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ANALYSIS OF NORTH SASKATCHEWAN RIVER FLOODS AT EDMONTON

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Analysis of
North Saskatchewan River Floods
at Edmonton

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ABSTRACT

Extreme floods have occurred historically (notably in 1899, 1900, 1915, 1944, 1952, 1954, and 1972) in the North Saskatchewan River through Edmonton and have been the cause of considerable damage. In order to identify the flood risk posed by the river to low valley lands in the vicinity of the City, River Engineering Branch of the Technical Services Division, Alberta Department of Environment, has delineated those areas throughout the valley bottom which would be covered by water in the event of floods of various frequencies.

Two dams, the Brazeau and Bighorn, were constructed in the headwaters of the North Saskatchewan River in 1962 and 1972 respectively. The effects of these two structures on flood peaks for the North Saskatchewan River through Edmonton are abstruse although, they have in general been considered as having some potential for peak flow reduction.

In view of the above, and as part of the program for updating floodplain studies carried out for various basins throughout the Province, River Engineering Branch requested (memo, February 14, 1979) that Hydrology Branch review and update the hydrology of the North Saskatchewan River at Edmonton. The results are used as input in the delineation and updating of the floodplain for the North Saskatchewan River through Edmonton.

This report investigates extreme flood events which have been experienced in the past and makes conclusions as to the cause. It investigates the Brazeau

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and Bighorn Dams and their effects on peak flows through the City for selected flood events. Lastly the report investigates the available data and establishes the frequency of various flood magnitudes.

1.0 INTRODUCTION

The North Saskatchewan River originates within the eastern slopes of the Rocky Mountains and passes through three topographic and hydrologic zones - mountains, foothills and parkland - as it flows north-easterly to Edmonton. Its watershed is approximately 28,000 square kilometers (10,800 square miles).

Mean annual precipitation over the area increases from east to west in the basin and varies from a low of approximately 430 mm (17 inches) per year at Edmonton to greater than 1270 mm (50 inches) per year in the extreme western reaches of the basin.

In general, flows through Edmonton are low in the winter, begin to increase in April due to melting snow from the relatively flat parkland region west of Edmonton and continue to rise during May when rainfall in the parkland area is complemented by snowmelt from the largest of the three topographic regions, the foothills. Water levels within the North Saskatchewan River usually reach their maximum levels in June or July when melt waters from the mountains, the region producing the largest portion of the flow at Edmonton, enter the system.

2.0 REVIEW OF HISTORICAL FLOODS IN EDMONTON

2.1 General

River stages through Edmonton have been measured by a staff gauge since 1911 and by automatic recorder from 1950 to the present date. The date of the annual maximum mean daily flow at Edmonton has varied from as early as April 12 in 1943 to as late as September 4 in 1926 and occurs on the average around June 23. The three largest floods to occur during the period of record were in 1915, 1944 and 1952. However, historical information prior to the installation of the measuring gauge indicates that large floods occurred in each of the years 1899 and 1900. A large flood was also recorded in 1972. However, the peak flow from this event was reduced due to the dampening effect of the Brazeau Reservoir, which was constructed in 1962, and the Bighorn Reservoir, which was being constructed in 1972.

2.2 1899 and 1900 Floods

These two flood peaks were approximated after 1911 when the staff gauge was installed in Edmonton.

The 1899 flood peak occurred in August and reached a gauge height of 12.61 meters (41.37 feet)(1) which is approximately 5100 cubic meters per second (180,000 cfs). During the spring of 1899, the Low Level Bridge was under construction, and as a direct result of the flood, the piers were raised 8 feet to cope with dangerous flood levels. (2) In Whyte's (1) opinion the cause of the flood of 1899 was attributable to: "the exceptionally heavy rains of August".

The flood of 1900 is not as well documented, however, Whyte(1) states that, "considerable damage was done all along the river, and that the river reached a gauge height of 11.55 meters (37.9 feet) on the gauge at Edmonton". The discharge for this gauge height was later estimated at 4250 cms (150,000 cfs).

2.3 1915 Flood

The 1915 flood peak is the largest recorded flood on the North Saskatchewan River at Edmonton. The damage from this flood was about $750,000 (1915 dollars) in Edmonton alone and approximately eight hundred families were left homeless.[2]

On June 28, 1915 the water rose to a gauge height of 13.73 meters (45.04 feet). The discharge at this gauge height has been estimated 5800 cms (205,000 cfs). According to Whyte [1], "the direct cause of this flood was no doubt the heavy rainfall between June 24 and 27".

2.4 1972 Flood

The 1972 flood through Edmonton had an instantaneous peak of 3290 cms or 0.12 cms/km² (116,000 cfs or 11 cfs/sq.mi.). The flood producing mechanism was very similar to that which produced the very large floods in 1964 which produced 1.18 cms/sq.km. (108 cfs/sq.mi.) on the Waterton River and 1.49 cms/sq.km. (136 cfs/sq.mi.) on the Belly River. [4] These floods were caused by heavy rainstorms that moved into Alberta from the south or southwest, moved north-west along the foothills, and then quickly shifted towards the west. Upon reaching the frontal range of mountains the weather fronts were forced upwards causing extremely heavy rainfall.

3.0 CAUSE OF EXTREME FLOODS

Throughout the history of extreme floods on the North Saskatchewan River, it appears from Whyte (1) that the large floods are caused primarily by rainfall rather than snowmelt. The flood of 1899 which was estimated at 5099 cms or .19 cms/sq.km (180,000 cfs or 17.1 cfs/sq.mi.) at Edmonton, was, in his opinion caused by excessive rainfall while the snowmelt was a very minor contributor. Similarly, with the floods of 1915, 1944, 1952, 1954, and 1972, the heavy rainfall in the foothills region was the primary cause of the excessive flows. Snowmelt runoff, for all of the aforementioned years, is considered as having created the saturated ground conditions which caused the high runoff coefficient.

