Summer Field Investigations at the Haig Glacier, Alberta

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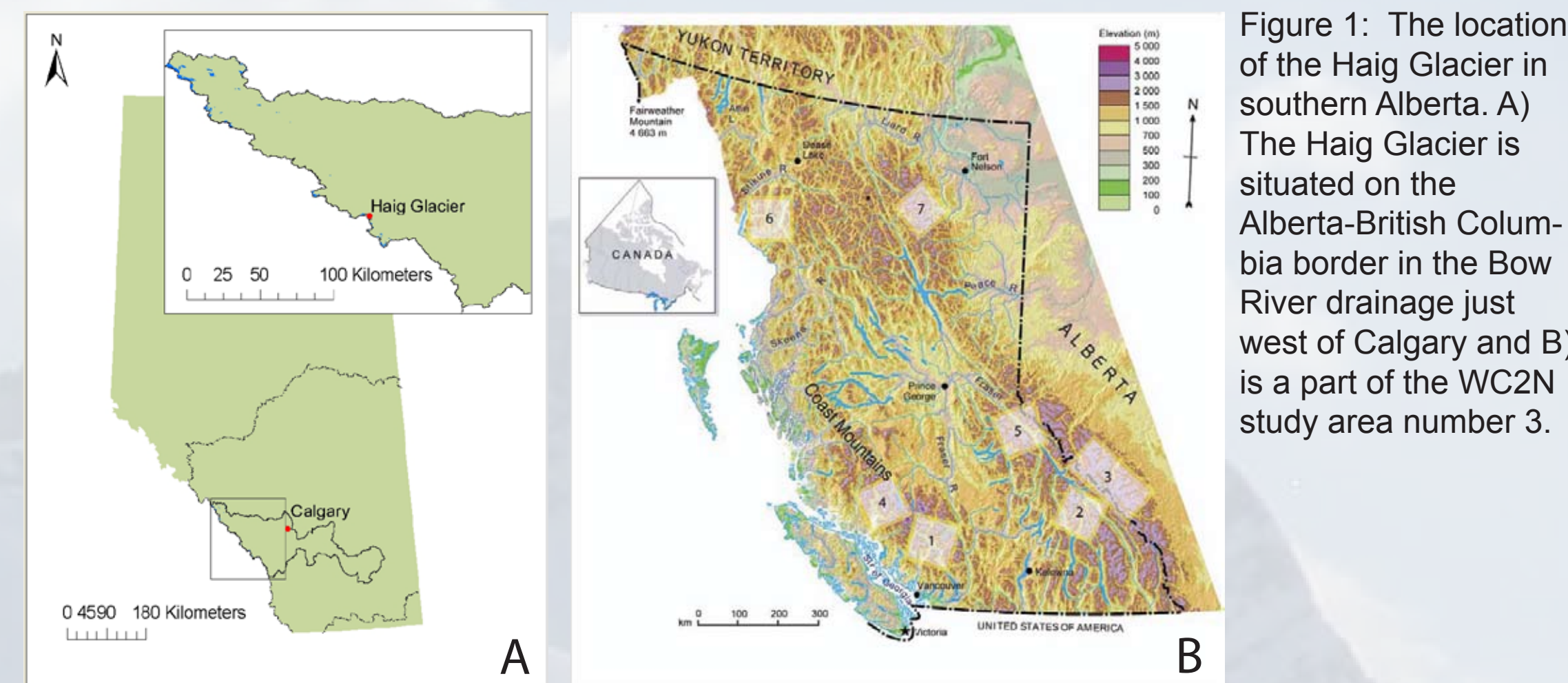*eleanor.bash@ucalgary.ca

Introduction

Field investigations at the Haig Glacier were undertaken in the summer of 2009 as part of an ongoing study. Weather data has been collected at the Haig since 2001 at two automatic weather stations as well as 9 temperature sensors along the centerline of the glacier and in the fore field. In addition to the continued work, three main areas were investigated in 2009: surface velocity, ice thickness and hydrology.

The Haig Glacier is located in the Eastern slopes of the Canadian Rockies along the Alberta-British Columbia border (Figure 1b). The glacier is also located in area 3 of the WC2N project (Figure 1a). The Haig covers an area of 3km2, which is only slightly larger than the average glacier of the southern Rockies.

Figure 1: The location of the Haig Glacier in southern Alberta. A) The Haig Glacier is situated on the Alberta-British Columbia border in the Bow River drainage just west of Calgary and B) is a part of the WC2N study area number 3.

