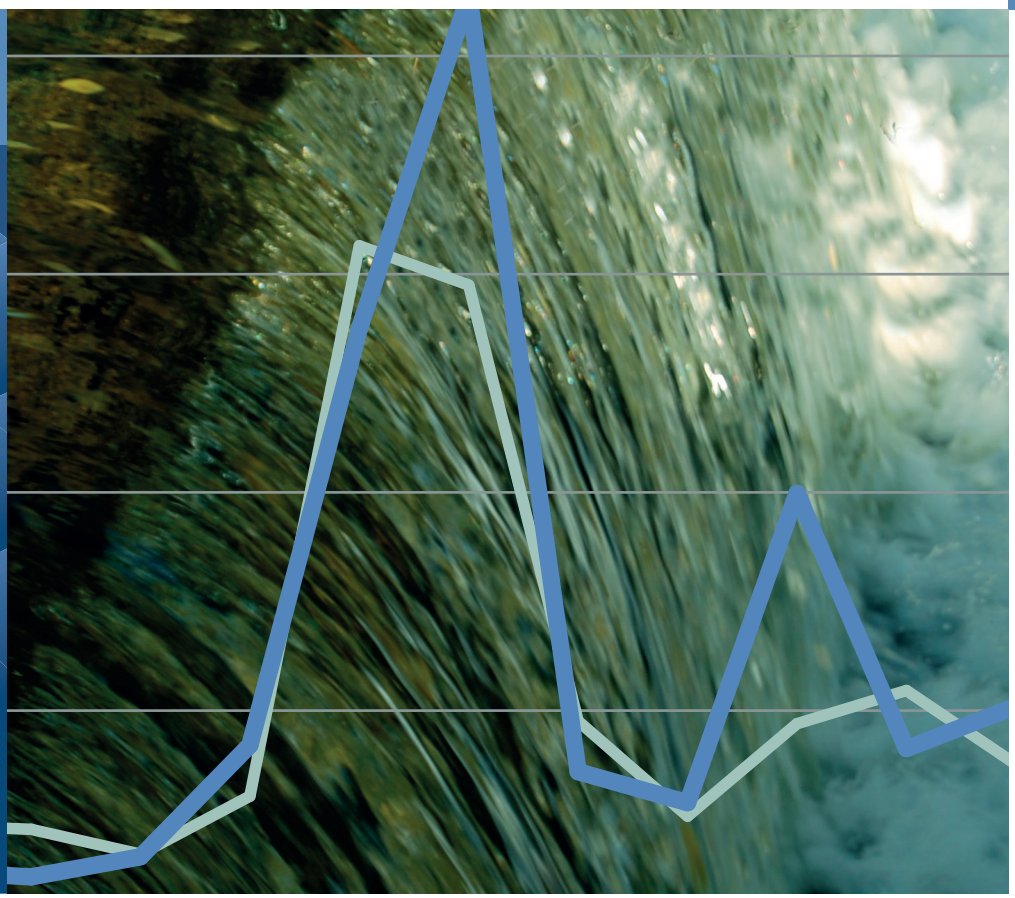
Capacity building in Hydrological Services

Course in Water Level recording and Data Processing
Ministry of Water and Energy
13th – 16th February 2012
Documentation

14
2012

RAPPORT



Capacity building in Hydrological Services - Course in Water Level recording and Data Processing

Documentation

Norges vassdrags- og energidirektorat
2012

Rapport nr 14 / 2012

Capacity building in Hydrological Services - Course in Water Level recording and Data Processing

Utgitt av: Norges vassdrags- og energidirektorat

Redaktør: Paul Christen Røhr, Line Dale, Demissew Kebede Ejigu, Sverre Husebye

Forfatter:

Trykk: NVEs hustrykkeri
Opplag: 40
Forsidefoto:
ISBN: 978-82-410-0796-5

Sammendrag:

Emneord:

Norges vassdrags- og energidirektorat
Middelthunsgate 29
Postboks 5091 Majorstua
0301 OSLO

Telefon: 22 95 95 95
Telefaks: 22 95 90 00
Internett: www.nve.no

February 2012

Preface

Activity 3 (A3), "Capacity Building of Hydrological Services", arranged theoretical training for hydrologists on the 13th – 16th February 2012 at the Hydrology and Water Quality Directorate in the MoWE office in Addis Ababa.

A3 is one of the activities under the Agreement regarding Institutional Cooperation for Feasibility Studies of the Mandaya and Beko-Abo Multipurpose Projects, between the Ministry of Water and Energy (MoWE) of the Federal Democratic Republic of Ethiopia, and the Norwegian Water Resources and Energy Directorate of the Kingdom of Norway.

The objective of the training was to show the importance of good hydrological data an how to achieve this. The goal was to illuminate errors in hydrometrical data and how to minimize errors with good routines and understanding for hydrological data.

The target group was relevant hydrological personnel at MoWE head office working with quality control and processing of discharge- and time series data in MoWE.

The training combined a theoretical training and a workshop discussing procedures and routines to increase data quality.

This training document contains the presentations given.

Oslo, Norway, March 2012

Sverre Husebye

Head of Section

Hydrology Department NVE

Content

Norges vassdrags- og energidirektorat

NVE

Training - Tentative Agenda

Topic:	**Training at MoWE – NVE February 2012** **Activity 3 Capacity building in hydrological services**				
Date:	13 – 16 February 2012	Hrs:	09:00 – 17:00	Place:	MoWE offices Addis Ababa
Chairman:				Minutes:	
Participants NVE:	Demissew Ejigu and Line Dale Sverre Husebye and Paul Christen Røhr will participate partly in Monday and Tuesday				
Participants MoWE:	*To be filled in by MoWE*				

Target group:	Relevant hydrological personnel at MoWE head office working with quality control and processing of discharge- and time series data.

Preparations:	Historical raw data for the 2008-2011 periods must be available and digitized by MoWE in advance of the training.

Outcome:	A conscious attitude to the importance of good hydrological data that are complete and of good quality

Day 1 - Monday 13th February 2012 – Introduction – Water Level Recording

10:00 – 10:15	Welcome an opening by MoWE	MoWE
10:15 – 10:30	Welcome and opening by NVE	NVE/SHU
10:30 – 11:00	Presentation of lectures and participants	All
11:00 – 12:00	Introduction and presentation of methods	NVE / SHU
12:00 – 12:30	Lecture on Water Level Recording	NVE / LDA
12:30 – 14:00	**Lunch**	
14:00 – 15:00	Lecture on Water Level Recording – cont.	NVE / LDA
15:00 – 15:30	Discussion	All
15:30 – 15:45	**Tea break**	
15:45 – 16:00	Introduction to group work	NVE
16:00 – 16:45	Group work on Water Lever Recording	All
16:45 – 17:00	Summing up group work	All

Norges vassdrags- og energidirektorat

NVE

Day 2 - Tuesday 14th February 2012 – Data processing – Discharge Measurements

09:00 – 09:15	Welcome and summing up day 1	NVE / LDA
09:15 – 09:45	Discharge measurements data at MoWE	MoWE
09:45 – 10:00	Discussion on MoWE practice	All
10:00 – 10:30	Lecture on Discharge measurements at NVE	NVE / LDA
10:30 – 10:45	**Tea break**	
10:45 – 11:45	Lecture on Discharge measurements at NVE	NVE / LDA
11:45 – 12:00	Discussion on Discharge Measurements at NVE	All
12:30 – 14:00	**Lunch**	
14:00 – 14:30	Summing up discharge measurements	NVE / LDA
14:30 – 15:00	Influence of errors in discharge measurements	NVE / PCR
15:00 – 15:30	Introduction to group work on influence of errors in discharge measurements	NVE / PCR
15:30 – 15:45	**Tea break**	
15:45 – 16:45	Group work exemplifying the influence of errors in discharge measurements – some practical computer calculations	All
16:45 – 17:00	Summing up group work on errors in discharge measurements	All / NVE

Day 3 - Wednesday 15th February 2012 – Data processing – Rating curves

09:00 – 09:15	Welcome and summing up day 2	NVE
09:15 – 09:30	Presentation on how rating curves are handled at MoWE	MoWE
09:30 – 10:30	Lecture on theoretical background for rating curves	NVE / LDA
10:30 – 10:45	Tea break	
10:45 – 11:30	Lecture on theoretical background for rating curves, contiued	NVE / LDA
11:30 – 12:30	Lecture on how rating curves are developed at NVE	NVE / LDA
12:30 – 14:00	Lunch	
14:00 – 14:30	Introduction to group work	NVE / LDA
14:30 – 15:30	Group work with hands on training on rating curves	All

15:30 – 15:45	**Tea break**	
15:45 – 16:45	Group work with hands on training on rating curves, continued	All
16:45 – 17:00	Summing up group work	All / NVE

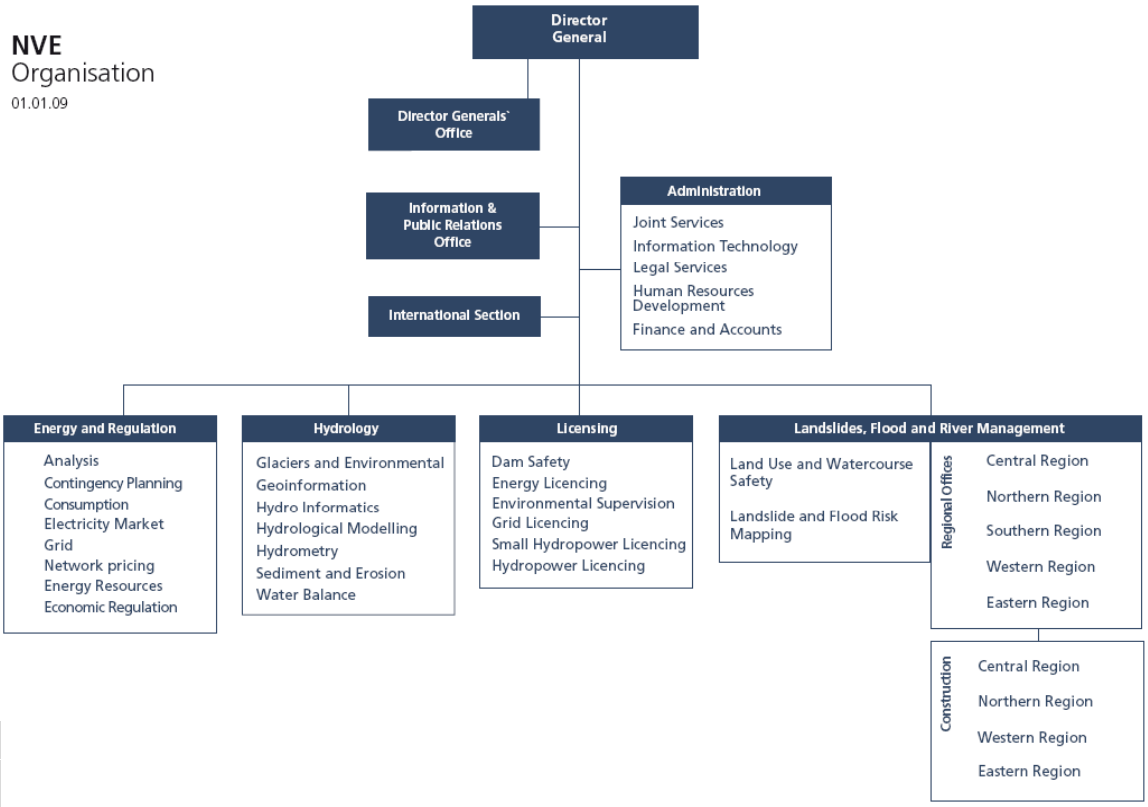
Day 4 - Thursday 16th February 2012 – Data processing – Time Series

09:00 – 09:15	Welcome and summing up day 3	NVE / LDA
09:15 – 09:45	Control of time series data at MoWE	MoWE
09:45 – 10:00	Discussion on MoWE practice	All
10:00 – 10:30	Lecture on control of time series data at NVE	NVE / LDA
10:30 – 10:45	**Tea break**	
10:45 – 11:15	Lecture on control of time series data at NVE, continued	NVE / LDA
11:15 – 11:45	Discussion on control of time series data at NVE	All
11:45 – 12:00	Introduction to group work	NVE / LDA
12:00 – 12:30	Group work with hands-on training in control of time series data	All
12:30 – 14:00	**Lunch**	
14:00 – 15:30	Group work with hands-on training in control of time series data	All
15:30 – 15:45	**Tea break**	
15:45 – 16:15	General discussion	All
16:15 – 16:30	Summing up	NVE / LDA
16:30 –	Closure	MoWE

Norwegian Water Resources and Energy Directorate

Norwegian Water Resources and Energy Directorate

- Directorate under the Ministry of Oil and Energy
- Approximately 550 employees
- Main office in Oslo
- 5 Regional offices
- Responsibility: Management of the water resources (quantitative) and energy resources (ex. Oil) in Norway
- Hydrology Department, 120 persons, 9 sections



We are happy to be back and seeing you again

Training data quality control

Follow up training in May 2011

We are:

Line Dale; Msc
Demissew Kebede Ejigu; Msc/civ.ing
Paul Christen Røhr; Dr.ing
Sverre Husebye; Msc

More during the presentation

Introduction to training
Data quality improvement
13 – 16th February 2012
MoWE Head Office
Addis Ababa
ETHIOPIA

By
Sverre Husebye
Head of Water Balance Section
Hydrology Department
NVE

Presentation outline:

- **Program in brief**
- **Training objective**
- **Data quality production line:**
  - **data monitoring and quality**
  - **Data processing**
- **Mode of work**
- **Outcome**

Program in brief

- 4 days
- Lectures (NVE)
- Practices at MoWE (MoWE)
- Discussions
- Group work
- Practical training
- Training and group work sum up

Objective

- **Activity 3 Project Perspective: Capacity building in hydrological services at Hydrology and Water Quality Directorate at MoWE**
- **Training Objective: To investigate sources of important data failures and how these might be reduced in order to improve the data quality at MoWE MoWE in Ethiopia**
  - **Data production line**
  - **Theoretical knowledge**
  - **Quality Control**
  - **Routines - handbook**

Training of field technicians and data processors at MoWE

- **Define sources to be handled by a data quality system**
- **Data quality line: From river to data base**
- **Define measures to reduce or eliminate the source**
  - **Trained staff**
  - **Methodology**
  - **Theoretical knowledge**
  - **Infrastructure**
  - **Equipment**
  - **Routines**

Measurement site

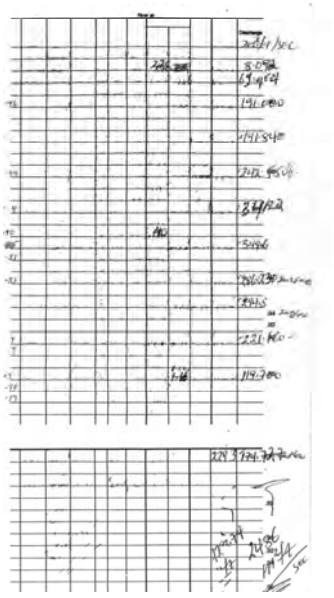
WATER LEVEL SCALE

Measurement

State of the art – improvement potential?

Maintain or dispose?

Field data processing



Field data processing

Place	Abay Kessie				Width (m)	73		Disharge m3	448.55		
Date	11 jul 09 (2 skjemaer på 11/7)				Area (m2)	323.4					
Party	Lemma ..... ?????				Velocity (m/s	1.39					Skrivr alle med ?? ekstra
					Gauge heigt	3.34					
	Distance from intial point	Width (ft)	Depth (ft)	Observation depth	Revolutions	Time in seconds	Velocity At point (m/s	Velocity Mean in vertic	Adjusted for hori. Angle	Area (ft2)	Discharge (ft2 , m/s)
106	0	3									
100	6	5	11.8	9.4	20	46	0.295	0.27		59	15.93
					20	56	0.244				
???	10	4	17.9	3.7	30	42	0.492	0.442		71.2	31.47
Slakk bolle					25	42	0.402				
Hatonen	14	4	19	3.8	80	52	1.03	???		76	72.27
					60	46	0.871				
	18	4	19	3.8	100	45	1.48	???		76	93.48
					60	41	0.978				
	22	4	19	3.8	100	41	1.62	1.48		76	108.68
					80	43	0.124				
	26	4	19.2	3.8	120	46	1.73	1.46		76.8	112.13
					80	45	1.19				
	30	4	18.6	3.7	150	48	2.08	1.8		74.4	133.92
					100	44	1.51				
	34	4	18.8	3.8	150	45	2.21	1.9		74.4	141.36
					100	42	1.59				
	38	4	18.4	3.7	150	42	2.37	???		73.6	156.3
					120	43	1.85				
	42	4	17.9	3.6	150	42	2.37	2.07		71.6	148.21
					120	45	1.77				
	46	4	16.1	3.2	150	44	2.26	2		64.4	128.8
					120	46	1.73				
	50	4	16	3.2	120	42	1.9	1.69		64	108.16
					120	46	1.73				
	50	4	16	3.2	120	42	1.9	1.69		64	108.46
					100	45	1.48				
	54	4	13.8	2.8	100	40	1.66	1.53		55.2	84.46
					100	48	1.39				
	58	4	13	2.6	100	46	1.45	1.21		52	62.92
					60	41	0.978				
	62	4	11.2	2.2	60	42	0.954	???		44.8	36.42
					50	50	0.671				

Field routines

- Document: Routines for field work procedures (training in May 2011)

In Office data prosessing

- Office infrastructure and routines?
- Punching routines?
- Quality control routines?

Motivation

Mode of work

- Theoretical presentations
- Presentations practices at MoWE
- Discussions and group work sessions
- Group work documentation
- Recommendations on actions and best practices to improve data quality at MoWE

Outcome

- Better understanding and knowledge of the complexity of sources for possible data failure
- I depth discussions and written summaries how to handle the most important sources reducing data quality
- Priority list of actions to be implemented to improve the data quality in MoWE

Thank you for your attention!

Sverre Husebye
Section Manager, NVE
shu@nve.no

Introduction

Line Dale
HHT

- Collecting data
- Controlling data
- Inspect the stations
- Fix\ uppgrade stations
- Measuring discharge
- Generate rating curves
- About 30 stations

Agenda and goals

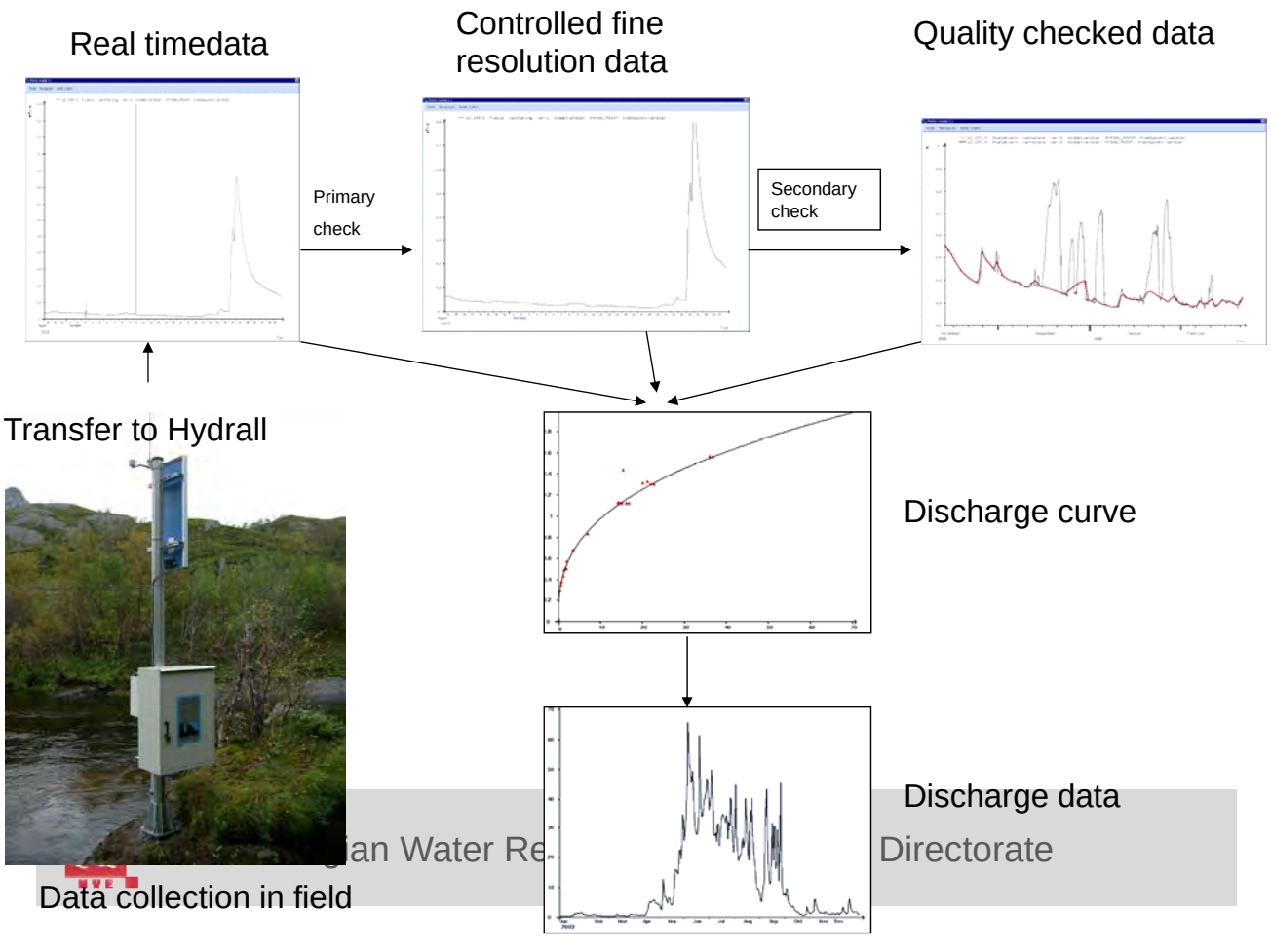
- Discussion and group work that leads to a written manual for collecting and controlling data in the MoWE

Topics

- Water level
- Discharge measurement data
- Rating curves
- Time series

Errors in hydrometrical data

- Errors in registerd water level
- Errors in the rating curve
- Errors because of completing data
- Errors because of ice



- It is serveral ways of doing things correct so it is important to have the same routins
- Focus on standard routins

Collecting and controlling water level data

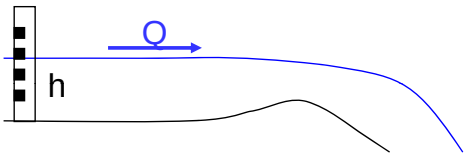
By Line Dale, HHT

Brief theory

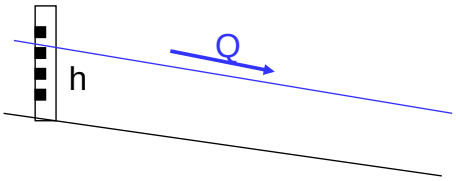
- Selection of the station site
- Observation and recording of stage
- Measurement of discharge

