FEDERAL PROVINCIAL FLOODPLAIN MAPPING AGREEMENT

PROVINCE OF BRITISH COLUMBIA
Ministry of Environment
Water Management Branch

A DESIGN BRIEF ON THE

Floodplain Mapping Study

BELLA COOLA RIVER

An Overview of the Study Undertaken
to Produce Floodplain Mapping for the
Bella Coola River from Tidewater to
Burnt Bridge Creek

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July, 1988

File: 91-2910-S.1

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DESIGN BRIEF ON THE

FLOODPLAIN MAPPING STUDY

BELLA COOLA RIVER

Preface

The purpose of this design brief is to present a description of the methodologies used and results of the study undertaken to produce the floodplain mapping sheets of the Bella Coola River, Drawings 87-56, Sheets 1 to 10 (Appendix 4) from tidewater to Burnt Bridge Creek.

1. Previous Studies

The Ministry of Environment issued five floodplain mapping sheets (Drawings 86-14) in November of 1986 covering the Bella Coola River from tidewater to the Nusatsum River confluence. The attached report, which presents an overview of the studies undertaken to produce the floodplain mapping sheets, was issued in November of 1986 (Appendix 3).

The November 1986 report provides background information on the Bella Coola River including general information on the river regime. Problems related to flooding, major channel dislocations and bank erosion, which have been ongoing since the valley was settled in the early 1860s, are discussed in the report.

2. Present Studies

Topographic information required to determine the limits of some of the tributary alluvial fans in the previous study area, including Snootli and Nooklikonnik Creeks, was not available. The topographic information has since been obtained from the Surveys and Mapping Branch.

The floodplain mapping sheets covering tidewater to the Nusatsum River confluence have been revised to include the additional topographic data in the alluvial fan areas and to take cognizance of a recent evaluation of tsunami levels along the British Columbia coast (Appendix 1.1). The maps have been included as part of the present study of the Bella Coola River. Drawing 87-56, Sheets 1 to 5, cover this reach. Information sources with respect to the previous studies are listed in Appendix 3 (attached).

Drawings 87-56, Sheets 6 to 10, cover the reach upstream of the previous studies to just upstream of the Burnt Bridge Creek confluence area. Information with respect to the studies carried out in this reach are discussed in this design brief.

Appendix 2 contains selected photos of the study area obtained during the June, 1986 site visit as discussed in Section 2.3.1 of the November, 1986 report. In addition, photos taken in November, 1978 (Appendix 1.7) are included in Appendix 2. These photos provide a visual indication of the existing flood hazards in the study area.

3. Location

The study area is located 300 kilometres west of Williams Lake, as shown on Figure 1. Highway 20, which provides the only road access from Williams Lake to the study area, is 465 kilometres in length.

The total length of the Bella Coola River in the study area from tidewater to just upstream of the Burnt Bridge Creek confluence is 54 kilometres. The length of the reach upstream of the Nusatsum River confluence (Sheets 6 to 10) is 30 kilometres.

The drainage area of the Bella Coola River above tidewater exceeds 5100 square kilometres. At the upper limit of the study area (Gauge 08FB007) the drainage area is 3730 square kilometres. Burnt Bridge Creek, the main tributary in the study area upstream of the Nusatsum River confluence, has a drainage area of approximately 320 square kilometres. The main tributaries upstream of the study area are the Talchako and Atnarko Rivers and have drainage areas of 1035 and 2590 square kilometres, respectively.

4. Designated Flood

In accordance with the policy of the Ministry of Environment, the flood levels and floodplain limits shown on the floodplain mapping sheets are based on a designated (1:200 year frequency) flow plus an allowance for freeboard. At tidewater the designated (daily) flow is 1970 m^3/s; upstream of the Nusatsum River confluence the designated (daily) flow is 1610 m^3/s.

5. Survey Data

The location of river channel cross sections were originally selected by the writer in July of 1981 (Appendix 1.2) and modified based on a site visit in June of 1986 and new topographic information. Survey data used in this study was obtained in the field by the Surveys Section in 1986 (Appendix 1.3). The data was presented in two volumes containing data from 50 river cross sections on the Bella Coola River, water surface and thalweg profiles and photographs of river cross sections. An air photo mosaic showing cross section and monument locations was also provided along with benchmark data related to Water Survey of Canada Gauge 08FB007.

Topographic base mapping for the study area was produced by the Mapping Section, Surveys and Resource Mapping Branch at a 1:5000 scale with two metre contour intervals in the floodplain area (Appendix 1.4).

6. Flood Magnitudes

Studies to determine peak flows at a number of locations along the Bella Coola River study area were carried out by the Hydrology Section, Water Management Branch in November, 1985. The attached report (Appendix 3) outlines the peak flow studies. The results applicable to the area upstream of the Nusatsum River confluence are as follows:

LOCATION	20-Year Peak		200-Year Peak	
	Inst. cms	24-hr cms	Inst. cms	24-hr cms
Above Burnt Bridge Creek	816	777	1140	1090
Below Burnt Bridge Creek	987	930	1400	1320
Above Cacoohtin Creek	1040	970	1470	1380
Below Cacoohtin Creek	1050	982	1490	1390
Above Noosgulch River	1080	1000	1530	1430
Below Noosgulch River	1180	1090	1680	1550
Above Nusatsum River	1220	1130	1740	1610

7. Hydraulic Analysis

7.1 General

The information sources listed in Appendix 1 were utilized in the HEC-2 water surface profile computer program developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, in Davis, California. The flood profile studies assumed open channel flow conditions.

Flood profiles were calculated for the Bella Coola River from upstream of the Nusatsum River confluence, a distance of 30 kilometres to the Burnt Bridge Creek confluence area. A plot run of river cross sections was obtained. An assessment was made of the river survey data and the extensions of the cross sections which were obtained from the existing topographic mapping. Output from the plot runs were also used to review other data such as flow regime, loss coefficients, bridge information, reach lengths, overbank information and relative Manning's "n" values. Following is an overview of the additional computer runs for the study area.

7.2 Model Calibration

The river model was calibrated to match the observed water levels at 50 river cross section locations obtained during the field survey on July 4, 1986 (Appendix 1.3). The flow was estimated to be 241 m^3/s upstream of the Nusatsum River confluence decreasing to 184 m^3/s at Gauge 08FB007 at the upstream end of the study area (Appendix 1.5).

Observed water level data at the 50 cross section locations in the study area averaged to within 0.17 metres of the computed levels. Mannings "n" values for the river channel averaged 0.04.

The water surface profiles for the calibration flow are indicated on Figures 3 and 4. The average gradient of the Bella Coola River is 0.24% and varies between 0.10 % to 0.54% in the study area.

Figure 2 indicates the stage discharge curve at Gauge 08FB007. Data from the Water Surveys of Canada rating table has been extended to include the calculated flood elevations determined in this study.

7.3 Calculated Flood Levels

Flood levels were calculated using Manning's "n" values obtained from the model calibration studies for the 1:20 year and 1:200 year daily and instantaneous flows listed in Section 6.

The 1:20 year and 1:200 year flood levels shown on the floodplain mapping sheets were based on the daily flows and include a 0.6 metre freeboard allowance. It was determined that the daily

flow levels plus 0.6 metre freeboard slightly exceeded the instantaneous flow levels plus 0.3 metre freeboard for both the 1:20 and 1:200 year flood events.

The water surface profile for a 1:200 year daily flow (0.6 metre freeboard included) is shown on Figures 3 and 4.

7.4 Sensitivity Studies

Calculations were undertaken in order to indicate the sensitivity of the model to flows which exceed the 1:200 year daily flow. Flood levels for a flow increase of 20% would rise an average of 0.4 metres, which is within the freeboard allowance of 0.6 metres.

An indication of the sensitivity of the model to increases in Manning's "n" values was determined. An average "n" value increase of 20% results in flood levels increasing by an average of 0.3 metres for a 1:200 year daily flow, which is within the freeboard allowance.

8. Floodplain Mapping

8.1 General

The flood levels determined in the study were used to locate the designated floodplain limits onto the existing 2 metre contour mapping of the study area.

The floodplain mapping of the Bella Coola River, Drawing 87-56, Sheets 1 to 10 (Appendix 4) was produced and provides the following information:

- the location of river cross sections, the designated floodplain limits, the flood levels determined in the study, survey monuments, and known protection works.

- the study area covers a distance of 54 kilometres from tidewater to the Burnt Bridge Creek confluence area.

- the Bella Coola is an alluvial, meandering river capable of moving large volumes of sediment and debris during high flow periods. A major channel avulsion area (1974) was recorded between cross sections 28 and 38, Drawings 87-56, Sheets 8 and 9. Detailed information on the limits of the historic channel locations, dating back to 1895, is provided in the Hart Report (Appendix 3).

- the Bella Coola River has a gradient which varies from 0.10% to 0.54% in the 30 kilometre reach (Sheets 6 to 10) as indicated in Figures 3 and 4. The average width of the floodplain in this reach is 700 metres and varies from a width of 100 metres (Burnt Bridge Creek alluvial fan area) to 1200 metres (1974 avulsion area downstream of the Burnt Bridge Creek confluence).

8.2 Tributary Alluvial Fans

Many of the tributary alluvial fans in the study area are known to be active based on documented (Appendix 3) information on flooding problems related to sediment deposition, channel avulsion and bank erosion. Following is a list of the fans outlined on the floodplain mapping sheets where topographic information is available and which are known to be active.

