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## **Hydrological and meteorological monitoring at Oskarshamn, July 2005 until December 2006**

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January 2007

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*Keywords:* Hydrological and meteorological stations, Discharge, Sea level, Conductivity, Water temperature, Air temperature, Precipitation, Barometric pressure, Global radiation, Wind speed, Wind direction, Snow depth, Ground frost, Accumulation and melting of ice, Calculated potential evapotranspiration, Evaporation.

This report concerns a study which was conducted for SKB. The conclusions and viewpoints presented in the report are those of the authors and do not necessarily coincide with those of the client.

Data in SKB's database can be changed for different reasons. Minor changes in SKB's database will not necessarily result in a revised report. Data revisions may also be presented as supplements, available at [www.skb.se](http://www.skb.se).

A pdf version of this document can be downloaded from [www.skb.se](http://www.skb.se).

## Abstract

In the Simpevarp area nearby Oskarshamn meteorological monitoring has been going on since year 2003 and hydrological monitoring since the beginning of year 2004. Meteorological measurements are performed at two places, Äspö and Plittorp. Measured and calculated parameters at these stations are temperature, wind speed and direction, air humidity, precipitation, air pressure, global radiation and potential evapotranspiration. The Swedish Meteorological and Hydrological Institute, SMHI, has been responsible for planning and designing of the two stations used for meteorological monitoring. Furthermore, SMHI has been responsible for planning and constructing fifteen hydrological measuring stations. At these hydrological stations, water levels in lakes and in the sea are taken. Additional water temperature and electrical conductivity are measured and discharges in watercourses decided. Hydrological measurements are performed at fifteen different places.

This report also includes the registration and measurements of certain weather parameters that have been done within the area during the measurement period. Snow depth, depth of frost and ice cover break up was registered during wintertime.

The quality of meteorological and hydrological measurements during the period concerned, starting 2005-07-01 and ending 2006-12-31 has showed to be rather good. It has been minor interruptions in measurements according to malfunctioning equipment or maintenance work.

At the hydrological stations intended for discharge measurements in watercourses, the rating curves have been determined and discharge recalculated from station start through quality checked water level data. However, an important remark regarding data quality has to be announced. Most rating curves still have too few control measurements of discharge to be regarded as reliable, especially at higher water levels. Further measurements are therefore strongly recommended to make the rating curves reach an approved level of quality. Hydrological monitoring is made according to elevation system RT90-RHB70.

## Sammanfattning

I Simpevarpsområdet utanför Oskarshamn har meteorologiska mätningar pågått sedan år 2003 och hydrologiska mätningar sedan början av år 2004. De meteorologiska mätningarna sker på två platser, på Äspö och i Plittorp. Här har master med registrerande instrument monterats. De meteorologiska parametrar som mäts och bestäms är temperatur, vindhastighet och riktning, luftfuktighet, nederbörd, lufttryck, globalstrålning och potentiell evapotranspiration. Sveriges Meteorologiska och Hydrologiska Institut, SMHI, har varit ansvariga för utformandet av de två meteorologiska mätstationerna. SMHI har också konstruerat och byggt 15 hydrologiska mätstationer. Vid dessa mäts vattennivåer i sjöar och i havet. Ytterligare parametrar som mäts är vattentemperatur och elektrisk konduktivitet samt bestämning av vattenföringar i vattendragen.

Under perioden har det även skett en registrering av vissa väderrelaterade parametrar. Snödjup, frostdjup, tidpunkt för isläggning samt islossning har registrerats och finns inkluderade i denna rapport.

Kvaliteten hos de meteorologiska och hydrologiska mätningarna utförda under perioden 2005-07-01 till och med 2006-12-31 har varit god. Det har endast förekommit några kortare avbrott i mätningarna orsakade av fel på mätutrustningen eller på grund av underhållsarbete.

Vid de hydrologiska mätstationer där vattenföringen skall bestämmas, har avbördningskurvorna fastställts och vattenföringen beräknats från stationsstart med hjälp av kvalitetsgranskade vattenståndsdata. En viktig kommentar måste dock framhållas. Flera avbördningskurvor innehåller fortfarande för få uppmätta samband för att kunna anses som tillförlitliga, speciellt vid högre vattenstånd. Ytterligare mätningar rekommenderas därför starkt så att avbördningskurvorna kan uppnå en godtagbar kvalitetsnivå. Alla hydrologiska mätningar görs i höjdsystemet RT90-RHB70.

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# 1 Introduction

This document reports the results of hydrological and meteorological measurements made in the area of Oskarshamn. The activities are performed within the site investigation at Oskarshamn and carried out in accordance to activity plan SKB AP PS 400-04-087 and SKB AP PS 400-04-088, (SKB internal controlling documents). This document also reports the data gained in “Registration of snow depth, depth of frost in the ground and time for ice cover/ice break up” which was also one of the activities performed within the site investigation at Oskarshamn. The work was carried out according to activity plan SKB AP PS 400-02-023 (SKB internal controlling document).

Hydrological measurements started in January 2004. Measured parameters are sea water level, water level in lakes and discharge in small creeks. Water temperature and conductivity are also measured at the runoff stations. At the moment hydrological measurements are made at fifteen different stations. Data presented in this document are quality checked and approved.

To characterise the investigation area regarding meteorological conditions SMHI has placed two stations with meteorological measuring equipment on the site. The results will be used for calculations of hydrological parameters.

The geographical locations of the meteorological and hydrological measuring stations can be seen on the map in Chapter 4.

This report presents the hydrological and meteorological monitoring and measurements of winter parameters during period 2005-07-01 until 2006-12-31.

Previous available monitoring reports and controlling documents used in the activity are presented in Table 1-1.

