

Comparison of Dilution, Hydro-acoustic and Current meter Discharge Measurements at Älgån, Sweden

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Discharge Measurements at Älgån, Sweden**

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Preface

The measurement of discharge in natural streams requires hydrometric personnel to use accurate measurements techniques and choose proper measurement sites. This report presents the results from a measurement experiment in a Swedish river. The experiment shows how important the choice of measurement technique and site is for obtaining satisfactory measurement accuracy.

Oslo, October 2004



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Introduction

Norwegian Water Resources and Energy Directorate (NVE) and Swedish Meteorological and Hydrological Institute (SMHI) use several methods for measuring river flow. They include; velocity-area methods applying the current meter, dilution techniques, Doppler based methods and application of artificial controls. Each of these methods has its advantages and limitations under different measuring conditions. Hence, both choice of method and place to measure, in addition to personal skills and experience, decides the overall quality of the measurement.

This report is meant only to document the results from the experiment at Älgån, and thus be a potential reference for other studies, and not a general assessment of discharge measurement.

Use of trade or product names does not imply endorsement by NVE and SMHI.

Preparation and accomplishment of the experiment

The experiment was done in conjunction with a hydrometric seminar in Sweden. Around 20 hydrologists from NVE and SMHI participated in realizing the project at Älgån. The 20 participants were distributed in four groups at four sites along the river of Älgån, and each of these groups performed measurements using different measurement methods.

The water level was checked at several places along the river during the experiment, and no changes were detected.

Site 1

We have no pictures from site 1, but its location was approximately 20 meters upstream site 2. A tag-line was stretched over the river defining a cross section. Methods involving current meter from boat, Flow Tracker from boat and ADCP using a trimaran were executed here.

The hydraulic conditions were considered to be very good at site 1. The flow was laminar with velocities up to 0.7 m/s. Also the river bed was ideal and smooth with a maximum depth at around 1.5 meters.

Site 2

This is the place where the dilution tracers were deposited into the river. Picture A1 in appendix shows this place, where a bridge, excellent delivering site, was present. A rapid which ran under the bridge ended in the falls between site 2 and site 3.

The reach between site 2 and site 3

Picture A2 in appendix A illustrates a part of the falls between site 2 and site 3. Here the river was fully turbulent, going white for a distance of 100 meters before reaching the flats ca. 15 meters upstream site 3. The falls were a perfect setting for dilution methods. Turbulence enabled for a thorough mixing of the tracers and water, ensuring a homogeneous blend.

Dilution sensors were placed and Rhodamine samples were taken at the flats just below the bottom of the falls (see picture A3)

Site 3

Wading measurements using current meter and Flow Tracker were performed here (see picture A4). The cross section was not well suited for velocity-area methods. The bottom was very rocky, and drift wood, both submerged and clamped to the river banks, was present. A wavy water surface and velocities up to 1.5 m/s made things difficult indeed.

Site 4

This cross section is shown in picture A5. Both Flow Tracker and current meter and wading were used here. The river bed was stony, and backwater effects were present at the left bank where the river was in heavy contact with terrestrial vegetation. The surface was a bit wavy and velocities up to 1 m/s were encountered in the middle of the channel. A small natural and almost inaccessible bypass channel was present between the trees at the left side of the river.

Tables of results

Table 1 Results from dilution methods using salt

Measurement number	Amount of Salt (kg)	Estimated discharge (m^3/s)	K value	$C_{\max} - C_0$
1	5	2.711	0.5322	61.00
2	5	2.781	"	101.00
3	5	2.781	"	74.40
4	3	2.877	"	43.40
5	3	2.808	"	45.30
6	1	2.743	"	13.10
7	5	2.662	0.4700	71.00
8	5	2.703	"	82.00
9	5	2.761	"	80.00
10	3	2.707	"	42.30
11	3	2.752	"	43.20
12	1	2.778	"	36.00
13	5	2.749	0.5361	57.00
14	5	2.765	"	64.10
15	5	2.743	"	60.10
16	3	2.723	"	44.30
17	3	2.738	"	42.30
18	1	2.780	"	45.00
19	5	2.712	0.5470	58.00
20	5	2.681	"	62.90
21	5	2.700	"	62.10
22	3	2.662	"	38.00
23	3	2.764	"	35.30

