CANADA/BRITISH COLUMBIA FLOODPLAIN MAPPING AGREEMENT

Ministry of Environment, Lands and Parks
Water Management Division

A Design Brief on the Floodplain Mapping Project for Naver and Hixon Creeks

An Overview of the Study Undertaken
to produce Floodplain Mapping for
Naver and Hixon Creeks
near Hixon, B.C.

Hixon Creek Flood - June 28, 1993

Flood Hazard Identification Section
Victoria, British Columbia
October, 1995
File: 35100-30/100-5229

Table of Contents

Title Page i
TABLE OF CONTENTS ii
Preface 1

1. **Background** 1

2. **Location** 2

3. **Present Studies** 2

4. **Designated Flood** 2

5. **Flood Magnitudes** 3
    5.1 Naver Creek 3
    5.2 Hixon Creek 3

6. **Hydraulic Analysis** 4
    6.1 General 4
    6.2 Flood Level Calculations 4
    6.3 Sensitivity Studies 5

7. **Floodplain Mapping** 6

8. **Conclusions** 7

9. **Recommendations** 7

Figures

Figure 1 - Study Area Location
Figure 2 - Key Map
Figure 3 - Hixon Creek Channel Erosion
Figure 4 WSC Gauge 08KE014 Naver Creek Cross Section Comparison

Tables

Table 1 - Naver Creek - Sensitivity to Starting Elevations (Page 1)
Table 2 - Naver and Hixon Creeks - Flood Level Selection (Pages 1 to5)
Table 3 Naver and Hixon Creeks - Sensitivity Studies (Pages 1 to 10)

Appendices

Appendix 1 - Detailed Information Sources
Appendix 2 - Hydrology Section Report - Naver Creek
Appendix 3 - Photographs
Appendix 4 - Floodplain Mapping - Naver and Hixon Creeks
Drawing No. 93-9, Sheets 1 to 3

Preface

The purpose of this design brief is to present a description of the methodologies used and results of the study undertaken to delineate the floodplains of Naver and Hixon Creeks at Hixon, Drawing 93-9, Sheets 1 to 3 (Appendix 4).

1. Background

The unincorporated community of Hixon is located along Highway 97 about midway between the cities of Prince George and Quesnel near the confluence of Naver and Hixon Creeks (Appendix 4, Sheet 1). The community provides the usual amenities to residents and travelers such as motels, gas stations, restaurants and is the location of the local highways maintenance contractor as well as other small businesses. Typical of many smaller communities in BC, much of the employment in the area is related to forest resource based activities. Land parcels range from residential sized lots and small acreages to larger farm and ranch parcels.

The Naver and Hixon Creeks valleys have had an ongoing history of flooding and erosion complaints dating back to the mid 1960's (Prince George Water Management Branch files). Because of the flood history, these valleys were identified as potential floodplain mapping project areas following the 1987 signing of the Canada-British Columbia Agreement Respecting Floodplain Mapping. Topographic base mapping was commenced in 1988. River channel cross sections within the downstream portion of the study area (sheet 1) on Naver Creek, including Hixon Creek, were also surveyed in 1988 at the request of the regional water management office in Prince George with regards to River Protection Assistance Program requests.

Major flood/erosion events in the study area were experienced during June of 1990 and subsequently in June of 1993 as a result of heavy rainfall events throughout the region. Severe erosion was experienced at many locations throughout the study area during both of the events. Channel avulsions and erosion threatened the Highway 97 bridge and embankment at Hixon Creek as shown in Figure 3. Failure of an earthfill/beaver dam at Pedley Lake during the 1993 event resulted in flood surges on Pedley Creek through to Naver Creek. Significant damages, estimated to exceed $1,000,000 to the adjacent stream banks and roads, were experienced (Appendix 1.6).

These events prompted an extension to the upstream reach of the study area and a complete resurvey of the Hixon Creek portion of the project was required due to major channel avulsions and associated stream restoration works having taken place in 1993 (Photo 3&4). Figure 3 indicates the erosion areas on Hixon Creek within the study area.

2. Location

Naver Creek drains the western slopes of the Fraser Plateau and flows generally northward where it empties into the Fraser River approximately 55 kilometres south of Prince George. The study area encompasses approximately a 20 kilometre reach of Naver Creek beginning near the unincorporated community of Hixon, approximately 1/2 kilometre downstream of the confluence of Naver and Hixon Creeks, continuing upstream and ending near the railway station of Strathnaver approximately 4.5 kilometres upstream of Terry Creek. The study also includes a reach of Hixon Creek from the confluence with Naver Creek upstream 1 kilometre. The study area lies within the Cariboo Regional District and the Fraser - Fort George Regional District(Figure 2).

Figure 1 is a location plan of the study area. Figure 2 is a key map at a scale of 1:250,000 showing the locations of the three floodplain mapsheets for the study area.

3. Present Studies

The 1995 studies undertaken to delineate the floodplains for the Naver and Hixon Creeks are based on the following information:

- Survey data obtained by the Technical Support Section, Hydrology Branch, Water Management Division , Project 88-RPP-11, May 1988, Project 9321F082, July 1993 and Project 9410F082, July 1994 (Appendix 1.2) and includes channel cross section data, longitudinal profiles, high water mark elevations, photographs and bridge details for Naver and Hixon Creeks (Appendices 1.1 to 1.3).

- Topographic base mapping of the study area issued in March 1993 by the Mapping Section, Surveys and Resource Mapping Branch, Project 89-005, NAD 83. The mapping is at a scale of 1:5,000 with 1 metre contour intervals and utilizes air photography obtained in September 1989 (Appendix 1.4).

- Hydrology studies of the Naver and Hixon Creeks watersheds performed by the Surface Water Section, Hydrology Branch, Study No. 414, January 12, 1995, (Appendix 2).

4. Designated Flood

In accordance with the policy of the Ministry of Environment, Lands and Parks, the flood levels and floodplain limits on the floodplain mapping sheets are based on a designated (1:200 year frequency) flow plus an allowance for hydraulic and hydrologic uncertainties. The mapping also includes 1:20 year flood frequency elevations to facilitate Public Health requirements for septic tank purposes (Table 2).

5. Flood Magnitudes

5.1 Naver Creek

As stated in Appendix 2 , annual peak flows in the Naver Creek watershed occur generally between mid spring and summer as a result of snowmelt or rain on snow events. Water Survey of Canada (WSC) operated gauge 08KE014 - Naver Creek at Hixon from 1956 to 1975 continuously except 1959 and 1961 (note the gauge was relocated in 1961). Annual daily extremes are available from the published data; instantaneous annual maximum discharges are not available. The maximum daily discharge recorded at the gauge occurred on May 20 1956 at 133 m3/s. The published drainage area for this gauge is 658 km2. The watershed ranges in elevation between 560m (1837 feet) and 1675m (5500 feet). Of this area approximately 140 km2 or about 21% of the watershed lies above 1070m (3500 feet). The gauge was located above the tributary inflow of Hixon Creek.

Peak flows for various points along Naver Creek were determined using a regional peak flow method as established in the Ministry's "Manual of Operational Hydrology in British Columbia". Details of the study are contained in Appendix 2.

5.2 Hixon Creek

The Hixon Creek watershed is 238 km2 and accounts for approximately 26% of the total combined area of the Naver Creek watershed. Hixon Creek drains higher and steeper slopes compared to the rest of the basin. Maximum elevation, as taken from 1:250,000 scale topographic mapsheet 93 G, is 1733m (5686 feet). Approximately 95 km2 or 39% of the watershed lies above 1070m (3500 feet). WSC has not operated a stream gauge for this watershed. A regional analysis was utilized to determine peak flows for the study area as detailed in the table below.

Stream Site	Drainage Area (km2)	Max. I/D	Recurrence Interval (years)					
			20			**200**		
			D	D	I	D	D	I
			L/s/km2	m3/s	m3/s	L/s/km2	m3/s	m3/s
1. Naver Cr. below Hixon Cr.	908	1.36	214	194	264	308	280	380
2. Naver Cr. above Hixon Cr.	661	1.40	223	154	216	307	203	284
3. Naver Cr. below Meadowbank Cr.	490	1.43	240	118	168	327	160	229
4. Hixon Cr. above Naver Cr.	238	1.52	295	70.2	107	446	106	161
5. Hixon Cr. below Government Cr.	210	1.54	300	63.0	97.0	460	96.6	149
6. Naver Cr. at Hixon (08KE014)	658	1.40	225	148	207	308	202	283

6. Hydraulic Analysis

6.1 General

The 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 flood profile calculations employ a standard step method and assumed open channel flow conditions.

Flood profiles calculated for Naver and Hixon Creeks in the study area are outlined as follows. A plot run of river cross sections was obtained. An assessment was made of the river channel survey data and cross section extensions which were obtained from the 1 metre contour topographic mapping. Output from the plot run was also used to review other data such as flow regime, loss coefficients, reach lengths, overbank information and relative Manning's "n" values. The selection of Manning's "n" values was made by utilizing colour photographs provided by the Surveys Section, experience gained in other studies and a review of the information provided in a book published by the US Department of the Interior entitled "Roughness Characteristics of Natural Channels" (Appendix 1.5).

6.2 Flood Level Calculations

As stated previously in Section 5.1, WSC gauge 08KE014 was abandoned following 1975 and therefore no flow records are available for the 1990 and 1993 flood events. Stage discharge data was made available from WSC. A comparison plot of the latest WSC cross section for the gauge (1974) was made to the 1993 surveyed section (XS 11) (Figure 4). The change in cross sectional area did not permit an accurate estimate of the peak flow for the 1993 event. The data was only useful in providing an approximate estimate from the 1974 stage discharge curve.

High water mark evidence was identified by the survey crew at the time of survey at most cross section locations on Naver Creek and used to calibrate the model. Relative "n" values were selected for each cross section as described in Section 6.1. A number of preliminary runs were made, making subtle changes to "n" values and discharge to provide a reasonable calibration of the model to the high water mark evidence obtained. The model output data, mapping and colour photographs were consulted to reconcile outliers to the calibration. At several locations it was determined that the high water mark may have been caused by overland flow from upstream. During the 1993 event, failure of a dam at Pedley Lake caused a major flood surge and may have been responsible for several anomalies in the reach below Pedley Creek on Naver Creek.

On Hixon Creek severe erosion occurred during the flood events resulting in major changes to the river regime and thus necessitated extensive remedial works. Due to these significant regime changes it was not possible to calibrate the model to the high water mark data obtained. In addition, Hixon Creek is ungauged and no flow data was available for calibration of the model. Conservative relative Manning's "n" values were selected based on the information described in Section 6.1.

Starting water surface elevations for Naver Creek were estimated utilizing a number of methods as follows;

- a model option was selected to start the model with a minimum water surface elevation corresponding to critical depth,
- an estimate of the 200 year flood level based upon observed high water elevations upstream; and
- a slope/area model option was selected utilizing a variety of slopes.

The studies indicated that the model is relatively insensitive to starting water surface elevations as the profiles quickly balanced out at cross section 0.3 at the "Limit of Study" (Table 1).

Starting water surface elevations for Hixon Creek were derived from the calculated 200 year and 20 year daily and instantaneous flood levels for Naver Creek at cross section 2 immediately downstream of the confluence. The studies indicated that the Naver Creek flood level dominates over the Hixon Creek flood level at the first cross section on Hixon Creek.