The storms which produce the heavy rainfall, associated with the occurrance of major floods in the North Saskatchewan River, are the result of low pressure systems (called "cold lows") which enter Alberta from the west or south-west. As the "cold lows" move to the east of the Rockies they induce an anti-clockwise flow of warm moist air around their centre. In Alberta the upslope conditions created by the foothills and easterly mountain ranges force the warm, moist air to rise and thereby generate large amounts of intense rain. In addition, weather patterns giving rise to these storms are difficult to predict and thus offer little warning for flood forecasting purposes.

4.0 BANKFULL DISCHARGE

The report by Water Survey of Canada, "1915 Flood in Alberta" (1), states that the North Saskatchewan River, "began to flood its banks at a gauge height of 35.0 feet at Edmonton and thus there was a depth of 10 feet of water at some points in the flats."

The Research Council of Alberta (3) has compiled hydrologic and geomorphic data along the North Saskatchewan River through Edmonton which shows that the bankfull height through Edmonton in about 11.65 meters (38.2 feet) above mean bed level. At the recording station at the Low Level Bridge, the zero gauge height corresponds to Alberta Research Council's mean bed level. It may, therefore, be assumed that the developed flats (i.e. Hawrelak Park, Victoria Park, Rossdale, Walterdale, etc.) will begin to flood when the river stage reaches about 11.65 meters above the mean bed level.

Although the geodetic equivalent of mean bed level varies with the reach of the river being considered due to the slope of the channel; at the recording station at the Low Level Bridge, mean bed level corresponds to 609.69 meters (1999.41 feet) Geodetic Survey of Canada datum or 622.69 meters (2042.41 feet) city datum.

5.0 EFFECTS OF BRAZEAU AND BIGHORN DAMS

5.1 Brazeau Dam

The Brazeau Dam is located approximately 160 kilometers (100 miles) south west of Edmonton on a plain which extends slightly into the frontal range of mountains. Most of its 5540 square kilometer (2,138 square miles) catchment area lies below the 1830 meter (6,000 foot) elevation.

The main storage dam for the Brazeau Reservoir was constructed and completed in the fall of 1962. This stage of the development created 437.7×10^6 cubic meters (355,000 acre-feet) of live storage with a reservoir full supply elevation of 964.63 meters. From 1962 to 1969, conduits, which had initially been designed to act as temporary diversion conduits during the construction of the dam, were used to pass surplus waters. The success of the conduits in performing this function led to their use as a temporary spillway.[17] During this period the reservoir was operated with fairly conservative filling rules.

The construction of a permanent spillway was commenced in the fall of 1967 and was completed in October of 1969 raising the full supply level (FSL) to elevation 966.46 meters and the dam crest elevation to 968.60 meters. The existing structure has a spillway capacity of 1924 cms (68,000 cfs) at FSL plus the capability of passing 736 cms (26,000 cfs) through two turbines and two venturis for a combined total discharge of 2660 cms (94,000 cfs).

It has been shown in previous sections that large floods on the North Saskatchewan River are caused by large rainstorms which usually occur from early June to the middle of August. Within the period of early June to mid August, the Brazeau Reservoir has during some years - June 22 onwards for 1972, periodically after July 2 in 1974 and from June 1 in 1978 - been operated at/or above elevation 964.63 meters (3164 feet). Since the full supply level for the reservoir is at elevation 966.46 meters, at times there remains 1.83 meters or approximately 71.5 X $10^6 m^3$ of live storage available for flood control purposes.

In order to assess the effect of the Brazeau Dam on flood peak reduction, the flood hydrographs of 1899, 1915 and 1972 were routed through the reservoir. The flood hydrographs of 1899 and 1915 were derived by Montreal Engineering[7] during design of the dam. The 1972 flood hydrograph was derived using flow measurements for the Brazeau River below Big Bend Plant (Station #05DD005) and measurements of daily water levels for the Brazeau Reservoir.

Flood routing was performed by assuming the reservoir to have a starting elevation of 964.46 meters (3164 feet). Each of the 1899, 1915 and 1972 flood hydrographs, using 12 hour time increments, was routed through the reservoir, by assuming the following three alternative drawdown procedures as operation rules during major flood events. The time of travel from the reservoir to Edmonton was assumed as 1 day.

Alternative I

Release at a rate of 141 cms (5000 cfs) through the powerhouse for the first day of the flood, thereafter use spilling facilities to their maximum.

Alternative II

Release at a rate of 141 cms (5000 cfs) through the powerhouse for reservoir elevations less than 964.94 meters (3165 feet).

Release at a turbine and venturi capacity rate of 736 cms (26,000 cfs) for reservoir levels of 964.94 to 965.55 meters (3165 to 3167 feet).

Release at a spillway capacity rate of 1924 cms (68,000 cfs) for reservoir levels of 965.55 to 966.16 meters (3167 to 3169 feet).

Release at a reservoir discharge capacity rate of 2660 cms (94,000 cfs) for reservoir levels greater than 966.16 meters (3169 feet).

<u>Alternative III</u>

Release rate of 142 cms (5,000 cfs) through the powerhouse for reservoir levels less than 964.94 meters (3165 feet).

Release at a turbine and venturi capacity of 1924 cms (26,000 cfs) for reservoir levels of 964.94 to 965.24 meters (3165 to 3166).

Release at a spillway capacity rate of 1924 cms (68,000 cfs) for reservoir levels of 965.24 to 965.85 meters (3166 to 3168).

Release at a reservoir discharge capacity of 2660 cms (94,000 cfs) for reservoir levels greater than 965.85 (3168 feet).

The effects on each of the three flood hydrographs for each of the operational alternatives are listed in Table 1.