Tastsquan Creek	Sheet 1
Thorsen Creek	Sheet 2
Snootli Creek	Sheet 3
Nooklikonnik Creek	Sheets 3 and 4
Salloomt River	Sheets 4 and 5
Nusatsum River	Sheet 5
Burnt Bridge Creek	Sheets 9 and 10

As noted on the floodplain mapping sheets, the entire area of the tributary fans are subject to special flood hazards due to possible channel avulsion and erosion caused by channel accretion and/or debris jamming.

The location of other known fans have been noted on the drawings based on air photo interpretation and experience in the study area. The limits of these fans have not been delineated due to a lack of topographic data and/or documented information on flooding problems.

8.3 Tsunami

As stated in the attached report dated November, 1986, tsunami is a seismic sea wave which may be generated by an earthquake in the vicinity of, or under, the bottom of the ocean. Such events can be very destructive to communities situated at lower elevation in exposed coastal areas. The 1964 Alaska earthquake and subsequent tsunami created extensive damage to the British Columbia coast, particularly in the Port Alberni area on Vancouver Island. The flood level in the tsunami inundation area at the mouth of the Bella Coola River was set at 6.0 metres GSC datum based on information available for the November, 1986 study.

An evaluation of tsunami levels along the British Columbia coast is contained in a report dated March, 1988, prepared for the

Department of Fisheries and Oceans (Appendix 1.1). The maximum tsunami water level for the mouth of the Bella Coola River was determined to be 2.2 metres. The maximum astronomic tide at Bella Coola is 3.0 metres GSC datum (Appendix 1.6). Based on this information, a tsunami level of 5.2 metres has been adopted for administrative purposes for the tsunami inundation area at the mouth of the Bella Coola River.

9. Conclusions

1. This design brief presents an overview of the studies undertaken to produce the floodplain mapping sheets of the Bella Coola River from the Nusatsum River confluence, a distance of 30 kilometres upstream to the Burnt Bridge Creek confluence area. A previous report (Appendix 3) was issued which covers the 24 kilometres from tidewater to the Nusatsum River confluence.

2. The floodplain mapping is deemed to be preliminary as it is based on 2 metre contour intervals within the Bella Coola River floodplain. In addition, the existing contour mapping is not adequate to define the limits of a number of the tributary alluvial fans in the study area.

3. Problems related to flooding, major channel dislocations, sediment deposition, bank erosion and debris jamming have been recorded in many areas of the valley, located within the Bella Coola River floodplain and on the tributary fans, since the valley was settled in the early 1890s.

10. Recommendations

1. It is recommended that the floodplains delineated on Drawings 87-56, Sheets 1 to 10, 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; floodproofing requirements in zoning and building bylaws; and the identification of floodable lands by Subdivision Approving Officers.

3. Documentation of flooding problems and topographic information should be obtained to define the limits of the tributary alluvial fans in the study area and the results shown on future revisions to the existing floodplain mapping of the Bella Coola River.

4. A river corridor study should be undertaken to delineate a zone of probable erosion and channel avulsion activity within the Bella Coola River floodplain based on the evidence of historical channel mobility, the existing floodplain mapping and relevant geological features. Consideration of such a zone would facilitate administrative decisions regarding land use proposals in the floodplain.

5. High water data for a flood exceeding a 1:20 year frequency should be obtained in the future to verify the calibration of the existing river model.

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Special Projects Section

RWN/cv



STUDY AREA LOCATION

100 0 100 200 300 KILOMETRES

Province of British Columbia
Ministry of Environment
WATER MANAGEMENT BRANCH

TO ACCOMPANY REPORT ON
FLOODPLAIN MAPPING STUDY
BELLA COOLA RIVER

SCALE: VERT ..... HOR AS SHOWN

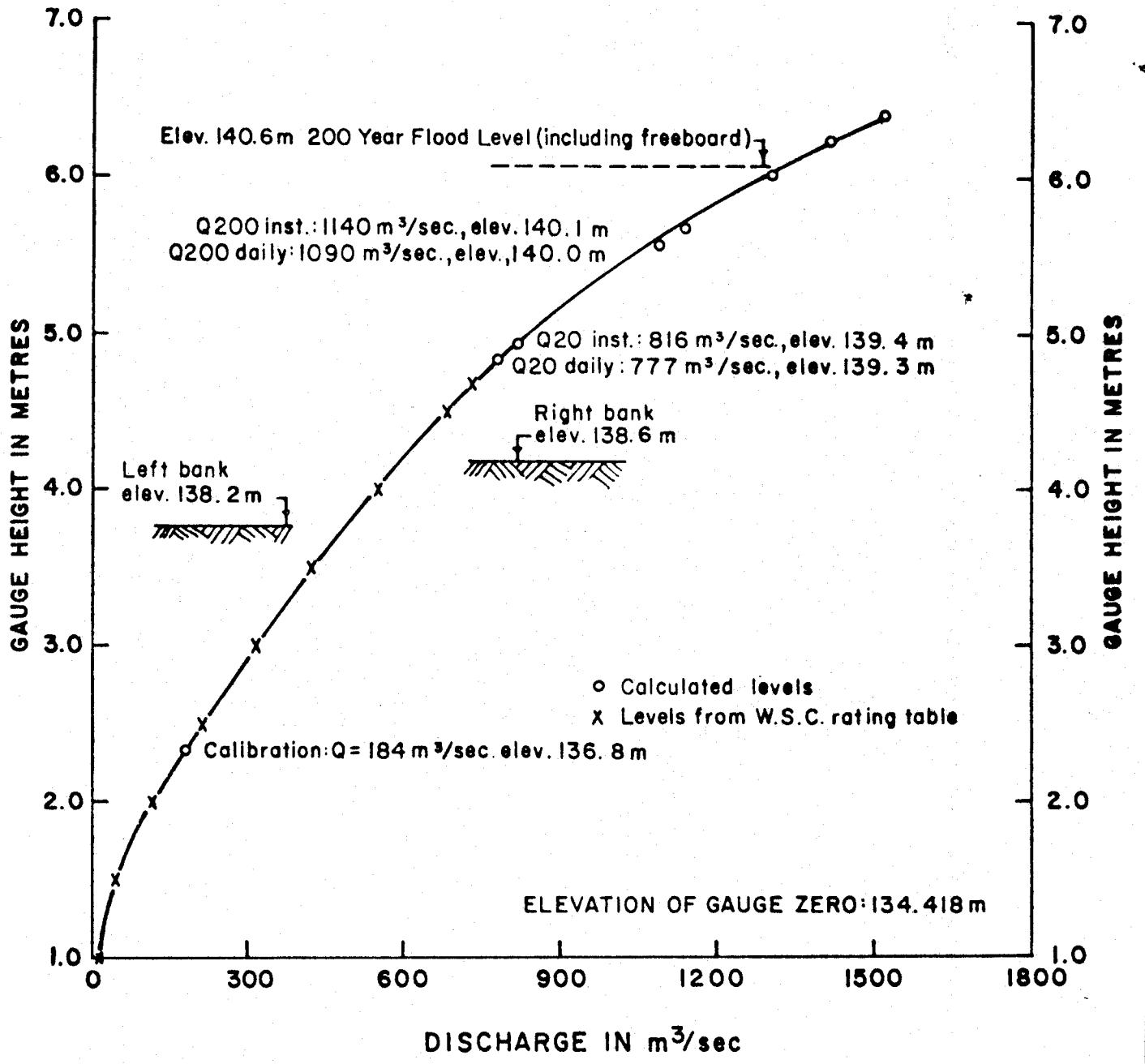
DATE FEBRUARY, 1988

R. W. NICHOLS ENGINEER

FILE No 91-2910-S.1 FIGURE 1

BCIL 7673-M E

STAGE-DISCHARGE CURVE, STATION No. 08FB007
BELLA COOLA RIVER ABOVE BURNT BRIDGE CREEK
LOCATED AT XS-50 (150)