In accordance with standard ministry practice, an allowance for hydraulic and hydrologic uncertainties is applied to the water surface elevations computed by the model for each cross section. An allowance of 0.3 metres and 0.6 metres is applied to the instantaneous and daily levels respectively, and the flood level which dominates is selected for the particular cross section. For both Naver and Hixon Creeks the instantaneous flood levels were found to dominate at the majority of the cross sections using this criteria (Table 2).

6.3 Sensitivity Studies

The total length of Naver Creek in the study area is approximately 19.5 km. The average gradient of the flood profile in the study area is 0.40 percent. A total of 58 channel cross sections were used in this reach. The reach length of Hixon

Creek is 1.28 km. A total of 23 cross sections were used in this reach which has an average flood profile slope of 0.96%. Manning's "n" values for the channel varied from 0.040 in the lower reaches to 0.060 in the upper reaches. As described previously, many areas along Hixon Creek have been subject to severe erosion forces and have since had portions of the channel and banks reinforced with heavy rock riprap. At these locations composite "n" values were employed utilizing "NH" cards to take cognizance of these erosion protection measures. In addition to the starting level sensitivity studies as previously described in section 6.2, the following sensitivity studies were also undertaken:

Sensitivity to discharge (Q) studies were made using the estimated Q200 instantaneous flow multiplied by factors of 1.1, 1.2, and 1.3. The studies indicate that the selected flood levels are sufficient to withstand increases to Q averaging between 20% and 30%. These studies indicated an average water level increase of about 0.12m for each 10% increase to "Q" (Table 3).

Sensitivity studies were also undertaken to determine the effect of increased Manning's "n" values on flood levels. A comparative run using the Q200 instantaneous flow and factored by values of 1.1, 1.2 and 1.3 resulted in an average rise in levels of about 0.11m for each incremental increase in "n" value (Table 3).

From these studies it was determined that the floodplain for Naver Creek is moderately sensitive to increases in "Q" and "n" values. Due to the lack of WSC gauging stations on Naver and Hixon Creeks and therefore an unmeasured flow for calibrating the 1993 high water mark data, a conservative approach was adopted in the selected "n" values for determining the Q200 flood levels.

7. Floodplain Mapping

The flood levels determined in the study were used to delineate the floodplain limits onto the existing 1 metre contour mapping for the study area. The studies were based on the information noted in Section 3.

The floodplain mapping of Naver and Hixon Creeks, Drawing No. 93-9 sheets 1 to 3 (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,
- the location of survey monuments established for the study, and
- notes pertaining to flood and erosion hazards.

In addition, a field inspection was undertaken in August of 1995 to verify the location of the floodplain boundary shown on the drawings.

8. Conclusions

1. This design brief presents an overview of the studies undertaken to produce the floodplain mapping sheets for Naver and Hixon Creeks. The floodplain limits shown correspond to the area which would be inundated by the designated flood.
2. The floodplain in the study area has a documented history of flooding and erosion dating back to the early 1960's.
3. The floodplain maps are not comprehensive floodplain management plans, nor do they provided solutions to site specific problems.
4. Flooding may occur outside the designated floodplain. Tributaries, ice jamming, channel obstructions, groundwater 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.

9. Recommendations

1. It is recommended that the floodplains delineated on Drawing 93-9, Sheets 1 to 3, 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. The Fraser - Fort George and Cariboo Regional Districts along with BC Environment, Hydrology Branch, should actively pursue the co-operation with Water Survey of Canada to establish gauges in the study area.
4. The 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.

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Province of British Columbia
Ministry of Environment, Lands and Parks
WATER MANAGEMENT DIVISION

TO ACCOMPANY A DESIGN BRIEF ON THE FLOODPLAIN MAPPING

NAVER AND HIXON CREEKS
STUDY AREA LOCATION

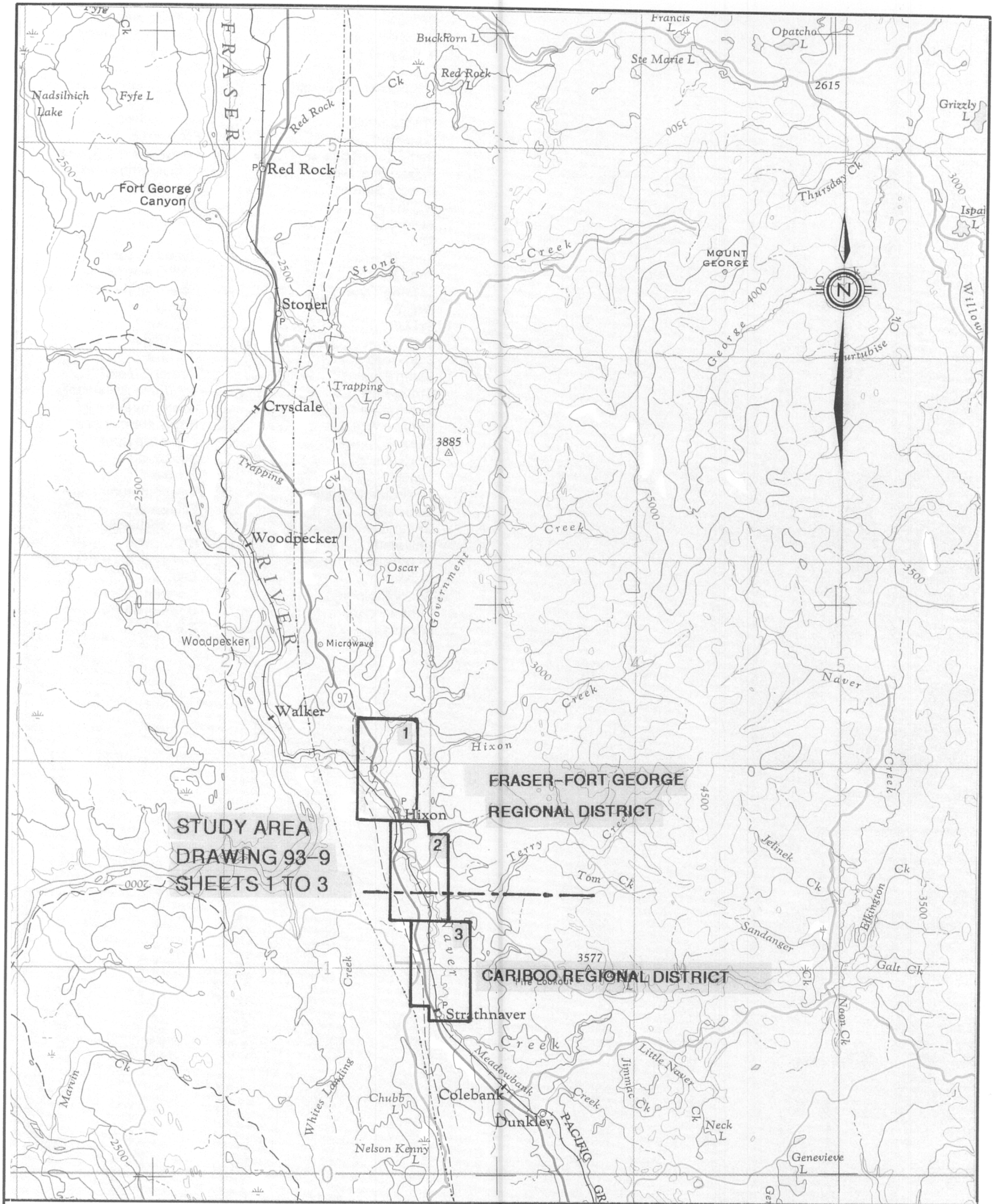
R.W. NICHOLS ENGINEER

SCALE: VERT / HOR NOT TO SCALE

DATE OCT 1995

FILE No. 35100-30/100-5229

DWG. No. FIGURE 1



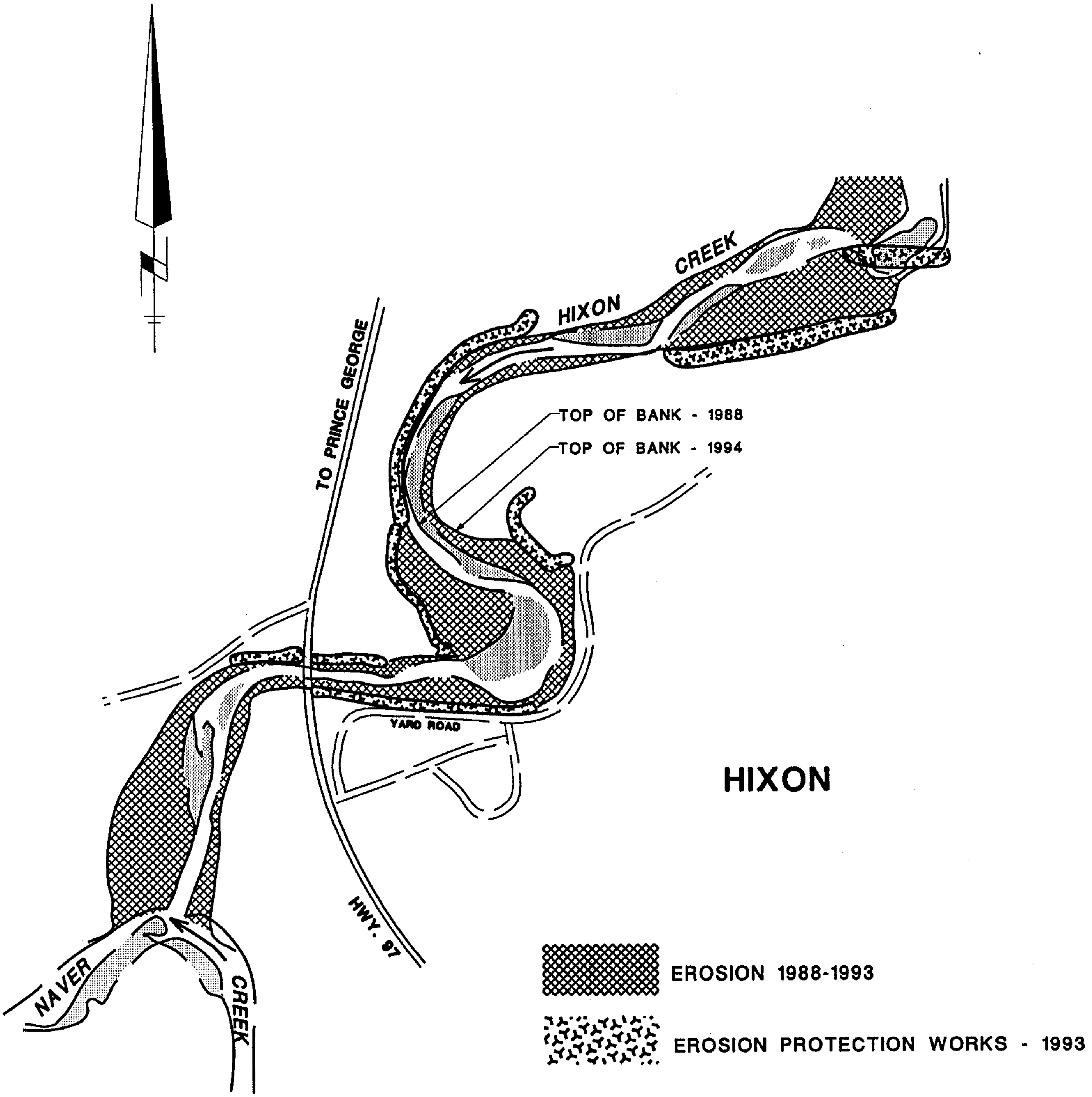
Province of British Columbia
Ministry of Environment, Lands and Parks
WATER MANAGEMENT DIVISION