TABLE 1

EFFECTS OF THREE ASSUMED OPERATIONAL RULES FOR THE

BRAZEAU RESERVOIR ON SELECTED FLOOD HYDROGRAPHS

Effects on:	FLOOD HYDROGRAPH		
Alternative I	1899	1915	1972
Peak flow immediately downstream of the reservoir	decreased peak flow from 3088 to 2663 cms (109,000 to 94,000 cfs)	decreased peak flow from 2974 to 2663 cms (105,000 to 94,000 cfs)	increased peak flow from 1105 to 2663 cms (39,000 to 94,000 cfs)
Peak flows at Edmonton	flood hydrographs for Edmonton are not available, therefore, the amount of peak reduction cannot be determined	reduced peak flow from 5258 to 5227 cms (185,600 to 184,500 cfs)	increased peak flow from recorded peak of 2974 cms (105,000 cfs) and natural peak of 3258 cms to 5156 cms (115,000 to 182,000 cfs)
Alternative II			
Peak flows immediately d/s of the reservoir	reduced peak flow from 3088 to 2663 cms (109,000 to 94,000 cfs)	reduced peak flow from 2974 to 2663 cms (105,000 to 94,000 cfs) peak delayed by 1 day	increased peak flow from 1105 cms (39,000 cfs) to 1289 cms (45,500 cfs)
Peak flows at Edmonton	flood hydrographs for Edmonton are not available, therefore, the amount of peak flow reduction cannot be determined	reduced peak flow from 2074 to 2663 cms (105,000 to 94,000 cfs) peak delayed by 1 day	reduced peak flow to 2833 cms (100,000 cfs) as compared to natural of 3258 cms (115,000 cfs) and recorded 2974 cms (105,000 cfs)
Alternative III			
Peak flows immediately d/s of the reservoir	reduced peak flow from 3088 to 2663 cms (109,000 to 94,000 cfs)	reduced peak flow from 2974 to 2663 cms (105,000 to 94,000 cfs)	increased peak flow from 1105 to 1289 cms (39,000 to 45,500 cfs)
Peak flows at Edmonton	flood hydrographs for Edmonton are not available, therefore, the amount of peak flow reduction cannot be determined	reduced peak flow from 5258 to 5227 cms (185,600 to 184,500 cfs)	increased peak flow from recorded peak of 2975 cms (105,000 cfs) and natural peak of 3258 cms (115,000 cfs) to 4390 cms (155,000 cfs)

On the basis of the analysis in Table 1, it may be concluded that, for major flood events, the degree of peak flow reduction at Edmonton due to the Brazeau Reservoir is, at best, negligible for the assumed operational procedures.

5.2 Bighorn Dam

The Bighorn Dam has a storage capacity of 143.6 X 10^7 cubic meters (1,165,000 acre-feet) and a drainage basin of 3700 square kilometers (1430 square miles). The drainage basin is situated west of the frontal range of mountains with 60% of its catchment area above elevation 1830 meters (6,000 feet). Due to the large capacity of the reservoir, the spillway capacity was set of 1415 cms (50,000 cfs) and the two turbines are capable of passing a total of 141 cms (5,000 cfs).

In general, the Bighorn Dam should have only a small effect on flood peaks in Edmonton as most of the runoff above the dam is generated from snowmelt, not rainfall. However, since the Bighorn Reservoir is filling during the period when floods are occuring, the dam must have some effect on reducing peak flows on the North Saskatchewan River. The reservoir behind the Bighorn Dam is drawn to a very low level by the beginning of June so that there should be sufficient capacity to store most floods. Thus, during a flood, the maximum discharge released is about 141 cms (5,000 cfs) through the turbines.

In order to assess the degree of flood reduction which the Bighorn Dam would have had on the North Saskatchewan River at Edmonton in the past, recorded flows for the North Saskatchewan River below Tershiner Creek (1954 - 56, 1959 - 68) were routed through the reservoir assuming a maximum release rate from the reservoir of 141 cms (5,000 cfs) and a two day travel period from the reservoir to Edmonton. The analysis shows that, for the previously stated period of record, the Bighorn Dam would have reduced peak flows at

Edmonton by a minimum of 33.1 cms (1170 cfs), a maximum of 286.6 cms (9480 cfs) and an average of 181.9 cms (6420 cfs).

It is of interest to note that had the reservoir been operational during the time period analyzed, the minimum reduction in peak flows ~33 cms (1170 cfs) which would have been realized on the North Saskatchewan River at Edmonton, would have taken place in 1954, and that this is also the year having the highest recorded flow at Edmonton during the 1954 to 1956 and 1959 to 1968 period analyzed.

A further analysis was carried out in order to assess the potential flood reducing capabilities of the Bighorn Dam. Within this investigation the flow frequencies were determined for the North Saskatcatchewan River at the Bighorn Dam Site. It was then assumed that the annual maximum peak flows from this site coincide with annual maximum peak flows at Edmonton, so that a reduction in peak flow at Bighorn would have a similar peak reduction at Edmonton. It was further assumed that the reservoir will limit the outflow rate at 142 cms (5,000 cfs). As may be seen from Table II, under these idealized conditions the 1 in 100 year natural flood at the Bighorn site, equal to 637 cms, would be reduced to 142 cms, a reduction of 496 cms (17,500 cfs).

TABLE II

MAXIMUM POTENTIAL PEAK REDUCTION AT EDMONTON

DUE TO OPERATION OF BIGHORN DAM

Assumptions:

a) Annual maximum peak flows for the two locations coincide

b) Maximum allowable outflow rate from reservoir limited to 142 cms

Return Period (years)	Natural Peak Flow (cms)	Flow after dam (cms)	Reduction in Peak (cms)
1:100	637	142	496
1:75	623	142	482
1:50	609	142	467

Based on the above analysis it may be concluded that the maximum flood reduction which could be experienced at Edmonton due to the operation of the Bighorn Dam is approximately 496 cms (17,500 cfs), however, since the two peaks rarely coincide, due to the spatial distribution of flood producing rainfall and due to travel time of the flood wave, the magnitude of reduction in peak flows in more likely to be in the order of 57 to 283 cms (2000 to 10,000 cfs).