Province of British Columbia
Ministry of Environment
WATER MANAGEMENT BRANCH

TO ACCOMPANY REPORT ON
FLOODPLAIN MAPPING STUDY
BELLA COOLA RIVER
TIDEWATER TO BURNT BRIDGE CREEK

SCALE: VERT AS SHOWN
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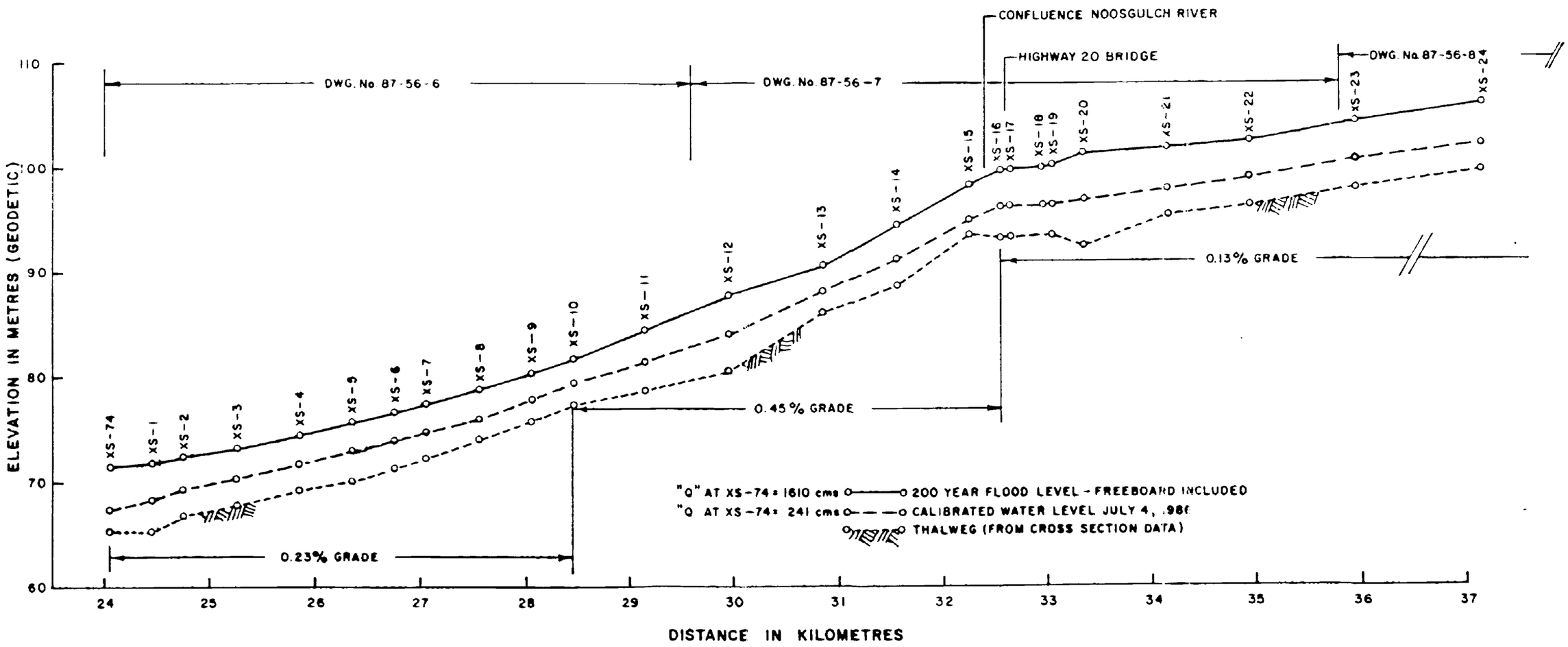
DATE
FEBRUARY, 1988

R. W. NICHOLS ENGINEER

FILE No 91-2910-S.1 FIGURE 2

BCIL 7573-M.E

BELLA COOLA RIVER
WATER SURFACE AND THALWEG PROFILES

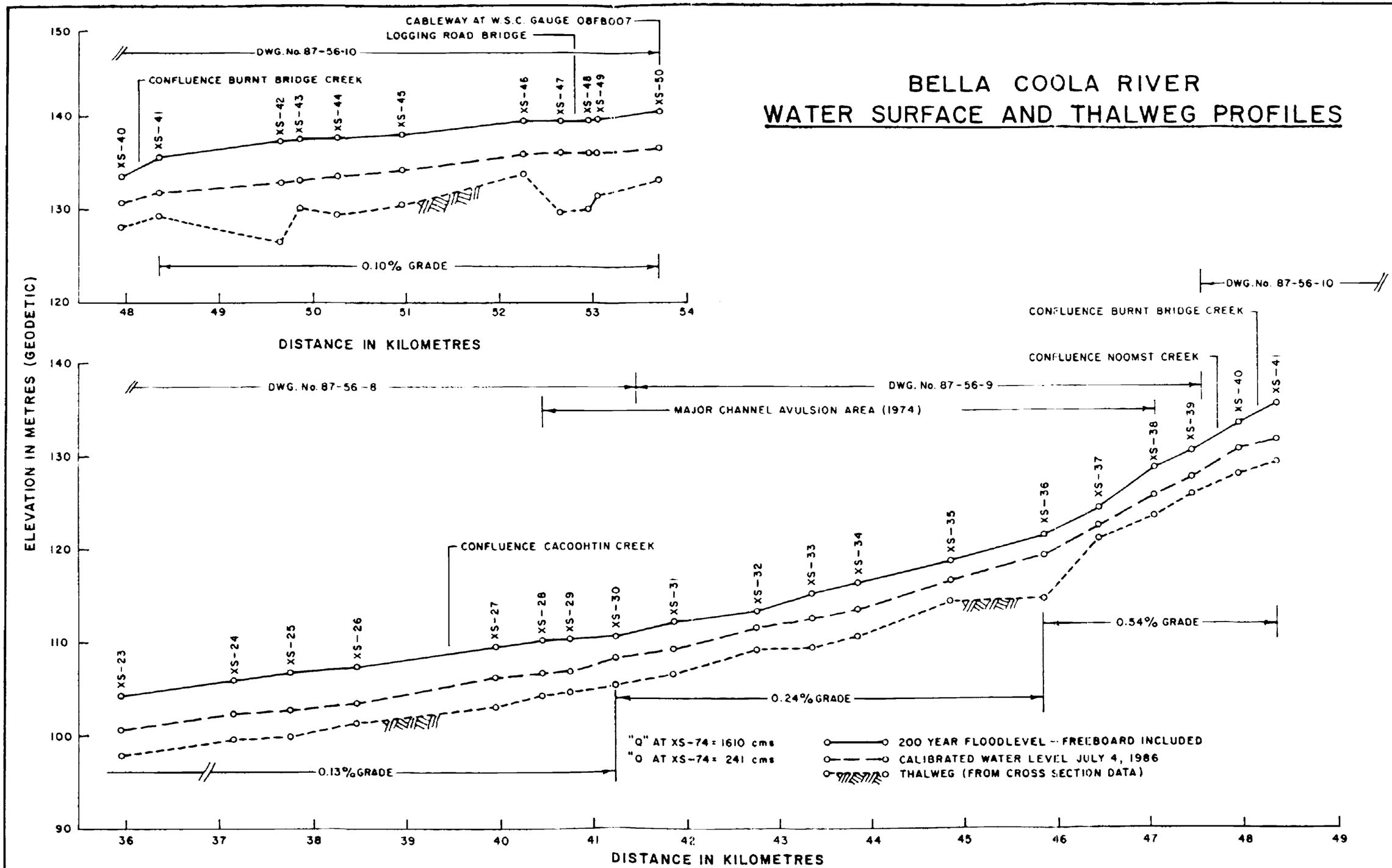


Province of British Columbia
Ministry of Environment
Water Management Branch

TO ACCOMPANY REPORT ON
FLOODPLAIN MAPPING STUDY
BELLA COOLA RIVER

SCALE: VERT. AS SHOWN	DATE
HOR. AS SHOWN	FEB. 1988
R. W. NICHOLS	ENGINEER
FILE No. 91-2910-8.1	FIGURE 3

BELLA COOLA RIVER
WATER SURFACE AND THALWEG PROFILES



Province of British Columbia
Ministry of Environment
Water Management Branch

TO ACCOMPANY REPORT ON
FLOODPLAIN MAPPING STUDY
BELLA COOLA RIVER

SCALE: VERT. AS SHOWN
HOR.
DATE FEB. 1988
R. W. NICHOLS ENGINEER
FILE No. 91-2910-S.1
FIGURE 4

APPENDIX 1

Detailed Information Sources

Bella Coola River Floodplain Mapping Study

NO.	SOURCE	CONTENTS
1.	Final report "Evaluation at Tsunami Levels Along the British Columbia Coast" prepared for Department of Fisheries and Oceans Sciences by Seaconsult Marine Research Ltd. March, 1988	Maximum tsunami water levels and currents have been computed. The model predictions have been verified against tide gauge data from the March 28, 1964 Alaska earthquake.
2.	Memo Re: "Bella Coola River Survey Requirements for Flood Profile Determination" dated June 11, 1981, File: 0310213-12 to R. G. Fernyhough, Surveys Subsection from R. W. Nichols, Planning Subsection, Ministry of Environment.	Locations of 112 river cross sections on the Bella Coola River and tributaries provided on air photo mosaics from tidewater to the Burnt Bridge Creek confluence area.
3.	Surveys Section, Water Management Branch, Victoria, Project No. 86-FDC-1, Ministry of Environment & Parks.	2 volumes containing 50 cross sections, profiles, photographs of cross sections and air photo mosaics showing locations of cross sections and reference points.
4.	Mapping Section, Surveys & Resource Mapping Branch, Ministry of Environment & Parks, Project No. 83-101T.	Topographic base mapping of the Bella Coola River, 1:5000 scale at 2 metre contour intervals based on August 18, 1982 air photography.
5.	Memo to R. W. Nichols from C. H. Coulson dated October 13, 1987, File: S2103. Re: "Bella Coola River, July 4, 1986."	Flow estimates along the Bella Coola River for July 4, 1986.
6.	"Canadian Tide and Current Tables" Pacific Coast 1988, published by Canadian Hydrographic Services, Fisheries and Oceans Canada.	Tides and current tables published through the Chief, Tides Currents and Water Levels, Canadian Hydrographic Service.
7.	"1978 Terrace Area Flooding" by McMullen, Talbot and Woods, Ministry of Environment, dated January, 1979 File: P78-42.	A brief description of stream related problems resulting from exceptional rainfall in November, 1978 in northwestern British Columbia.