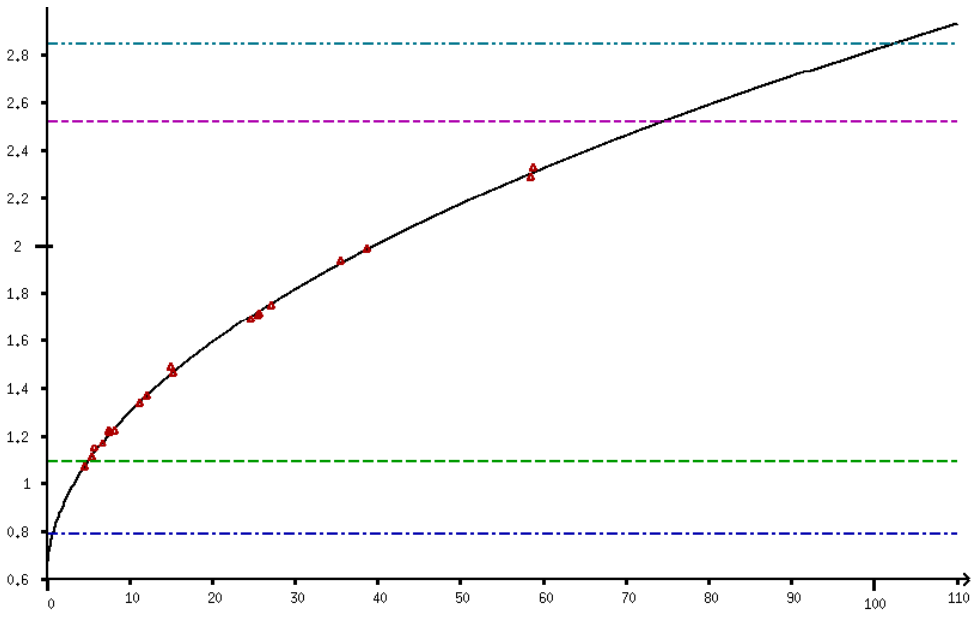
Relation water level – water discharge

Critical control

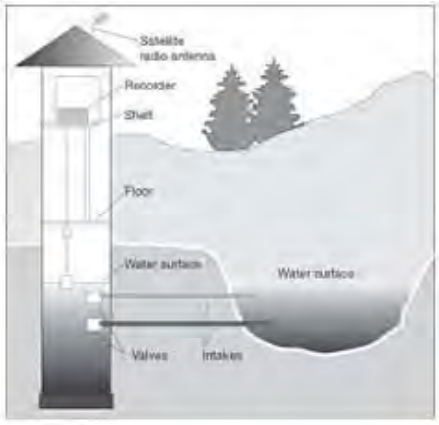


Channel control

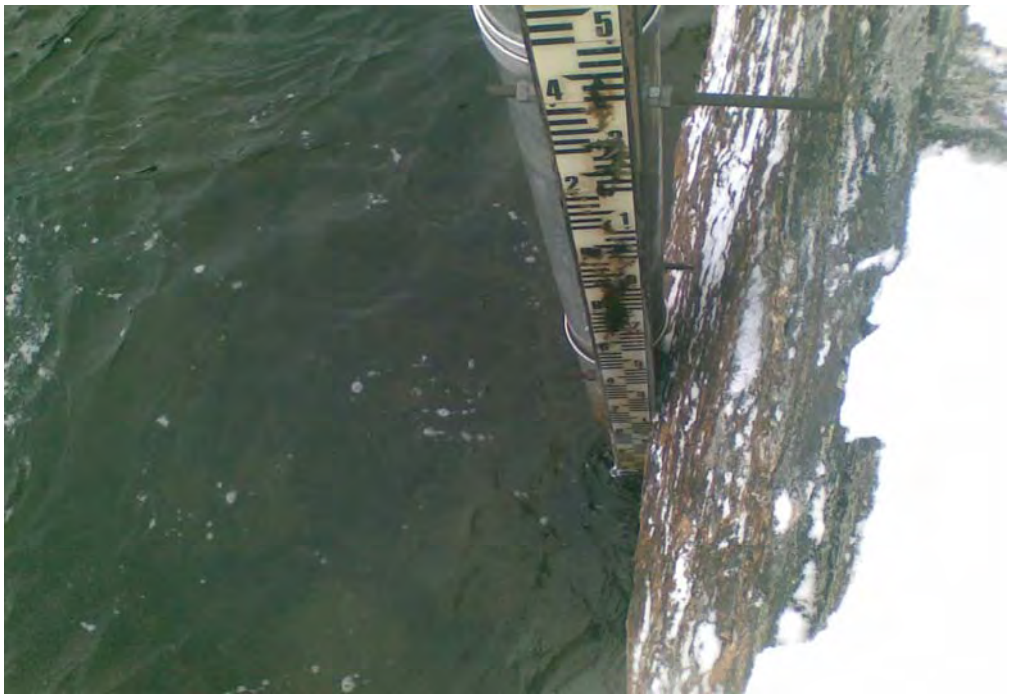




Why wrong water level?



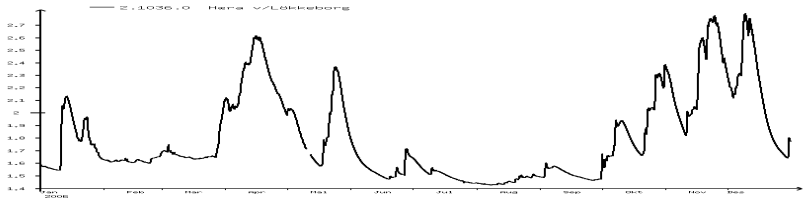
Staff gauge



NVE routins

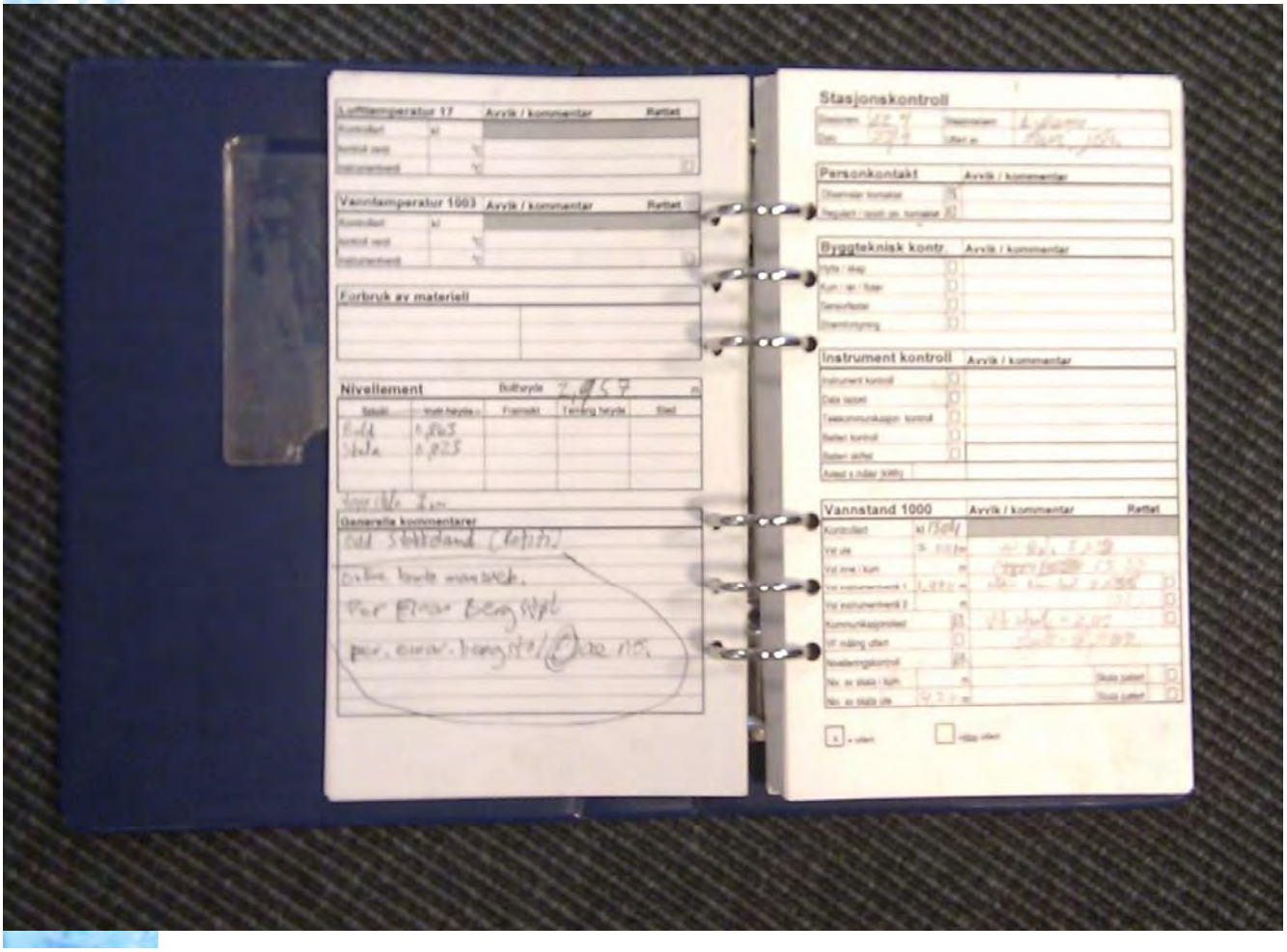
- Data loggers
- Observed values
- Inspections
- Primary control
- Secondary control
- Archives

Data loggers



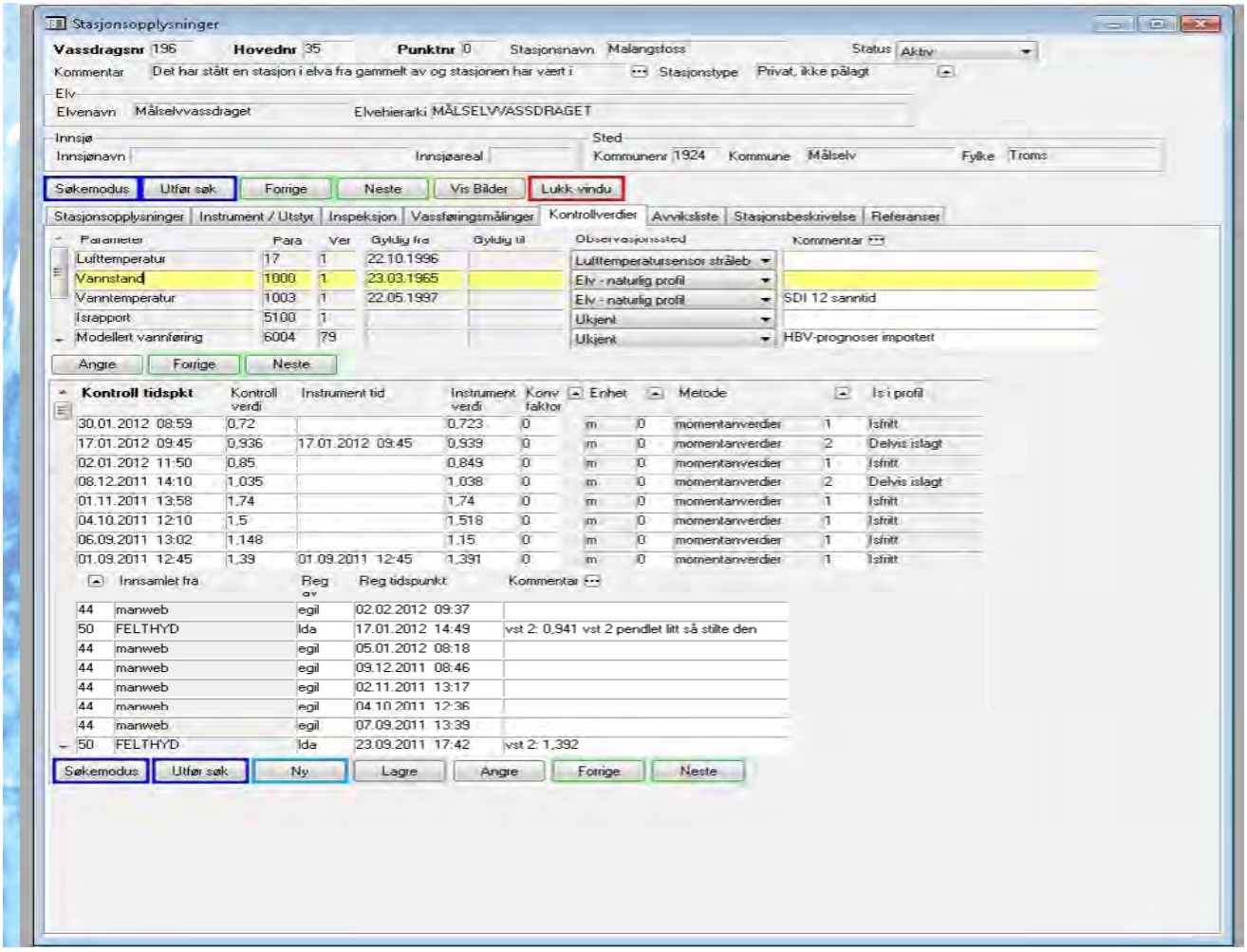
Collecting water level data in the field

- Observed values from a observer.
- Inspections by fieldhydrologist
  - field book with water resistant paper that are attached to the book.



Transmission to the database

- Punched data into the database straight after a fieldtrip
- Observed values are send in by post or through internet straight into the database
- Automatic message when observed value differ from logged value

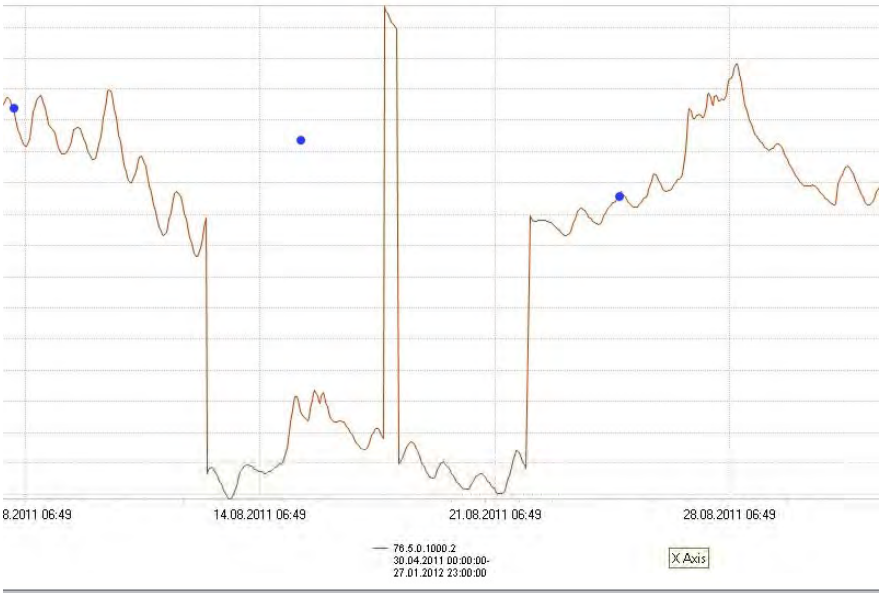


Controlling waterlevel data

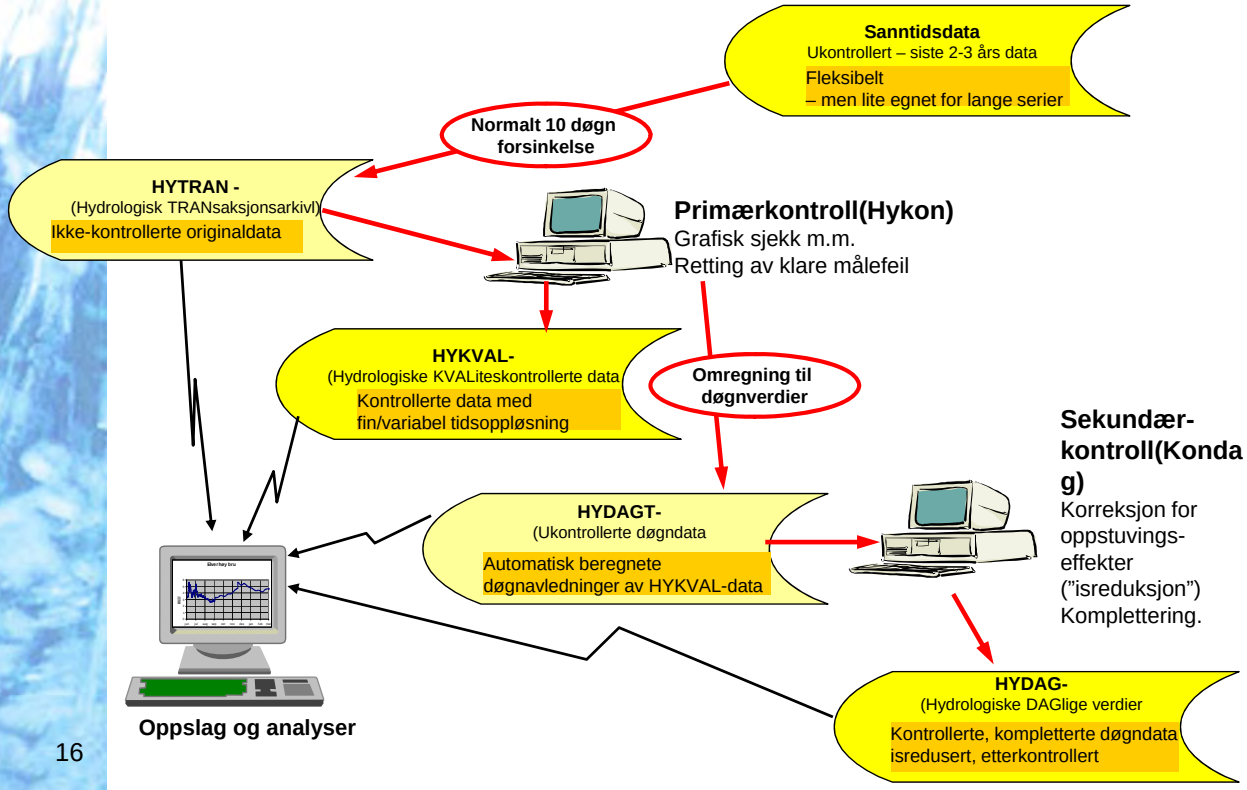
- Primary control
- Secondary control

We control data after rules that are written down in a quality system.

Example primary controll



Archives



Sources of error

- Wrong reading of the staff gauge
- Staff gauge is wrong
- Wrong punching

Discussion and groupwork

Routines for water level

- How does the observation of water level take place, is there a standard way for all discharges (direct visual observation, same location etc)?
- How frequent is the water level observed (during and off the measuring season)?
- How does the transmission of data from reading staff gauges to punching in database take place (during and off the measuring season)?
- What kind of routines exists for calculating mean value from the observed data for one day?

Discharge measurements

Line Dale, HHT

Collecting and controlling discharge measurements – NVE routines

450 m³\s

- Easy to read water level
- Difficult to measure discharge
- Again many errors. Be Aware!!!