**Table 1-1. Controlling documents for the performance of the activity.**

| <b>Activity plan</b>  | <b>Number</b>                     | <b>Version</b> |
|---|-----------------------------------|----------------|
| Yhydrologiskt monitoringsprogram  | SKB AP PS 400-04-087              | 1.0, 2.0, 3.0  |
| Meteorologiskt monitoringsprogram   | SKB AP PS 400-04-088              | 1.0, 2.0, 3.0  |
| Registrering av snödjup, tjäldjup och tider för isläggning/islossning vintern 2002/2003 | SKB AP PS 400-02-023              | 1.0            |
| Installation av tjäldjupsmätare   | Tillägg till SKB AP PS 400-02-023 |                |
| <b>Method descriptions</b>  | <b>Number</b>                     | <b>Version</b> |
| Meteorologiska mätningar  | SKB MD 364.007                    | 1.0            |
| Yhydrologiska mätningar   | SKB MD 364.008                    | 1.0            |
| <b>P-reports</b>  | <b>Number</b>                     |                |
| Hydrological and meteorological monitoring at Oskarshamn during 2003–2004               | P-05-227                          |                |
| Hydrological and meteorological monitoring at Oskarshamn, November 2004 until June 2005 | P-06-19                           |                |

## 2 Objective and scope

SKB conducts site investigations for a future deep repository for spent nuclear fuel in the Laxemar area close to Oskarshamn. To characterise the investigation area regarding the meteorological conditions SMHI has installed two stations with meteorological measuring equipment at the site. The results will be used for calculations of hydrological parameters.

Hydrological measurements are performed at fifteen stations located at different sites. Since the stations were built in a period of one year, their measurements do not all start at the same time. The first station was built in January 2004 and the last in the end of January 2005. Information about the hydrological stations and periods of measurements are given in the table in Appendix 1.

This report also comprises measurements and registrations of certain weather parameters within the Oskarshamn area, during wintertime.

The objective with this report is to present quality checked results from hydrological and meteorological monitoring made during the period 2005-07-01 until 2006-12-31.



## 3 Equipment

### 3.1 Hydrological measuring stations

Common for all stations is that the battery capacity is always measured and logged. This value is however only stored in the database at SMHI.

#### 3.1.1 Runoff stations

The runoff stations PSM000341, PSM000343, PSM000345, PSM000347 and PSM000365 are constructed in concrete as V-notch weirs (triangular shaped outlet of water). At these stations, measurements are made with a Campbell CR10X data logger. A cellular phone and a GSM modem Siemens TC35, 9600 baud, establish communication. A dry cellular battery, CellTech (15 V, 90 Ah) sustains power supply. Sensors and measured parameters are presented in Table 3-1.

At the runoff stations PSM000348, PSM000353, PSM000364 and PSM000368 discharge is measured according to a natural cross section in the watercourse. Equipment, sensors and measured parameters are the same as for the stations with constructed concrete dams. Water level is measured in metre above sea level, m.a.s.l. Sensors and measured parameters are presented in Table 3-2.

**Table 3-1. Sensors and measured parameters at stations PSM000341, PSM000343, PSM000345, PSM000347 and PSM000365.**

| Parameters                                       | Sensors   |
|--|---|
| Water level above V-notch. (cm)                  | DRUCK PDCR1830, mV, range 1.5 m, vented.                        |
| Conductivity and water temperature (mS/m and °C) | Campbell CS547, range 0.5–100 mS/m with interface CampbellA547. |

**Table 3-2. Sensors and measured parameters at stations PSM000348, PSM000353, PSM000364 and PSM000368.**

| Parameters                                       | Sensors   |
|--|---|
| Water level (m.a.s.l.)                           | DRUCK PDCR1830, mV, range 1.5 m, vented.                        |
| Conductivity and water temperature (mS/m and °C) | Campbell CS547, range 0.5–100 mS/m with interface CampbellA547. |

### 3.1.2 Water level stations

At the water level stations PSM000359 and PSM000371 measurements are carried out with a Campbell CR510 data logger. A cellular phone and a GSM modem Siemens TC35, 9600 baud, establish communication. Power supply is sustained by a charger 1.5 A, 14 VDC connected to 230 VAC. The stations are connected to ground and equipped with a lightning conductor. Sensors and measured parameters are presented in Table 3-3.

At the water level stations PSM000369 and PSM000370 the equipment is almost the same as for PSM000359 and PSM000371 but a dry cellular battery, Celltech 14 V, 90 Ah sustains power supply. Sensors and measured parameters are presented in Table 3-4.

### 3.1.3 Calibration of equipment used at hydrological measuring stations

The manufacturers calibrate the measuring equipment. DRUCK calibrates the level pressure probes and Campbell Scientific, inc. calibrates the conductivity and temperature probe. The function of every probe was thoroughly tested before deployment. These tests were performed by FDS mätteknik AB a sub-contractor to SMHI. Protocols from calibration have been delivered to SKB.

## 3.2 Meteorological measuring stations

The table below gives technical information about the equipment. Polycarbonate cupboards house data loggers (type Campbell CR10X), modem (Siemens TC35 and COM200E) and are earthed for lightning protection.

The wind is measured at 10 metres above ground level, the other parameters at 2 metres.

**Table 3-3. Sensors and measured parameters at stations PSM000359 and PSM000371.**

| Parameters             | Sensors                                  |
|------------------------|--|
| Water level (m.a.s.l.) | DRUCK PDCR1830, mV, range 1.5 m, vented. |

**Table 3-4. Sensors and measured parameters at stations PSM000369 and PSM000370.**

| Parameters             | Sensors                                  |
|------------------------|--|
| Water level (m.a.s.l.) | DRUCK PDCR1830, mV, range 1.5 m, vented. |

**Table 3-5. Measuring equipment for collecting of meteorological data at the stations.**

| Parameters               | Equipment   |
|--------------------------|---|
| Wind speed and direction | RM Young Wind monitor   |
| Air temperature          | Pt100 sensor with radiation shield and ventilated Young 41004 |
| Humidity                 | Rotronic HygroClip MP 100H                                    |
| Precipitation            | Geonor T200 complete with pedestal and wind shield            |
| Pressure                 | PTB200  |
| Global radiation at Äspö | Kipp&Zonen CM21 with warming and fan                          |

### **3.2.1 Calibration of equipment used at meteorological measuring stations**

Calibration of the instruments using data submitted by the manufactures was done by FDS along with the installation of the instruments. No further need of calibration has been required.