5.3 Summary of Effects of the Brazeau and Bighorn Dams

The primary purposes for the construction of these two dams were power generation and winter flow augmentation, and the reservoirs are operated accordingly. The control of floods is not paramount but is an important concern in the careful release of large quantities of water.

It was demonstrated in earlier sections that significant portions of the flow at Edmonton are generated within the catchment area of the Brazeau Dam, however, during recent years the reservoir has been operated at fairly high levels during the flooding season thus leaving relatively little live storage for flood reduction. The Bighorn Dam, as has been demonstrated, has large storage capabilities, however, the contribution of its drainage area to peak flows at Edmonton is generally not significant.

In summary, it may be concluded that, while the Brazeau and Bighorn Dams might under favourable circumstances provide some flood control, the relative degree of peak reduction tends to decrease with the magnitude of the event and, therefore, no definte flood reduction should be attributed to the reservoirs. Furthermore, analyses of flood flows at Edmonton should recognize that the reservoirs under the present situation, of having no definite operation rules for flood events, can not be relied upon to reduce the peak flow of major events.

6.0 STATISTICAL INTERPRETATION OF AVAILABLE DATA

Table III provides a summary of all recorded annual maximum flows for the North Saskatchewan River at Edmonton. Included within the table are: annual maximum mean daily flows, annual maximum instantaneous flows and where available, their related time of occurrence, and historical flows.

The Brazeau Dam was put into operation in 1963. Consequently flood peaks recorded, and listed in Table II, since 1963 represent regulated flows. A spillway was constructed on the Brazeau Dam in 1969, therefore, reservoir filling curves and operations since 1969 are different than for the 1963 to 1968 period.

In view of the above, and with due consideration of the conclusion arrived at in previous sections regarding the limited flood reduction potential of the Brazeau and Bighorn Dams, it was felt that peak flows for the North Saskatchewan River at Edmonton should be reconstructed so as to negate any effects the Brazeau Dam may have had. Adjustments for the Bighorn Dam were not carried out since, as was demonstrated earlier,its effect on peak flows through Edmonton is relatively minor. The reconstructed, natural annual maximum mean daily flows are listed in Table IV.

Recorded annual maximum mean daily flows for 1911 to 1963 and reconstructed flows for 1964 to 1978 were lumped together and treated in all subsequent analysis as a homogeneous sample of 68 random independent events. The above data was then analyzed according to the following distribution types:

1. Gumbel
2. Log-Gumbel
3. Normal
4. Log-Normal
5. Gamma III
6. Log-Gamma III
7. Pearson III
8. Log-Pearson III

Statistical parameters for the first six assumed population distributions were estimated by the method of maximum likelihood, while the parameters for the last two distribution types were estimated by the method of moments.

TABLE III

NORTH SASKATCHEWAN RIVER AT EDMONTON - STATION NO. 05DF001

RECORDED MAXIMUM ANNUAL FLOWS IN CMS

YEAR	MAXIMUM INSTANTANEOUS FLOW	MAXIMUM MEAN DAILY FLOW
1911	---	---
1912	---	2099 CMS ON JUL 10
1913	---	924 CMS ON AUG 15
1914	---	1748 CMS ON JUN 9
1915	5807 CMS ON JUN 28	4646 CMS ON JUN 29
1916	1745 CMS ON JUN 22	1666 CMS ON JUN 22
1917	---	1858 CMS ON MAY 18
1918	---	1000 CMS ON JUN 16
1919	---	564 CMS ON JUN 24
1920	---	1620 CMS ON MAY 10
1921	776 CMS ON MAY 23	705 CMS ON MAY 23
1922	810 CMS AT 1900 MST ON AUG 18	731 CMS ON AUG 18
1923	2821 CMS AT 0900 MST ON JUN 25	2382 CMS ON JUN 25
1924	782 CMS ON JUL 5	779 CMS ON JUL 5
1925	2181 CMS AT 1150 MST ON AUG 18	2147 CMS ON AUG 18
1926	---	1663 CMS ON SEP 4
1927	1283 CMS AT 1800 MST ON JUN 28	1144 CMS ON JUN 29
1928	---	1734 CMS ON JUL 27
1929	---	1079 CMS ON JUN 5
1930	677 CMS AT 0600 MST ON JUN 13	671 CMS ON JUL 17
1931	---	1110 CMS ON JUL 2
1932	---	1870 CMS ON JUN 4
1933	---	975 CMS ON JUN 19
1934	---	796 CMS ON JUN 1
1935	---	1312 CMS ON JUL 11
1936	---	1144 CMS ON APR 19
1937	---	892 CMS ON JUL 17
1938	---	1133 CMS ON JUL 4
1939	---	856 CMS ON JUN 28
1940	---	1011 CMS ON APR 18
1941	---	756 CMS ON JUN 28
1942	---	1198 CMS ON JUL 14
1943	---	1246 CMS ON APR 12
1944	3569 CMS AT 1600 MST ON JUN 16	3456 CMS ON JUN 16
1945	---	688 CMS ON JUN 1
1946	---	1266 CMS ON JUN 24
1947	---	810 CMS ON JUN 13
1948	---	1853 CMS ON MAY 25
1949	---	926 CMS ON JUL 22

TABLE III (cont'd)