Brief theroy

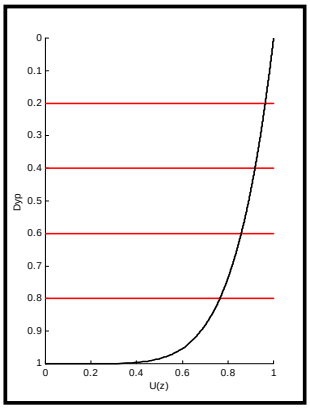
- Q = A X V

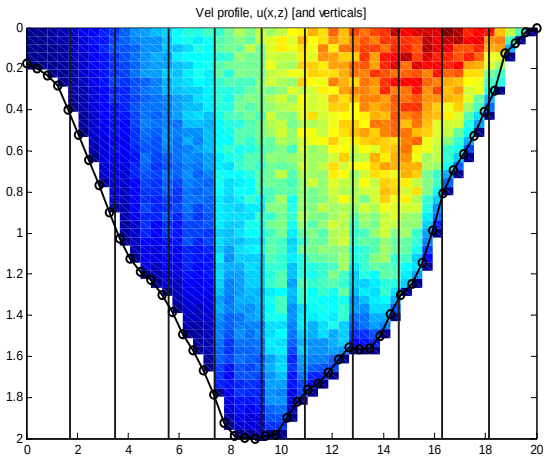
(Q – water discharge, A – Area. V – Velocity)

Several ways of measuring discharge

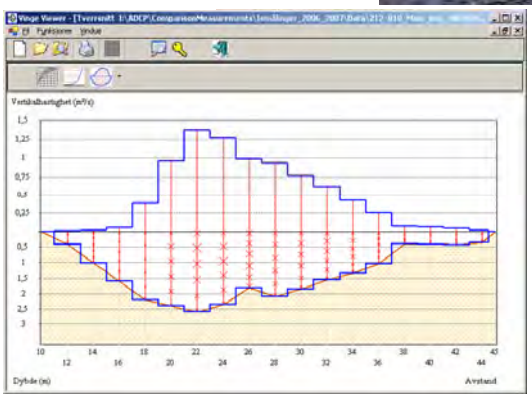
Measuring discharge

- Mechanical
  - propeller
- Acoustics
  - ADCP
- chemical
  - Salt, rhodamin

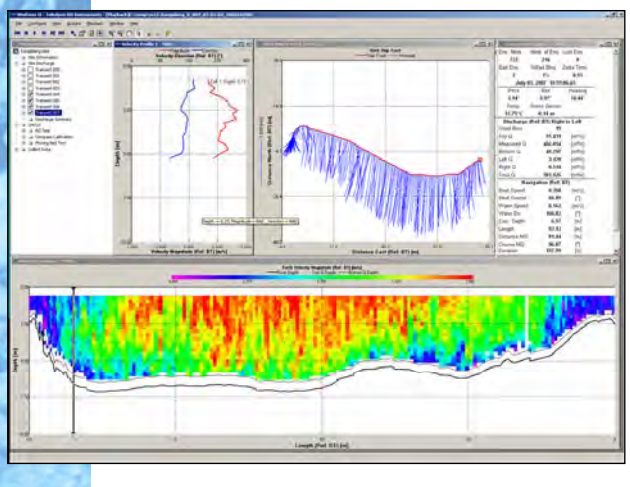


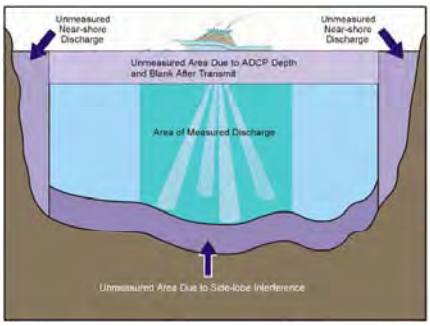


Discharge - propellar



Discharge - ADCP

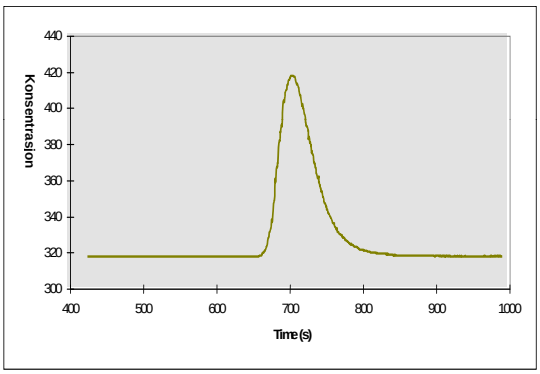




Discharge - Salt

- Measuring the salt concentration
- **Q = M / (∫ (C - C0) dt)**

Q - discharge in l /s
M - injected quantity in mg
C - tracer concentration in mg/l
C0 - tracer concentration equivalent to the background conductivity
t - period of time of the tracer passage in sec



Measuring site

- Important that it is possible to measuring high water and low water
- Easy access → better data

NVE routines for discharge measurements

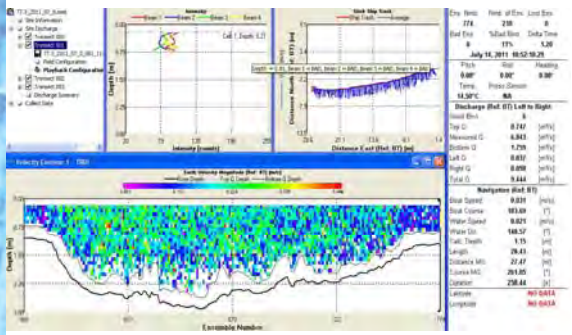
- Planning
  - Careful preparations
  - Check conditions/status before going into field
  - Maintain and prepare equipment
  - Weather forecast

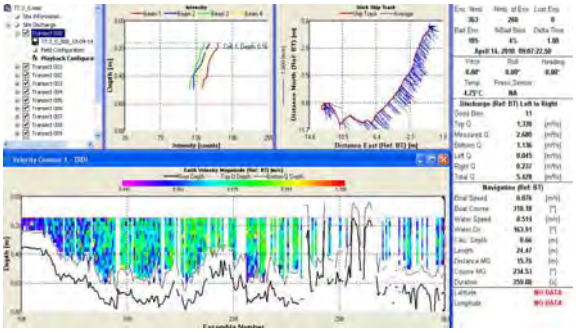
NVE routines

- In field
  - Identify the best suited location for measurement
  - Read water level
  - Check rating curve on printed paper
  - Carry out measurement
  - Note down any special details concerning the measurement
  - Read water level after measuring
  - Write down representative water level and measured discharge

NVE routines

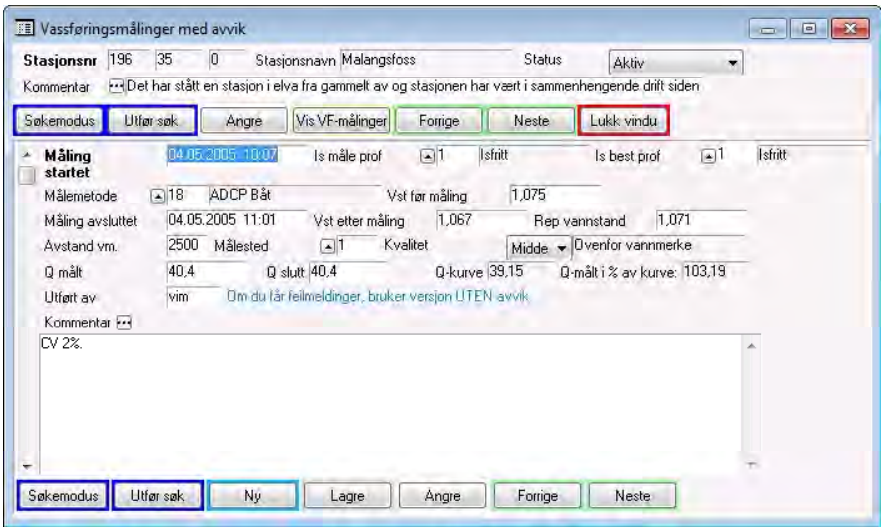
- In office – immediately after ended field trip
  - Store all the raw data on database
  - Reprocess and quality check the measurements





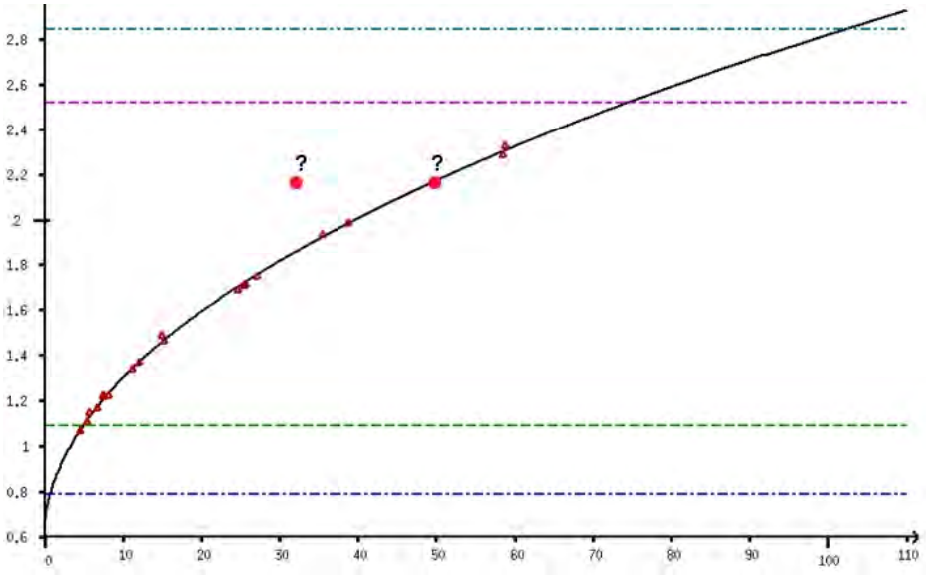
NVE routines

- In office – immediately after ended field trip
  - Punch the result into the database with a quality label, and any remarks



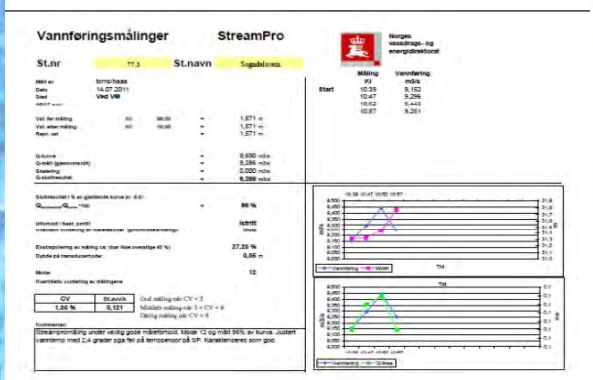
NVE routines

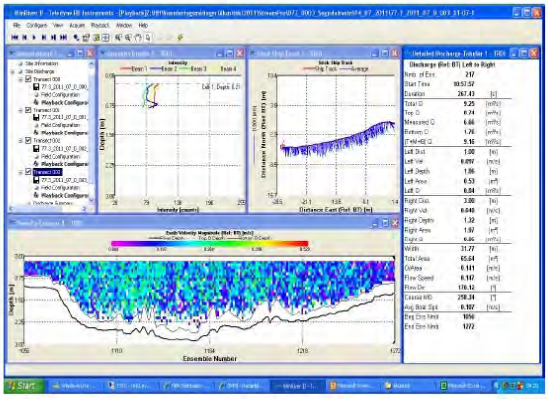
- In office – immediately after ended field trip
  - Compare the measurement with the rating curve



NVE routines

- In office – immediately after ended field trip
  - Prepare and store report





Sources of error

- Difficult measuring conditions
- Inherent uncertainty in measuring instruments
  - Maintenance
  - Updating
- Personal differences conducting measurements
  - Focus on standard procedures
  - Collective training and exchange of knowledge

Sources of error

- Errors during punching, reprocessing or storing the data/results
- Loss of data
  - Instument / computer failure
  - Loss of notes

Discussions and group work

- Identifying problem
- Routines for quality control
- Suggestions for improvement on problem to make better data

Routines for discharge measurements

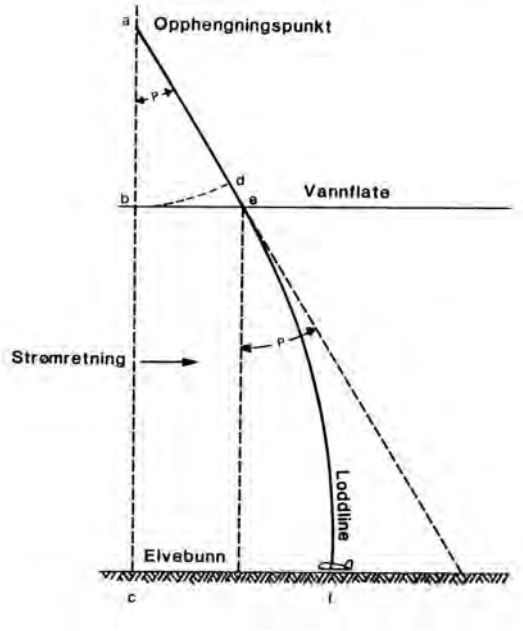
- Before the measurement
  - How is the maintenance of the Price current meters. Are there any Calibration formulaes.
  - How is the practice for deciding the start and end point if the measurement.
- During the measurement
  - practice for readings and calculations for the angels
  - practice for finding the depth of each vertical
  - practice for deciding how many points to measure in one vertical
  - practice for deciding how many verticals
  - practice for taking notes

Routines for discharge measurements

- After the measurement
  - practice for calculating the result
  - practice for calculate the result when you only have one point measured in a vertical
  - Practice for deciding what water level to tie to the water discharge measured
  - practice checking the result and say something about the quality of the measurement
  - practice for transmission of data to the database from the field

Discharge measurement

- Measuring site
- Profile
- Number of verticals
- Stream flow – straight?
- Drift angle issues



The influence of errors in current meter measurements on discharge calculations

Tuesday 14th February 2012

Paul Christen Røhr, dr. ing.
NVE-HV

Content:

- Introduction
- Errors in discharge measurements
- Calculating discharge with errors

Objective for lecture:

- Illustrate the influence of (human) errors in the field on final discharge calculation

Illustration purposes only

May be

Shortcuts in the calculation

Methods regarding equations, etc.

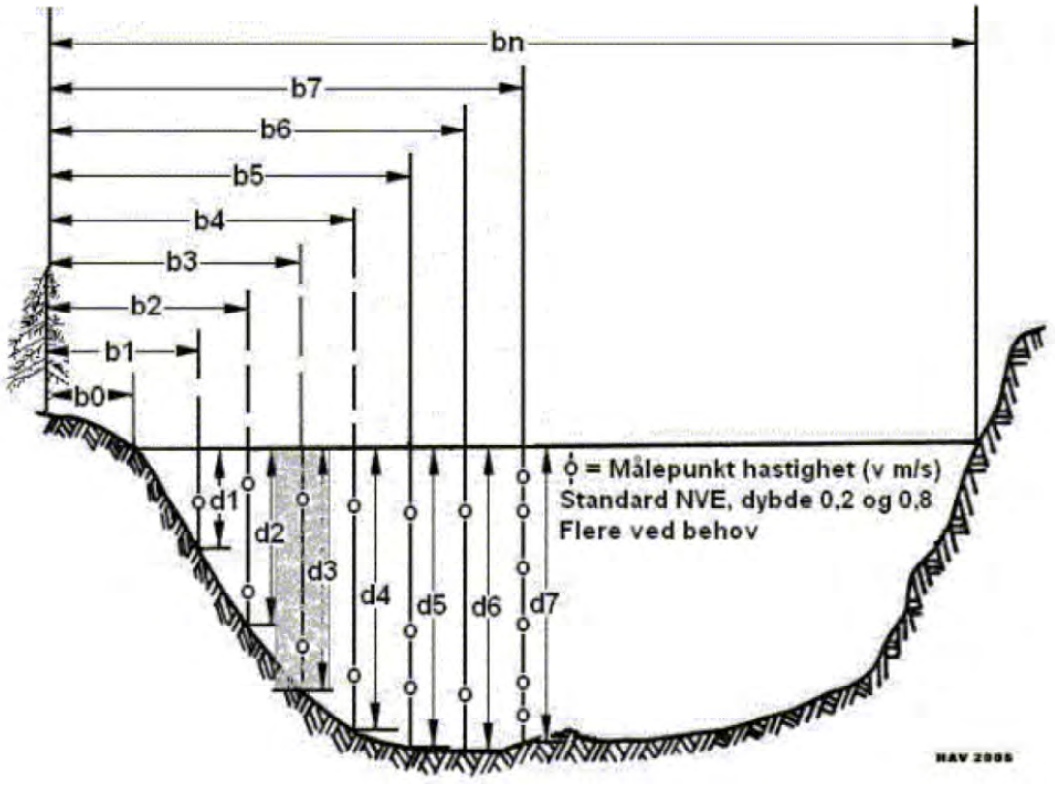
Metods for illustration:

- Excel spreadsheet tools to be used for the calculations
- Real data from 2009 measurment season
- Some simplified calculations
- Satisfactory for illustration purposes

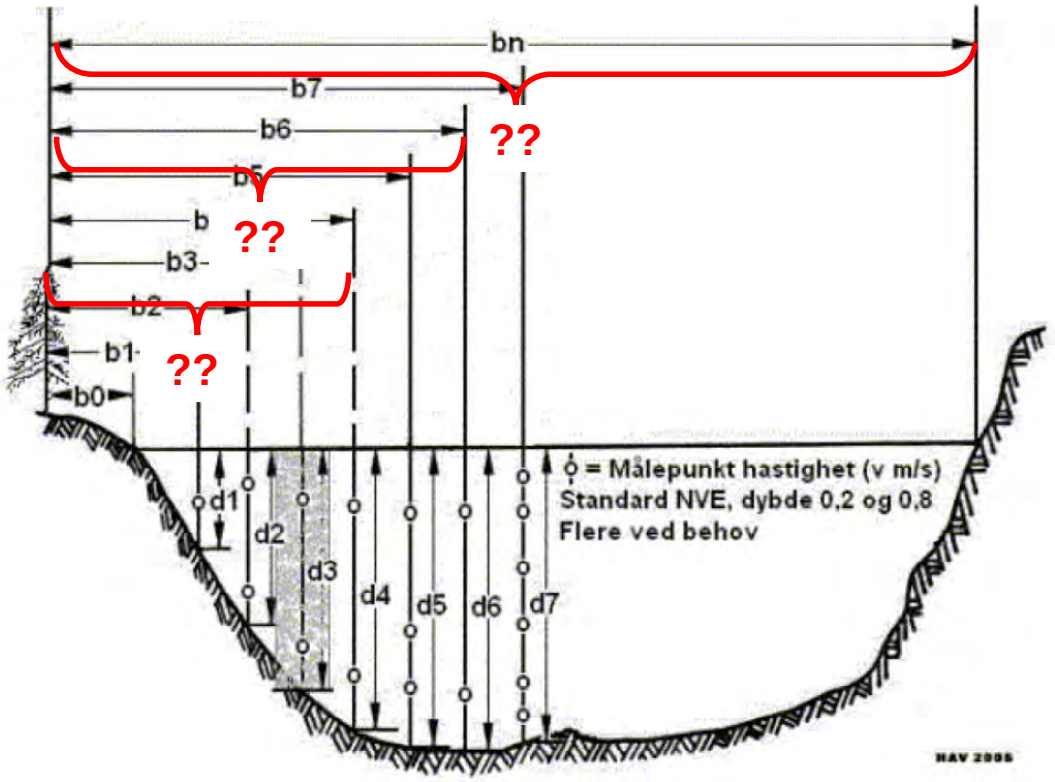
The discharge measurement – Some measurements:

- Distances
  - Bank to bank
  - Bank to section
- Depth
  - In each section
  - From surface to meausurement point for velocity
- Velocity

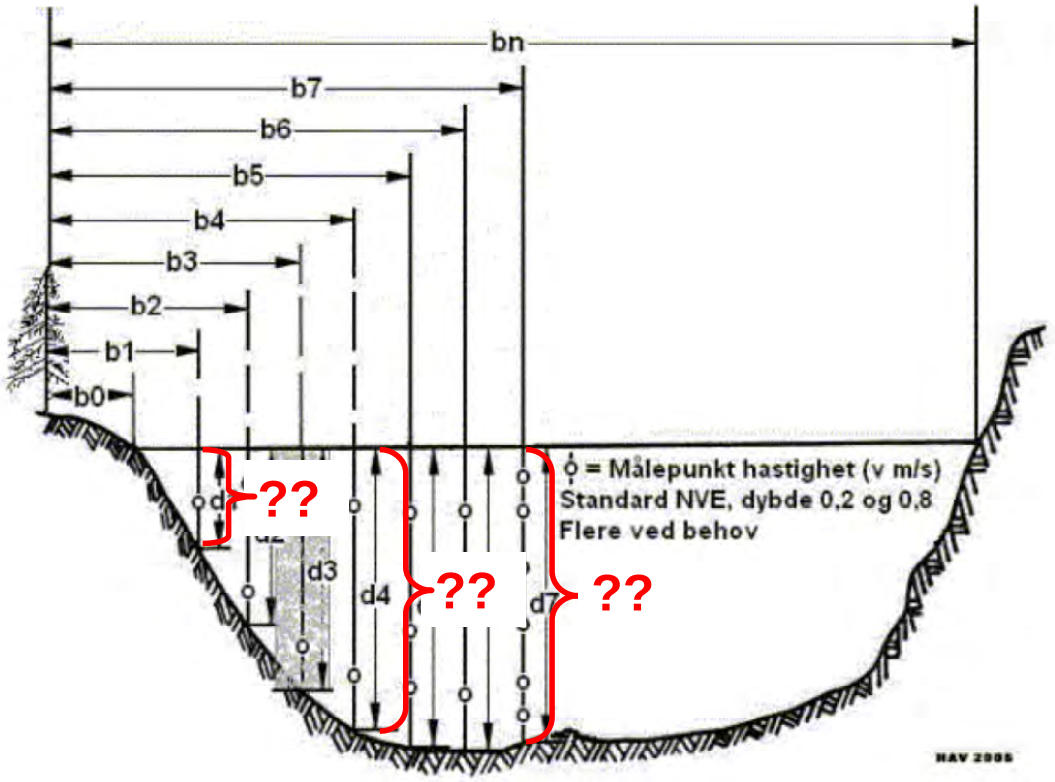
Error sources in the cross section:



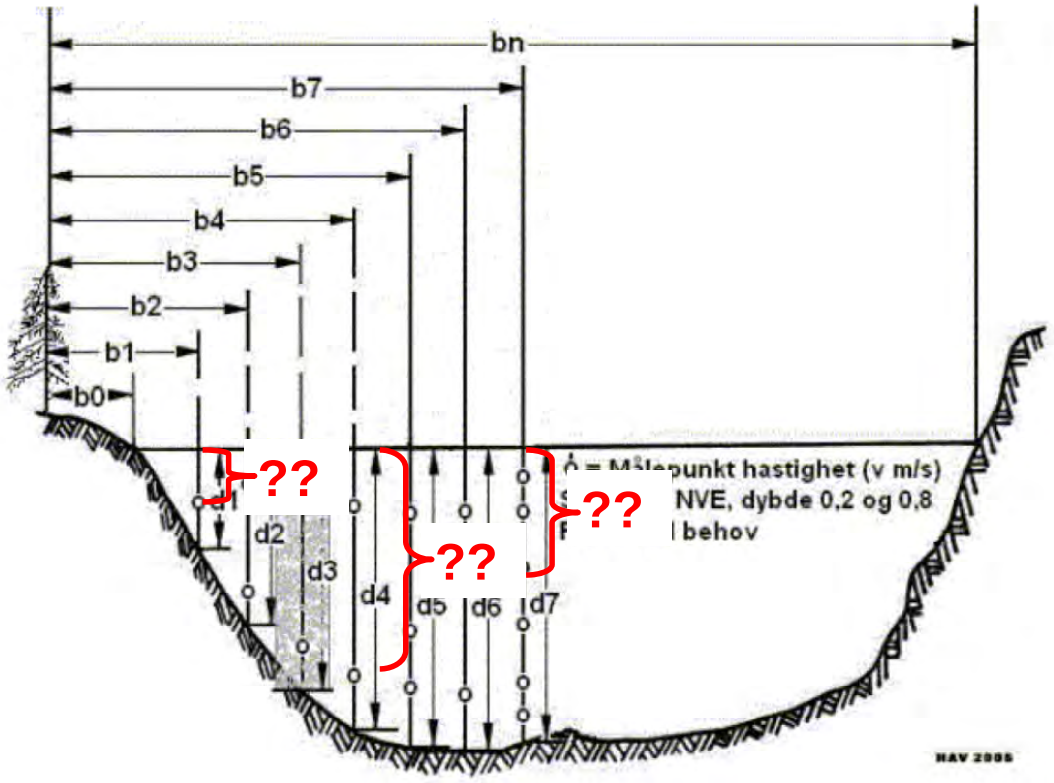
Error sources in the cross section – Distance:



Error sources in the cross section - Depth:

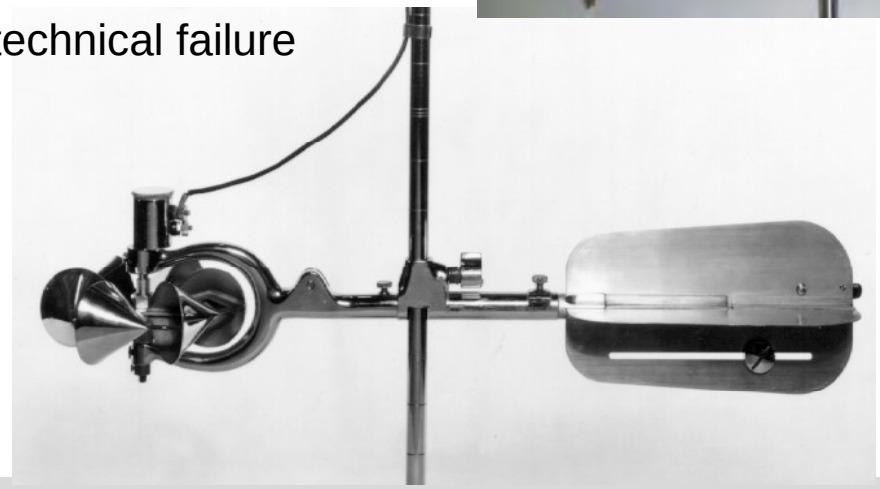


Error sources in the cross section - Depth:

