FLOODING IN PEMBERTON VALLEY

October 7-9, 1984

Prepared By

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March 1986

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1986

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INTRODUCTION

Persistent heavy rains occurring over the three-day period October 7-9, 1984 caused severe flooding in the Pemberton area of British Columbia, about 150 kilometres north of Vancouver (Figure 1). As a result, floods and debris torrents occurred in the Meager Creek area in the headwaters of the Lillooet River on October 8 and widespread flooding of the Lillooet River valley occurred the following day. Heavy rains continued through October 9 and, although flood levels were dropping, the flood situation remained critical. By the afternoon of October 10 the situation had eased considerably and forecasts indicated no further heavy rains. The flood waters had receded by October 11. Extensive flood damages had occurred as a result of this 3-day rainstorm.

The most serious damage occurred in the Pemberton Meadows area which includes the village of Pemberton, upstream of the B.C. Railway crossing of the valley. In these meadows the whole of the valley floor was inundated, an area of about one by four kilometres. Downstream for a distance of about twelve kilometres, approximately 60 per cent of the valley bottom was flooded, including the Mount Currie Indian Reserve. At the lower end of the valley, record water levels of Lillooet Lake caused additional flooding. However, no fatalities or serious injuries were reported although many livestock were lost.

FLOOD DAMAGES

An estimated 175 houses were flooded in the Pemberton area with damages between three and five million dollars. In addition, dykes were breached and overtopped, sections of bank protection were destroyed, Indian Reserve lands were flooded and extensive damage to agriculture lands, buildings and livestock was sustained. Numerous washouts occurred to roads in the Pemberton area. Two logging bridges at Meager Creek Hot Springs collapsed in the creek. The B.C. Railway was washed out, a train was derailed and the railway was out of operation until October 12.

B.C. Ministry of Environment estimated that the expected cost to the governments would be between six and seven million dollars including compensation to individuals and businesses and repair of roads, bridges and dykes. The expected total cost to the B.C. Government would be about four million dollars with the remainder to be paid by the federal government under a cost-sharing formula.

METEOROLOGICAL CONDITIONS

During the period from October 7 to the morning of October 9, 1984, a fairly broad frontal system moved onto the B.C. coast. The frontal system stalled over the south coast of B.C. giving measured rainfall amounts of from 50 to 200 mm during the two-day period ending on the evening of October 8, 1984.(1) Severe flooding resulted in the Lillooet River valley near Pemberton and along the upper Squamish River. A further 25 to 50 mm of rain on October 9 compounded flooding problems.

Rainfall records are not available for the Lillooet River valley upstream from Pemberton. AES reported that the rain gauge at Pemberton Airport was under water and that records were not available for the period October 7 to 9. However, gauge readings of B.C. Forest Service at Pemberton were available as shown in the following table along with gauge readings of nearby AES sites.

	24 Hour Precipitation Amounts Ending at:	
	7 p.m. (except as noted) Sunday, Oct. 7, 1984	7 p.m. (except as noted) Monday, Oct. 8, 1984
Pemberton BCFS	68.4 mm (7 a.m. Oct. 8)	23.6 mm (7 a.m. Oct 9.)
Alta Lake	46.5 mm	51.7 mm
Squamish Airport	101.2 mm	69.9 mm
Vancouver Airport	30.6 mm (10 p.m.)	19.0 mm (10 p.m.)

An extreme value analysis of the one-day storm rainfall indicates that the storm had a return period of five years or less in the Pemberton-Squamish area. However, if the three-day rainfall is examined, the return period of the storm becomes more significant. The 119.8 mm at Pemberton and the 127.9 mm recorded at Alta Lake for October 7-9, 1984 results in the three-day storm having a return period of 20 years for these two sites. It was observed that the slow-moving nature of the frontal system led to persistent rainfall over the storm area.

HISTORICAL FLOODS

Prior to 1984, the most severe flood in the Pemberton Valley occurred on October 19, 1940 when it appeared that the flood had inundated the valley from mountain wall to mountain wall.(2) However, the material damage was minor due to small investment in the flood plain. Between 1946 and 1953, P.F.R.A. completed some 15 miles of dykes, 6 miles of river cutoffs and 11 miles of ditches. As a result, the river was changed from a meandering channel to a straight one with a greatly increased slope. The steepness of the river channel was increased even more because of the lowering of Lillooet Lake by eight feet as a result of extensive dredging of the narrows downstream of the lake under a flood relief program.

At the same time, new agricultural land was brought into use and the amount of logging in the valley tributaries to Lillooet River was rapidly intensifying. These activities caused large amounts of sediment to be deposited into the Lillooet Lake each year. After years of such sediment deposition Lillooet River now has one of the fastest growing deltas in North America. Increased development on the flood plain during the 1950s to 1970s resulted in greater financial losses when floods occurred.