TO ACCOMPANY A DESIGN BRIEF ON THE
FLOODPLAIN MAPPING STUDY

NAVER AND HIXON CREEKS

KEY MAP

SCALE: VERT HOR 1 : 250,000	DATE APRIL 1995	R.W. NICHOLS ENGINEER FILE No. 35100-30/100-5229 DWG. No. FIGURE 2



Province of British Columbia
Ministry of Environment, Lands and Parks
WATER MANAGEMENT DIVISION

TO ACCOMPANY A DESIGN BRIEF ON THE
FLOODPLAIN MAPPING STUDY
NAVER AND HIXON CREEKS

HIXON CR. CHANNEL EROSION

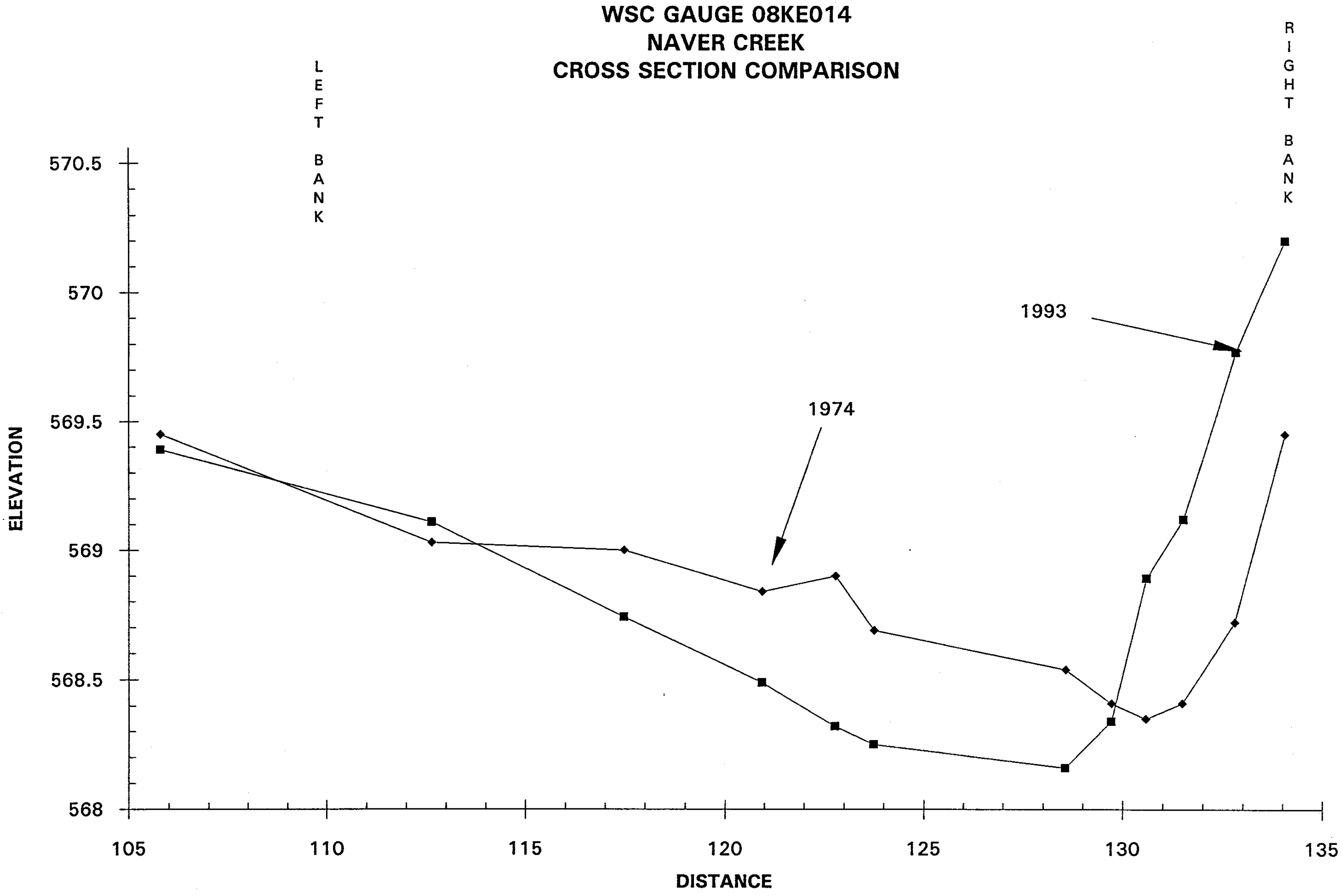
R.W. NICHOLS ENGINEER

SCALE: VERT
HOR 1 : 5,000

DATE
SEPT 1995

FILE No. 35100-30/100-5229 DWG. No. FIGURE 3

FIGURE 4



WSC GAUGE 08KE014
NAVER CREEK
CROSS SECTION COMPARISON

TABLE 1

NAVER CREEK AT HIXON

SENSITIVITY TO STARTING ELEVATIONS

XS	START METHOD	Q	10*KS	XLCH	CWSEL	SELECTED FLOOD LEVEL
0.1	CRITICAL DEPTH	380	198.83	0	560.50	**561.60**
0.1	ESTIMATE	380	84.10	0	561.00	
0.1	SLOPE AREA .003	380	29.97	0	*561.64*	
0.1	SLOPE AREA .004	380	39.86	0	561.45	
0.1	SLOPE AREA .005	380	49.60	0	561.32	
0.1	SLOPE AREA .006	380	59.07	0	561.21	
0.2		380	63.24	67	561.66	**561.95**
0.2		380	76.15	67	561.50	
0.2		380	55.32	67	561.79	
0.2		380	62.46	67	561.67	
0.2		380	67.37	67	561.61	
0.2		380	70.79	67	561.56	
0.21	CRITICAL DEPTH	380	58.06	6	561.73	**562.02**
0.21	ESTIMATE	380	68.74	6	561.59	
0.21	SLOPE AREA .003	380	52.36	6	561.84	
0.21	SLOPE AREA .004	380	58.32	6	561.74	
0.21	SLOPE AREA .005	380	62.21	6	561.68	
0.21	SLOPE AREA .006	380	64.83	6	561.64	
0.3*		380	39.74	292	563.39	**563.70**
0.3*		380	39.18	292	563.41	
0.3*		380	39.40	292	563.40	
0.3*		380	39.46	292	563.40	
0.3*		380	39.40	292	563.40	
0.3*		380	39.32	292	563.40	
1	CRITICAL DEPTH	380	41.41	295	564.63	**564.95**
1	ESTIMATE	380	41.57	295	564.63	
1	SLOPE AREA .003	380	41.44	295	564.63	
1	SLOPE AREA .004	380	41.00	295	564.63	
1	SLOPE AREA .005	380	41.33	295	564.63	
1	SLOPE AREA .006	380	41.49	295	564.63	
2		380	72.10	199	565.56	**565.90**
2		380	71.76	199	565.56	
2		380	72.14	199	565.56	
2		380	73.01	199	565.55	
2		380	72.31	199	565.56	
2		380	71.99	199	565.56	

* Limit of Study (Dwg. 93-9, Sheet 1)

TABLE 2

NAVER CREEK FLOOD LEVEL SELECTION

SUMMARY PRINTOUT

XS	FRQ	Q	K*XNCH	CWSEL	FLD LVL	XS	FRQ	Q	K*XNCH	CWSEL	FLD LVL
0.1	Q 200 I	380	49.50	561.00	560.30	6	Q 200 I	283	44.00	567.96	568.26
0.1	Q 200D	280	49.50	561.00	**561.60**	6	Q 200D	202	44.00	567.69	**568.29**
0.1	Q 20 I	264	45.00	560.50	560.80	6	Q 20 I	207	40.00	567.64	567.94
0.1	Q 20 D	194	45.00	560.50	**561.10**	6	Q 20 D	148	40.00	567.43	**568.03**
0.2		380	49.50	561.65	**561.95**	7		283	49.50	569.20	**569.50**
0.2		280	49.50	561.13	561.73	7		202	49.50	568.83	569.43
0.2		264	45.00	560.95	561.25	7		207	45.00	568.74	**569.04**
0.2		194	45.00	560.76	**561.36**	7		148	45.00	568.42	569.02
0.2	Q 200 I	380	49.50	561.72	**562.02**	8	Q 200 I	283	44.00	569.96	**570.26**
0.2	Q 200D	280	49.50	561.19	561.79	8	Q 200D	202	44.00	569.57	570.17
0.2	Q 20 I	264	45.00	561.02	561.32	8	Q 20 I	207	40.00	569.51	**569.81**
0.2	Q 20 D	194	45.00	560.79	**561.39**	8	Q 20 D	148	40.00	569.15	569.75
0.3		380	49.50	563.40	**563.70**	9		283	44.00	570.31	**570.61**
0.3		280	49.50	562.96	563.56	9		202	44.00	569.98	570.58
0.3		264	45.00	562.76	**563.06**	9		207	40.00	569.93	570.23
0.3		194	45.00	562.29	562.89	9		148	40.00	569.68	**570.28**
1.0	Q 200 I	380	44.00	564.63	564.93	10	Q 200 I	283	49.50	570.65	570.95
1.0	Q 200D	280	44.00	564.35	**564.95**	10	Q 200D	202	49.50	570.43	**571.03**
1.0	Q 20 I	264	40.00	564.24	**564.54**	10	Q 20 I	207	45.00	570.38	570.68
1.0	Q 20 D	194	40.00	563.90	564.50	10	Q 20 D	148	45.00	570.20	**570.80**
2.0		380	55.00	565.55	565.85	11		283	49.50	571.70	**572.00**
2.0		280	55.00	565.30	**565.90**	11		202	49.50	571.36	571.96
2.0		264	50.00	565.16	**565.46**	11		207	45.00	571.32	**571.62**
2.0		194	50.00	564.85	565.45	11		148	45.00	570.95	571.55
3.0	Q 200 I	283	49.50	566.30	**566.60**	12	Q 200 I	283	46.20	571.87	**572.17**
3.0	Q 200D	202	49.50	565.90	566.50	12	Q 200D	202	46.20	571.48	572.08
3.0	Q 20 I	207	45.00	565.74	**566.04**	12	Q 20 I	207	42.00	571.44	**571.74**
3.0	Q 20 D	148	45.00	565.38	565.98	12	Q 20 D	148	42.00	571.05	571.65
4.0		283	49.50	566.69	**566.99**	13		283	49.50	572.47	**572.77**
4.0		202	49.50	566.27	566.87	13		202	49.50	571.98	572.58
4.0		207	45.00	566.16	**566.46**	13		207	45.00	571.95	**572.25**
4.0		148	45.00	565.81	566.41	13		148	45.00	571.51	572.11
5.0	Q 200 I	283	44.00	567.12	**567.42**	14	Q 200 I	283	49.50	572.86	**573.16**
5.0	Q 200D	202	44.00	566.75	567.35	14	Q 200D	202	49.50	572.41	573.01
5.0	Q 20 I	207	40.00	566.67	566.97	14	Q 20 I	207	45.00	572.29	**572.59**
5.0	Q 20 D	148	40.00	566.41	**567.01**	14	Q 20 D	148	45.00	571.95	572.55