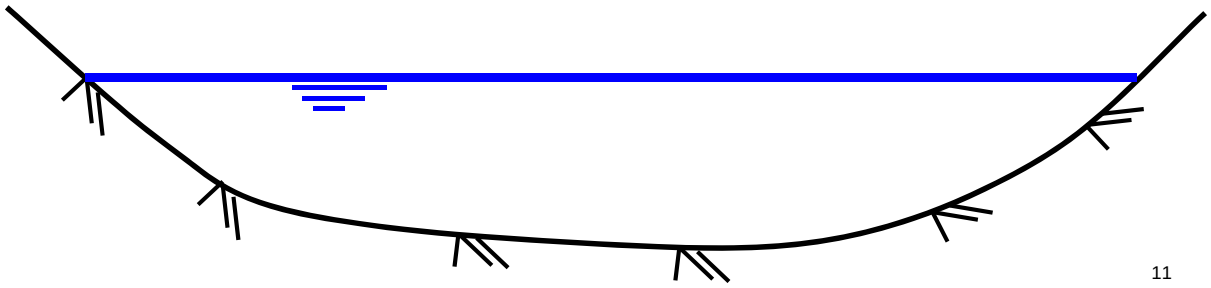


Error sources in the cross section - Velocity:

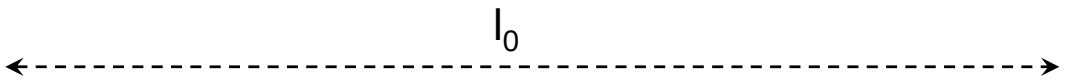
- Counting wrong
- Incorrect timing
- Other technical failure

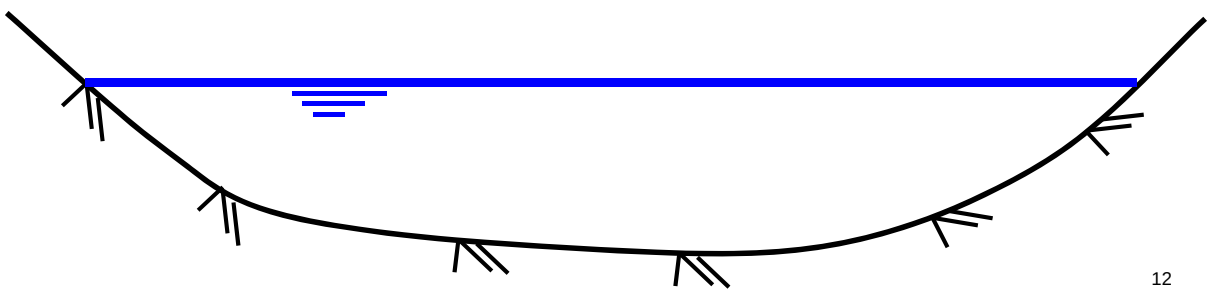


Error sources in the cross section – Distance - Type of error:

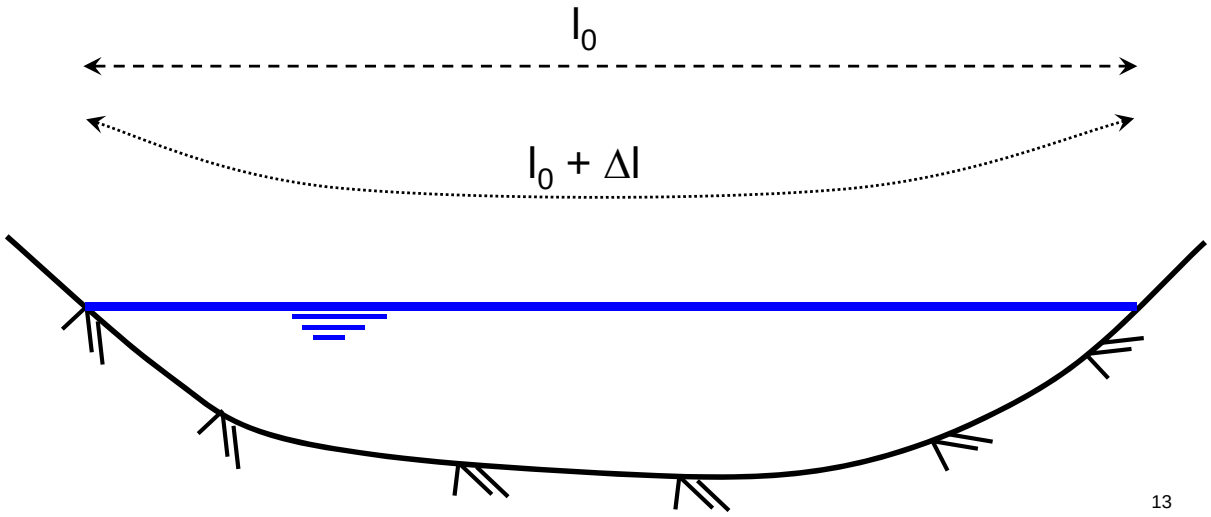


Error sources in the cross section – Distance - Type of error:

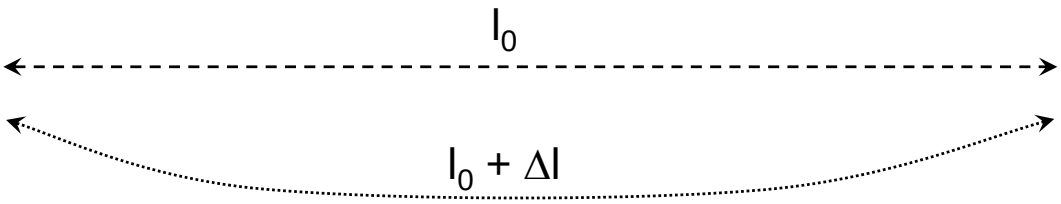




Error sources in the cross section – Distance - Type of error:



Error sources in the cross section – Distance - Type of error:

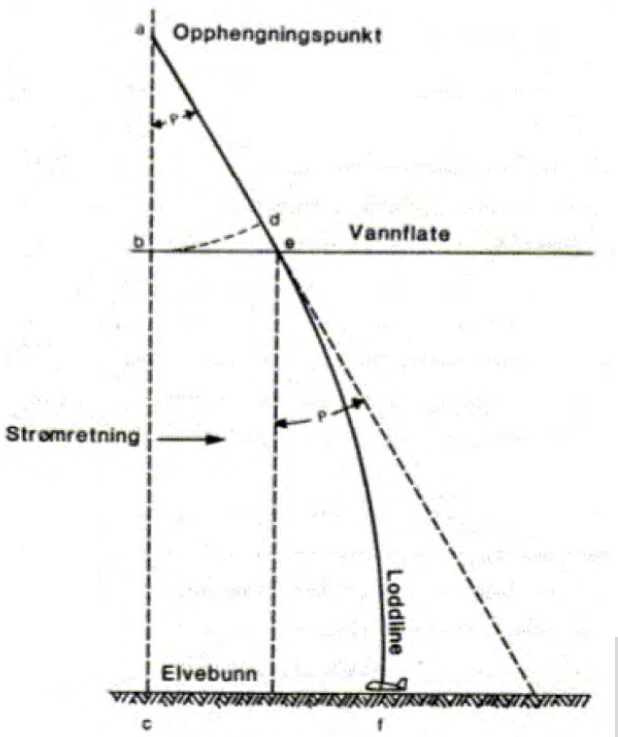


- Always: $l_0 > l_0 + \Delta l$
- Overestimation of width

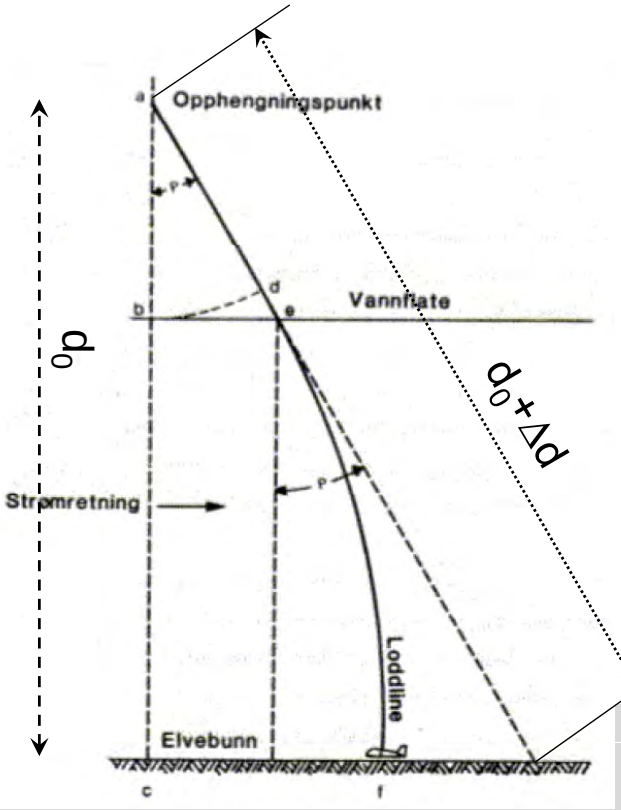
Error sources in the cross section – Depth - Type of error:

- Impossible to make errors measuring the depth?
- Just to drop the wire to the bottom?

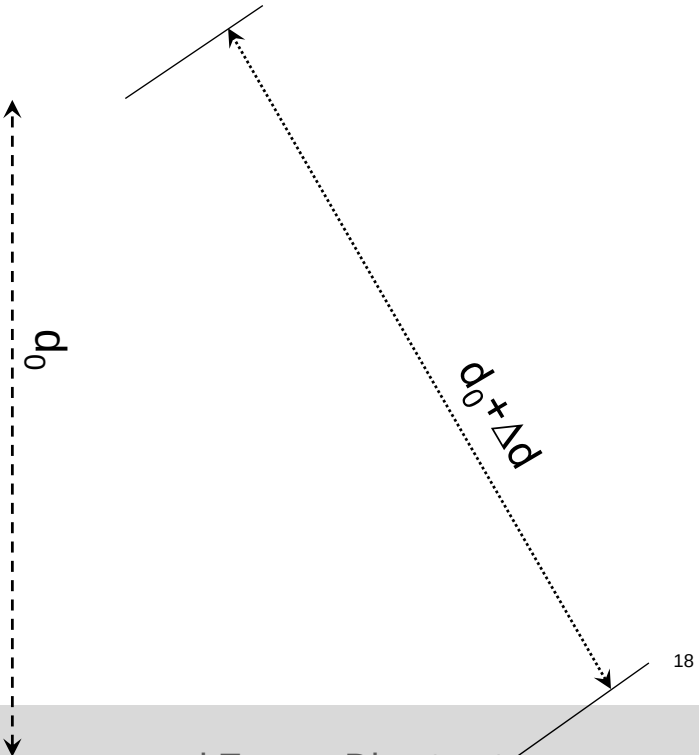
Error sources in the cross section – Depth - Type of error:



Error sources in the cross section – Depth - Type of error:

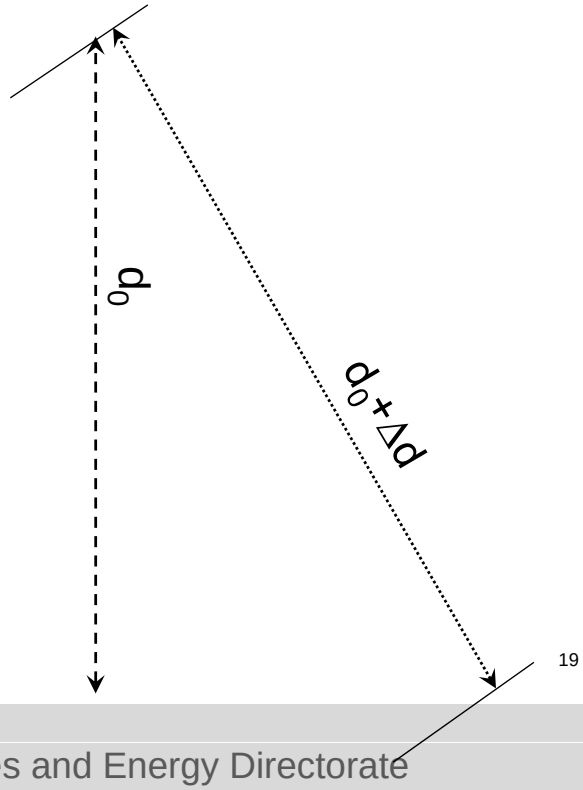


Error sources in the cross section – Depth - Type of error:



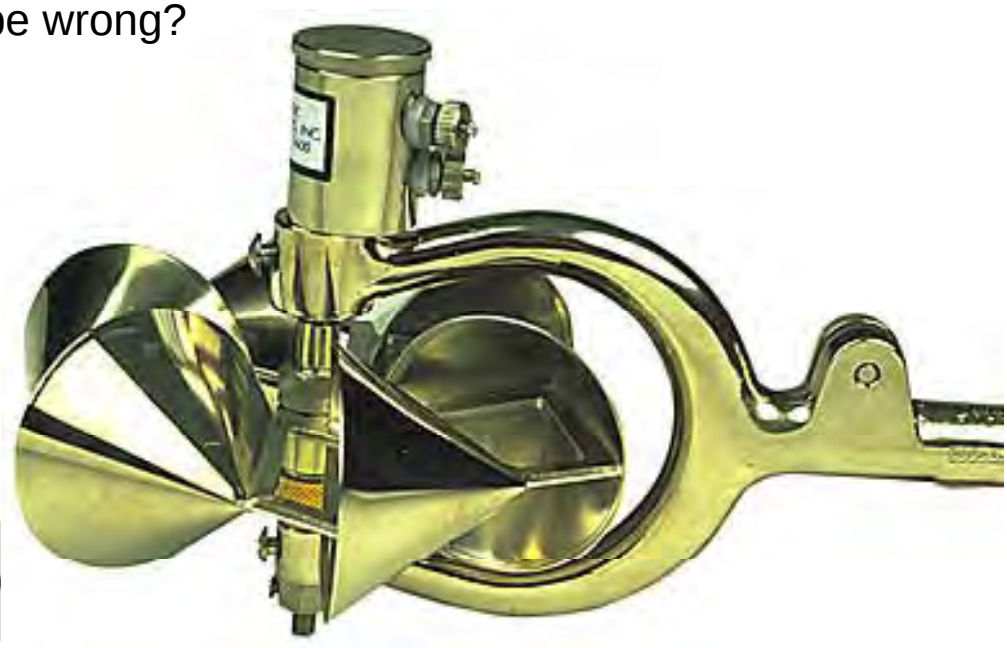
Error sources in the cross section – Depth - Type of error:

- Always $d_0 < d_0 + \Delta d$
- Overestimation of the depth



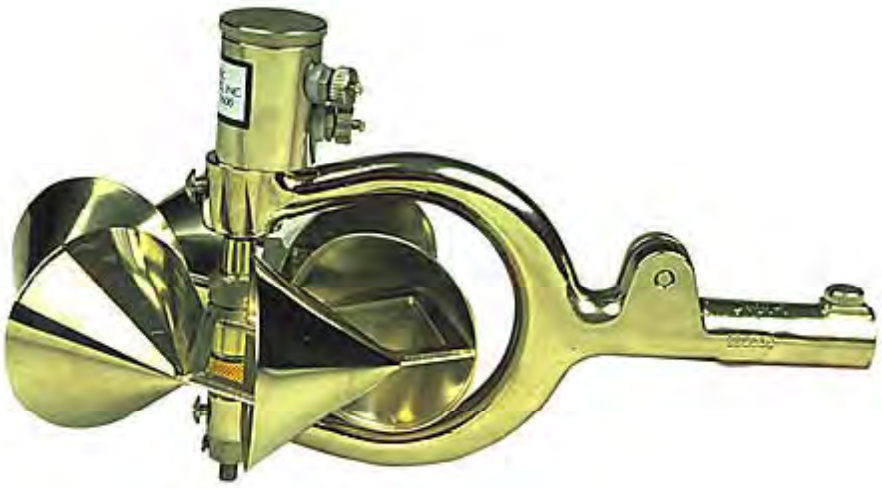
Error sources in the cross section - Velocity:

- Carefully machined instrument
- Can not be wrong?



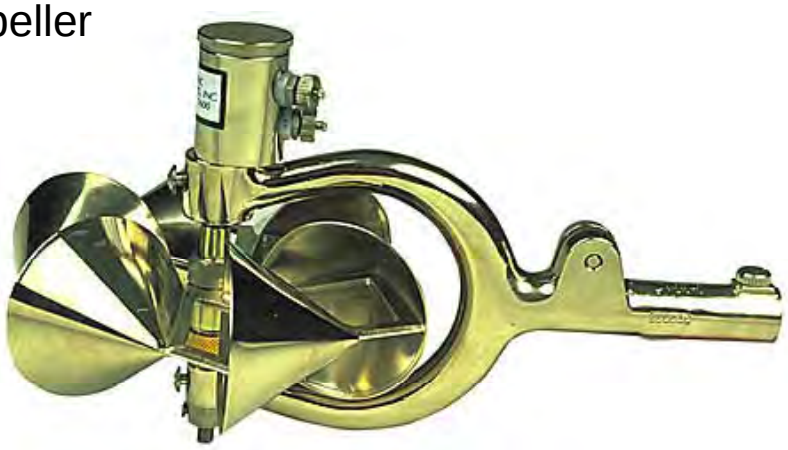
Error sources in the cross section - Velocity:

- Propeller calibrated
- Connection between rpm and velocity
- Technical damage influence spinning



Error sources in the cross section - Velocity:

- Difficult to imagine that propeller get mor smooth and turns faster
- Damage on the propeller
- More coarse
- Turns slower

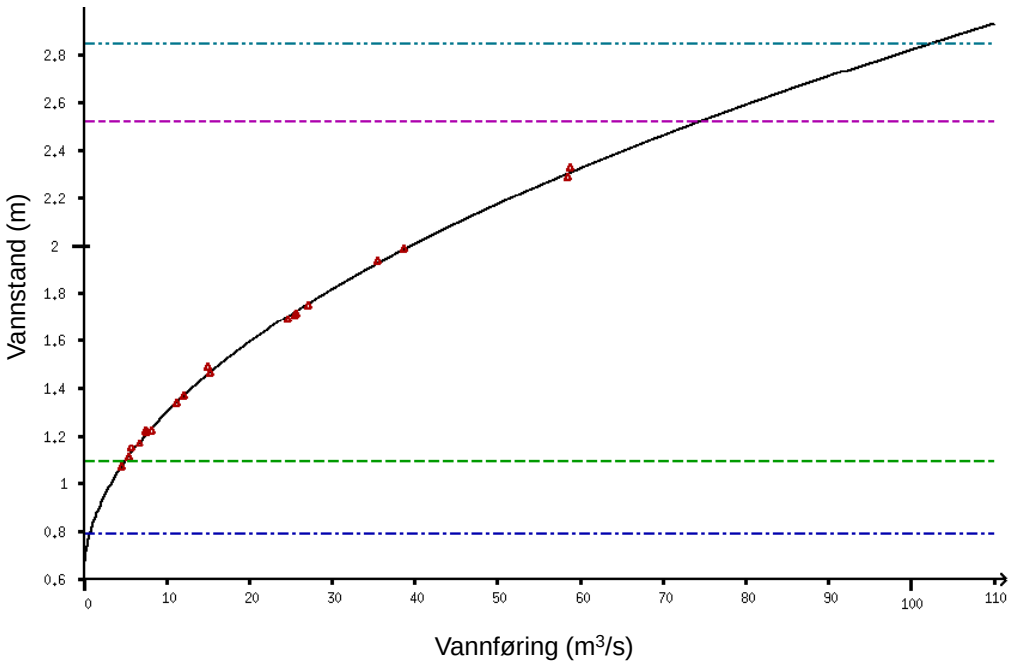


Time for practical calculations:

- Will go to computers on 3rd floor and do practical calculations
- Will use spreadsheet that will be distributed
- SEE, READ and DO
- (and ask)

Rating Curves

Line Dale, HHT

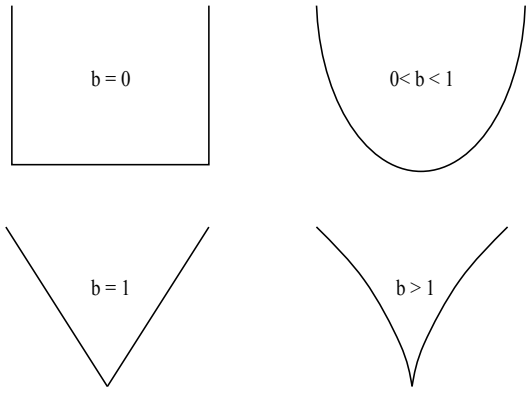


Why rating curve?

