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FRASER RIVER
UPSTREAM STORAGE STUDY

PROBABLE MAXIMUM FLOODS FOR THE FRASER RIVER AT HOPE AND MISSION

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Inland Waters Directorate
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TASK #12

Probable Maximum Floods for the Fraser River at Hope and Mission

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ABSTRACT

Four different simplistic methods are used to derive values of the peak discharge for a probable maximum flood on the Fraser River at the communities of Hope and Mission. The results of each method are compared and one value of the peak discharge and peak river stage is selected, for use in the Fraser River Upstream Storage Study, to represent the probable maximum flood in these areas. Also provided are similar estimates for the communities of Kamloops, Prince George and Quesnel.

RESUME

Quatre différentes méthodes, de grande simplicité, sont utilisées pour connaître les valeurs des débits de pointe d'une crue maximale probable sur le fleuve Fraser aux communautés de Hope et de Mission. Les résultats de chaque méthode sont comparés et une valeur de débit de pointe et d'une phase de pointe d'une rivière est choisie, aux fins d'utilisation dans l'étude de la retenue des eaux d'amont du fleuve Fraser pour représenter une crue probable dans ces régions. Il y a également des prévisions analogues pour les communautés de Kamloops, Prince George et Quesnel.

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INTRODUCTION

Task #12 of the Fraser River Upstream Storage Study requires that probable maximum floods be estimated for the Fraser River at Hope and at Mission. These maximum probable floods will be used as input to Tasks 14 and 15, which require an estimation of the consequences of flows in excess of dyke capacity.

A probable maximum flood (p.m.f.) is considered to be the largest flood that could conceivably occur at a given location on a river. Probable maximum floods are ordinarily computed on the basis that all factors contributing to floods could reach their critical magnitudes simultaneously. These critical magnitudes are derived by accepted hydrometeorological techniques that use available hydrological and meteorological data to establish limiting values. Since the likelihood of occurrence of such a flood is extremely remote and may be considered as zero, the p.m.f. values presented in this report indicate upper limits of floods that could ever occur and are not given as a basis for the design of any measures for mitigating the consequences of flooding.

It was considered that a detailed analysis using a rational method, generating floods from extreme meteorological events, was not warranted for this Task. A hydrograph of the p.m.f. was not required because only the peak flow was needed to define the flood profile on the river. Thus, this Task was limited to the derivation of the peak value of the p.m.f. using simplified methods.

A search was made for previous work that incorporated simplified or empirical methods which might be applicable to the Fraser basin and for usable data. Studies that had been carried out in the nearby Columbia basin and p.m.f.'s developed under Task #4 for the proposed System E reservoir sites were found useful in estimating p.m.f.'s for Hope and Mission. Values of the p.m.f. peaks were computed by each of the methods considered applicable, and the recommended values chosen by consideration of these several estimates.

The assumption was made that the entire natural basin above the points of interest would contribute to the p.m.f. peak. There are now two storage projects in the Fraser basin, the Nechako Reservoir and Diversion which regulates about 5,500 sq. mi. and the Bridge River Reservoirs which regulate about 1,350 sq. mi. If these reservoirs were able to completely regulate their inflows during the p.m.f. flood, the reduction to the p.m.f. peaks at Hope and Mission would be only about 5%. There is no assurance, however, that these reservoirs would not be full and spilling at or near the natural flow rate at the time of the peak. It was therefore considered that the reduction to the p.m.f. peak available from these reservoirs would be negligible, and all calculations were made on the basis of natural flow conditions.

The recommended values for the probable maximum flood peaks are:

Fraser River at Mission	1,400,000 cfs.
Fraser River at Hope	1,250,000 cfs.

COMPARISON WITH COLUMBIA RIVER

The first estimates of probable maximum flood peaks for the Fraser River at Hope and Mission were made using a method developed by the U.S. Corps of Engineers for preliminary estimates at sites on the Columbia River.[1] Because the Columbia and Fraser are adjacent basins having similar topography and climate, it was considered that this method would yield useful estimates for the Fraser River sites.

The Corps had developed p.m.f.'s for a number of sites on the Columbia using a rational method for snowmelt floods. In order to make preliminary estimates for sites where a detailed calculation was not made, two sets of curves were derived from the floods that were computed, one relating surface runoff for the maximum flood season to mean annual precipitation and drainage area and the second relating p.m.f. peak to surface runoff for the maximum flood season and to drainage areas. These curves were used to derive the Fraser estimates.

The mean annual precipitation for the Fraser above Hope is about 32 inches. Drainage areas above Hope and Mission are approximately 84,000 sq. mi. and 87,000 sq. mi. respectively. Entering the curves with these values yields a p.m.f. peak discharge of 13.5 cfs./sq. mi., or 1,130,000 cfs. at Hope and 1,200,000 cfs. at Mission.

As a test of the current validity of these curves, a comparison was made with two recently derived p.m.f.'s. Probable maximum flood peak values were computed for the Mica and Arrow damsites, two relatively recent developments on the Columbia River, using the curves discussed above. These values were then compared with the values that were adopted in the design of those two projects. The curves predicted values which were about 20% lower than the design values for those sites. Since the design values were derived from a detailed analysis using a rational method for snowmelt floods,[6] using more data than was used in the development of the curves in 1948, it is believed that values derived from the curves should be adjusted upward. It was therefore decided to increase by the 20% factor the values predicted by the curves for Hope and Mission. The resulting values are 1,400,000 cfs. at Hope and 1,500,000 cfs. at Mission.

USGS EXTREME FLOOD FORMULA

The 1958 Fraser River Board Preliminary Report[2] suggested estimating a probable maximum flood peak using extreme flood formulae derived by the United States Geological Survey for the Columbia River basin. These are modified Myer formulae.

