately frequent, moderately unstable obstructions & deflectors move with high water causing bank cutting and filling of pools.	(6)	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	(8)	7
	8	Little or none evident. Infrequent raw banks less than 6" high generally.	(4)	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	(8)	Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.	(12)	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	(16)	8
	9	Little or no enlargement of channel or point bars.	(4)	Some new increase in bar formation, mostly from coarse gravels.	(8)	Moderate deposition of new gravel & coarse sand on old and some new bars.	(12)	Extensive deposits of predominantly fine particles. Accelerated bar development.	(16)	9
Bottom	10	Sharp edges and corners, plane surfaces roughened.	(1)	Rounded corners and edges, surfaces smooth and flat.	(2)	Corners & edges well rounded in two dimensions.	(3)	Well rounded in all dimensions, surfaces smooth.	(4)	10
	11	Surfaces dull, darkened, or stained, Gen. not "bright".	(1)	Mostly dull, but may have up to 35% bright surfaces.	(2)	Mixture, 50-50% dull and bright, ± 15% ie. 35-65%.	(3)	Predominantely bright, 65%+, exposed or scoured surfaces.	(4)	11
	12	Assorted sizes tightly packed and/or overlapping.	(2)	Moderately packed with some overlapping.	(4)	Mostly a loose assortment with no apparent overlap.	(6)	No packing evident. Loose assortment, easily moved.	(8)	12
	13	No change in sizes evident. Stable materials 80-100%.	(4)	Distribution shift slight. Stable materials 50-80%.	(8)	Moderate change in sizes. Stable materials 20-50%.	(12)	Marked distribution change. Stable materials 0-20%.	(16)	13
	14	Less than 5% of the bottom affected by scouring and deposition.	(6)	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	(12)	30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools.	(18)	More than 50% of the bottom in a state of flux or change nearly yearlong.	(24)	14
	15	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.	(1)	Common. Algal forms in low velocity & pool areas. Moss here too and swifter waters.	(2)	Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	(3)	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	(4)	15
		EXCELLENT COLUMN TOTAL →		GOOD COLUMN TOTAL →		FAIR COLUMN TOTAL →		POOR COLUMN TOTAL →		

Add values in each column and record in spaces below. Add column scores.

E.___ + G.___ + F.___ + P.___ = _________ Total Reach Score.

Modified from R1-Form 2500-5A Rev. 1-75

REACH

Reach No.

System Name
No.
Survey Date yr mo day | Compiling Agency | Field Obs.
Access | Weather
Field Photo Init. | Photo Nos.
Photo Interp. Init. | NTS Sheets
Air Photo. | Yr. | Scale 1:

C	ACTIVE VALLEY WALL PROC.	Loc	
	Avalanche		Nil L M H
	Debris flow/torrent		Nil L M H
	Slump		Nil L M H
	Slide		Nil L M H
	Gully		Nil L M H
	Periglacial		Nil L M H

	TOTAL POOLS (%)	
	Bedrock control (%)	
	BED MATERIAL (%)	
	Fines: clay silt sand	
	Gravel (2-64 mm)	
	Large (64 mm+)	
	Bedrock	

	BAR PRESENCE	
	Side / Point	Nil L M H
	Mid Channel	Nil L M H
	Transverse	Nil L M H
	Junction	Nil L M H
	Diamond / Braiding	Nil L M H
	Lee	Nil L M H
	Dunes	Nil L M H
	Islands	Nil L M H

	LATERAL CHANNEL MOVEMENT		
	Apparently Stable	Yes No	
	Bar Veg. Progressions	Nil L M H	
	Cut-Offs / Ox Bows	Nil L M H	
	Meander Scars	Nil L M H	
	Avulsions	Yes No	#
	Terraces	Yes No	#
	Constrictions	Yes No	#
	Unstable Banks (%)		

	CHANNEL COVER: Level	% Area	Distr.
	Crown		
	Overhang		

	RIPARIAN VEG.: Storey	Sp	Distr.
	Coniferous		
	Deciduous		
	Understorey		
	Ground		

	CHAN. WIDTH (m)	
	Stage	Dry L M H Fld
	Flow Char.	P S R B T
	Valley:Chan	0-2 2-5 5-10 10+ N/A
	Confinement	Ent Conf Fr Oc Un N/A
	Pattern	St Sin Ir Im Rm Tm
	Vert. Stab.	Deg ? Agr N/A
	Side Chan	Nil L M H

FISH SUMMARY				
C	Species	Use	Ref	Map

STREAM FEATURE			
F	Type Code	Ht (m)	Length (m)

	Channel Debris	Nil L M H		Stable Debris (%)	
	Floodplain Debris	Nil L M H		Turbidity	Nil L M H

(Fish)

(Width) (Vall: Chan) (Slope) (Bed Material)

R 5 80

POINT SAMPLE

Point No. of

System Name
No.
Site Location
Reach No.
Date yr mo day | Time | Access
NTS Map | Agency | Crew
Field Photo Init. | Photo Nos.
Weather | Fish Sample No.
Air Temp. °C | Water Sample No.