APPENDIX 2

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Bella Coola River Floodplain Mapping Study

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1	1	Thorsen Creek - Bella Coola River 1968 flood. Photo provided by Ministry of Transportation and Highways (M.O.T.H.) Location - Drwg. 87-56-2 near confluence area.
1	2	Slumping and erosion on right bank of Bella Coola River, June, 1986. Location - Drwg. 87-56-2 at XS-68
2	3	Left bank of Bella Coola River showing trees cabled to reduce bank erosion, June, 1986. Location - Drwg. 87-56-2 near XS-54.
2	4	Airport area flooded due to dyke breach in 1968. Photo provided by M.O.T.H. Location - Drwg. 87-56-3.
3	5	Bella Coola River 1968 flood showing inundation of Highway 20 at Hagensborg Hotel. Photo provided by M.O.T.H. Location - Drwg. 87-54-4
3	6	Mr. Sollids' home opposite Highway 20 at Hagensborg, June, 1986. Property was inundated to the top of the basement window in 1936. (Reference November 1986 Report, Section 2.3.2) Location - Drwg. 87-56-4
4	7	Nooklikonnik Creek fan at confluence with Bella Coola River. Note channel deposition, November 8, 1978 Location - Drwg. 87-56-4
4	8	Salloomt River fan just upstream of Bella Coola River confluence, November 8, 1978. Note debris and channel migration. Location - Drwg. 87-56-5

APPENDIX 2

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Bella Coola River Floodplain Mapping Study

(Continued)

Photo Sheet Number	Photo Number	Description
5	9	Salloomt River, November 29, 1978. Debris in former channel. Location - Drwg. 87-56-5
5	10	Nusatsum River fan area upstream of Bella Coola River confluence, June 1986. Note evidence of channel avulsion, bank erosion and bed load deposition. Location - Drwg. 87-56-5
6	11	Abandoned home on right bank of Bella Coola River, June 1986. The main channel shown in the photo was farmland prior to the 1974 major channel avulsion in this reach. Location - Drwg. 87-56-6 between XS-31 and 32
6	12	Burnt Bridge Creek fan downstream of Highway 20 showing channel avulsion area, November 3, 1978. Location - Drwg. 87-56-10

APPENDIX 2

Bella Coola River
Floodplain Mapping Study
Photos of Study Area



Photo 1



Photo 2

APPENDIX 2

Bella Coola River
Floodplain Mapping Study
Photos of Study Area



Photo 3



Photo 4

APPENDIX 2

Bella Coola River
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Photos of Study Area



Photo 5



Photo 6

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Bella Coola River
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Photos of Study Area



Photo 7



Photo 8

APPENDIX 2

Bella Coola River
Floodplain Mapping Study
Photos of Study Area



Photo 9



Photo 10

APPENDIX 2

Bella Coola River
Floodplain Mapping Study
Photos of Study Area

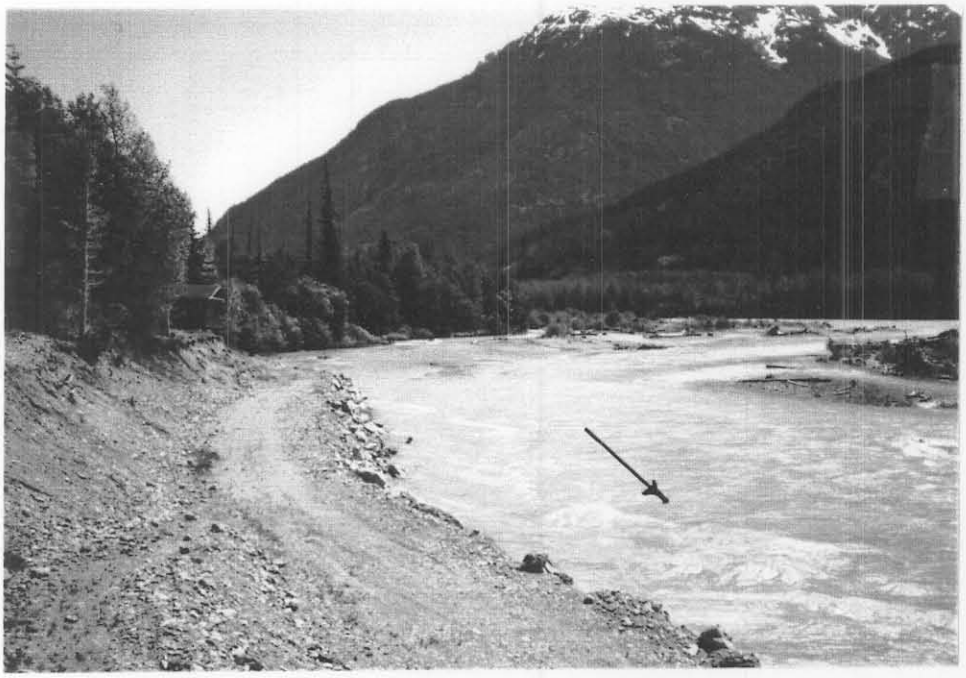


Photo 11

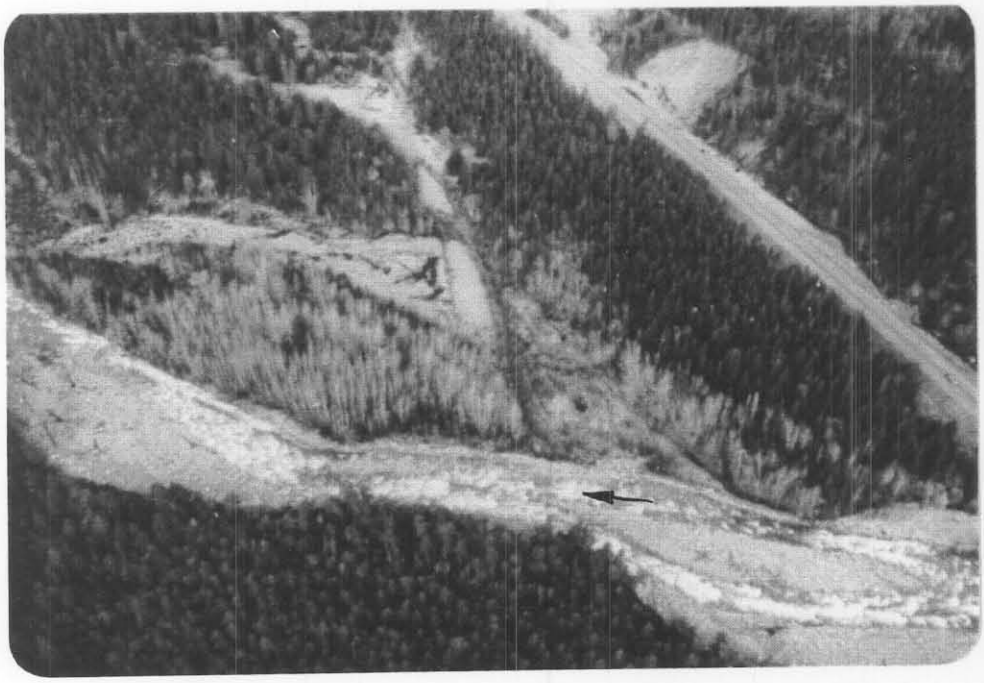


Photo 12

APPENDIX 3

"Report on the Floodplain Mapping Study,
Bella Coola River" by R.W. Nichols, P. Eng.
November, 1986, File: 91-2910-S.1

PROVINCE OF BRITISH COLUMBIA

MINISTRY OF ENVIRONMENT AND PARKS

WATER MANAGEMENT BRANCH

Report on the Floodplain Mapping Study

BELLA COOLA RIVER

An Overview of the Study Undertaken to Produce Floodplain Mapping for the Bella Coola River from tidewater to the Nusatsum River confluence

by

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Senior Hydraulic Engineer
Special Projects Section

Victoria, B.C. November 1986
File: 91-2910-S.1

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Appendix 1 - Detailed Information Sources used in the Floodplain Mapping Study

Appendix 2 - Floodplain Mapping, Bella Coola River Drawing 86-14, Sheets 1 to 5

REPORT ON THE FLOODPLAIN MAPPING STUDY BELLA COOLA RIVER

Preface

The purpose of this report is to present a description of the methodologies used and results of the study undertaken to produce the floodplain mapping sheets of the Bella Coola River shown in Appendix 2. Detailed information sources used in the study are available from sources listed in Appendix 1.

1. Location

The study area is located 300 kilometres west of Williams Lake, as shown in Figure 1. Highway 20, which provides the only road access from Williams lake to the study area is 465 kilometres in length.

Elevation in the watershed varies from tidewater at the mouth of the Bella Coola River to above 3,000 metres. There are several glaciers located in the higher elevations of the watershed. Figure 2 indicates the watershed boundaries of the Bella Coola River and the location of the floodplain mapping study area.

The drainage area of the Bella Coola River above tidewater exceeds 5100 sq. km. As indicated in Figure 2, two of the main tributaries, the Salloomt and Nusatsum Rivers are located within the study area and have drainage areas of approximately 160 and 270 sq. km., respectively. The main tributaries upstream of the study area are the Talchako and Atnarko Rivers having drainage areas of 1035 and 2590 sq.km., respectively. Figure 2 also indicates the boundary of Tweedsmuir Provincial Park which extends into the Bella Coola River watershed.