## **3.3 Winter parameters**

### **3.3.1 Depth of snow**

The snow depth has been measured according to SMHI's Handbook for observers (In Swedish: SMHI:s handbok för observatörer) /7/. The measuring device has been a measuring stick graded in centimetres.

### **3.3.2 Depth of frost in ground**

The depth of frost in the ground has been measured according to SMHI's Handbook for observers /7/. The measurements are performed with a specific measuring device. The device consists of a protective tube with a disc and a protective hood, including a measurement tube with solution. The solution consists of methylene blue and distilled water. When the water freezes the blue colour disappears and this is utilized when observing the position of frost in the ground. The measurement tube is graded in centimetres.

The ground level is marked and this together with the protective hood is what is usually seen above ground. When installing the device at Oskarshamn there were some difficulties because of the large numbers of boulders in the ground. Because of this a small part of the measuring tube is also present above ground, see Figure 3-1. This has no impact on the measurements, however.

### **3.3.3 Ice cover**

The observation of ice freeze and break up was performed by visual inspection.



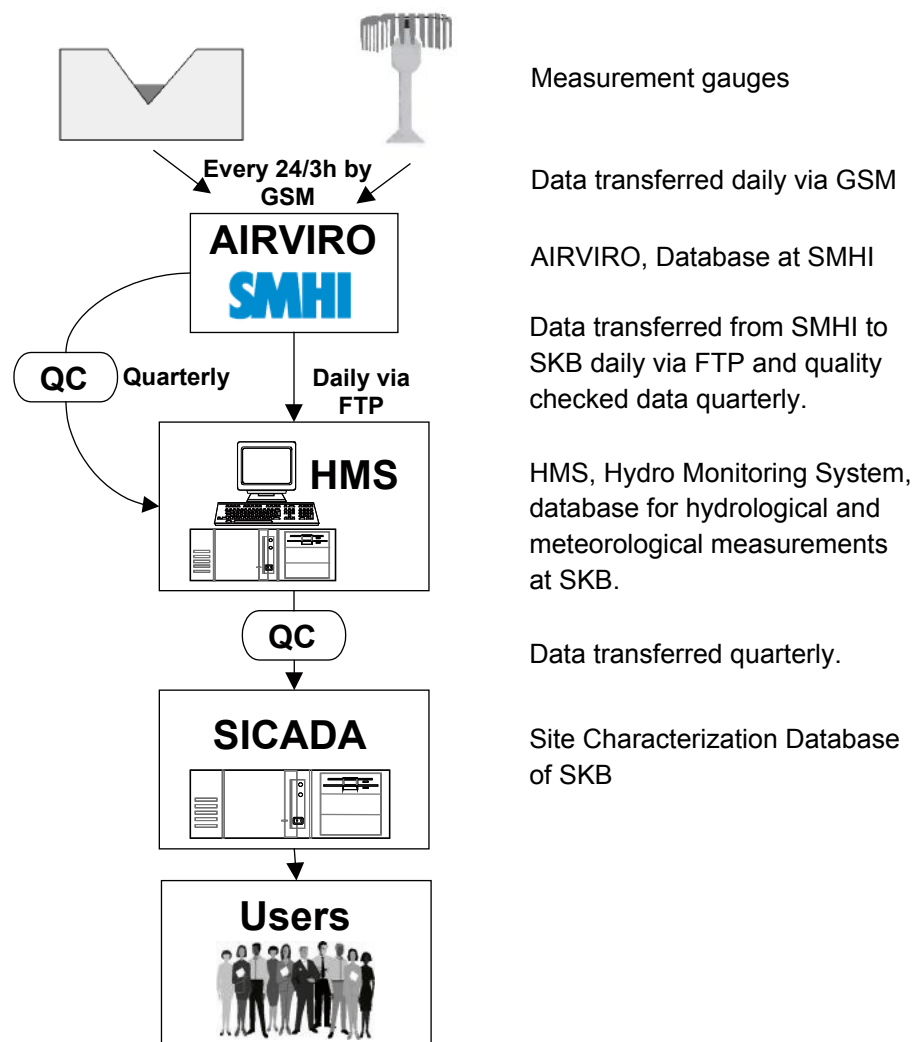
*Figure 3-1. Measuring device for registration of depth of frost in the ground at PSM006980.*

## 4 Execution

### 4.1 General

This execution chapter is intended to describe the complete course of events, from measuring, via quality check, data handling to the storage in SICADA. On the map in Figure 4-2 it is pointed out where all monitoring stations are geographically located.

Two terms that are frequently used in this context is HMS and SICADA, SKB's data system, could therefore require a definition. HMS (Hydro Monitoring System) is SKB's network for the monitoring of hydrological, hydrogeological and meteorological parameters. This is a system for collection, calculation, and data check up and presentation. SICADA is the database that contains all of SKB's quality assured data. It is from these data the modelling and analyses are done, see Figure 4-1.