Hydrology

Discharge was measured in the proglacial stream from July 15 to September 6, 2009 using a LevelTroll depth sensor and a rating curve. The depth sensor was installed in a stilling well and supported by a cairn on the stream bed (Figure 2). It measured depth at 2 minute intervals throughout the season. The rating curve was constructed by measuring discharge in close proximity to the depth gauge so that the simultaneous measurements could be related. The discharge was calculated using a velocity-profile method 24 times throughout the season..
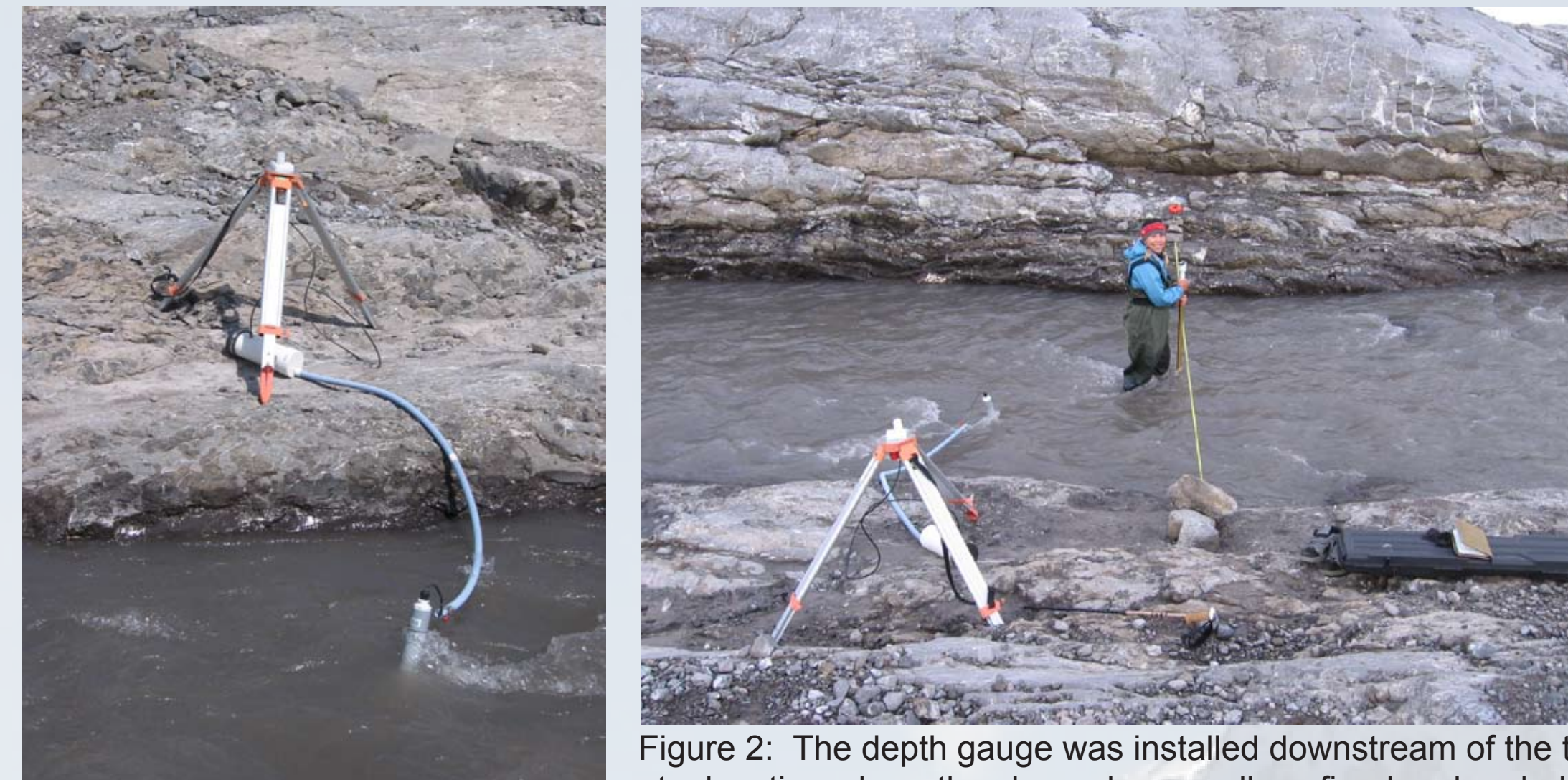