2. Background

2.1 General

The Bella Coola gap was the route used by Alexander MacKenzie to cross to the Pacific in 1793. Settlement of the valley by Norwegian colonists began in the early 1860's and in 1884 a settlement was established at Hagensborg.

Information related to development in the Bella Coola Region is available in a Regional Study (Appendix 1.1) undertaken by the British Columbia Forest Service in December 1974 to evaluate integrated resource use constraints related to wood allocation. The report outlines community, transportation, industry and human resource development in the region.

... 2

2.2 Channel Avulsion and Bank Erosion

The Bella Coola is an alluvial, meandering river which is capable of moving large volumes of sediment and debris during high flow periods. Numerous main channel avulsions have been recorded over the past 100 years. The report by Church and Russell (Appendix 1.2) provides general information related to the river regime. Problems related to flooding, major channel dislocations and bank erosion have been ongoing since the valley was settled by the Norwegian colonists. The report by Tempest (Appendix 1.3) indicates that over $1 million in expenditures were made by the Province between 1925 - 1974 for bank protection, tributary clearing and road and bridge repairs. Information related to the flooding problems in the Bella Coola valley is also available in files of the Rivers Section, Water Management Branch in Victoria. (Appendix 1.4)

During the river survey carried out in 1981 (Appendix 1.5) heavy bank erosion was observed at cross sections noted in Figures 3 and 4. At cross section 46 and 48, a recent channel dislocation combined with heavy bank erosion was observed. Large trees were falling into the river at the time of the survey and survey monuments had to be re-established due to bank erosion. At cross section 54, attempts to prevent bank erosion have been made by the cabling of felled trees along the river bank. Similar problems were noted during a site visit by members of the Special Projects Section in June of 1986. (Appendix 1.6)

The report by Tempest (Appendix 1.3) states that an average width of 60 metres of bank was lost between 1961 and 1974 on the south bank of the river upstream from the Thorsen Creek confluence (Figure 3). Six hundred metres of bank was revetted with rock rip-rap in this area in 1974.

As an example of a major channel avulsion in the Bella Coola valley, just downstream of the Burnt Bridge Creek confluence a channel relocation took place in 1974 as outlined in the report by Hart (Appendix 1.7). Figure 2 indicates the location of Burnt Bridge Creek which is upstream of the present floodplain mapping study area. Problems related to existing development as a result of this channel dislocation are documented on files in the Rivers Section, Water Management Branch (Appendix 1.4). Experience indicates that major channel avulsions occur rapidly during high flow periods and remedial works to lessen flood damage during the event is impractical.

Historic channel shifting is noted in the Hart report (Appendix 1.7) from the Burnt Bridge Creek confluence to tidewater. A high channel rating was given where shift rates were estimated to exceed one percent of channel width per year, including channel dislocations by

... 3

avulsion or meander cut off. A high channel shift rating was given to 29.2 kilometres of the 50.0 kilometre reach studied. A high channel shift rating was given to the area at cross sections 46 and 48 and the area downstream of the Burnt Bridge Creek confluence as outlined above. The area upstream of the Thorsen Creek confluence was also given a high rating for channel shifting.

The Hart Report (Appendix 1.7) provides detailed information on the limits of the Bella Coola River channel locations, dating back to 1893, in the study area.

2.3 Field Reconnaissance, 1986

2.3.1 Photographs of Area

A reconnaissance of the Bella Coola valley was made by staff members of the Special Projects Section in June of 1986. A number of photographs were taken of the study area including the area around Burnt Bridge Creek. Photographs taken during previous floods were provided by personnel of the Ministry of Transportation and Highways located in Hagensborg. The photos and comments noted, which provide an indication of the existing problems related to channel avulsion, bank erosion, sediment deposition and flood levels in the valley, are available in the Special Projects Section (Appendix 1.6). A river jet boat provided by the Surveys Section was used in the field reconnaissance of the area.

2.3.2 Interview with Long Term Residents

Mrs. Mikkelson lives along Grant Road opposite XS-53 (Appendix 2, Drawing 86-14, Sheet 2) in a home built in 1948. Mrs. Mikkelson indicated that the basement of her home had been flooded several times but did not perceive channel avulsion as being a threat to her home and property.

Mr. Sollid's home, located between XS-79 and 80, (Appendix 2, Drawing 86-14, Sheet 4) was inundated to the top of the basement window in the flood of 1936 (magnitude not recorded) to elevation 46.5 metres, G.S.C. datum. The 1:200 year flood level at this location (freeboard included) is estimated to be one metre higher than the 1936 flood. Mr. Sollid reported that a barn, located on the south side of the highway, floated away in 1936. Large logs have been deposited during high flow periods on the Sollid property creating high velocities in the immediate vicinity and resulting in scour holes up to 2 metres deep. Mr. Sollid's experience indicates that fencing (now removed) created a local backwater effect during recent high floods. Mr. Sollid also indicated that the floods of 1932 and 1934 were of significance. (Confirmed by Tempest report, Appendix 1.3).

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Mr. Norman Saugstad indicated that his mother arrived as a settler in the Bella Coola valley in the fall of 1898. Soon after her arrival, the valley was completely inundated by a major flood of unknown magnitude which apparently exceeded the 1936 flood. Mr. Saugstad also stated that the presently inactive river channels north of the Sollid homesite were used in the past by local residents to travel to the Hagensborg store by canoe.

Mr. Odegaard's property is located near the airport opposite XS-23 (Appendix 2, Drawing 86-14, Sheet 3). He indicated that the property was inundated in 1936, and that flooding of the airport lands occured in January 1968. Mr. Odegaard indicated that the area known as Walker Island, located downstream of the airport, was inaccessible in the 1930's as the main river channel was adjacent to Highway 20. (Confirmed by Hart Report, Appendix 1.6). As indicated on Drawing 86-14, Sheet 3, the present main river channel is located north of Walker Island.

The owner of Mecham's garage provided information on levels associated with the January 1965 flood. Photos provided by the Ministry of Highways indicate the highway in the Hagensborg area was completely inundated in 1968 (Appendix 1.6).

Messrs. Sollid, Saugstad and Odegaard, being long term residents and having experienced the floods of the 1930's and the more recent floods of 1965 and 1968, are well aware of the dangers inherent in living within the Bella Coola floodplain. They stated that recent arrivals to the valley will occasionally seek advice on homesite locations with respect to the flood hazard. However, such advice is often ignored as the newcomers refuse to accept the experience of these long term residents.

3. Designated Flood

In accordance with the policy of the Ministry of Environment and Parks, the flood levels and floodplain limits shown on the floodplain mapping sheets are based on a designated flood (1:200 year daily) plus an allowance for freeboard of 0.6 metres.

4. Survey Data

Survey data on the Bella Coola River used in the study was obtained in the field by the Surveys Section in the summer of 1981. Additional data was available on the Bella Coola River as a result of surveys undertaken in 1968 (Appendix 1.5). High water profile information for the Bella Coola River was obtained during the survey on July 16, 1981.

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Topographic base mapping of the Bella Coola valley was produced by the Mapping Section, Surveys and Mapping Branch, Ministry of Environment and Parks (Appendix 1.8). The mapping is at a 1:5000 scale with 2 metre contour intervals and was based on air photos obtained on August 18, 1982.

5. Flood Magnitudes

5.1 General

The Hydrology Section, Water Management Branch, carried out a study to determine peak flows at a number of locations along the lower Bella Coola valley (Appendix 1.9).

The lower reaches of the river are subject to high peak flows from three distinct causes. The first is the annual flood resulting from the melting of the seasonal snowpack, this event normally occurs in the May - June period. High peak flows occasionally occur during the August - September period which are due to intense summer rain occurring with heavy glacier melt. The third cause is that which has produced the greatest floods on record but is not an event which occurs every year - the heavy warm rain falling on a shallow snowpack event normally occurring in the October - January period.

Continuous hydrometric data is available for three hydrometric gauges in the lower Bella Coola River area. For the study, flow data for the period 1965 through 1984 (20 years) was utilized from these gauges, which are located as indicated on Figure 2: Bella Coola River above Burnt Creek Bridge (8FB007), Nusatsum River near Hagensborg (8FB005), and Salloomt River near Hagensborg (8FB004).

5.2 Frequency Analysis

Frequency analyses were completed for each of the three gauges used in this study. Maximum annual events were selected using the climatic year beginning March 1st. Twenty years of annual maximums for both daily and instantaneous were analized (estimates of missing data were used where necessary). The computer results were reviewed and the log-Pearson type III distribution was selected as best fit overall for the data sets. Table 1 lists the results of the frequency analysis for Station 8FB007. Results for the 20-year and 200-year events are as follows:

		Flow - cms	
Gauge	Condition	20-Year	200-Year
8FB007	instantaneous	816	1142
8FB005	instantaneous	250	326
	daily	172	283
8FB004	instantaneous	173	323
	daily	120	208

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5.3 January 1968 Flood

The period January 22 to 24, 1968 brought extremely heavy warm rain to the Bella Coola River basin. This rain fell on a snowpack which was not yet deep enough to absorb the warm rain and as a result the snow melted and both rain and snowmelt contributed to the resulting flood. This storm event produced the highest flow observed in the Bella Coola River since 1947 when continuous records begin.