*Figure 4-1. Flowchart – meteorological and hydrological data.*

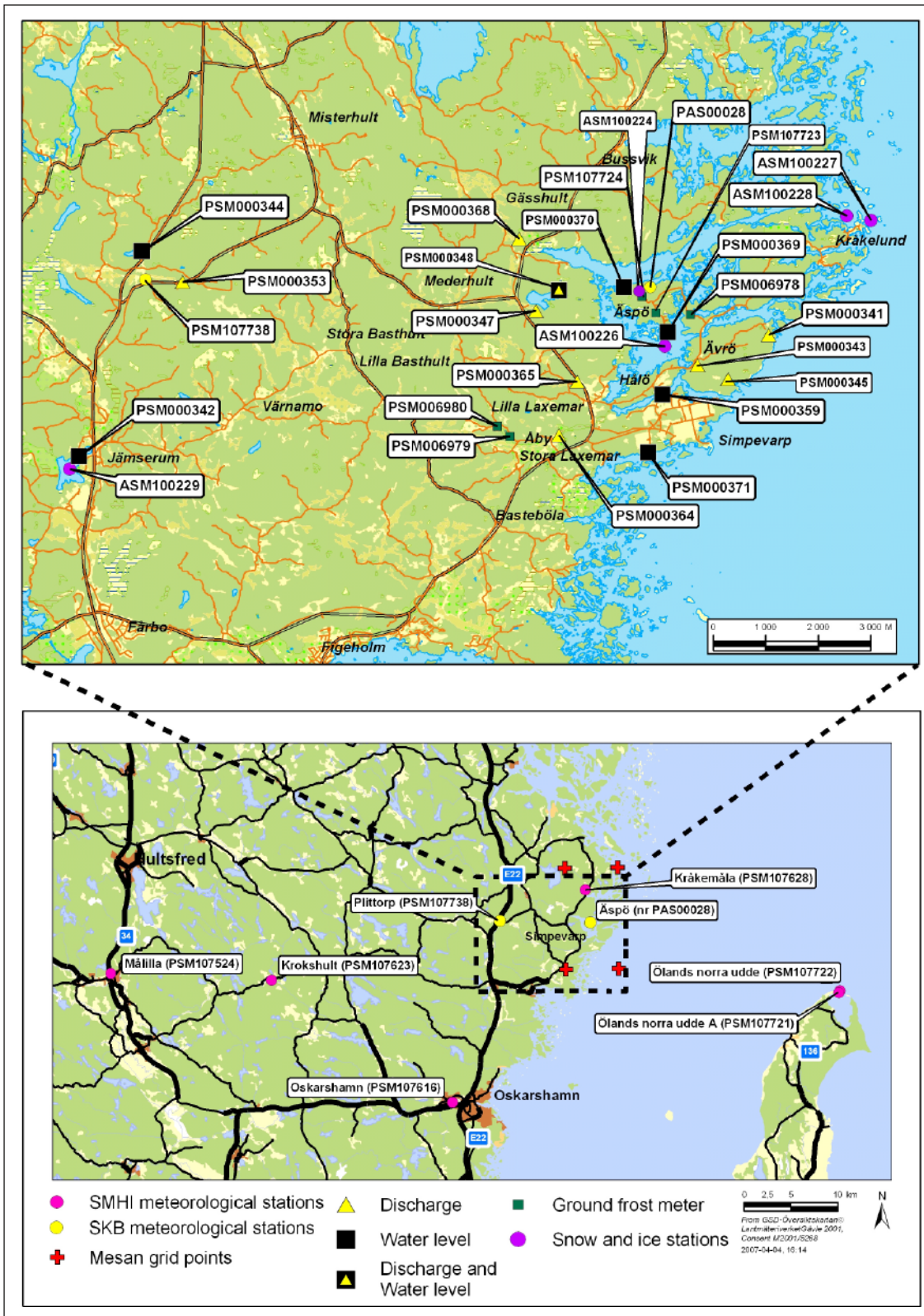


Figure 4-2. Map showing objects of all monitoring stations except Station Gladhammar (PSM107642) which is located 45 km north of Oskarshamn.

## 4.2 Hydrological measurements

All sensors, probes and other equipment shall be checked and serviced once a year or if needed as soon as possible. SMHIs sub contractor, FDS Mätteknik AB will handle malfunction of equipment. During 2006-05-03 to 2006-05-04 SMHI inspected all hydrological stations in the Simpevarp area. At each station the water level sensor was checked to log correct values and the concrete dams were levelled to check that they had not moved since they were built. At most of the stations the sensors for temperature and conductivity were cleansed. The water temperature was checked with a reference thermometer and water specimens were sent to the SKB laboratory for conductivity analysis.

The level pressure sensors are tested by measuring the present water level. The water level is then compared to the value in the data logger. If any discrepancy is detected the logger is adjusted.

At the runoff stations, the water head above the V-notch should be set in the data logger.

The probe used for measuring conductivity and water temperature should be tested in water with known conductivity. During the inspection a simultaneous water sample was analysed at the Äspö laboratory for comparison. The water temperature should be measured with a reference thermometer. The measured value in the data logger of conductivity and temperature are then compared with the reference values.

The runoff stations need some extra care because it is very important that the flow trough the V-notch is not blocked or influenced by ice, leaves or debris. For this reason SKB have established a scheduled standard procedure for regular inspection of the stations. The inspection and cleaning records are stored in the SICADA database.

### 4.2.1 Discharge in water courses

Hourly measurements of discharge have been made at nine stations. Four of these stations – PSM000348, PSM000353, PSM000364 and PSM000368 – are situated at sites where a natural cross section has been used to establish the rating curves.

The other five stations – PSM000341, PSM000343, PSM000345, PSM000347 and PSM000365 – are situated at sites where concrete dams are built and where the discharge is measured with a V-notch weir. The V-notch weir is a concrete dam with a triangular, V-notch shaped, outlet. The opening angle in the V-notch varies between these stations from 45°, 60° and 120° and theoretically, the discharge (Q), could be derived from a discharge formula. The upstream level is uniquely related to the discharge over the crest where the flow passes through critical conditions. For a V-notch weir, the discharge formula becomes /1/:

$$Q = 8/15 \cdot \mu \cdot (2g)^{1/2} \cdot h^{5/2} \cdot \tan \alpha / 2$$

Q Discharge (m<sup>3</sup>/s)

$\mu$  Coefficient approximately constant, a value between 0.60 and 0.65.

g Gravity constant (9.81 m/s<sup>2</sup>)

h Head above the V-notch (m)

$\alpha$  Angle in V-notch

The water level (head) above the V-notch point is measured. When the water stage is at the same level as the V-notch, discharge from the weir also equals zero; i.e. the level of the V-notch point is set to zero. It should be pointed out that it is the water level that is measured at the discharge stations and not directly the discharge. The discharge has to be calculated from the discharge formula. Calculations with this equation are only reliable when the weirs are built with idealistic proportions. Due to conditions of local ground structure at the building site, idealistic dam

proportions are sometimes hard to achieve. Therefore, in most cases a rating curve has to be established before any reliable calculations of discharge can be made. Until then calculation of discharge has to be made with assumed values of parameters in the discharge formula and will be delivered as such.

