CANADA / BRITISH COLUMBIA
FLOODPLAIN MAPPING AGREEMENT

PROVINCE OF BRITISH COLUMBIA
Ministry of Environment, Lands and Parks
Water Management Division

**Design Brief on the
Floodplain Mapping Study**

Seymour River
North Vancouver

An Overview of the Study Undertaken
to Produce Floodplain Mapping
for the Seymour River
in North Vancouver

Floodplain Mapping Program
Hydrology Branch
Victoria, British Columbia

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DESIGN BRIEF ON THE FLOODPLAIN MAPPING STUDY

SEYMOUR RIVER AT NORTH VANCOUVER

PREFACE

The purpose of this design brief is to present a description of the methodologies used and the results of the study undertaken to produce the floodplain mapping sheet for the Seymour River at North Vancouver, Drawing 93-5, Sheet 1 (Appendix 4).

1. LOCATION

The Seymour River flows south from Seymour Lake and empties into the sea in Burrard Inlet at Second Narrows, immediately east of the Second Narrows Bridge which links Vancouver and North Vancouver. The portion of the river covered in this study lies entirely in the North Vancouver District Municipality. Figure 1 shows the study area location.

Figure 2 is a Key Map of the study area which indicates the location of the floodplain mapping drawing produced for the study. The study area is located approximately 4 km from the North Vancouver business district and within 10 km of downtown Vancouver. During the 1994 visits to the study area by staff of the Hydrology Branch, it was noted that existing lots were being subdivided/developed in the study area (Appendix 2, photos 17 and 18).

2. BACKGROUND TO STUDY

The headwaters of the Seymour River originate over 32 kilometres inland from Burrard Inlet on Crown land north of Vancouver, as shown in Figure 3. The river is regulated by the Seymour Falls Dam at the south end of Seymour Lake, approximately 16 kilometres upstream from the river mouth. The total drainage area is 188 km^2, of which 67% or 126 km^2, is upstream of Seymour Dam. The dam is operated and maintained by the Greater Vancouver Water District (GVWD) and the stored water is part of the Greater Vancouver water supply.

A $4.7 million interim seismic upgrade of the Seymour Falls Dam was scheduled for completion in 1994. A full $14 million upgrade of the dam has been postponed by the GVWD until a further water supply source is decided. If the Seymour source is selected, a new higher dam will be constructed in the next decade (Appendix 1.7).

Over the years, four different gauging stations have been established on the Seymour River by the Water Survey of Canada (WSC). Of these, gauge 08GA030 is the only one still in existence, and it has been in operation continuously since 1928.

The flood of record, which occurred on October 31, 1981, caused structural damage to buildings located downstream of the Dollarton Highway bridge, severely eroded banks in several locations and flooded homes in residential areas. (Appendix 2, photos 8, 10, 12, 16, 19, 21 & 22). The peak instantaneous flow recorded was 650 cms. Following this event, a survey was carried out by the Survey Section of the Water Management Branch to identify and obtain the elevation of high water marks (Appendix 1.2).

At the request of the District of North Vancouver, Kerr Wood Leidal (KWL) Associates Limited produced a report dated June 1982 (Appendix 1.4). This report determined that the safe channel capacity of the Lower Seymour River was in the order of 14,000 cfs or 400 cms. Prior to 1981, floods with instantaneous peaks exceeding this capacity occurred on January 15, 1961 (585 cms), November 3, 1955 (545 cms), and October 18, 1940 (485 cms).

Staff of the Hydrology Branch were in contact with the staff of the District of North Vancouver in September, 1994 with respect to a proposal (September 1994) by KWL for a river management plan for the Seymour River in the study area. The data obtained for this floodplain delineation study has been provided to KWL to assist in the management plan to avoid duplication of effort in these matters.

This watercourse was listed as a high priority for floodplain mapping by the Water Management regional office in Surrey in support of the administration of subdivison approvals under the Land Title Act and local government bylaws regulating development in flood hazard areas.

With reference to the floodplain mapping sheet (Appendix 4), the upper portion of the study area north of Mount Seymour Parkway is primarily a residential area of single family dwellings with newer homes in the northern portion. On the left (east) bank between the Parkway and the Dollarton Highway are found a mixture of earlier residental dwellings, Maplewood Farm and commercial buildings. On the opposite (west) bank the Squamish Nations Band Indian Reserve has commercial/industrial developments, buildings housing the Band and Administrative offices and a recently developed golf driving range facility (Appendix 2, photo 6). The area around the actual river mouth is a harbour with docks for a pile driving company and other marine industries.

3. PRESENT STUDY

The 1994 floodplain mapping study is based on a field survey carried out by the Technical Support Section during July and September, 1992 (Appendix 1.1). Twenty-six cross sections cover the Seymour River from Burrard Inlet upstream approximately 3.7 kilometres to a point where the river becomes well incised in a steep canyon. Large boulders, some exceeding 1 metre in diameter, can be found throughout the entire length of the channel in the study area (Appendix 2, photo 20).

One metre interval, 1:5000 scale topographic mapping based on 1990 air photography was used in the study (Appendix 1.3). This mapping was produced by the Surveys and Resource Mapping Branch for the Floodplain Mapping Program.

A hydrology study (Appendix 3) requested in July, 1993, was completed in February, 1994. In addition to the high water level data obtained as a result of the flood of record (650 cms) of October 31, 1981, water levels were also obtained by staff members of the Hydrology Branch on March 3, 1994, after heavy continuous rain fell over the Lower Mainland and Vancouver Island during late February and early March (Appendix 1.1). The peak instanteous flow for that time period (278 cms) was obtained from Water Survey of Canada as well as the peak hourly daytime flows for March 3. High water mark observations were recorded at locations where similar observations were made following the 1981 event.

4. FLOOD MAGNITUDES

4.1 General

Peak flow events for this and other coastal areas of British Columbia usually occur in the late fall and winter, and are caused by westerly frontal rainstorms of low intensity but prolonged duration. Occasionally frontal storms become unstable and remain stationary over a watershed for several days, producing thunderstorms and heavy showers which could cause severe flooding and damage.

Seymour Lake, being a storage reservoir for the GVWD, is maintained at full capacity (Appendix 3), and provides minimal attenuation to extreme flood flows.

As mentioned previously, the October, 1981 event flooded properties on Seymour Road on the right bank of the river. The bank was overtopped upstream of Grantham Road and flowed down Seymour Boulevard before returning to the channel, damaging at least one rock wall in the process (Appendix 2, photo 22).

4.2 Hydrometric Data

Water Survey of Canada have established four gauging stations on the Seymour River beginning in 1914. Of these, only gauge 08GA030 is still active and has been since 1928, with limited interruption. The maximum daily discharge (QD) recorded at this station was 430 cms, which occurred on October 31, 1981. The maximum instantaneous flow (QI) of 650 cms was also recorded on that date.

4.3 Hydrology Studies

Peak flow estimates were provided by the ministry's Hydrology Branch based on a computer frequency analysis of the daily and instantaneous discharges recorded for the aforementioned WSC gauge, and with reference to the *Fraser Delta Strategic Plan*, a regional peak flow study completed in 1983.

The February, 1994 Hydrology Section Report, Study No. 403, is included in this design brief as Appendix 3.

The hydrology study provided estimated discharges of 363 and 551 cms for the 20-year and 200-year daily flows at the mouth of the Seymour River. Instantaneous discharges for similar recurrences were 530 and 808 cms.

The 1981 maximum recorded QD and QI discharges of 430 cms and 650 cms were estimated to have a recurrence interval of 55 and 64 years, respectively.

The March 1, 1994 instantaneous discharge was 278 cms, while 70 cms was the peak flow for March 3, 1994. This data was received from Water Survey of Canada in May, 1994.

5. FLOOD LEVELS

5.1 Coastal Flood Level

The coastal flood level adopted by the Ministry for administrative purposes is the highest ocean stillwater level (exclusive of wave runup from normal wind-generated waves and flooding from tsunamis) that might result from the most severe combination of hydrometeorological and other factors, that is considered reasonably possible at a specific coastal site.

The coastal flood level includes astronomical tide, storm surge, and an allowance for uncertainties of local wind chop, seiche, number truncation and unit conversion errors. Since the coastal flood level does not include wave runup, buildings must be adequately set back from the natural boundary. The coastal flood level does not consider tsunami effects.

At Vancouver and Point Atkinson, higher high water large tide (HHLWT) is 5.0 m Chart Datum, which is about 1.9 m GSC. The astronomical tides every December are within ± 0.1 m of this level. Most storms, storm surges and heavy rains also occur during December (coincident with the highest yearly tides); therefore, HHWLT (1.9 m Geodetic) has been used as a basis for estimating the coastal flood level.

Estimates of storm surge were determined from the differences between the predicted tides and the recorded extreme water levels. Data from the Strait of Georgia stations show surges of 0.9 m at several sites. Point Atkinson and Vancouver both have long continuous records (44 and 45 years) and have recorded the same (0.9 m) storm surge as other Strait of Georgia stations. It is estimated that a reasonable maximum storm surge for Vancouver Harbour at the mouth of the Seymour River is about 1.2 m above the tide.

Seaconsult Marine Research Ltd. carried out a study of the coastal flood levels in Boundary Bay for the B.C. Ministry of the Environment. This study included a detailed analysis of the historical storm surges in the Strait of Georgia using the Point Atkinson tide data. This analysis estimated that the 200 year storm surge off Point Atkinson was 1.15 m above the tide. This study confirms that a reasonable maximum storm surge for Vancouver Harbour is about 1.2 m above the tide.

The ocean water level in Vancouver Harbour at the mouth of the Seymour River is the sum of HHWLT (1.9 m Geodetic) and the maximum storm surge (1.2 m). It is reasonable to add these two values, because both storms and extreme high tides do occur at the same time each year. For Vancouver Harbour an ocean water level of 3.1 m Geodetic is recommended as a stillwater level.

For floodplain administration purposes, this stillwater level is not deemed to be adequate. A coastal flood level adopted by the Ministry has an allowance for uncertainties of 0.3 m above the stillwater level for wind chop, seiches and number truncation errors. For floodplain administration purposes, the coastal flood level then should be (3.1 + 0.3) 3.4 m geodetic for Vancouver Harbour near the mouth of the Seymour River. This level assumes that coastal buildings have adequate setback distances from the natural boundary of the sea to safeguard buildings against wave erosion.

The coastal flood level adopted for Vancouver Harbour (Burrard Inlet) governs the designated flood level for the Seymour River up to between cross sections 4 and 5 as indicated on the mapping sheet. During the field survey, the tidal effect was obvious at low river flow conditions at the Dollarton Road bridge (cross sections 6 & 7) as the tide level rose to the point where it became impossible to wade the river.

5.2 RIVER FLOOD LEVELS

Information sources listed in Appendix 1 were utilized in the PC microcomputer version of the HEC-2 water surface profile computer program, Version 6.4, developed by the Hydrologic Engineering Centre, U. S. Army Corps of Engineers in Davis, California. The flood profile calculations assume open water flow conditions.