This peak flow event is used as the basis of this study, the 20-year and 200-year events have been sized in proportion to the 1968 event. Hourly flow data for the three gauges during the flood was obtained from Water Survey of Canada; the hourly hydrographs were plotted, smoothed and compared. The two tributary hydrographs were found to be quite different with the Nusatsum River reacting quickly to the beginning and end of storm while the Salloomt River reacts slower and has a much extended recession.

The hourly hydrographs for the ungauged tributaries along the lower Bella Coola River were estimated. Tributaries entering from the north side were assumed to be similar to the Salloomt River and those from the south similar to the Nusatsum River. Hydrograph coordinates for the ungauged tributaries were estimated from unit hydrograph techniques with

time proportional to $(L.L_{CA})^{0.3}$

flow proportional to $\dfrac{A}{(L.L_{CA})^{0.3}}$

where L is length of longest stream channel
L_{CA} is length from mouth to centre of area
A is watershed area.

These derived tributary inflows with appropriate time lag were added to the observed upstream flow at 8FB007. This reproduced flows during the January 1968 flood from the gauge above Burnt Bridge Creek to the mouth. As the results were compatible with other limited data available the method was utilized to estimate return period flows.

5.4 20-Year and 200-Year Peak Flow

It was assumed that the 20-year and 200-year peak flow events were the result of conditions similar to that of January 1968. The mainstem and derived tributary hydrographs were modified from unit hydrograph techniques by the ratio of the peak instantaneous 20 or 200-year flow to that of the January 1968 flow for gauge 8FB007.

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These ratios were: 20-year = 0.983
200-year = 1.373

The modified tributary hydrographs were added to the modified upstream hydrograph with appropriate time lags to estimate flows along the lower reaches of the mainstem for both the 20-year and 200-year events. Maximum hourly and maximum 24-hourly flows were extracted from the results. Because the timing of this type of event is essentially unrelated to the diurnal cycle maximum 24-hourly flow is extracted rather than the maximum daily flow.

5.5 Study Results

Results of the study are summarized as follows:

LOCATION	20-Year Peak		200-Year Peak	
	Inst. cms	24-hr. cms	Inst. cms	24-hr. cms
above Burnt Bridge Cr.	816	777	1140	1090
below Burnt Bridge Cr.	987	930	1400	1320
above Cacoohtin Cr.	1040	970	1470	1380
below Cacoohtin Cr.	1050	982	1490	1390
above Noosgulch R.	1080	1000	1530	1430
below Noosgulch R.	1180	1090	1680	1550
above Nusatsum R.	1220	1130	1740	1610
below Nusatsum R.	1290	1190	1850	1700
above Salloomt R.	1290	1190	1850	1700
below Salloomt R.	1390	1280	2000	1850
above Nooklikonnik Cr.	1420	1310	2040	1880
below Nooklikonnik Cr.	1430	1320	2050	1890
above Snootli Cr.	1440	1340	2080	1920
below Snootli Cr.	1450	1350	2090	1930
above Thorsen Cr.	1450	1350	2090	1940
below Thorsen Cr.	1460	1370	2100	1960
at tidewater	1470	1370	2110	1970

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6. Hydraulic Analysis

6.1 General

The information sources listed in Appendix 1 were utilized in the HEC-2 water surface profile computer program developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, in Davis, California.

Flood profiles were calculated for the Bella Coola River from tidewater to the Nusatsum River confluence, a distance of 24 kilometres. A plot run of river cross sections was obtained. An assessment was made of the river survey data and the extensions of the cross sections which were obtained from the existing topographic mapping. Output from the plot runs were also used to review other data such as flow regime, loss coefficients, bridge information, reach lengths, overbank information and relative Manning's "n" values. Following is an overview of the additional computer runs for the study area.

6.2 Model Calibration

The river model was calibrated to match the observed water levels obtained during the field survey on July 16, 1981 (Appendix 1.5). The flow at tidewater was estimated to be 355 cms, decreasing to 269 cms above the Nusatsum River confluence. (Appendix 1.9) Observed water level data at the 38 locations in the study area averaged to within 0.2 metres of the computed levels. Manning's "n" values for the river channel averaged 0.035.

The calibrated model was used to compare observed high water levels obtained for the June 26, 1968 flood as noted in the Tempest report (Appendix 1.3). A total of 5 observed levels were available for comparison and the computed levels averaged to within 0.2 metres of that observed. Flows at tidewater for the June 26, 1968 flood were estimated to be 739 cms, decreasing to 584 cms above the Nusatsum River confluence. (Appendix 1.9)

The water surface profiles for the calibration flows are indicated in Figures 3 and 4 attached. As shown, the average gradient of the Bella Coola River is 0.24% from tidewater to cross section 24, a distance of 13 kilometres. From cross section 24, upstream to cross section 74, a distance of 11 kilometres, the average gradient increases to 0.33%.

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6.3 Calculated Flood Levels

Flood levels were calculated using Manning's "n" values obtained from the model calibration studies for the 1:20 year and 1:200 year daily and instantaneous flows listed in Section 5.

The 1:20 year and 1:200 year flood levels shown on the floodplain mapping sheets were based on the daily flows and include a 0.6 metre freeboard allowance. It was determined that the daily flow levels plus 0.6 metres freeboard slightly exceeded the instantaneous flow levels plus 0.3 metres freeboard for both the 1:20 and 1:200 year flood events.

The tidal range at Bella Coola is 6.4 metres. The high water extreme tide, approximately 3.2 metres GSC datum, was used in the flood profile studies. The tsunami flood level of 6.0 metres, discussed in Section 7.3, extends just upstream of XS-42 as indicated in Figure 3.

The water surface profile for a 1:200 year daily flow (0.6 metre freeboard included) is shown on Figures 3 and 4.

6.4 Sensitivity Studies

Calculations were undertaken in order to indicate the sensitivity of the model to flows which exceed the 1:200 year daily flow of 1970 cms at tidewater. Flood levels for a flow increase of 20% (2,360 cms) at tidewater was determined. Levels would rise an average of 0.4 metres for the higher flow, which is within the freeboard allowance of 0.6 metres.

An indication of the sensitivity of the model to increases in channel "n" values was determined. An average channel "n" value increase from 0.035 to 0.045 results in flood levels in the study area increasing by an average of 0.4 metres for a 1:200 year daily flow of 1970 cms, which is within the freeboard allowance.

7. Floodplain Mapping

7.1 General

The flood levels determined in the study were used to locate the designated floodplain limits onto the existing 2 metre contour mapping of the study area.

The floodplain mapping of the Bella Coola River, Drawing 86-14, Sheets 1 to 5, (Appendix 2) were produced and provide the following information:

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- the location of river cross sections, the designated floodplain limits, the flood levels determined in the study and the location of survey monuments are indicated.

- the study area covers a distance of 24 kilometres from tidewater to the Nusatsum River confluence.

- the Bella Coola River has an average gradient of 0.24% from tidewater to the vicinity of the Bella Coola airport, a distance of 13 kilometres. The average gradient increases to 0.33% in the remaining 11 kilometres of the study area.

- the Bella Coola is an alluvial, meandering river capable of moving large volumes of sediment and debris during high flow periods. Numerous main channel avulsions have been recorded and historic channel shifting is evidenced in the topographic information on the floodplain mapping sheets. Detailed information of the limits of the historic channel locations, dating back to 1893, is provided in the Hart Report (Appendix 1.7).

7.2 Tributary Alluvial Fans

The limits to the alluvial fans of Tastsquam Creek, Thorsen Creek, the Salloomt River and the Nusatsum River are indicated on Floodplain Mapping sheets 1, 2, 4 and 5, respectively.

Detailed topographic information is not available to adequately define the limits of the alluvial fans of other tributaries in the study area including Snooti Creek and Nooklikonnik Creek. A request has been made to Surveys and Mapping Branch to provide the necessary topographic data in these areas.

As noted on the floodplain mapping sheets, the entire area of the tributary fans are subject to special flood hazards due to possible channel avulsion and erosion caused by channel accretion and/or debris jamming.

7.3 Tsunami

Tsunami is a seismic sea wave which may be generated by an earthquake in the vicinity of, or under, the bottom of the ocean. Such events can be very destructive to communities situated at low elevation in exposed coastal areas. The 1964 Alaska earthquake and subsequent tsunami created extensive damage to the British Columbia coast, particularly in the Port Alberni area on Vancouver Island.

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A report entitled "Tsunami Warning Plan" (Appendix 1.10) rates municipalities along coastal British Columbia as low, medium or high vulnerability to tsunami. Bella Coola is rated as being in an area of high vulnerability. It is the practice of the Ministry of Environment and Parks that flood levels in areas of high tsunami vulnerability be 4.0 metres above the natural boundary of the sea where no site specific records of past tsunami levels are available. The flood level in the tsunami inundation area at the mouth of the Bella Coola River has accordingly been determined to be 6.0 metres, GSC datum, as indicated on Drawing 86-14, Sheet 1.

8. Conclusions:

1. This report presents an overview of the studies undertaken to produce the floodplain mapping sheets of the Bella Coola River from tidewater to the Nusatsum River confluence, a distance of 24 kilometres.

2. The floodplain mapping is deemed to be preliminary as it is based on 2 metre contour intervals within the Bella Coola River floodplain. In addition, the existing contour mapping is not adequate to define the limits of a number of the tributary alluvial fans in the study area.