At the moment discharges at station PSM000341, PSM000343 and PSM000345 are calculated from rating curves established from control measurements made by SKB and SMHI. At station PSM000347 and PSM000365 discharge is calculated with the discharge formula. In calculations at these stations the value of the coefficient  $\mu$  has been set to a reasonable level of 0.60. Presently we do not know if this is a proper value of the coefficient  $\mu$  for both these stations. The discharge values presented in this report are for that reason affected with a degree of uncertainty and later on adjustments in accordance to rating curves will be made.

The drainage areas where dams are built are very small. Therefore, the creeks or ditches will be dried up during main part of the year. The drainage area estimated by SKB and the opening angle in V-notch for each dam are presented in Table 4-1.

At the stations PSM000348, PSM000353, PSM000364 and PSM000368 discharge should be measured according to a natural cross-section in the watercourse, i.e. no dams are constructed. All water levels are measured in metre above sea level (m.a.s.l.) in elevation system RT90-RHB70. The drainage area estimated by SKB for each station is presented in Table 4-2.

At 2006-10-01 the rating curves for all discharge stations were determined, and discharge recalculated from station start through quality checked water level data. See the rating curves in Appendix 2. All discharge data was sent to SKB 2006-10-05. A rating curve describes the relationship between the measured water stage and the corresponding discharge. It usually takes some time to gain a reliable rating curve and until then measurements of water level are stored at these four stations. However, an important remark regarding data quality has to be made. Most rating curves still have too few control measurements of discharge to be regarded as reliable, especially at high water levels. Further measurements are therefore strongly recommended to make the rating curves reach an approved level of quality.

**Table 4-1. Drainage area and V-notch angle for the dams.**

| Station Id | Object         | Measuring place | V-notch opening angle | Drainage area (km <sup>2</sup> ) |
|------------|----------------|-----------------|-----------------------|----------------------------------|
| PSM000341  | Ävrö NE        | Dam             | 45°                   | 0.29                             |
| PSM000343  | Ävrö SW        | Dam             | 45°                   | 0.11                             |
| PSM000345  | Ävrö SE        | Dam             | 45°                   | 0.16                             |
| PSM000347  | Frisksjön (in) | Dam             | 60°                   | 0.91                             |
| PSM000365  | Ekerumsån      | Dam             | 120°                  | 2.38                             |

**Table 4-2. Drainage area for PSM000348, PSM000353, PSM000364 and PSM000368.**

| Station Id | Object            | Measuring place                | Drainage area (km <sup>2</sup> ) |
|------------|-------------------|--------------------------------|----------------------------------|
| PSM000348  | Frisksjön (out)   | Lake and natural cross-section | 1.88                             |
| PSM000353  | Laxemarån (upper) | Natural cross-section          | 14                               |
| PSM000364  | Laxemarån (lower) | Natural cross-section          | 40                               |
| PSM000368  | Kärrviksån        | Natural cross-section          | 27                               |



## **4.2.2 Water temperature and electrical conductivity, (EC)**

At all stations monitoring discharge and also the water temperature and electrical conductivity, EC, are measured. At stations where dams are constructed, temperature and EC are measured in the small basin upstream the concrete dam. At stations where natural cross sections are used the sensor is placed as deep as possible in the creek or the lake.

## **4.2.3 Water level**

The logged water level is an arithmetic mean value calculated from measurements made every fifth second during one hour. Hourly mean values are stored.

### ***Sea water level***

Sea water level is measured at three places in the surroundings of Äspö. The stations are PSM000369, PSM000370 and PSM000371. At these stations, measurements have been performed since January 2004. Measurements are taken in elevation system RT90-RHB70 and they are expressed as metre above sea level (m.a.s.l.).

### ***Water level measured in lakes and reservoirs***

Water level is also measured at station PSM000342 and PSM000344. At PSM000342 water level is measured in lake Jämsen and at station PSM000344 in lake Plittorpsgöl. All measurements are in elevation system RT90-RHB70. At one station, PSM000359, the water level in the reservoir at Sörå is measured. This is an artificial reservoir created as a backup for the freshwater supply to the nuclear power station. Measurements are in metre above sea level, (m.a.s.l.), in elevation system RT90-RHB70.

## **4.2.4 Quality check of hydrological data**

Before any data are finally stored in SKB's database SICADA they have to be approved. Each week SMHI performs a primary check for deviating values and every third month a senior hydrologist will check and approve data before the delivery for final storage in SKB's database, SICADA. Delivery of checked and approved data to SKB is carried out quarterly.

### ***Quality check of discharge stations***

Weekly data is checked to limit possible disturbances and interruptions. Measurements of runoff are compared between neighbouring stations. Runoff from stations in nearby areas should mostly show the same pattern. Corrections of data are made if any disturbances or irregularities appear.

Water temperature and conductivity measurements are also compared between nearby stations. Even here, the same pattern is mostly expected. Disturbances or irregularities are corrected. Measurements of conductivity and water temperature are not approved when the water level is equal to or below the V-notch point in the dams. No water is then running in the creek and temperature and conductivity values are therefore not representative.

### ***Quality check of water level stations***

Data checks are made weekly to limit possible disturbances and interruptions.

Measurements from seawater level stations compare to each other because the same pattern is mostly expected. Corrections and adjustments of any disturbances or irregularities are made.

Water level at PSM000359, being a reservoir, does not follow the same pattern as the sea level stations. For this reason, measurements of water level at this station are judged separately. Disturbances or irregularities are corrected.

Water levels taken in lakes are compared to each other because the same behaviour is expected.

