CANADA / BRITISH COLUMBIA FLOODPLAIN MAPPING AGREEMENT

Ministry of Environment, Lands and Parks
Resources Inventory Branch

A Design Brief
on the
Floodplain Mapping Project

Bulkley River
Quick to Houston

Water Inventory Section
Victoria, British Columbia
March, 1998

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Preface

The purpose of this design brief is to present a description of the methodologies used and the results of the study undertaken to delineate the floodplain of the Bulkley River and tributaries between Quick and Houston in British Columbia.

1. Introduction

This floodplain mapping project was prepared by the Water Inventory Section of the B.C. Ministry of Environment, Lands and Parks, under the terms of the Canada/British Columbia agreement dated December, 1987 and entitled "An Agreement Respecting Floodplain Mapping in the Province of British Columbia" (Amended August 2, 1994).

The study area is within the boundaries of the Regional District of Bulkley-Nechako and a portion of the District of Houston. It is located approximately 25 km. southeast of Smithers in the Intermontane System, one of the six main physiographic areas of the Province. Figure 1 shows the study area location. The location of floodplain mapping drawings 96-10, Sheets 1 to 6, are shown on Figure 2.

The Bulkley River flows in a westerly direction from Bulkley Lake in the Nechako Plateau through the District of Houston to the Morice River confluence. Downstream of this confluence the river flows to the northwest a distance of 125 km. passing through Quick, Telkwa and Smithers to the confluence of the Skeena River at Hazelton. A hydrometric gauge (08EE004) is located at the downstream end of the study area at Quick. Mean annual precipitation in the study area averages between 40 and 50 cm. which is low in comparison to the main tributary to the Bulkley River, the Morice River, where values exceed 350 cm.(Appendix 1.1).

2. Background

Floodplain mapping of the Bulkley River has been issued in several areas as follows:

Project Number	Project Name	Issue Date	Designation Date	No. of Drawings
A.3.28	Skeena and Bulkley Rivers at Hazelton	September 1994	September 1994*	1
A.1.30	Bulkley and Telkwa Rivers Smithers-Telkwa	December 1984	December 1987	8
A.2.15	Bulkley River: Quick Area	November 1986	September 1988*	4
A.1.31	Bulkley River at Houston (Including Buck Creek)	November 1985	December 1987	3

(*A design brief was prepared for projects designated after December 1987.)

This study will extend the existing floodplain mapping from Quick to Houston, resulting in a continuous coverage of the Bulkley River floodplain from Smithers to Houston, a total distance along the river of approximately 34 km.

Staff of the Water Management Branch of BC Environment were involved in an assessment of ice jam flooding which occurred on the Bulkley River at Quick in December of 1984. A review of the available information (Appendix 1.2 to 1.4) indicated that ice jam problems have occurred on at least two other occasions between 1937 and 1984 at Quick.

Available information suggests that ice jam flooding problems are not unique to the Quick area along the Bulkley River (Appendix 1.5).

Flood profile calculations for floodplain mapping purposes are based on open water conditions and do not account for potential problems related to ice jam flooding. Site specific or general notes are placed on the mapping sheets when special flood hazards such as ice or debris jam flooding or bank erosion problems are known to occur in a study area.

3. Present Floodplain Mapping Study

Topographic mapping (1, 2 and 10 meters) extending from the area just upstream of Quick to just upstream of the Morice/Bulkley River confluence in the Distrct of Houston was produced by the Ministry's Surveys and Resource Mapping Branch in 1984, under the Provincial Large Scale Mapping Program. This contour mapping was used as a basis for the floodplain mapping drawings.

The 1997/98 studies undertaken to delineate the floodplain for the Bulkley River from Quick to Houston utilized the following information:

- Floodplain Survey, Project # 9610F050, June 25 to July 10, 1996, Resource Inventory Branch, Technical Support Section, BC Environment (Appendix 1.6).

- Topographic base mapping of the study area produced by the Mapping Section, Surveys and Resource Mapping Branch, Project 82-071(T-O). This mapping is based on 1982 air photography at 1:5000 scale with 1 or 2 meter contour intervals as indicated (Appendix 1.7).

- Hydrology study of the Bulkley and Morice Rivers carried out by the Water Inventory Section, Resources Inventory Branch, July 2, 1997, File No. 42500-40/REG 6 (Appendix 2).

4. Flood Magnitudes

Appendix 2 is a memorandum outlining the study undertaken to determine peak flow estimates for the study area.

The headwaters of the Morice River and the western drainage of the Bulkley River project reach are located in the high peak flow zone of the coast mountains. The eastern and upper reaches of the Bulkley drain the lower peak flow zone of the Hazelton Plateau. Spring snow melt and rain-on-snow events account for 90% of annual peak flows in this region and pacific frontal fall rainfall storms cause the remainder.

The peak flow estimates were based on frequency analyses of annual peak flows of hydrometric stations on the Bulkley River (08EE003 and 08EE004) and Morice River (08ED002) as listed in the following table of peak flows. The record length of these three stations are 33, 66 and 35 years, respectively. The procedures used in the peak flow estimates and a discussion of the results of the estimates are summarized in Appendix 2. Results of the estimates are as follows:

STREAM LOCATION	DRAINAGE AREA (km^2)	RATIO OF MAXIMUM INSTANT-ANEOUS-TO-DAILY DISCHARGE	PEAK FLOW							
			Daily						Instantaneous	
			Mean Annual		20-Year		200-Year		20-Year	200-Year
			($L/s/km^2$)	(m^3/s)	($L/s/km^2$)	(m^3/s)	($L/s/km^2$)	(m^3/s)	(m^3/s)	(m^3/s)
Bulkley River at Quick (08EE004)	7360	1.16	78.5	578	113	829	137	1010	960	1200
Bulkley River near Houston (08EE003)	2380	1.20	51.3	122	78.2	186	96.2	229	220	270
Bulkley River below Morice River	6650	1.16	-	-	117	780	140	930	900	1100
Morice River near Houston (08ED002)	1910	1.01	128	245	179	342	222	424	-	-
Morice River at the mouth	4270	1.18	-	-	150	640	180	770	760	910

5. Hydraulic Analysis

5.1 General

Information sources listed in Appendix 1 and 2 were utilized in the HEC-2 water surface profile computer program version 6.4, developed by the Hydrologic Engineering Centre, US Army Corps of Engineers in Davis, California and currently administered by Haestad Methods, Inc. The profile calculations employ a standard step method and assume open flow channel conditions.

Appendix 3 is a summary of all the computer runs executed for this study.

In the cross section plot run, an assessment was made of the surveyed river sections which incorporated extensions obtained from the base contour topographic mapping. This run was also used to review other data such as flow regime, loss coefficients, reach lengths, overbank information and relative Manning's "n" values.

Manning's "n" values were selected using the color photographs included in the survey project, experience gained in other studies and a review of the information provided in the book "Roughness Characteristics of Natural Channels" (Appendix 1.8).

5.2 Calculated Flood Levels

Using stage discharge data available from the 1986 floodplain mapping study (Project A.1.31, Bulkley River - Quick Area, Appendix 1.9) a typical stage discharge curve was plotted for the Bulkley River at the downstream end of the present study area at X-Section 1 (Figure 3). Data for the curve was also available from the 1996 calibration data discussed below.

The model was calibrated using the high water marks observed in the field (Appendix 1.6) and the flows recorded on June 5, 1996 provided by Water Survey of Canada (WSC). The calibration flow for the Bulkley River at Quick was 600 m^3/s. The model was calibrated to within an average of +/- 0.13 meters of the observed levels. Appendix 3, Run # 3, summarizes the calibration run data and results.

Once a satisfactory match was obtained for the calibration model, estimated 200 and 20 year daily and instantaneous flow profiles were calculated (Appendix 3). Model starting levels were obtained from Figure 3. Sensitivity to flow (Q) and Manning's "n" values were also undertaken as discussed in Section 5.3.

In accordance with standard Ministry practice, an allowance for hydraulic and hydrologic uncertainties (freeboard) was applied to the water surface elevations computed by the model for each cross section. An allowance of 0.3 meters and 0.6 meters was applied to the instantaneous and daily levels respectively, and the higher flood level selected and shown on the floodplain mapping sheets.

The designated flood levels are listed in Table 1.