Table 2 Additional statistics from Table 1

	Mean discharge of measurements (m^3/s)	Standard dev. of discharge measurements (m^3/s)
All equipments (measurement 1-23)	2.743	0.049
Equipment 1 (measurement 1-6)	2.784	0.057
Equipment 2 (measurement 7-12)	2.727	0.044
Equipment 3 (measurement 13-18)	2.750	0.020
Equipment 4 (measurement 19-23)	2.704	0.039
Measurements with 5 kg salt	2.729	0.040
Measurements with 3 kg salt	2.754	0.066
Measurements with 1 kg salt	2.767	0.021

Table 3 Results from dilution methods using Rhodamine

Measurement Number	Estimated discharge (m^3/s)
1 (2 samples)	2.681

Table 4 Results from current meter measurements

Method	Vertical Method	Averaging time	Estimated area of cross-section	Estimated Mean velocity in cross-section	Estimated Discharge (m^3/s)	Site
Wading	5 point with 9 verticals	45 sec.	3.88 m^2	0.742 m/s	2.875	4
Wading	5 point with 11 verticals	45 sec.	4.00 m^2	0.750 m/s	2.999	4
Wading	5 point with 13 verticals	45 sec.	3.05 m^2	0.886 m/s	2.706	3
Wading ^{*,1}	5 point with 11 verticals	40 sec.	3.05 m^2	0.793 m/s	2.422	3
Wading ^{*,1}	5 point with 12 verticals	44 sec.	3.35 m^2	0.747 m/s	2.505	3
From boat	5 point with 8 verticals	45 sec	7.22 m^2	0.403 m/s	2.909	1

* Done with current meter with a smaller propeller. ¹Person unaccustomed with the instrument.

Table 5 Additional statistics from the Table 4

	Mean discharge of measurements (m^3/s)	Standard dev. of discharge measurements (m^3/s)
All current meter measurements	2.736	0.233

Table 6 Results from Flow Tracker measurements

Method	Vertical Method	Averaging time	Estimated area of cross-section	Estimated Mean velocity in cross-section	Estimated Discharge (m^3/s)	Site
Wading ¹	1 point with 19 verticals	45 sec.	3.10 m^2	0.826 m/s	2.575	3
Wading ¹	1 point with 20 verticals	45 sec.	3.15 m^2	0.798 m/s	2.628	3
Wading ¹	1 point with - verticals	45 sec.	3.17 m^2	0.859 m/s	2.701	3
Wading ¹	2 point with 17 verticals	45 sec.	3.14 m^2	0.781 m/s	2.457	3
Wading ¹	1 point with - verticals	45 sec.	4.04 m^2	0.480 m/s	2.464	4
From boat	2 point with - verticals	45 sec	-	-	2.735	1

¹Person unaccustomed with the instrument.

Table 7 Additional statistics from the Table 6

	Mean discharge of measurements (m^3/s)	Standard dev. of discharge measurements (m^3/s)
All Flow Tracer measurements	2.593	0.117

Table 8 Results from the ADCP measurements

Method	Averaging time	Estimated Discharge (m^3/s)	Site
Mode 5	instantaneously	2.569	1
Mode 5	instantaneously	2.750	1
Mode 5	instantaneously	2.544	1
Mode 5	instantaneously	2.905	1
Mode 5	instantaneously	3.172	1
Mode 5	instantaneously	2.842	1
Mode 5	instantaneously	2.670	1
Mode 5	instantaneously	2.855	1
Mode 5	instantaneously	2.529	1
Mode 11	instantaneously	2.835	1
Mode 11	instantaneously	2.711	1

Table 9 Additional statistics from the Table 7

	Mean discharge of measurements (m^3/s)	Standard dev. of discharge measurements (m^3/s)
All ADCP measurements	2.762	0.190
ADCP measurements after removing the highest and lowest measurements	2.742	0.130

Appendix



Picture A1



Picture A2



Picture A3



Picture A4



Picture A5

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