3. Problems related to flooding, major channel dislocations, sediment deposition, bank erosion and debris jamming have been recorded in many areas of the valley, located within the Bella Coola River floodplain and on the tributary fans, since the valley was settled in the early 1890's.

9. Recommendations:

1. The floodplain mapping of the Bella Coola River may be used for administrative purposes related to the preparation of hazard map schedules for official plans; floodproofing requirements in zoning and building bylaws; and the identification of floodable lands by Subdivision Approving Officers, provided that cognizance is taken of Recommendation 2 below.

2. Development of properties should be discouraged in the following areas, as experience indicates that such development would be placed in an untenable position unless comprehensive protective works are constructed;
   - within areas of the Bella Coola River floodplain that are subject to the ongoing hazard of channel avulsions,
   - within all alluvial fans of the tributaries to the Bella Coola River.

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3. The necessary topographic information should be obtained to define the limits of the tributary alluvial fans in the study area and the results shown on future revisions to the existing floodplain mapping of the Bella Coola River.

4. A river corridor study should be undertaken to delineate a zone of probable erosion and channel avulsion activity within the Bella Coola River floodplain based on the evidence of historical channel mobility, the existing floodplain mapping and relevant geological features. Consideration of such a zone would facilitate administrative decisions regarding land use proposals in the floodplain.

R. W. Nichols, P. Eng.
Sr. Hydraulic Engineer
Special Projects Section

RWN:ja

Attachment

TABLE 1

BELLA COOLA RIVER ABOVE BURNT BRIDGE CREEK STN NO 08FB007 DA 3730 SQ KM
MAXIMUM INSTANTANEOUS DISCHARGE IN CUBIC METERS PER SECOND 1965-84

LOG-PEARSON TYPE III -METHOD OF MOMENTS

MEAN= 6 17 S D = 0 31 SKEW COEF = 0 2543

A= 0 39266E-01 B= 60 8619 MU= 3 7427

TABLE OF ESTIMATES AND STATISTICAL MEASURES OF THEIR ACCURACY

PROBABILITY	RECURRENCE INTERVAL (IN YEARS)	ESTIMATE	STANDARD ERROR OF ESTIMATE	UPPER 95% CONFIDENCE LIMIT	LOWER 95% CONFIDENCE LIMIT	RETURN PERIOD PEAK FLOW TO MEAN PEAK FLOW RATIO
0 9990	1 0010	206 08740	29 651801	277 29135	153 16748	0 41
0 9500	1 0526	294 95109	28 211318	359 85038	241 75644	0 59
0 8000	1 2500	368 24436	27 542890	430 37732	315 08145	0 73
0 5000	2 0000	472 81055	32 602663	545 94755	409 47123	0 94
0 2000	5 0000	618 38639	53 779089	741 10821	515 98636	1 23
0 1000	10 0000	716 95666	74 442657	889 50209	577 88155	1 43
0 0500	20 0000	815 51544	98 469689	1047 2548	635 05597	1 63
0 0400	25 0000	844 32066	106 01352	1094 8791	651 10143	1 68
0 0200	50 0000	941 41498	132 94606	1259 9367	703 41804	1 88
0 0100	100 0000	1040 5227	162 57693	1435 0268	754 47194	2 07
0 0050	200 0000	1142 4298	195 04038	1621 3989	804 95054	2 28
0 0020	500 0000	1282 4187	242 58761	1887 0166	871 53321	2 56
0 0010	1000 0000	1392 8957	282 30413	2103 9077	922 16901	2 78

INPUT DATA

776 000	405 000	828 000	468 000	614 000	331 000	436 000	524 000
682 000	453 000	368 000	564 000	317 000	518 000	394 000	725 000
321 000	601 000	317 000	389 000				

NO OF INPUT DATA VALUES	20
MAXIMUM	828 000
MINIMUM	317 000
RANGE	511 000
MEDIAN	460 500
MEAN	501 550
VARIANCE	25293 1
STANDARD DEVIATION	159 038
COEFFICIENT OF VARIATION	0 317093
COEFFICIENT OF SKEW	0 659385

Note: Information Source Appendix 1.9



STUDY AREA LOCATION

100 0 100 200 300
KILOMETRES

Province of British Columbia
Ministry of Environment and Parks
WATER MANAGEMENT BRANCH

TO ACCOMPANY REPORT ON
FLOODPLAIN MAPPING STUDY
BELLA COOLA RIVER

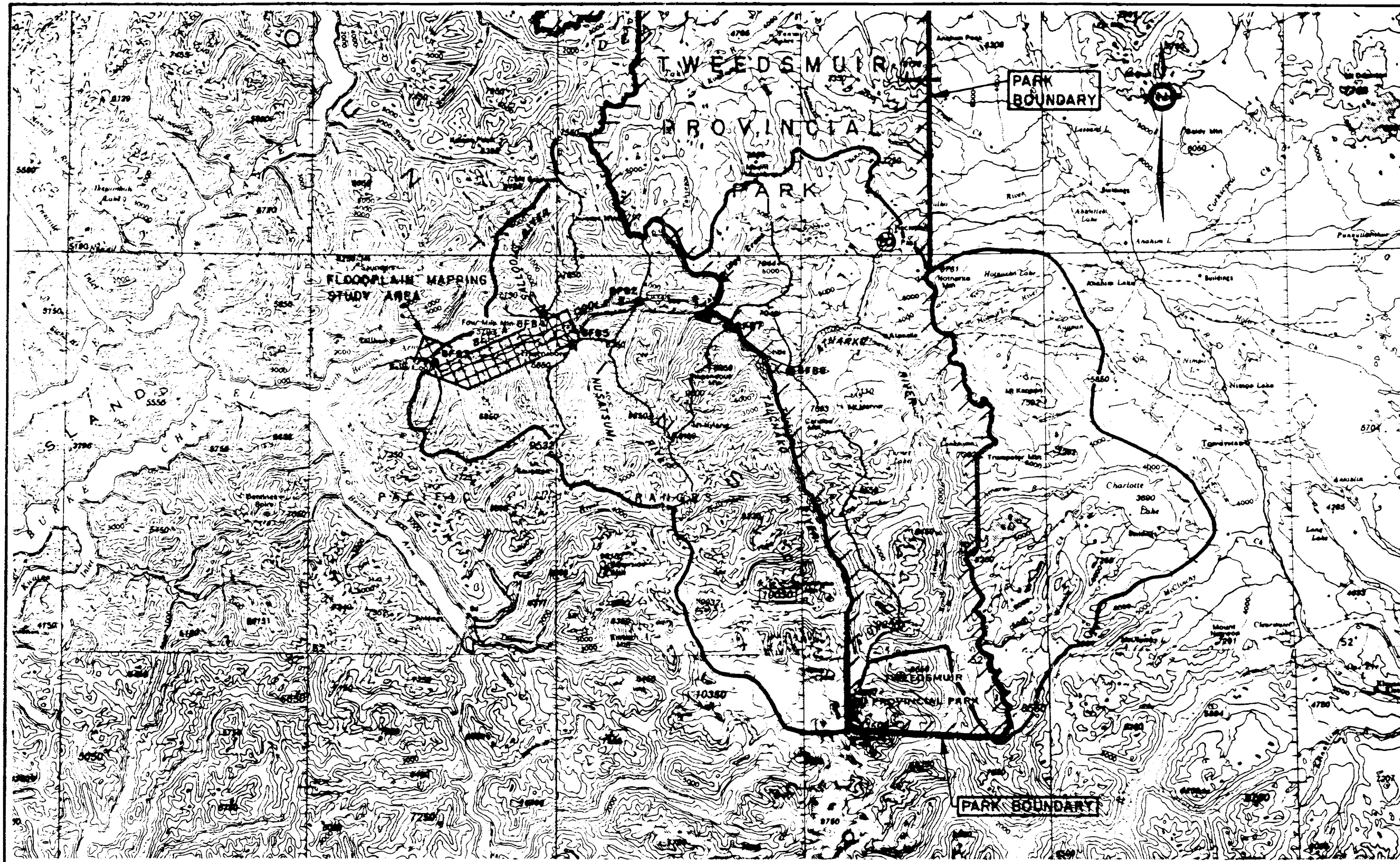
SCALE: VERT ..... HOR AS SHOWN

DATE NOVEMBER, 1986

R.W. NICHOLS ..... ENGINEER

FILE No 91-2910-S.1 Figure No. 1

BCIL 7873-M E



BELLA COOLA RIVER DRAINAGE

- BELLA COOLA RIVER WATERSHED BOUNDARY
- BOUNDARY OF WATERSHED AT GAUGING STATIONS
- ● LOCATION OF GAUGING STATION

Province of British Columbia
Ministry of Environment and Parks
Water Management Branch