5.3 Sensitivity Studies

Sensitivity to flow (Q) studies were undertaken using the Q200 daily flows multiplied by factors of 1.1 to 1.4 The results indicate that the designated flood levels (0.6 meters of freeboard included) are sufficient to withstand increases in the Q 200 daily flow of up to 30%. A flood level increase of about 0.17 meter occurs for each 10% increase in flow.

Sensitivity studies were also undertaken to determine the effect of increased Manning's "n" values on flood levels. A comparative computer model run using the Q 200 daily flow and factors of 1.1 to 1.4 applied to the "n" values was made (Appendix 3). Results indicated an average flood level rise of about 0.16 meter for each 10% increase in "n" values.

6. Floodplain Mapping

The flood levels determined in the study were used to delineate the floodplain limits onto the existing contour mapping in the study area. The studies were based on the information noted in Section 3.

In accordance with the policy of the Ministry of Environment, Lands and Parks, the flood levels and floodplain limits shown on floodplain mapping sheets are based on a designated (1:200 year frequency) flood level plus an allowance for hydraulic and hydrologic uncertainties.

The flood levels shown on the mapping sheets are compatible with the information on the downstream (Appendix 1.9) and upstream (Appendix 1.10) floodplain mapping projects as indicated in Table 1.

The mapping indicates the location of the floodplain limits, cross section and monument locations, and flood level isograms. Roads and dykes are also identified. Particular attention should be paid to the "Notes" on the mapsheets with regard to ponding, ice and debris jamming.

The flood level isograms (lines of equal 200 year flood levels) were extended across the floodplain, based on Ministry experience in reviewing flood levels from significant floods in other designated floodplains in the province.

7. Conclusions

1. This design brief presents an overview of the studies undertaken to produce the floodplain mapping sheets for the Bulkley River and tributaries between Quick and Houston in British Columbia. The floodplain limits outline the area which would be inundated by the designated flood.

2. The study area has a documented history of flooding and erosion.

3. The floodplain maps are administrative tools to provide information which will help to minimize future flood damages. They are not comprehensive floodplain management plans, nor do they provide solutions to site specific problems.

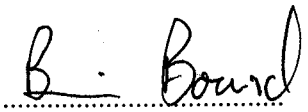
4. Flooding may occur outside the designated floodplain. Tributaries, ice jamming, channel obstructions and larger flood events may cause flooding which exceeds the flood levels shown on the drawings. These limitations are noted on the floodplain mapping sheets under "floodplain data" and under notes of caution on individual sheets.

8. Recommendations

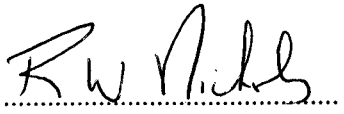
1. It is recommended that the floodplains delineated on Drawing 96-10, Sheets 1 to 6, be interim designated under the terms of the Federal Provincial Floodplain Mapping Agreement.

2. The drawings may be used for administrative purposes related to the preparation of hazard map schedules for official plans; flood proofing requirements in zoning and building bylaws; and the identification of lands by Subdivision Approving Officers.

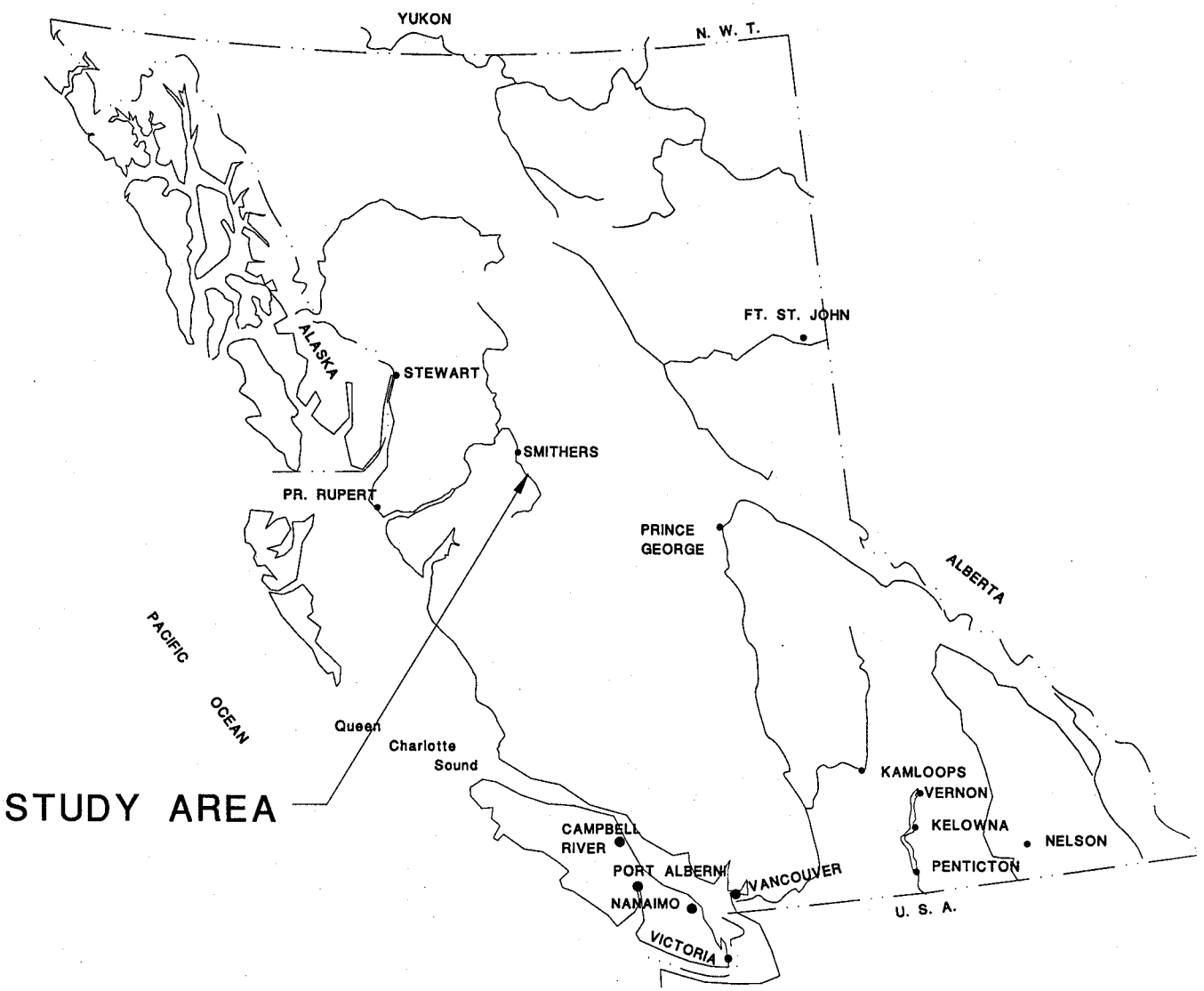
3. These floodplain maps should be reviewed to maintain the adequacy, accuracy and usefulness of the information when significant flood events, erosion, floodplain development or other changes occur within the study area.