## **4.3 Meteorological measurements**

Data are collected every half-hour. The different parameters are valid for the following time period:

- Precipitation: Accumulated sum of precipitation every 30 min. The 30-min precipitation value is the difference between two adjacent accumulated precipitation sums.
- Temperature: Arithmetic mean of 1-second values for 30 minutes.
- Air pressure: Arithmetic mean of 1-second values for 30 minutes.
- Relative humidity: Arithmetic mean of 1-second values for 30 minutes.
- Wind speed and wind direction: The latest 10-minutes mean value for the actual half-hour, hence for the 10.00 data the measurement is from 09.51 to 10.00.
- Global radiation: Arithmetic mean of 1-second values for 30 minutes.

### **4.3.1 Quality check of meteorological data**

Before any data finally will be stored in SKB's database SICADA they have to be controlled and approved by SMHI. Every week a primary check for missing and incorrect values will be performed by SMHI and every third month the check will be performed by a meteorologist at SMHI that will approve data, calculate potential evapotranspiration and estimate the true precipitation before delivery for final storage in SKB's database, SICADA.

### **4.3.2 Data handling/post processing**

The data logger at the station has an internal memory to secure the data in case of communication disturbances. The system is called upon every three hours through SMHI's air quality system AIRVIRO, where the data is stored and the quality assurance and check is done. After this check has been performed, data is delivered to the HMS database.

SMHI has constructed a homepage according to SKB's wishes, where the results of the measurements can be shown as graphs and from which data can be extracted. The address is: <http://www.airviro.smhi.se/oskarshamn/>.

## **4.4 Winter parameters**

### **4.4.1 Measurement of co-ordinates**

Coordinates for each station, Figure 4-2, were measured according to SKB's instruction SKB MD 110.001 /8/. The co-ordinates were then noted in a specific protocol. Each object received a specific ID-code, see Table 4-4. For measurement of snow depth and observations of ice conditions, the objects were registered as surfaces, while the objects for frost in the ground and ice conditions were registered as points.

**Table 4-4. Id-code numbers for the objects in this activity.**

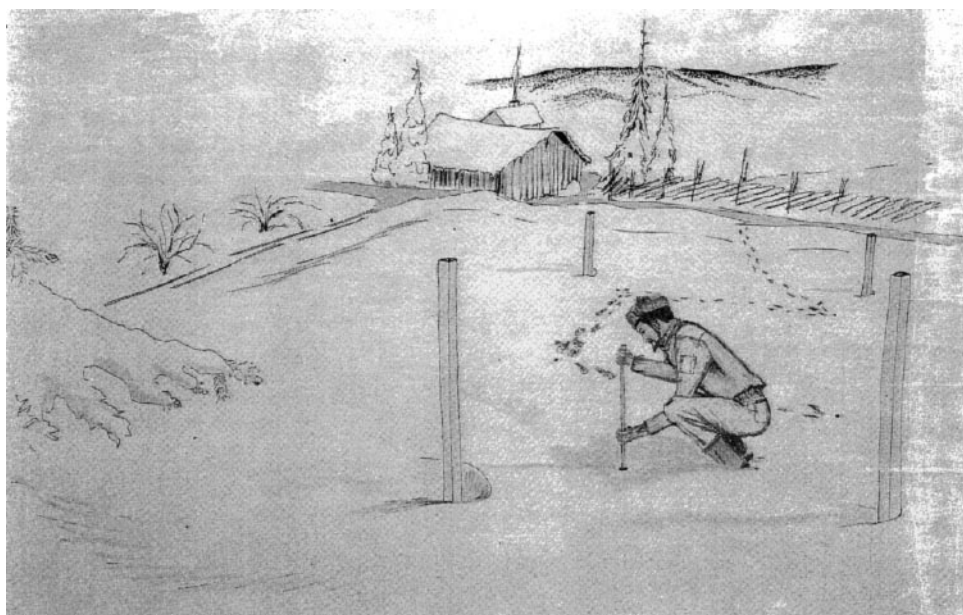
| Measurement/observation | Id-code   | Name            |
|-------------------------|-----------|-----------------|
| Snow depth              | ASM100224 | Grillplatsen    |
| Frost in ground         | PSM007724 | Grillplatsen    |
|                         | PSM006978 | Löv1            |
|                         | PSM006979 | Grindstugan     |
|                         | PSM006980 | Åker            |
| Ice cover               | ASM100226 | Äspö brygga     |
|                         | ASM100227 | Kråkelund yttre |
|                         | ASM100228 | Kråkelund inre  |
|                         | ASM100229 | Jämsen          |

#### 4.4.2 Snow depth

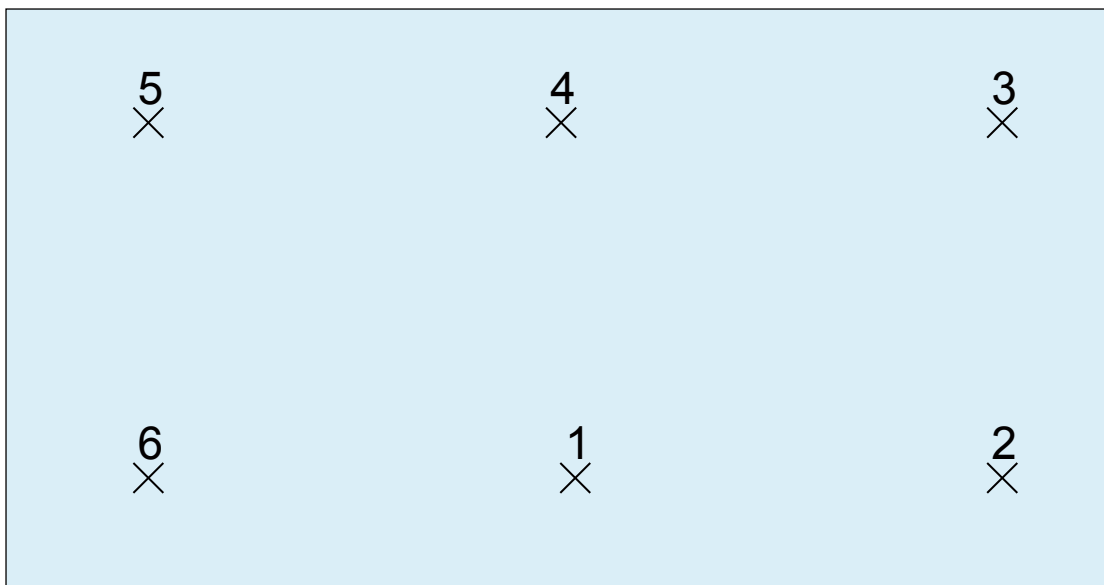
Snow depth is in this case defined as the depth of snow from snow surface to ground. The characteristics of the site for execution of the measurement are of vital importance. The site should have a fairly smooth ground surface and the snow should not fall in drifts or be blown away. The sampling station has been a forest glade (see map in Figure 4-2). The chosen areas were marked with poles of such a length that they would be seen even at maximum snow depth, Figure 4-3.