TABLE 2

NAVER CREEK FLOOD LEVEL SELECTION

SUMMARY PRINTOUT

XS	FRQ	Q	K*XNCH	CWSEL	FLD LVL	XS	FRQ	Q	K*XNCH	CWSEL	FLD LVL
15.0	Q 200 I	283	49.50	574.12	**574.42**	24	Q 200 I	283	70.07	581.17	**581.47**
15.0	Q 200D	202	49.50	573.66	574.26	24	Q 200D	202	67.27	580.82	581.42
15.0	Q 20 I	207	45.00	573.60	**573.90**	24	Q 20 I	207	60.79	580.78	**581.08**
15.0	Q 20 D	148	45.00	573.19	573.79	24	Q 20 D	148	57.31	580.48	581.08
16.0		283	49.50	574.92	**575.22**	25		283	67.96	582.13	582.43
16.0		202	49.50	574.45	575.05	25		202	60.52	581.89	**582.49**
16.0		207	45.00	574.37	**574.67**	25		207	53.02	581.84	582.14
16.0		148	45.00	574.01	574.61	25		148	44.54	581.67	**582.27**
17.0	Q 200 I	283	46.20	575.52	**575.82**	26	Q 200 I	283	46.20	584.75	585.05
17.0	Q 200D	202	46.20	575.19	575.79	26	Q 200D	202	46.20	584.47	**585.07**
17.0	Q 20 I	207	42.00	575.11	575.41	26	Q 20 I	207	42.00	584.42	584.72
17.0	Q 20 D	148	42.00	574.84	**575.44**	26	Q 20 D	148	42.00	584.17	**584.77**
18.0		283	49.50	576.82	**577.12**	27		283	55.00	587.85	**588.15**
18.0		202	49.50	576.34	576.94	27		202	55.00	587.29	587.89
18.0		207	45.00	576.26	**576.56**	27		207	50.00	587.18	**587.48**
18.0		148	45.00	575.85	576.45	27		148	50.00	586.73	587.33
19.0	Q 200 I	283	49.50	577.52	**577.82**	28	Q 200 I	283	44.00	590.41	**590.71**
19.0	Q 200D	202	49.50	577.07	577.67	28	Q 200D	202	44.00	590.00	590.60
19.0	Q 20 I	207	45.00	577.00	**577.30**	28	Q 20 I	207	40.00	589.93	**590.23**
19.0	Q 20 D	148	45.00	576.55	577.15	28	Q 20 D	148	40.00	589.61	590.21
20.0		283	44.00	578.20	**578.50**	29		283	49.50	592.34	**592.64**
20.0		202	44.00	577.80	578.40	29		202	49.50	592.01	592.61
20.0		207	40.00	577.71	**578.01**	29		207	45.00	591.94	592.24
20.0		148	40.00	577.34	577.94	29		148	45.00	591.69	**592.29**
21.0	Q 200 I	283	49.50	578.96	**579.26**	30	Q 200 I	283	46.20	594.19	594.49
21.0	Q 200D	202	49.50	578.56	579.16	30	Q 200D	202	46.20	593.89	**594.49**
21.0	Q 20 I	207	45.00	578.49	**578.79**	30	Q 20 I	207	42.00	593.82	594.12
21.0	Q 20 D	148	45.00	578.10	578.70	30	Q 20 D	148	42.00	593.57	**594.17**
22.0		283	49.50	579.48	579.78	31		283	52.80	596.21	**596.51**
22.0		202	49.50	579.18	**579.78**	31		202	52.80	595.75	596.35
22.0		207	45.00	579.12	579.42	31		207	48.00	595.66	**595.96**
22.0		148	45.00	578.91	**579.51**	31		148	48.00	595.26	595.86
23.0	Q 200 I	283	52.80	580.16	580.46	32	Q 200 I	283	55.00	598.15	**598.45**
23.0	Q 200D	202	52.80	579.94	**580.54**	32	Q 200D	202	55.00	597.59	598.19
23.0	Q 20 I	207	48.00	579.88	580.18	32	Q 20 I	207	50.00	597.49	**597.79**
23.0	Q 20 D	148	48.00	579.69	**580.29**	32	Q 20 D	148	50.00	597.05	597.65

TABLE 2

NAVER CREEK FLOOD LEVEL SELECTION

SUMMARY PRINTOUT

XS	FRQ	Q	K*XNCH	CWSEL	FLD LVL	XS	FRQ	Q	K*XNCH	CWSEL	FLD LVL
33.0	Q 200 I	283	49.50	598.42	**598.72**	42	Q 200 I	283	44.00	612.51	**612.81**
33.0	Q 200D	202	49.50	597.84	598.44	42	Q 200D	202	44.00	612.18	612.78
33.0	Q 20 I	207	45.00	597.72	**598.02**	42	Q 20 I	207	40.00	612.08	**612.38**
33.0	Q 20 D	148	45.00	597.31	597.91	42	Q 20 D	148	40.00	611.77	612.37
34.0		283	49.50	598.51	**598.81**	43		250	44.00	613.58	**613.88**
34.0		202	49.50	597.88	598.48	43		175	44.00	613.19	613.79
34.0		207	45.00	597.76	**598.06**	43		180	40.00	613.13	**613.43**
34.0		148	45.00	597.34	597.94	43		128	40.00	612.77	613.37
35.0	Q 200 I	283	46.20	598.87	**599.17**	44	Q 200 I	250	44.00	615.64	**615.94**
35.0	Q 200D	202	46.20	598.13	598.73	44	Q 200D	175	44.00	615.22	615.82
35.0	Q 20 I	207	42.00	597.98	**598.28**	44	Q 20 I	180	40.00	615.13	**615.43**
35.0	Q 20 D	148	42.00	597.52	598.12	44	Q 20 D	128	40.00	614.75	615.35
36.0		283	44.00	600.55	**600.85**	45		250	44.00	617.67	**617.97**
36.0		202	44.00	600.25	600.85	45		175	44.00	617.15	617.75
36.0		207	40.00	600.20	**600.50**	45		180	40.00	617.08	**617.38**
36.0		148	40.00	599.86	600.46	45		128	40.00	616.67	617.27
37.0	Q 200 I	283	55.00	603.28	**603.58**	46	Q 200 I	250	44.00	619.30	**619.60**
37.0	Q 200D	202	55.00	602.69	603.29	46	Q 200D	175	44.00	618.83	619.43
37.0	Q 20 I	207	50.00	602.59	**602.89**	46	Q 20 I	180	40.00	618.76	**619.06**
37.0	Q 20 D	148	50.00	602.26	602.86	46	Q 20 D	128	40.00	618.35	618.95
38.0		283	49.50	604.95	**605.25**	47		250	44.00	621.43	**621.73**
38.0		202	49.50	604.54	605.14	47		175	44.00	620.99	621.59
38.0		207	45.00	604.47	604.77	47		180	40.00	620.91	**621.21**
38.0		148	45.00	604.19	**604.79**	47		128	40.00	620.58	621.18
39.0	Q 200 I	283	49.50	606.58	**606.88**	48	Q 200 I	250	44.00	625.20	**625.50**
39.0	Q 200D	202	49.50	606.24	606.84	48	Q 200D	175	44.00	624.75	625.35
39.0	Q 20 I	207	45.00	606.16	606.46	48	Q 20 I	180	40.00	624.68	**624.98**
39.0	Q 20 D	148	45.00	605.87	**606.47**	48	Q 20 D	128	40.00	624.28	624.88
40.0		283	57.20	608.98	**609.28**	49		250	51.70	626.95	**627.25**
40.0		202	57.20	608.52	609.12	49		175	51.70	626.40	627.00
40.0		207	52.00	608.44	**608.74**	49		180	47.00	626.31	**626.61**
40.0		148	52.00	607.92	608.52	49		128	47.00	625.85	626.45
41.0	Q 200 I	283	55.00	612.22	**612.52**	50	Q 200 I	250	51.70	628.73	**629.03**
41.0	Q 200D	202	55.00	611.90	612.50	50	Q 200D	175	51.70	628.21	628.81
41.0	Q 20 I	207	50.00	611.82	**612.12**	50	Q 20 I	180	47.00	628.12	**628.42**
41.0	Q 20 D	148	50.00	611.47	612.07	50	Q 20 D	128	47.00	627.72	628.32

TABLE 2

NAVER CREEK FLOOD LEVEL SELECTION

SUMMARY PRINTOUT

XS	FRQ	Q	K*XNCH	CWSEL	FLD LVL	XS	FRQ	Q	K*XNCH	CWSEL	FLD LVL
51.0		250	44.00	631.26	**631.56**	53.0		250	44.00	635.73	**636.03**
51.0		175	44.00	630.89	631.49	53.0		175	44.00	635.37	635.97
51.0		180	40.00	630.84	631.14	53.0		180	40.00	635.31	**635.61**
51.0		128	40.00	630.56	**631.16**	53.0		128	40.00	635.01	635.61
52.0	Q 200 I	250	44.00	633.88	634.18	54.0	Q 200 I	250	44.00	637.58	637.88
52.0	Q 200D	175	44.00	633.70	**634.30**	54.0	Q 200D	175	44.00	637.31	**637.91**
52.0	Q 20 I	180	40.00	633.66	633.96	54.0	Q 20 I	180	40.00	637.26	637.56
52.0	Q 20 D	128	40.00	633.48	**634.08**	54.0	Q 20 D	128	40.00	637.04	637.64

HIXON CREEK FLOOD LEVEL SELECTION

SUMMARY PRINTOUT

XS	FRQ	Q	K*XNCH	CWSEL	FCL	XS	FRQ	Q	K*XNCH	CWSEL	FCL
0.1	Q200I	161	44.00	565.50	565.80	3.2	Q200I	161	59.25	570.31	**570.61**
0.1	Q200D	106	44.00	565.50	**566.10**	3.2	Q200D	106	56.46	569.65	570.25
0.1	Q20I	107	44.00	565.50	**565.80**	3.2	Q20I	107	56.48	569.66	**569.96**
0.1	Q20D	70.2	44.00	565.00	565.60	3.2	Q20D	70.2	55.47	569.24	569.84
1.1		161	44.00	565.71	566.01	4.0		161	55.76	570.62	**570.92**
1.1		106	44.00	565.44	**566.04**	4.0		106	55.24	570.03	570.63
1.1		107	44.00	565.43	565.73	4.0		107	55.25	570.04	**570.34**
1.1		70.2	44.00	565.24	**565.84**	4.0		70.2	54.81	569.67	570.27
2.1	Q200I	161	44.00	567.32	567.62	4.1	Q200I	161	53.14	571.10	571.40
2.1	Q200D	106	44.00	567.06	567.66	4.1	Q200D	106	53.18	570.57	571.17
2.1	Q20I	107	44.00	567.08	567.38	4.1	Q20I	107	53.17	570.58	570.88
2.1	Q20D	70.2	44.00	566.86	567.46	4.1	Q20D	70.2	52.72	570.23	570.83
3.0		161	60.50	568.60	**568.90**	4.2		161	51.74	571.19	571.49
3.0		106	60.50	568.07	568.67	4.2		106	51.65	570.71	571.31
3.0		107	60.50	568.08	**568.38**	4.2		107	51.65	570.72	571.02
3.0		70.2	60.50	567.76	568.36	4.2		70.2	52.00	570.40	571.00
3.0	Q200I	161	60.50	569.46	**569.76**	5.1	Q200I	161	58.74	571.49	571.79
3.0	Q200D	106	60.50	568.79	569.39	5.1	Q200D	106	52.07	571.11	571.71
3.0	Q20I	107	60.50	568.80	**569.10**	5.1	Q20I	107	52.07	571.11	571.41
3.0	Q20D	70.2	60.50	568.26	568.86	5.1	Q20D	70.2	51.84	570.86	571.46
3.1		161	44.00	569.73	**570.03**	5.2		161	51.09	571.60	**571.90**
3.1		106	44.00	569.02	569.62	5.2		106	49.45	571.22	571.82
3.1		107	44.00	569.04	**569.34**	5.2		107	49.45	571.23	571.53
3.1		70.2	44.00	568.51	569.11	5.2		70.2	48.21	570.98	**571.58**