Figure 2: The depth gauge was installed downstream of the toe at a location where the channel was well confined and underlain primarily by bedrock. Velocity measurements were made at 10cm increments over the cross section. The velocity-profile measurements were recorded 24 times throughout the season under a variety of flow conditions.
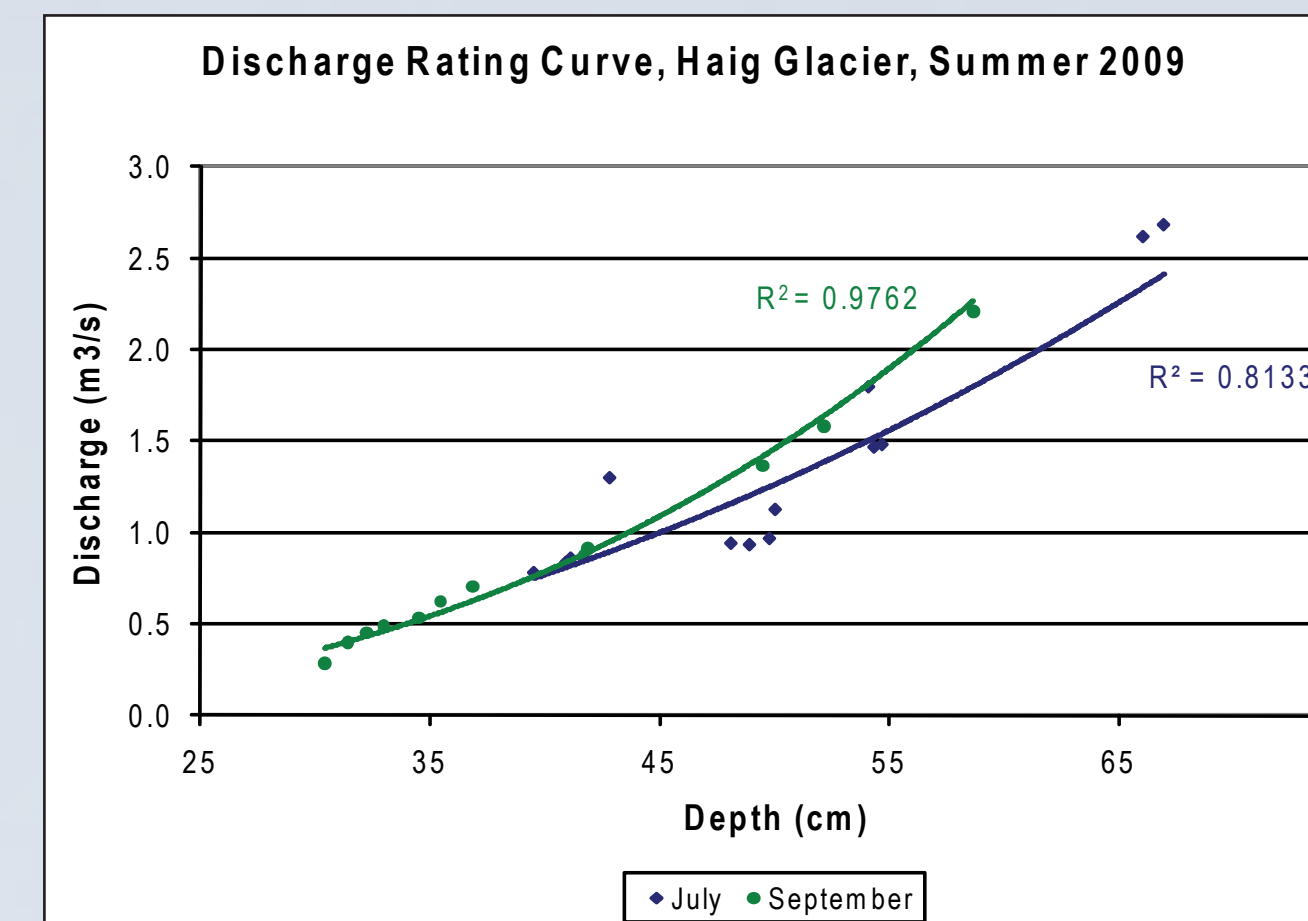

