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Fish Habitat Improvement in the Valleyfield River, P.E.I. (1988): Biological, Chemical and Physical Aspects.

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Fish Habitat and Enhancement Division
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**Canadian Data Report of
Fisheries and Aquatic Sciences
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Canadian Data Report of Fisheries and Aquatic Sciences

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by

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ABSTRACT

Vromans, A. and D. Caissie. 1989. Fish Habitat Improvement in the Valleyfield River, P.E.I. (1988): Biological, Chemical and Physical Aspects. Can. Data Rep. Fish. Aquat. Sci. No. 740. 47p.

This report presents biological, chemical and physical data collected for fish habitat improvement research in the Valleyfield River, P.E.I. (1988). The project consisted of installing six fish habitat improvement devices (1 low head barrier, 4 single deflectors and 1 double deflector) in a stream reach of approximately 200 meters. A control section of approximately 100 meters was also studied upstream of the first device. Biological data, including fish and invertebrate populations, and physical data, including stream gradient, streambed profiles, silt load and water velocity and discharge, were collected before the installation of the devices and following the installation to monitor short term changes. A complete water chemistry analysis was performed on a single sample. Dissolved oxygen levels (ppm), pH, and specific conductance (μmho) were measured on three additional dates. Water temperatures (°C) were recorded every 30 minutes from July 14 to November 20, 1988.

RÉSUMÉ

Vromans, A. and D. Caissie. 1989. Fish Habitat Improvement in the Valleyfield River, P.E.I. (1988): Biological, Chemical and Physical Aspects. Can. Data Rep. Fish. Aquat. Sci. No. 740. 47p.

Cette étude présente les données biologiques, chimiques et physiques de la rivière Valleyfield à l'I.-P.-E (1988). Ce projet de recherche sur l'amélioration de l'habitat du poisson consiste à installer six dispositifs pour l'amélioration de l'habitat (1 obstacle de basse chute, 4 déflecteurs simples et 1 déflecteur double) sur une section d'environ 200 mètres de la rivière. Une section de contrôle d'environ 100 mètres a également été considérée en amont du premier dispositif. Les données biologiques incluant les populations de poisson et d'invertébré, et les données physiques incluant, la pente du cours d'eau, le profil de fond du cours d'eau, la quantité de limon, la vitesse d'écoulement et le débit ont été mesurés avant l'installation des dispositifs et suivant l'installation afin d'observer les changements à court terme. Un échantillon d'eau pour une analyse complète de la chimie de l'eau a été éffectué. L'oxygène dissout (ppm), le pH, et la conductivité (μmho) ont été mesurés par trois reprises. La température de l'eau a été mesurée chaque 30 minutes à partir du 14 juillet jusqu'au 20 novembre, 1988.

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Introduction

The abundance and distribution of salmonids is directly related to the quality of the stream habitat (Binns and Eiserman, 1979). A critical aspect of fish habitat, the physical aspect, broadly comprises cover, spawning and rearing areas, and water (depth, velocity, quality and quantity).

The study of the biological components of a stream can provide measures of abundance and types of fish and aquatic invertebrates present. This, in effect, gives an indication of stream productivity.

The chemical analysis, too, can provide insight into stream productivity. It can show whether any imbalances exist which can interfere with the sustenance and/or propagation of fish and aquatic invertebrate populations.

The physical analysis of streams is important to help identify types of aquatic habitats and potential problem areas. When some of the physical parameters are impaired, either naturally or through human-induced destruction, techniques can be applied to improve, restore or develop the aquatic environment. Some stream improvements are accomplished through manipulation of the physical parameters in order to create more favorable conditions for growth and reproduction of fish populations.

Many Prince Edward Island streams, while very productive, have been plagued by fish habitat destruction. This destruction is primarily the result of highway, agricultural and forestry practices which have led to large amounts of silt entering the streams (Robert Thompson, Dept. of Community and Cultural Affairs, Fish and Wildlife Division, P.O.Box 2000, Charlottetown, P.E.I, C1A 7N8, pers. comm.). Saunders and Smith (1967) noted the siltation problem in P.E.I. due to agricultural practices. They observed that some improvement devices were successful in removing silt from the stream bottom.

There has been limited documented evidence of benefits of stream improvement devices, particularly in the Atlantic Provinces of Canada. The objective of this project was to qualify and quantify the biological, chemical and physical changes resulting from the installation of different fish habitat improvement devices. This report presents data collected through a monitoring program of these aspects in a selected portion of the Valleyfield River.

Study Area

The Valleyfield River is a tributary of the Montague River system (Figure 1.). The study area falls within a section of the Valleyfield River which had received improvements in the mid 1970's. (Art Smith, Dept. of Community and Cultural Affairs, Fish and Wildlife Division, P.O.Box 2000, Charlottetown, P.E.I, C1A 7N8, pers. comm.) These improvements included limited debris removal and obstruction removals. Heavy streamside alder growth was also cut back to open the stream channel.

In 1988, some areas of the Valleyfield River were again subjected to stream cleanup practices similar to those employed in the mid-1970's. The areas affected were: approximately 3 kilometers of stream beginning 100 meters below the study area and continuing downstream to the Maritime Electric Dam (June-July); 350m of stream on the southwest branch from Heatherdale Pond (Egolf's) to Prowses Pond (August); and, about 1 kilometer of the west branch from Heatherdale Pond upstream to Mathesons Pond (July-August) (Robert Thompson, Dept. of Community and Cultural Affairs, Fish and Wildlife Division, P.O.Box 2000, Charlottetown, P.E.I, C1A 7N8, pers. comm.). The cleanup work was not a part of the study for which data are presented in this report.

The study area was approximately 7 kilometers above the head of tide. The upper limit of the study area was a distance of 60 meters below Highway 206. A total distance of 300 meters was included of which 100 meters was the control section (reach 1) and 200 meters was the experimental section (reaches 2 and 3) (Figure 2.).

Approximately 15 meters upstream of the study area, an area of the stream comprising about 15 m^2, was utilized for cattle watering.

Known fish species present in the Valleyfield River include Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*) and three-spine stickleback (*Gasterosteous aculeatus*). Also present in the system is a private aquaculture facility for rainbow trout (*Onchorynchus mykiss*) .

The drainage area above the study site is 68.2 square kilometers with geodetic elevations ranging from 23 meters at the site to 122 meters at the highest elevation of the drainage basin. Figure 3 illustrates the profile of the Valleyfield River and its relatively constant gradient of 0.38%. The location of the study area is also indicated. The elevation ranges from mean sea level (MSL) to approximately 80 meters at the head waters.

Methods, Materials and Results

Biological Assessment:

Two electroseining stations were established: one for control and one for experimental purposes. Station 1, the control section, was comprised of reach 1 (Figure 2). Reach 2 , a 100 meter stretch of the experimental section (Figure 2), was the second station.

Electroseining of the stations was performed on three separate occasions (Tables 1, 2 and 3). In mid-June, before installation of the improvement devices began, reaches 1 and 2 were electrofished. Approximately 4 weeks after all of the devices were installed (early September), the same electroseining procedures were employed to look at short term fish population changes in the river. A third sampling occurred about 5 months after device installation was completed (mid-December).

For the June and September sampling dates, barrier nets were installed at the upper and lower limits of each station. Due to large amounts of floating debris, it was necessary to use larger mesh barriers (150 mm, stretched mesh) at the lower limit of the sections to prevent nets from washing out. Smaller mesh barriers (75 mm , stretched mesh) were installed at the upper limits of the sections. In December, water levels were too high to allow the installation of barrier nets.

Each station was electroseined using a Smith-Root Model XI electrofishing unit. Shocking began in all cases at the lower end of each station and proceeded upstream. For the June and September sampling dates, 4 to 5 complete passes of each station were made with the electroseine. In December, only one pass of the control station and two passes of the experimental station were possible due to low air temperatures and the rapid depletion of battery energy.

After completing each pass of the stations, all fish were measured and enumerated. Fork lengths for salmonids were recorded to the nearest millimeter. Weight data for salmonids (to the nearest 0.1 gram) was recorded during the December sampling period only.

A sub-sample, consisting of length and weight data and scale samples for brook trout, was collected one week after the September electroseining date. Fish were collected by electroseine. Scale samples were used to verify ages determined by length frequency (Table 4).

A fork length:log weight regression analysis was performed on the September sub-sample data and on the December length and weight data for brook trout (Table 6). The regression formula was used to estimate weights of fish measured at earlier dates for which weight data was not available. Mean fork length at-age and mean weight at-age data are presented in Tables 5 and 7 respectively.

Density estimates by the removal method (Zippin, 1956) were performed for brook trout in the control and experimental stations for the June and September sample dates (Table 8). Estimates were made for each age group present as well as for all fish combined. Ages were determined by the length frequency distributions of fish captured on each sample date (Table 4). There were insufficient data to perform population estimates for the December sample.

The sampling of the benthic invertebrate community was performed to identify specimens to the nearest Order and to determine their abundance. Before the installation of any devices in reach 3, Surber samples and drift net samples were collected. Sample locations were selected within approximately 5 to 10 meters below each of the proposed sites of the three lowermost improvement devices respectively and one from the control area (Table 9). At each location, six Surber samples were collected over various substrates and positions below improvement device locations. Samples from the control area were taken over various bottom types.

Three drift nets were positioned across the thalweg (one in the centre and one on each edge of the thalweg) at the lowermost limit of the experimental section. The vertical opening of each net measured approximately 35mm wide by 260mm high. The nets were placed so as to collect invertebrates in the upper 200mm of the water column and on the water surface.

Each Surber and drift net sample was placed in an individual labeled plastic container. A 10% formalin solution was used to preserve the samples. The materials in each sample were later separated by visual inspection. All invertebrate animals for each sample were subsequently placed in individual small glass vials containing a 90% ethanol solution as a preservative. Identification was made to the Order level for all invertebrates found (Table 10 and 11).

Chemical Assessment:

Water temperatures (°C) were recorded every 30 minutes from July 14 to November 20, 1988. To perform this function, a Ryan Tempmentor electronic temperature recorder was installed in the road culvert above the study area. The daily mean, minimum and maximum water temperatures are displayed in Table 12. On December 15, 1988, a second recorder was installed at the same location to record over-winter water temperatures.

Dissolved oxygen levels (ppm), pH, specific conductance (µmho) and water temperature (°C) were sampled immediately above the study area on three occasions (Table 13). These parameters were measured using a Hydrolab meter (model # 4041). In addition, a 2 liter sample of water was collected in mid-December. The sample was sent to the Moncton laboratory of Environment Canada for a complete water quality analysis. These data are shown in Table 14.

Physical Assessment:

Before the installation of the devices, a survey of the stream was carried out. In this survey, 3 reaches were considered as shown in Figure 3. Reach number 1 was chosen as the control section while reaches 2 and 3 were utilized for device installation.

At the beginning of the project a temporary bench mark was established on the road culvert at approximately 60 meters upstream of the study site. All geodetic elevations were referenced to this temporary bench mark of assumed elevation of 100.0 meters. For economical and practical reasons a second temporary bench mark was established in reference to the first at approximately mid-distance of the three study reaches.

Along an imaginary center line in the stream, bottom and water surface profiles were measured for each survey (June 22, 23, July 20, and September 26, 1988), as shown in Figure 3, using a level (Type Topcon, Model # AT-F6). The profiles, indicating a slope of 0.0038 m/m, 0.0021 m/m, and 0.0028 m/m for reaches 1, 2, and 3 respectively, are considered to be typical of a low gradient stream.

Physical characteristics of the study reaches were quantified by performing cross sectional, slope and current velocity measurements and calculations. The cross sectional measurements of the stream quantified a number of pertinent parameters such as stream width, hydraulic depth, wetted perimeter and area, Manning's roughness coefficient and silt load. These characteristics can be used to determine some spatial and temporal differences between reaches.

To measure the hydraulic and physical characteristics of each reach, a total of 36 cross sections were measured at 10 meter intervals. These sections were also perpendicular to the center line as shown in Figure 3. For all of the cross sections, the water surface elevation was measured with the level. Using a meter stick, the depth of water was taken at 0.5 meter intervals. Knowing the water surface elevation and the depth of water it was possible to calculate the elevation for every measurement taken. To measure cross sectional elevation using the depth of water, the assumption of a level water surface was made. A plot of each cross section is shown in Appendix A.

Hydraulic characteristics were calculated using discharge information which was measured during the course of the project (June 22, 23, July 20 and September 26). Silt, the difference between the firm bottom and visible stream bottom, was measured at each cross section. The silt load, the total volume of silt, for each reach has been estimated. A summary of these physical and hydraulic characteristics is presented in Tables 15, 16 and 17.

For each reach, Manning's roughness coefficient (n) was calculated using the following formula (Chow, 1959):

$$n = (A\,R^{2/3}\,S^{1/2})\,/\,Q$$

with: A = wetted area
R = hydraulic radius
S = slope
Q = discharge.

This parameter for each reach gives an indication of the roughness of the stream bottom, i.e. it reflects the bottom type. The Manning's roughness coefficient was calculated at 0.069, 0.061 and 0.068 for reach 1, 2 and 3 respectively. A straight, concrete-lined canal has a Manning's roughness coefficient of 0.01 and a crooked, natural river with many roots, trees and bushes has a Manning's roughness coefficient of 0.15 (Chow, 1959).

Six devices were installed in reaches 2 and 3. As shown in Figure 4, the first device was a low head barrier. Devices 2 to number 5 are log crib deflectors installed on each side of the stream in an alternating sequence. The last structure, device 6, the double deflector, is a pair of log crib deflectors on opposite sides of the stream (Figure 4).

The devices were designed and installed according to the manual 'A Guide For Fish Habitat Improvement' prepared by Vromans (1988). This information was supplemented by other studies such as Paquet (1986 and 1983) and the Department of Fisheries and Oceans and the British Columbia Ministry of the Environment (1980).

All of the devices were constructed using logs of approximately 20 to 30 cm in diameter so that no heavy equipment was required. The logs were embedded into the streambanks and held to the bottom of the stream with steel rebars of 15 mm in diameter. These were driven into the stream leaving approximately 10 cm exposed. This portion was then bent over in the downstream direction.

The area inside of each log crib (except the low head barrier) was filled with rocks from a nearby farmer's field, local material (soil, twigs, branches, stumps, etc.) and sandbags containing sand only. The cribs on each stream bank of the low head barrier were filled with local materials and with bags containing a dry mixture of sand and cement. The sand-cement bags were easily handled and would harden when in place. Once the materials were in place, the surface was topped with soil and seeded with a highway mixture of grass seed. Chicken wire mesh and fiberglass fly screen were used on the upstream side of the low head barrier to prevent streambed flushing below the logs.

In addition to those taken previously, eight cross sections at each device location were measured at one meter intervals to highlight changes in the immediate vicinity (Figure 4). Similar measurements were carried out within one week after the installation of the devices and two months following, in September (Appendix B).

Acknowledgements

This project operated under the direction of the Department of Fisheries and Oceans, Science Branch personnel. However, several other groups have also had an involvement. Funding for most of the materials and provision of 3 to 6 high school students as work assistants was gratefully accepted from the South Kings Wildlife Federation for this study. In addition, the Montague Watershed Cooperative Project had willingly provided extra assistance when required - a special thanks to Bob Thompson, Wade MacKinnon and Alan MacLennan. A particular thank you goes to university summer student Ian Johnson without whose persistent direction as crew leader the work would not have been completed within the deadlines assigned.

We wish to acknowledge the contributions made by DFO personnel: Perry Swan for participating in all aspects of the data collection, assistance in the device installations, aquatic invertebrate sampling, processing and identification; Jim Conlon for participating in the collection of data on the physical and chemical aspects of the study area, assisting with device installations and the presentation of a large portion of the physical data in the form of the figures in this report; Bill Ritchie for taking a key role in the aquatic invertebrate sampling, and assisting with invertebrate identification and processing procedure; summer student Yo-Anne Beauchamp for her role in data collection, device installations and creating a photographic and video record of all steps of the project; Ron Gray for his continued support and guidance; and Ross Alexander and Dr. Rick Cunjak for their valued comments presented as review of this document.

References

BINNS, N. A., and F. M. EISERMAN. 1979. Quantification of Fluvial Trout Habitat in Wyoming. Trans. Am. Fish. Soc. 108: 3. 215-228.

CHOW, V.T., (1959), Open-Channel Hydraulics, McGraw-Hill Inc., New York, U.S.A. 680 pages.

DEPARTMENT OF FISHERIES AND OCEANS and the BRITISH COLUMBIA MINISTRY OF THE ENVIRONMENT, (1980), Stream Enhancement Guide, Queen's Printer for British Columbia, 82 pages and 4 Appendices.

PAQUET, G., (1983), Technique for the Construction of Dams in Small Streams, Direction générale de la faune, Ministère du loisir, de la Chasse et de la Pêche, Québec, 44 pages.

PAQUET, G., (1986), Guidelines for the Improvement and Restoration of the Fish Habitat in Small Streams, Service des étude écologiques, Ministère du loisir, de la Chasse et de la Pêche, Québec, 70 pages.

SAUNDERS, J.W., and SMITH, M.W., (1962), Physical Alteration of Stream Habitat to Improve Brook Trout Production, Trans. Amer. Fish. Soc., 91: 185-188.

VROMANS, A., Editor, (1988), A Guide for Fish Habitat Improvement, Department of Fisheries and Oceans, Gulf Region, Science Branch, Fish Habitat and Enhancement Division, P.O.Box 5030, Moncton, New Brunswick, E1C 9B6, 26 pages, 4 Appendices and 7 Fact Sheets.

ZIPPIN, C., 1956. An evaluation of the removal method of estimating animal populations. Biometrics, 12: 163-189.

Table 1. Length frequency distribution (mm) of brook trout in samples collected from the Valleyfield River, P.E.I., on June 23 and 24, 1988.