B.J.E. Board
Project Technician
Water Inventory Section



R.W. Nichols, P.Eng.
Head
Floodplain Mapping Program



Province of British Columbia
Ministry of Environment, Lands and Parks
RESOURCES INVENTORY BRANCH
WATER INVENTORY SECTION

TO ACCOMPANY A DESIGN BRIEF ON THE
FLOODPLAIN MAPPING
BULKLEY RIVER AND MORICE RIVER
QUICK TO HOUSTON

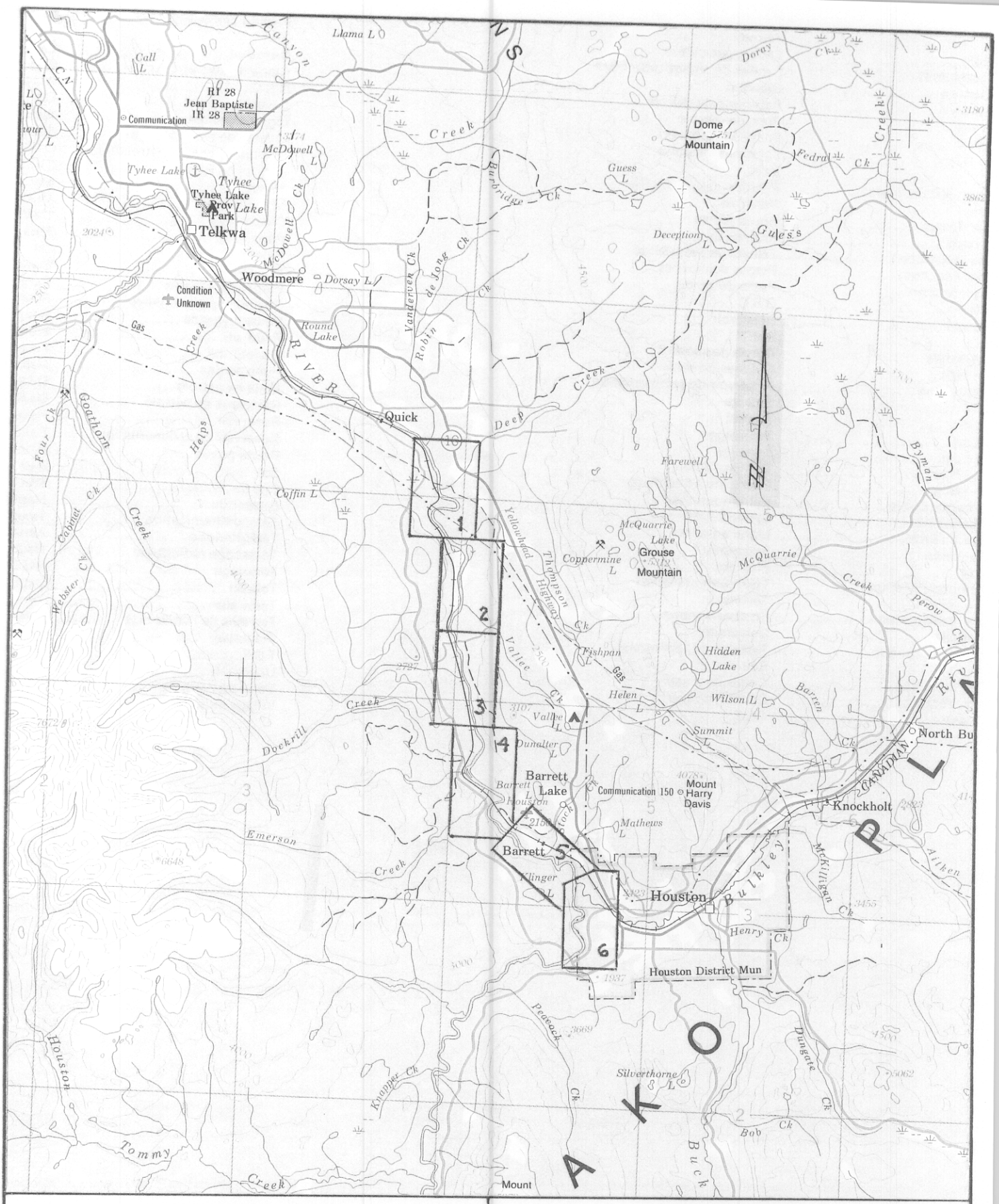
STUDY AREA LOCATION

SCALE: VERT NOT TO SCALE
HOR

DATE
SEPTEMBER 1998

R.W. NICHOLS ENGINEER

FILE No. 35100-30/460-0000 DWG. No. FIGURE 1



Province of British Columbia
Ministry of Environment
Resources Inventory Branch

TO ACCOMPANY REPORT ON
FLOODPLAIN MAPPING STUDY
BULKLEY RIVER, QUICK TO HOUSTON
KEY MAP

SCALE: VERT
HOR 1:250,000

DATE
SEPT.1998

R.W.Nichols ENGINEER

FILE No. 35100-30/460-0000 DWG No. Figure 2

BCIL 7673-M E

FIGURE 3
Stage-Discharge Data for XS-1
Bulkley River near Quick

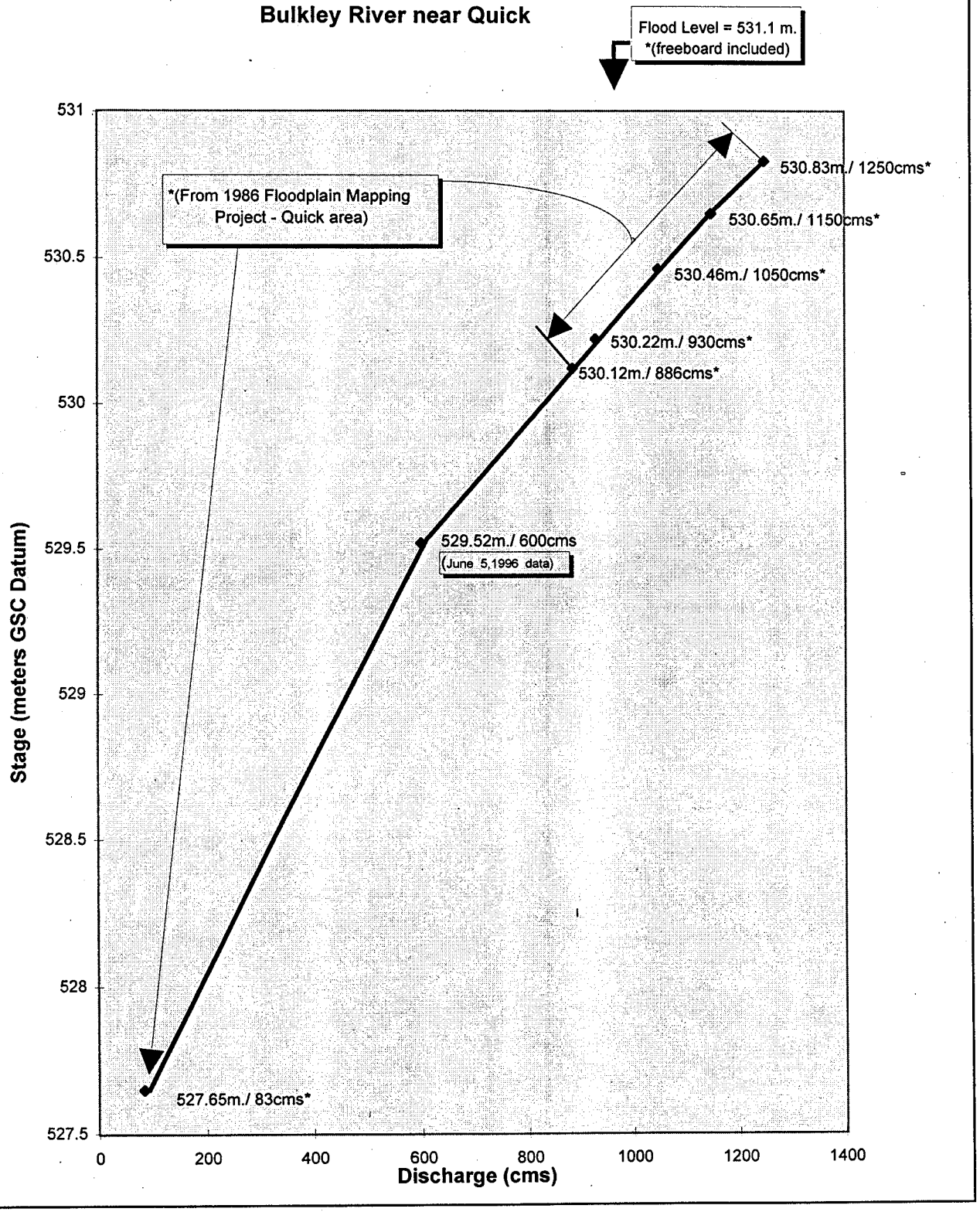


Table 1
Flood Levels [1] - Bulkley River

River XS #	Selected 200 Year [2] Flood Level (m)	Selected 20 Year [2] Flood Level (m)
1	531.1[3]	530.7[3]
2	532.2	531.8
3	533.3	532.9
4	534.4	534.0
5	535.5	535.1
6	537.1	536.8
7	539.8	539.3
8	540.7	540.1
9	541.6	541.0
10	542.5	542.0
11	543.0	542.6
12	544.1	543.7
13	545.4	545.1
14	547.3	546.9
15	549.2	548.8
15.1	549.9	549.5
16	550.6	550.3
17	552.0	551.7
18	553.4	553.1
19	554.7	554.3
20	555.7	555.4
21	557.3	557.0
22	558.7	558.4
23	560.6	560.2
24	561.7	561.4
25	563.0	562.8
26	564.7	564.2
27	565.4	565.1
27.1	565.4	565.1
28	566.4	566.0
29	567.2	566.8
30	568.1	567.9
31	570.6	570.4
32	572.2	572.0

(1) Includes freeboard allowance. **(2)** Shown on Floodplain Mapping Sheets at even gradient intervals.
(3) Based on data from Figure 3.