Figure 3: Depth data averaged during periods of discharge measurement is plotted against discharge to construct two ratings curves, for July and August-September. The resulting curves are
Q = 0.0002d2.2157 (R2=0.81) and
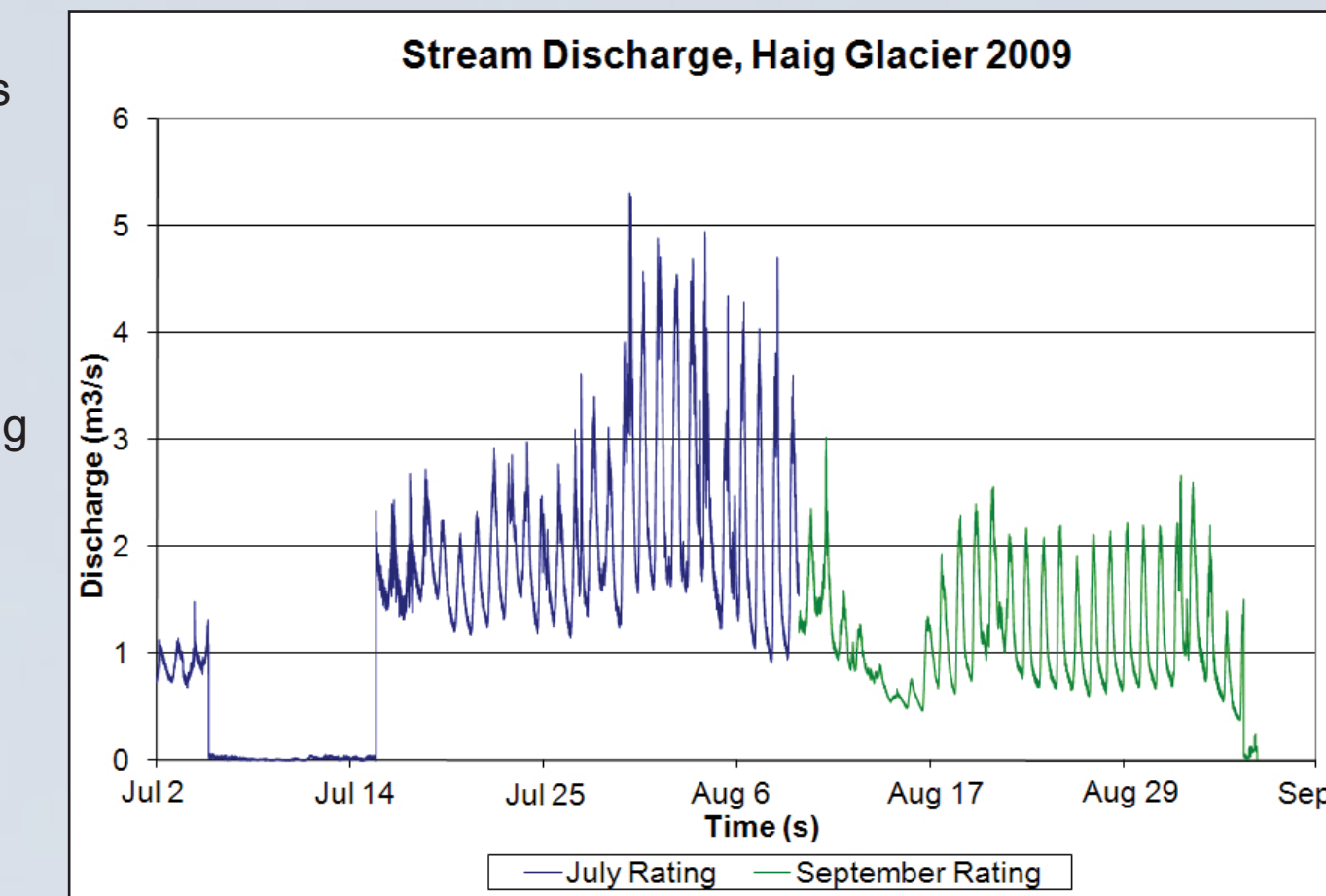Q = 3x10-5d2.7653 (R2=0.98), respectively.

Figure 4: Calculated discharge for the period of July 2 – September 6, 2009. Discharge for the period of July 2 – August 9 and August 10 – September 6 were calculated using separate rating curves. The depth sensor shifted due to high flow between August 1 and August 10, necessitating the use of a new rating curve for the remainder of the season.

To calculate discharge, velocity and depth were measured at 10cm intervals along a profile of the stream. At each interval a velocimeter was used to find an average velocity for the whole water column, as well as measuring the depth. The discharge is calculated by summing the discharge in each 10cm column of water. These discharge measurements lasted from 30-60 minutes. Depth data from the LevelTroll were averaged for the period of the discharge measurement and used to construct the rating curve (Figure 3).

Discharge was measured a total of 14 times in July under a variety of flow conditions in order to best capture the variability of the stream. A separate rating curve was constructed for August and September using 10 discharge measurements, after the gauge shifted due to high flows in early August. A curve was fit to the data for each time period, resulting in R2 values of 0.81 in July and 0.98 for the remainder of the season. A more rigorous statistical analysis will be undertaken to verify the models. The rating curves were then used to calculate discharge at 2 min intervals from the recorded depth data (Figure 4).

Surface Velocity

Topcon Positioning System's GB-1000 with a dual-frequency and GPS+ features was used to conduct a Stop and Go Kinematic Survey. The data was processed using Topcon Tools software to yield the positions of velocity stakes (Table 1). The displacements of stakes over summer 2009 are listed in the upper portion of the table. The lower portion contains the displacements between August 2008 and Sept 2009. The position of the stakes as they appeared on September 6, 2009 can be seen in Fig. 6.