Flood profiles were calculated for the Seymour River a distance of 3.7 km upstream from the river mouth at Burrard Inlet.

A plot run was obtained to assess the ground survey data and the extensions of surveyed cross sections obtained from the existing topographic mapping. Output from the plot run was used to review other data such as flow regime, loss coefficients, bridge information, reach lengths, overbank data and relative Manning's "n" values. Detail for the Canadian National Railway bridge at cross section 3 and the three road bridges upstream was coded into the input data.

Model calibration was undertaken by matching known flows and water level elevations. Highwater data corresponding to measured flows was available for the flood of record which occurred on October 31, 1981. Additional highwater data was obtained for an event which occurred on March 1 & 2, 1994. This data, together with colour photographs provided by the Survey Section (Appendix 2, photo 20 is an example), site visits, experience gained in other studies and a review of the information available in a book published by the U.S. Department of the Interior entitled "Roughness Characteristics of Natural Channels", was used to assist in the determination of Manning's "n" values in the study area.

There are three road bridges and one railway bridge in the study area as shown on Drawing 93-5-1 and Figure 2. At the time of the 1981 flood, the Mount Seymour Parkway bridge had not been constructed. The Grantham Road Bridge was a Bailey bridge (Appendix 2, photo 19) which was replaced by the current structure in 1987.

A total of 26 river cross sections were obtained along the 3.7 km thalweg distance of the Seymour River from the sea at Burrard Inlet. Four additional cross sections were created from surveyed sections and the base mapping, and added as follows:

-at the end of the bar downstream of cross section 1 (cross section 1.9)

-at the downstream edge and parallel to the railway bridge (cross section 2.9)

-at a concrete weir just upstream of cross section 4 and numbered as section 4.5. The weir was surveyed in the field and included in the survey data as an unnumbered cross section.

-at the downstream edge of the Grantham Road bridge (cross section 17.9)

The thalweg profile has an average slope of 0.8% in the mapped section as shown in Figure 4.

Manning's "n" value for the channel under flood flow conditions was estimated to range between 0.022 and 0.050 in the study area. Overbank areas were estimated to have an "n" value of 0.10. Flows used in the backwater analysis are listed in Section 4.3.

In accordance with the policy of the Ministry of Environment, Lands and Parks, the flood levels and floodplain limits shown on floodplain mapping sheets assume open channel flow conditions and are based on a designated (1:200 year frequency) flow plus an allowance for hydraulic and hydrologic uncertainties. Flood levels shown on Drawing 93-5 are equal to the 1:200 year daily level plus 0.6m or the 1:200 year instantaneous level plus 0.3m, whichever elevation is the greater. Using the above noted allowances for uncertainty, the flood levels shown on the mapping are generally based on the Q200 instantaneous levels which average 0.2 m above the Q200 daily levels.

Sensitivity studies indicate that for the daily instantaneous flow of 808 cms, an increase in Manning's "n" values of 20% results in flood levels at the 22 cross sections located above the coastal flood level influence increasing to within an average of 0.06 metres of the flood levels shown on the mapping sheet. At 7 of the 22 sections, the calculated flood level was marginally above (i.e. less than 0.1 m) the flood levels shown on the map. Table 2 lists results of the sensitivity to Mannings "n" calculated.

The flood levels shown on the drawing average 0.8 metres above the 1981 maximum flood of record which has a return period of 64 years. Table 1 lists the results of sensitivity to "Q" calculated.

Table 3 indicates flood levels at the river cross sections in the study area. Also shown are elevations of top of bank spoil (I.R. #2), top of rock walls, bridge low chords and other data of interest.

6. FLOODPLAIN MAPPING

6.1 General

The flood levels determined in the study, including an allowance for uncertainties, were used to delineate floodplain limits onto the 1 metre contour mapping of the study area. The floodplain mapping for the Seymour River, Drawing No. 93-5, Sheet 1, indicates the location of river cross sections and survey monuments, the floodplain limits and the flood levels determined in the study.

A field visit was undertaken on November 24 and 25, 1994 to verify, by visual inspection, the location of the floodplain boundary as shown on the drawing. Mr. M. V. Currie, P. Eng., of KWL Associates Ltd., met with Hydrology Branch staff to discuss the results of the inspection. Prints of one-half metre contour interval, 1:2000 scale mapping (Appendix 1.8) provided to the Ministry by the District of North Vancouver, through Mr. Currie, were also reviewed to confirm the floodplain boundary.

Additional information with respect to the inundation of the 1981 flood was obtained from the Maplewood Farm manager. As discussed in Section 2, the farm is located opposite the Squamish Nation's Seymour Creek Indian Reserve #2.

6.2 Conclusions

1. This design brief presents an overview of the studies undertaken to produce the floodplain mapping sheet for the Seymour River, a distance upstream of approximately 3.7 km from the outlet to the ocean at Burrard Inlet in Vancouver Harbour.

2. The floodplain mapping sheet, Drawing 93-5, is based on 1 metre contour interval mapping within the floodplain area. Site specific ground elevations within or adjacent to the floodplain limits should be confirmed by ground survey.

3. Floodplain mapping is an administrative tool showing designated floodplain limits and flood levels used to determine minimum floodproofing elevations for building bylaw and subdivision approvals.

4. Floodplain mapping is not a comprehensive river management plan nor does it provide solutions to site specific flood hazard problems; these will require detailed engineering analyses. As indicated on Drawing 93-5 and photos in Appendix 2, problems related to deposition of bedload material, severe bank erosion and other flooding hazards have been documented in the Seymour River valley as a result of high flood flows.

5. The information obtained in this study will be provided to the District of North Vancouver to assist in the proposed river management study which is scheduled to be initiated by KWL Associates Ltd. in January of 1995.

6. It may be necessary to review Drawing 93-5 as a result of significant floods, erosion rates, floodplain development or other situations, to maintain the adequacy, accuracy and usefulness of the existing information.

6.3 Recommendations

1. It is recommended that the floodplains delineated on Drawing 93-5, Sheet 1, be Designated under the

terms of the Canada / British Columbia Floodplain Mapping Agreement.

2. The Drawing may be used for administrative purposes related to the preparation of hazard map schedules for offical plans; floodproofing requirements in zoning and building bylaws; and the identification of floodable lands by Subdivision Approving Officers.

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Brian Board
Project Technician
Hydrology Branch

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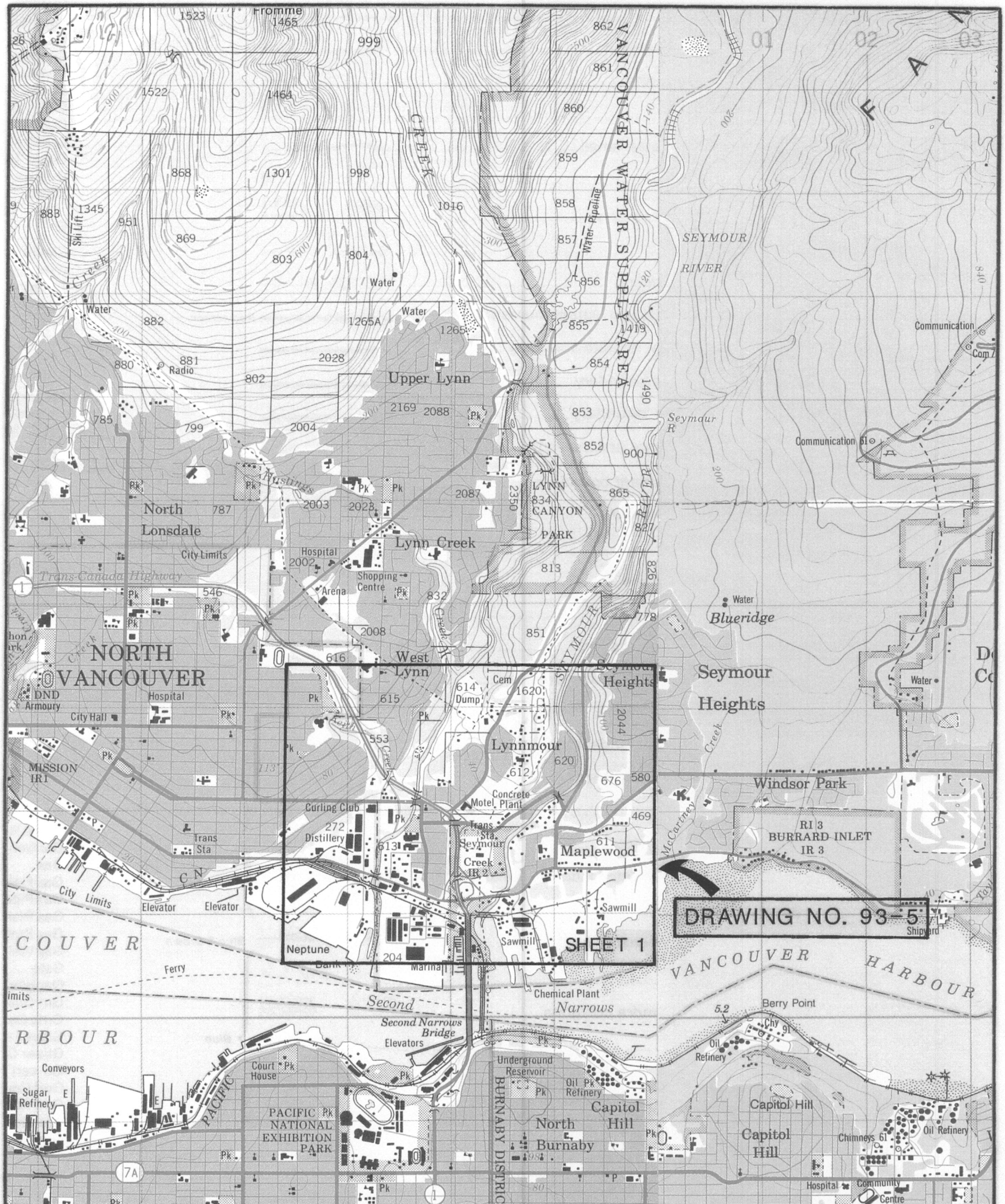
R. W. Nichols
Senior Hydraulic Engineer
Hydrology Branch

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

TO ACCOMPANY A DESIGN BRIEF ON THE
FLOODPLAIN MAPPING
SEYMOUR RIVER
STUDY AREA LOCATION

SCALE: VERT / HOR NOT TO SCALE	DATE JULY 1994	R.W. NICHOLS ENGINEER
		FILE No. 35100-30/900-0661 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 SEYMOUR RIVER KEY MAP

SCALE: VERT.	DATE
HOR. 1 : 50 000	JULY 1994

R.W. NICHOLS ENGINEER

FILE No. 35100-30/900-0661 DWG. No. FIGURE 2

BCIL 7673-M E

Province of British Columbia
MINISTRY OF ENVIRONMENT,
LANDS AND PARKS
WATER MANAGEMENT DIVISION