Table 1 (Continued)

Flood Levels[1] -Bulkley River

River XS #	Selected 200 Year[2] Flood Level (m)	Selected 20 Year[2] Flood Level (m)
33	574.1	573.9
34	575.7	575.4
35[3]	576.0	575.7
36	576.8	576.6
37	578.6	578.4
38	580.0	579.8
39	580.6	580.3
40	580.7	580.5
1[4]	580.7	580.5
2	580.8	580.6
4	581.4	581.1
5	582.8[5]	582.5

Flood Levels[1] -Morice River

River XS #	Selected 200 Year[2] Flood Level (m)	Selected 20 Year[2] Flood Level (m)
34	At Confluence with Bulkley River - See Above	At Confluence with Bulkley River - See Above
1	576.0	575.7
2	576.9	576.6
3	578.5	578.2
4	579.7	579.5
5	582.2	582.0
6	584.9	584.6
7	585.1	584.9
8	585.5	585.1

(1) Includes freeboard allowance
(2) Shown on Floodplain Mapping Sheets at even gradient intervals.
(3) Upstream of Morice River Confluence.
(4) Cross sections 1 to 5 from Project A.1.31, Bulkley River at Houston, December 1985.
(5) Flood levels compatible with results of the 1985 study.

APPENDIX 1

Detailed Information Sources

APPENDIX 1

Detailed Information Sources

No.	Source	Contents
1.	Atlas of British Columbia, U.B.C. Press W.R. 912.711 F231C.4	General information on the people, environment and resource use.
2.	"The 1984 Quick Flood Bulkley River", by L.E. Garinger and J.B. McGonigal dated January 3, 1985	A preliminary report to describe the chronology of events regarding the flood which occurred at Quick between December 24 and December 30, 1984.
3.	Memo outlining the ice jam flooding of Dec.1984 by B. McMullen, P.Eng., Rivers Section, W.M.B. dated Jan. 9, 1985, File P84-1.	A preliminary analysis, observations and suggestions for further study regarding the ice jam flooding at Quick.
4.	"Bulkley River at Quick, B.C. Assessment of Ice Jam Flooding of December 1984", prepared by NW Hydraulic Consultants Limited, dated March, 1985.	A report prepared for the WM Branch to review available data and recommend measures to mitigate the possible flooding from the 1985 break-up at Quick.
5.	"State of Emergency Follows Water, Sewage Problems", from the Interior News, Smithers, B.C. April 13,1966.	A newspaper article on the ice jam damage and flooding at the Bulkley Highway Bridge in Smithers.
6.	Floodplain Survey, Project # 9610F050, June 25 to July 10,1996, Resource Inventory Branch, Technical Support Section, BC Environment.	Forty-two river cross sections were surveyed on the Bulkley River from 3 kilometers upstream of Quick along a reach of 34 kilometers to the CNR rail crossing near Highway 16 at Houston. Eight cross sections were surveyed on the Morice River in a 4.8 kilometers reach upstream of the confluence with the Bulkley River. High water marks were surveyed at all cross sections.
7.	Topographic base mapping of the study area produced by the Mapping Section, Surveys and Resource Mapping Branch, Project 82-071(T-O).	This mapping is based on 1982 air photography and is 1:5000 scale with 1 or 2 meter contour intervals as indicated.
8.	"Roughness Characteristics of Natural Channels" Geological Survey Water-Supply Paper 1849, by H. H. Barnes, Jr., US Department of the Interior, Geological Survey	Photographs and descriptive data including Manning's "n" values for stream channels for which roughness coefficients have been determined.
9.	Report on the 1986 Floodplain Mapping Study Bulkley River- Quick Area, File: 46-0000-S.1	An overview of the study undertaken to produce floodplain mapping for the Bulkley River near Quick.
10.	Design File on the Floodplain Mapping Study Bulkley River at Houston, 1985	Information on the study undertaken to produce floodplain mapping for the Bulkley River at Houston.

APPENDIX 2

Hydrology Report

Bulkley River and Tributaries

Quick to Houston

Province of British Columbia
MINISTRY OF ENVIRONMENT, LANDS AND PARKS

BC Environment
WATER MANAGEMENT DIVISION

MEMORANDUM

To: R.W. Nichols
Senior Hydrologic Engineer

Date: July 2, 1997
File No. 42500-40/REG 6

Re: Bulkley River and Morice River
Peak Flow Estimates

In response to the memorandum of May 7, 1997 from R.W. Nichols peak flows were estimated for the above rivers. Detailed specifications of the floodplain mapping project memorandum of April 17, 1997 from B. Board were followed. Daily and instantaneous peak flow estimates were required for 20- and 200-year recurrence intervals for Bulkley River at Houston and at Quick and for Morice River at its mouth. Also, stage-discharge relationships were required for both Bulkley stations from Environment Canada.

Study Area

The floodplain project area extends from five km upstream of the mouth of Morice River and Bulkley River near Houston to Bulkley River at Quick. The headwaters of Morice River and the western drainage of the Bulkley River project reach lie in the high peak flow zone of the coast mountains, whereas the eastern and upper reaches of the Bulkley drain the lower peak flow zone of the Hazelton Plateau. The eastern slopes of the Hazelton Mountains produce sharp peak flood hydrographs (large peak flow instantaneous-to-daily discharge ratios), whereas the Morice Lake and the upper Bulkey small headwater lakes and swamps of the plateau area produce flatter peak flood hydrographs. Spring snowmelt and rain-on-snow events account for 90% of annual peak flows in this region whereas Pacific frontal fall rainfall storms cause the remainder.

Procedure and Results

The procedure used to make the required peak flow estimates were based on frequency analyses of annual peak flows of Bulkley River hydrometric stations near Houston (08EE003) and at Quick (08EE004) and Morice River near Houston (08ED002), which is located at the mouth of Morice Lake. The record lengths for the three stations are 33, 66 and 35 years, respectively. The first two stations only have staff gauges (no instantaneous data); the third has a recorder but its instantaneous record is of little value for this study due to the large storage effect on the streamflow. The frequency results for these stations are given in the following table. The estimates were based on the best-fit Pearson Type III distribution using the Kolmogorov-Smirnov statistic. The daily peak flow estimate for Morice River at its mouth was based on a regional graphical analysis of peak flow curves from the Skeena-Nass Strategic Plan Hydrology Study (1983) and updated to 1996 with the reference station data.

STREAM LOCATION	DRAINAGE AREA (km^2)	RATIO OF MAXIMUM INSTANT-ANEOUS-TO-DAILY DISCHARGE	PEAK FLOW							
			Daily						Instantaneous	
			Mean Annual		20-Year		200-Year		20-Year	200-Year
			($L/s/km^2$)	(m^3/s)	($L/s/km^2$)	(m^3/s)	($L/s/km^2$)	(m^3/s)	(m^3/s)	(m^3/s)
Bulkley River at Quick (08EE004)	7360	1.16	78.5	578	113	829	137	1010	960	1200
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Morice River near Houston (08ED002)	1910	1.01	128	245	179	342	222	424	-	-
Morice River at the mouth	4270	1.18	-	-	150	640	180	770	760	910

Discussion of Results

The daily peak flow estimates for the three hydrometric stations are considered reliable (maximum 95% confidence limits of 16%). The instantaneous peak flow estimates are less reliable, with another maximum compounded error of 17%. Note that the instantaneous-to-daily ratios are given to three significant figures to distinguish the differences between the stream sites, but are accurate to only two. All instantaneous estimates were reduced to two significant figures. It should also be noted that the recurrence interval flood estimates are for each stream site individually. For the same frequency flood magnitudes for each stream would not occur simultaneously since different events would be involved. A 200-year flood below the confluence from the combined upstream tributaries would be smaller than the addition of 200-year upstream floods experienced individually.