Fork length range (cm)	Control site					Experimental site						Total
	Sweep					Sweep						
mid-pt.	1	2	3	4	All	1	2	3	4	5	All	
<3.00	0	0	0	0	0	0	0	1	1	0	2	2
3.25	1	3	1	0	5	0	0	1	3	0	4	9
3.75	3	1	3	1	8	1	3	3	2	1	10	18
4.25	4	1	3	1	9	4	5	5	6	0	20	29
4.75	1	1	5	5	12	6	3	4	1	4	18	30
5.25	4	3	3	2	12	9	6	9	7	3	34	46
5.75	2	0	0	0	2	0	3	0	0	0	3	5
6.25	1	0	0	2	3	0	0	0	0	0	0	3
6.75	1	0	0	1	2	0	0	0	0	0	0	2
7.25	1	0	0	0	1	0	0	0	1	0	1	2
7.75	1	1	2	0	4	0	1	0	5	1	7	11
8.25	0	0	1	0	1	1	1	4	3	1	10	11
8.75	2	4	4	0	10	7	4	2	3	0	16	26
9.25	3	8	3	0	14	2	8	10	2	1	23	37
9.75	8	4	9	2	23	8	10	6	2	2	28	51
10.25	7	2	5	4	18	8	3	5	5	2	23	41
10.75	9	10	1	1	21	7	11	9	6	5	38	59
11.25	9	6	3	1	19	9	7	6	9	0	31	50
11.75	8	2	3	2	15	3	5	2	8	1	19	34
12.25	3	2	1	0	6	4	6	2	2	2	16	22
12.75	3	1	0	2	6	1	3	2	1	1	8	14
13.25	2	2	1	1	6	0	1	2	1	0	4	10
13.75	2	0	0	0	2	2	1	3	0	1	7	9
14.25	1	1	0	0	2	4	3	1	2	0	10	12
14.75	2	1	0	1	4	1	0	1	1	0	3	7
15.25	1	2	0	0	3	4	1	1	2	1	9	12
15.75	3	3	1	0	7	2	3	0	0	0	5	12
16.25	2	0	1	0	3	2	2	1	1	0	6	9
16.75	1	0	0	0	1	0	0	0	0	1	1	2
17.25	0	1	1	0	2	0	1	1	0	0	2	4
17.75	1	0	0	0	1	0	1	0	0	0	1	2
18.25	0	0	0	0	0	0	0	0	0	0	0	0
18.75	0	0	0	0	0	1	1	0	0	0	2	2
19.25	0	0	0	0	0	0	0	0	0	0	0	0
19.75	0	0	1	0	1	0	1	0	0	0	1	2
20.25	0	0	0	0	0	0	1	1	0	0	2	2
20.75	0	1	0	0	1	0	0	0	0	0	0	1
total	86	60	52	26	224	86	95	82	74	27	364	588

Table 2. Length frequency distribution (mm) of brook trout in samples collected from the Valleyfield River, P.E.I., on August 31 and September 1, 1988.

Fork length range (cm) mid-pt.	Control site						Experimental site						Total
	Sweep						Sweep						
	1	2	3	4	5	All	1	2	3	4	5	All	
<4.00	0	0	0	0	0	0	0	0	0	0	0	0	0
4.25	1	0	0	0	0	1	0	1	1	0	1	3	4
4.75	1	2	0	0	0	3	4	3	3	3	0	13	16
5.25	6	8	2	1	0	17	5	4	5	2	0	16	33
5.75	21	7	2	3	2	35	20	7	10	3	5	45	80
6.25	18	12	3	6	2	41	15	5	15	4	0	39	80
6.75	13	13	2	10	8	46	12	8	10	2	1	33	79
7.25	17	9	5	2	5	38	6	6	3	4	0	19	57
7.75	6	7	2	3	2	20	5	1	3	1	0	10	30
8.25	1	1	0	0	0	2	2	1	2	0	0	5	7
8.75	1	2	1	0	1	5	4	0	1	1	0	6	11
9.25	9	1	2	2	1	15	6	2	3	1	1	13	28
9.75	12	5	3	3	1	24	8	1	1	1	0	11	35
10.25	10	7	8	6	4	35	12	7	4	0	3	26	61
10.75	15	10	5	4	3	37	6	5	3	4	1	19	56
11.25	15	9	7	2	2	35	11	8	8	4	3	34	69
11.75	14	5	4	4	4	31	11	6	5	1	2	25	56
12.25	17	7	3	1	1	29	9	5	5	2	0	21	50
12.75	5	8	1	3	3	20	5	5	1	1	0	12	32
13.25	12	1	1	6	0	20	6	1	0	1	3	11	31
13.75	4	3	1	1	2	11	2	1	0	0	0	3	14
14.25	4	0	0	2	1	7	2	1	0	1	0	4	11
14.75	3	3	0	0	0	6	1	4	1	1	0	7	13
15.25	0	3	1	0	0	4	1	0	0	1	2	4	8
15.75	0	0	0	0	0	0	2	0	1	0	0	3	3
16.25	4	0	2	2	2	10	2	1	0	0	1	4	14
16.75	3	2	1	0	1	7	0	0	0	0	0	0	7
17.25	3	0	1	2	0	6	0	1	1	0	0	2	8
17.75	0	0	0	0	1	1	2	0	0	0	0	2	3
18.25	1	2	0	0	0	3	1	0	0	0	0	1	4
18.75	0	0	0	0	0	0	0	1	0	0	0	1	1
19.25	0	0	0	0	0	0	2	0	0	0	0	2	2
19.75	0	0	0	0	0	0	0	0	0	0	0	0	0
20.25	0	0	0	0	0	0	0	0	0	0	0	0	0
20.75	1	0	0	0	0	1	0	0	0	0	0	0	1
21.25	0	0	0	0	0	0	1	0	0	0	0	1	1
21.75	0	0	1	0	0	1	0	0	0	0	0	0	1
total	217	127	58	63	46	511	163	85	86	38	23	395	906

Table 3. Length frequency distribution (mm) of brook trout in samples collected from the Valleyfield River, P.E.I., on December 13 and 14, 1988.

Fork length range (cm) mid-pt. 1	Control site	Experimental site			Total
	Sweep	Sweep			
	1	2	all		
<3.00	0	0	0	0	0
3.25	0	0	0	0	0
3.75	0	0	0	0	0
4.25	0	0	0	0	0
4.75	0	0	1	1	1
5.25	1	1	4	5	6
5.75	4	13	2	15	19
6.25	18	24	5	29	47
6.75	24	22	9	31	55
7.25	29	21	15	36	65
7.75	15	18	13	31	46
8.25	11	11	5	16	27
8.75	8	2	1	3	11
9.25	4	2	2	4	8
9.75	11	7	4	11	22
10.25	10	4	7	11	21
10.75	7	6	7	13	20
11.25	15	15	3	18	33
11.75	7	5	2	7	14
12.25	4	6	4	10	14
12.75	5	1	3	4	9
13.25	1	6	0	6	7
13.75	7	1	0	1	8
14.25	2	1	1	2	4
14.75	0	2	0	2	2
15.25	2	2	3	5	7
15.75	0	2	0	2	2
16.25	1	2	1	3	4
16.75	2	1	0	1	3
17.25	0	1	0	1	1
17.75	0	0	0	0	0
18.25	0	0	0	0	0
18.75	1	0	1	1	2
19.25	0	0	0	0	0
19.75	0	0	0	0	0
20.25	0	0	0	0	0
Total	189	176	93	269	458

Table 4. Fork length (cm) at-age of brook trout as determined by scale analysis and length frequency distribution.

Fork length (cm)	Ages		Size (cm)		
	Scale method[1]	Length freq.[2]	June[3]	September[3]	December[3]
6.4	0+	0+	<= 7.0	<= 8.5	<= 9.5
6.8	0+	0+			
7.3	0+	0+			
7.5	0+	0+			
9.1	1+	1+	7.1 - 14.0	8.6 - 14.0	9.5-14.5
9.5	1+	1+			
9.5	1+	1+			
10.0	1+	1+			
10.1	1+	1+			
10.2	1+	1+			
10.3	1+	1+			
10.5	1+	1+			
10.8	1+	1+			
10.9	1+	1+			
11.1	1+	1+			
11.6	1+	1+			
11.8	1+	1+			
11.8	1+	1+			
11.8	1+	1+			
12.1	1+	1+			
12.3	1+	1+			
12.5	1+	1+			
12.6	1+	1+			
13.5	1+	1+			
13.6	1+	1+			
13.7	1+	1+			
13.8	1+	1+			
15.9	2+	2+	>14.0*	>14.0*	>14.0*
16.4	2+	2+			
17.2	2+	2+			
17.2	2+	2+			
17.5	2+	2+			
17.6	2+	2+			

1 - Fish collected in September sub-sample.
2 - Ages based on length frequency obtained from brook trout captured on September 1 electroseining.
3 - Taken from length frequency distributions of brook trout captured on respective electroseining dates.

* - No fish older than age 2+ were captured, therefore the upper limit of the size range is undefined. All fish larger than the specified size of the lower limit are grouped as fish older than age 1+.

Table 5. Mean fork length (cm) at-age of brook trout in samples collected from the Valleyfield River, P.E.I., study area (1988).

Sample group	Age group 0+			Age group 1+			Age group 2+			Age group All		
	Mean	Std.	N	Mean	Std.	N	Mean	Std.	N	Mean	Std.	N
Control:												
June	4.9	0.899	53	10.7	1.366	146	16.2	1.604	25	10.0	3.556	224
Sept.	6.6	0.765	203	11.4	1.254	262	16.4	1.663	46	9.9	3.238	511
Dec.	7.4	0.871	113	11.4	1.255	68	16.6	1.323	6	9.2	2.584	187
Experimental:												
June	4.8	0.659	91	10.7	1.409	231	16.0	1.672	42	9.8	3.595	364
Sept.	6.3	0.850	183	11.3	1.188	181	16.2	1.806	31	9.4	3.296	395
Dec.	7.2	0.877	171	11.4	1.127	81	169.0	1.016	15	8.9	2.756	267
Combined:												
June	4.8	0.755	144	10.7	1.391	377	16.0	1.640	67	9.9	3.578	588
Sept.	6.5	0.817	386	11.3	1.227	443	16.3	1.712	77	9.7	3.273	906
Dec.	7.2	0.878	285	11.4	1.194	151	16.1	1.114	21	9.0	2.690	457
All	6.4	9.500	814	11.1	1.328	969	16.2	1.613	165	9.6	3.259	1948

Std. - Standard deviation N - Sample size

Table 6. Fork length (cm) and log weight (g) linear regression analysis for brook trout captured in the Valleyfield River, P.E.I. (L = fork length; W = weight)

Sample date	Location	Regression equation	R^2	Sample size
June 16, 1988	n/a	no L-W data collected		
Sept. 01, 1988	experimental site	$W = 10^{(0.1197 \cdot L - 0.2250)}$	0.97	5
Dec. 15, 1988	experimental site	$W = 10^{(0.1332 \cdot L - 0.3980)}$	0.96	269
	control site	$W = 10^{(0.1294 \cdot L - 0.3419)}$	0.96	189
	sites combined	$W = 10^{(0.1319 \cdot L - 0.3774)}$	0.96	458

Table 7. Mean weight (g) at-age of brook trout in samples collected from the Valleyfield River, P.E.I., study area (1988).

Sample group	Age group 0+			1+			2+			All		
	Mean	Std.	N	Mean	Std.	N	Mean	Std.	N	Mean	Std.	N
Control:												
June	2.3	0.616	53	12.3	4.854	146	58.7	37.029	25	15.1	20.480	224
Sept.	3.8	0.774	203	14.6	5.158	262	61.1	29.009	46	14.5	19.990	511
Dec.	4.3	1.699	113	15.5	5.082	68	45.9	11.591	6	9.7	9.322	187
Experimental:												
June	2.3	0.387	91	12.1	4.956	231	55.0	33.731	42	14.6	19.368	364
Sept.	3.5	0.854	183	14.1	4.693	181	59.5	38.723	31	12.8	18.353	395
Dec.	3.8	1.513	171	15.1	4.529	81	41.6	12.227	15	9.4	10.207	267
Combined:												
June	2.3	0.485	144	12.2	4.911	377	56.4	34.765	67	14.8	19.783	588
Sept.	3.6	0.821	386	14.4	4.974	443	60.5	39.449	77	13.7	19.302	906
Dec.	4.0	1.603	285	15.3	4.800	151	42.9	11.924	21	9.5	9.839	457
All	3.5	1.271	814	13.7	5.063	969	56.6	35.442	165	13.1	17.827	1948

Std. - Standard deviation N - Sample size

*** estimated from the regression function: weight=$10^{(0.1197 * \text{fork length} - 0.2250)}$.**

Table 8. Estimates of abundance (no.) and density (no./100m^2) of brook trout in the Valleyfield River, P.E.I., study area (June and September), 1988.[1]

Group	Observed no.						Area	Estimated population						P
	Sweep						(m^2)	Size			Density (/100m^2)			
	1	2	3	4	5	All		No.	c.i.	s^2	No.	c.i.	s^2	
June samples:														
Control...							1203							
age (0+)	17	9	15	12		53		223	2218.1	1229934.0	18.5	184.4	8498.7	23.8
age (1+)	58	42	33	13		146		181	31.6 ^	249.9	15.0	2.6 ^	1.7	80.9
age (>1+)	11	9	4	1		25		27	*	15.3	2.3	*	0.1	91.6
age (>0+)	69	51	37	14		171		206	29.6	218.9	17.1	2.5	1.5	82.9
all ages	86	60	52	26		224		298	55.4	767.0	24.8	4.6	5.3	75.1
Experimental...							1128							
age (0+)	20	20	23	20	8	91		187	172.4 ^	7430.5	16.6	15.3 ^	58.4	48.5
age (1+)	52	61	53	48	17	231		386	132.4	4379.1	34.2	11.7	34.4	59.8
age (>1+)	14	14	6	6	2	42		48	*	38.1	4.3	*	0.3	87.0
age (>0+)	66	75	59	54	19	273		415	102.1	2606.7	36.8	9.1	20.5	65.8
all ages	86	95	82	74	27	364		586	144.1	5190.1	52.0	12.8	40.8	62.1
Sept. samples:														
Control...							1203							
age (0+)	84	59	16	25	19	203		985	1242.0	385614.6	81.9	103.2	2664.5	27.2
age (1+)	114	58	36	34	22	262		300	24.3	147.8	24.9	2.0	1.0	88.0
age (>1+)	19	10	6	6	5	46		54	15.7 ^	61.8	4.5	1.3 ^	0.4	84.1
age (>0+)	133	68	42	38	27	308		350	26.4	173.7	29.1	2.2	1.2	87.9
all ages	217	127	58	63	46	511		549	32.3	267.6	48.2	2.7	1.9	88.2
Experimental...							1128							
age (0+)	69	36	52	19	7	183		210	21.7	117.3	18.6	1.9	0.9	87.3
age (1+)	80	41	31	16	13	181		199	15.5 ^	59.9	17.6	1.4 ^	0.5	91.0
age (>1+)	14	8	3	3	3	31		34	*	17.6	3.0	*	0.1	90.8
age (>0+)	94	49	34	19	16	212		233	16.7	69.7	20.7	1.5	0.5	91.0
all ages	163	85	86	38	23	395		442	26.0	169.4	39.2	2.3	1.3	89.4

c.i. - confidence interval (+ or -)
s^2 - sample variance
P - Percent of the estimated population captured after all sweeps.
* Confidence limits not calculated due to small sample size.
^ 90% confidence (95% where not indicated)

1 - December samples were too small for population estimates. They consisted of 1 sweep of the control station (189 fish) and 2 sweeps of the experimental station (176 and 93 fish respectively).

Table 9. Benthic invertebrate sample locations and substrate composition at these sites in the Valleyfield River, P.E.I., study area.

Site	Sample no.	Location	Substrate composition(%) B	C	G	S	F	D	Sample no.	Location	Substrate composition(%) B	C	G	S	F	D
Sample date: July 20, 1988.									Sample date: August 24, 1988.							
I	1.	3m from TLB; (mid-channel)		80	20				25.	3m from TLB; 4m below DD			80	20		
	2.	2m from TLB		50	50				26.	5m from TLB; 2m below DD		60	20	20		
	3.	6m from TRB	10	70	20				27.	1m from TLB; 10m below DD			30	70		
	4.	4m from TLB	70	20	10				28.	4m from TLB; 9m below DD		50	40	10		
	5.	1m from TLB			100				29.	1m below tip of DF on TRB		10	40	50		
	6.	4m from TRB		50	50				30.	1m below tip of DF on TLB	40	30	30			
II	7.	mid-channel; 5m from TLB TLB; 4m below flag		50	50				31.	4m from TLB; 10m below DF			50	50		
	8.	3m from TRB; 3m below flag		40	60				32.	6m from TLB; 7m below DF			80	20		
	9.	mid-channel; 5m from TRB; 7m below flag		70	30				33.	5m from TRB; 6m below DF				100		
	10.	2m from TLB		70	30				34.	5m from TLB; 5m below DF			80	20		
	11.	4m from TLB; 2m below flag		80	20				35.	2m from TLB; 2m below DF			20	60		20
	12.	1.5m from TRB		10	90				36.	**1m below tip of DF			60	40		
III	13.	5m from TLB; 5m below flag		90	10				37.	3m from TLB; 10m below DF			70	30		
	14.	3m from TRB		80	20				38.	**8m from TLB; 9m below DF			70	30		
	15.	3m from TLB; 2m below flag		40	60				39.	1.5m from TRB; 4m below DF		50	30	20		
	16.	3m from TLB; 5m below flag		90	10				40.	2m from TRB; 3m below DF			60	40		
	17.	1m from TLB; 6m below flag			60	40			41.	4m from TLB; 3m below DF			80	20		
	18.	3.5m from TRB; 6m below flag		80	20				42.	2m from TLB; 1m below DF			20	70		10
IV	19.	by red stake; 4.5m from TLB	70	20	10				43.	3m from TLB; by red stake			30	70		
	20.	by red stake; 2.5m from TLB		20	80				44.	5m from TLB; by red stake		30	70			
	21.	by red stake; 4.5m from TRB		80	20				45.	3m from TRB; by red stake		20	70	10		
	22.	* below CA; 1.5m from TLB		50	50				46.	3m from TLB (at ULS)			50	50		
	23.	mid-channel below CA; 7m from TRB		60	40				47.	3m from TRB; 5m below ULS	20	20	40	20		
	24.	below CA; 2m from TRB		50	50				48.	2.5m from TRB; 8m above #47		40	50	10		

Codes:
DF - Deflector
DD - Double deflector
CA - Cattle access
TLB - True left bank
TRB - True right bank
ULS - Upper limit of section

Substrate types:
B - Boulders
C - Cobble
G - Gravel
S - Sand
F - Fines
D - Detritus

Site I - area of double deflector
Site II - area of deflector no. 4
Site III - area of deflector no. 3
Site IV - upper section of Control site

* Aquatic macrophytes dense; ** aquatic vegetaion present.

Table 10. Numbers of benthic invertebrates in Surber samples collected form the Valleyfield River, P.E.I., study area (1988).