The measurement was executed once a week starting from the autumn's first snowfall until the snow surface was completely gone during springtime. The measurement was performed once a week, even if no snow had been falling, since packing, melting or evaporation should be considered as well.

The measurement was performed with a graded measuring stick, which was vertically squeezed through the snow layer until the ground was hit. The snow depth was read in centimetres. The measurement was performed at six places in the measuring area, Figure 4-4. The average snow depth was then calculated.



*Figure 4-3. Measurement of snow depth, from SMHI's Handbook for observers /7/.*



*Figure 4-4. Placement of the graded measuring stick in the area for measuring of snow depth. The distance between the measuring points is 1.5–2 m.*

#### **4.4.3 Frost in ground**

For measurement of frost in the ground, equipment according to section 3.3.2 was used. The measurements were carried out at four places representative for the local conditions, taking in consideration soil characteristics and topography.

The measuring device is read by observing the uncoloured part of the tube solution, i.e. the frozen part, which shows the border between ice and water. The distance from ground surface to the frost in the ground, was received by reducing the read values with the distance from the scale zero to the ground surface. The measurements were performed once a week in connection to registration of snow depth.

#### **4.4.4 Ice cover**

The time for ice freeze up/ice break was noted for sea bays (ASM100226–ASM100228) and for lakes in the area (ASM100229).

For the sea, ice conditions were registered every morning during working week and for the lake once a week. While ice freeze up was observed on the lake, the other lakes in the area were also observed, to check the representatively of Lake Jämsen (ASM100229).

The time for the first ice freeze up, which is important to register in the observations, is defined as the first time of the season when a lasting ice cover occurs. The time for the last ice break up is defined as the time when the ice cover from the winter season finally breaks up. Short periods in early autumn, with thin ice covers were ignored, as well as partial ice during springtime.

#### **4.4.5 Data handling and documentation**

Field personnel from the SKB executed all measurements and observations of snow depth, frost in ground and ice cover in the activity. The primary data was registered in SICADA.

## 4.5 Analyses and interpretations

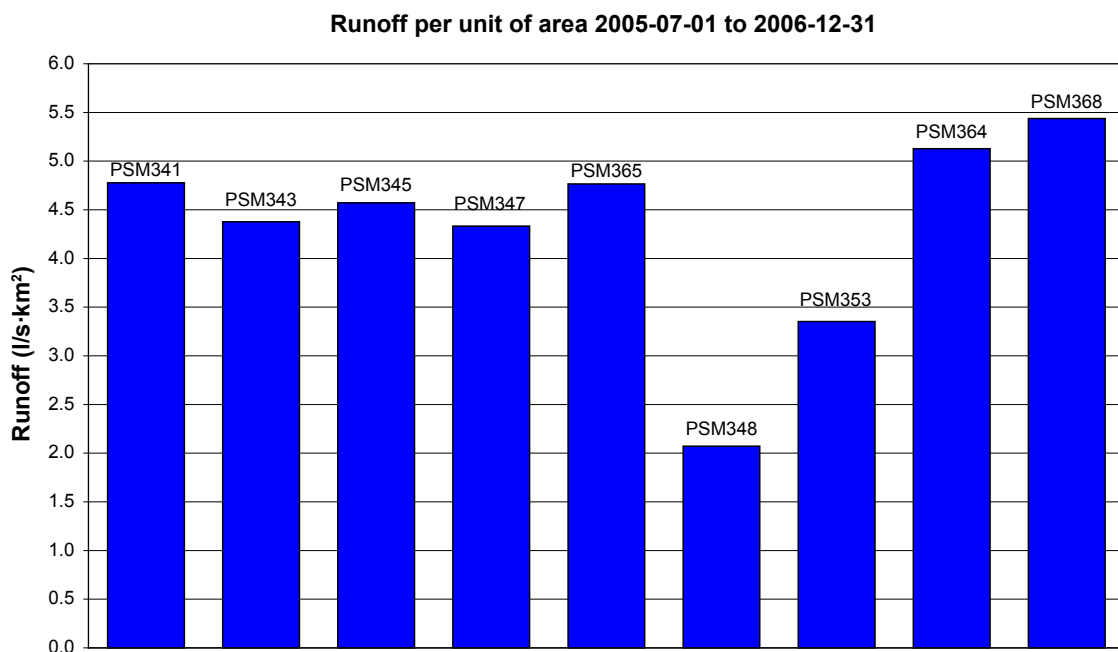
### 4.5.1 Hydrological measurements

Runoff per unit of area has been calculated for all discharge stations during the period 2005-07-01 to 2006-12-31. Runoff in this part of Sweden based on measurements during the years 1961–1990 is about 5 l/(s·km<sup>2</sup>). The discharge is calculated using rating curves based on control measurements made by SKB and SMHI. Compared to the long-term mean value all stations except for PSM000348 and PSM000353 seem to be close to this value, see Figure 4-5. However, more control measurements are needed to assure reliable discharge data. Such control measurements are carried out continuously and historical measurements of discharge recalculated when reliable rating curves are established. The stations PSM000348 and PSM000353 seem to be underestimated and need more control measurements. The drainage areas are estimated by SKB.