TABLE 2

NAVER CREEK FLOOD LEVEL SELECTION

SUMMARY PRINTOUT

XS	FRQ	Q	K*XNCH	CWSEL	FLD LVL	XS	FRQ	Q	K*XNCH	CWSEL	FLD LVL

HIXON CREEK FLOOD LEVEL SELECTION

SUMMARY PRINTOUT

XS	FRQ	Q	K*XNCH	CWSEL	FCL	XS	FRQ	Q	K*XNCH	CWSEL	FCL
7.1	Q200I	161	57.65	572.53	572.83	9.2		161	57.19	576.23	**576.53**
7.1	Q200D	106	56.99	572.28	**572.88**	9.2		106	56.78	575.79	576.39
7.1	Q20I	107	57.01	572.28	**572.58**	9.2		107	56.79	575.80	576.10
7.1	Q20D	70.2	56.65	571.92	572.52	9.2		70.2	56.60	575.59	**576.19**
7.2		161	85.14	573.67	**573.97**	9.3	Q200I	161	63.23	576.41	576.71
7.2		106	85.14	573.23	573.83	9.3	Q200D	106	62.40	576.12	**576.72**
7.2		107	85.14	573.23	**573.53**	9.3	Q20I	107	62.43	576.12	576.42
7.2		70.2	85.14	572.85	573.45	9.3	Q20D	70.2	56.62	575.84	**576.44**
7.3	Q200I	161	61.51	574.07	**574.37**	10.1		161	60.50	577.43	577.73
7.3	Q200D	106	60.67	573.66	574.26	10.1		106	60.50	577.16	**577.76**
7.3	Q20I	107	60.68	573.67	**573.97**	10.1		107	60.50	577.16	577.46
7.3	Q20D	70.2	59.97	573.28	573.88	10.1		70.2	60.50	576.94	**577.54**
8		161	67.51	574.39	**574.69**	10.2	Q200I	161	55.00	577.76	578.06
8		106	65.96	573.94	574.54	10.2	Q200D	106	55.00	577.50	**578.10**
8		107	66.01	573.95	**574.25**	10.2	Q20I	107	55.00	577.51	577.81
8		70.2	64.01	573.51	574.11	10.2	Q20D	70.2	55.00	577.29	**577.89**
9.1	Q200I	161	75.54	575.63	**575.93**						
9.1	Q200D	106	57.42	575.13	575.73						
9.1	Q20I	107	57.42	575.14	**575.44**						
9.1	Q20D	70.2	57.11	574.72	575.32						

TABLE 3

NAVER CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY					"n" SENSITIVITY			
XS	Q	FCTR	CWSEL	FLD LVL (I+0.3)	FLD LVL (D+0.6)	Q	K*XNCH	FCTR	CWSEL
0.1	380	1	560.5	560.80	**561.10**	380	49.5	1	560.5
0.1	418	1.1	560.6			380	54	1.1	560.5
0.1	456	1.2	560.78			380	58.5	1.2	560.5
0.1	494	1.3	561			380	63	1.3	560.5
0.2	380		561.66	**561.95**	561.73	380	49.5		561.65
0.2	418		561.8			380	54		561.77
0.2	456		561.87			380	58.5		561.88
0.2	494		561.84			380	63		561.98
0.21	380	1	561.73	**562.02**	561.79	380	49.5	1	561.72
0.21	418	1.1	561.88			380	54	1.1	561.83
0.21	456	1.2	561.95			380	58.5	1.2	561.94
0.21	494	1.3	561.96			380	63	1.3	562.04
0.3	380		563.39	**563.70**	563.56	380	49.5		563.4
0.3	418		563.56			380	54		563.53
0.3	456		563.73			380	58.5		563.65
0.3	494		563.88			380	63		563.76
1	380	1	564.63	564.93	**564.95**	380	44	1	564.63
1	418	1.1	564.73			380	48	1.1	564.72
1	456	1.2	564.84			380	52	1.2	564.81
1	494	1.3	564.94			380	56	1.3	564.9
2	380		565.56	565.85	**565.90**	380	55		565.55
2	418		565.64			380	60		565.65
2	456		565.72			380	65		565.74
2	494		565.8			380	70		565.83
3	283	1	566.3	**566.60**	566.50	283	49.5	1	566.3
3	311.3	1.1	566.44			283	54	1.1	566.4
3	339.6	1.2	566.57			283	58.5	1.2	566.49
3	367.9	1.3	566.7			283	63	1.3	566.58
4	283		566.69	**566.99**	566.87	283	49.5		566.69
4	311.3		566.83			283	54		566.8
4	339.6		566.95			283	58.5		566.9
4	367.9		567.07			283	63		566.99
5	283	1	567.12	**567.42**	567.35	283	44	1	567.12
5	311.3	1.1	567.24			283	48	1.1	567.23
5	339.6	1.2	567.35			283	52	1.2	567.33
5	367.9	1.3	567.46			283	56	1.3	567.43

TABLE 3

NAVER CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY					"n" SENSITIVITY			
XS	Q	FCTR	CWSEL	FLD LVL	FLD LVL	Q	K*XNCH	FCTR	CWSEL
				(I+0.3)	(D+0.6)				
6	283	1	567.96	568.26	**568.29**	283	44	1	567.96
6	311.3	1.1	568.04			283	48	1.1	568.05
6	339.6	1.2	568.12			283	52	1.2	568.13
6	367.9	1.3	568.2			283	56	1.3	568.22
7	283		569.2	**569.50**	569.43	283	49.5		569.2
7	311.3		569.31			283	54		569.3
7	339.6		569.42			283	58.5		569.38
7	367.9		569.51			283	63		569.45
8	283	1	569.96	**570.26**	50.17	283	44	1	569.96
8	311.3	1.1	570.06			283	48	1.1	570.03
8	339.6	1.2	570.16			283	52	1.2	570.09
8	367.9	1.3	570.24			283	56	1.3	570.15
9	283		570.31	**570.61**	570.58	283	44		570.31
9	311.3		570.41			283	48		570.39
9	339.6		570.5			283	52		570.46
9	367.9		570.58			283	56		570.52
10	283	1	570.65	570.95	**571.03**	283	49.5	1	570.65
10	311.3	1.1	570.74			283	54	1.1	570.79
10	339.6	1.2	570.83			283	58.5	1.2	570.91
10	367.9	1.3	570.89			283	63	1.3	571
11	283		571.7	**572.00**	571.96	283	49.5		571.7
11	311.3		571.78			283	54		571.73
11	339.6		571.85			283	58.5		571.81
11	367.9		571.95			283	63		571.9
12	283	1	571.87	**572.17**	572.08	283	46.2	1	571.87
12	311.3	1.1	571.97			283	50.4	1.1	571.91
12	339.6	1.2	572.08			283	54.6	1.2	571.99
12	367.9	1.3	572.21			283	58.8	1.3	572.07
13	283		572.47	**572.77**	572.58	283	49.5		572.47
13	311.3		572.62			283	54		572.53
13	339.6		572.77			283	58.5		572.61
13	367.9		572.92			283	63		572.68
14	283	1	572.86	**573.16**	573.16	283	49.5	1	572.86
14	311.3	1.1	573.01			283	54	1.1	573.01
14	339.6	1.2	573.16			283	58.5	1.2	573.14
14	367.9	1.3	573.31			283	63	1.3	573.27

TABLE 3

NAVER CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY					"n" SENSITIVITY			
XS	Q	FCTR	CWSEL	FLD LVL	FLD LVL	Q	K*XNCH	FCTR	CWSEL
				(I+0.3)	(D+0.6)				
15	283	1	574.12	**574.42**	574.26	283	49.5	1	574.12
15	311.3	1.1	574.24			283	54	1.1	574.21
15	339.6	1.2	574.35			283	58.5	1.2	574.3
15	367.9	1.3	574.46			283	63	1.3	574.39
16	283		574.92	**575.22**	575.05	283	49.5		574.92
16	311.3		575.04			283	54		575.02
16	339.6		575.17			283	58.5		575.13
16	367.9		575.3			283	63		575.23
17	283	1	575.52	**575.82**	575.79	283	46.2	1	575.52
17	311.3	1.1	575.63			283	50.4	1.1	575.65
17	339.6	1.2	575.74			283	54.6	1.2	575.77
17	367.9	1.3	575.84			283	58.8	1.3	575.89
18	283		576.82	**577.12**	576.94	283	49.5		576.82
18	311.3		576.95			283	54		576.91
18	339.6		577.09			283	58.5		577.02
18	367.9		577.22			283	63		577.12
19	283	1	577.52	**577.82**	577.67	283	49.5	1	577.52
19	311.3	1.1	577.65			283	54	1.1	577.61
19	339.6	1.2	577.78			283	58.5	1.2	577.71
19	367.9	1.3	577.91			283	63	1.3	577.8
20	283		578.2	**578.50**	578.40	283	44		578.2
20	311.3		578.32			283	48		578.32
20	339.6		578.44			283	52		578.44
20	367.9		578.55			283	56		578.55
21	283	1	578.96	**579.26**	579.16	283	49.5	1	578.96
21	311.3	1.1	579.09			283	54	1.1	579.05
21	339.6	1.2	579.22			283	58.5	1.2	579.15
21	367.9	1.3	579.35			283	63	1.3	579.24
22	283		579.48	**579.78**	**579.78**	283	49.5		579.48
22	311.3		579.59			283	54		579.57
22	339.6		579.69			283	58.5		579.65
22	367.9		579.79			283	63		579.74
23	283	1	580.16	580.46	**580.54**	283	52.8	1	580.16
23	311.3	1.1	580.21			283	57.6	1.1	580.24
23	339.6	1.2	580.26			283	62.4	1.2	580.32
23	367.9	1.3	580.31			283	67.2	1.3	580.4