Sample Site date	Sample no.	Order of Invertebrate									
		Ephemeroptera	Tricoptera	Diptera	Odonata	Oligochaeta	Plecoptera	Coleoptera	Hemiptera	Amphipoda	Arachnidae
July 20											
Double deflector	1	19	8	15	0	2	0	45	0	0	0
	2	0	0	1	0	0	0	3	0	0	1
	3	4	7	0	0	0	0	2	0	0	0
	4	6	13	7	0	1	1	5	0	0	0
	5	0	0	2	0	2	0	0	0	0	0
	6	6	7	9	0	1	0	17	0	0	0
	sub-total	35	35	34	0	6	1	72	0	0	1
Deflector 4	7	11	35	8	0	9	0	21	0	0	1
	8	42	17	11	0	8	2	12	0	0	1
	9	16	44	10	0	4	5	6	0	0	0
	10	2	1	11	0	19	1	1	0	0	0
	11	9	13	3	0	1	2	1	0	0	0
	12	2	0	7	0	59	0	0	0	0	0
	sub-total	82	110	50	0	100	10	41	0	0	2
Deflector 3	13	14	71	4	0	2	2	3	1	0	0
	14	18	34	0	0	18	3	21	0	0	0
	15	7	7	6	0	2	0	6	0	0	0
	16	10	26	3	0	3	0	1	0	0	0
	17	1	1	4	1	1	0	0	0	0	0
	18	7	37	2	0	7	2	10	0	0	0
	sub-total	57	176	19	1	33	7	41	1	0	0
	total	174	321	103	1	139	18	154	1	0	3
Control	19	12	4	0	0	0	3	0	0	0	0
	20	5	5	3	0	0	0	1	0	0	0
	21	20	23	2	0	4	2	2	0	0	0
	22	28	5	7	0	3	1	8	0	0	0
	12	3	4	0	0	0	3	0	0	0	0
	24	4	4	3	0	4	0	6	0	0	0
	total	72	45	15	0	11	9	17	0	0	0
August 24											
Double Deflector	25	3	3	5	0	3	0	11	0	0	0
	26	8	10	1	0	0	0	4	0	0	0
	27	2	9	2	0	0	0	0	0	0	0
	28	5	4	1	0	1	0	1	0	0	0
	29	33	12	8	0	1	0	1	0	0	0
	30	30	7	1	0	0	3	0	0	0	0
	sub-total	81	45	18	0	5	3	17	0	0	0
Deflector 4	31	31	7	5	0	46	1	2	0	0	0
	32	16	2	5	0	8	1	0	0	0	0
	33	1	4	1	0	4	0	0	0	0	0
	34	17	9	1	0	4	0	11	0	0	0
	35	17	27	4	0	3	1	5	0	0	0
	36	8	4	0	0	4	0	0	0	0	0
	sub-total	90	53	16	0	69	3	18	0	0	0
Deflector 3	37	11	9	4	0	3	2	1	0	0	0
	38	4	19	3	0	0	0	0	0	0	0
	39	3	5	0	0	0	2	0	0	0	0
	40	5	1	2	0	27	0	0	0	0	0
	41	9	33	5	0	12	1	2	0	0	0
	42	2	5	7	0	14	2	0	0	0	0
	sub-total	34	72	21	0	56	7	3	0	0	0
	total	205	170	55	0	130	13	38	0	0	0
Control	43	4	0	12	0	4	0	3	0	0	0
	44	34	49	6	0	5	5	1	0	0	0
	45	17	24	7	0	6	1	4	0	0	0
	46	23	46	19	0	16	1	18	0	0	0
	47	6	10	2	0	3	1	0	0	0	0
	48	2	13	2	0	1	0	0	0	0	0
	total	86	142	48	0	35	8	26	0	0	0

Table 11. Numbers of invertebrates in drift net samples collected from the Valleyfield River, P.E.I., study area, 1988.

Sample date	Sample no.	Order of Invertebrates									
		Ephemeroptera	Tricoptera	Diptera	Odonata	Oligochaeta	Plecoptera	Coleoptera	Hemiptera	Amphipoda	Arachnidae
July 20											
	1	24	2	15	0	0	0	1	0	0	0
	2	36	29	8	0	0	4	2	1	0	1
	3	12	4	18	0	1	5	3	0	0	1
	Total	72	35	41	0	1	9	6	1	0	2
August 24											
	4	62	10	14	0	0	1	7	1	0	2
	5	90	14	11	0	1	10	1	0	1	0
	6	67	4	10	0	0	0	1	0	2	1
	Total	219	28	35	0	1	11	9	1	3	3

Table 12. Daily mean, minimum and maximum water temperatures (°C) in the Valleyfield River, P.E.I. (July 14 to November 20, 1988).

Date		Temperature			Date		Temperature			Date		Temperature		
		Mean	Min.	Max.			Mean	Min.	Max.			Mean	Min.	Max.
July	14	15.3	12.6	18.3	August	27	14.1	12.8	15.8	October	10	7.2	6.3	8.6
	15	15.7	14.4	17.9		28	14.0	12.3	16.0		11	7.9	6.9	9.0
	16	14.4	13.0	15.6		29	14.7	13.6	16.1		12	8.2	7.3	9.6
	17	14.7	13.4	16.3		30	14.0	13.3	14.6		13	7.2	6.1	8.0
	18	14.6	13.4	16.4		31	13.4	12.3	15.0		14	6.9	6.1	7.7
	19	14.3	13.3	15.0	Sept.	1	13.1	11.3	15.6		15	6.5	5.2	7.6
	20	14.6	13.6	16.3		2	13.0	11.4	14.8		16	5.5	3.7	7.5
	21	14.0	12.5	15.7		3	13.0	11.3	14.0		17	6.0	4.4	8.1
	22	13.5	13.1	14.2		4	11.6	9.4	14.1		18	6.3	4.8	8.1
	23	14.2	11.8	17.2		5	12.2	11.4	13.1		19	7.4	6.7	7.8
	24	13.5	13.0	14.6		6	12.5	11.6	13.9		20	7.9	7.1	8.5
	25	13.3	12.7	14.1		7	11.5	10.1	13.0		21	6.6	5.5	7.7
	26	13.3	12.7	14.1		8	11.8	9.8	14.3		22	5.6	4.4	6.6
	27	13.7	12.1	15.8		9	12.2	10.5	14.6		23	7.6	6.4	8.5
	28	14.7	13.4	16.2		10	12.3	11.3	13.4		24	8.1	7.6	9.5
	29	14.9	13.9	16.3		11	12.5	11.8	13.3		25	8.9	7.4	10.3
	30	15.7	13.4	18.3		12	11.7	10.4	12.8		26	8.2	7.6	9.3
	31	16.3	14.8	18.1		13	10.7	9.2	12.0		27	7.2	6.4	7.8
August	1	16.1	14.0	18.4		14	11.6	10.7	12.8		28	7.0	6.1	8.0
	2	16.7	15.1	18.8		15	10.8	10.0	11.6		29	7.4	6.8	8.1
	3	15.5	14.6	16.4		16	10.1	8.9	11.3		30	6.4	5.7	7.0
	4	15.4	13.8	17.7		17	9.5	7.8	11.8		31	5.5	4.2	6.1
	5	16.0	15.1	16.9		18	10.1	8.9	11.6	Nov.	1	4.5	3.3	5.7
	6	16.3	14.7	18.4		19	11.0	10.4	11.8		2	5.9	5.0	6.8
	7	17.3	15.6	19.3		20	11.3	10.5	12.4		3	6.4	5.7	7.0
	8	17.4	16.4	18.8		21	10.9	9.2	12.6		4	6.1	5.7	6.8
	9	17.1	15.6	19.0		22	11.4	10.8	12.0		5	6.6	5.8	7.5
	10	17.4	15.7	19.9		23	10.6	9.4	12.1		6	7.7	6.7	8.8
	11	17.2	15.3	19.6		24	11.2	10.4	12.6		7	8.2	7.8	8.9
	12	17.0	15.4	19.0		25	10.3	9.0	12.0		8	7.8	7.4	8.3
	13	16.3	14.9	18.1		26	10.1	8.1	12.3		9	7.1	6.4	7.4
	14	15.3	14.3	16.3		27	9.8	8.5	11.8		10	6.4	6.0	7.1
	15	13.8	13.4	14.1		28	9.4	8.6	10.2		11	7.0	6.3	7.7
	16	13.8	13.4	14.6		29	9.2	8.1	9.8		12	5.3	4.6	6.1
	17	13.4	12.8	14.1		30	8.0	6.9	9.1		13	4.4	3.6	5.2
	18	13.1	12.1	13.7	October	1	10.0	8.5	11.8		14	5.3	4.5	6.1
	19	12.7	11.0	15.2		2	11.4	10.1	13.1		15	5.4	4.9	5.9
	20	13.1	11.8	15.3		3	11.5	10.3	12.0		16	4.9	4.1	5.5
	21	12.5	11.0	14.1		4	10.0	9.4	10.5		17	5.3	3.9	7.3
	22	11.9	11.0	12.8		5	9.1	8.6	9.5		18	5.9	5.0	7.4
	23	11.3	9.7	12.8		6	8.9	7.8	9.7		19	4.5	4.1	5.0
	24	11.0	9.2	12.8		7	7.6	6.5	8.8		20	4.1	3.6	4.6
	25	11.2	9.0	13.5		8	6.4	5.7	7.1					
	26	12.8	11.3	14.8		9	6.9	6.4	7.6					

Table 13. Water quality data collected from the Valleyfield River, P.E.I. (1988).

Date	Dissolved oxygen (ppm)	pH	Specific conductance (μmho)	Temperature (°C)
July 20	9.3	8.4	230	15.3
Aug. 17	9.6	8.4	230	14.2
Sept. 27	*	8.4	251	8.4

* Meter malfunctioned

Table 14. Detailed water quality analysis: Valleyfield River, P.E.I. (1988).

Parameter	Value	Units
pH	7.3	(pH units)
Specific conductance	182.0	(μmho)
Turbidity	1.3	(NTU)
Alkalinity (total)	74.0	(mg/l)
Color apparent	5.0	(rel. units)
Calcium - dissolved	18.0	(mg/l)
Magnesium - dissolved	9.5	(mg/l)
Potassium - dissolved	1.5	(mg/l)
Sodium - dissolved	3.4	(mg/l)
Chloride - dissolved (by IC)	7.1	(mg/l)
Sulphate - dissolved	4.9	(mg/l)
Sulphate - dissolved (by IC)	4.6	(mg/l)
Copper extractable	0.003	(mg/l)
Zinc extractable	< 0.01	(mg/l)
Cadmium extractable	< 0.001	(mg/l)
Lead extractable	< 0.002	(mg/l)
Aluminum extractable	0.04	(mg/l)
Iron extractable	0.07	(mg/l)
Manganese extractable	0.01	(mg/l)
Carbon - diss. org. (colorimetric)	0.8	(mg/l)
Nitrogen - dissolved NO2, NO3	0.86	(mg/l)
Nitrogen - total	0.93	(mg/l)
Silica reactive	2.45	(mg/l)

Table 15. Physical and hydraulic parameters of reach 1 of the Valleyfield River, P.E.I., study area (June 23, 1988).

STA	A	W	P	R	D	V	SILT	WS ELE.
A-A	4.190	15.0	15.4	0.272	0.279	0.422	1.312	99.537
B-B	4.800	14.6	15.0	0.320	0.329	0.369	1.164	99.532
C-C	4.323	15.0	15.7	0.276	0.288	0.409	0.695	99.482
D-D	4.830	14.5	14.9	0.325	0.333	0.366	0.937	99.407
E-E	4.050	12.0	12.3	0.328	0.338	0.437	0.895	99.342
F-F	4.176	11.6	11.8	0.355	0.360	0.424	0.275	99.297
G-G	4.610	11.5	11.8	0.391	0.401	0.384	0.397	99.272
H-H	4.150	11.4	11.6	0.359	0.364	0.427	0.227	99.259
I-I	3.717	11.4	11.6	0.321	0.326	0.476	0.010	99.247
J-J	3.540	9.8	10.2	0.348	0.361	0.500	0.084	99.192
K-K	4.115	11.0	11.2	0.368	0.374	0.430	0.468	99.122
Mean	4.23	12.5		0.341	0.422			
Std.	0.404	1.87		0.036	0.041			

A = Wetted area (m^2)
W = Width of stream (m)
P = Wetted perimeter (m)
R = Hydraulic radius (m)
Std. = Standard deviation

D = Hydraulic depth (m)
V = Mean velocity (m/s)
SILT = Silt area (m^2)
WS ELE. = Water surface elevation from TBM (100.00 m)

Discharge = 1.77 m^3/s

TABLE 16. Physical and hydraulic parameters of reach 2 of the Valleyfield, P.E.I., study area (June 22, 1988).

STA	A	W	P	R	D	V	SILT	WS ELE.
L-L*	4.077	11.1	11.3	0.361	0.367	0.375	0.638	99.123
M-M*	4.080	10.5	10.9	0.375	0.389	0.375	0.105	99.108
N-N	4.873	12.2	12.5	0.389	0.399	0.314	0.638	99.088
O-O	4.387	10.9	11.1	0.396	0.402	0.349	0.308	99.098
P-P	4.077	8.4	8.8	0.461	0.485	0.375	0.245	99.073
Q-Q	3.909	11.6	11.9	0.329	0.337	0.391	0.300	99.053
R-R	3.770	11.7	12.2	0.310	0.322	0.406	0.689	99.016
S-S	4.490	9.5	10.2	0.442	0.473	0.341	0.340	99.000
T-T	3.858	11.4	11.8	0.328	0.338	0.397	0.048	98.978
U-U	5.259	11.7	12.0	0.437	0.449	0.291	0.132	98.948
V-V	4.041	11.8	12.2	0.332	0.342	0.379	0.930	98.908
W-W	3.798	11.0	11.6	0.327	0.345	0.403	0.000	99.883
X-X	4.637	11.4	12.0	0.387	0.407	0.330	0.325	98.863
Y-Y	4.271	12.0	12.7	0.336	0.356	0.358	0.268	98.858
Mean	4.28	11.1			0.388	0.361		
Std.	0.467	1.11			0.056	0.037		

A = Wetted area (m^2)

W = Width of stream (m)

P = Wetted perimeter (m)

R = Hydraulic radius (m)

Std. = Standard deviation

D = Hydraulic depth (m)

V = Mean velocity (m/s)

SILT = Silt area (m^2)

WS ELE. = Water surface elevation from TBM (100.00 m)

Discharge = 1.77 m^3/s

* Supplement to reach 2

Table 17. Physical and hydraulic parameters of reach 3 of the Valleyfield River, P.E.I., study area (July 20, 1988).

STA	A	W	P	R	D	V	SILT	WS ELE.
A1-A1	3.425	11.8	12.3	0.278	0.290	0.342	0.620	98.769
B1-B1	3.451	11.4	11.9	0.289	0.303	0.339	0.470	98.720
C1-C1	3.239	12.3	12.6	0.255	0.263	0.361	0.451	98.688
D1-D1	3.870	10.8	11.4	0.341	0.358	0.302	0.654	98.666
E1-E1	3.875	11.1	11.4	0.341	0.349	0.302	0.480	98.659
F1-F1	4.070	12.0	12.2	0.333	0.339	0.287	2.060	98.633
G1-G1	4.175	12.7	13.0	0.322	0.329	0.280	0.608	98.633
H1-H1	4.198	9.8	10.1	0.415	0.428	0.279	0.618	98.626
I1-I1	3.004	11.0	11.3	0.266	0.273	0.389	0.260	98.588
J1-J1	2.908	10.5	10.8	0.269	0.277	0.402	0.770	98.541
Mean	3.62	11.3			0.321	0.328		
Std.	0.480	0.908			0.050	0.045		

A = Wetted area (m^2)

W = Width of stream (m)

P = Wetted perimeter (m)

R = Hydraulic radius (m)

Std. = Standard deviation

D = Hydraulic depth (m)

V = Mean velocity (m/s)

SILT = Silt area (m^2)

WS ELE. = Water surface elevation from TBM (100.00 m)

Discharge = 1.17 m^3/s

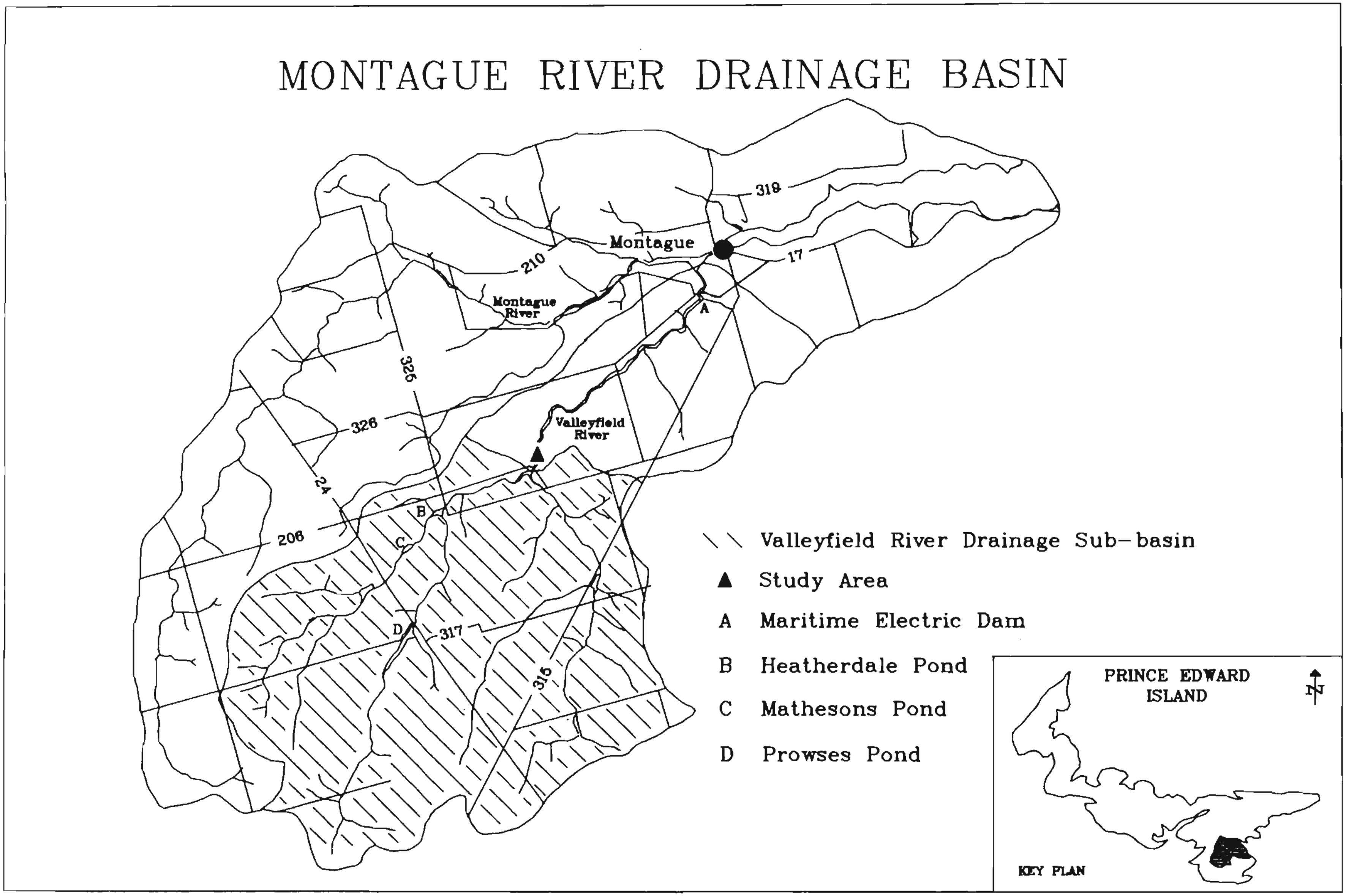


Figure 1. Site plan of study area and drainage basin, Valleyfield River, P.E.I.