Attached are written comments and stage-discharge tables for Bulkley River at Quick (08EE003) and near Houston (08EE004) from Environment Canada.

W. Obedkoff, P.Eng.
Water Inventory Section
Resources Inventory Branch
387-9474

cc: W. Dreher

APPENDIX 3

HEC-2 Computer Run Summaries

Bulkley River Hec-2 Run Summary

Run # **Comments**

1. **Plot Run** - Quick to Houston (1996 River Surveys XS-1 to 40)

2. **Work File and Plot Run** -1986 River Survey to XS-5 (upstream of 1996 survey data)

3. **Calibration Run**
   - 3.1 Quick to Morice River confluence at XS-35
     June 5, 1996 flood, Q = 600 m^3/s at Quick
     Q = 560 m^3/s d/s of Morice confluence (estimated)
     Starting elevation = 529.6 m.(from figure 3)
     Calibrated to an average of +/- 0.12 meters of HWM data.
   - 3.2 Morice River confluence to XS-5 (1986 survey)
     May 26,1996 flood, Q = 128 m^3/s at Houston
     Calibrated to an average of +/- 0.19 meters of HWM data.

4. **Q200 Daily Run**
   - 4.1 Quick to Morice River confluence at XS-35
     Q = 1010 m3/s at Quick
     Starting elevation = 534.4 m.(from Figure 3)
   - 4.2 Morice River confluence to XS-5 (1986 survey)

5. **Multiple Q Run** - Q200 D & I, Q20 D & I **(FL's Selected (Including freeboard))**
   - 5.1 Quick to Morice River confluence at XS-35
     Starting levels from Figure 3
   - 5.2 Morice River confluence to XS-5 (1986 survey)

6. **Sensitivity to Manning's "n"** - (Using Q200 Daily Flows)
   - 6.1 Quick to Morice River confluence at XS-35
     Each 10% rise in "n" values raises flood levels by an average of 0.16 meters.
   - 6.2 Morice River confluence to XS-5 (1986 survey)
     Each 10% rise in "n" values raises flood levels by an average of 0.10 meters.

7. **Sensitivity to "Q"** - (Relative to Q200 Daily Flows)
   - 7.1 Quick to Morice River confluence at XS-35
     Each 10% rise in "Q" values raises flood levels by an average of 0.17 meters.
   - 7.2 Morice River confluence to XS-5 (1986 survey)
     Each 10% rise in "Q" values raises flood levels by an average of 0.10 meters.

Morice River Hec-2 Run Summary

Run #	Comments
1.	**Plot Run** - Upstream of Bulkley confluence (1996 River Surveys XS-1 to 8)
2.	**Work file** - Reviewed data etc.
3.	**Calibration Run** - June 5, 1996 flood, Q= 460 m^3/s at confluence Starting elevation = 574.4m.(from Bulkley River model at confluence area) Modeled to within an average 0.14 m. of the HWM data.
4.	**Q200 Daily Run** Q = 770 m^3/s Starting elevation = 575.34 m (from Bulkley River model at confluence area)
5.	**Multiple Q Run** Q200 D & I, Q20 D & I **(FL's Selected (Including freeboard))** Starting elevations from Bulkley River model at confluence area.
6.	**Sensitivity to Manning's "n"** - (Using Q200 Daily Flows) Each 10% rise in "n" values raises flood levels by an average of 0.14 meters.
7.	**Sensitivity to "Q"** - (Relative to Q200 Daily Flows) Each 10% rise in "Q" values raises flood levels by an average of 0.14 meters.

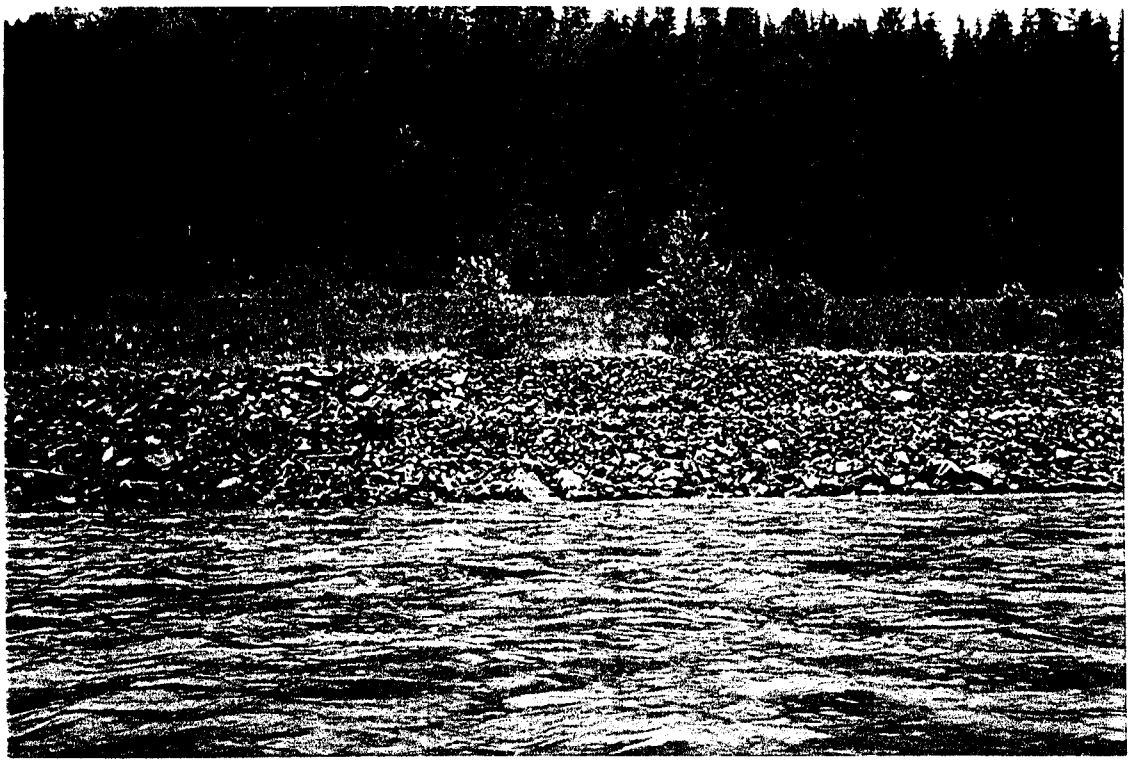
APPENDIX 4

PHOTOS

Bulkley River - Houston to Quick

(X/S 21 - 1985)