TABLE 3

NAVER CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY					"n" SENSITIVITY			
XS	Q	FCTR	CWSEL	FLD LVL (I+0.3)	FLD LVL (D+0.6)	Q	K*XNCH	FCTR	CWSEL
24	283	1	581.17	**581.47**	581.42	283	70.07	1	581.17
24	311.3	1.1	581.28			283	76.86	1.1	581.23
24	339.6	1.2	581.38			283	83.66	1.2	581.29
24	367.9	1.3	581.48			283	90.53	1.3	581.35
25	283		582.13	582.43	**582.49**	283	67.96		582.13
25	311.3		582.21			283	76.07		582.21
25	339.6		582.29			283	84.16		582.28
25	367.9		582.37			283	92.24		582.35
26	283	1	584.75	585.05	**585.07**	283	46.2	1	584.75
26	311.3	1.1	584.83			283	50.4	1.1	584.83
26	339.6	1.2	584.9			283	54.6	1.2	584.91
26	367.9	1.3	584.97			283	58.8	1.3	584.98
27	283		587.85	**588.15**	587.89	283	55		587.85
27	311.3		588.03			283	60		588.01
27	339.6		588.21			283	65		588.16
27	367.9		588.39			283	70		588.3
28	283	1	590.41	**590.71**	590.60	283	44	1	590.41
28	311.3	1.1	590.55			283	48	1.1	590.54
28	339.6	1.2	590.68			283	52	1.2	590.66
28	367.9	1.3	590.85			283	56	1.3	590.8
29	283		592.34	**592.64**	592.61	283	49.5		592.34
29	311.3		592.45			283	54		592.43
29	339.6		592.55			283	58.5		592.52
29	367.9		592.68			283	63		592.62
30	283	1	594.19	**594.49**	594.49	283	46.2	1	594.19
30	311.3	1.1	594.28			283	50.4	1.1	594.28
30	339.6	1.2	594.37			283	54.6	1.2	594.37
30	367.9	1.3	594.44			283	58.8	1.3	594.45
31	283		596.21	**596.51**	596.35	283	52.8		596.21
31	311.3		596.35			283	57.6		596.34
31	339.6		596.48			283	62.4		596.46
31	367.9		596.62			283	67.2		596.58
32	283	1	598.15	**598.45**	598.19	283	55	1	598.15
32	311.3	1.1	598.32			283	60	1.1	598.3
32	339.6	1.2	598.5			283	65	1.2	598.44
32	367.9	1.3	598.65			283	70	1.3	598.58

TABLE 3

NAVER CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY					"n" SENSITIVITY			
XS	Q	FCTR	CWSEL	FLD LVL	FLD LVL	Q	K*XNCH	FCTR	CWSEL
				(I+0.3)	(D+0.6)				
33	283	1	598.42	**598.72**	598.44	283	49.5	1	598.42
33	311.3	1.1	598.6			283	54	1.1	598.6
33	339.6	1.2	598.8			283	58.5	1.2	598.76
33	367.9	1.3	598.97			283	63	1.3	598.91
34	283		598.51	**598.81**	598.48	283	49.5		598.51
34	311.3		598.72			283	54		598.69
34	339.6		598.93			283	58.5		598.86
34	367.9		599.11			283	63		599.01
35	283	1	598.87	**599.17**	598.73	283	46.2	1	598.87
35	311.3	1.1	599.07			283	50.4	1.1	599.03
35	339.6	1.2	599.25			283	54.6	1.2	599.18
35	367.9	1.3	599.41			283	58.8	1.3	599.31
36	283		600.55	**600.85**	600.85	283	44		600.55
36	311.3		600.66			283	48		600.66
36	339.6		600.78			283	52		600.79
36	367.9		600.9			283	56		600.91
37	283	1	603.28	**603.58**	603.29	283	55	1	603.28
37	311.3	1.1	603.41			283	60	1.1	603.38
37	339.6	1.2	603.54			283	65	1.2	603.5
37	367.9	1.3	603.66			283	70	1.3	603.61
38	283		604.95	**605.25**	605.14	283	49.5		604.95
38	311.3		605.06			283	54		605.05
38	339.6		605.16			283	58.5		605.14
38	367.9		605.25			283	63		605.22
39	283	1	606.58	**606.88**	606.84	283	49.5	1	606.58
39	311.3	1.1	606.69			283	54	1.1	606.7
39	339.6	1.2	606.79			283	58.5	1.2	606.81
39	367.9	1.3	606.88			283	63	1.3	606.91
40	283		608.98	**609.28**	609.12	283	57.2		608.98
40	311.3		609.07			283	62.4		609.05
40	339.6		609.16			283	67.6		609.11
40	367.9		609.24			283	72.8		609.18
41	283	1	612.22	**612.52**	612.50	283	55	1	612.22
41	311.3	1.1	612.29			283	60	1.1	612.3
41	339.6	1.2	612.35			283	65	1.2	612.36
41	367.9	1.3	612.4			283	70	1.3	612.43

TABLE 3

NAVER CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY					"n" SENSITIVITY			
XS	Q	FCTR	CWSEL	FLD LVL (I+0.3)	FLD LVL (D+0.6)	Q	K*XNCH	FCTR	CWSEL
42	283	1	612.51	612.81	612.78	283	44	1	612.51
42	311.3	1.1	612.59			283	48	1.1	612.62
42	339.6	1.2	612.67			283	52	1.2	612.71
42	367.9	1.3	612.73			283	56	1.3	612.8
43	250		613.58	613.88	613.79	250	44		613.58
43	275		613.7			250	48		613.67
43	300		613.82			250	52		613.76
43	325		613.93			250	56		613.86
44	250	1	615.64	615.94	615.82	250	44	1	615.64
44	275	1.1	615.76			250	48	1.1	615.77
44	300	1.2	615.88			250	52	1.2	615.9
44	325	1.3	616			250	56	1.3	616.02
45	250		617.67	617.97	617.75	250	44		617.67
45	275		617.81			250	48		617.79
45	300		617.95			250	52		617.9
45	325		618.08			250	56		618.01
46	250	1	619.3	619.60	619.43	250	44	1	619.3
46	275	1.1	619.44			250	48	1.1	619.43
46	300	1.2	619.57			250	52	1.2	619.54
46	325	1.3	619.7			250	56	1.3	619.65
47	250		621.43	621.73	621.59	250	44		621.43
47	275		621.56			250	48		621.55
47	300		621.68			250	52		621.66
47	325		621.79			250	56		621.77
48	250	1	625.2	625.50	625.35	250	44	1	625.2
48	275	1.1	625.34			250	48	1.1	625.33
48	300	1.2	625.46			250	52	1.2	625.45
48	325	1.3	625.59			250	56	1.3	625.57
49	250		626.95	627.25	627.00	250	51.7		626.95
49	275		627.11			250	56.4		627.09
49	300		627.27			250	61.1		627.21
49	325		627.41			250	65.8		627.33
50	250	1	628.73	629.03	628.81	250	51.7	1	628.73
50	275	1.1	628.88			250	56.4	1.1	628.87
50	300	1.2	629.01			250	61.1	1.2	629
50	325	1.3	629.15			250	65.8	1.3	629.13

TABLE 3

NAVER CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY					"n" SENSITIVITY			
XS	Q	FCTR	CWSEL	FLD LVL	FLD LVL	Q	K*XNCH	FCTR	CWSEL
				(I+0.3)	(D+0.6)				
51	250	1	631.26	**631.56**	631.49	250	44	1	631.26
51	275	1.1	631.37			250	48	1.1	631.35
51	300	1.2	631.47			250	52	1.2	631.44
51	325	1.3	631.58			250	56	1.3	631.52
52	250		633.88	634.18	**634.30**	250	44		633.88
52	275		633.93			250	48		633.95
52	300		633.97			250	52		634
52	325		634.01			250	56		634.06
53	250	1	635.73	**636.03**	635.97	250	44	1	635.73
53	275	1.1	635.84			250	48	1.1	635.81
53	300	1.2	635.94			250	52	1.2	635.89
53	325	1.3	636.04			250	56	1.3	635.97
54	250		637.58	637.88	**637.91**	250	44		637.58
54	275		637.62			250	48		637.62
54	300		637.69			250	52		637.69
54	325		637.76			250	56		637.76

HIXON CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY						"n" SENSITIVITY		
XS	Q	FCTR	CWSEL	FLD LVL	FLD LVL	Q	K*XNCH	FCTR	CWSEL
				(I +0.3)	(D+0.6)				
0.1	161	1	565.5	**565.80**		161	44	1	565.50
0.1	177.1	1.1	565.5			161	48	1.1	565.50
0.1	193.2	1.2	565.5			161	52	1.2	565.50
0.1	209.3	1.3	565.5			161	56	1.3	565.50
1.1	161		565.71	566.01	**566.04**	161	44		565.71
1.1	177.1		565.77			161	48		565.71
1.1	193.2		565.82			161	52		565.71
1.1	209.3		565.86			161	56		565.78
2.1	161	1	567.32	567.62	**567.66**	161	44	1	567.32
2.1	177.1	1.1	567.38			161	48	1.1	567.40
2.1	193.2	1.2	567.45			161	52	1.2	567.49
2.1	209.3	1.3	567.5			161	56	1.3	567.52
2.99	161		568.6	**568.90**	568.67	161	60.5		568.60
2.99	177.1		568.72			161	66		568.60
2.99	193.2		568.84			161	71.5		568.60
2.99	209.3		568.93			161	77		568.60

TABLE 3

NAVER CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY					"n" SENSITIVITY			
XS	Q	FCTR	CWSEL	FLD LVL	FLD LVL	Q	K*XNCH	FCTR	CWSEL
				(I+0.3)	(D+0.6)				
3	161	1	569.46	**569.76**	569.39	161	60.5	1	569.46
3	177.1	1.1	569.66			161	66	1.1	569.52
3	193.2	1.2	569.85			161	71.5	1.2	569.57
3	209.3	1.3	570.04			161	77	1.3	569.62
3.1	161		569.73	**570.03**	569.62	161	44		569.73
3.1	177.1		569.9			161	48		569.82
3.1	193.2		570.07			161	52		569.89
3.1	209.3		570.25			161	56		569.97
3.2	161	1	570.31	**570.61**	570.25	161	59.25	1	570.31
3.2	177.1	1.1	570.47			161	65.41	1.1	570.40
3.2	193.2	1.2	570.63			161	71.57	1.2	570.49
3.2	209.3	1.3	570.8			161	77.85	1.3	570.57
4	161		570.62	**570.92**	570.63	161	55.76		570.62
4	177.1		570.77			161	61.01		570.73
4	193.2		570.91			161	66.26		570.82
4	209.3		571.05			161	71.56		570.92
4.1	161	1	571.1	**571.40**	571.17	161	53.14	1	571.10
4.1	177.1	1.1	571.23			161	57.96	1.1	571.18
4.1	193.2	1.2	571.36			161	62.79	1.2	571.26
4.1	209.3	1.3	571.49			161	67.61	1.3	571.33
4.2	161		571.19	**571.49**	571.31	161	51.74		571.19
4.2	177.1		571.32			161	56.65		571.28
4.2	193.2		571.45			161	61.59		571.36
4.2	209.3		571.57			161	66.55		571.44
5.1	161	1	571.49	**571.79**	571.71	161	58.74	1	571.49
5.1	177.1	1.1	571.59			161	64.15	1.1	571.57
5.1	193.2	1.2	571.69			161	69.57	1.2	571.64
5.1	209.3	1.3	571.8			161	75.24	1.3	571.72
5.2	161		571.6	**571.90**	571.82	161	51.09		571.60
5.2	177.1		571.7			161	56.22		571.70
5.2	193.2		571.78			161	60.97		571.78
5.2	209.3		571.88			161	65.76		571.86
7.1	161	1	572.53	572.83	**572.88**	161	57.65	1	572.53
7.1	177.1	1.1	572.59			161	63.05	1.1	572.58
7.1	193.2	1.2	572.64			161	68.44	1.2	572.62
7.1	209.3	1.3	572.73			161	73.86	1.3	572.67