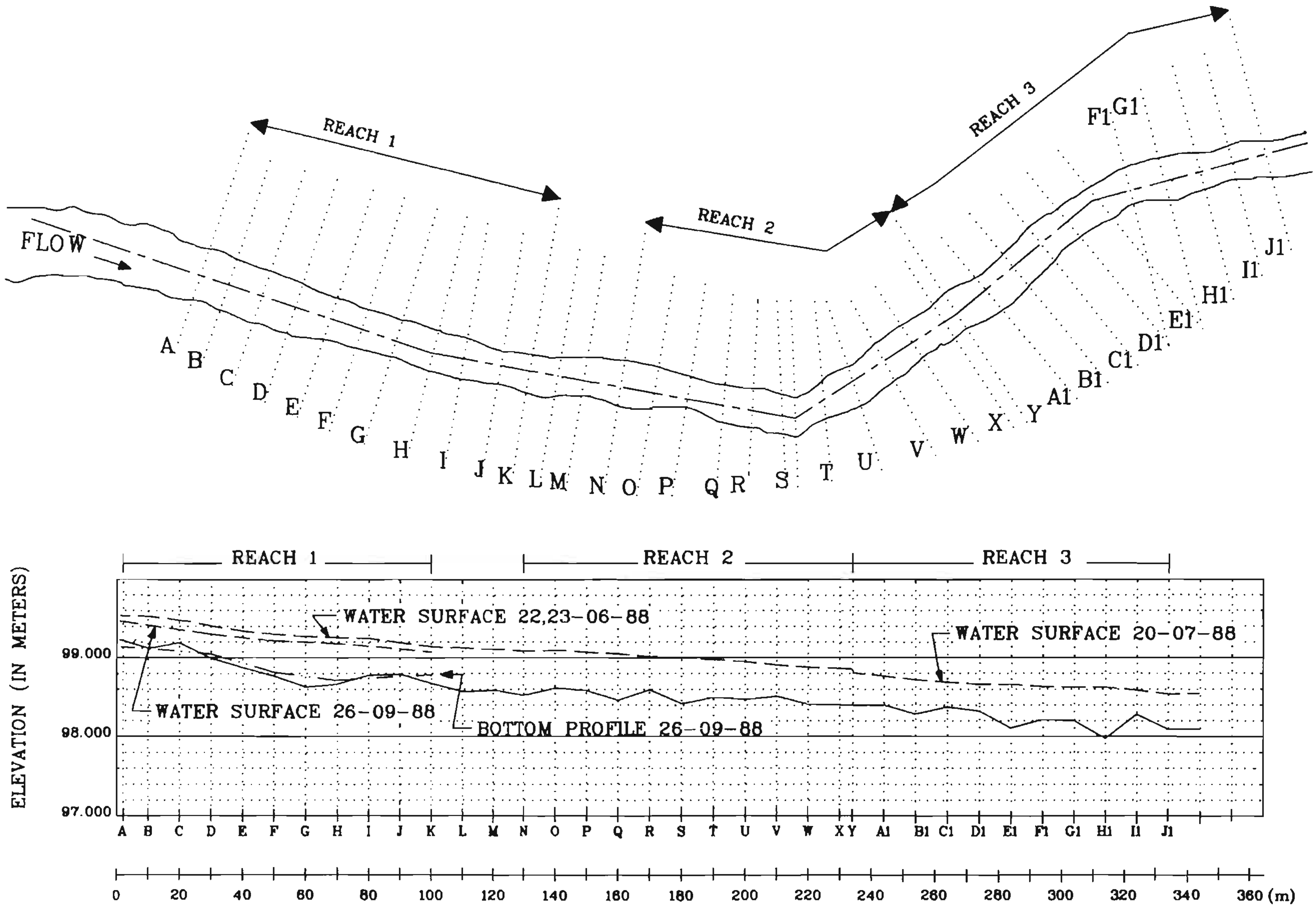


Figure 2. Plan, profile and location of the study reaches and cross sections, Valleyfield River, P.E.I.

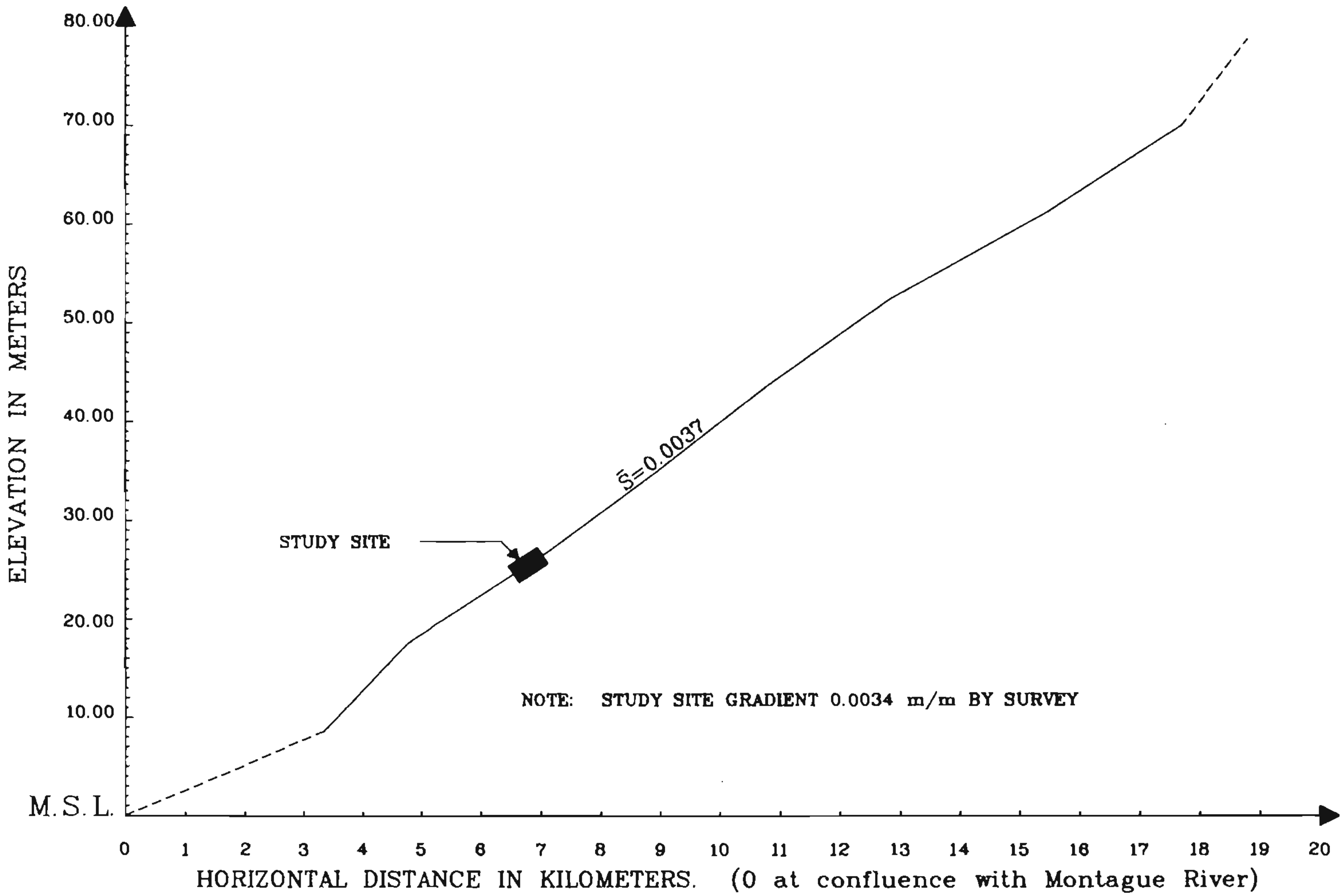


Figure 3. Profile of the Valleyfield River, P.E.I.

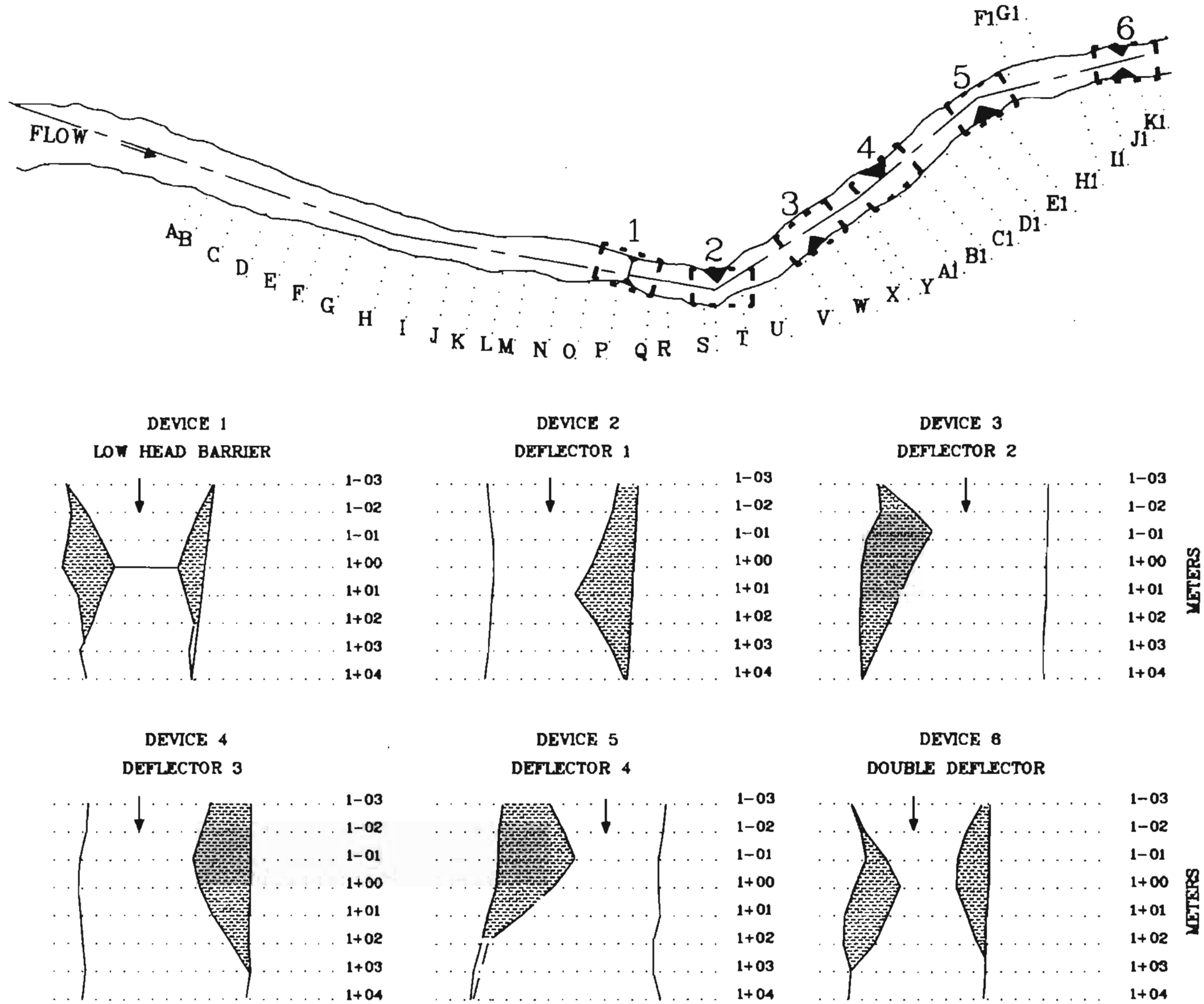


Figure 4. Site plan of the habitat improvement devices and cross section locations for each device, Valleyfield River, P.E.I.

Appendix A

Cross sections indicating bottom and sediment profiles for study reach 1, 2 and 3.

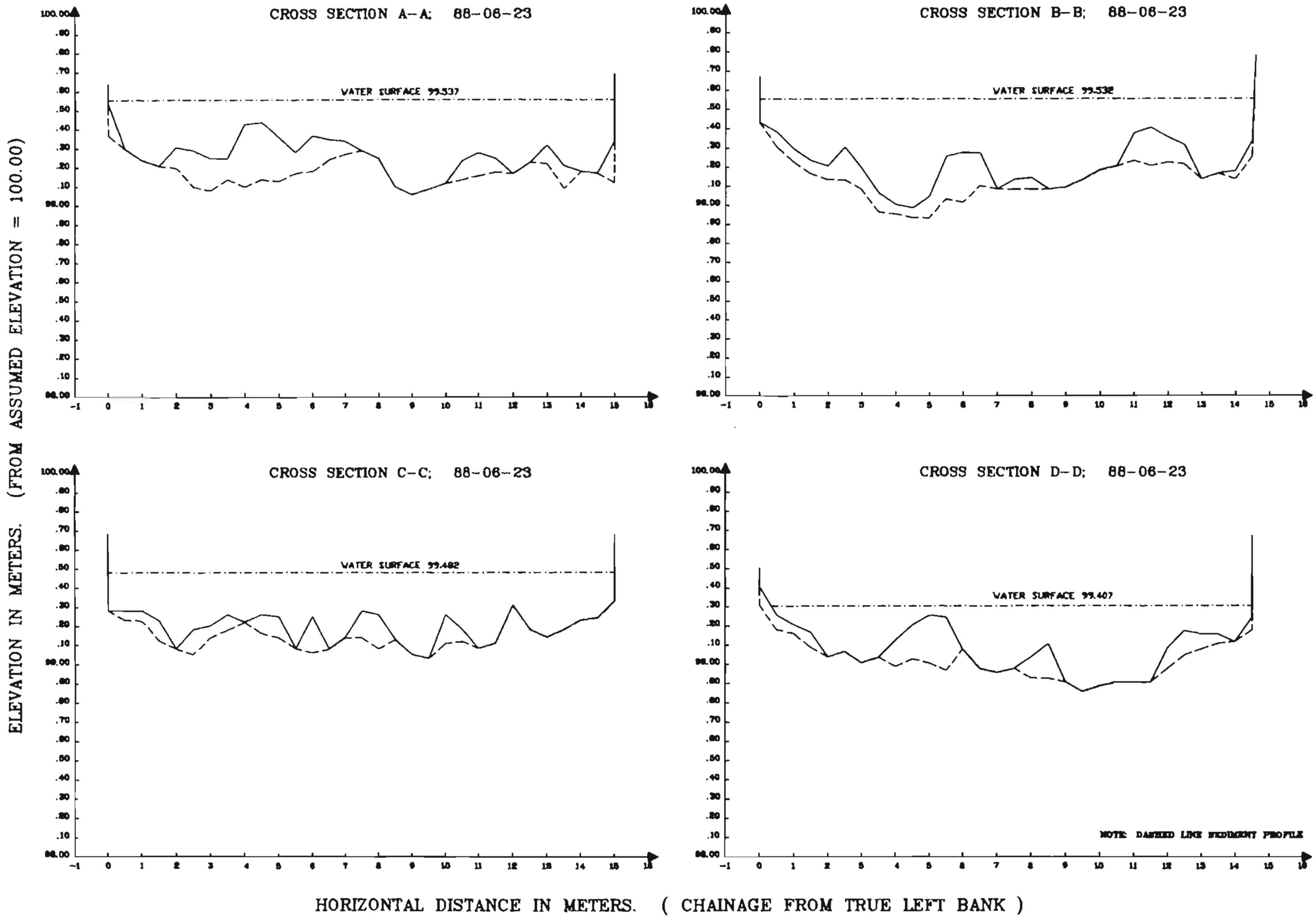
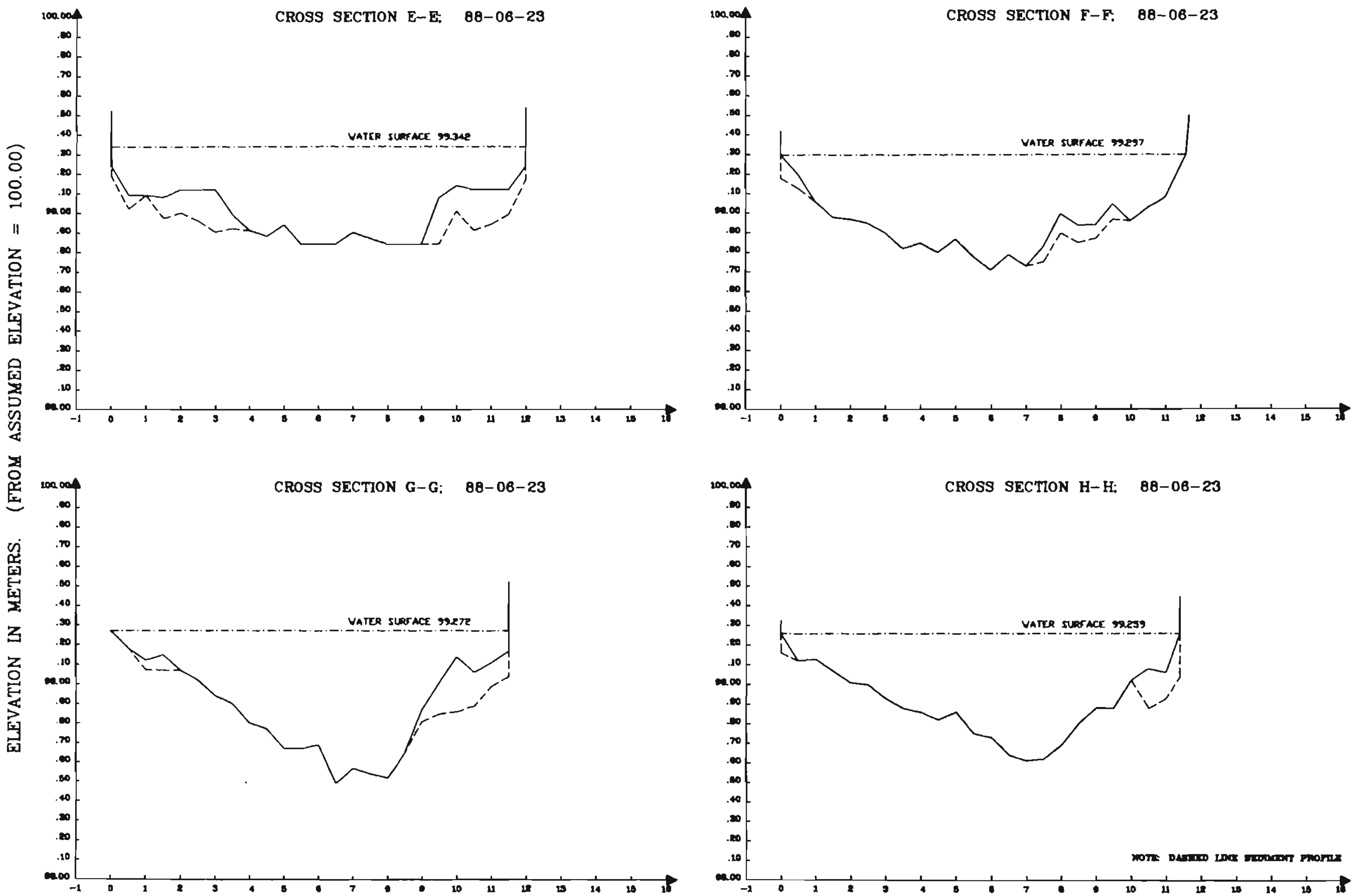


Figure A1. Cross sections A-A to D-D showing bottom and silt contour, Valleyfield River, P.E.I.