CROSS SECTION 1



Leftbank

Rightbank

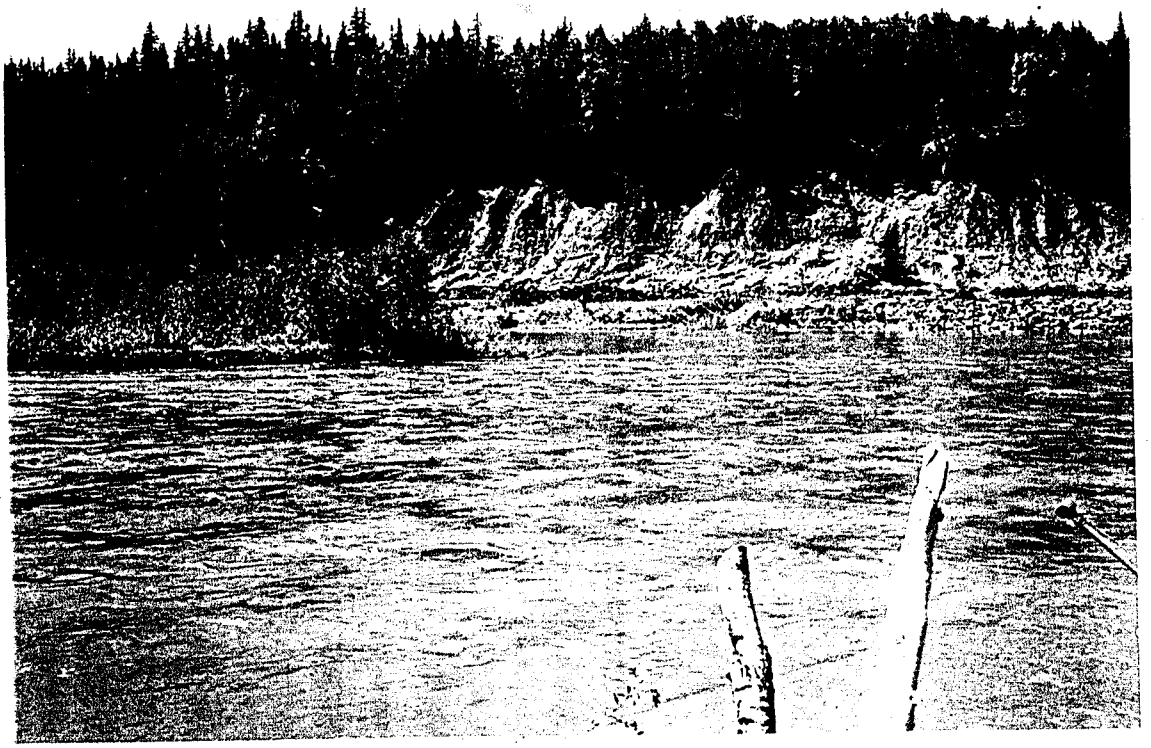
July 5, 1996

9610F050

Bulkley River - Houston to Quick

CROSS SECTION 10

Leftbank



Rightbank

July 6, 1996

9610F050

Bulkley River - Houston

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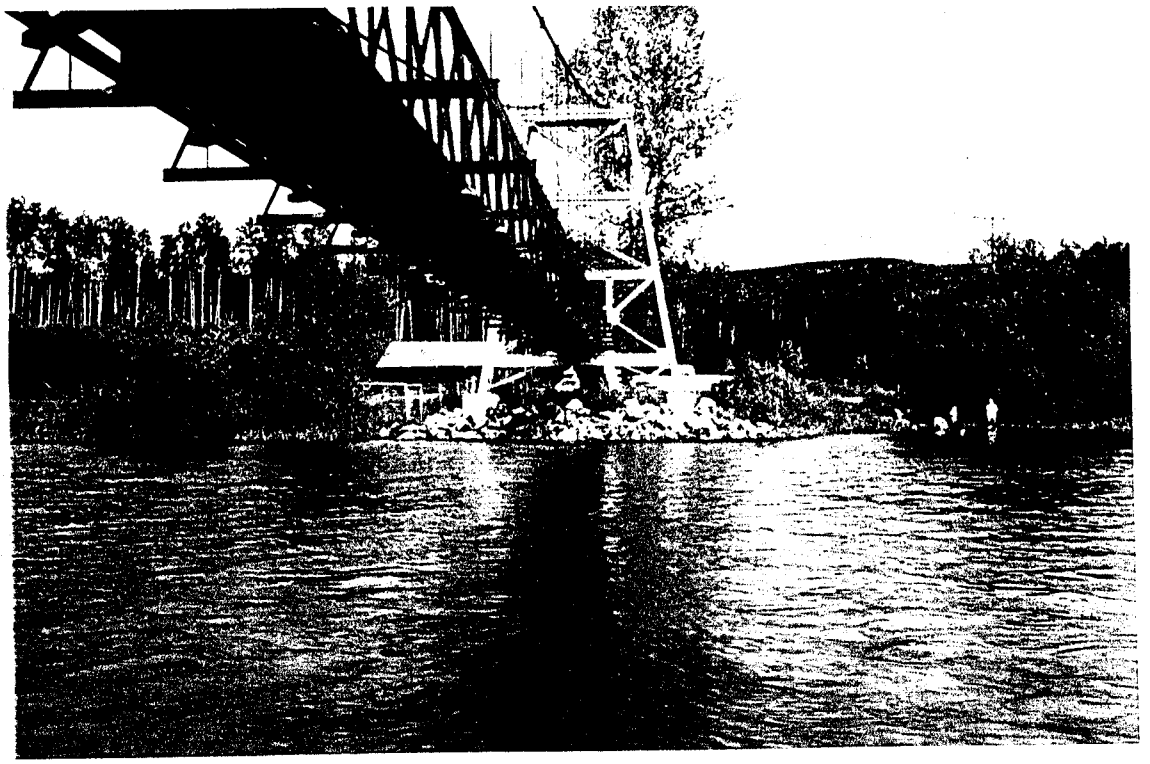
Leftbank