The known historical floods since records began in 1914 are given in the following table:

Year	Date	Maximum Daily Discharge (m^3/s)
1940	Oct. 19	900
1957	Sept. 6	716
1968	June 27	790
1975	Nov. 5	782
1980	Dec. 27	790
1981	Nov. 1	832
1984	Oct. 8	1100 (estimated)

HYDROLOGY OF 1984 FLOOD

During the flood of October 7-9, 1984 the WSC recorder station for Lillooet River near Pemberton (08MG005) was operational but the water levels were affected by a dyke breaching which caused part of the flow to bypass the gauging station. The amount of overflow was estimated by B.C. Water Management Branch to be 184 cubic metres per second (m^3/s). After the adjustment of this bypassed overbank flow, the resulting estimated flows for October 8 at the gauging station are:

Instantaneous Peak Flow = 1310 m^3/s
Daily Peak Flow = 1110 m^3/s

WSC records show that October 8 water levels and flows at this station were the highest since records began in 1914. The previous maximum daily flow was 900 m^3/s recorded on October 19, 1940.

Following the record October 1984 flood, B.C. Ministry of Environment carried out a comprehensive study and a study report was presented in July 1985.(3) The study analyzed floods for 20, 50 and 200-year return periods, taking into consideration the record 1984 flood, and examined the various levels of flood protection for the predominantly rural Pemberton Valley. The result of flood frequency analysis presented in Appendix B of the study report showed that the flood with a 200-year return period would have a magnitude of 992 m^3/s. In comparison to 1110 m^3/s of October 8, 1984 flood, it appears that the 1984 event has a return period greater than 200 years. However, the frequency study used a previously estimated daily maximum flow of 920 m^3/s. It is expected that the 200-year flood will be greater if a revised daily maximum flow of 1110 m^3s is included in the frequency analysis. This in turn could result in the October 8, 1984 flood being somewhat less than the 200-year flood.

Water Planning and Management Branch, Pacific and Yukon Region, carried out a separate flood frequency analysis for Lillooet River near Pemberton using the computer program FDRPFFA(4) developed by IWD headquarters. The analysis(5) used the maximum daily flows recorded since 1914 up to and including the flood of October 8, 1984. These maximum daily flows were caused mainly by rainstorms that occurred during the periods September to February. Separation of rainstorm events from snowmelt events was necessary because each of them represents different distributions statistically. By analyzing the rainstorm events, the program FDRPFFA produced flood frequency curves for the following distributions:

(1) Gumbel I Distribution
(2) Log-Normal Distribution
(3) Three-Parameter Log-Normal Distribution
(4) Log Pearson Type III Distributions by the Method of Maximum Likelihood and the Method of Moments.

Among these distributions, the flood frequency curve produced by the Three-Parameter Log-Normal is recommended for the estimation of extreme flood. The choice was based on how closely the skewness and kurtosis approximate theoretical values and on how closely the fitted curves follow the most extreme flood on the plotted graphs. The result of computer runs show that the skewness and kurtosis of log (x-a) for the Three-Parameter Log-Normal Distribution are -0.03 and 3.43 respectively. These values compare favourably with the theoretical values of 0.0 and 3.0.

Figure 2 shows the flood frequency curve produced by the program FDRPFFA using the Three-Parameter Log-Normal Distribution. Using the flood frequency curve, it is estimated that the return period for the October 1984 flood of 1110 m^3/s would be about 120 years. Alternatively, the flood with a 200-year return period would have a magnitude of 1190 m^3/s.

CONCLUSION

The heavy rainfall in the Squamish-Pemberton area was a result of the persistence of the most active portion of a frontal system over the area. According to AES report, the frontal system itself was neither abnormally large or active. The rather unusual orientation of the frontal system in an almost north-south direction for most of the storm period may explain the extreme water levels on the Lillooet River. The short-term rainfall rates were not exceptional in the storm. The slow-moving nature of the frontal system led to persistent rainfall over the storm area and a three-day storm return period of close to 20 years.

The flooding in Pemberton Valley was a direct result of this rainstorm as well as snowmelt triggered by the rainfall. The flood frequency analysis carried out by Water Planning and Management Branch using the Three-Parameter Log-Normal Distribution indicates that the return period of the October 1984 flood is about 120 years. Alternatively, the flood with a 200-year return period would have a magnitude of 1190 m^3/s.

REFERENCES

(1) John Thomas and Stan Stobbe, "Pacific Region Technical Notes", Pacific Weather Centre, AES, Environment Canada, November 29, 1984.