TO ACCOMPANY A DESIGN BRIEF ON THE
FLOODPLAIN MAPPING
SEYMOUR RIVER
WATERSHED BOUNDARY

SCALE: VERT.		R.W. NICHOLS	ENGINEER
HOR. 1 : 250 000	DATE JULY 1994	FILE No. 35100-30/900-0661	DWG. No. FIGURE 3

BCIL 7673-M.E

FIGURE 4

SEYMOUR RIVER THALWEG PROFILE

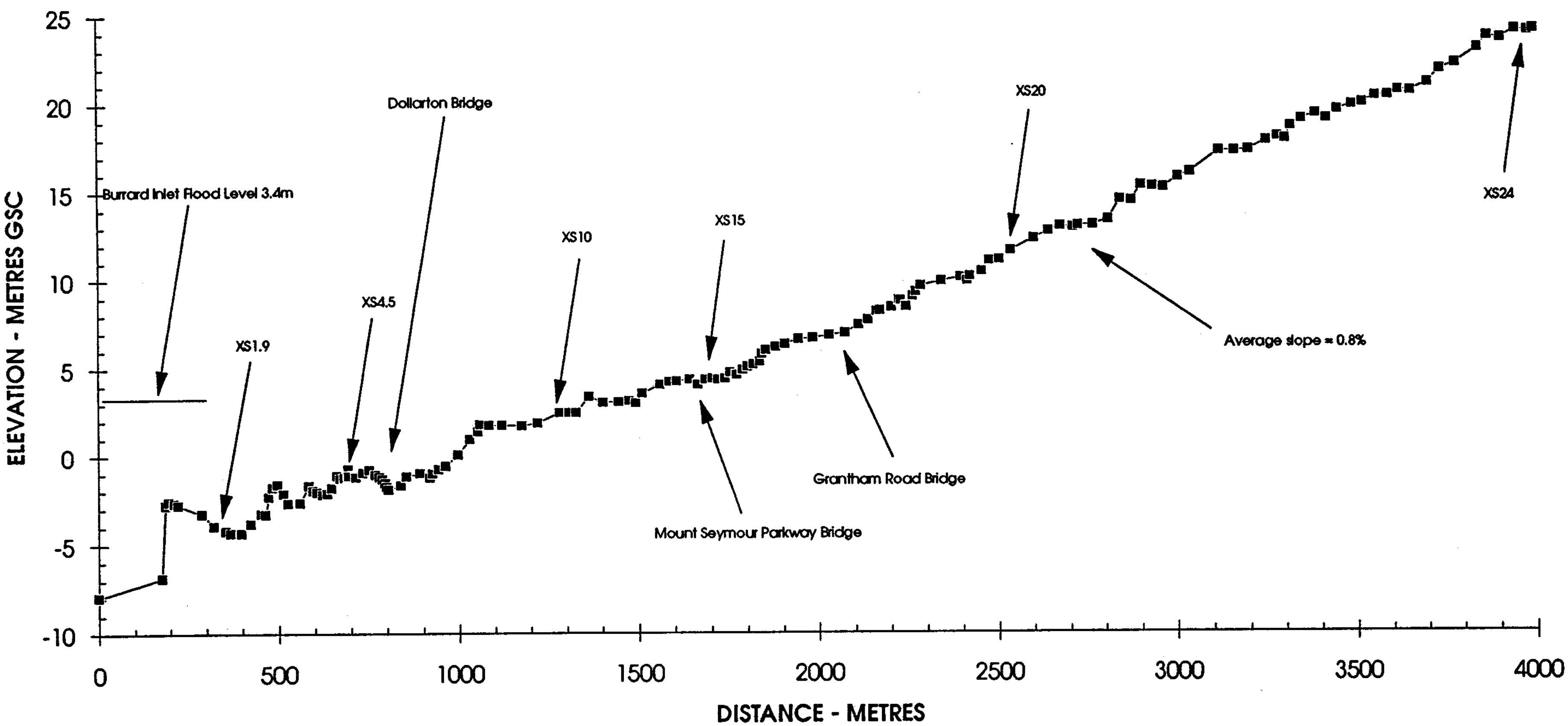


FIGURE 5

SEYMOUR RIVER WATER LEVEL PROFILES
XS1.9 TO XS24

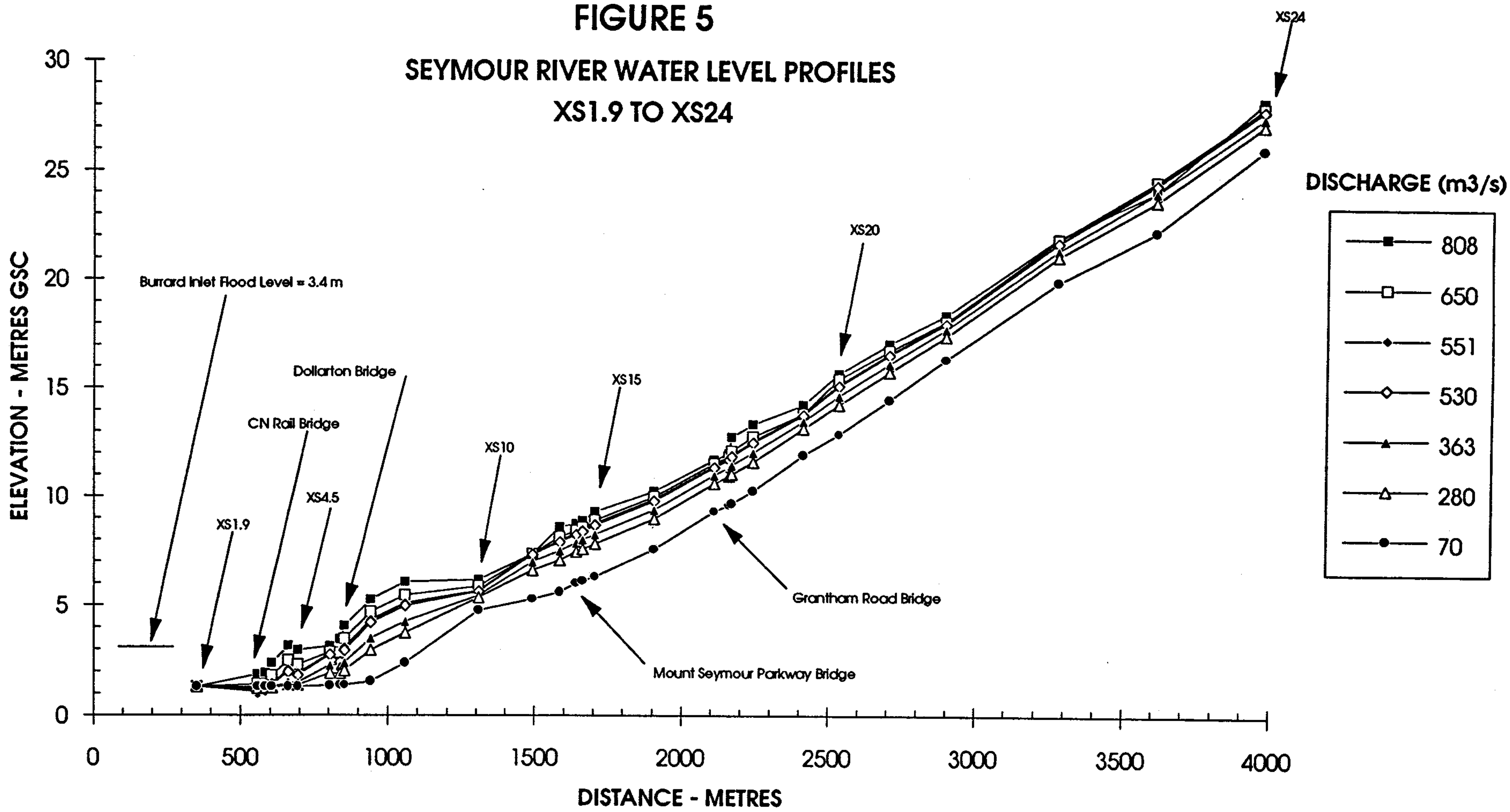
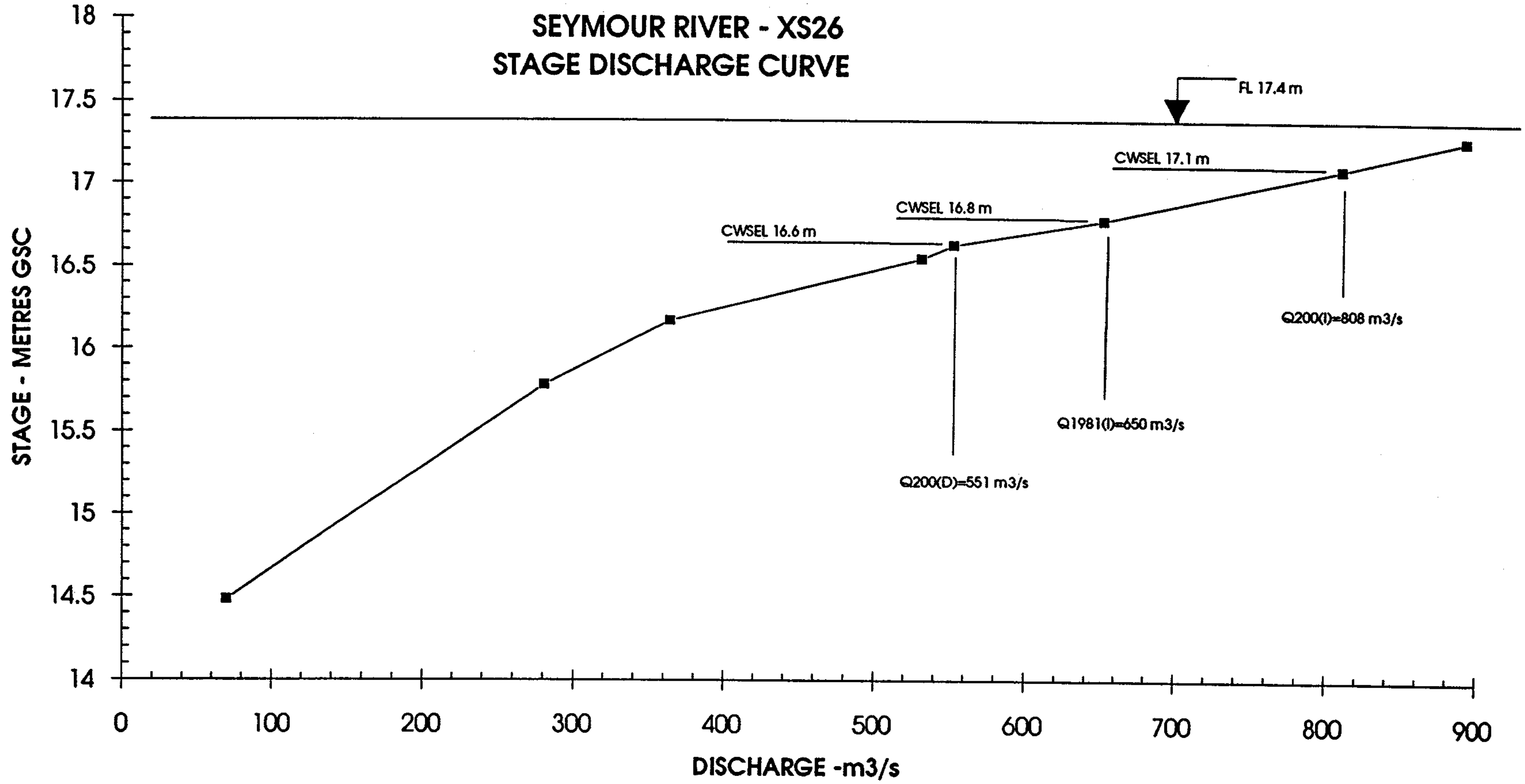