- Decide how much water running past a certain point in the river
- It is not possible to measure every point in the staff gauge → extrapolation

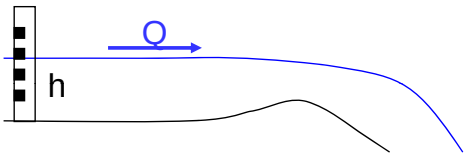
Rating curve looks depends on

- Channel form \ profile

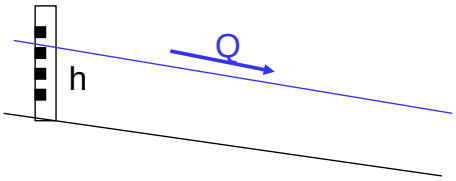


Relation water level – water discharge – zero point

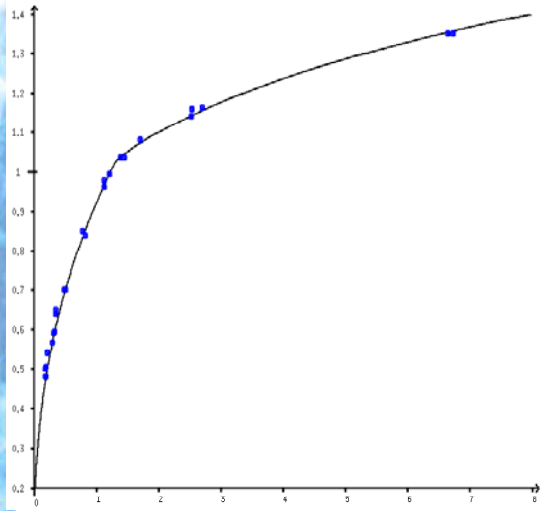
Critical control

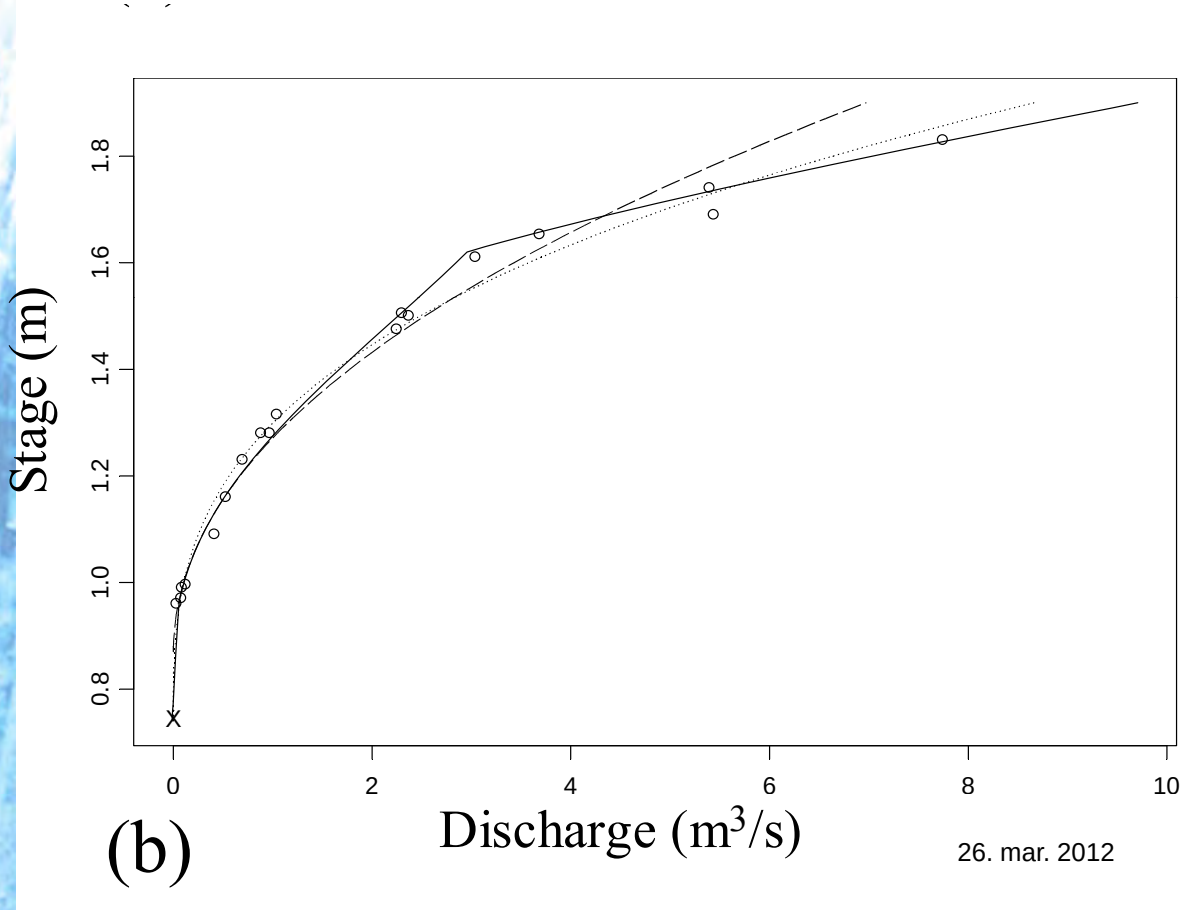


Channel control



segments





Important that the ones that are generating the rating curve has knowledge about the site

Several ways of generate rating curves

- On paper
- In excel
- Special data programs

Several different theories

The series of differences method .....
The logarithmic method .....
The stage-velocity-area method .....
The Manning-equation method .....
The Chezy-equation method .....
The hydraulic river-model analysis method ..

Water discharge can be expressed with an equation

$$Q = C\,(h - h_0)^b$$

Q= water discharge

C = constant

H= water level

H0= zeropoint

A lot of formulas

$$Q \approx \frac{1}{n}\frac{S_0^{1/2}\lambda}{(\beta+1)^{5/3}}(h-h_0)^{5/3+\beta} = C(h-h_0)^b$$

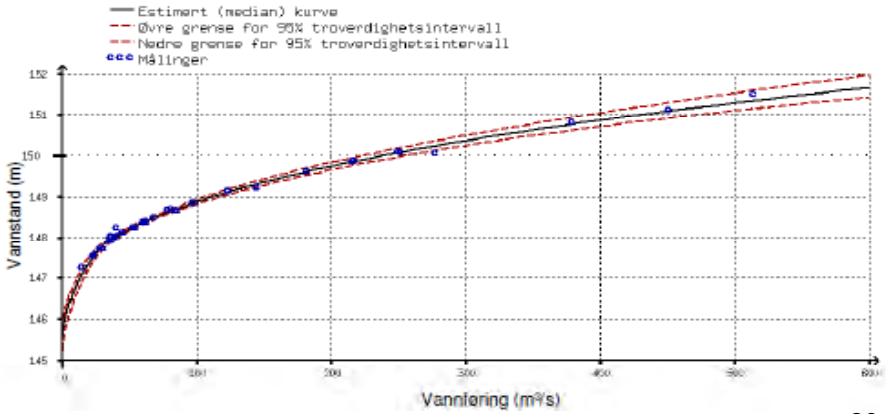
$$\log(Q_i) = \log(C) + n\log(H_i - H_0) + \varepsilon_i$$

NVE routines

- Rating curves on every station
- Have an opinion of the profile stability
- consider background information as sadel point and channel geometry
- Using bayesian statistics and VF kurve 3 (special adapted data program for generating rating curves)
- Put a quality label on the rating curves (Check rating curve, automatic, data program)
- Look at stability history to see if the profile, data has changed and evaluate if new rating curve is needed.

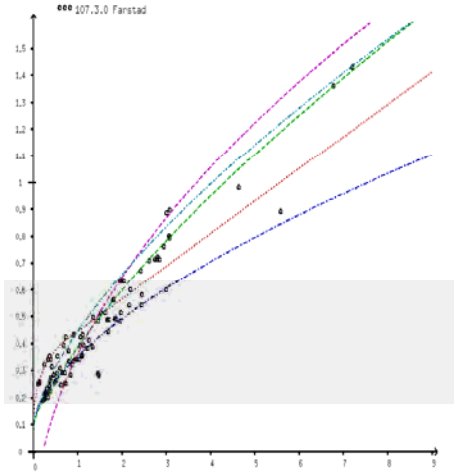
bayesian statistics, putting in knowledge about the site

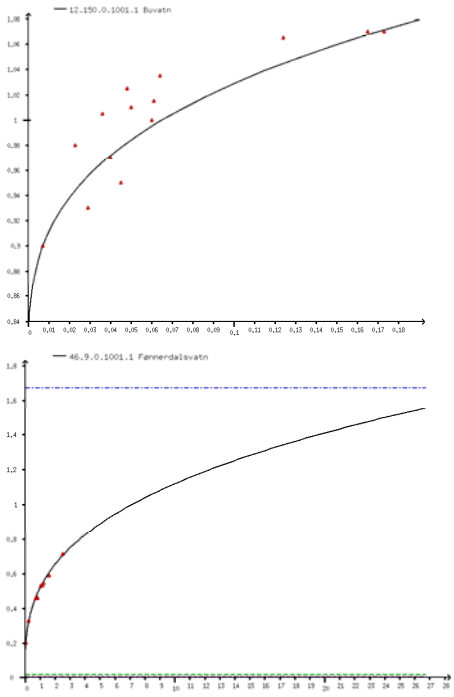
$$Q = \begin{cases} C_1 (h - h_{0,1})^{b_1} & \text{hvis } h \le \omega_1 \\ C_2 (h - h_{0,2})^{b_2} & \text{hvis } \omega_1 \le h \le \omega_2 \\ \vdots & \\ C_n (h - h_{0,n})^{b_n} & \text{hvis } \omega_{n-1} \le h \end{cases}$$

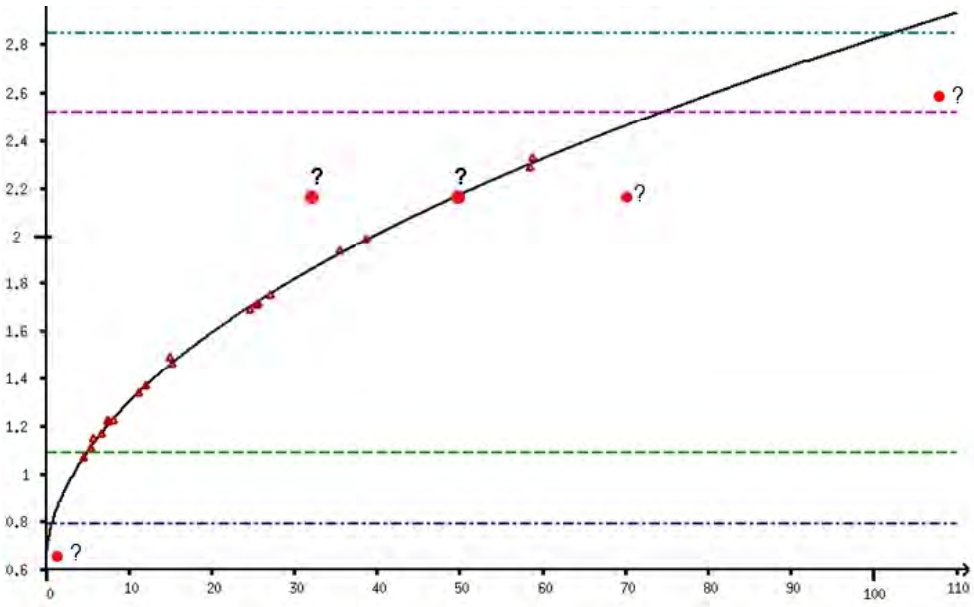


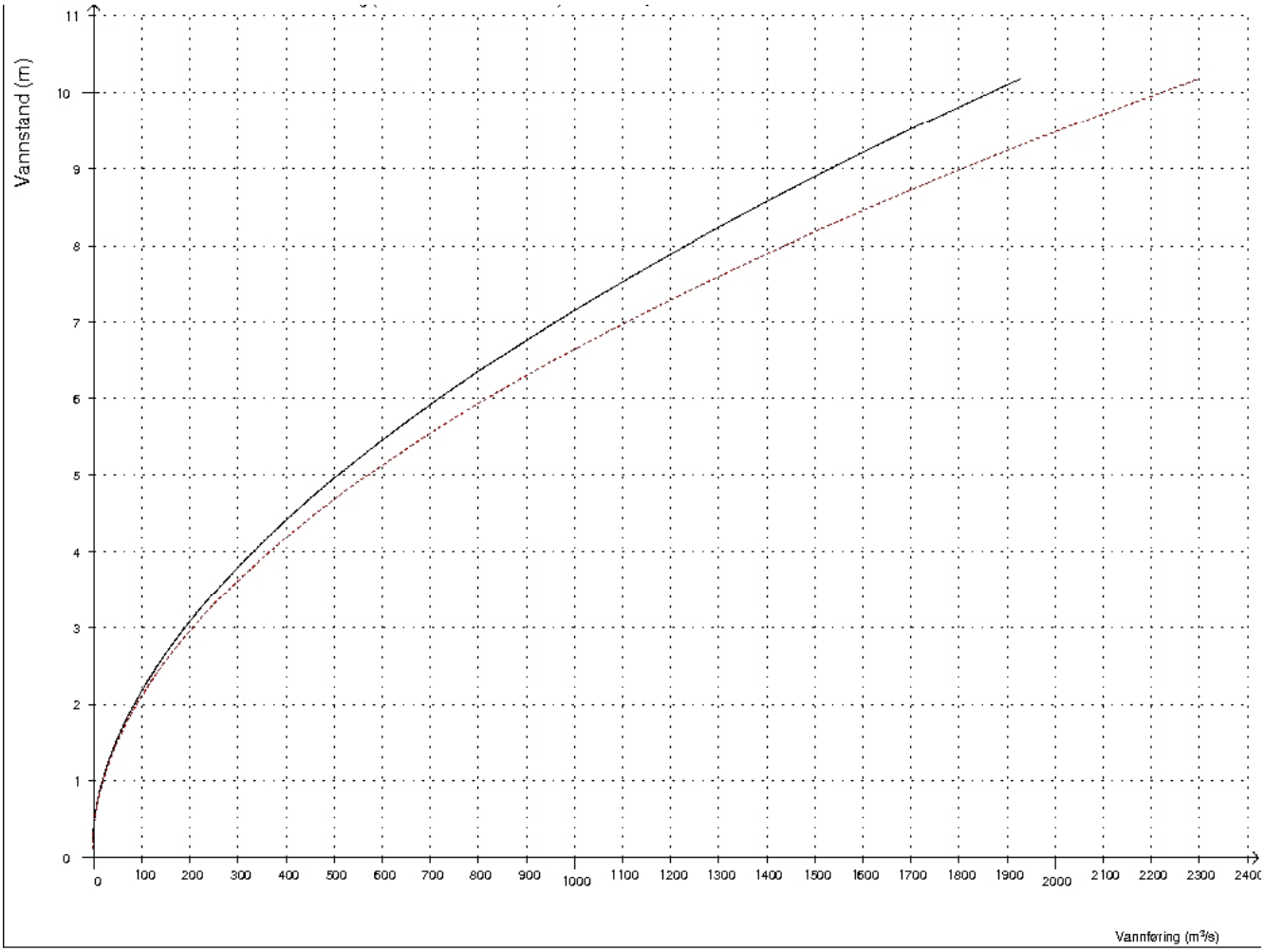
Examples of errors

- Wrong interpolation caused by uncertain measurements
- Wrong extrapolation
- Changes in the profile

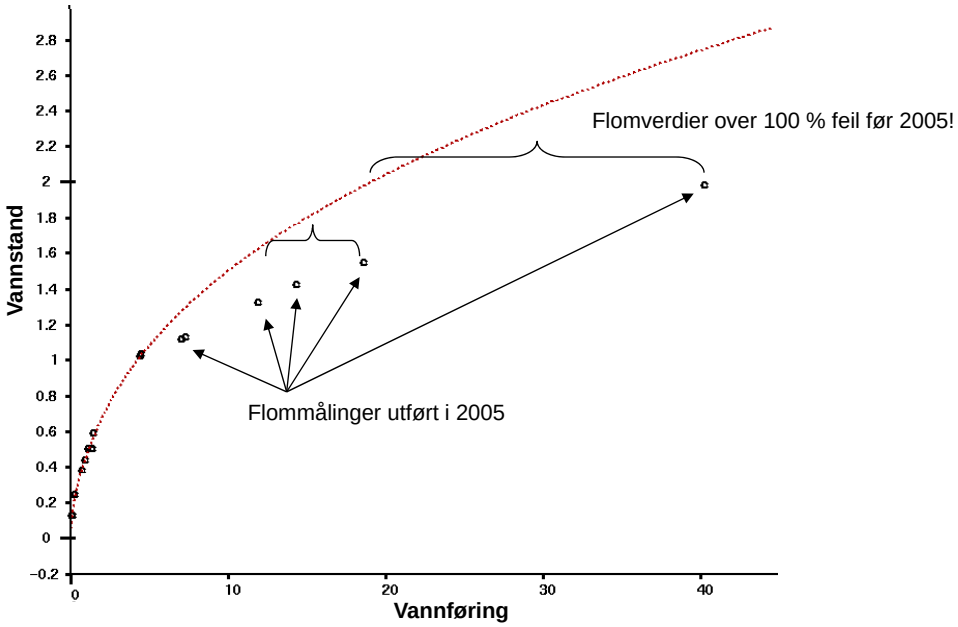






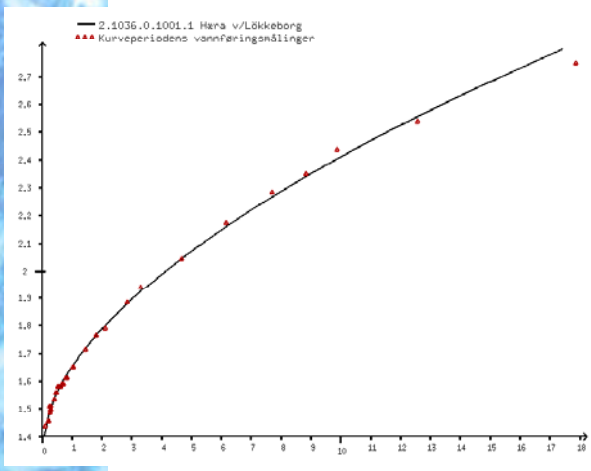


Insufficient measuring of the rating curve is often the biggest contributor to errors and uncertainty

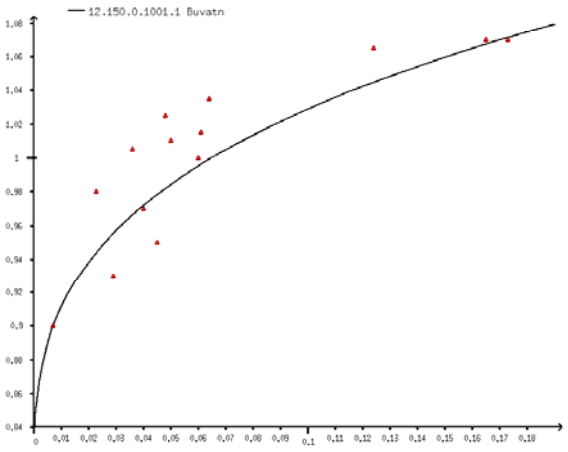


Rating Curve quality

- Good quality



- Bad quality



Discussions

Routines rating curves

- How do MoWE generate rating curves
- How often are the rating curves compared with new measurements?
- How often are new rating curves generated?
- How many measurements do MoWE require to generate a rating curve?
- Check that measurements made at similar water levels result in approximately equal discharges?

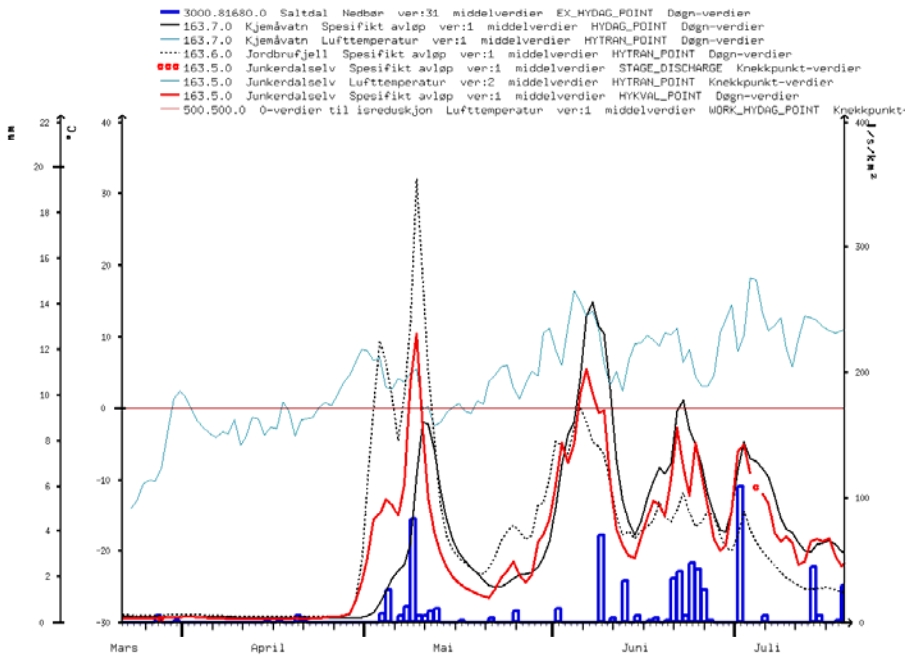
Routines rating curves

- System for quality labeling of measurements? Classify measurements on the basis of their quality?
- Annual profiling at the measuring site?
- Annual quality check for staff gauges, database for benchmark heights, reference marks at the bridges?