TABLE 3

NAVER CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY					"n" SENSITIVITY			
XS	Q	FCTR	CWSEL	FLD LVL	FLD LVL	Q	K*XNCH	FCTR	CWSEL
				(I+0.3)	(D+0.6)				
7.2	161		573.67	**573.97**	573.83	161	85.14		573.67
7.2	177.1		573.78			161	92.88		573.73
7.2	193.2		573.88			161	100.62		573.78
7.2	209.3		573.96			161	108.36		573.84
7.3	161	1	574.07	**574.37**	574.26	161	61.51	1	574.07
7.3	177.1	1.1	574.17			161	67.29	1.1	574.16
7.3	193.2	1.2	574.26			161	73.09	1.2	574.24
7.3	209.3	1.3	574.35			161	78.97	1.3	574.32
8	161		574.39	**574.69**	574.54	161	67.51		574.39
8	177.1		574.49			161	73.98		574.49
8	193.2		574.58			161	80.49		574.58
8	209.3		574.67			161	87.17		574.67
8.1	161	1	575.01	**575.31**	575.1	161	55	1	575.01
8.1	177.1	1.1	575.14			161	60	1.1	575.11
8.1	193.2	1.2	575.26			161	65	1.2	575.21
8.1	209.3	1.3	575.38			161	70	1.3	575.30
8.2	161		575.31	**575.61**	575.44	161	57.96		575.31
8.2	177.1		575.44			161	63.38		575.41
8.2	193.2		575.56			161	68.81		575.50
8.2	209.3		575.67			161	74.27		575.59
9.1	161	1	575.63	**575.93**	575.73	161	75.54	1	575.63
9.1	177.1	1.1	575.74			161	83.02	1.1	575.72
9.1	193.2	1.2	575.87			161	90.58	1.2	575.82
9.1	209.3	1.3	575.98			161	102.83	1.3	575.92
9.2	161		576.23	**576.53**	576.39	161	57.19		576.23
9.2	177.1		576.33			161	62.46		576.31
9.2	193.2		576.43			161	67.75		576.39
9.2	209.3		576.53			161	73.08		576.49
9.3	161	1	576.41	576.71	**576.72**	161	63.23	1	576.41
9.3	177.1	1.1	576.48			161	68.98	1.1	576.41
9.3	193.2	1.2	576.55			161	74.87	1.2	576.45
9.3	209.3	1.3	576.61			161	81.05	1.3	576.57
10.1	161		577.43	577.73	**577.76**	161	60.5		577.43
10.1	177.1		577.5			161	66		577.47
10.1	193.2		577.57			161	71.5		577.51
10.1	209.3		577.63			161	77		577.53

TABLE 3

NAVER CREEK SENSITIVITY STUDIES

	"Q" SENSITIVITY					"n" SENSITIVITY			
XS	Q	FCTR	CWSEL	FLD LVL	FLD LVL	Q	K*XNCH	FCTR	CWSEL
				(I+0.3)	(D+0.6)				
10.2	161	1	577.76	578.06	**578.10**	161	55	1	577.76
10.2	177.1	1.1	577.82			161	60	1.1	577.82
10.2	193.2	1.2	577.89			161	65	1.2	577.88
10.2	209.3	1.3	577.95			161	70	1.3	577.94

APPENDIX 1

Detailed Information Sources

No.	Source	Contents
1.	Technical Support Section, Water Management Division Project No. 88-RPP-11 May 1988	11 cross sections on Hixon Creek, and 25 cross sections on Naver Creek, including photos of each section and bridge details
2.	Technical Support Section, Water Management Division Project No. 93 21 F 082 July 1993	Cross Sections 0.1 to 0.3 and 26 to 54 on Naver Creek, including photos and bridge details
3.	Technical Support Section, Water Management Division Project No. 94 10 F 082 July 1994	30 Cross Sections on Hixon Creek including repeats of the 1988 survey, including photos at each cross section
4.	Map Production Division, Surveys and Resource Mapping Branch, Project No. 89-005, March 1993	Base mapping for Naver and Hixon Creeks - 1:5000 scale 1 metre contours, NAD83 from 1989 Air photography
5.	United States Geological Survey Water Supply Paper #2339	Guide for selecting Manning's Roughness Coefficients for Natural Channels and Floodplains
6.	Prince George Regional Water Management Files	Background information on flood and erosion complaints

CANADA/BRITISH COLUMBIA FLOODPLAIN MAPPING AGREEMENT

APPENDIX 2

January 12, 1995
File No. 42500-40/R5
Study No. 414

HYDROLOGY SECTION REPORT

NAVER CREEK

INTRODUCTION

In response to a request (memorandum of August 10, 1994) from R.W. Nichols, Flood Hazard Identification Section, peak flow estimates were made as input to a floodplain mapping project for lower Naver Creek. Also, stream channel data were obtained from Water Survey of Canada for the hydrometric station Naver Creek at Hixon (08KE014) for a backwater model calibration. A stage-discharge curve and cross-section data are supplied under separate cover.

Naver Creek drains west facing slopes of the eastern edge of the Fraser Plateau into Fraser River, five km west of Hixon. Annual peak flows in this region occur between mid spring and start of summer from snowmelt and rain-on-snow events. However, an occasional westerly frontal air mass will produce an annual peak rainstorm event in mid to late summer. The northern portion of the watershed, which reaches a height of 1804 m, experiences slightly higher unit peak flow than the lower, southern portion.

REGIONAL PEAK FLOW

A regional peak flow method was used to make the required frequency estimates at various points along lower Naver Creek and Hixon Creek near its mouth. This procedure was based on Section 7.4 of the Ministry's *Manual of Operational Hydrology in British Columbia.* A frequency analysis was conducted of 20 nearby long-term hydrometric stations with adequate annual maximum daily discharge records. Estimates of 20- and 200-year recurrence interval daily peak flow were based on the log-Pearson III frequency distribution that was the best-fit for a majority of the stations. These estimates were plotted as unit peak flow (L/s/km^2) against drainage area (km^2) on log-log graph paper, as shown in Figure 1. Envelope curves (straight lines on a log-log scale) were drawn for the southern and northern portions or subregions of the Naver Creek watershed. A common slope was based on that of a nearby study (*Lowhee Creek Peak Flow Estimates*, Study 266, September 30, 1987).

The vertical positions of the subregional unit peak flow curves were based on the plot positions of the hydrometric station points within the study basin and the neighbouring watersheds. The lower 200-year curve for the southern portion of the Naver Creek basin was positioned through Cottonwood River (08KE009), a southerly neighbouring watershed, and Little Swift River (08KE024), it's tributary. Considering the frequency results of these two stations the 95% confidence limits of this curve are estimated to be approximately -20 and +30%. The upper 200-year curve for the northern Naver basin was based on the Lowhee Creek Study that would reflect its higher unit peak flow. The Willow River (08KD006) point for the east-neighbouring watershed plots higher, but would plot on the curve if other than the best-fit log-Pearson III frequency distribution was used. The Naver Creek point (08KE014) plots slightly lower than the curve but its record, which has been discontinued since 1975, is missing high peaks of the last decade. Considering the regional location of the upper 200-year curve with respect to the plotted points (the curve was not positioned on a specific point for this study) the 95% confidence limits of the curve are estimated to be approximately -20 and +20%.

The unit daily peak flow curves for the 20-year recurrence interval condition were positioned with respect to the relative plot positions of the 20-year points. The lower curve for the southern Naver basin was positioned through the Cottonwood and Little Swift points, as for the 200-year case. However, the upper curve was positioned through the Willow River point, since its best-fit distribution estimate plot gave a good representation of the upper portion of the Naver basin. The 95% confidence limits of the 20-year curves would be approximately five to 10% lower than for 200-year curves, based on the statistics of the relevant plot points (e.g., -18 to +27% for the lower curve and -18 to +18% for the upper curve).

A regional procedure for estimating instantaneous peaks from the daily peak flow estimates was used because of insufficient instantaneous data. Of the 20-station data set 13 stations had adequate maximum instantaneous discharge data but these records were much shorter and the key study stations had no instantaneous data. This procedure was based on Section 7.3.2 of the *Manual of Operational Hydrology in British Columbia.* A plot was made, as shown in Figure 2, of maximum instantaneous-to-daily peak flow ratios (I/D) of the highest peaks versus drainage area. An envelope curve was defined with curvature based on that of the Lowhee Creek Study but passing through the highest point of this study, Charleson Creek (08KG004), a westerly neighbouring watershed. This curve represents the whole Naver watershed and was used to convert daily peak flow estimates into instantaneous in the next section.

PEAK FLOW ESTIMATES

The envelope curves of Figures 1 and 2 were applied to a number of streamflow sites in lower Naver Creek and Hixon Creek near its mouth, as specified in the study request. The digitized drainage areas, parameter curve values and resulting peak flow estimates for 20- and 200-year recurrence intervals are given in Table 1. The estimating points for Watershed 1 were positioned halfway between the northern and southern basin unit peak flow curves for each respective recurrence interval, reflecting the approximate contribution of each portion of the watershed. Watershed 4 and 5 estimates were positioned on the northern curves and 2, 3, and 6 on the southern curves for each recurrence interval. Note that the estimated values are given to three significant figures but are valid to only two.

TABLE 1 PEAK FLOW ESTIMATES

STREAM SITE	DRAINAGE AREA (km^2)	MAX I/D	RECURRENCE INTERVAL (years)					
			20			200		
			D ($L/s/km^2$)	D (m^3/s)	I (m^3/s)	D ($L/s/km^2$)	D (m^3/s)	I (m^3/s)
1. Naver Creek below Hixon Creek	908	1.36	214	194	264	308	280	380
2. Naver Creek above Hixon Creek	661	1.40	223	154	216	307	203	284
3. Naver C. below Meadowbank C.	490	1.43	240	118	168	327	160	229
4. Hixon Creek above Naver Creek	238	1.52	295	70.2	107	446	106	161
5. Hixon Creek bl. Government C.	210	1.54	300	63.0	97.0	460	96.6	149
6. Naver C. at Hixon (08KE014)	656	1.40	225	148	207	308	202	283

D, daily discharge
I, instantaneous discharge

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Hydrology Section
Hydrology Branch
387-9474