FIGURE 6



CWSEL = calculated water surface elevation
FL = flood level including allowance for uncertainties

TABLE 1

SEYMOUR RIVER (N. Van.) - Sensitivity to "Q"											
SECNO	CWSEL	Q	FREQUENCY	K*XNCH	DIFF to Q200I	SECNO	CWSEL	Q	FREQUENCY	K*XNCH	DIFF to Q200I
1.9	1.90	550	Q200D	0.022	0.00	14	8.45	550	Q200D	0.04	-0.85
1.9	1.90	650	1981 QI	0.022	0.00	14	8.80	650	1981 QI	0.04	-0.50
1.9	1.90	808	Q200I	0.022		14	9.30	808	Q200I	0.04	
1.9	1.90	888.8	Q200I +10%	0.022	0.00	14	9.54	888.8	Q200I +10%	0.04	0.24
2	1.13	550	Q200D	0.022	-0.73	15	8.77	550	Q200D	0.042	-1.15
2	1.42	650	1981 QI	0.022	-0.44	15	9.23	650	1981 QI	0.042	-0.69
2	1.86	808	Q200I	0.022		15	9.92	808	Q200I	0.042	
2	2.09	888.8	Q200I +10%	0.022	0.23	15	10.27	888.8	Q200I +10%	0.042	0.35
2.9	1.25	550	Q200D	0.025	-0.89	16	9.88	550	Q200D	0.045	-0.81
2.9	1.61	650	1981 QI	0.025	-0.53	16	10.21	650	1981 QI	0.045	-0.48
2.9	2.14	808	Q200I	0.025		16	10.69	808	Q200I	0.045	
2.9	2.39	888.8	Q200I +10%	0.025	0.25	16	10.93	888.8	Q200I +10%	0.045	0.24
3	1.69	550	Q200D	0.025	-0.95	17	11.43	550	Q200D	0.05	-0.77
3	2.04	650	1981 QI	0.025	-0.60	17	11.76	650	1981 QI	0.05	-0.44
3	2.64	808	Q200I	0.025		17	12.20	808	Q200I	0.05	
3	2.88	888.8	Q200I +10%	0.025	0.24	17	12.39	888.8	Q200I +10%	0.05	0.19
4	2.45	550	Q200D	0.03	-1.26	17.9	11.31	550	Q200D	0.045	-0.70
4	2.97	650	1981 QI	0.03	-0.74	17.9	11.61	650	1981 QI	0.045	-0.40
4	3.71	808	Q200I	0.03		17.9	12.01	808	Q200I	0.045	
4	4.08	888.8	Q200I +10%	0.03	0.37	17.9	12.15	888.8	Q200I +10%	0.045	0.14
4.5	2.37	550	Q200D	0.03	-1.26	18	11.89	550	Q200D	0.042	-1.04
4.5	2.89	650	1981 QI	0.03	-0.74	18	12.25	650	1981 QI	0.042	-0.68
4.5	3.63	808	Q200I	0.03		18	12.93	808	Q200I	0.042	
4.5	4.00	888.8	Q200I +10%	0.03	0.37	18	13.34	888.8	Q200I +10%	0.042	0.41
5	2.75	550	Q200D	0.03	-1.06	19	12.56	550	Q200D	0.05	-1.10
5	3.17	650	1981 QI	0.03	-0.64	19	12.95	650	1981 QI	0.05	-0.71
5	3.81	808	Q200I	0.03		19	13.66	808	Q200I	0.05	
5	4.13	888.8	Q200I +10%	0.03	0.32	19	14.07	888.8	Q200I +10%	0.05	0.41
6	2.66	550	Q200D	0.04	-0.86	25	13.83	550	Q200D	0.045	-0.65
6	3.02	650	1981 QI	0.04	-0.50	25	14.11	650	1981 QI	0.045	-0.37
6	3.52	808	Q200I	0.04		25	14.48	808	Q200I	0.045	
6	3.78	888.8	Q200I +10%	0.04	0.26	25	14.68	888.8	Q200I +10%	0.045	0.20
7	2.86	550	Q200D	0.04	-1.09	20	15.16	550	Q200D	0.045	-0.92
7	3.30	650	1981 QI	0.04	-0.65	20	15.53	650	1981 QI	0.045	-0.55
7	3.95	808	Q200I	0.04		20	16.08	808	Q200I	0.045	
7	4.26	888.8	Q200I +10%	0.04	0.31	20	16.34	888.8	Q200I +10%	0.045	0.26
8	4.04	550	Q200D	0.05	-1.13	26	16.62	550	Q200D	0.047	-0.74
8	4.51	650	1981 QI	0.05	-0.66	26	16.93	650	1981 QI	0.047	-0.43
8	5.17	808	Q200I	0.05		26	17.36	808	Q200I	0.047	
8	5.49	888.8	Q200I +10%	0.05	0.32	26	17.57	888.8	Q200I +10%	0.047	0.21
9	4.92	550	Q200D	0.045	-1.19	21	18.06	550	Q200D	0.047	-0.64
9	5.41	650	1981 QI	0.045	-0.70	21	18.32	650	1981 QI	0.047	-0.38
9	6.11	808	Q200I	0.045		21	18.70	808	Q200I	0.047	
9	6.45	888.8	Q200I +10%	0.045	0.34	21	18.88	888.8	Q200I +10%	0.047	0.18
10	5.68	550	Q200D	0.045	-0.61	22	21.77	550	Q200D	0.045	-0.63
10	5.85	650	1981 QI	0.045	-0.44	22	22.03	650	1981 QI	0.045	-0.37
10	6.29	808	Q200I	0.045		22	22.40	808	Q200I	0.045	
10	6.61	888.8	Q200I +10%	0.045	0.32	22	22.58	888.8	Q200I +10%	0.045	0.18
11	7.33	550	Q200D	0.04	-0.48	23	24.47	550	Q200D	0.045	-0.83
11	7.59	650	1981 QI	0.04	-0.22	23	24.82	650	1981 QI	0.045	-0.48
11	7.81	808	Q200I	0.04		23	25.30	808	Q200I	0.045	
11	7.85	888.8	Q200I +10%	0.04	0.04	23	25.54	888.8	Q200I +10%	0.045	0.24
12	7.96	550	Q200D	0.044	-0.92	24	27.87	550	Q200D	0.05	-0.71
12	8.34	650	1981 QI	0.044	-0.54	24	28.16	650	1981 QI	0.05	-0.42
12	8.88	808	Q200I	0.044		24	28.58	808	Q200I	0.05	
12	9.15	888.8	Q200I +10%	0.044	0.27	24	28.78	888.8	Q200I +10%	0.05	0.20
13	8.29	550	Q200D	0.044	-0.83						
13	8.64	650	1981 QI	0.044	-0.48						
13	9.12	808	Q200I	0.044							
13	9.35	888.8	Q200I +10%	0.044	0.23						

Burrard Inlet Flood Level (3.4m)
dominates to cross section 5

CWSEL = calculated water surface elevation
Channel "n" (K*XNCH)assumed constant with "Q"

TABLE 2

SEYMOUR RIVER (North Vancouver) - SENSITIVITY TO "n" INCREASES - Q200I -"n" x 1.0, 1.1, 1.2, 1.3											
SECNO	CWSEL	Q	K*XNCH	FL	DIFF	SECNO	CWSEL	Q	K*XNCH	FL	DIFF
1.9	1.30	808	0.0176	3.4	2.10	14	8.89	808	0.032	9.19	0.30
1.9	1.30	808	0.01936		2.10	14	9.05	808	0.0352		0.14
1.9	1.30	808	0.02112		2.10	14	9.21	808	0.0384		-0.02
1.9	1.30	808	0.02288		2.10	14	9.37	808	0.0416		-0.18
2	1.86	808	0.0176	3.4	1.54	15	9.29	808	0.0336	9.59	0.30
2	1.86	808	0.01936		1.54	15	9.44	808	0.03696		0.15
2	1.86	808	0.02112		1.54	15	9.59	808	0.04032		0.00
2	1.86	808	0.02288		1.54	15	9.74	808	0.04368		-0.15
2.9	1.94	808	0.02	3.4	-1.94	16	10.26	808	0.036	10.56	0.30
2.9	1.94	808	0.022		-1.94	16	10.47	808	0.0396		0.09
2.9	1.94	808	0.024		-1.94	16	10.67	808	0.0432		-0.11
2.9	1.94	808	0.026		-1.94	16	10.87	808	0.0468		-0.31
3	2.37	808	0.02	3.4	1.03	17	11.72	808	0.04	12.04	0.32
3	2.35	808	0.022		1.05	17	11.93	808	0.044		0.11
3	2.40	808	0.024		1.00	17	12.12	808	0.048		-0.08
3	2.38	808	0.026		1.02	17	12.28	808	0.052		-0.24
4	3.16	808	0.024	3.46	0.30	17.9	12.01	808	0.036	12.39	0.38
4	3.20	808	0.0264		0.26	17.9	12.23	808	0.0396		0.16
4	3.24	808	0.0288		0.22	17.9	12.44	808	0.0432		-0.05
4	3.30	808	0.0312		0.16	17.9	12.67	808	0.0468		-0.28
4.5	2.96	808	0.024	3.26	0.30	18	12.76	808	0.0336	13.06	0.30
4.5	3.04	808	0.0264		0.22	18	12.61	808	0.03696		0.45
4.5	3.11	808	0.0288		0.15	18	12.74	808	0.04032		0.32
4.5	3.19	808	0.0312		0.07	18	12.98	808	0.04368		0.08
5	3.13	808	0.024	3.43	0.30	19	13.35	808	0.04	13.65	0.30
5	3.30	808	0.0264		0.13	19	13.36	808	0.044		0.29
5	3.44	808	0.0288		-0.01	19	13.57	808	0.048		0.08
5	3.57	808	0.0312		-0.14	19	13.70	808	0.052		-0.05
6	3.44	808	0.032	3.74	0.30	25	14.25	808	0.036	14.55	0.30
6	3.44	808	0.0352		0.30	25	14.26	808	0.0396		0.29
6	3.44	808	0.0384		0.30	25	14.41	808	0.0432		0.14
6	3.44	808	0.0416		0.30	25	14.66	808	0.0468		-0.11
7	4.06	808	0.032	4.36	0.30	20	15.69	808	0.036	15.99	0.30
7	4.15	808	0.0352		0.21	20	15.93	808	0.0396		0.06
7	4.22	808	0.0384		0.14	20	16.05	808	0.0432		-0.06
7	4.29	808	0.0416		0.07	20	16.17	808	0.0468		-0.18
8	5.25	808	0.04	5.55	0.30	26	17.08	808	0.0376	17.39	0.31
8	5.36	808	0.044		0.19	26	17.25	808	0.04136		0.14
8	5.47	808	0.048		0.08	26	17.43	808	0.04512		-0.04
8	5.57	808	0.052		-0.02	26	17.60	808	0.04888		-0.21
9	6.07	808	0.036	6.37	0.30	21	18.39	808	0.0376	18.70	0.31
9	6.16	808	0.0396		0.21	21	18.41	808	0.04136		0.29
9	6.26	808	0.0432		0.11	21	18.61	808	0.04512		0.09
9	6.36	808	0.0468		0.01	21	18.80	808	0.04888		-0.10
10	6.15	808	0.036	6.45	0.30	22	21.96	808	0.036	22.38	0.42
10	6.15	808	0.0396		0.30	22	22.25	808	0.0396		0.13
10	6.35	808	0.0432		0.10	22	22.35	808	0.0432		0.03
10	6.55	808	0.0468		-0.10	22	22.47	808	0.0468		-0.09
11	7.35	808	0.032	7.96	0.61	23	24.88	808	0.036	25.18	0.30
11	7.59	808	0.0352		0.37	23	24.98	808	0.0396		0.20
11	7.69	808	0.0384		0.27	23	25.21	808	0.0432		-0.03
11	7.80	808	0.0416		0.16	23	25.40	808	0.0468		-0.22
12	8.59	808	0.0352	8.89	0.30	24	28.25	808	0.036	28.55	0.30
12	8.69	808	0.03872		0.20	24	28.33	808	0.0396		0.22
12	8.81	808	0.04224		0.08	24	28.49	808	0.0432		0.06
12	8.92	808	0.04576		-0.03	24	28.67	808	0.0468		-0.12
13	8.75	808	0.0352	9.05	0.30						
13	8.89	808	0.03872		0.16						
13	9.05	808	0.04224		0.00						
13	9.19	808	0.04576		-0.14						