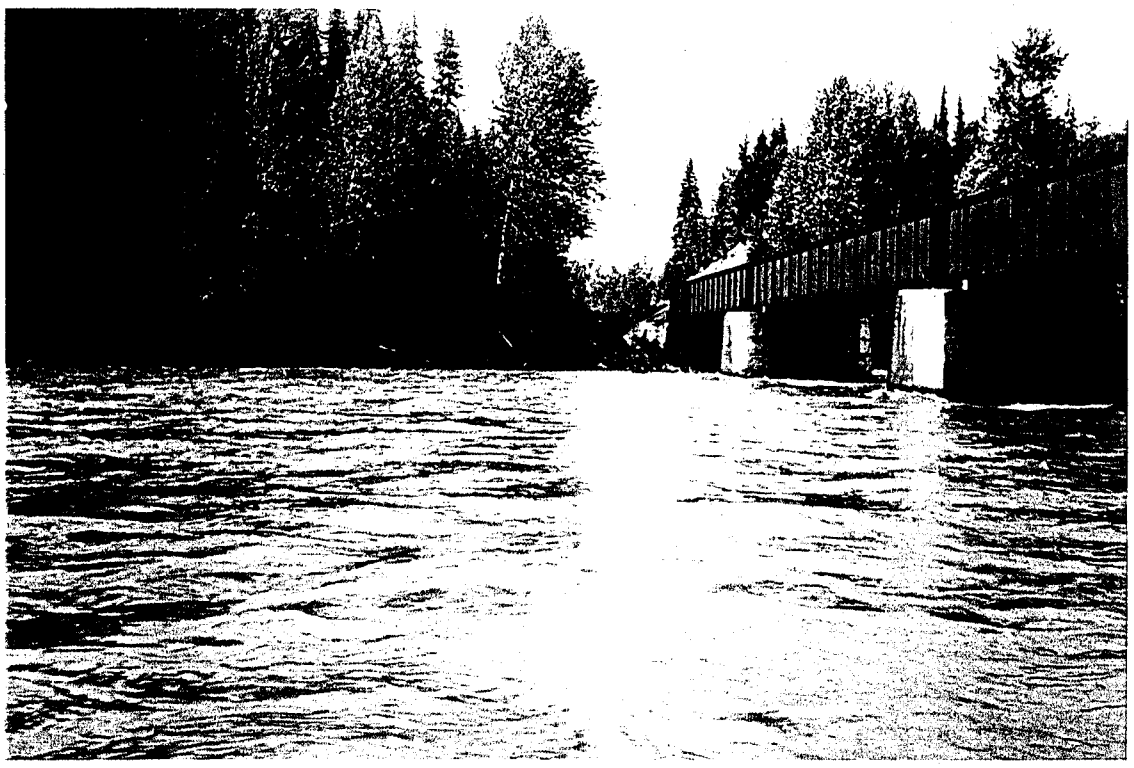
Rightbank

July 8, 1996

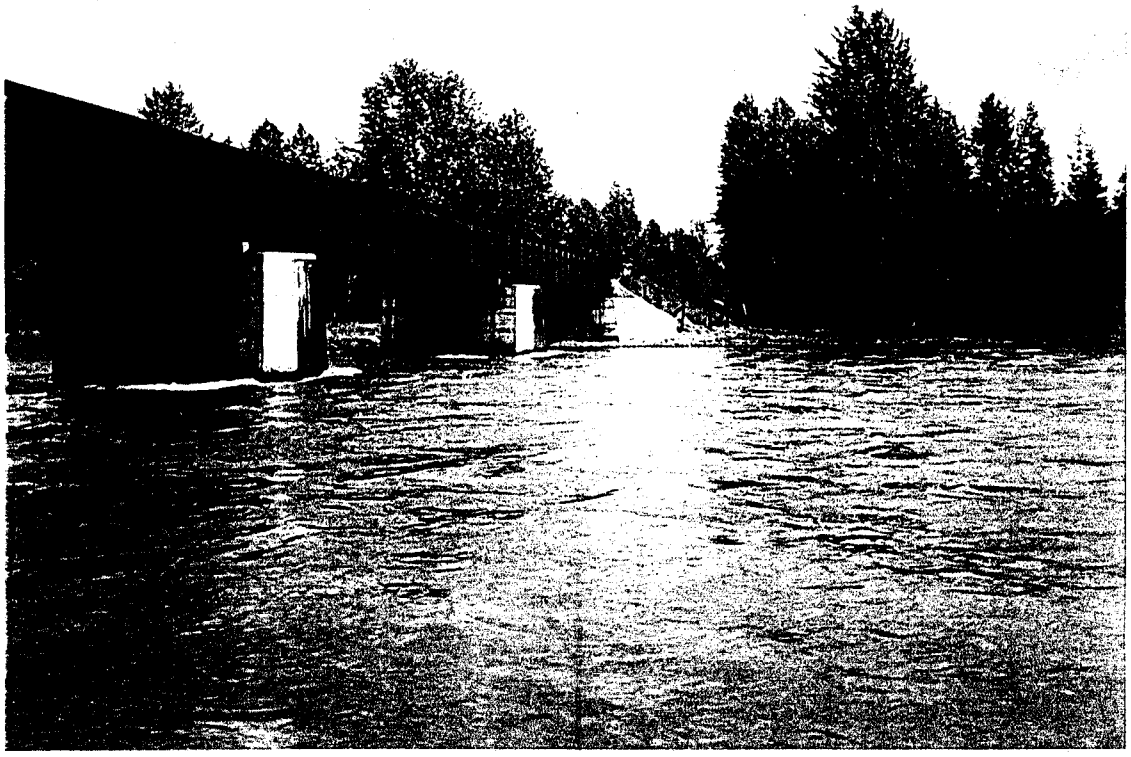
9610F05(

Bulkley River - Houston

CROSS SECTION 27.1



Leftbank



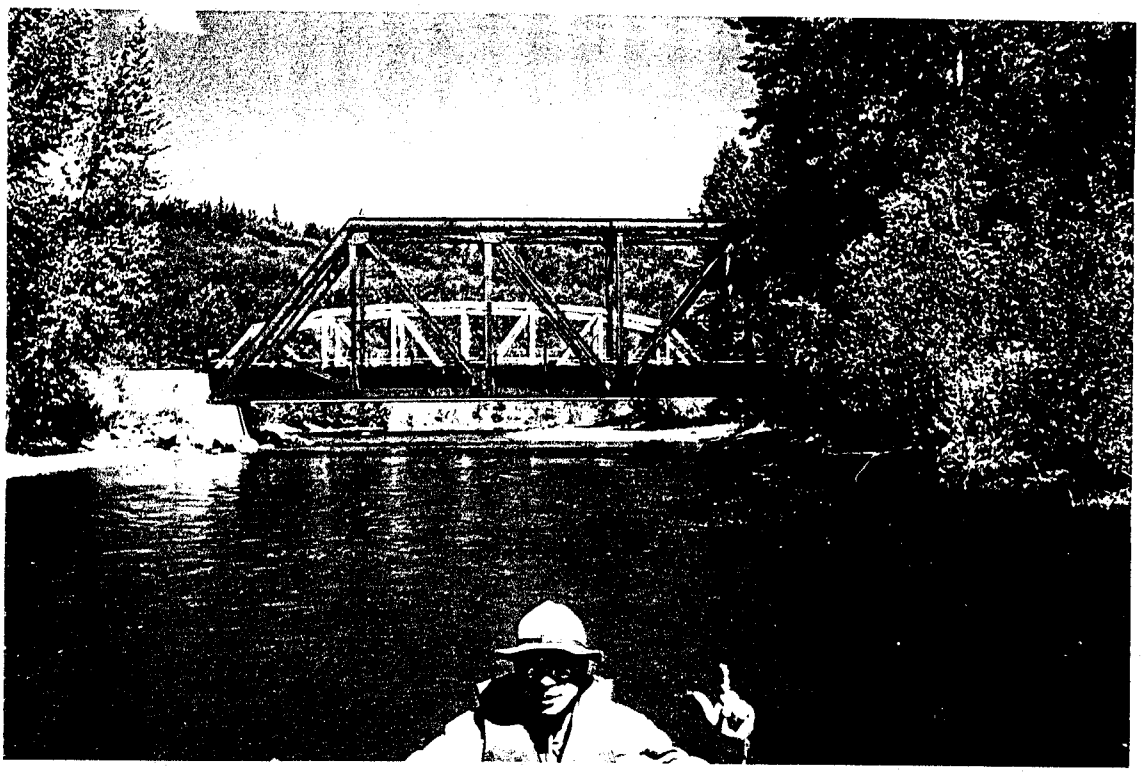
Rightbank

July 8, 1996

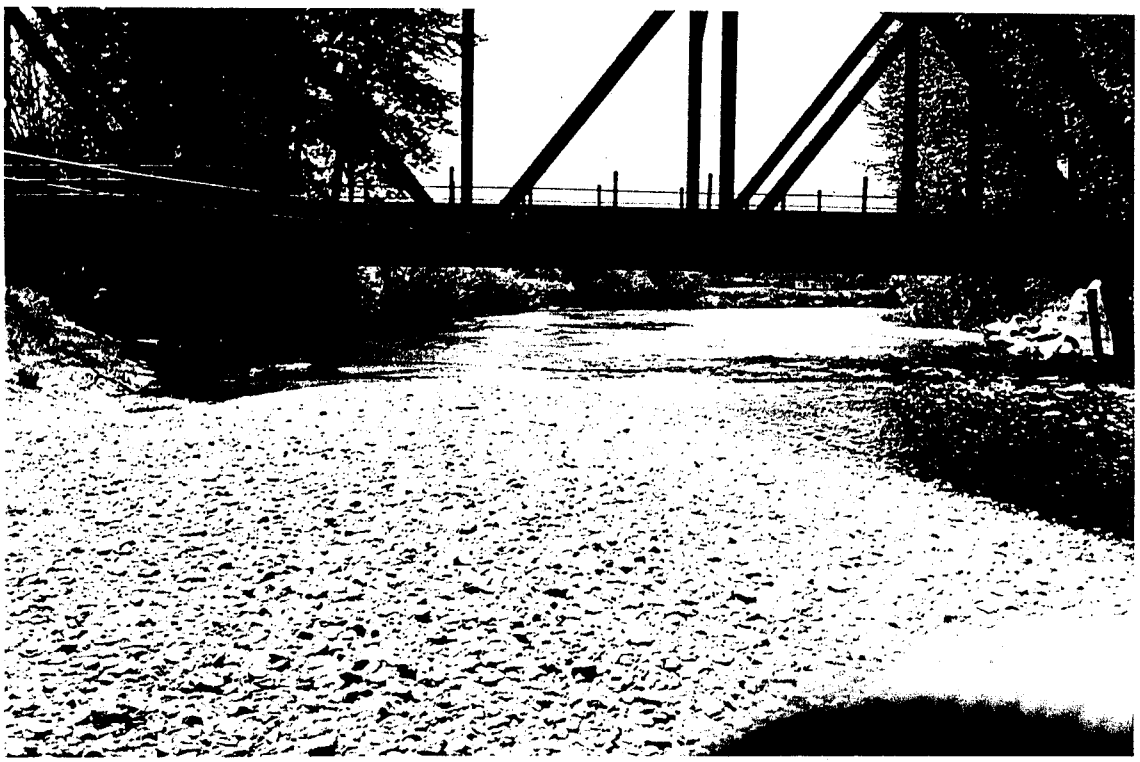
9610F050

Bulkley River - upstream of confluence

CROSS SECTION 40