FIGURE 1 NAVER CREEK BASIN PEAK FLOW

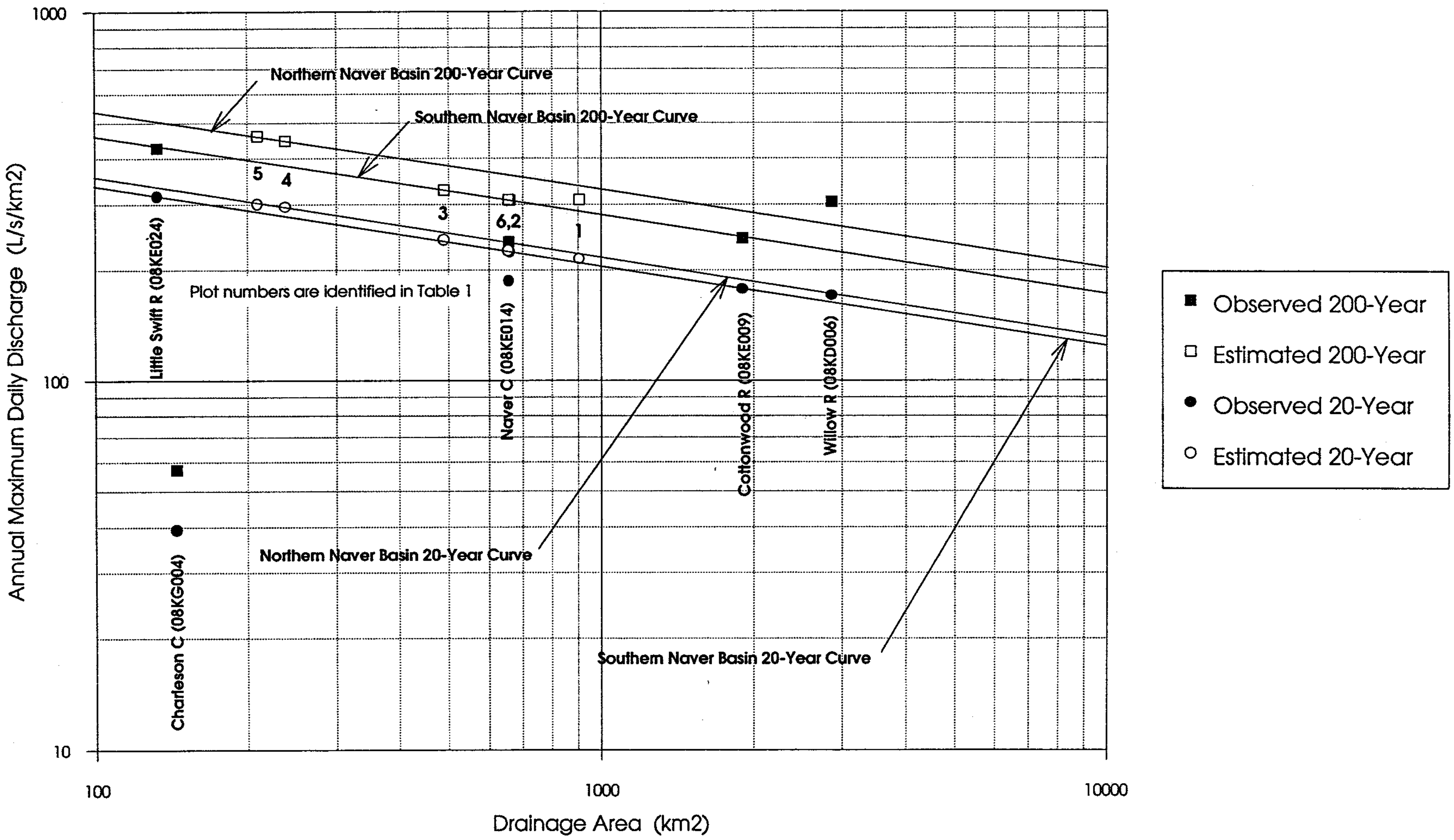
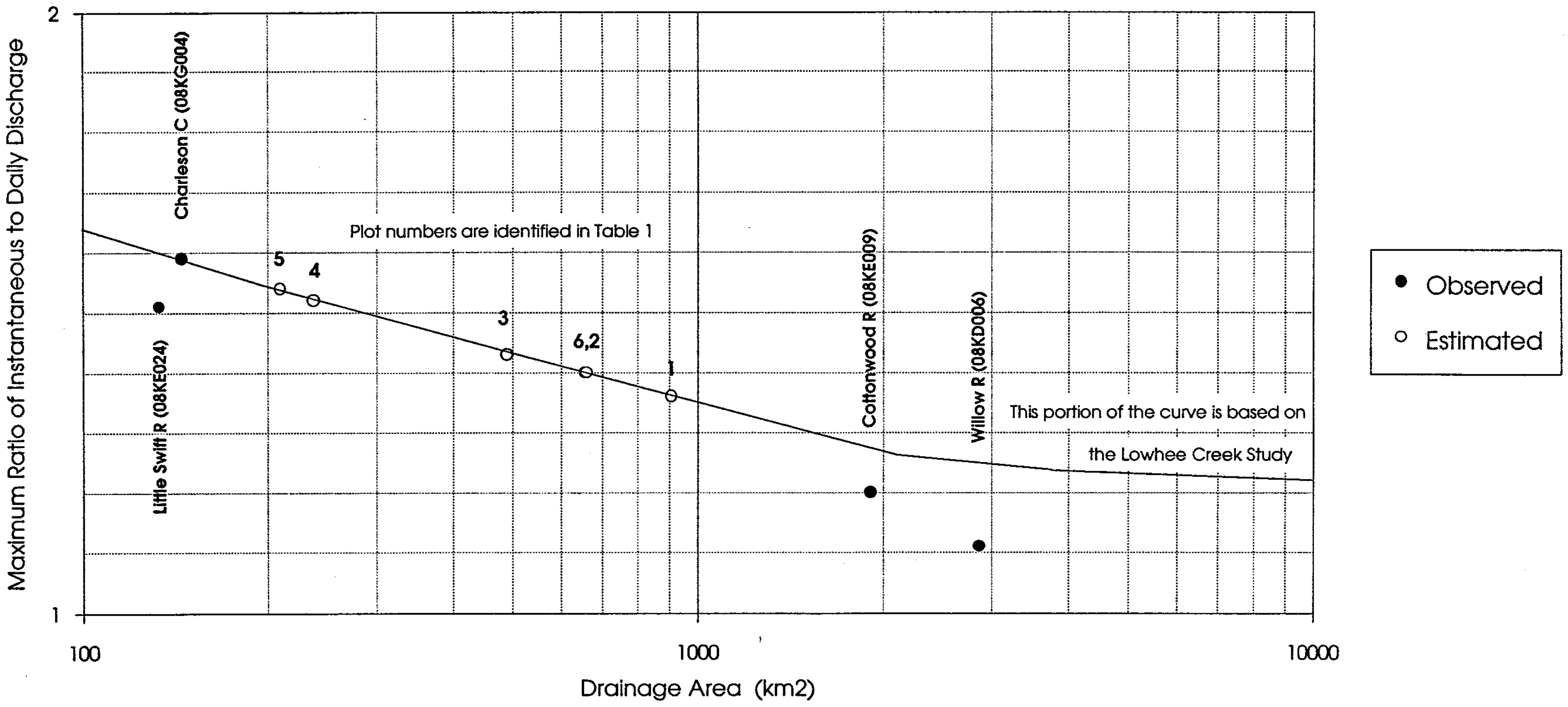


FIGURE 2 NAVER CREEK BASIN INSTANTANEOUS-DAILY RATIO PEAK FLOW



APPENDIX 3

PHOTOGRAPHS

PHOTO 1: Hixon Cr. looking D/S from XS 2 Swanson Road

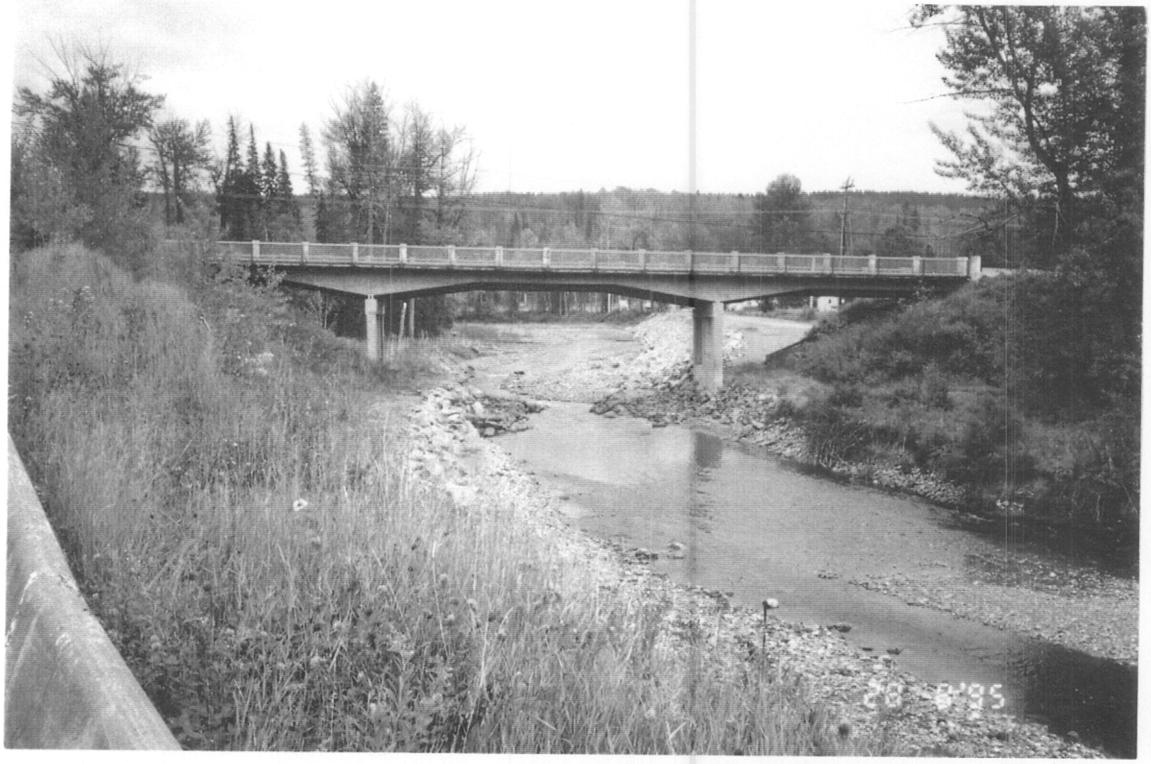


PHOTO 2: Hixon Cr looking upstream towards Hwy 97 Bridge.

Photo 3 & 4: Hixon Creek - Pan view D/S, across and U/S from XS 4 Yard Road
Note erosion protection works, groynes and highway stabilization toe berm

APPENDIX 3

PHOTOGRAPHS

Photo 5 & 6: Hixon Creek -Pan view looking U/S from XS 4 Yard Road toward XS 5.1 & 5.2

APPENDIX 3

PHOTOGRAPHS

Photo 7: Naver Creek looking D/S towards XS 6 from XS 7

Photo 8: Naver Creek looking U/S towards XS 8 from XS 7

APPENDIX 3

PHOTOGRAPHS

Photo 9: Naver Creek - Recently constructed home vicinity of XS 7 & 8
Note use of fill to achieve some flood protection

Photo 10: Naver Creek - looking D/S at erosion protection works and high cut bank vicinity XS 20

APPENDIX 3

PHOTOGRAPHS

Photo 11: Naver Creek - looking at house on edge of floodplain Taylor Road vicinity of XS 29 & 30

Photo 12 : Naver Creek - looking U/S from bridge XS 34

APPENDIX 3

PHOTOGRAPHS

Photo 13: Naver Creek - looking across floodplain from R/B vicinity of XS 35 & 36

Photo 14: Naver Creek - looking D/S across floodplain from R/B vicinity of XS 38