Burrard Inlet Flood Level (3.4m) dominates to cross-section 5

TABLE 3

SEYMOUR RIVER (North Vancouver) FLOOD LEVELS at RIVER CROSS-SECTIONS		
River Cross Section #	Flood Level (metres GSC)	Comments
2	3.4 (coastal FL)	groin on l/b, elev. 3.24 m
3 CNR bridge	3.4 (coastal FL)	bridge bottom chord = 3.4 m
		track elev. = 4.6 m
		bridge dwgs. dated April 1956
4	3.4 (coastal FL)	r/b floor of building at 4.57 m
		l/b = 3.21 m
		r/b = 3.05 m
4.5 (weir)	3.4 (coastal FL)	r/b top = 2.49 m
		l/b top = 3.16 m
5 (d/s of Dollarton bridge)	3.43	l/b floor of building = 4.03 m
		r/b top = 3.46 m
6 (Dollarton bridge)	3.74	bottom chord = 4.59 m
7 (Dollarton bridge)	4.36	bridge dwgs. dated Nov. 1945
8 (deposition area)	5.55	l/b top = 5.06 m
		r/b top = 4.29 m
9 (d/s Maplewood Farm)	6.37	l/b ground level at house = 5.02 m
		r/b = 4.41 m
10 (Maplewood/I.R.#2	6.45	l/b fenceline = 6.37 m
		r/b top = 7.80 m (spoil area, I.R. #2)
11 (Maplewood/I.R.#2)	7.65	l/b = 8.14 m
		r/b = 7.89 m (spoil area I.R .#2)
12 (Maplewood/I.R. #2 @ Mount	8.89	l/b = 8.61 m
Seymour Parkway bridge)		r/b = 8.80 m (spoil I.R. #2)
		HWM 1981 = 8.029 m
13 (Seymour Parkway bridge)	9.05	bottom chord = 11.30 m
14 (Seymour Parkway bridge)	9.19	bottom chord = 10.44 m
		l/b top = 12.60 m
15 (u/s Seymour Parkway bridge)	9.59	l/b natural ground = 8.16 m
		top retaining wall l/b = 9.31 m
		r/b = 8.51 m
		r/b natural ground = 8.50 m
16	10.56	l/b top = 10.52 m
		l/b natural ground = 10.52 m
		r/b top spoil = 8.40 m
		r/b top retaining wall = 10.40 m
		r/b natural ground = 10.39 m
17	12.04	ground level at house = 12.77 m
		r/b top = 11.34 m
		HWM 1981 = 11.64 m

l/b......left bank r/b......right bank
d/s.....downstream u/s.....upstream

(cont'd......)

TABLE 3

SEYMOUR RIVER (North Vancouver) FLOOD LEVELS at CROSS-SECTIONS		
Cross Section #	**Flood Level (metres GSC)**	**Comments**
17.9/18 (Grantham Road bridge)	12.39	bottom chord = 13.20 m
		HWM 1981 = 11.81 m
19	13.65	l/b top = 13.15 m
		r/b top = 12.46 m
		HWM 1981 = 12.51 m
25	14.55	l/b top = 16.54 m
		top retaining wall = 13.83 m
		r/b natural ground = 13.16 m
20	15.99	l/b = 20.83 m
		r/b natural ground = 15.01 m
		top retaining wall = 15.41 m
26	17.39	l/b = 22.56 m
		r/b = 15.97 m
		r/b natural ground = 16.13 m
		HWM 1981 = 16.56 m
21	18.7	l/b top = 18.11 m
		r/b top = 16.94 m
		r/b top lawn = 21.79 m
22	22.38	l/b = 24.02 m
		r/b = 24.10 m
23 to 24		incised

l/b......left bank r/b......right bank
d/s.....downstream u/s.....upstream

APPENDIX 1

DETAILED INFORMATION SOURCES

1. Seymour River Project 92 22 F 023, Cross Sections and Profiles, carried out during July and September, 1992, by the Technical Support Section of the Hydrology Branch, Water Management Division, B.C. Ministry of Environment. Includes highwater mark survey data acquired on March 3, 1994 by the Flood Hazard Identification Section of the Floodplain Management Branch, Water Management Division, B.C. Ministry of Environment, Lands and Parks.

2. Project 81-FDC-6, Field Survey, carried out on November 4 & 5, 1981, by Surveys Section, Water Management Branch. Contains photographs and elevations for 16 highwater marks as well as water level elevations at the time of survey and an air photo mosaic showing the location of reference points.

3. Project 89-079T, mapsheets at 1:5000 horizontal scale, 1 & 5 metre contours, produced by Surveys and Resource Mapping Branch (sheet 92G.035.2.2), based on air photography flown during 1990.

4. "Working Paper No. 10: Report on Seymour River", a "Report on Creek Systems and Stormwater Control, District of North Vancouver", by Kerr Wood Leidal Associates Ltd., Consulting Engineers, dated June 1982.

5. "Coastal Flood Level, Vancouver Harbour, Seymour River Mouth" by B. J. Holden, P. Eng., file 35100-30/900/0661, dated December, 1994.

6. Klohn Leonoff report entitled "Seymour Falls Dam", a "Supporting Document for Operation and Maintenance Manual, Hydrologic and Hydraulic Aspects", PB 3640 01 06, dated August 1987, for the Greater Vancouver Water District.

7. Greater Vancouver Regional District "Reflections", issue #3, August 1994, Regional Drinking Water Public Consultation Publications.

8. The Corporation of the District of North Vancouver standard map series, 1:2000 scale contour series, 0.5 and 1 metre contour interval, map nos. 2J01, -03, -05, 07 and 2L03, -05, -07, dated December, 1993.

APPENDIX 2

1. Looking upstream to XS-2 at the right (west) bank showing the culvert under the CNR track from the drainage channel connecting Seymour Creek Indian Reserve #2 to tidewater. (see photos 3 to 5)

2. Looking upstream to the CN rail bridge at XS-2/3. Low chord elevation of the bridge equals the Coastal Flood Level of 3.4 metres GSC. (1981 photo)

APPENDIX 2

3. View northeast from Second Narrows Bridge showing drainage channel with culverts (to the left and in the foreground) connecting Seymour Creek Indian Reserve #2 to tidewater. Note commercial storage facility built on fill in the centre of the photo.

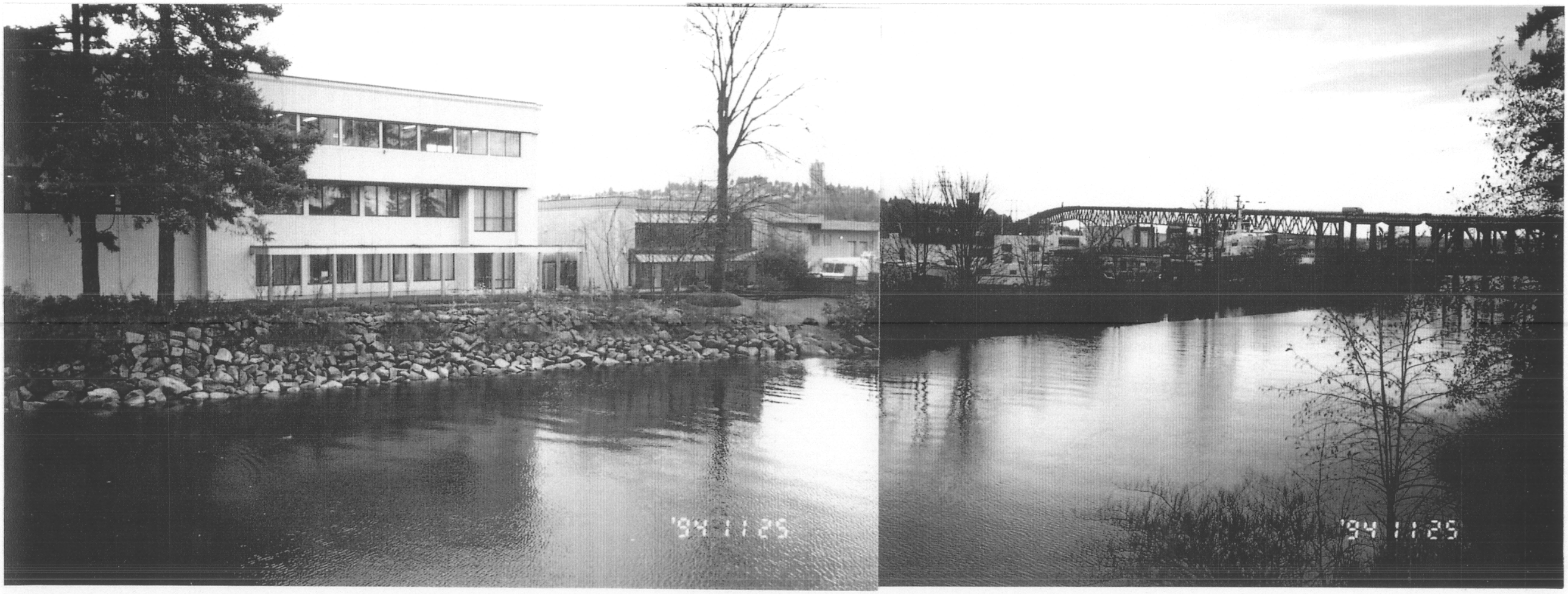
4. Looking downstream (south) on the drainage channel from Seymour Creek Indian Reserve #2 at the downstream set of six culverts under the Dollarton Highway and Highway 1 offramp.