HORIZONTAL DISTANCE IN METERS. (CHAINAGE FROM TRUE LEFT BANK)

Figure A2. Cross sections E-E to H-H showing bottom and silt contour, Valleyfield River, P.E.I.

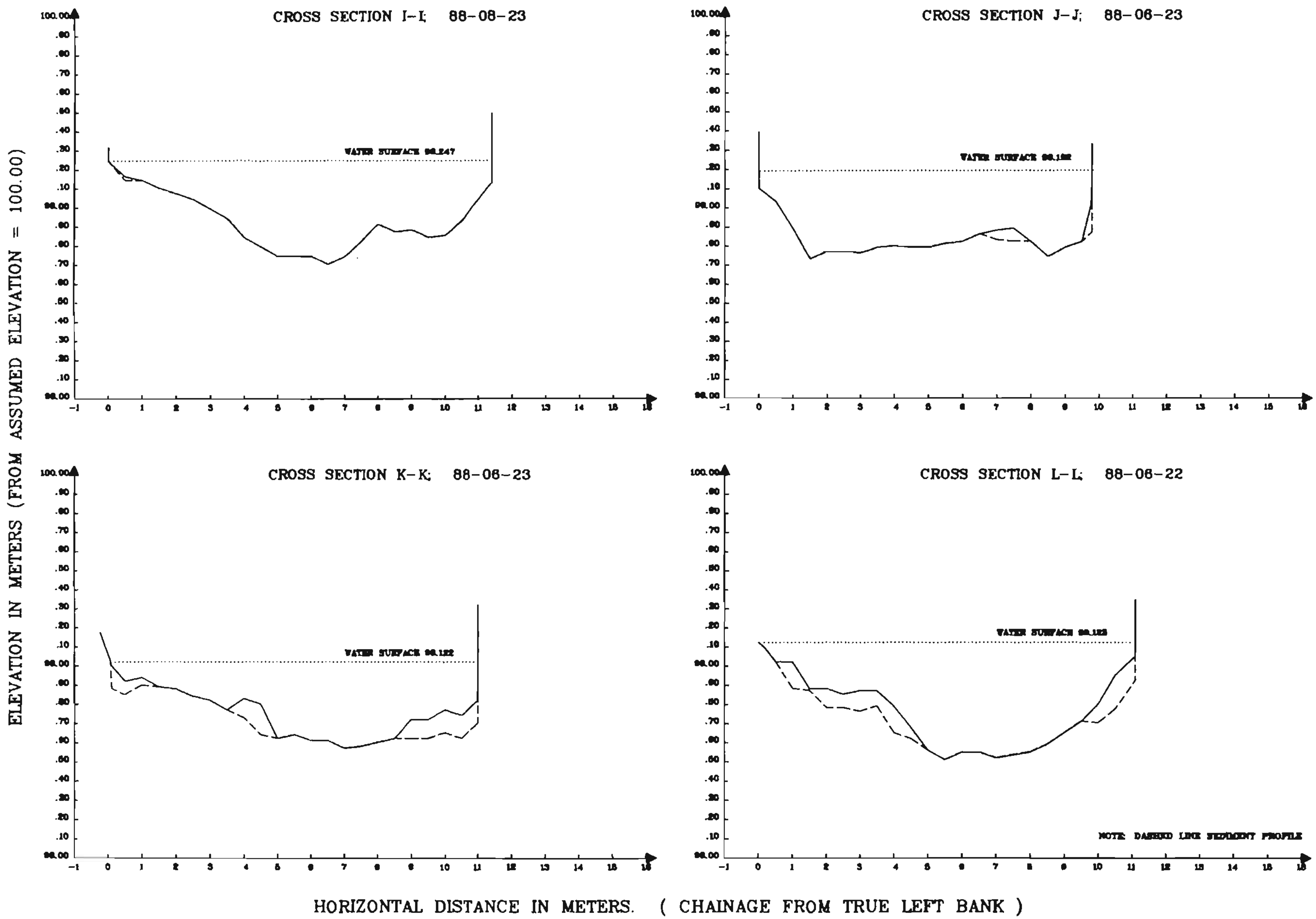


Figure A3. Cross sections I-I to L-L showing bottom and silt contour, Valleyfield River, P.E.I.

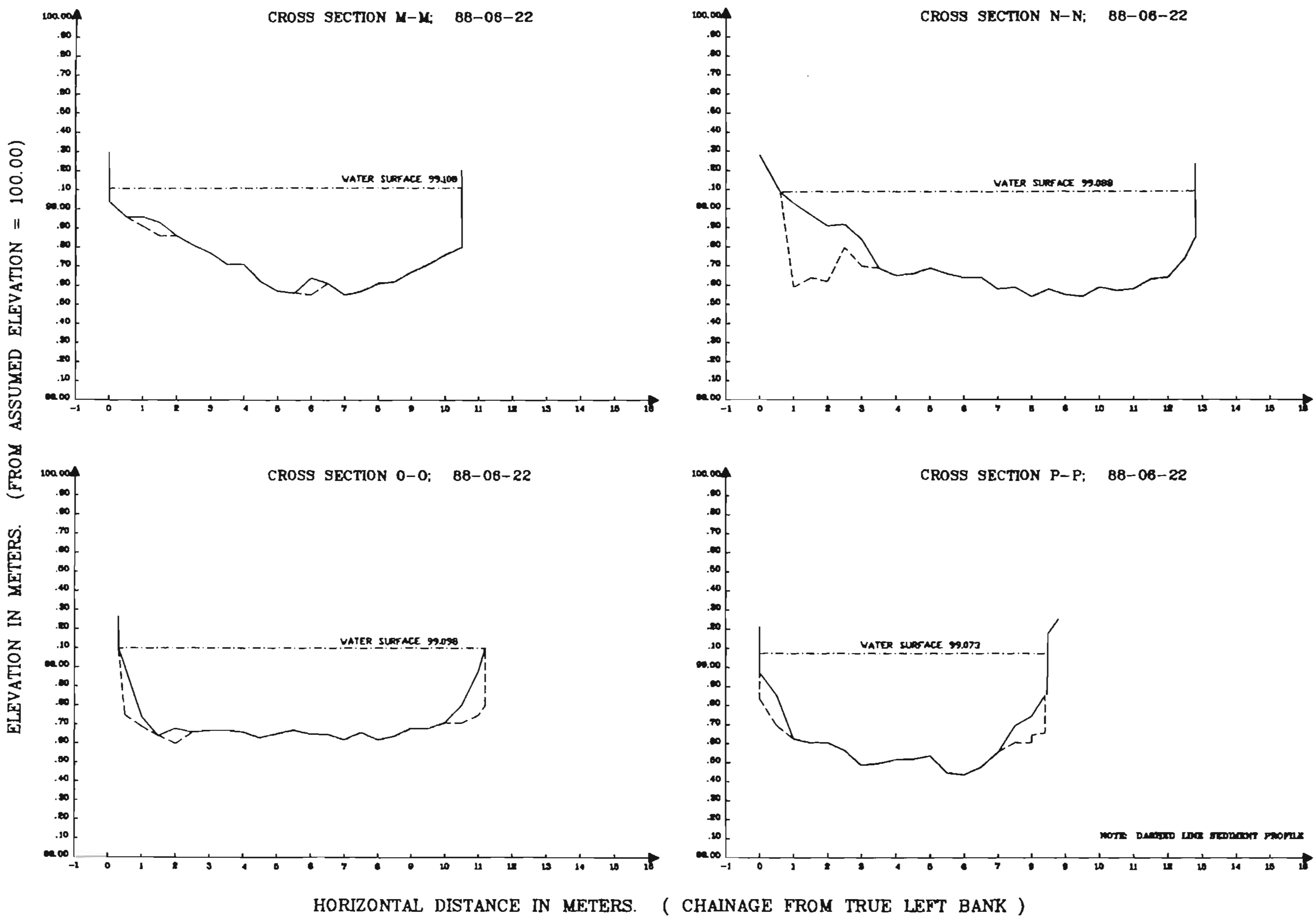


Figure A4. Cross sections M–M to P–P showing bottom and silt contour, Valleyfield River, P.E.I.

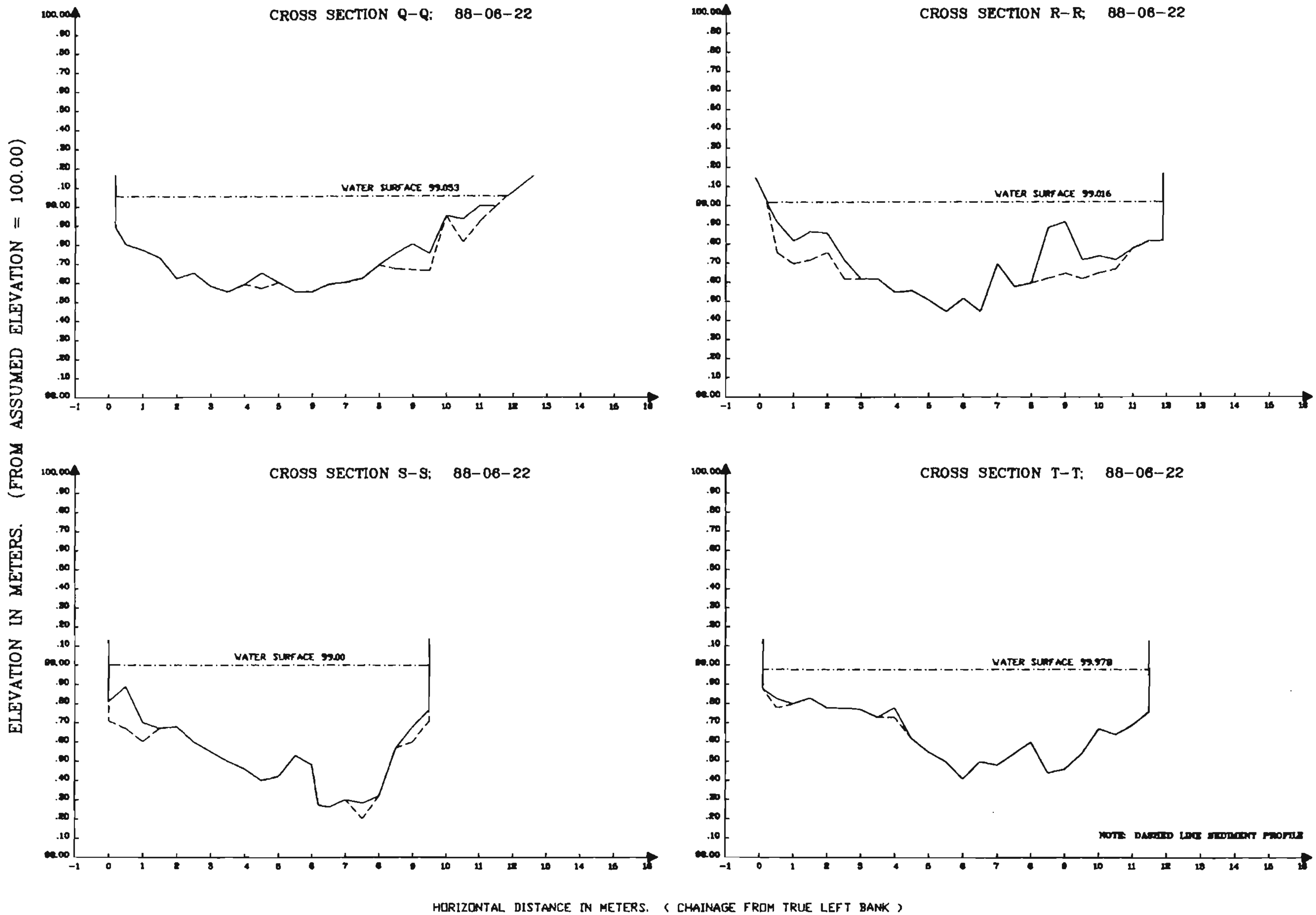
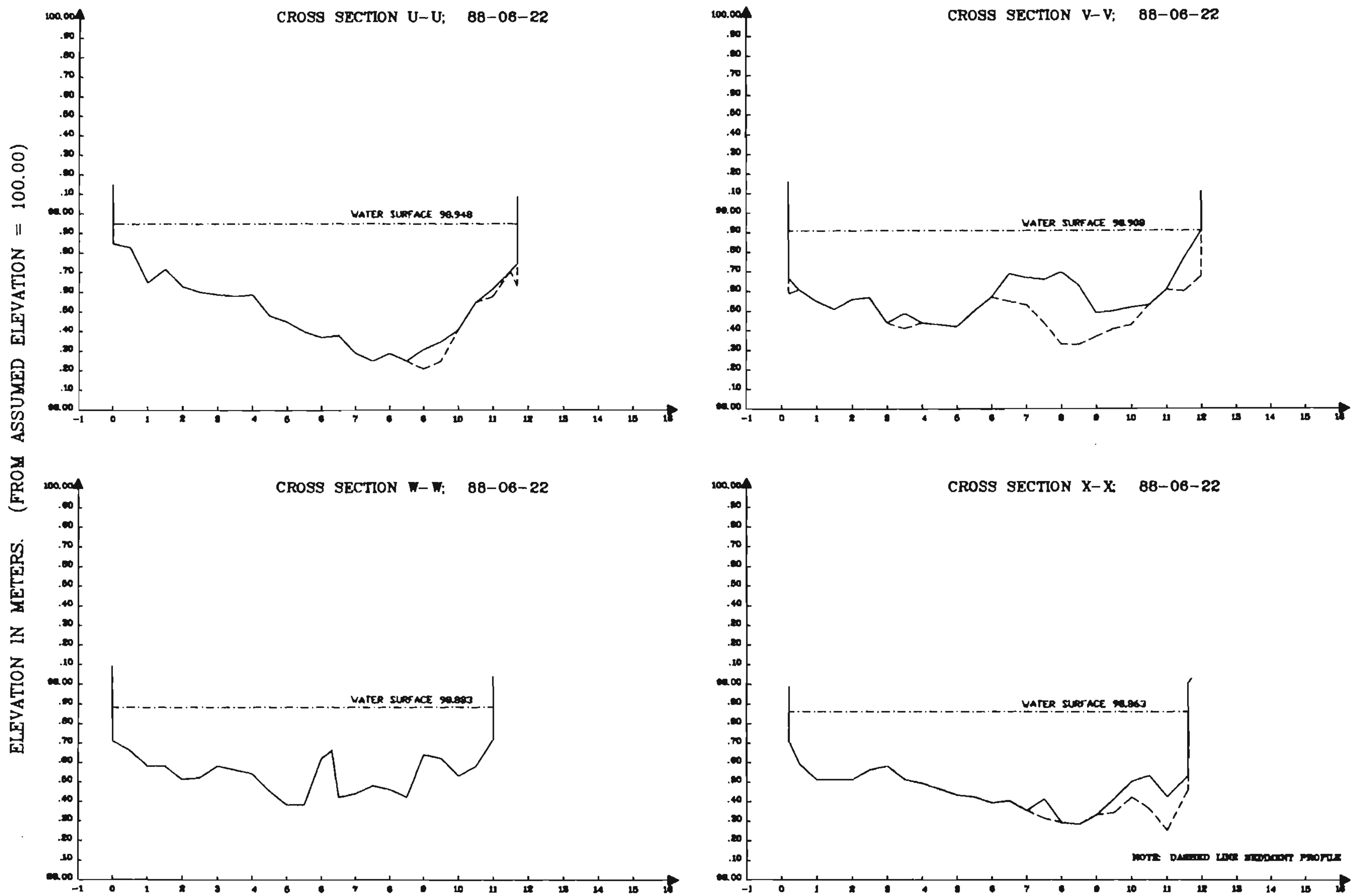


Figure A5. Cross sections Q-Q to T-T showing bottom and silt contour, Valleyfield River, P.E.I.



HORIZONTAL DISTANCE IN METERS. (CHAINAGE FROM TRUE LEFT BANK)

Figure A6. Cross sections U-U to X-X showing bottom and silt contour, Valleyfield River, P.E.I.

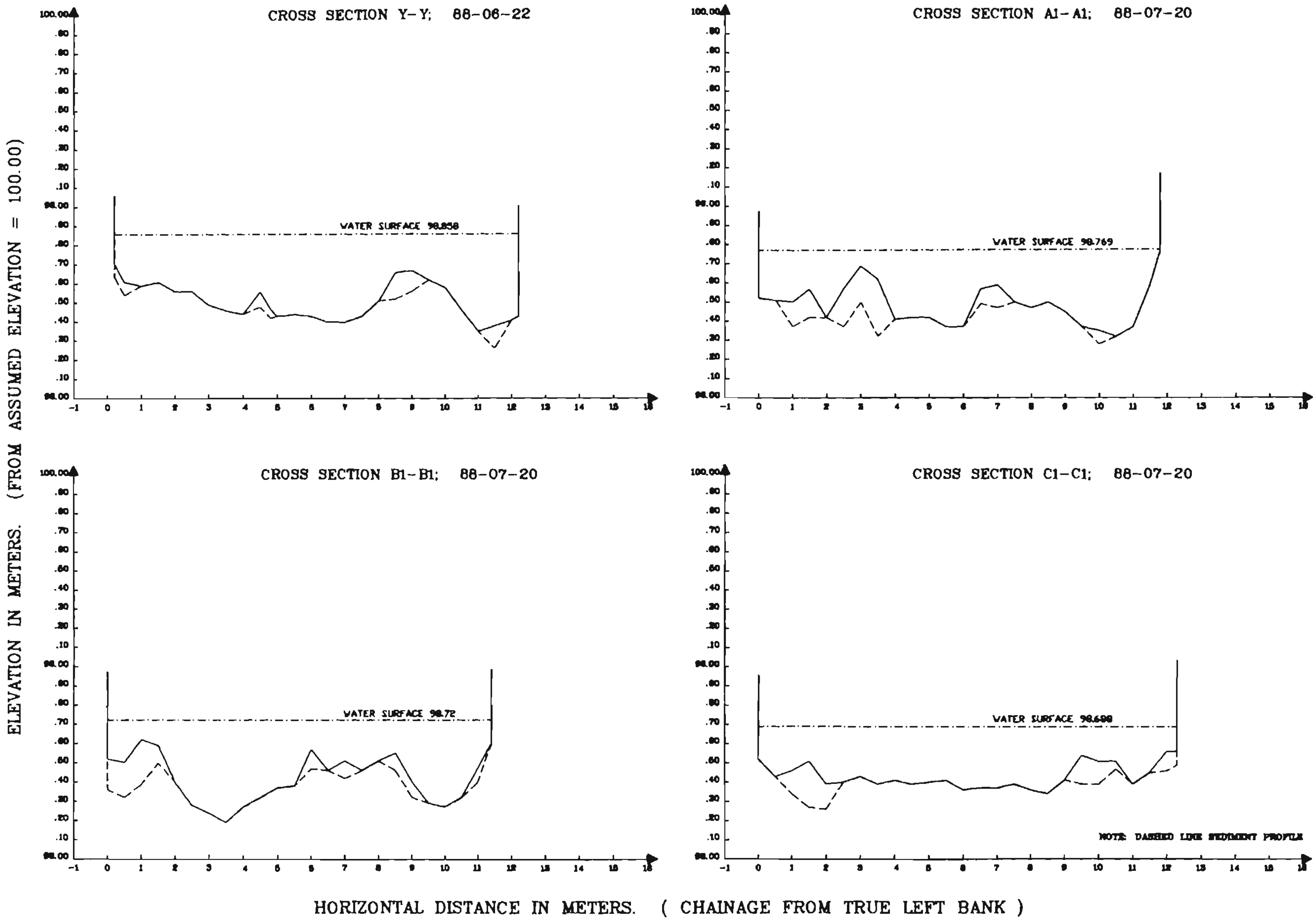


Figure A7. Cross sections Y-Y to C1-C1 showing bottom and silt contour, Valleyfield River, P.E.I.