TO ACCOMPANY REPORT ON

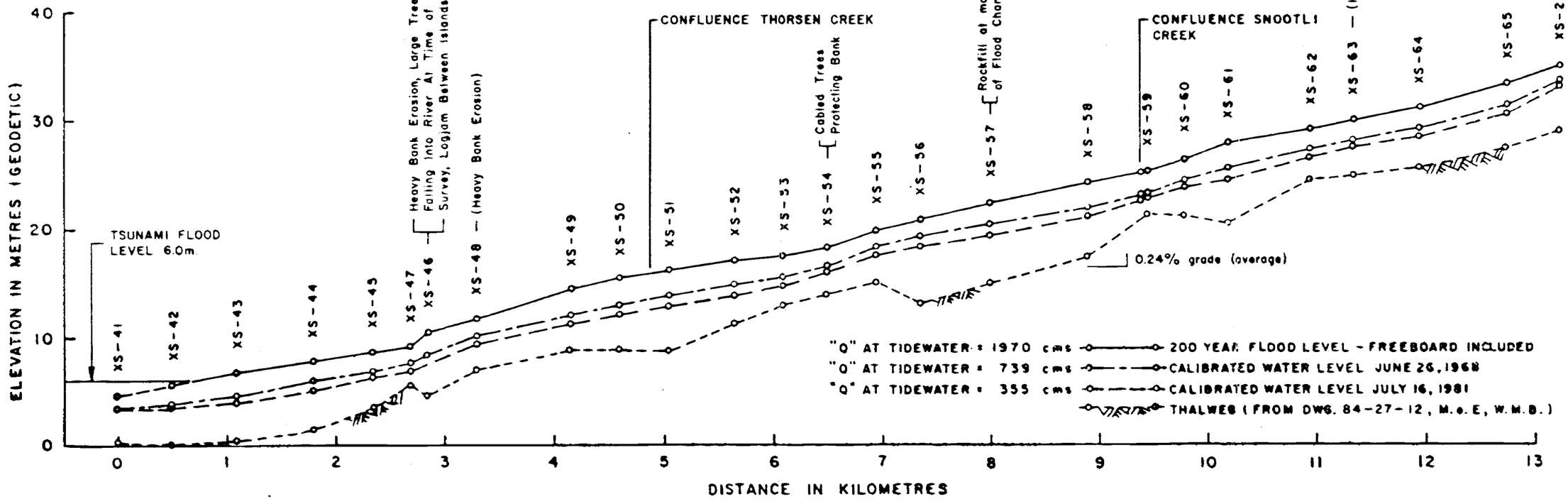
FLOODPLAIN MAPPING STUDY

BELLA COOLA RIVER

BELLA COOLA RIVER WATERSHED

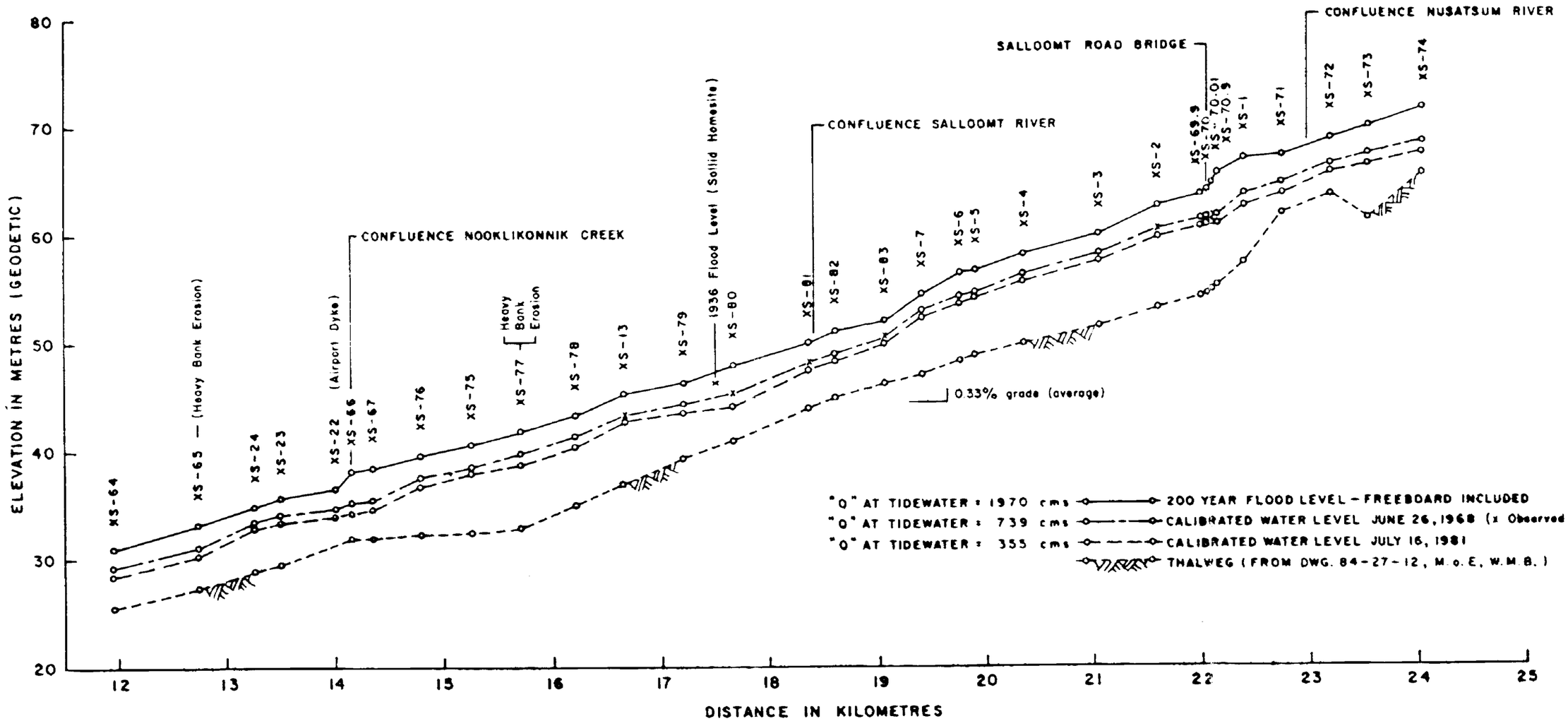
SCALE: 1:500 000	DATE NOVEMBER 1986
R. W. NICHOLS ENGINEER	
FILE No. 91-2910-S.1	FIGURE 2

BELLA COOLA RIVER
WATER SURFACE AND THALWEG PROFILES



	Province of British Columbia Ministry of Environment and Parks Water Management Branch	TO ACCOMPANY REPORT ON FLOODPLAIN MAPPING STUDY BELLA COOLA RIVER	SCALE: VERT. AS SHOWN HOR. AS SHOWN DATE NOVEMBER, 1988 R. W. NICHOLS ENGINEER FILE No. 91-2910-S.1 FIGURE No. 3

BELLA COOLA RIVER
WATER SURFACE AND THALWEG PROFILES



Province of British Columbia
Ministry of Environment and Parks
WATER MANAGEMENT BRANCH

TO ACCOMPANY REPORT ON
FLOODPLAIN MAPPING STUDY
BELLA COOLA RIVER

SCALE: VERT. AS SHOWN
HOR. AS SHOWN
DATE NOVEMBER, 1988
R. W. NICHOLS ENGINEER
FILE No. 91-2910-5.1 FIGURE No. 4

Appendix 1

Detailed Information Sources used in the
Floodplain Mapping Study - Bella Coola River
(Tidewater to Nusatsum River Confluence)

No.	Source	Contents
1.	Bella Coola Regional Study, December 1974, Special Studies Division, British Columbia Forest Service.	Evaluation of Integrated Resource Use Constraints related to wood allocation.
2.	"The Characteristics and Management of the Bella Coola River and Tributaries at the Bella Coola Indian Reserve", by M.A. Church and S.O. Russell, November 1977.	An assessment of the present situation at the Reserve regarding erosion and flooding and to provide some insight into the possible future behaviour of the Bella Coola River and its tributaries.
3.	"Bella Coola River Flood and Erosion Control", by W. Tempest, P. Eng., dated September 1974, Rivers Section File: 0254122 #11.	A study of the works necessary to provide flood control in the Village of Hagensborg and other areas within the Bella Coola valley.
4.	Rivers Section, Water Management Branch, Victoria, File: P71-27	Information on flooding problems in the Bella Coola valley.
5.	Survey Section, Water Management Branch, Victoria, Project Nos. 81-FDC-2 (1981), 68-2 (1968).	A total of 55 cross sections on the Bella Coola River including water level and thalweg information, photos of bank and river conditions at each cross section, bridge data and a listing of bench marks and monuments.

Appendix 1 (continued)

No.	Source	Contents
6.	"Oldroyd Appeal - Proposed Subdivision of Parcel G (DD1165531) of NW-1/4, Section 31, TWP. 1, Range 3, except Parcel 1, (DD235059-1), Coast District", Special Projects Section File: 91-2910-S.1 memo dated July 17, 1986.	A review of a subdivision appeal of of a property located upstream of the Thorsen Creek confluence in the Bella Coola River floodplain.
7.	"The Physical Environment of the Bella Coola River Valley", by J.S. Hart, January 1981.	A preliminary description of the Bella Coola River valley for land use planning purposes.
8.	Mapping Section, Surveys and Mapping Branch, Proj. No. 83-101T	1:5000 scale, 2 metre contour Planimetric mapping based on air photos obtained on August 18, 1982. 11 mapping sheets.
9.	"Bella Coola River Peak Flows", File: S2103, Hydrology Section, Water Management Branch, memo dated November 1985.	Results of a hydrology study to determine peak flows at a number of locations in the lower Bella Coola River valley.
10.	"Tsunami Warning Plan", Provincial Emergency Program, Province of British Columbia, March 1986.	A plan to disseminate warnings regarding tsunami events to coastal areas of British Columbia.