5. View upstream on the drainage channel from Seymour Creek IR #2 showing upper six culverts under the Dollarton Highway offramp to Highway 1. Seymour Creek IR #2 beyond roadway.

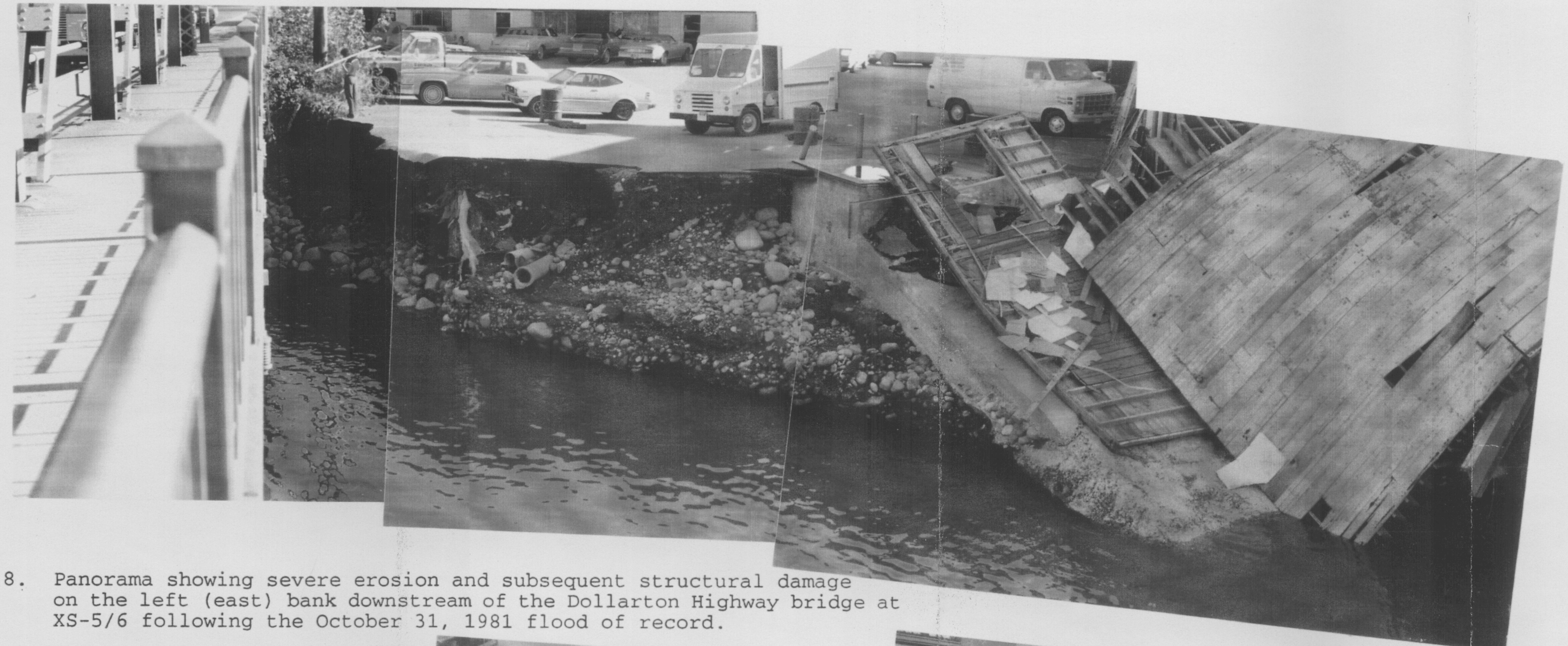
APPENDIX 2

6. Golf driving range on Seymour Creek IR #2 looking northeast from Dollarton Highway offramp to Highway 1. The Squamish Nations Band office is located in the building in the background. Driving range structure has been elevated by building on fill.

APPENDIX 2

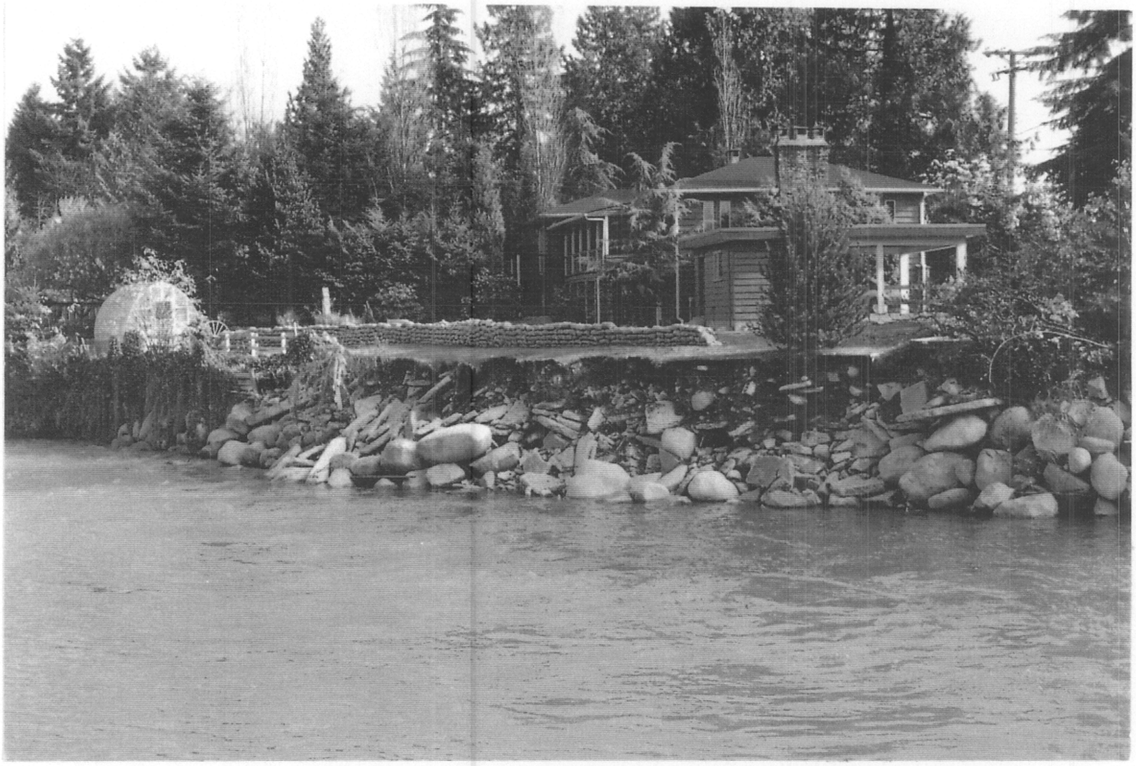


7. Looking to the left (east) bank downstream of the Dollarton Highway bridge at XS-5. Note low ground elevation of lawn area and parking lot beyond.

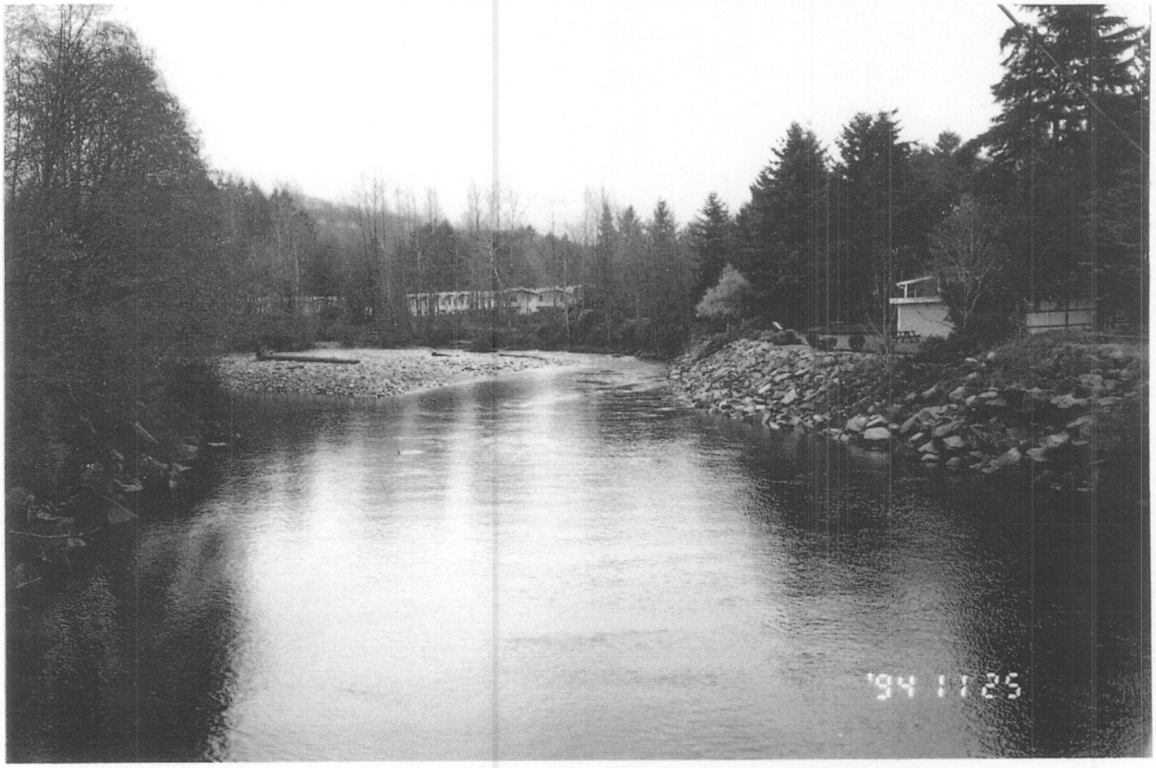


8. Panorama showing severe erosion and subsequent structural damage on the left (east) bank downstream of the Dollarton Highway bridge at XS-5/6 following the October 31, 1981 flood of record.