Timeseries

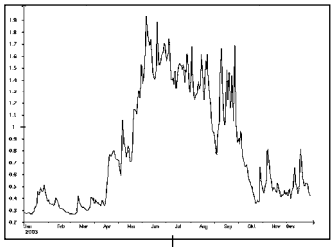
Line Dale, HHT

Examples of a time series

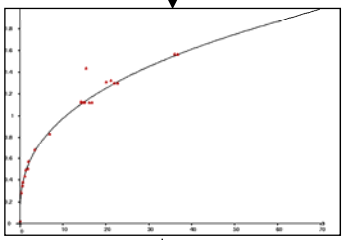


NVE routins

- Generate water discharge data from water level data by means of rating curves
- Secondary control
- Time trend to survey data



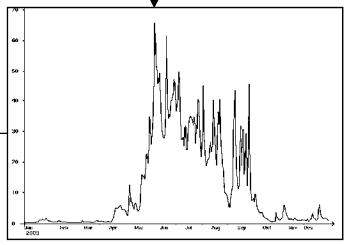
Vst



Vf-kurve

Uncertaintys and errors

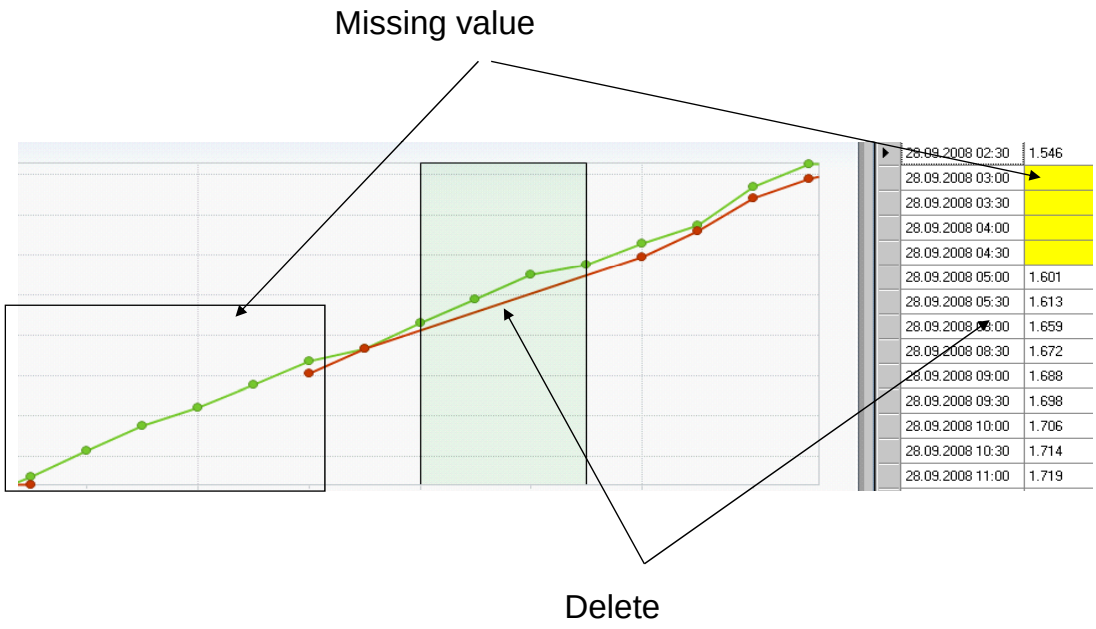
Isreduksjon og komplettering

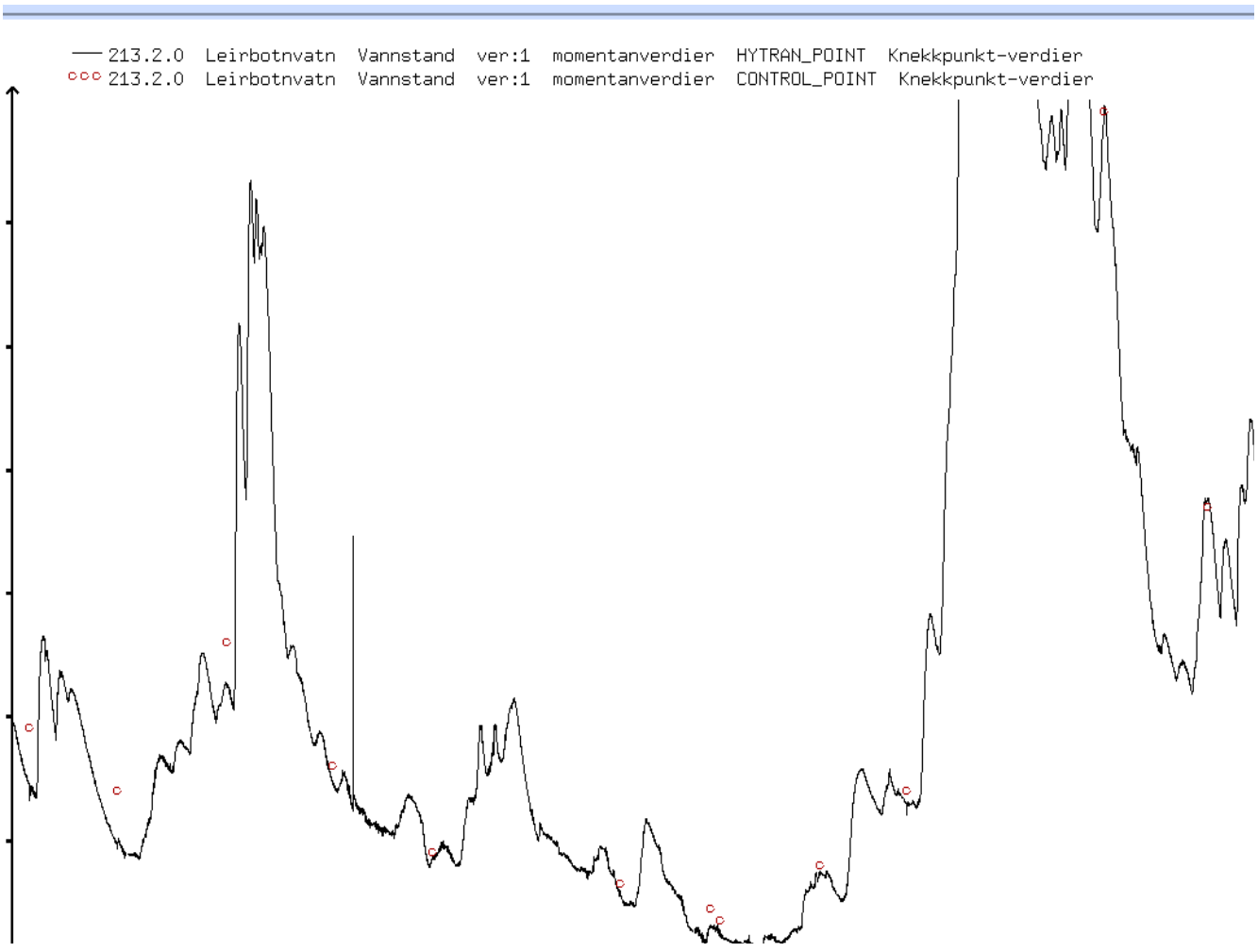


Vf

HYDRA 2

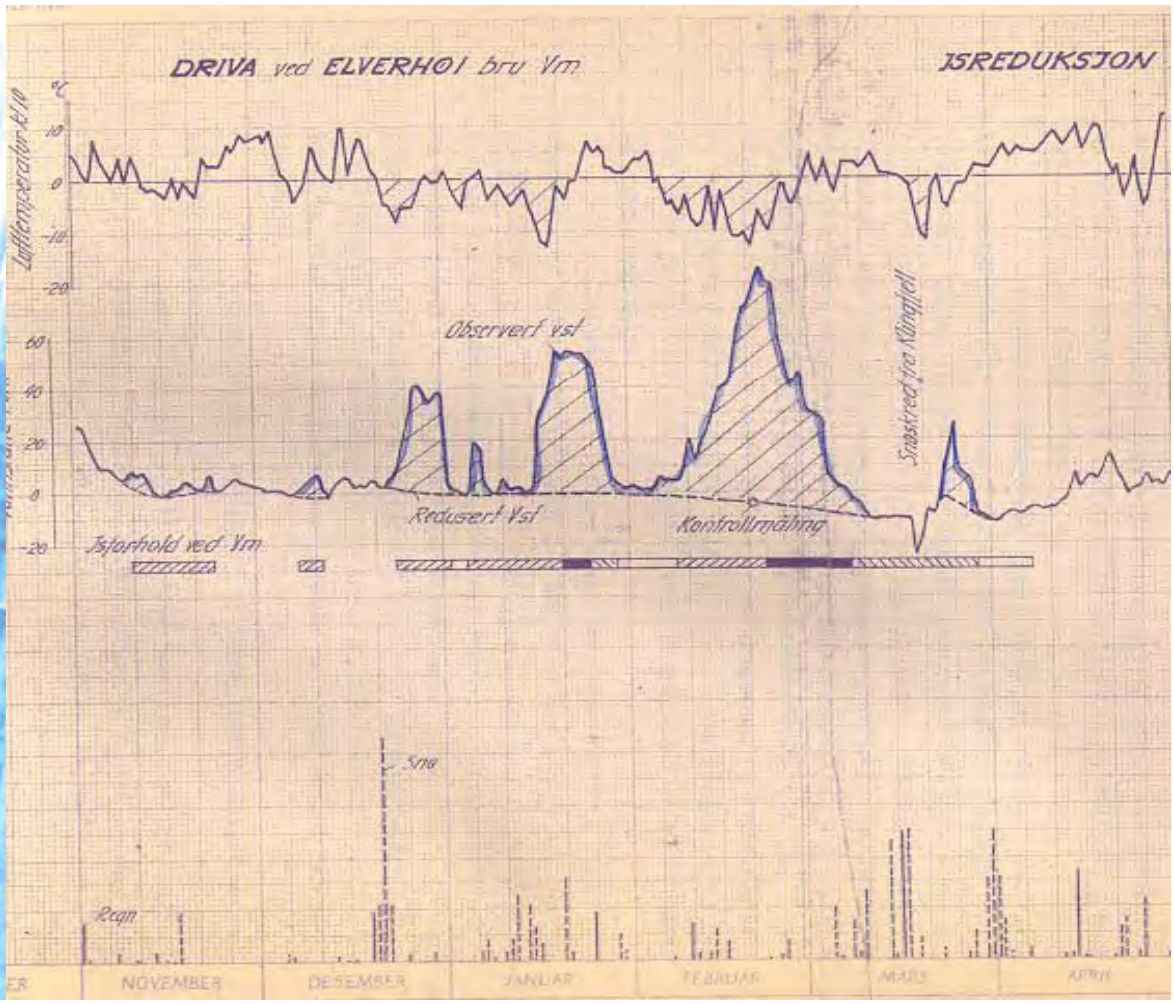
Remember the primary control?



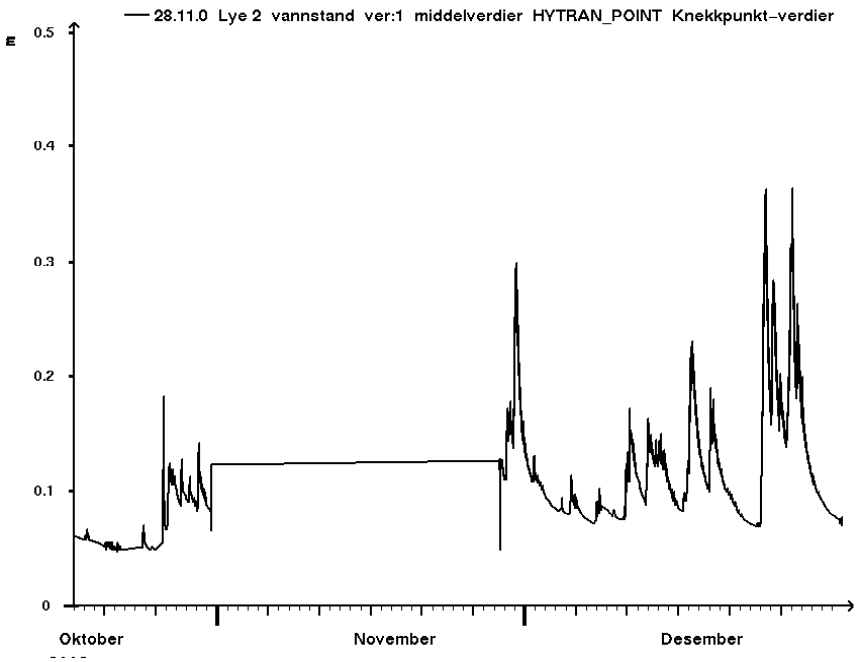


secondary controll

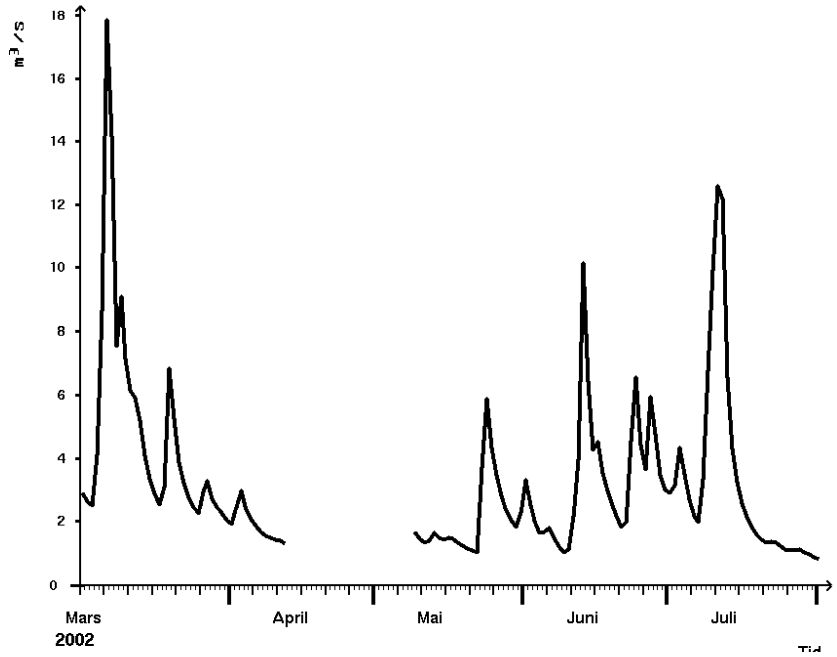
- Completion of data filling gaps
  - Interpolatidion (<20 days)
  - Using comparable data and metrological data
- Norway→ Ice→Ice reduction



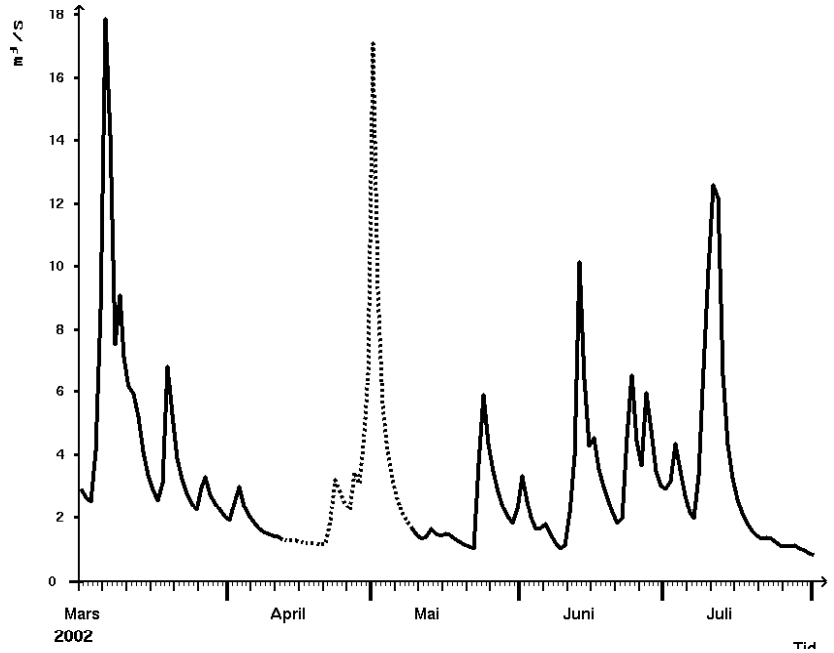
Data with errors



Missing data! What to do?



Completation



Secondary control, completing data

- Subjective methods
  - ”Penn and paper” method with or without observed values and comparable data
- Objective methods
  - Hydrological models
  - Regional analysis → regression

When to complete data or not?

- Every discharge series from non regulated rivers
- But!! :

  - We have to reproduce data of a certain satisfactions and accuracies

  - if loooong periods completed → less quality on the data .
- Data from power plants and dams we do not complete

Why do we have to complete data?

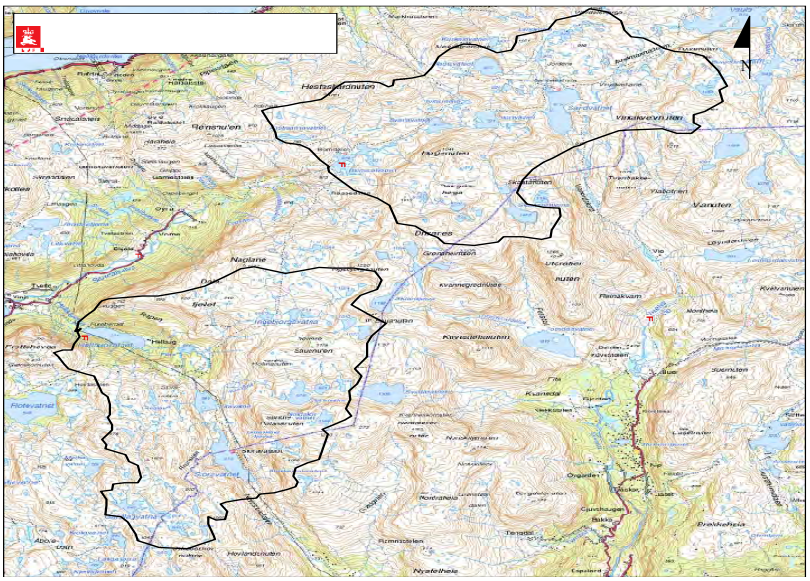
- A good product
- Gaps in the time series makes often gaps in other series →sediment data, water quality data etc.
- Many of our programs depend on it
- Tradition

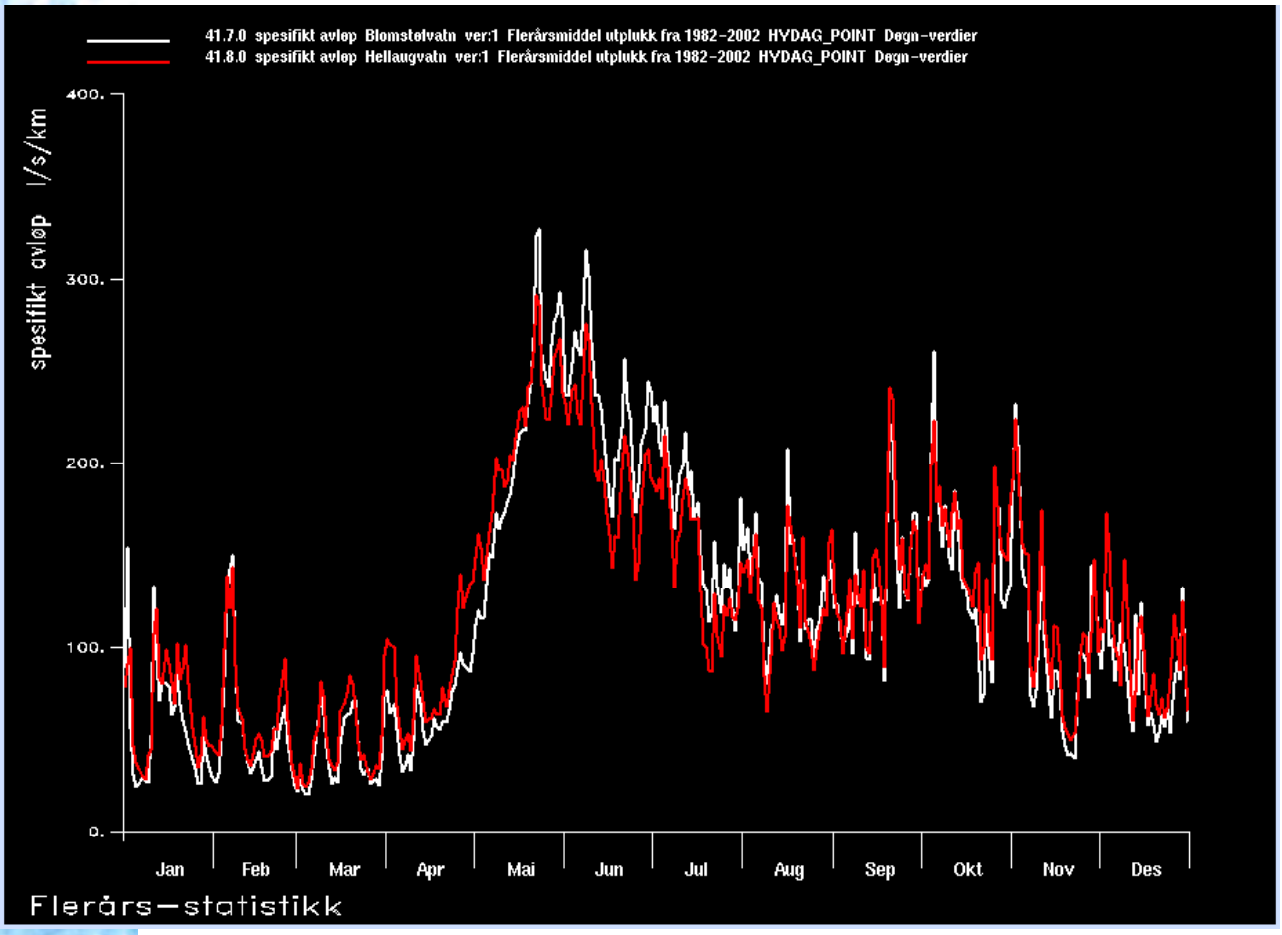
Comperable data

- Visualization
- Data quality in comparison stations
- Observation length
- Comparable hydrological regime
- Comparable field characteristics

Eksempel: Kun en sammenligningsstasjon

Obs. Per.: 1982 -2002	**Feltareal (km^2)**	**Felthøyde (moh)**	**Eff. Sjøprosent**	**Snaufjellprosent**	**Feltlengde**	**Feltgrad.**
Blomstølv. 41.7.0	25.7	Min 628 Median 922 Max 1134	0.6	92	6.95	34
Hellaugv. 41.8.0	27.0	Min 271 Median 904 Max 1263	1.42	83	Na	Na