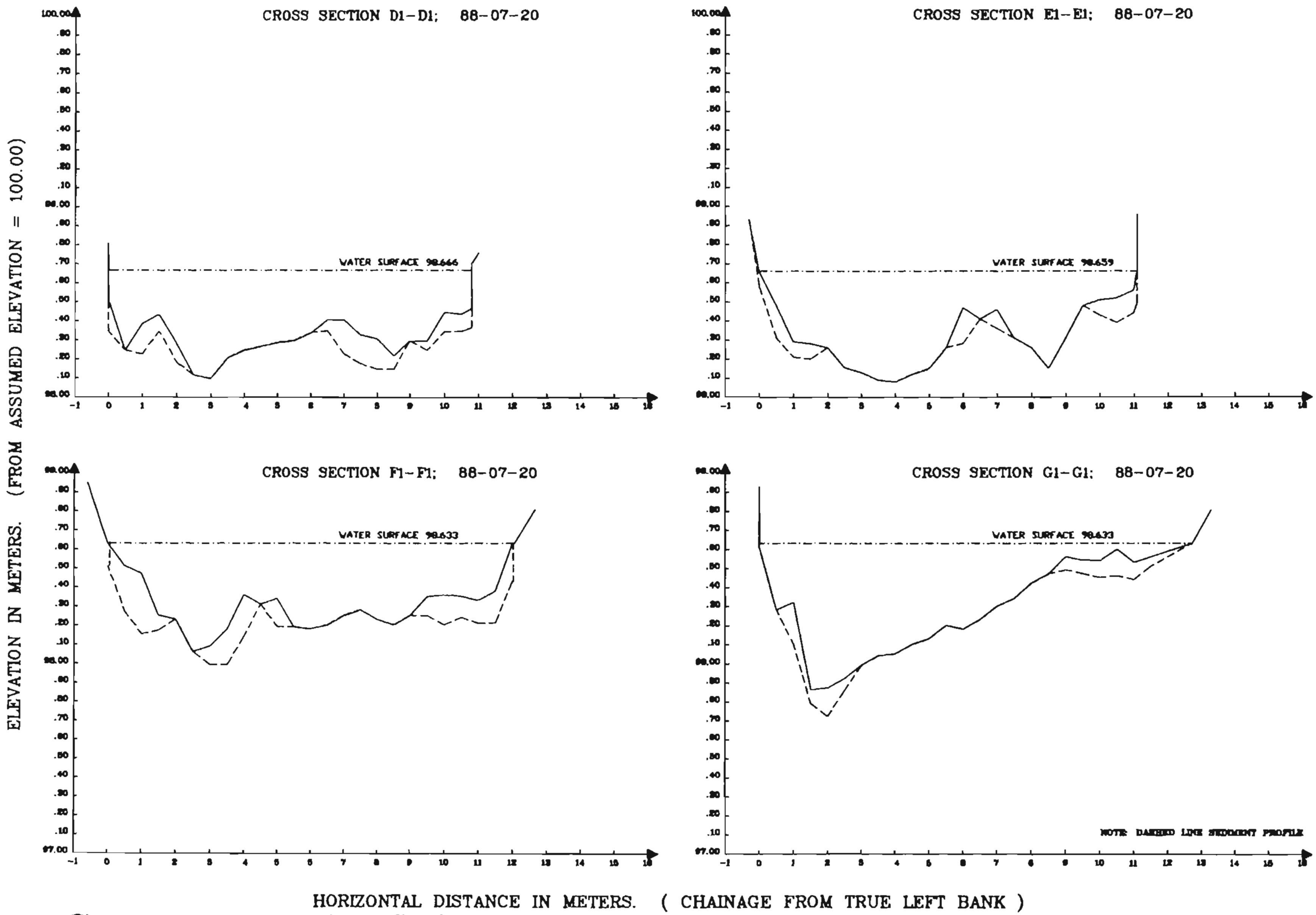


Figure A8. Cross sections D1–D1 to G1–G1 showing bottom and silt contour, Valleyfield River, P.E.I.

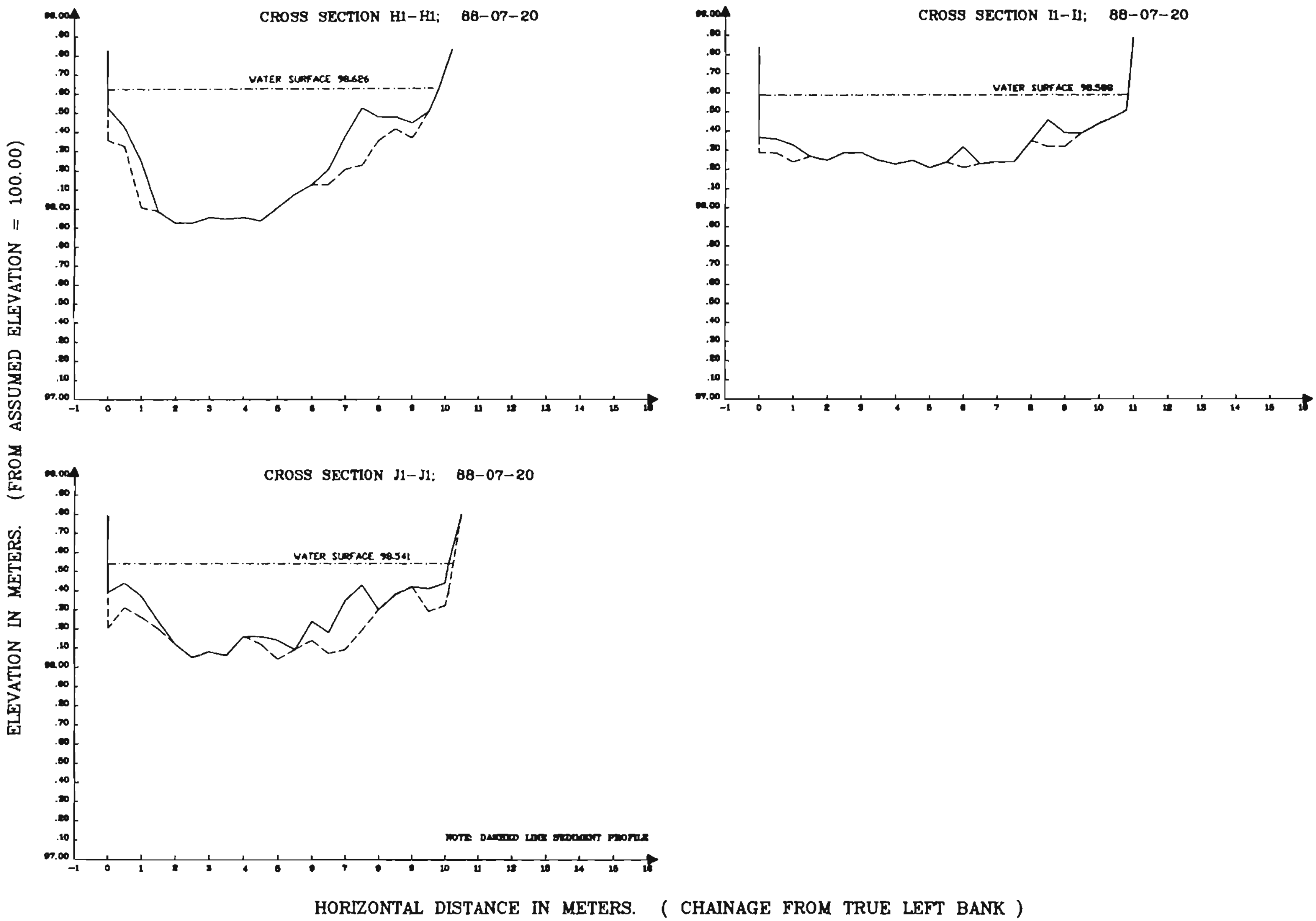


Figure A9. Cross sections H1-H1 to J1-J1 showing bottom and silt contour, Valleyfield River, P.E.I.

Appendix B

Device cross-sections indicating bottom profiles and short term changes.

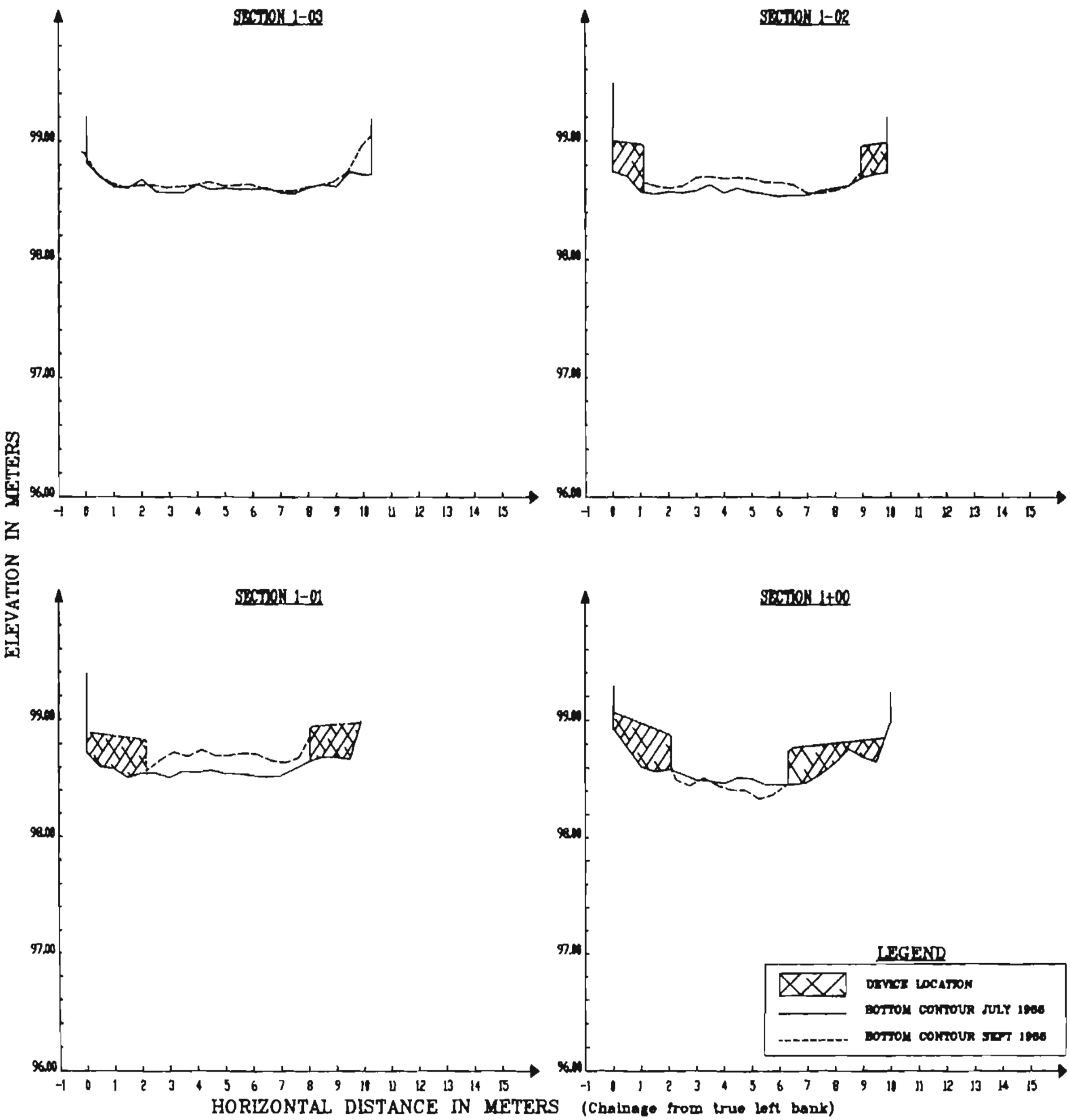


Figure B1. Device 1 cross sections 1-03 to 1+00 showing short term change, Valleyfield River, P.E.I.

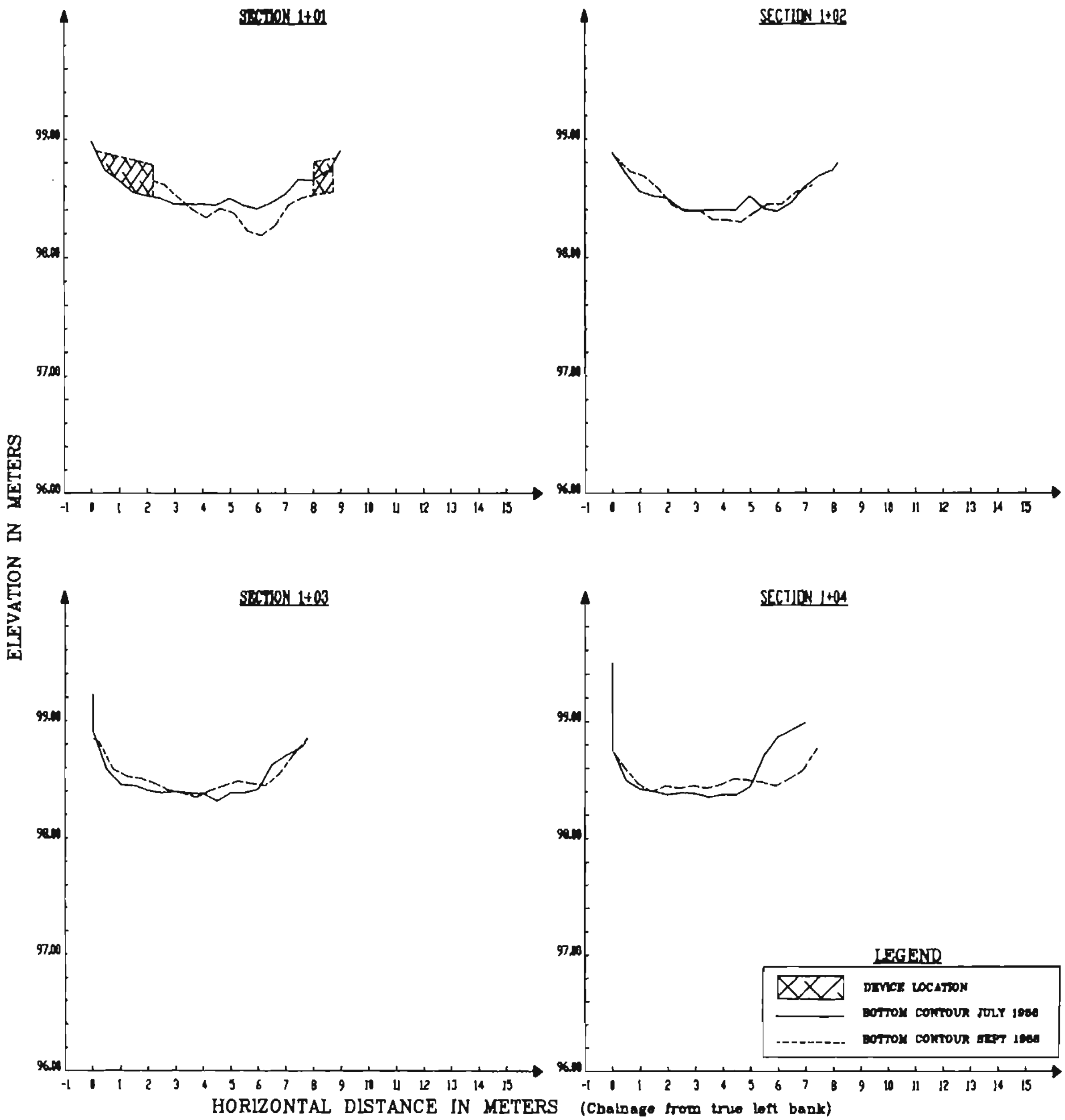


Figure B2. Device 1 cross sections 1+01 to 1+04 showing short term change, Valleyfield River, P.E.I.