9. November 1994 photo of a portion of the left (east) bank at XS-6 shown in the previous photo. Riprap is partially covered with asphalt.

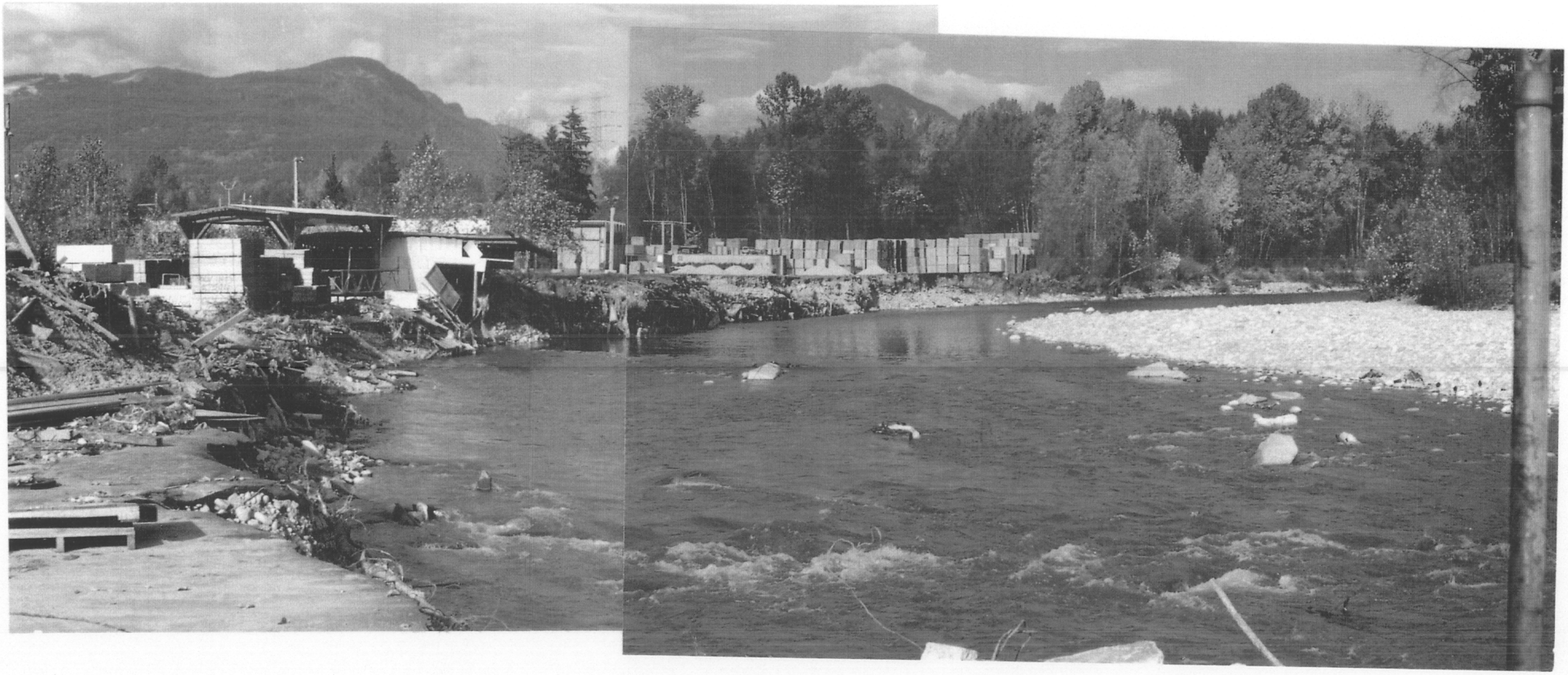


10. Looking upstream to the left (east) bank at XS-8 upstream of the Dollarton Highway bridge following the October 31, 1981 flood of record. Note severe bank erosion and sandbags on lawn.



11. November 1994 photo showing the riprapped left (east) bank at XS-8 pictured in the photo above. Note the large gravel deposition on the right side of the channel.

APPENDIX 2



12. 1981 photo looking upstream towards XS-10. Severe erosion and structural damage to structures on Indian Reserve #2 land are a result of the October 1981 flood. Note gravel deposition on the left (east) bank side.

13. Looking toward the right (west) bank in the vicinity of XS-11 at Indian Reserve #2, after the 1981 flood.

14. Photo taken during 1992 survey showing the right (west) bank at XS-11. Note the addition of spoil in this reach to protect Indian Reserve land. Some property behind spoil appears to have been filled since the 1981 flood.

15. View of the left (east) bank upstream of the Seymour Parkway bridge. Surveyed XS-15 is located at the downstream end of the residence. Note rock wall located at edge of property.

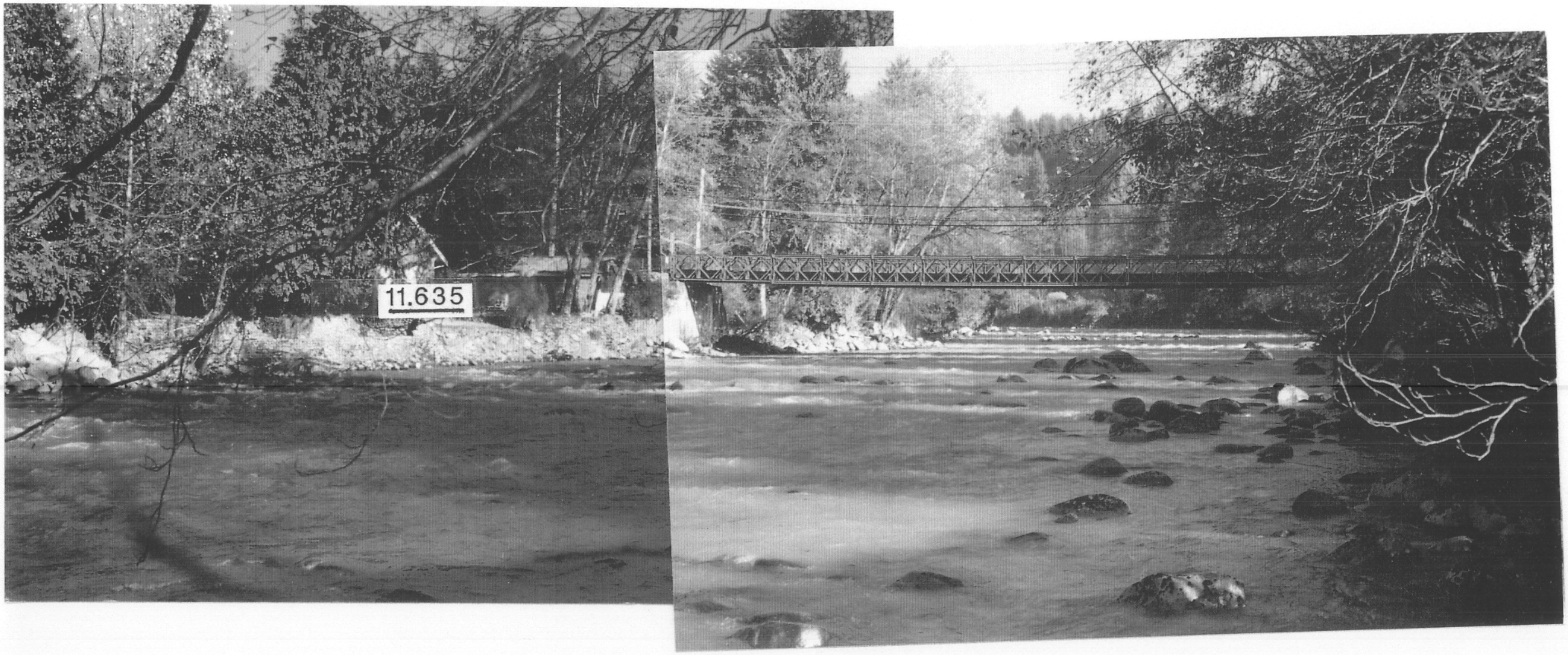
APPENDIX 2

16. Looking to the right (west) bank downstream of XS-16, approximately 200 metres upstream of the Seymour Parkway bridge. Flood level reached the base of the sandbags on the lawn in this 1981 photograph. House floor level is about 0.5 metres lower than the lawn.

17. Looking southeast at 660 Seymour Boulevard, which is west of the house in photo 16. This house appears to be constructed at the natural ground elevation below road level and is approximately one metre lower than an older home (not shown) on the downstream side.

18. Looking southeast at 734 Seymour Boulevard and its' upstream neighbour. These homes appear to be constructed above the natural ground elevation.

APPENDIX 2



19. Looking upstream from the left (east) bank to XS-17.9 at the downstream edge of the Bailey bridge. This 1981 photo indicates the October 31 flood level and elevation.

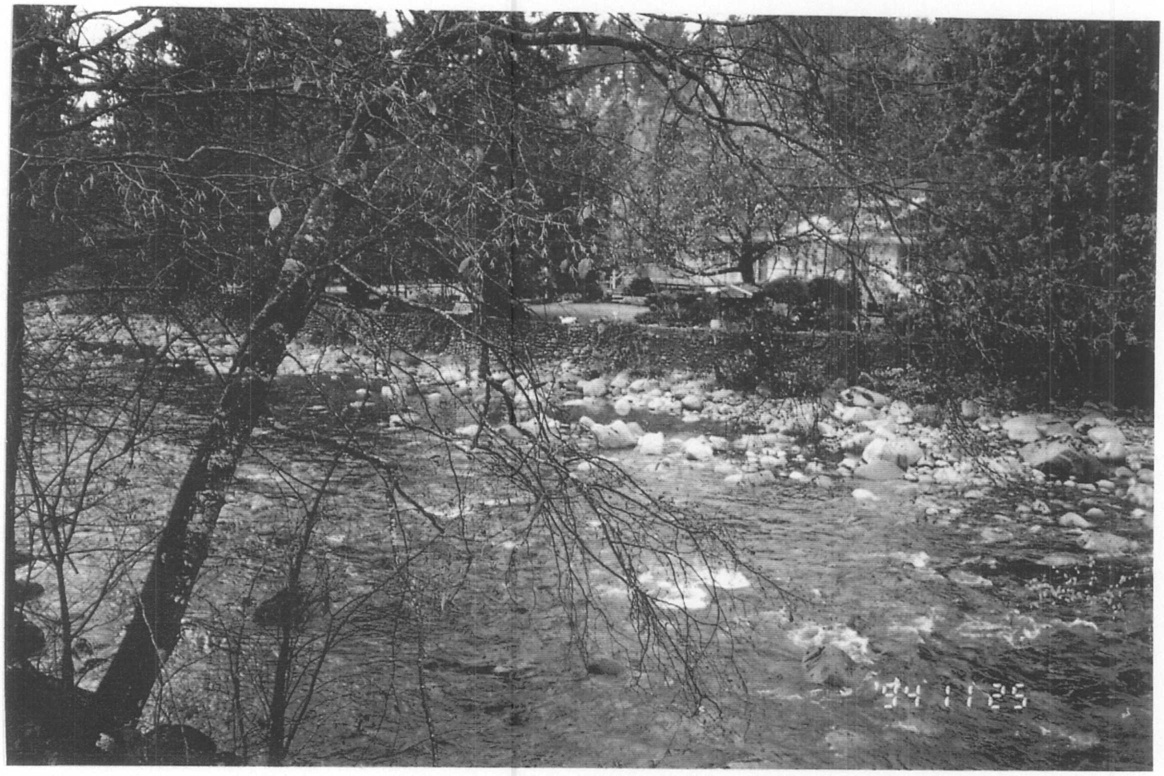
APPENDIX 2

20. Looking at XS-19, located 50 metres upstream of the Grantham Road bridge, during the 1992 field survey. Note the extent and the size of the material deposited in the channel.