YEAR	MAXIMUM INSTANTANEOUS FLOW	MAXIMUM MEAN DAILY FLOW
1950	1521 CMS AT 0500 MST ON JUN 17	1425 CMS ON JUN 17
1951	1161 CMS AT 1300 MST ON MAY 3	1105 CMS ON MAY 3
1952	3739 CMS AT 1100 MST ON JUN 25	3541 CMS ON JUN 25
1953	1297 CMS AT 1000 MST ON JUN 5	1272 CMS ON JUN 5
1954	3343 CMS AT 2145 MST ON JUN 8	3031 CMS ON JUN 8
1955	907 CMS AT 0100 MST ON JUN 15	850 CMS ON JUN 15
1956	754 CMS AT 1600 MST ON JUN 7	722 CMS ON JUN 7
1957	663 CMS AT 0700 MST ON MAY 22	618 CMS ON JUN 11
1958	1476 CMS AT 1800 MST ON JUN 30	1414 CMS ON JUL 1
1959	1465 CMS AT 2200 MST ON JUN 28	1306 CMS ON JUN 29
1960	1099 CMS AT 1300 MST ON JUL 3	1042 CMS ON JUL 3
1961	853 CMS AT 2100 MST ON JUL 31	771 CMS ON JUL 31
1962	807 CMS AT 0800 MST ON JUL 14	765 CMS ON AUG 6
1963	1130 CMS AT 2359 MST ON JUL 17	1051 CMS ON JUL 18
1964	1407 CMS AT 0100 MST ON JUN 21	1348 CMS ON JUN 21
1965	2700 CMS AT 2000 MST ON JUN 29	2595 CMS ON JUN 29
1966	1751 CMS AT 1200 MST ON JUL 6	1629 CMS ON JUL 6
1967	1048 CMS AT 0900 MST ON JUN 19	1000 CMS ON JUN 19
1968	660 CMS AT 0800 MST ON JUN 13	598 CMS ON AUG 9
1969	1847 CMS AT 2149 MST ON JUL 7	1737 CMS ON JUL 7
1970	1615 CMS AT 1424 MST ON JUN 18	1521 CMS ON JUN 18
1971	---	1181 CMS ON JUN 11
1972	3201 CMS AT 2000 MST ON JUN 27	2975 CMS ON JUN 27
1973	---	589 CMS ON JUN 26
1974	1125 CMS AT 0140 MST ON APR 24	1062 CMS ON APR 20
1975	708 CMS AT 1900 MST ON MAY 2	419 CMS ON MAY 7
1976	487 CMS AT 2230 MST ON AUG 19	431 CMS ON AUG 19
1977	980 CMS AT 1750 MST ON MAY 30	921 CMS ON MAY 31
1978	---	946 CMS ON JUL 13

MAXIMA OF FLOW FOR THE PERIOD OF RECORD

MAXIMUM INSTANTANEOUS FLOW IS 5807 CMS ON JUNE 28, 1915
MAXIMUM DAILY FLOW IS 4646 CMS ON JUNE 29, 1915

HISTORICAL FLOWS

1899	5099 CMS
1900	4249 CMS

NOTE: CMS MEANS CUBIC METERS PER SECOND

Data Source - Water Survey of Canada - hydrometric station #05DF001

TABLE IV

NORTH SASKATCHEWAN RIVER AT EDMONTON - STATION NO. 05DF001

MAXIMUM ANNUAL FLOWS IN CMS

YEAR	RECONSTRUCT MEAN DAILY MAXIMUM FLOW	RECORDED MAXIMUM MEAN DAILY FLOW
1911		---
1912		2099 CMS ON JUL 10
1913		924 CMS ON AUG 15
1914		1748 CMS ON JUN 9
1915		4646 CMS ON JUN 29
1916		1666 CMS ON JUN 22
1917		1858 CMS ON MAY 18
1918		1000 CMS ON JUN 16
1919		564 CMS ON JUN 24
1920		1620 CMS ON MAY 10
1921		705 CMS ON MAY 23
1922		731 CMS ON AUG 18
1923		2382 CMS ON JUN 25
1924		779 CMS ON JUL 5
1925		2147 CMS ON AUG 18
1926		1663 CMS ON SEP 4
1927		1144 CMS ON JUN 29
1928		1734 CMS ON JUL 27
1929		1079 CMS ON JUN 5
1930		671 CMS ON JUL 17
1931		1110 CMS ON JUL 2
1932		1870 CMS ON JUN 4
1933		975 CMS ON JUN 19
1934		796 CMS ON JUN 1
1935		1312 CMS ON JUL 11
1936		1144 CMS ON APR 19
1937		892 CMS ON JUL 17
1938		1133 CMS ON JUL 4
1939		856 CMS ON JUN 28
1940		1011 CMS ON APR 18
1941		756 CMS ON JUN 28
1942		1198 CMS ON JUL 14
1943		1246 CMS ON APR 12
1944		3456 CMS ON JUN 16
1945		688 CMS ON JUN 1
1946		1266 CMS ON JUN 24
1947		810 CMS ON JUN 13
1948		1853 CMS ON MAY 25
1949		926 CMS ON JUL 22

TABLE IV (cont'd)

YEAR	RECONSTRUCT MEAN DAILY MAXIMUM FLOW	RECORDED MAXIMUM MEAN DAILY FLOW
1950		1425 CMS ON JUN 17
1951		1105 CMS ON MAY 3
1952		3541 CMS ON JUN 25
1953		1272 CMS ON JUN 5
1954		3031 CMS ON JUN 8
1955		850 CMS ON JUN 15
1956		722 CMS ON JUN 7
1957		618 CMS ON JUN 11
1958		1414 CMS ON JUL 1
1959		1306 CMS ON JUN 29
1960		1042 CMS ON JUL 3
1961		771 CMS ON JUL 31
1962		765 CMS ON AUG 6
1963		1051 CMS ON JUL 18
1964	1334	1348 CMS ON JUN 21
1965	2584	2595 CMS ON JUN 29
1966	2136	1629 CMS ON JUL 6
1967	1102	1000 CMS ON JUN 19
1968	748	598 CMS ON AUG 9
1969	2136	1737 CMS ON JUL 7
1970	1929	1521 CMS ON JUN 18
1971	1516	1181 CMS ON JUN 11
1972	3269	2975 CMS ON JUN 27
1973	799	589 CMS ON JUN 26
1974	1110	1062 CMS ON APR 20
1975	436	419 CMS ON MAY 7
1976	459	431 CMS ON AUG 19
1977	1006	921 CMS ON MAY 31
1978	1113	946 CMS ON JUL 13