C	L BANK R		
	Proc.	Form	Proc.
		Genetic Mat.	
		Texture %	
F		Org.	F
		Clay	
		.004 Silt	
		.062 Sand	
G		2 S. Gr.	G
		16 L. Gr.	
L		64 Cob.	L
		256 Boul.	
		Bedr.	

Distr.	Sp	VEG.	Sp	Distr.
		Conif.		
		Decid.		
		Under		
		Ground		

CHANNEL COVER				
Distr.	% Area	Level	% Area	Distr.
		Crown		
		Over.		

BIOTA	Sp	Abun
Aquatic Veg.		
Invertebrates		
Algae		

C	BED MATERIAL	
	Ice Scouring	Y ? N
	Imbric	Nil L M H
	Compac	Nil L M H
	Log	Nil L M H
	D_{90} (cm)	

C	Texture (%)	
	Org.	F
	Clay	
	Silt	
	Sand	
	S. Gr.	G
	L. Gr.	
	Cob.	L
	Boul.	
	Bedr.	

HYDRAULICS		Meth
Valley W (m)		
Chan W (m)		
Wet W (m)		
Slope (%)		
Max Depth (cm)		
Avg. Depth (cm)		
Wet X-sec area		
Velocity (m/sec)		
Flow (m^3/sec)		
Bank Height (m)		
Fld. Signs (Ht./Type)	/	
Bank Ice Scour	Y ? N	
Stage	Dry L M H Fld	
Flow Char.	P S R B T	
Valley:Chan	0-2 2-5 5-10 10+ N/A	
Side Chan	Nil L M H	

DEBRIS		
	Channel	Nil L M H
	Stable %	
	Floodplain	Nil L M H

C	WATER QUAL.	Water temp. °C	Turbidity m cm	TDS	D. O.	pH

FISH SPECIES PRESENT:

L STREAM CROSS-SECTION R

(looking downstream)

PS 5 80

FISH SAMPLE

Fish Sample No.
Card of

Total No	Species	Method	Size (cm) Min	Max	Fish Use	Sampling Length (m)	Time (s,m,h)		# Sets	Diff.

System Name
No.
Site Location
Point No.
Sample Date yr mo day Time Reach No.
NTS Map Access Weather
Field Photo Init. Photo Nos.
Agency Crew

WATER QUALITY	C	Turbidity	C	Horiz. Visibility
		m cm		m

C / CX	COMMENTS

FS 3 80

INDIVIDUAL FISH DATA

Sample Type & No(s)	
Age	
Weight (gm)	
Fork Length (cm)	
Maturity	
Sex	
Sampling Method	
Species	
Fish No.	

APPENDIX 3

SUMMARY OF THE UNITED STATES FOREST SERVICE/ENVIRONMENTAL PROTECTION AGENCY METHODOLOGY FOR EVALUATING TOTAL POTENTIAL SEDIMENT YIELD FROM NON POINT SOURCES

(Source USEPA, 1980)

Step	Procedure
1.	Subdrainage and stream reach characterization.
2.	Determination of pre-and post-silvicultural activity hydrographs on flow duration curves.
3.	Establish sediment rating curves and determine stream channel stability.
4.	Calculate pre-silvicultural activity potential suspended sediment discharge.
5.	Calculate post-silvicultural activity potential suspended sediment discharge.
6.	Convert suspended sediment limits in mg/L to tons/yr.
7.	Establish bedload rating curve.
8.	Calculate pre-silvicultural activity potential bedload discharge.
9.	Calculate total pre-silvicultural activity potential sediment discharge (bedload and suspended load).
10.	Calculate post-silvicultural activity potential bedload discharge.
11.	Obtain induced sediment from soil mass movement.
12.	Obtain total coarse size sediment from soil mass movement.
13.	Determine fine size volume from soil mass movement.
14.	Obtain total introduced suspended sediment (tons/yr) from surface erosion.
15.	Compare post-silvicultural activity (total potential suspended sediment (in tons) to selected limits.
16.	Post-silvicultural activity total potential sediment discharge from all sources.
17.	Increase in total potential sediment discharge from silvicultural activities.
18.	Collect channel geometry data for stream.
19.	Evaluate post-silvicultural activity channel impacts.
20.	Establish bedload sediment transport rate-stream power relationship for stream reach.
21.	Qualitative determinations of channel charge potential based on introduced sediment from soil mass movement and channel impacts.