21. Erosion on the left (east) bank from the 1981 flood of record, approximately 80 metres upstream of the Grantham Road bridge.

22. Stone wall at 936 Seymour Boulevard (right bank between XS-19 and XS-25) knocked over by the October 1981 floodwaters coming down the road and returning to the river through this property.

APPENDIX 2



23. 1994 view of the right (west) bank of the Seymour River near XS-25 showing the retaining wall on this reach.

APPENDIX 3

File No. 42500-40/R2
Study No. 403
February 15, 1994

HYDROLOGY SECTION REPORT

SEYMOUR RIVER

INTRODUCTION

In response to a request (memorandum of July 20, 1993) from R.W. Nichols, Flood Hazard Identification Section, peak flow estimates were made as input to a floodplain mapping project for Seymour River at its mouth. Also, two consultant's reports on Seymour River flooding were reviewed.

Seymour River drains the southern slopes of the Pacific Ranges from an elevation of 1727 m (Cathedral Mountain) to sea level into Burrard Inlet. Seymour Lake, located about 16 km inland, contributes to 67% of its drainage area, however, due to its regulation for water supply to maintain a full reservoir it does not attenuate peaks from heavy storm runoff during the flood season that occur at the mouth of Seymour River.

Peak flow events in south coastal regions of British Columbia are generally caused by late fall and winter westerly frontal rainstorms of low intensity but long duration. Occasionally frontal storms become unstable and remain stationary over a watershed for several days, producing thunderstorms and heavy showers which could cause severe flooding and damage.

Peak flow estimates for Seymour River were based on frequency analysis of local hydrometric data and a regional peak flow study done for the coastal mainland region (hydrology report for the *Fraser Delta Strategic Plan*, June 15. 1983). This report has been used as a reference in recent peak flow studies done for Vancouver Island and lower mainland areas.

REPORT REVIEW

As requested in the study memorandum the two reports listed below were reviewed to ascertain the effect of Seymour Falls Dam on high peak flows at the lower Seymour River gauge (08GA030).

6940217

1. *Working Paper No. 10: Report on Seymour River*, Report on Creek Systems and Stormwater Control. District of North Vancouver. Kerr Wood Leidal Associates Ltd. June, 1982.

2. *Seymour Falls Dam*, Supporting Document for Operation and Maintenance Manual, Hydrologic and Hydraulic Aspects. Greater Vancouver Water District. Klohn Leonoff. August, 1987.

The first report was a flood study of the lower reaches of Seymour River. The record from the Seymour River near North Vancouver gauge (08GA030) was used for frequency analysis to estimate the 200-year recurrence interval peak flow and to define the October 31, 1981 peak, the highest on record. The operation of the Seymour Falls Dam is to have the reservoir full and have *surplus inflows simply spill over the face of the dam*. The report states that there is limited storage capacity for regulating outflows and that the extent of the downstream flooding during the 1981 flood would have been unchanged had the storage been regulated for flood control. However, a brief and simple analysis was made of the 1981 Seymour River hydrograph to show that the dam reduced its peak by 25%. The time lag between the peaks at the dam and the lower Seymour River gauge was two hours which was insignificant for the shape of the hydrograph.

The second report was a peak flow design study for the Seymour Falls Dam. The lower Seymour River (08GA030) data were not used but reservoir inflows and outflows were estimated based on long-term Capilano Lake inflows and the hydraulics of Seymour Falls Dam. It is significant to note that their analyses of the October 31, 1981 and the November 15, 1983 floods showed that the Seymour Dam peak outflow magnitudes were the same as those of the peak inflow and that the time lags between the peaks were two hours. The report states that operation of the reservoir for flood regulation has minimal effect during an extreme flood.

DATA

Data used in this study consisted of annual maximum discharges from the Water Survey of Canada hydrometric station Seymour River near North Vancouver (08GA030) which is located 800 m upstream of the floodplain. The period of record for annual maximum daily discharge is 1929-87, 1989-92 and preliminary 1993 for a total of 64 years and for annual maximum instantaneous discharge is 1930, 1933-48, 1950-57, 1959-61, 1963-67, 1969-87, 1989-92 and preliminary 1993 for a total of 57 years.

PEAK FLOW ANALYSIS

The peak flow procedure consisted first of a computer frequency analysis (FREQAN3) of the Seymour River record for both annual maximum daily and instantaneous discharges. Estimates for 20- and 200-year recurrence intervals were based on the log-Pearson III frequency distribution which was the best-fit distribution for the instantaneous data. It was the second best-fit distribution for the daily data but gave reasonable estimates and for consistency, was also chosen to make the 200-year daily estimates. The results are presented in the next section.

The frequency analyses results were plotted as unit peak flow ($L/s/km^2$) against drainage area (km^2) on log-log graph paper, as shown in the figure. A mean annual peak flow envelope curve (straight line on a log-log scale) from the Fraser Delta study (Transition and Coast Mountain Zone) was copied on this graph and was used for defining the common slope of the mean-, 20- and 200-year estimating curves. These curves were drawn through the Seymour River 08GA030 points to make the additional required estimates at the mouth.

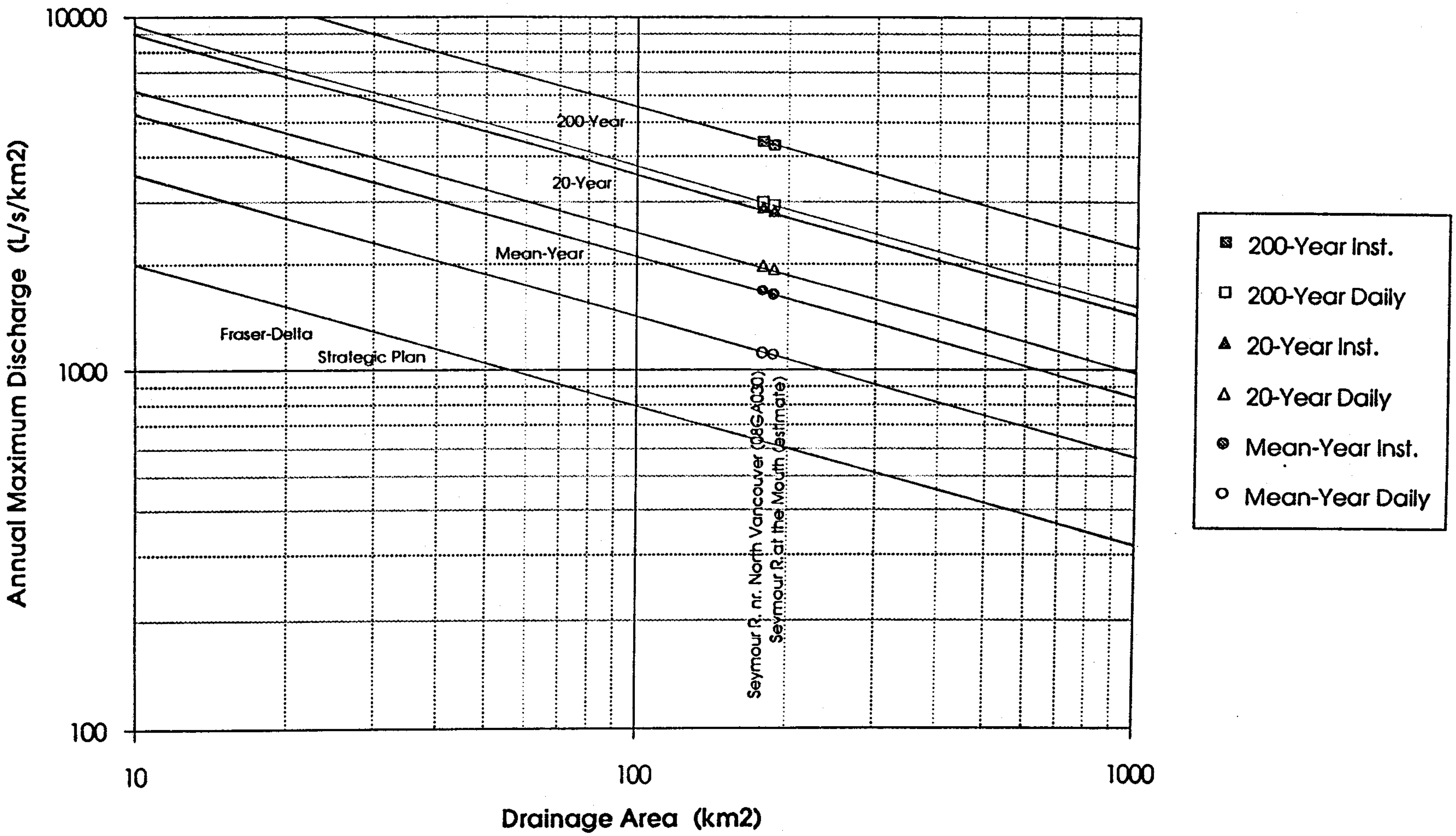
PEAK FLOW ESTIMATES

The recommended peak flow estimates, as requested for 20- and 200-year recurrence intervals, for Seymour River near the mouth, are given in the table below. The 95% confidence limits for the 200-year estimates are -20% and +28%. Recurrence interval estimates for the highest recorded peak of the Seymour River gauge 08GA030 on October 31, 1981 of 430 m^3/s, daily, and 650 m^3/s, instantaneous, are 55 and 64 years, respectively.

	Drainage Area (km^2)	Annual Maximum Discharge (m^3/s)			
			Recurrence Interval (years)		
			Mean	20	200
Seymour River near North Vancouver (08GA030)	179	Daily	199	353	535
		Instantaneous	299	517	787
Seymour River at the mouth	188	Daily	207	363	551
		Instantaneous	306	530	808

W. Obedkoff, P.Eng.
Senior Hydrologic Engineer
Hydrology Section
Hydrology Branch
387-9474

SEYMOUR RIVER PEAK FLOW CURVES



APPENDIX 4