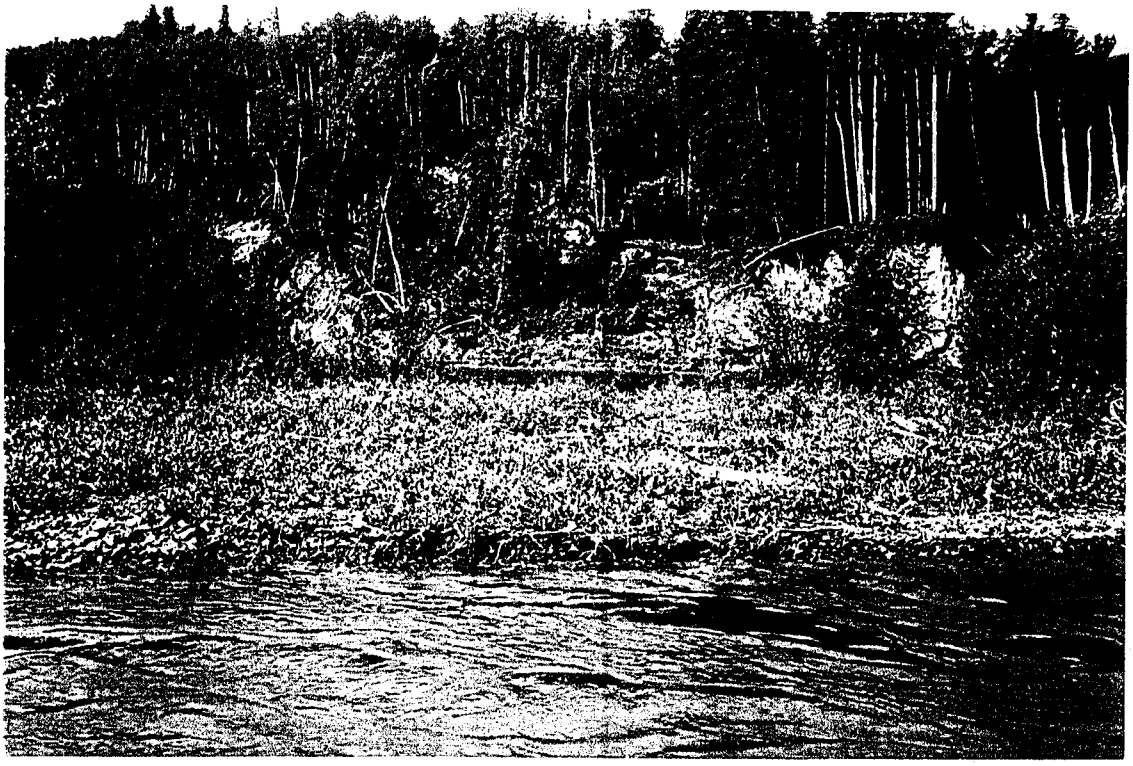
Upstream



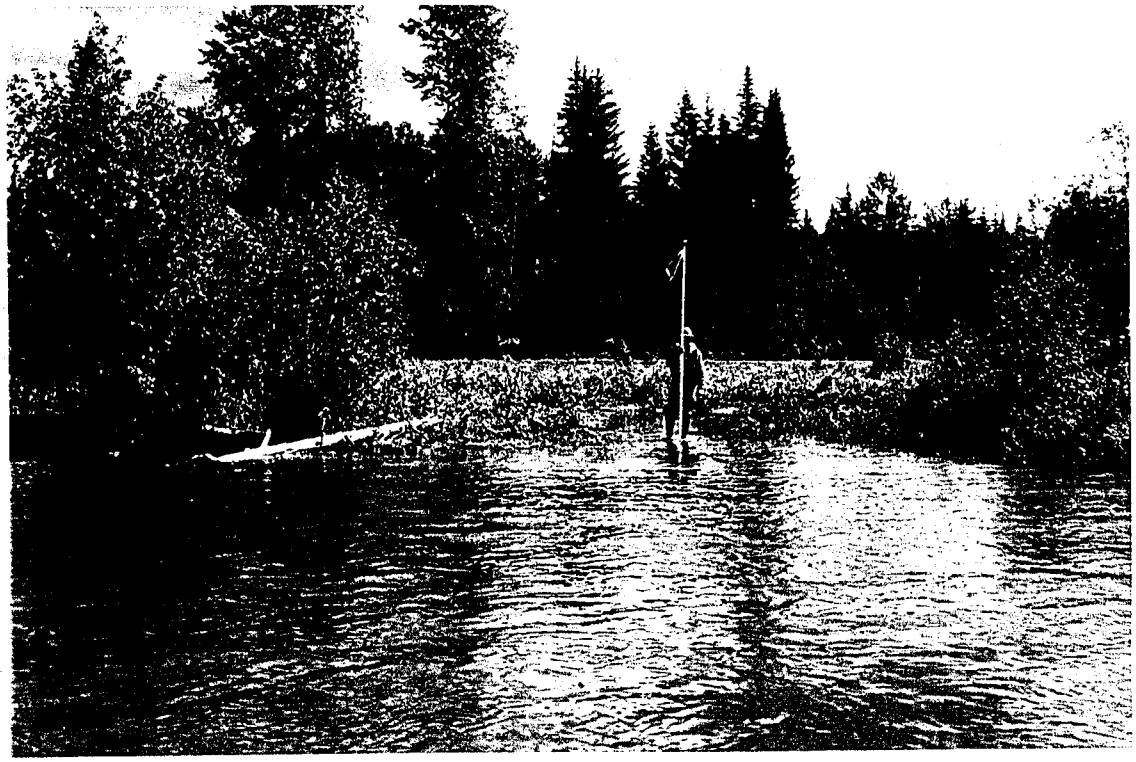
Downstream

Morice River

CROSS SECTION 2



View over island to leftbank



View over island to rightbank

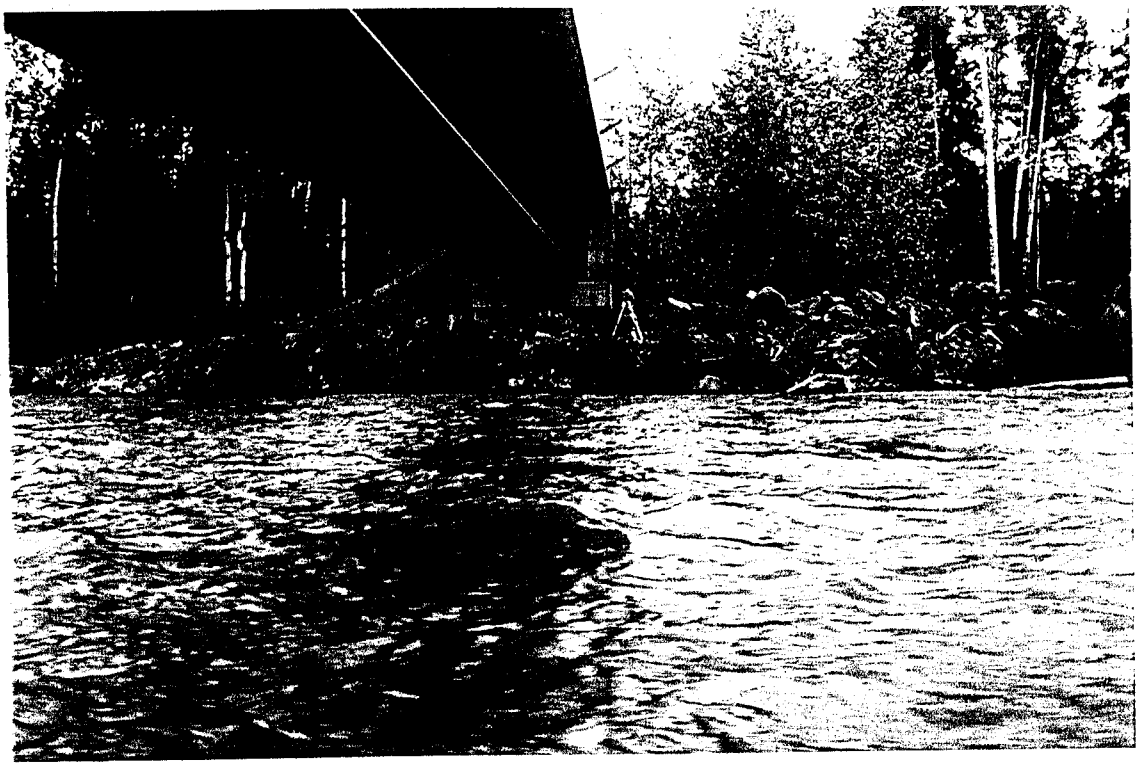
July 4, 1996

9610F050

Morice River - Houston

CROSS SECTION 7

Leftbank



Rightbank

June 28, 1996

9610F050