Data requirements for the step procedures are summarized in the following table:

TABLE 3

SUMMARY OF INPUT REQUIRED TO USE THE TOTAL SEDIMENT DISCHARGE PROCEDURE

Data Requirements	Procedural Steps																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Aerial photography and stream reach selection	x																				
Pre-silvicultural activity hydrographs		x		x		x		x													
Post-silvicultural activity hydrographs		x			x					x											
Measured suspended sediment (mg/L)			x	x	x	x															
Measured stream discharge (m^3/s)			x	x	x	x	x	x		x											
Measured bedload sediment (tonnes/day)							x	x		x											
Allowable maximum sediment concentration (from water quality objective) (mg/L)						x															
Fine particle size from soil mass movement source (tonnes)											x		x								
Coarse particle size from soil mass movement source (tonnes)											x	x									
Surface erosion (tonnes)														x							
Bankful stream width (m)																					x
Bankful surface water slope (m/m)																					x
Bankful depth (m)																					x
Bankful discharge (m^3/s)																					x
Measured width from measured third order stream discharge (m)																		x		x	
Measured depth from measured third order stream discharge (m)																		x		x	
Measured surface water slope from measured third order stream discharge (m/m)																		x		x	
Predicted change in width with post-silvicultural activity																			x		
Predicted change in surface water slope with post-silvicultural activity																			x		

Source: USEPA 1980 (converted to SI units)

APPENDIX 4

SUSPENDED SEDIMENT IN THE STREAM CHANNEL ENVIRONMENT

1) Methods of Entrance

- vegetative cover is of primary importance in reducing surface erosion: it reduces the possibility of overland flow by depleting soil moisture through evapotranspiration, dissipates raindrop energy, improves soil structure, and offers a continuous root mat to help bind soil together.
- in undisturbed forest conditions water generally moves (1) overland in established drainage channels and (2) subsurface via seepage routes; little suspended sediment is normally generated from undisturbed forests.
- increases in total water yield generally occur after a watershed has been logged: this is mainly due to (1) reduced evapotranspiration and (2) increased overland flow due to the compaction of the soil during road-building and logging and (3) the redistribution of snow by forest harvesting openings. Streamflow peaks may also be increased due to interception of subsurface flow by road cuts and ditches.
- size of peak flows may or may not be increased following logging; significant increases in peak flows are generally not expected unless roughly 12% or more of total area is compacted by roads, tractors etc., or over 25% of the basin is harvested. An increase can be expected in the average peak flows in the fall but not so much in winter, and the large peaks are generally not affected by logging although summer low flows do increase.
- in low gradient streams bank failure caused by lateral stream erosion probably delivers most of the finer material.
- in steep terrain most sediment enters via avalanches, soil mass movements and increased bank instability from encroachment of slumps and slides into the channel.
- grazing tends to increase run-off and erosion by reducing plant cover density and by compacting or detaching surface soils.

2) Effects on Stream

- reduces potability and increases water treatment costs
- aesthetically objectionable/unattractive
- reduces recreation potential
- harms fishery resource
  - suspended sediment input to lakes reduces light penetration thereby lowering productivity and fish growth.
  - invertebrate biomass is closely related to suspended sediment loading probably because the deposited sediment clogs the gravel interstices reducing the living space for the invertebrates.
  - rubble areas in riffles, runs, and pools provide summer and especially over-winter habitat for trout and salmon - these areas can be easily filled in by sediment.
  - high sediment loadings in May to July may cause substantial subgravel deposition even though surface gravels are swept clean. This condition causes low egg survival especially if oxygen levels fall below 4 mg/L in the gravel.

3) Land Management Activities: Suggestions

- attempt to log at low or normal periods of flow; avoid periods of high soil water content.
- reduce harvesting rate or use extra protective measures in high elevation areas subject to sudden snowmelt.
- avoid logging close to lake outlet streams.
- as there exists an inverse relationship between the rate of erosion and the percentage of roots in stream banks, buffer strips are exceedingly important in most areas.
- in disturbed areas - use: contoured skid-trail design, water-bars and cross-ditches on skid and secondary roads, and revegetate landings, skid-trails, and cut and fill slopes.

4) Summary: Suspended Sediment

The effects of increased suspended sediment loading on stream habitat may not be as readily observable as those caused by excessive debris but are just as important and are almost exclusively adverse.