Id No.	Station	Displacement, m	Time Period, days
V1	HGSP01	3.67	105
V2	HGCL02	2.97	105
V4	HGV22W	2.86	105
V5	HGCL03	0.79	105
V10	HGAWS	7.56	105
V11	HGCL32	1.96	105
V12	HGCL04	2.23	105
V13	HGCL05	1.18	105
V14	HGCL12	1.31	105
V15	HGCL06	0.74	105
V6	HGV3E1	3.64	394
V7	HGV3E2	1.74	394
V8	HGV3E3	19.67	394
V9	HGV3E4	0.68	394

Table 1: The displacement of velocity stakes over 105 days from May 24 to Sept 6, 2009 (upper portion), and over 394 days from August 8, 2008 to September 6, 2009 (lower portion). Note that the measurements in August 2008 were made using a simple handheld GPS.

Figure 5: A rover antenna recording the position of one of the velocity stakes.

Ice Thickness

A pulseEKKO Pro radar system, employing 12.5 MHz centre frequency antennas with 1000 V transmitter, was used to image the subglacial surface of Haig Glacier. The transmitting and receiving antennas were mounted on separate sleds and placed one after another maintaining 8 m spacing in between (Fig. 6). The survey was conducted along a centre flowline and 15 cross-profiles. The locations of these profiles are shown in Fig. 7.