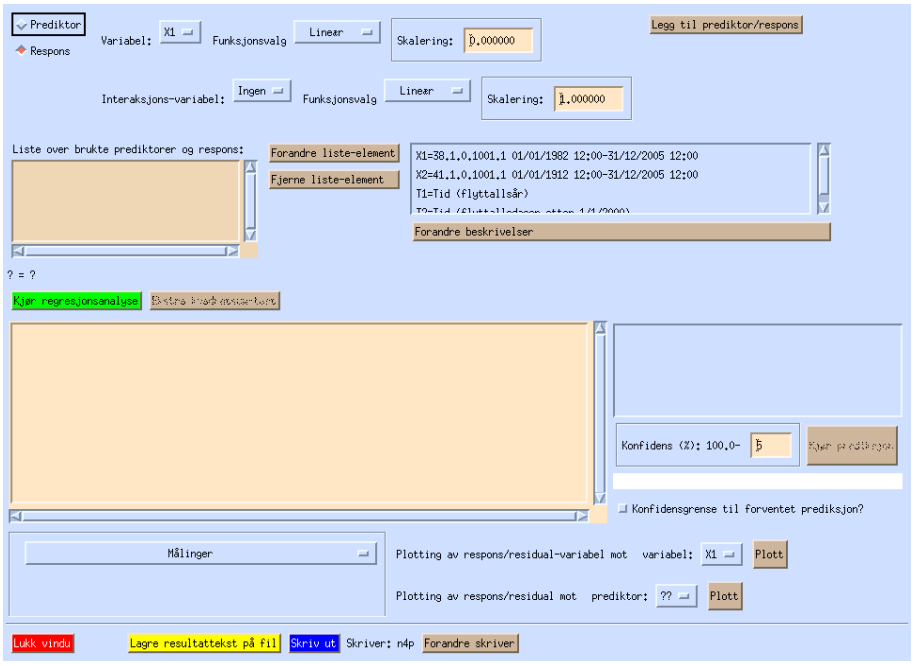




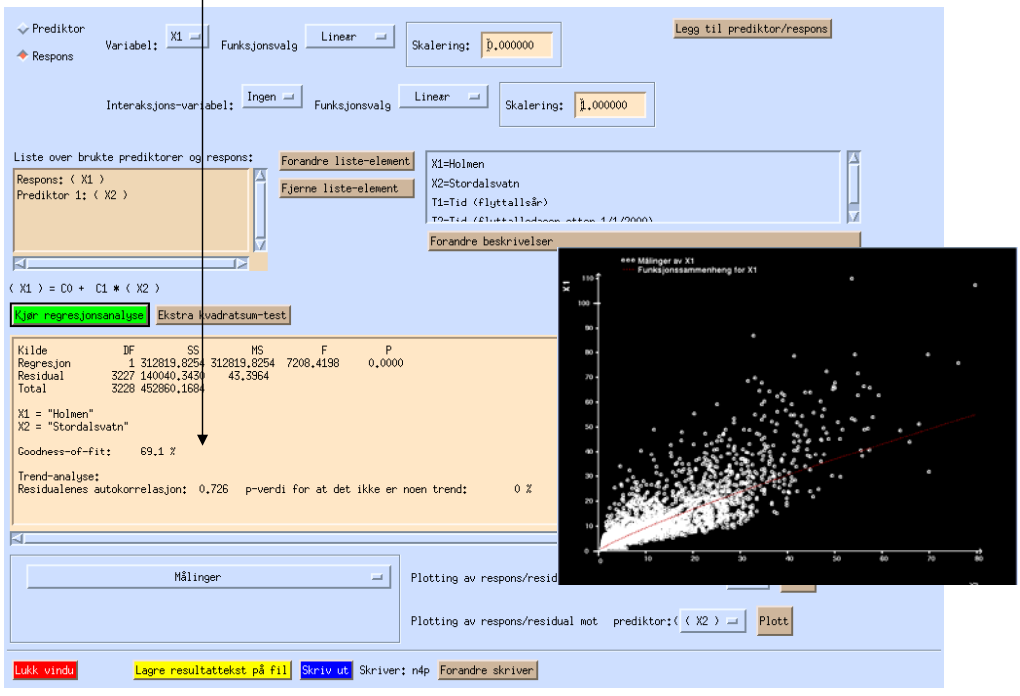
Completing using Regression

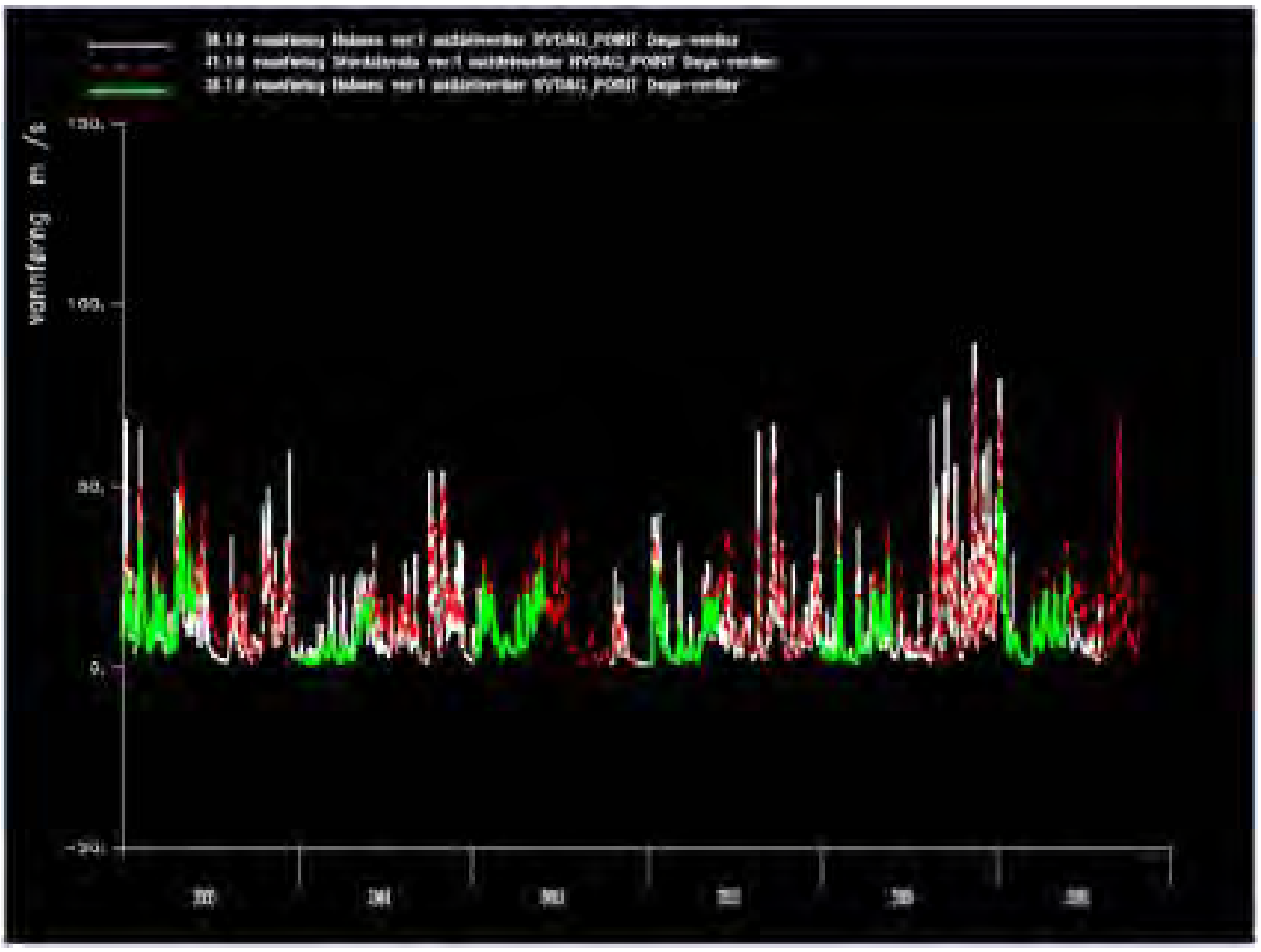
- missing data is explained mathematically by means of one or more comparison stations.
- Assuming a linear relationship between flow data (log)
- With a comparison stations, a linear regression be of the form
  - $y = a + bx$
- With multiple comparisons stations
  - $y = a + b_1x + b_2x \ldots + b_ix,$

Dataprogram helps us ☺

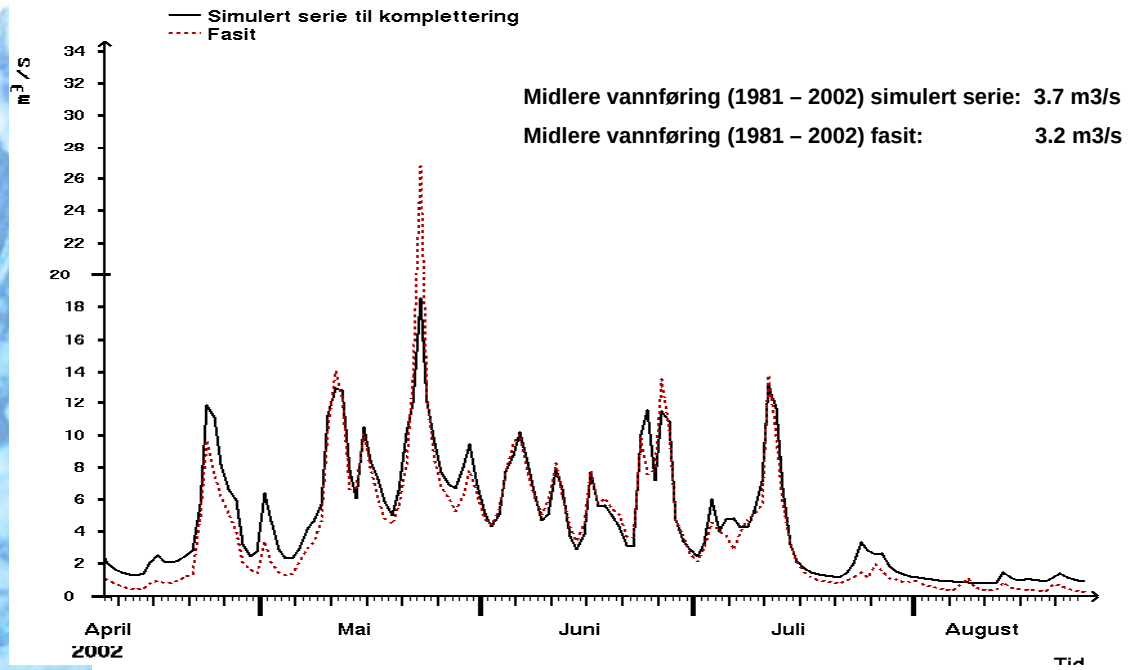


- Results and diagnostics appears on the display. Especially important is the Goodness-of-fit (GOF). For example, if the GOF is equal to 69.1%, the correlation coefficient equal 0.6910.5 = 0.83





Benyttet periode 15/05 – 31/08 for komplettering:
Konsekvens -> Totalt feil flomverdi selv på døgnmiddelnivå!



Midlere vannføring (1981 – 2002) simulert serie: 3.7 m3/s

Midlere vannføring (1981 – 2002) fasit: 3.2 m3/s

Different statistics programs for discover errors with the dataseries

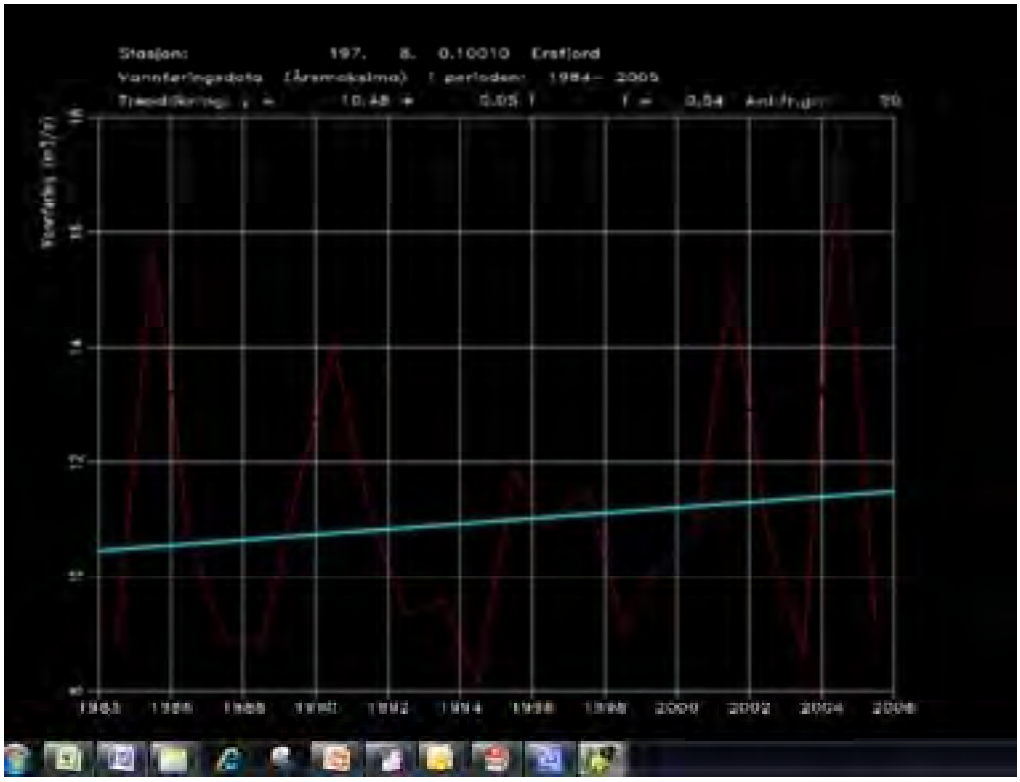
- Change in the profile
- Changes in the height system
- Extreme events

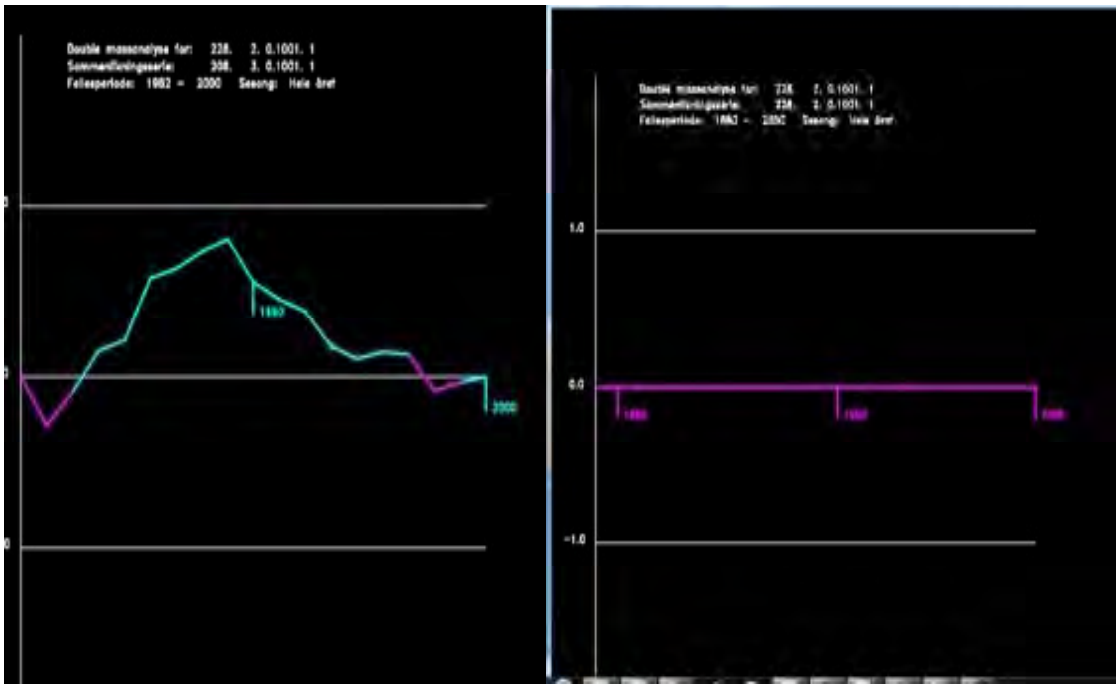
Systems

- Check homogeneity
- Double mass analysis

and others……

Trend in times





So working with data in NVE for a field hydrologist means:

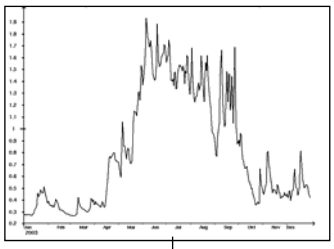
- Punching data after field trip
- Primary control
- Secondary control
- Rating cure analyzing
- Look more closely into the data, get friends with them

Closure

Line Dale, HHT

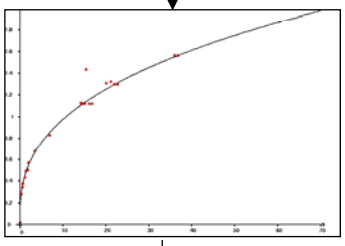
For NVE is important to focus on minimaize the errors to make better data…….. HOW?

- Routines
- Training
- Uniform way of working
- communication

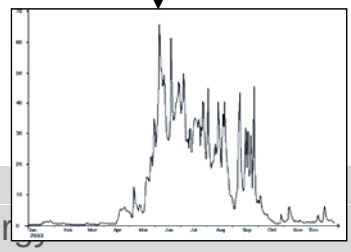


WL

DM



rating curve



WD

Questions or comments??????????????

Thanks for very good work to you all

☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺☺

Thank you very much for your attention!!!

Group I Presented by Gedamu Chane from Regional office (Bahir Dar).

Water level reading

- Read water level twice a day by local observer
- During discharge measurement the observer reads the staff gauge more than twice, if it fluctuates, including at the start and end of discharge measurements.
- Mean value of the morning and evening reading is calculated by technician.
- The data collected by the observer once again checked by the technician and sent to the head office (hard copy).
- The Technicians visits every station once in four month (contact observers).

Discharge measurements presented by Beyene Minda from Regional office (Awassa)

The procedure of discharge measurements before and after making at a site:

1. Planning

- Discuss about the field work operation with the crew members.
- Select the station for making flow measurement (it depends on the regulation of data processor).
- Choose the tour line to give priority for selected stations.
- Select the appropriate instrument and equipments for making flow measurement by wading cable way or bridge.
- Assess the chamber box, check spin test and propeller.
- Check the equipments after prepare and ready before loading on the vehicle using by check list.
- Check the stationeries, formats measuring note, gauge books and different types of charts according to the types of recorders.

2. Procedure on the site

- Contact local observer
- Inspect the site together with the observer (staff gauges, auxiliary marks and others damage phenomenon).
- Check the automatic recorder if it works properly (may be it needs set up; re-set the time using 24 hrs system; gauge reading and write important information about the observing condition).
- Winding the clock of recorder manually or change the dry cell battery by new as it was using this type.
- Charts show red line starting from left to the right, it identify the chart will be end less than 30 days, so it replaced by the other and remove the previous chart.

3. Procedure of taking flow measurement.

- Select the appropriate measuring station

- Assemble and test the current meter.
- Tight the meter tape from one side of the river bank to the other side by avoiding sag across the stream.
- Measure “man check the click” accuracy according to mono or penta alternatives with click interval.
- Measure “man ready” for starting flow measurement
- Note man read the staff gauge.
- Identify name of the stream and exact location of site for miscellaneous measurement.
- Time measurement was started using 24 or 2 hr clock system.
- Bank of stream that was the starting point.
- Control conditions
    - Gauge heights and corresponding times
    - Water temperature is necessary for additional information but we don’t have the instrument.
    - Other pertinent information regarding the accuracy of discharge measurement and conditions which might affect the stage-discharge relation.
    - The stream bank is identified by the letters LEW or REW (left edge of water or right edge of water, respectively when facing downstream.
- Measure man starts his procedures
    - Follow up seriously the conditions of velocity distribution in front of him
    - Count the click by giving attention.
    - Highly concentrated following the time taking for avoiding missing the fraction of seconds
    - Communicate with the note man each vertical continue at the end of measurement.
    - Note man avoids unnecessary talking with the others externally.
    - Read the staff gauge and record the time parallel
    - De-assemble current meter.
    - Clean all the instrument
    - Pack the instruments in an appropriate way

Suggestions by Group I

- The technicians suggested that, in order to get good quality of data it is better to visit the station more often than before, at least every two months.
- Capacity building for Field technicians is very important to introduce Hi-Tec measuring equipments.
- Except few, almost all stations do not have data loggers or automatic data loggers. And the group suggests if it is possible to install on each and every stations.
- Appropriate software and other new technologies related with discharge measurements and data quality control.
- Field vehicles are one of the main problems (very old, bad tyres, etc……)

Group II presented by Solomon Kebede from Head office

Hydrological Data collection Experience in Ministry of Water and Energy Hydrology and Water Quality Directorate

In Ethiopia Hydrological data's, which means surface, Ground water and water quality data, are collected (monitored) and analysis by the hydrology and water quality directorate in the ministry.

Out of those duties Surface water monitoring and analysis are done with 9 regional offices and in head office experts.

How the hydrological data are collected?

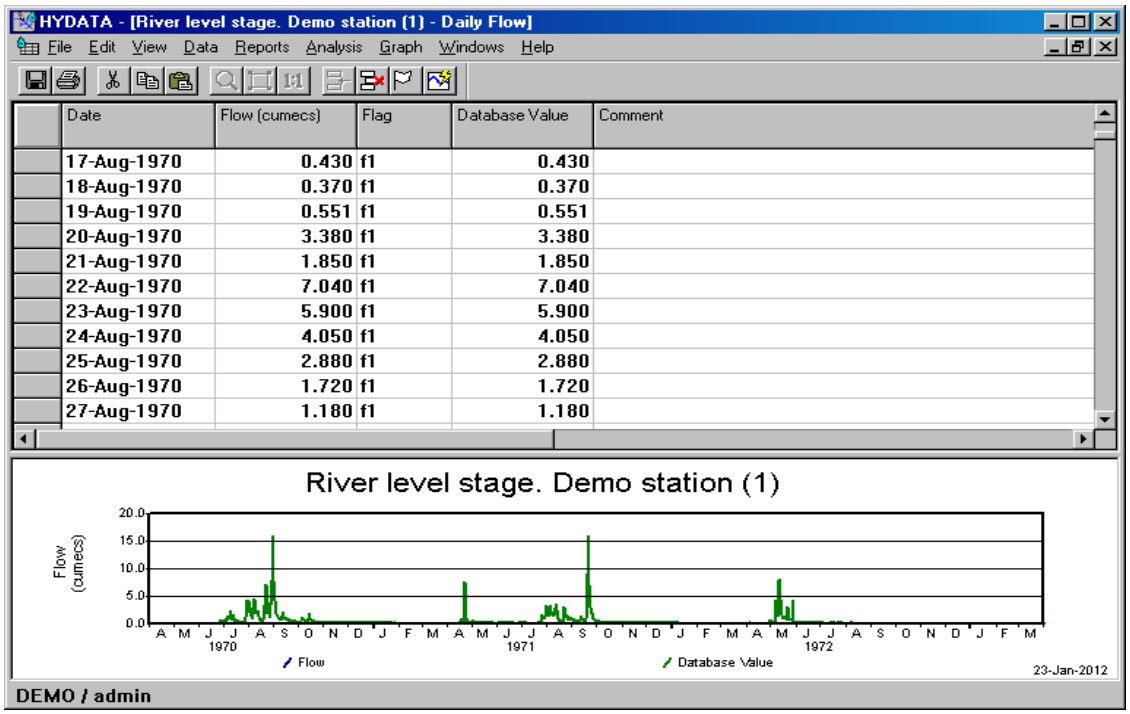
When we say hydrological data we mean that surface water monitoring from rivers, Lakes, Dams and reservoirs. Detail activities are as follows:
The ministries have established 473 stations though out the country and all stations have staff gauges and some of them have automatic data recorders.
All of those stations have local observers which are monitor two times a day but for some stations spatially on rainy season the observer reads hourly then transmit by the radio to the head office this is done for flood forecasting and dam monitoring stations. All of them level readings has established from arbitrary Bench marks this bench marks established on two ways one by identifying the point of point flow from section control for others for big rivers by taking maximum depth's reference we establish 3 bench marks on different location Starting from BM we erect number of staff gauges unto the maximum flood marks. After establishment of the station we wrote the station description, coordinate and other details then produce report to the head office.

The system of water level data collection: - local observers train how he/she can read and take care of data's and Instruments, on the training time we introduce and clarify the importance of his/her collected data on the country future development and also we train him how he can read from auxiliary pointes because in some case the meter section is washed or broken so we put an alternative reading points for the continuity of data. After desiccation by making some questions we watch his/her understanding and reading quality. In some cases the observer may not around so we advice them to train other family members.

The ministry water level record books has four columns the first (gauge reading) and forth (remarks) filled by the observers the second filled by field technicians the third column filled (corrected level) by data processor this book can record for 120 days that is 4 months after this the field technicians collect those gauge books and compute daily mean water level then deliver to the head office. Observers collect two times a day then the field technicians check the primary data quality by seeing the continues of observations and checking with remarks, if he saw some data problems he ask the observer and write additional remarks for data processor on his field report.

Every year on dry season we collect survey data on each river stations by making check from Benchmark then we prepare maintenance report and brought to the head office.
All water level data make corrections after the maintenance report is submitted to the data processors.