For Pacific Slope basins in Washington and the Upper Columbia basin the recommended formula is $Q = 4600\ A_d^{0.5}$. This formula yields values of 1,330,000 cfs. and 1,400,000 cfs. for Hope and Mission respectively.

RATIO WITH MAXIMUM OBSERVED PEAK

A quick estimate for a probable maximum flood peak is sometimes made simply by multiplying the maximum recorded peak by a factor of two.

The maximum flood of recent record at Mission occurred in 1948 and reached elevation 24.98 feet at the Mission gauge, or 590,000 cfs. However the 1894 flood reached elevation 26 feet estimated at 675,000 cfs. Twice 675,000 is 1,350,000 cfs.

At Hope the 1894 flood peak was estimated to be about 600,000 cfs. Twice 600,000 is 1,200,000 cfs.

RATIO WITH PROJECT PROBABLE MAXIMUM FLOODS

The final method that was used to estimate probable maximum floods for Hope and Mission was by comparison with p.m.f.'s developed for the proposed System E reservoir sites. The drainage basins above these sites contribute in total about 32% of the average annual runoff at Hope. P.m.f. hydrographs had been developed for these sites using a rational method, as described in the report for Task #4 of the Fraser River Upstream Storage Study.[4]

The estimate was made as follows. The peak flows at the sites were summed for the large flood years 1948, 1967, and 1972, and for the p.m.f. Then the percentages of the sums to the corresponding unregulated peak flows at Hope and at Mission were computed for each of the selected historic years and the average of these percentages was determined. Finally the Hope and Mission p.m.f. estimates were computed by dividing the sum of the p.m.f. peaks at the sites by the average percentage of the sum of the historic site peaks to the Hope and Mission peaks respectively.

The computation is shown below:

	Peak Flows (1000 cfs.)			
	1948	1967	1972	p.m.f.
Site				
Lower McGregor	51	42	68	182
Grand Canyon	74	70	97	296
Cariboo Falls	22	17	18	66
Hemp Creek	52	42	55	136
Sum	199	171	238	680
Hope				
Peak	536	417	498	
%	37	41	48	

Average % = 42%

P.m.f. estimate = $\frac{680{,}000 \text{ cfs.}}{.42}$ = 1,620,000 cfs.

	Peak Flows (1000 cfs.)		
	1948	1967	1972
Mission			
Peak	590	512	546
%	34	33	44

Average % = 37%

P.m.f. estimate = $\frac{680{,}000 \text{ cfs.}}{.37}$ = 1,840,000 cfs.

It should be noted that the values computed by this method represent floods that are even less likely to occur than the site p.m.f.'s. This is because it is virtually impossible that critical conditions causing the peak flows at the sites would occur simultaneously over the whole basin. Therefore each of the values computed here should be taken as beyond reality and should be used only as a check on other computed values. Any valid estimates must be smaller than these values in order to be consistent with the studies carried out under Task #4.

RESULTS

The probable maximum flood peak estimates obtained from the various methods are summarized in the following table:

Method	P.M.F. Peak Flow (cfs.)	
	Hope	Mission
Comparison with Columbia River	1,400,000	1,500,000
USGS Extreme Flood Formula	1,330,000	1,400,000
Ratio with Maximum Observed Peak	1,200,000	1,350,000
Ratio with Project Probable Maximum Floods	1,620,000	1,840,000

The first two methods are based on results of Columbia River Studies. Due to the proximity of the Fraser basin and the Columbia basin and their similar topography and climate, these methods and the resulting p.m.f. values are considered to be valid for the Fraser River.

The values computed as twice the maximum observed peak are only rule of thumb values. However, since the 1894 flood is known with a reasonable degree of certainty to have been the largest flood in over one hundred years,[3] it is believed that these rule of thumb values give a strong confirmation of the values estimated by the first two methods.

As noted previously, the last method produces values that are expected to be too high, and these values should only be used as a check on the other computed values. The other three methods produce values that fall within a fairly narrow range and values within that range were chosen as best representing the probable maximum flood peak values. It is recommended that the Fraser River Joint Advisory Board adopt as probable maximum floods the values of 1,250,000 cfs. for the Fraser River at Hope and 1,400,000 cfs. for the Fraser River at Mission.

In addition to the requirements of Task #12, similar computations were made to develop probable maximum flood estimates for the Thompson River at Kamloops, the Fraser River at Prince George and the Fraser River at Quesnel. The resulting p.m.f. estimates, recommended for use at those locations, are listed below:

Location	Probable Maximum Floods	
	peak flow (cfs)	peak elevation (feet msl)
Thompson River at Kamloops	350,000	1160
Fraser River at Prince George	550,000	1890
Fraser River at Quesnel	600,000	1565
Fraser River at Hope	1,250,000	145
Fraser Riverat Mission	1,400,000	40

REFERENCES

1) U.S. Army Corps of Engineers, North Pacific Division, Review Report on Columbia River and Tributaries, Appendix M, Co-ordinated Water Use Development, October, 1948.

2) Fraser River Board, Preliminary Report on Flood Control and Hydro-Electric Power in the Fraser River Basin, Victoria, June 1958.

3) Fraser River Board, Final Report of the Fraser River Board on Flood Control and Hydro-Electric Power in the Fraser River Basin, Victoria, September 1963.

4) Department of the Environment, Water Planning & Management Branch, Fraser River Upstream Storage Study, Task #4, "Spillway Design Floods for System E Reservoirs" (under preparation)

5) Linsley Kohler & Paulhus, Hydrology for Engineers, McGraw-Hill, 1958.

6) Caseco Consultants Limited, Columbia River Development Progress Report, Vol. IX, May 1962.