Points within the data set were arranged in decreasing order and their Hazen plotting positions were determined and then plotted on normal, log-normal and Gumbel-probability paper as were the analytically determined discharge probabilities of each of the eight distribution types. A visual inspection of these plots indicated the Pearson III, Log-Pearson III and the Gamma III most accurately approximated the Hazen plots of the observed data as well as giving approximately equivalent flood magnitudes throughout the frequency range of interest. Based on the above investigation, the Pearson III distribution was selected as the frequency distribution most representative of the sample population.

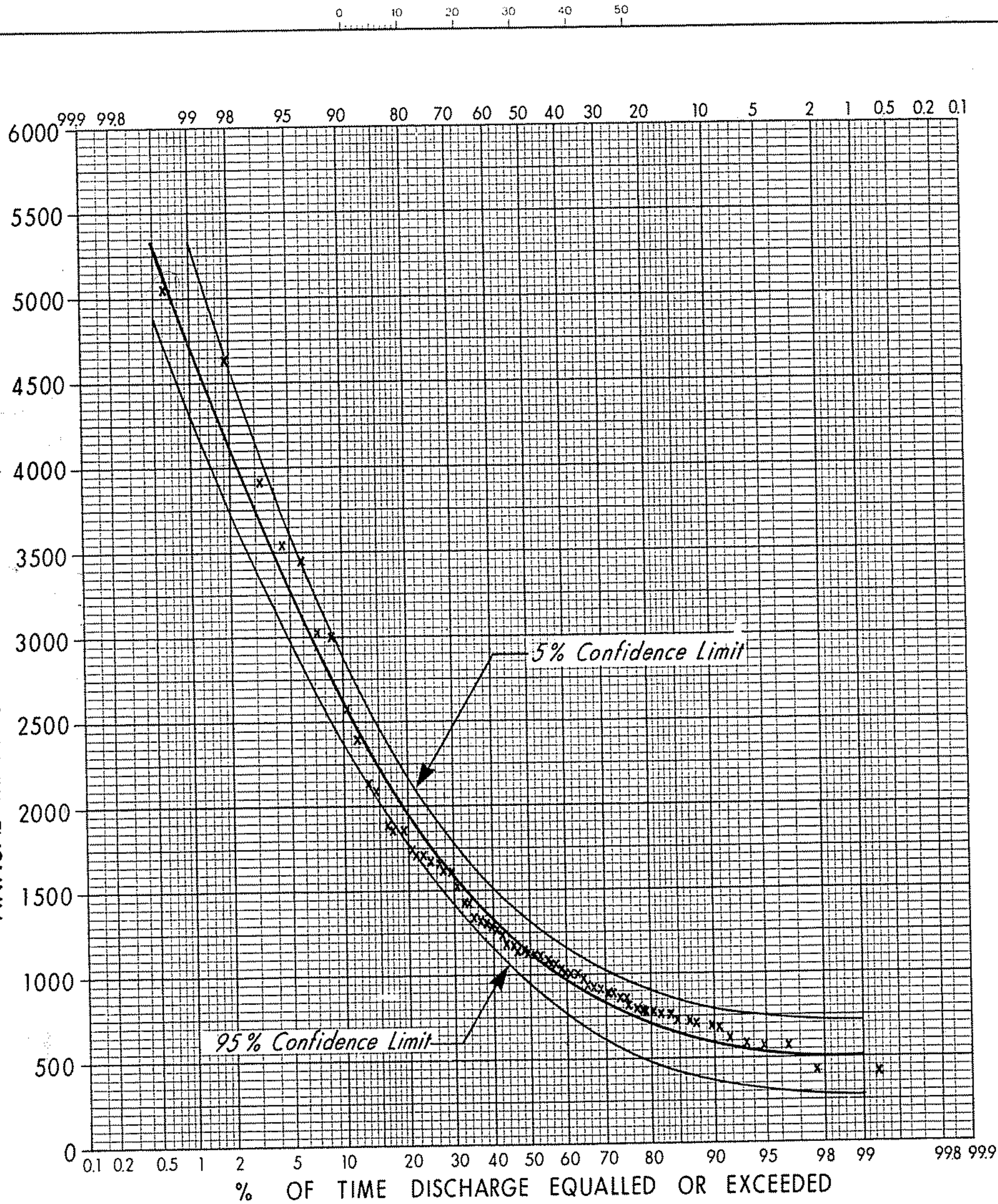
Flood magnitudes obtained by means of the Pearson III distribution were then historically adjusted [12] so as to include the floods of 1899 and 1900 -since these values represent peak flow they were adjusted by the average ratio of peak to mean daily flows-and the 90% confidence interval for the resultant distribution was determined. The final results of the above analysis are summarized in Table V and are presented graphically on Figure 1.