(2) B.C. Motorist, Volume 13, November-December 1974. (available at Northwest History Section, Vancouver Public Library)

(3) H.H. Nesbitt-Porter, "Pemberton Valley Flood Protection", Water Management Branch, B.C. Ministry of Environment, July 1985. W.P. & M. Library No. F309-HF.1

(4) R. Condie, G.A. Nix and L.G. Boon, "Flood Damage Reduction Program Flood Frequency Analysis" (FDRPFFA), Inland Waters Directorate, Environment Canada, Ottawa, 1976.

(5) Mike Payne, "Lilloet River Flood Frequency Analysis", Inland Waters Directorate, Pacific and Yukon Region, Environment Canada. W.P. & M. Library No. F309-HF.W.1

Figure 1 - SQUAMISH-PEMBERTON AREA

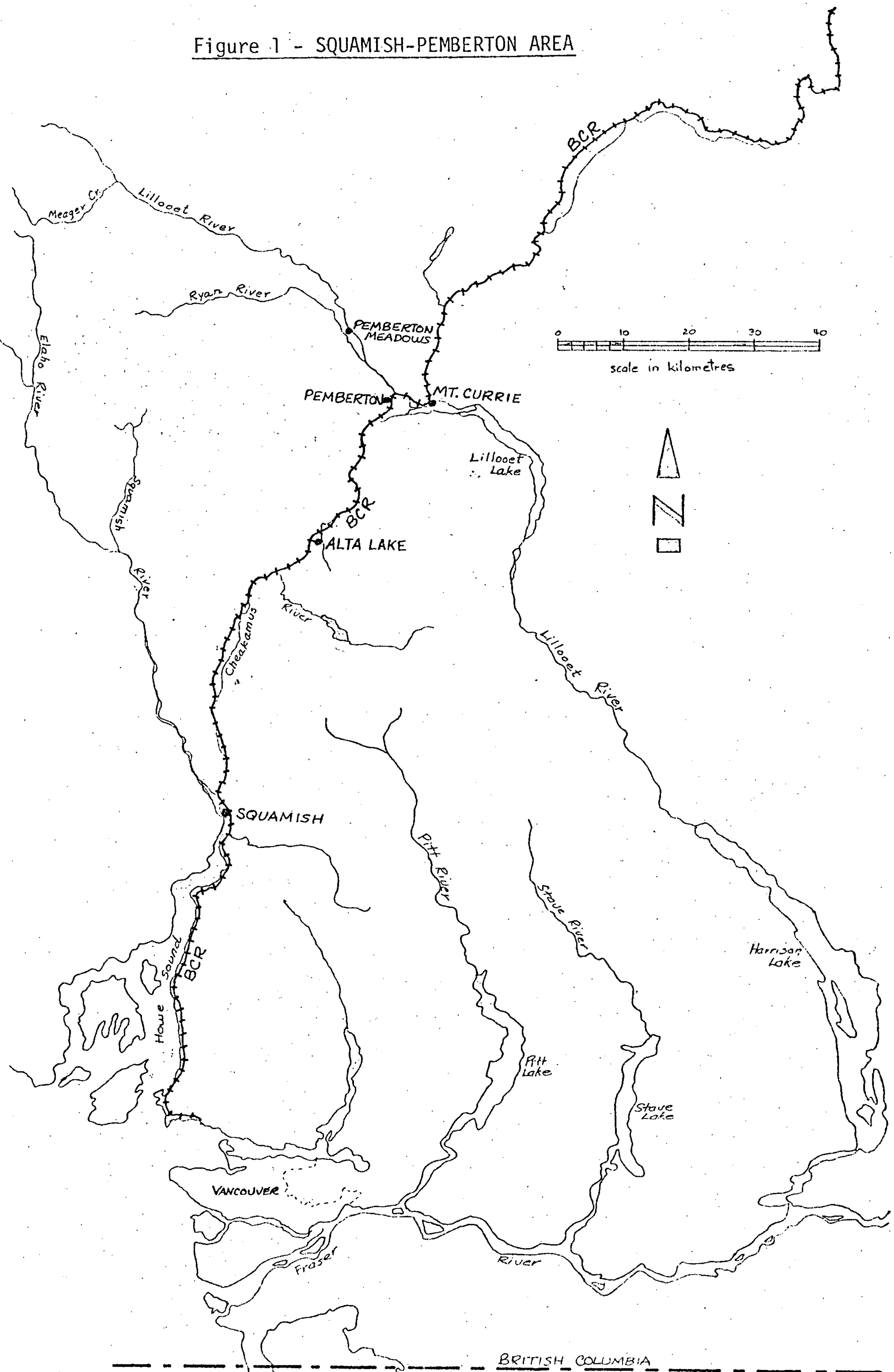

Figure 2

08MG005 LILLOOET RIVER, TO 1984, DAILY DISCHARGE, RAINFALL

THREE PARAMETER LOG-NORMAL DISTRIBUTION

PARAMETERS ESTIMATED BY MAXIMUM LIKELIHOOD