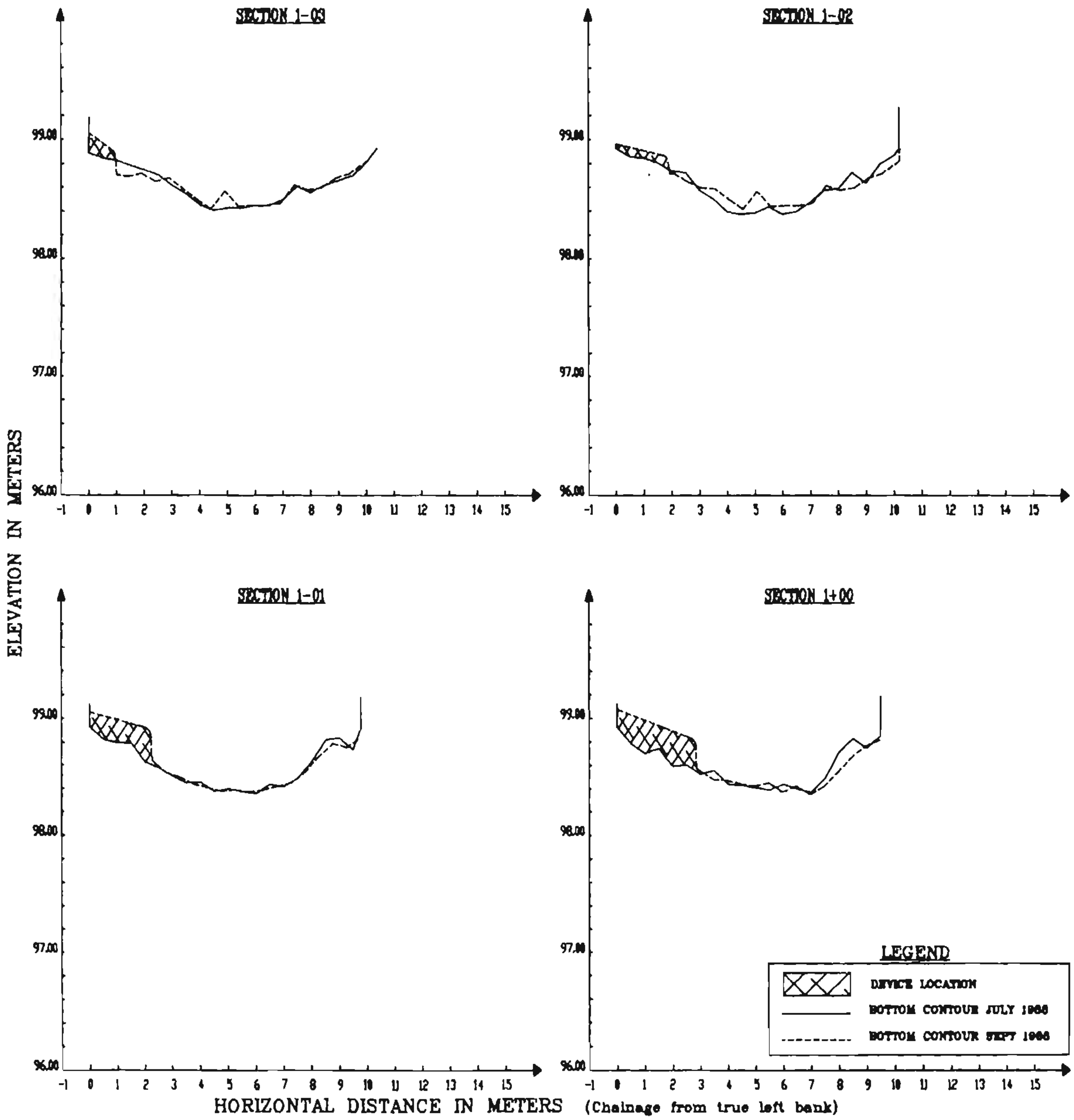


Figure B3. Device 2 cross sections 1–03 to 1+00 indicating short term change, Valleyfield River, P.E.I.

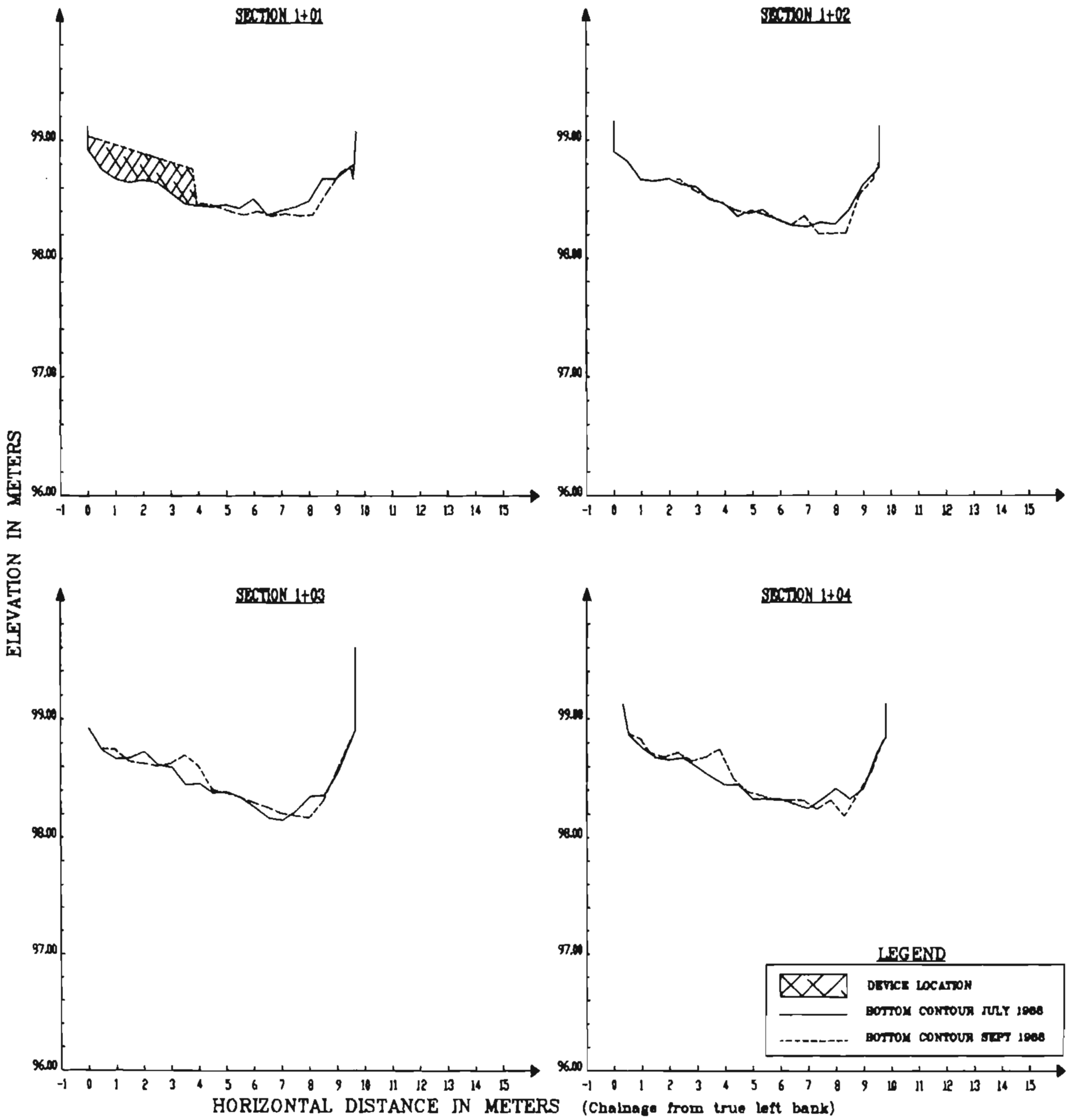


Figure B4. Device 2 cross sections 1+01 to 1+04 indicating short term change, Valleyfield River, P.E.I.

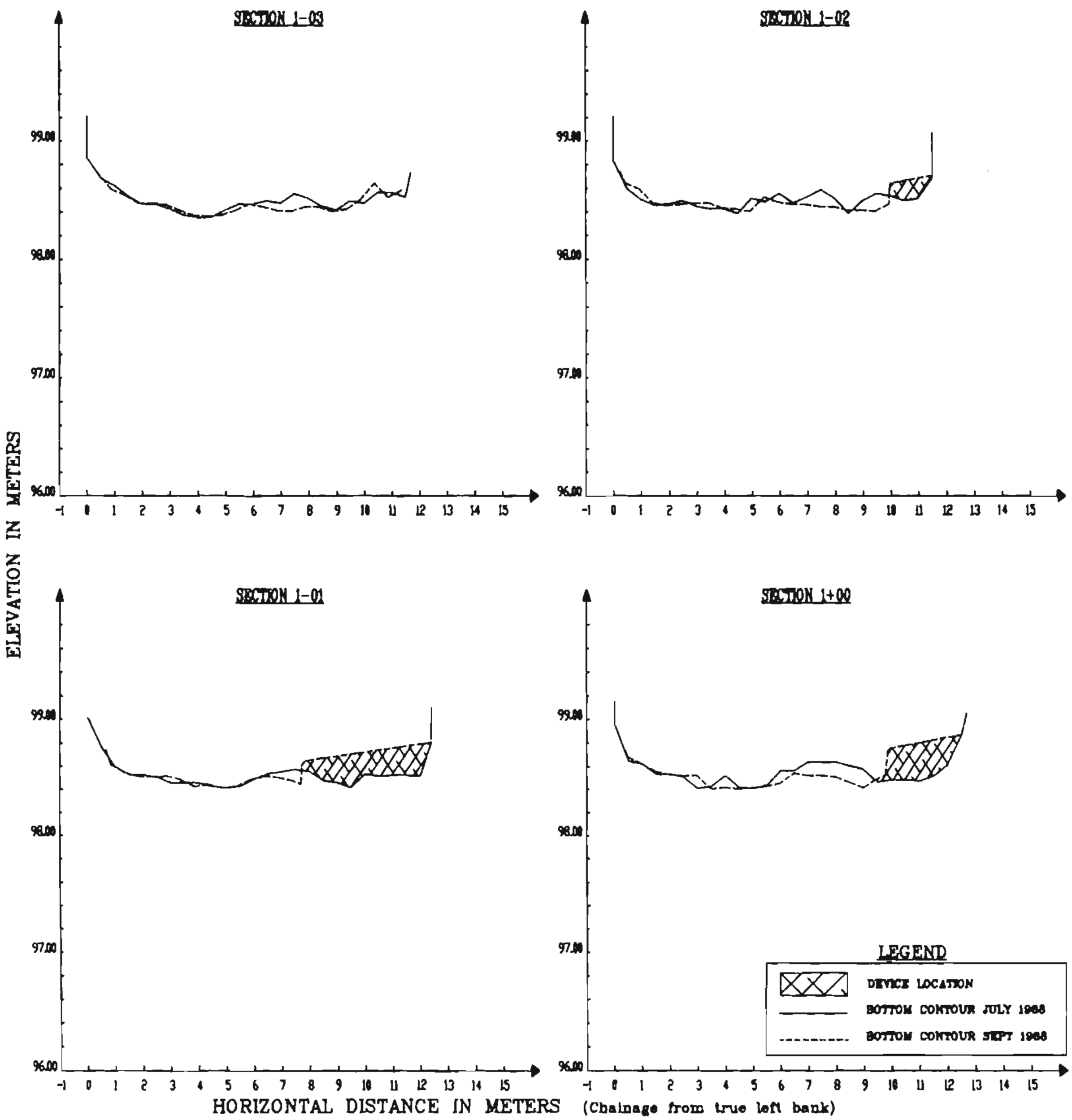


Figure B5. Device 3 cross sections 1-03 to 1+00 indicating short term change, Valleyfield River, P.E.I.

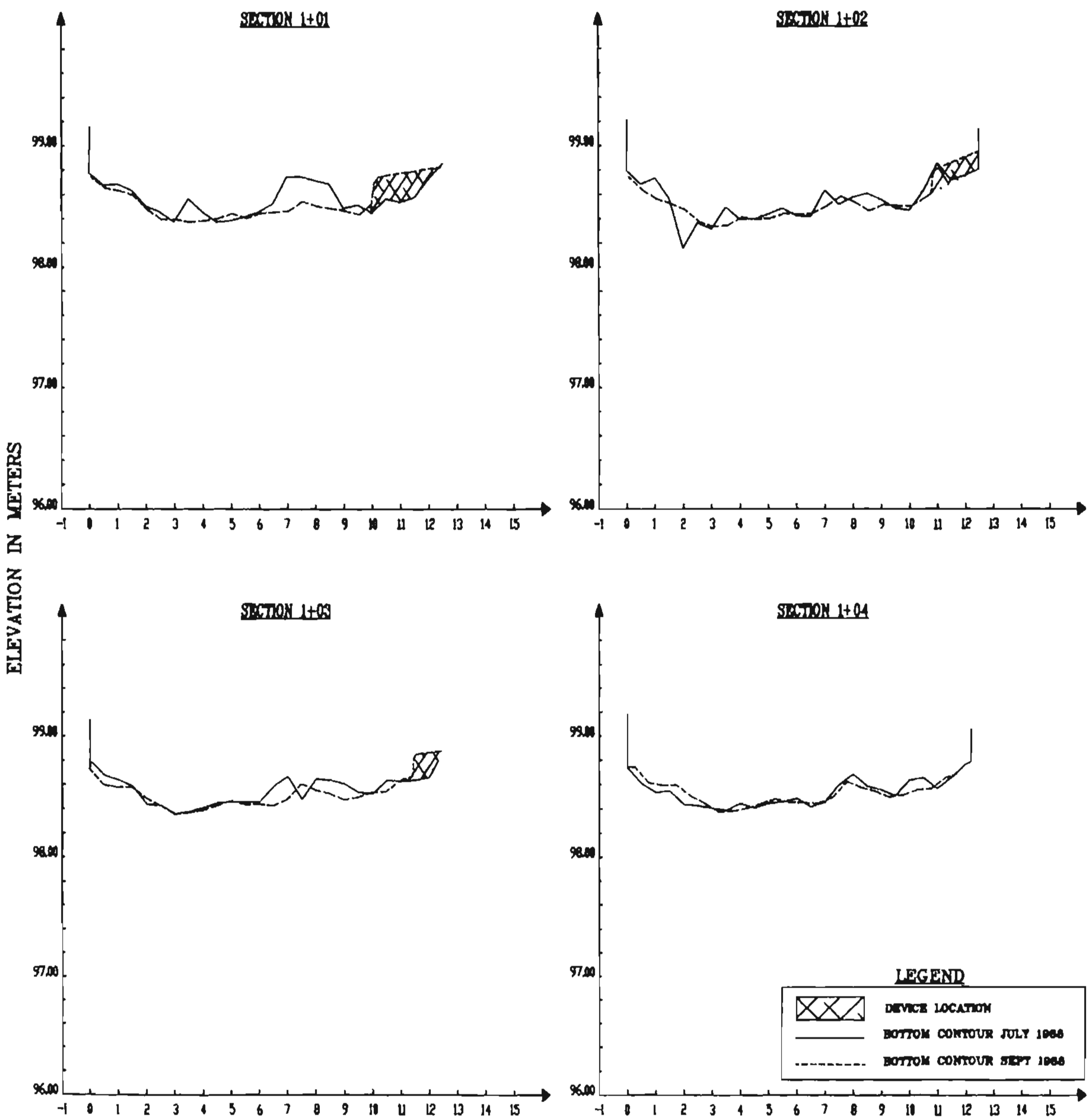


Figure B6. Device 3 cross sections 1+01 to 1+04 indicating short term change, Valleyfield River, P.E.I.

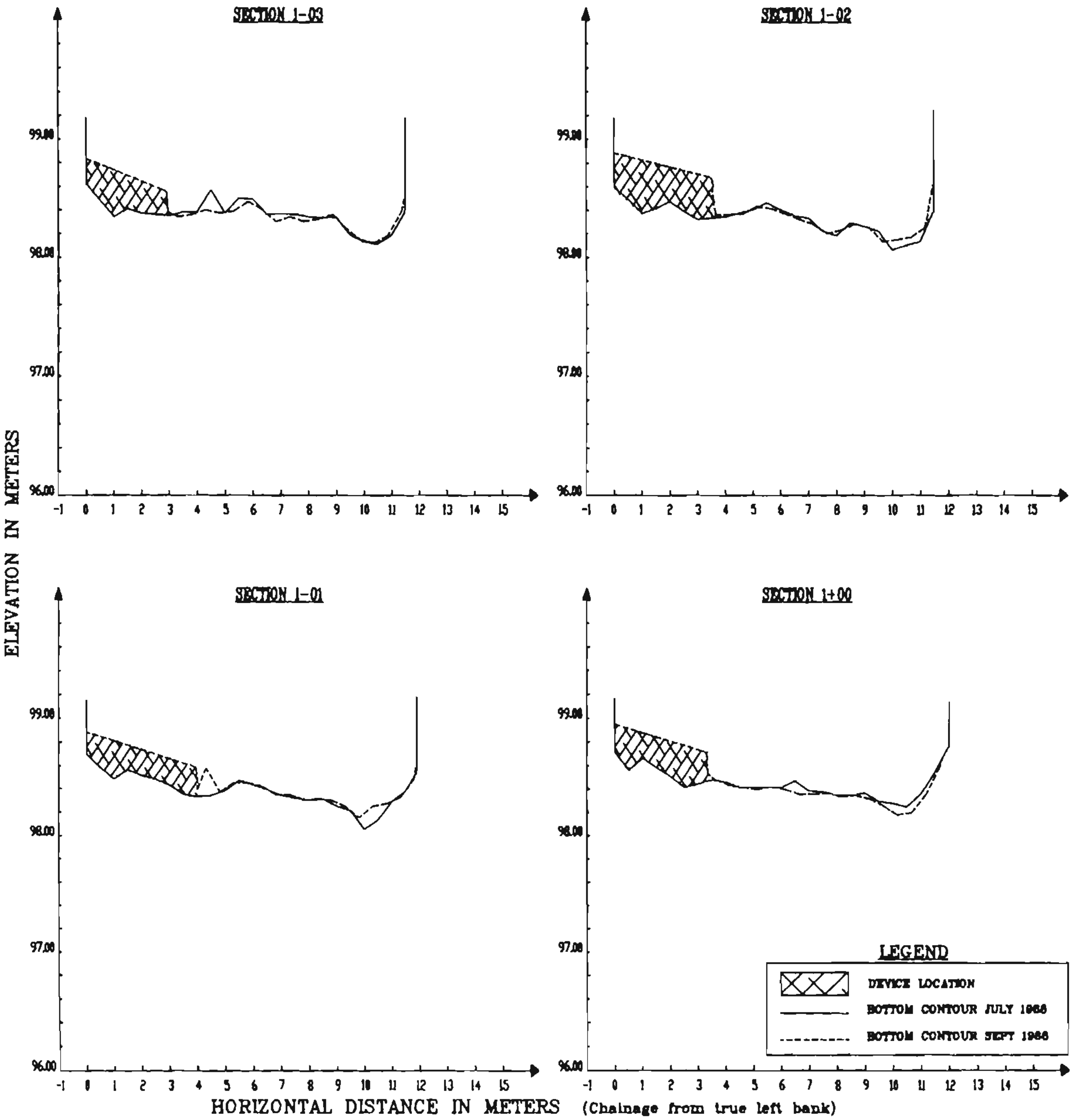


Figure B7. Device 4 cross sections 1-03 to 1+00 indicating short term change, Valleyfield River, P.E.I.