Figure 6: Orientation of GPR antennas during data collection. The direction of drag is towards the bottom of the photograph.
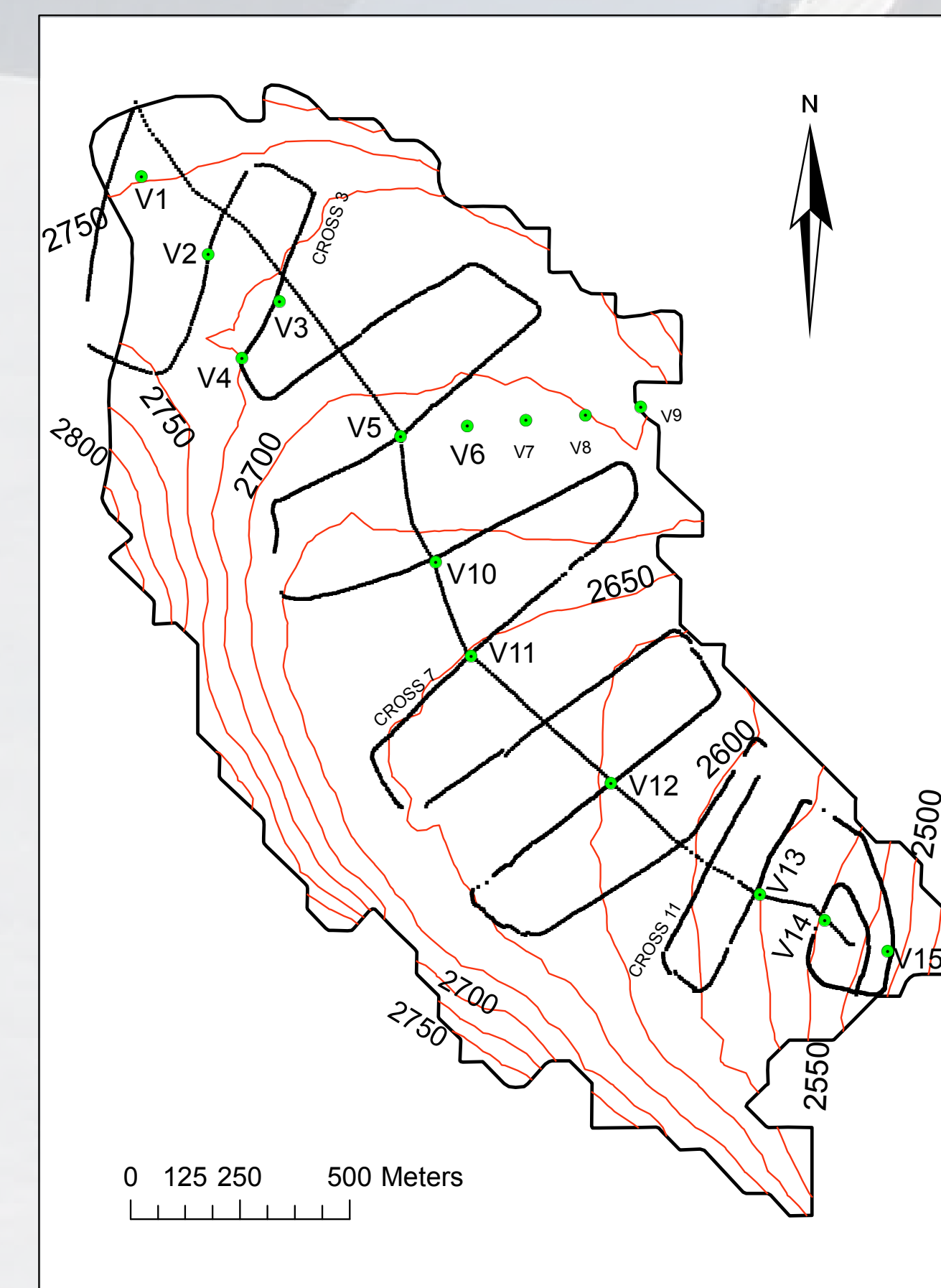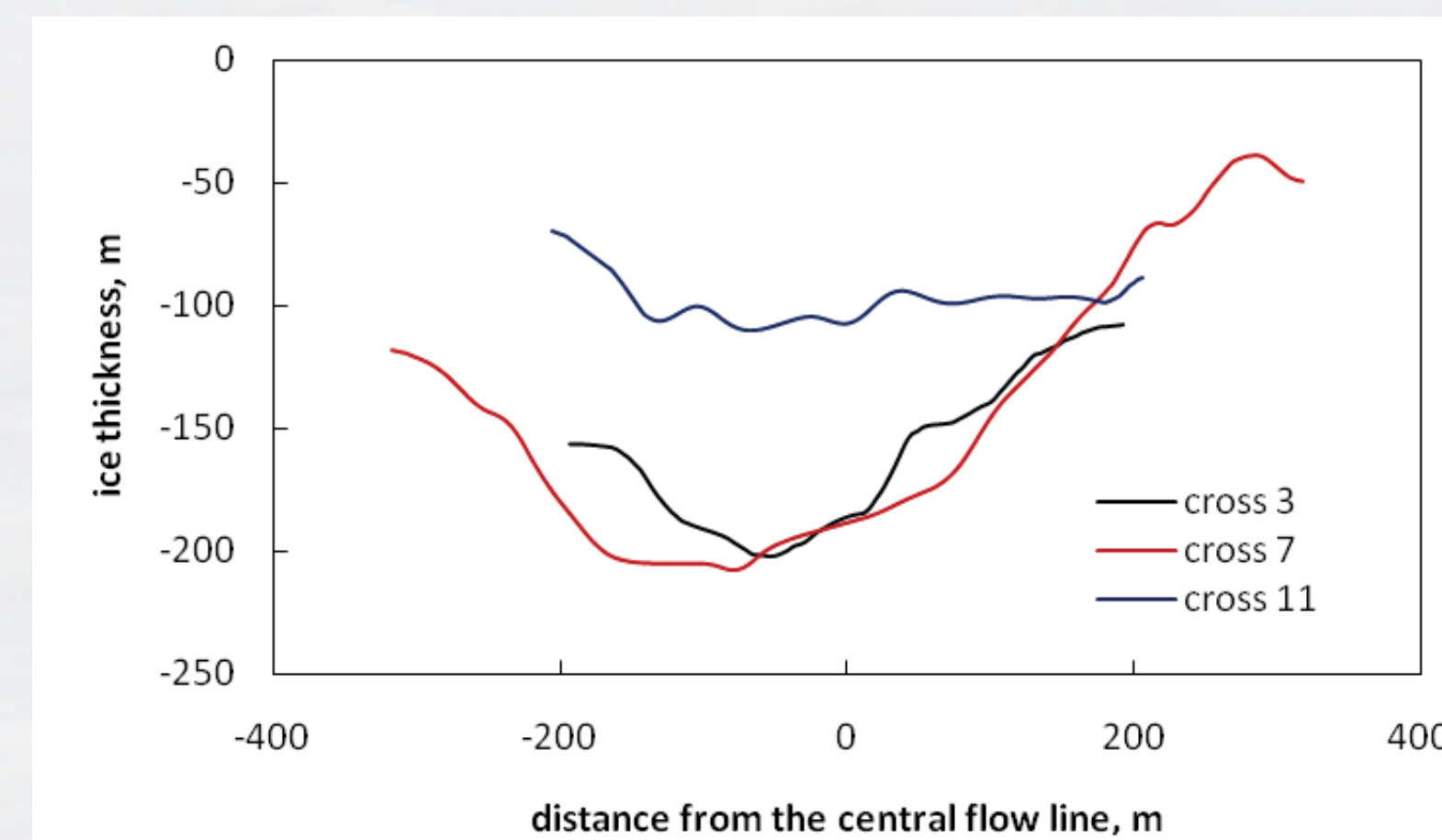

Figure 7: The surface topography of Haig Glacier (AD 2005) along with the position of survey lines/points. The red lines are contours of 25 m interval, black lines are GPR profiles, and green dots are velocity stakes.