The data processor inter the data to the data base, HYDATA which can see the time serious if here is some problems on the continuity of the data he/she make additional data quality checking and may ask the reason of the change from field report. The sample of database is as follows:-



Date	Flow (cumecs)	Flag	Database Value	Comment
17-Aug-1970	0.430	f1	0.430	
18-Aug-1970	0.370	f1	0.370	
19-Aug-1970	0.551	f1	0.551	
20-Aug-1970	3.380	f1	3.380	
21-Aug-1970	1.850	f1	1.850	
22-Aug-1970	7.040	f1	7.040	
23-Aug-1970	5.900	f1	5.900	
24-Aug-1970	4.050	f1	4.050	
25-Aug-1970	2.880	f1	2.880	
26-Aug-1970	1.720	f1	1.720	
27-Aug-1970	1.180	f1	1.180	

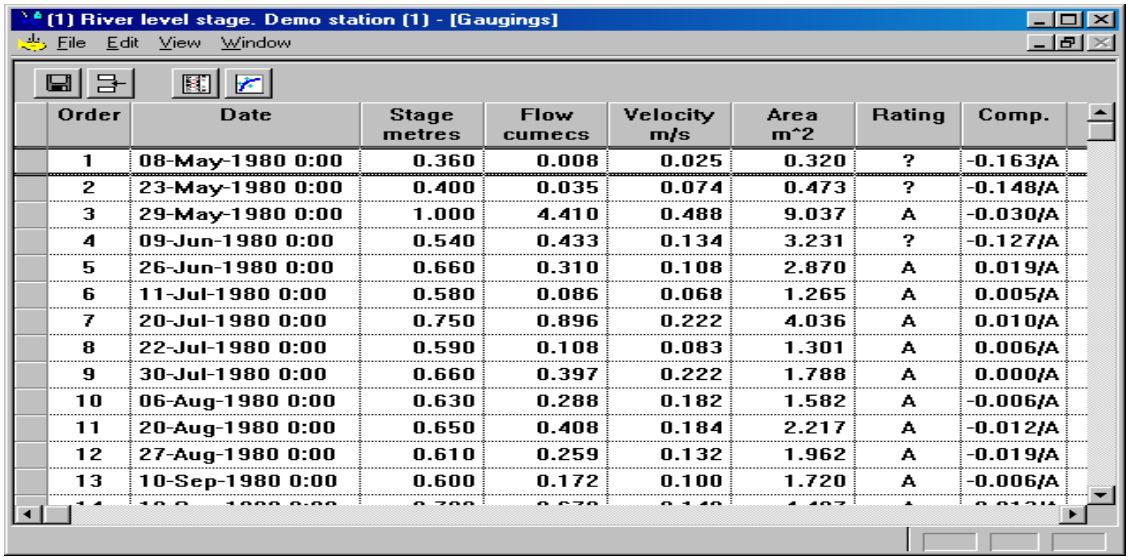
Discharge measurement

Till now the field program is arranged by the head office, according to the beget and logistical arrangement but starting form this year we put annual program and seasonal program discussing and consulting with senior hydrologist.

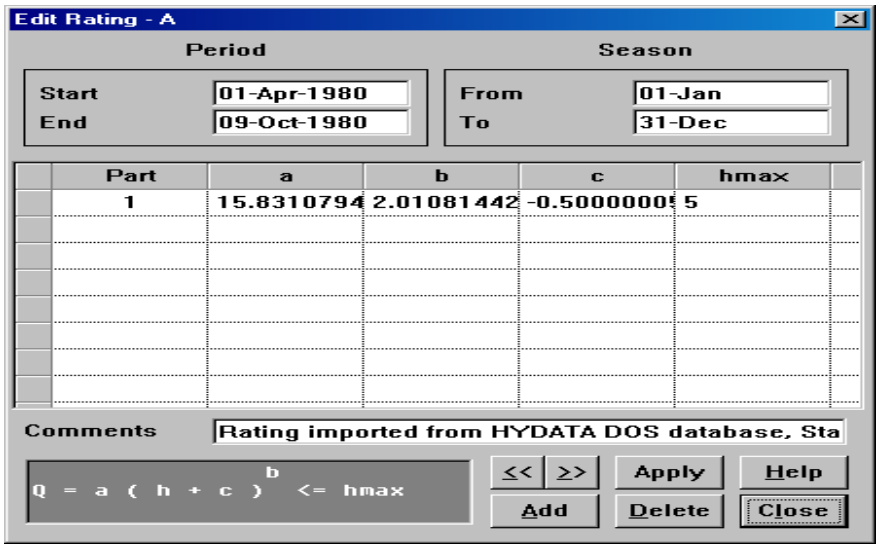
How we collect flow measurement data?

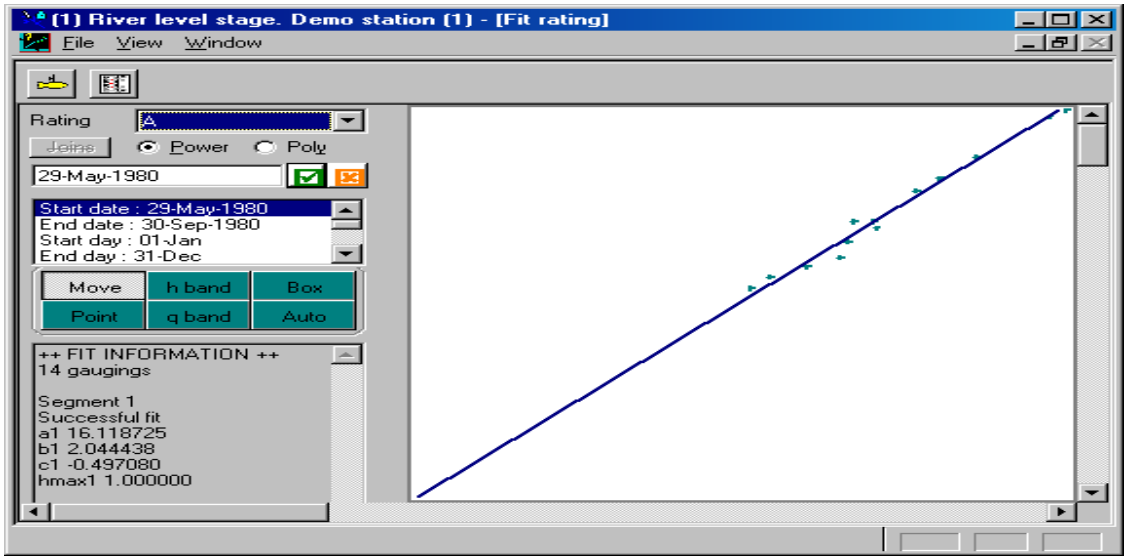
We collect flow measurement data with current meter. Low flow measurements by wading medium and high flow measurements by Bank operating cable way and Bridge crane. All collected data process by field technician and the rating curve are produced by data processors then the daily flow is converted by data processors too.

We collect suspended sediment sampling on rainy season but we did not compute and analyst the collected data we put the raw rata for users. We have some problems for analyzing sediment data.



Order	Date	Stage metres	Flow cumecs	Velocity m/s	Area m^2	Rating	Comp.
1	08-May-1980 0:00	0.360	0.008	0.025	0.320	?	-0.163/A
2	23-May-1980 0:00	0.400	0.035	0.074	0.473	?	-0.148/A
3	29-May-1980 0:00	1.000	4.410	0.488	9.037	A	-0.030/A
4	09-Jun-1980 0:00	0.540	0.433	0.134	3.231	?	-0.127/A
5	26-Jun-1980 0:00	0.660	0.310	0.108	2.870	A	0.019/A
6	11-Jul-1980 0:00	0.580	0.086	0.068	1.265	A	0.005/A
7	20-Jul-1980 0:00	0.750	0.896	0.222	4.036	A	0.010/A
8	22-Jul-1980 0:00	0.590	0.108	0.083	1.301	A	0.006/A
9	30-Jul-1980 0:00	0.660	0.397	0.222	1.788	A	0.000/A
10	06-Aug-1980 0:00	0.630	0.288	0.182	1.582	A	-0.006/A
11	20-Aug-1980 0:00	0.650	0.408	0.184	2.217	A	-0.012/A
12	27-Aug-1980 0:00	0.610	0.259	0.132	1.962	A	-0.019/A
13	10-Sep-1980 0:00	0.600	0.172	0.100	1.720	A	-0.006/A





Problems on Hydrological data collections.

Lack of automatic data recorders, we had strip chart recorders but now a day we could not get strip chats on the market. So it is better to change those in digital data loggers. Of course now a day we have 36 shaft encoder data loggers that down load by down loaders manually, four pressure sensors are received from NVE but till now we do not have any knowledge to install and use those instruments and by WFP we receive 4 radar sensor with telemetry device and data recorders but till now it is not functional.

We have limited data down loaders and Laptops so we need additional Laptops for each field crew we have 11 field crew and two inspection crew We prefer to have Laptops because we may receive different brands of data loggers so it is difficult to have different downloader's but it is easy to load the software to the lap top. We have a shortage of Vehicles and limited for budget.

Group III Presented by Frazer Assefa from Head office.

- The observation of water level takes place twice a day during mornings and afternoons and then we take the average of the daily readings. This taken as a daily water level reading.
- During measuring season we observed the water level once in four month and during the off measuring season the gauge observes the gauge twice a day but during rainy season the observer reads three or more times a day.
- During measuring seasons and off measuring season we simply enter the data collected from the field after processing it and then converted to database system.
- We simply add the two reading of the day and then divide by two to get the daily mean of the water level.

Group IV presented by Dawit Tefera

- Water Level will be taken 2 times per day from staff gauge reading

Error in water level occurs from the observers' carelessness, some of them fill without checking the stations

The readings on the staff gauge are damaged and this also leads to error

Lack of awareness on the use of this data in some of the observers makes them not to check frequently and at same time the frequency of inspection by the hydrology technicians with longer duration leads to error

Suggestion – To upgrade the primary stations to data loggers and stations for floods and reservoirs monitoring to transmit real time data. Improve the frequency of inspection if it possible every one month for primary stations and for others may every two month. Equipped with latest hydrological instruments and also use better condition vehicles and lastly solve the budget and human resource constraints and at the same time strength the capacity of the technicians by giving training.

- For discharge measurement water level will be taken 2 times for Stable River but if it fluctuates more than two. Most of our rivers don't have stable flow regimes, so sometimes if the staff gauge is installed below the bridge the location of the discharge measurement will be in different location preferably upstream of the bridge.

- Water Level will be taken 2 times per day by the observer but for stations for floods and reservoirs monitoring at rainy season reading will be taken everyone hour and it is transmitted by radio to the head office.

Suggestion - Develop to telemetric transmission

- Data transmission is manual all the water level recorder books will be collected from the regional offices and submit to the head office personally by the regional heads every four month

Suggestion – Connect all regional offices with the head office with internet connection and at the same time improve the database system.

- From the two water level readings per day the average will be calculated and this will be taken as daily mean average level

Group V Presented by Birhanu Legesse from Regional office (Awassa)

1. We have two seasonal ways of observing water level:
    a. In rainy / wet season our observers observe two or more times a day according to the frequency of water level fluctuation occurs.
    b. In dry season as a result of as a result of less fluctuation frequency in a day observation is taken twice in the morning and late afternoon.

Discharge measurements

We use two methods of measuring flow discharge in a year:

a. High flow measurement during wet seasons, this time since high volume of water with high speed flow is occurred we use high flow measuring devices like bank operated cables, side bridge, overhead cable way, boat measurement and in the like.
b. Medium and low flow measurements, this time mostly the depth and the stream along the measuring site is relatively less than that of high flow we use wading method to measure discharge.

2. When discharge measurements are done during dry season water level can be recorded twice i.e. at the beginning and at the end of the given measurements since the fluctuation frequency is less or it is constant. But when discharge measurements are done during rainy/wet season since the water level fluctuates frequently it can be recorded several times on discharge measurement note book to represent a good stage discharge relationship.
3. Annually we collect gauge height books from each station and submit to head office as hard copy.
4. We calculate the mean and gauge height by averaging daily observations.

Suggestions from our group

If we inspect stations at least four times a year the data we collect will be better quality.

Otherwise if we inspect all stations according to WMO standards this will be the best.

Group VI Presented by Demeke Nigatu from Head office

- Member of the group have discussed about the training given in the morning and prepaid presentation. We were the last presenter and we listened the presentation of other groups from 1 to 5 and they have raised most of the points so by assuming that there is no use to the trainees to repeat the same points again and again in order to save time we don`t present the resolution, but we want to mention two points.
    - We appreciate and thanks to NVE for giving us participation certificate for previous training.
    - In the training given and by looking from the power point Norway is far ahead in hydrological technology but in our case even though we are started hydrological studies work almost 60 years ago due to lack of wealth and external support we remained back and We hope in the near future with the aid of NVE we shall meet the new technology modernize and approve our work.

Rating curve development practice at MoWE presented by Surafel Mamo

1 Data processing

Data processing is a system of converting raw data or unprocessed data in to a recognizable format that has been collected and encoded from the given gauging station. In other words, it is the process that starting from data acquisition from the field to database management in the office where the data will be given for users and stored in the database. Hydrological data are valuable in that they are relatively expensive to collect, are irreplaceable and have the potential to have very high value following certain events. Thus the methods used to collect and process them must be available in a readily followed form. The data processing system includes to:

- Register the data after collection to confirm its existence and track its processing
- Keep backups of the data in its original form
- Identify the individual data at the various stages of processing
- Identify the status of data as to its origin and whether it has been verified as fit for use
- Present and store evidence or comments of any modifications to the data
- File all field observations which verify the data
- Control the amount and type of editing which can be performed
- Presented the data in number of ways for checking and auditing by trained who are independent of the process

1.1 Correcting Errors and Data Entry

Before entering the raw data in to computer the data should be corrected if there are errors prone such as, data missing during data recording at the station and/ or during data computation. Once the error is corrected throughout the series, then the corrected data would be encoded to the computer to get processed and analysed for different applications.

1.2 Developing Rating Curve

The discharge of a stream is the volume of water flowing through a cross section of the stream per unit time which is normally expressed in cubic meters per second. Discharge measurements are as a rule involved the considerations of both stage and velocity of the flow. When a gauging station has been set up on stream, continuous records of stage (gauge height) can be observed. A continuous record of discharge is obtained by converting the gauge height reading into discharge by means of the stage-discharge relationship for the station. To establish the relation between the stage and the volume of flowing water in the stream, a sufficient number of discharge measurements should be made at different stages.

Required data:

- River/ lake water levels
- River flow measurements

- River cross section profiles

The establishment of reliable relationship between the variable stage and the corresponding discharge is called **rating curve**. The array of points usually lies on the curve which is approximately parabolic and the best fit curve is drawn evenly and smoothly through the scatter of plotted data points. The rating curve is developed either manually or using HYDATA software.

The measurements are plotted on Semi-log graph paper (manual) against their corresponding gauge heights to produce stage-discharge relation. All the discharge measurements are plotted against the corresponding mean stages on suitable logarithmic scales. The correct analysis of the proper shape and position of the rating curve requires knowledge of channel characteristics at the particular hydrological stations in question, knowledge of open channel hydraulics and considerable experience and professional judgments.

1.2.1 Procedures to develop rating curve

1. Manual

Steps/ procedures to establish the rating curve:

i. Plot the discharge measurements on semi-log paper with discharge with horizontal scale and corresponding gauge height on the vertical scale or vice versa
ii. Label the plotted data points in their chronological order of risin g and falling stage du ring measurement and indicate using distinguish symbols (yearly basis)
iii. Drawn appropriately and smoothly through the plotted data points using French curve

Once the discharge measurement and water level are plotted, the following flow parameters would be calculated. Here one should consider that the data extremely far from the fitting curve is considered as outliers and are not considered in the computation.

iv. Low and high flow points should be identified, (G_1, Q_1) and (G_2, Q_2),
v. Compute Q_3 using equation 1

$$Q_3 = \sqrt{Q_1 \times Q_2} \quad \text{---------- (1)}$$

vi. Read G_3 from the corresponding readings of Q_3 from the plot
vii. Determine the three parameters, zero gauge height (G_0 = e), the slope (b) and the flow coefficient (c) using the following empirical equations

$$G_0 = \frac{G_1 \times G_2 - G_3^{\,2}}{G_1 + G_2 - 2G_3} \quad \text{---------- (2)}$$

$$b = \frac{LOGQ_2 - LOGQ_1}{LOG(G_2 - e) - LOG(G_1 - e)} \quad \text{---------- (3)}$$

$$C = \frac{Q_2}{(G_2 - e)^b} \quad \text{---------- (4)}$$

Lastly, the relationship between the staff gauge (G) and discharge (Q) is expressed by a single valued equation, see equation 5, which is used to convert the river water levels to the corresponding time series river flows.

$$Q = c * (G-e)^{b} \quad \text{---------- (5)}$$

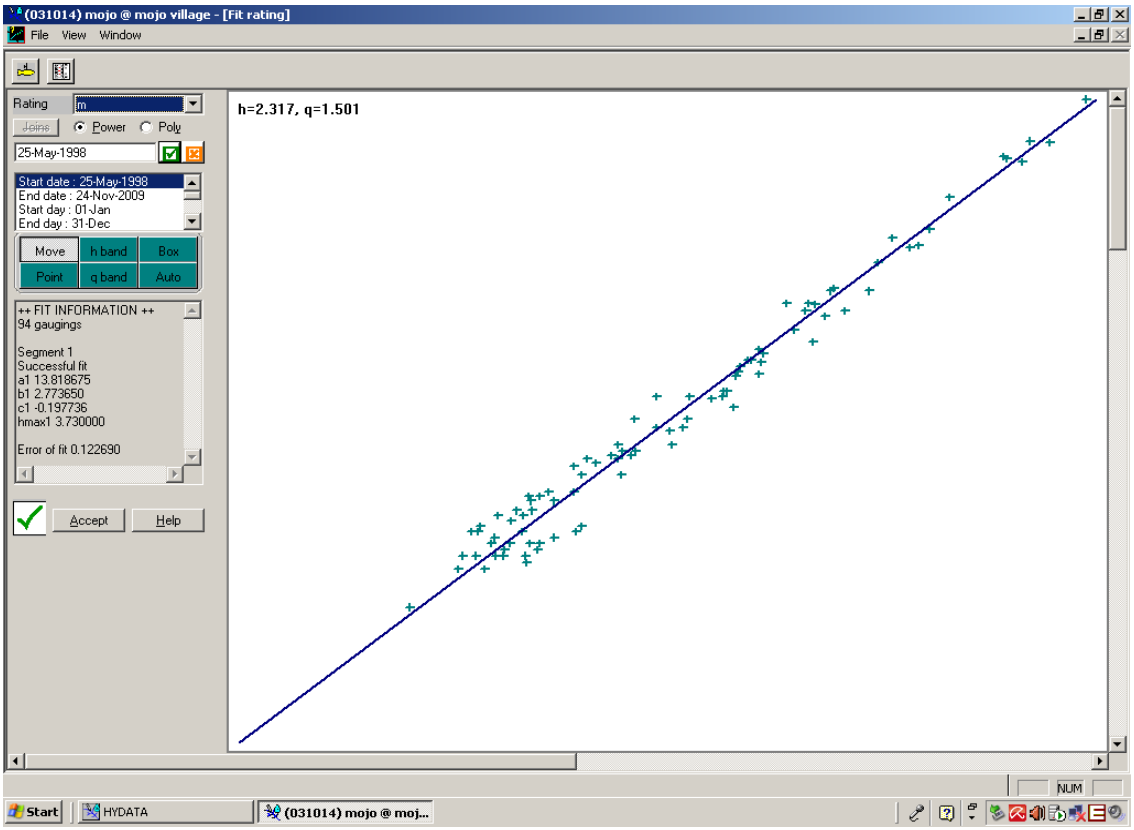
Where: G is stage height in meter, Q is discharge in m^3/s, c is constant number, e is zero gauge height, and b is slope of the river reach.

2. HYDATA software

The rating curves are also developed using HYDATA software using the following steps/ procedures.

i. Create a database
ii. Register the station name and
iii. Register the required time series in the created database such as
    a. River/ lake levels (input)
    b. River gauging and ratings (input)
    c. Flow measurements (output)
iv. Encode the **river/ lake water levels** and **river gauging and ratings** to the software
v. Then convert the river water levels into **flows** as per your time series intervals or the established relationship

Sample rating curve developed by HYDATA software



1.3 Flow determination

Once the rating curves are determined, either manual or using software, flows are estimated from the river water levels. The HYDATA software is also estimates and handled errors easily while developing the rating curve. However, it is difficult to assess and estimate the errors manually based on the number of data population.

Note: if the stage-discharge relationship doesn't change with time, it is considered as a permanent control if not it is a shifting control. Shifting control is usually due to erosion or deposition of sediment at the stage measurements. This is determined from the **cross section profile** of the river.

Denne serien utgis av Norges vassdrags- og energidirektorat (NVE)

Utgitt i Rapportserien i 2012

Nr. 1 Kvikkleireskred ved Esp, Byneset i Trondheim. Kari Øvrelid (20 s.)

Nr. 2 Årsrapport for tilsyn 2011 (40 s.)

Nr. 3 Første inntrykk etter ekstremværet Dagmar, julen 2011 (27 s.)

Nr. 4 Energy consumption. Energy consumption in mainland Norway (59 s.)

Nr. 5 Climate change impacts and uncertainties in flood risk management:
Examples from the North Sea Region (62 s.)

Nr.6 Kvartalsrapport for kraftmarknaden. 4. kvartal 2011. Finn Erik Ljåstad Pettersen (red.) (86 s.)

Nr. 7 Statistikk over nettleie i regional- og distribusjonsnettet 2012. Inger Sætrang (53 s.)

Nr. 8 Flomrisikoplan for Gaula ved Melhus. Et eksempel på en flomrisikoplan etter EUs flomdirektiv (78 s.)

Nr. 9 Inntak Viddal – FoU-prosjekt på tilbakespyling. Sluttrapport. Jan Slapgård (31 s.)

Nr. 10 Oversikt over vedtak og utvalgte saker. Tariffer og vilkår for overføring av kraft 2011 (15 s.)

Nr. 11 Flomsonekart: Delprosjekt Ålen: Kjartan Orvedal, Julio Pereira

Nr. 12 NVEs årsmelding 2011

Nr. 13 Vannet vårt. Hydrologi i Norge 2011

Nr. 14 Capacity building in Hydrological Services Course in Water Level recording and Data Processing
at Ministry of Water and Energy 13th – 16th February 2012. Documentation (23 s.)

Norges
vassdrags- og
energidirektorat

Norges vassdrags- og energidirektorat

Middelthunsgate 29
Postboks 5091 Majorstuen
0301 Oslo

Telefon: 09575
Internett: www.nve.no