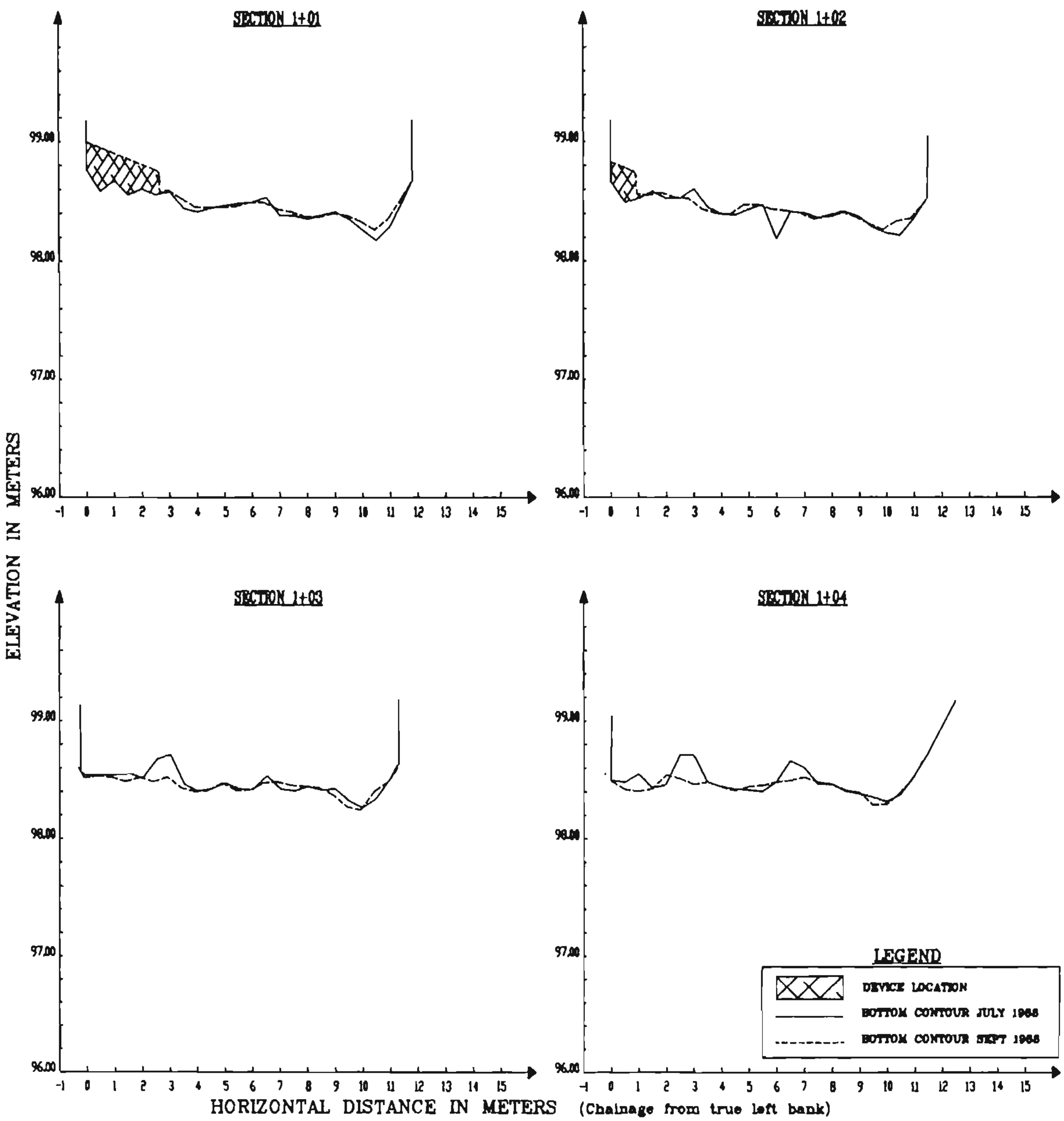


Figure B8. Device 4 cross sections 1+01 to 1+04 indicating short term change, Valleyfield River, P.E.I.

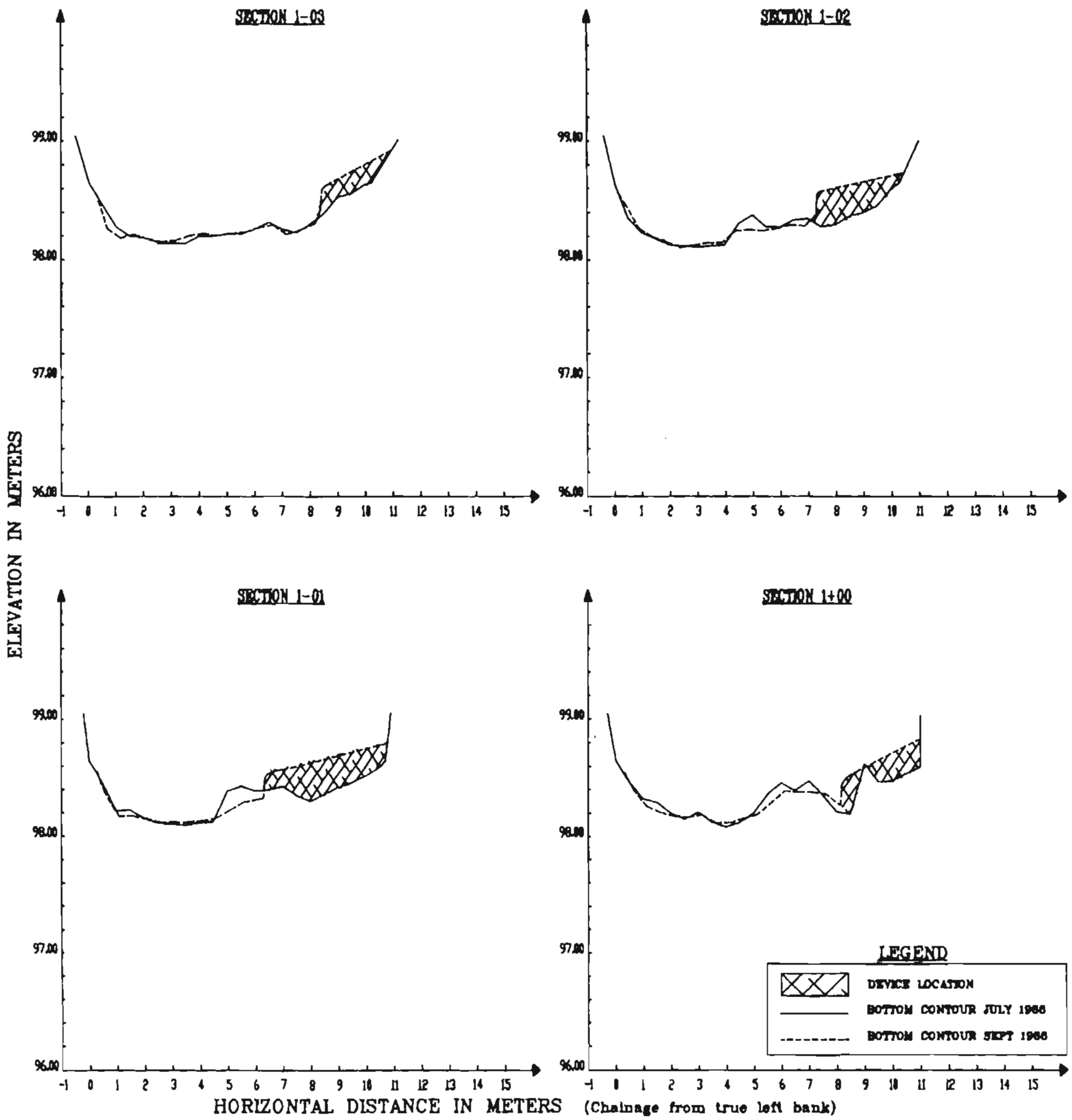


Figure B9. Device 5 cross sections 1-03 to 1+00 indicating short term change, Valleyfield River, P.E.I.

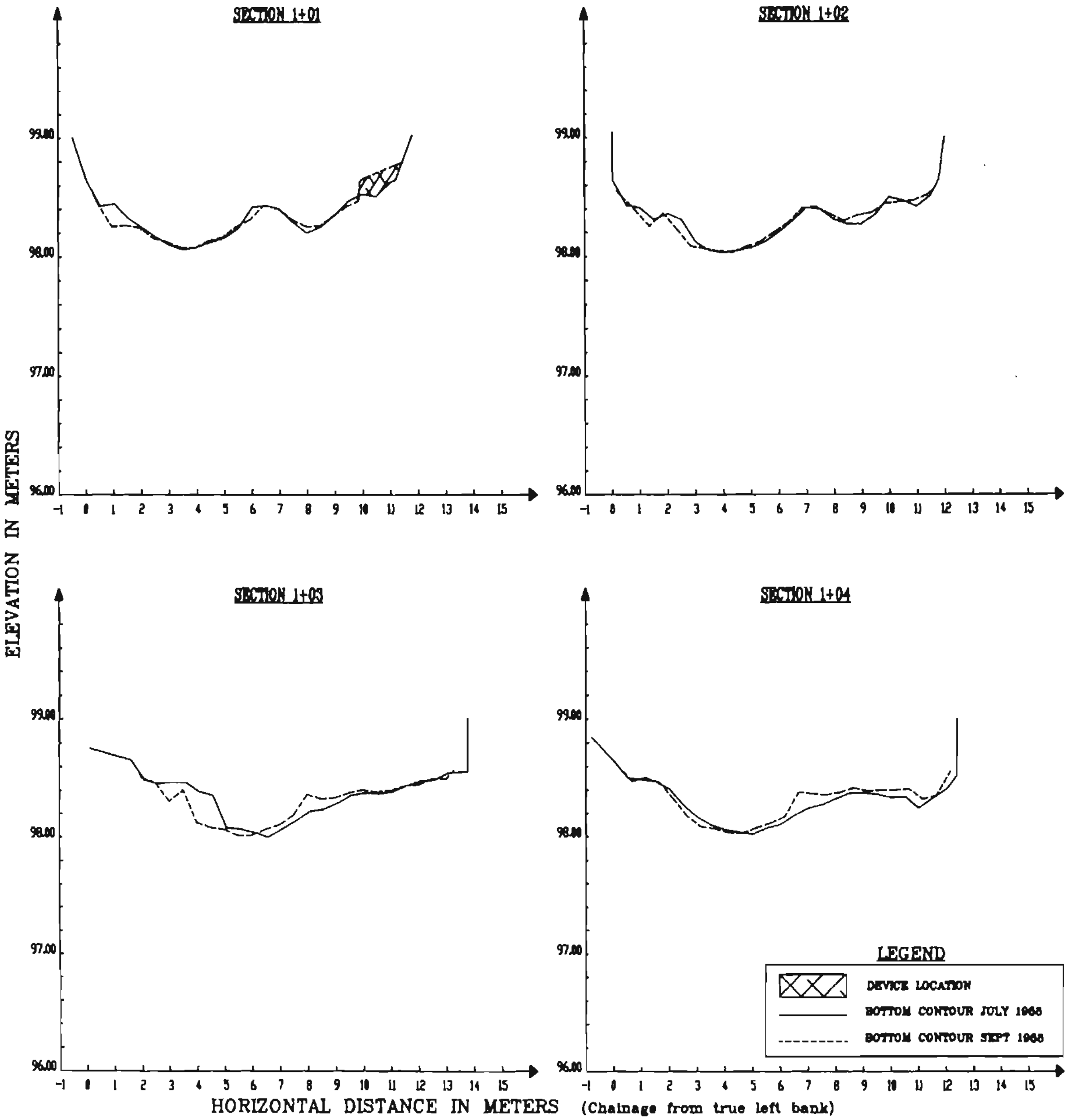


Figure B10. Device 5 cross sections 1+01 to 1+04 indicating short term change, Valleyfield River, P.E.I.

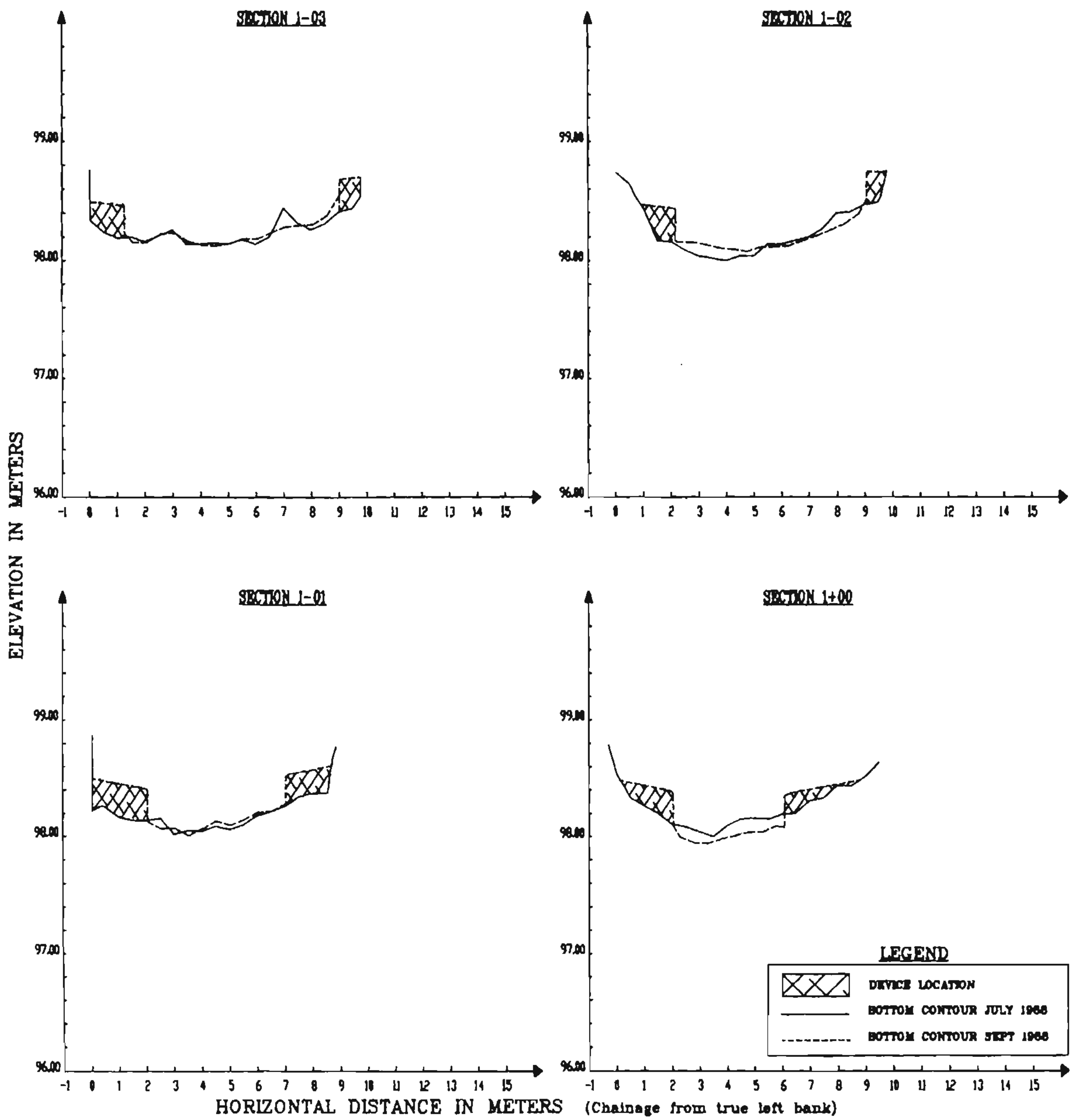


Figure B11. Device 6 cross sections 1–03 to 1+00 indicating short term change, Valleyfield River, P.E.I.

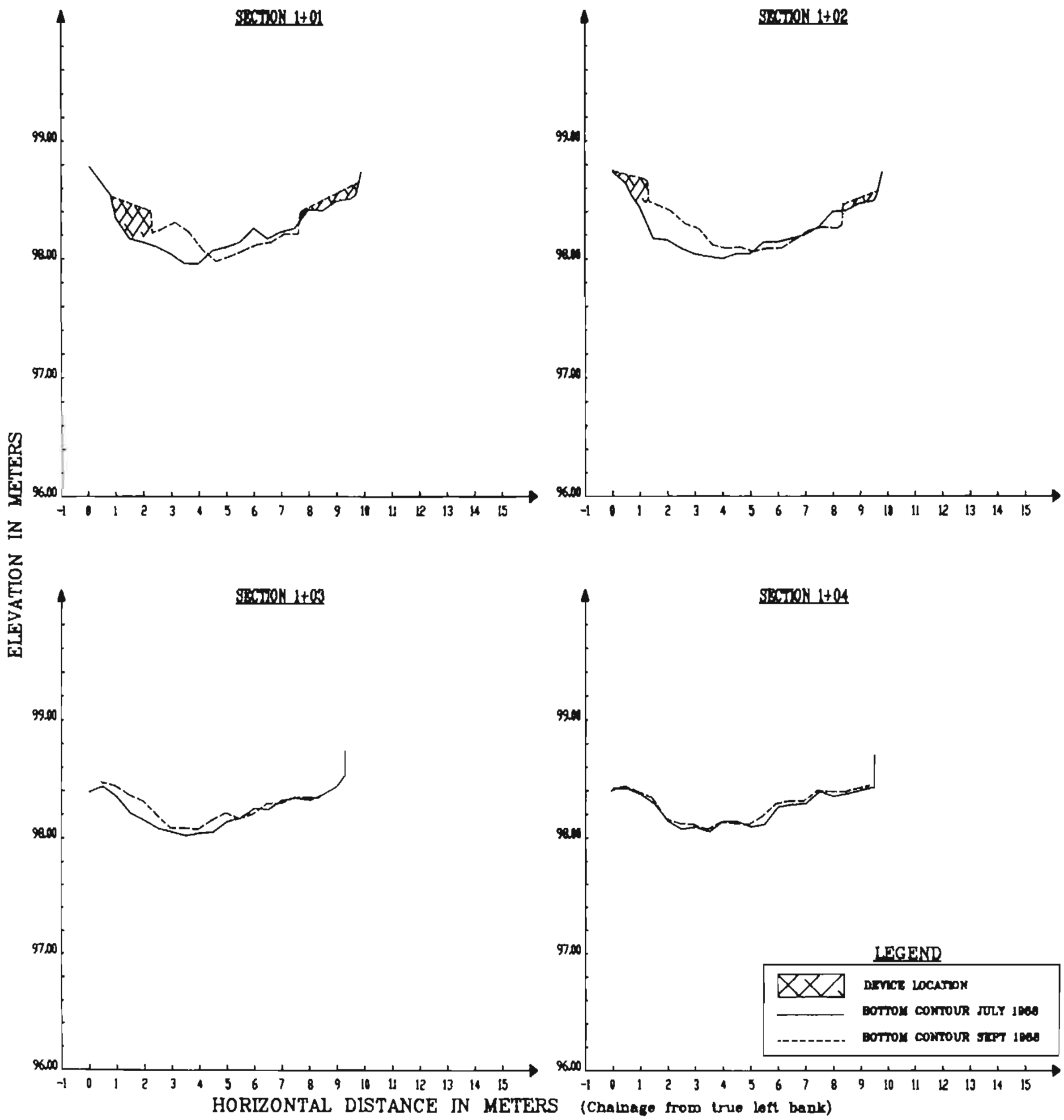


Figure B12. Device 6 cross sections 1+01 to 1+04 indicating short term change, Valleyfield River, P.E.I.