TABLE V

FLOOD FREQUENCIES FOR NORTH SASKATCHEWAN RIVER AT EDMONTON

Recurrence Interval	Mean Daily Peak	Confidence Limits 5% Limit (cms)	Confidence Limits 95% Limit (cms)
1 in 50	4100	4590	3730
1 in 75	4550	5080	4110
1 in 100	4750	5320	4300

Measurements of the annual maximum instantaneous flows are available for only 36 of the 67 years of record. A comparison of the annual maximum mean daily flows for the 36 years for which simultaneous measurements of instantaneous



Historical Flow (Adjusted to Mean Daily) 1899 - 1900
Period of Record 1911 - 1963
Reconstructed Record 1964 - 1978

Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	NORTH SASKATCHEWAN RIVER at EDMONTON PEARSON III FREQUENCY DISTRIBUTION ANNUAL MAXIMUM DAILY FLOWS	
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		DATE	FIGURE No. 1

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peaks are available, to the 67 years of records, utilized in the frequency analysis of mean daily flows, indicate the shorter period to have a higher population mean and standard deviation than the long record. Secondly, the standard error of estimate of the magnitude of an event for a given probability is proportioned to $6/\sqrt{2N}$. In view of the above, it was felt that if the frequency analyses of instantaneous peaks was based solely on the 36 years for which instantaneous peak flow data are available rather than on the entire period of record, a considerable reduction in the precision of the estimate would be introduced. To offset the above effect the following procedure was utilized in the determination of the frequency of instantaneous peaks:

a) A frequency analyses was carried out, using the three parameter Pearson distribution, for both the annual maximum mean daily flows and instantaneous peaks for the 36 years for which simultaneous measurements of both parameters were available.

b) On the basis of "a" the peak to mean ratio was determined for various probability levels.

c) The peak to mean ratios determined in "b" were applied to corresponding probability levels of the long record frequency distribution of mean daily flows to obtain the frequency distribution of instantaneous peaks.

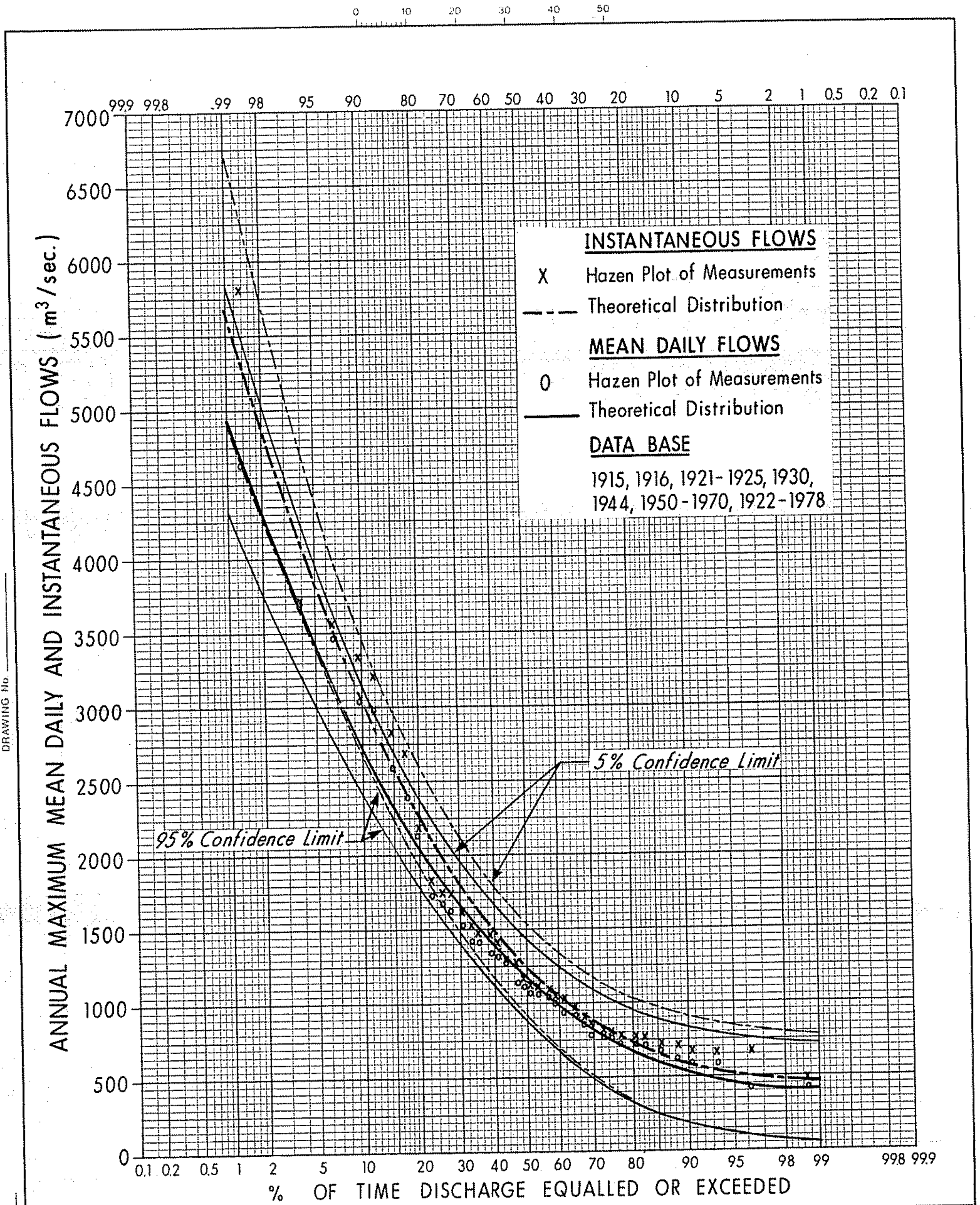
The results of step "a" are shown in Figure 2. The results of step "c" are shown in Figure 3 and summarized in Table VI.