A typical profile as seen on the pulseEKKO's DVL while recording the data is shown in Fig. 8a. This data represents for the longitudinal profile all along the distance from the glacier head. The IcePicker software was used to extract the glacier ice thickness. IcePicker computes the thickness from the two-way travel time, assuming homogeneous ice velocity (160 m µs-1) and a parallel-planer geometry of ice surface and bed in the vicinity of the measurement. The longitudinal profile of the glacier, after post processing the data, is depicted in Fig. 8b. The glacier is typically 200 m deep around the middle part. Similarly the ice thickness along a few cross profiles (cross 3, 7 and 11, see Fig. 7 for their position) are plotted in Fig. 9.

The idea of GPR survey is to obtain a three-dimensional ice domain of Haig Glacier so that it can be empolyed as a baseline data to model the glacier ice flow. With the sparse data at hand, we couldn't produce a reliable one. The more data, covering more area, will be collected in the next trip (Spring 2010).

Figure 9: Ice thickness along the three selected cross-profiles. Cross 11 reveals a typical rectangual cross-section, while other two reveal a parabolic valley cross-section.
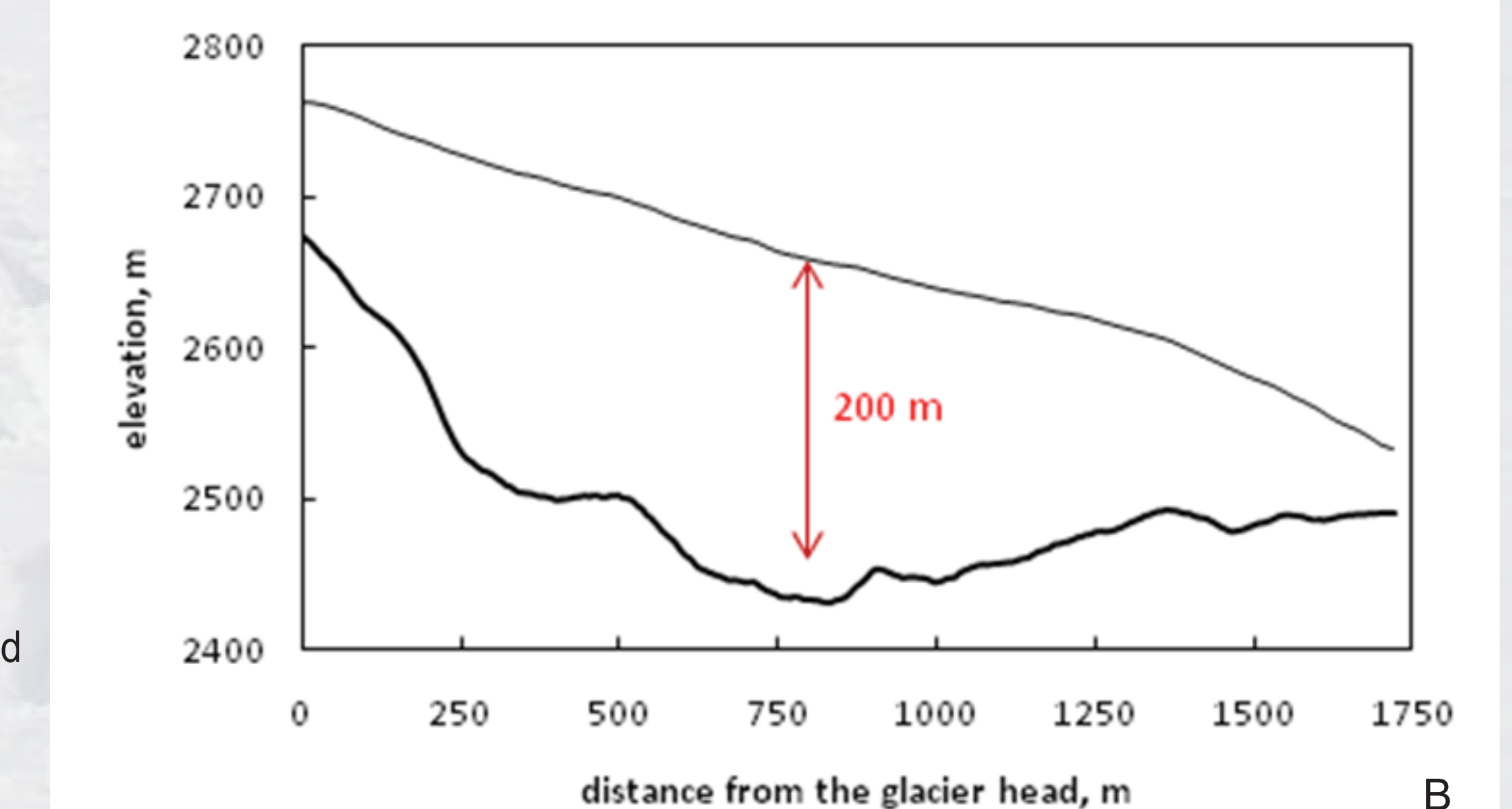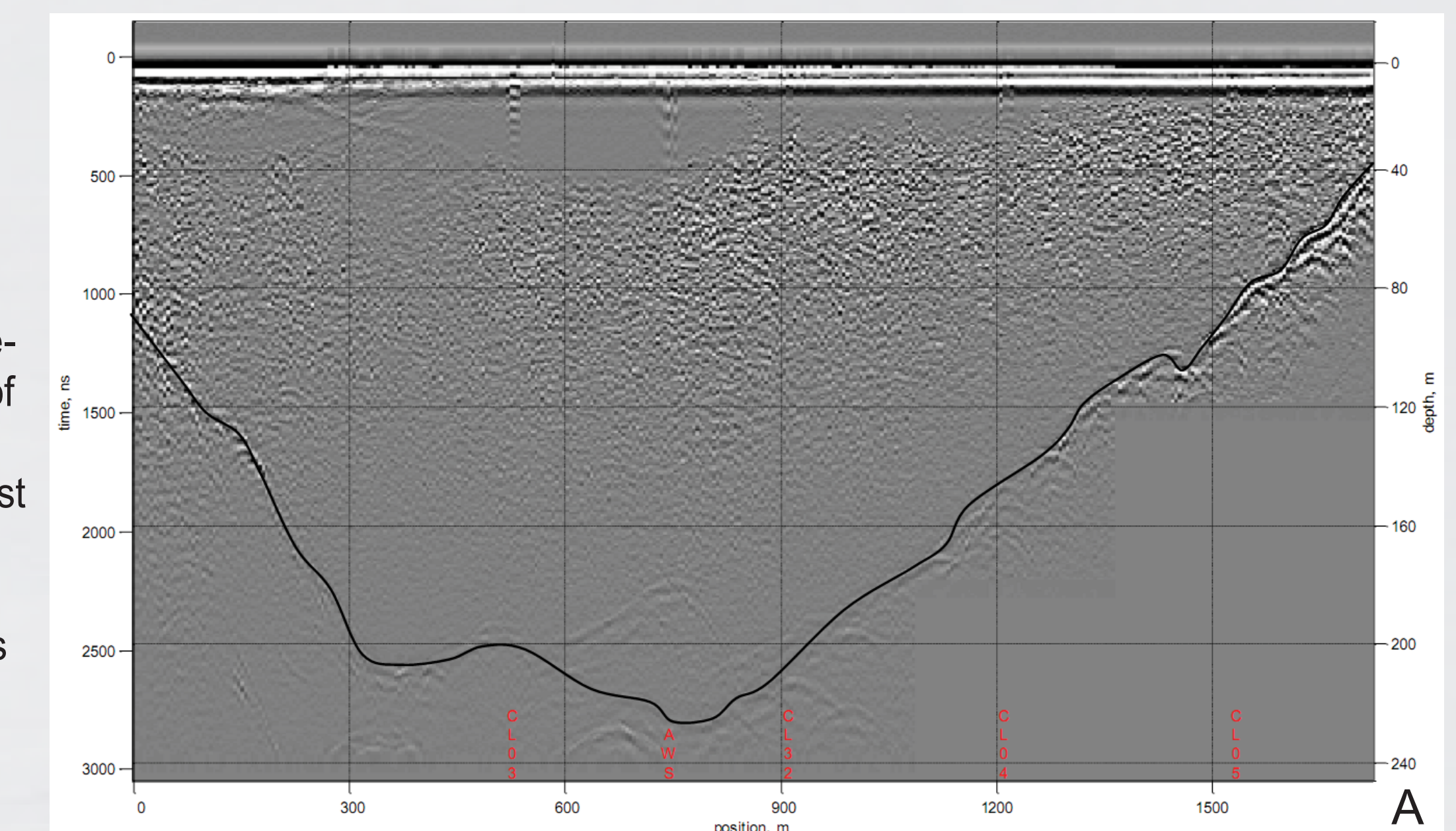

Figure 8: (a) The GPR data as seen on the DVL. The black curve follows the ice-bedrock interface as delineated by the IcePicker software and red marks are fiducial marks, indicating locations of known intrumentation. (b) The same (longitudinal) profile after processing the data, showing surface and basal topography.