TABLE VI

FLOOD FREQUENCIES FOR NORTH SASKATCHEWAN RIVER

AT EDMONTON

Recurrence Interval	Instantaneous Peak	Confidence Limits 5% Limit (cms)	Confidence Limits 95% Limit (cms)
1 in 50	4640	5694	4250
1 in 75	5150	6330	4700
1 in 100	5390	6645	4920



Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	NORTH SASKATCHEWAN RIVER at EDMONTON PEARSON III FREQUENCY DISTRIBUTION FOR SIMULTANEOUS MEASUREMENTS OF MAXIMUM MEAN DAILY AND INSTANTANEOUS FLOWS.
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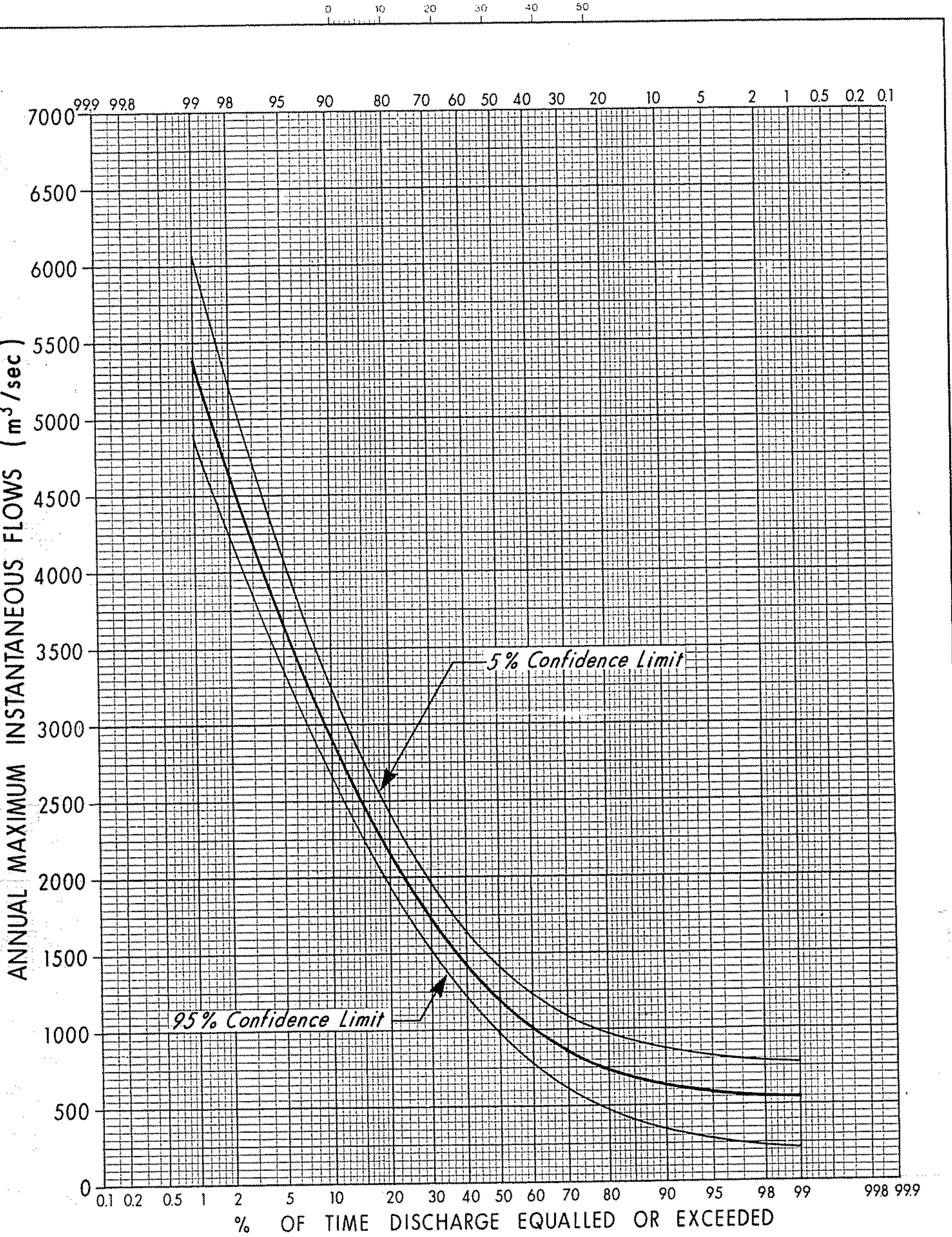

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Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION HYDROLOGY BRANCH	NORTH SASKATCHEWAN RIVER at EDMONTON PEARSON III FREQUENCY DISTRIBUTION OF ANNUAL MAX-IMUM INSTANTANEOUS FLOW (ADJUSTED TO LONG-TERM RECORD USED IN FIGURE 1)	
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7.0 CONCLUSIONS AND RECOMMENDATIONS

This report has investigated the extreme floods which have been experienced on the North Saskatchewan River through Edmonton and the cause of these events. On the basis of this investigation the report concludes that extreme floods through the study area are caused primarily by rainfall events rather than by snowmelt.

The report has also investigated the effects of the Brazeau and the Bighorn Dams on peak flows through Edmonton by routing selected extreme floods through the two structures for three assumed operating rules. On the basis of this analysis it was concluded that, while the Brazeau and Bighorn Dams will provide some reduction in peak flows of minor events and might under favorable circumstances provide some flood control for major events, no definite flood reduction should be attributed to the reservoirs until definite operational rules for flood events are established. In this regard, it was recommended that flood frequency analyses for the North Saskatchewan River through Edmonton take the above conclusion into account by reconstructing and analyzing the peak flows which would have been experienced had the two reservoirs not been in place.

Based on the above conclusions, "natural" peak flows for the North Saskatchewan River at Edmonton were reconstructed. The natural peaks were then analyzed using various distribution types and based on a visual inspection the Pearson III distribution was selected as most accurately approximating the Hazen plots of the observed data. Flood magnitudes computed by means of the Pearson III distribution were then adjusted so as to include historical events and thus obtain the flood frequency distribution of the North Saskatchewan River at Edmonton.

This investigation represents the most detailed study of peak flows through Edmonton which has been carried out to date. It is, therefore, recommended that flood frequencies, for the North Saskatchewan through Edmonton computed within this report, be used to determine the flood plain for the North Saskatchewan River through Edmonton.

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