### 4.5.2 Meteorological measurements

SMHI has continuously checked the collected data, i.e. checked that the data is within the limits of reason for each parameter. The data have also been compared with data from SMHI's analysing system MESAN. MESAN is an automatic system for mesoscale analysis of meteorological parameters, built on manual as well as automatic observations and including satellite- and radar information.

The values are interpolated from the nearest grid points in MESAN. The resolution of MESAN is 22×22 km and an analysis is made every hour. Corrected data has been stored in a special database. In Table 4-4 you can see the coordinates of the nearest grid points.



*Figure 4-5. Runoff expressed as l/s·km<sup>2</sup>. Runoff at stations PSM000348 and PSM000353 seem to be underestimated and more control measurements are required.*

**Table 4-4. Mesan grid points.**

| Latitude | Longitude |
|----------|-----------|
| 57.490   | 16.614    |
| 57.490   | 16.707    |
| 57.393   | 16.614    |
| 57.393   | 16.707    |

## **4.6 Nonconformities**

### **4.6.1 Hydrological measurements**

During SMHIs inspection and levelling of the hydrological stations during 2006-05-03 to 2006-05-04, some discrepancies regarding water levels were detected.

At station PSM000341 (Vadvikebäcken) the logged water level appeared to be 3.2 cm too low. A deviation report has been sent.

At station PSM000343 (Gloebäcken) the logged water level appeared to be 1.3 cm too high.

At station PSM000345 (Skölkebäcken) the logged water level appeared to be 2.8 cm too high.

At station PSM000364 (Laxemarån) lower the logged water level appeared to be 5.5 cm too low.

At station PSM000368 (Kärrviksån) the logged water level appeared to be 2.2 cm too low.

At station PSM000359 (Lake Söråmagasinet) the logged water level appeared to be 2.9 cm too high.

Every discrepancy has been corrected in the logger during 2006-05-23 to 2006-05-24. At station PSM000341 the error is supposed to have started during its built-up period, and all discharge from station start up to 2006-05-24 was therefore recalculated. The consequence of the correction was that the flow area was increased and accordingly the discharge. For the stations PSM000343, PSM000345, PSM000364 and PSM000368 the discharge has not been recalculated since it is not known from what date the error started.

Nonconformities due to maintenance work took place at station PSM000359 where the water level was low during 2006-09-04 to 2006-11-28.

### **4.6.2 Meteorological measurements**

Two deviation reports have been sent:

1. The air pressure instrument at Plittorp gave wrong value 2005-07-10 23:00 2005-07-12 09:30. By mistake, these values were sent from SMHI to SKB as approved data.
2. The calculation of the potential evapotranspiration has been done without adjusting the wind speed from 10 m above ground to 2 m above ground. Wrong values have been calculated from start to 2006-06-30 at Äspö and Plittorp.

These errors have been corrected.

Additionally there has been a major deviation concerning the calculation of potential evapotranspiration between SMHI's regional stations PSM107642 (Gladhammar) and PSM107721 (Ölands Norra Udde A) compared to SKB's stations (PAS000028 Äspömasten and PSM107738 Plittorp). Initially all regional data have been calculated and stored in the SICADA database according to the "old calculation method" described in /4/. Since the calculation method has been further developed, all regional data stored in SICADA have been re-delivered and replaced

in the database. This deviation type however did not affect the local meteorological stations because the “new calculation method” was already in use since the measurements started in Laxemar. In section 5.2.8 the current calculation method is described in more detail.

## **4.7 Missing data and system malfunctions**

### **4.7.1 Hydrological measurements**

At station PSM000371 Clab data was lost 2005-11-18 to 2005-11-21 when the main fuse for power supply broke and the capacity of the spare battery was too low. Between 2006-02-22 to 2006-03-13 the main fuse broke again. However, this time the capacity of the spare battery was enough and no data was lost.

At station PSM000341 Vadvikebäcken the thermometer went out of order 2006-08-31. Due to this, no temperature data is available during the periods 2006-08-31 to 2006-09-14 and 2006-09-18 to 2006-09-25. The thermometer was replaced 2006-09-25. A deviation report has been sent.

For station PSM000364 Laxemarån lower the date from which it starts to deliver quality controlled data is 2004-11-24.

### **4.7.2 Meteorological measurements**

There have not been any problems at Äspö but at Plittorp there have been some problems:

When the wind was calm, suddenly very high wind speeds were reported. To avoid this problem FDS has added 0.01 m/s to the measured value to avoid 0.00 m/s.

There have more problems with the wind speed at Plittorp. At 2006-01-01 the temperature decreased below 0°C and the anemometer was frozen. The reported wind speed was 0.01 m/s until 2006-01-10 when the temperature exceeded 0°C. These values are missing in SKB's database. The potential evapotranspiration is also missing these dates for Plittorp because the wind speed is needed for the calculation.

The wind speed at Plittorp was too high at 13 observations from 2008-08-08 to 2006-08-17. The potential evapotranspiration is also missing these dates for Plittorp because the wind speed is needed for the calculation.

There have also been problems with the pressure between 2006-07-03 to 2007-08-26. The instrument has suddenly reported too low values. There were also problems the values from the precipitation gauge 2007-07-17 between 11:00 and 13:00.

At Plittorp 2006-10-03 16:30 the reported pressure was about 10 hPa too low. The observations before and after that value are correct.

## 5 Results

### 5.1 Hydrological monitoring

Totally fifteen hydrological stations are built. Hydrological measurements at these stations have worked rather well during the period 2005-07-01 to 2006-12-31. It has only been minor interruptions in measurements caused by malfunctioning equipment. The quality of measurements regarding water levels in lakes, reservoirs and sea is very good and no adjustments of data have been necessary.

At the discharge stations where constructed dams are built, quality of measured data almost exclusively depends on the maintenance of the basin upstream the dam. Therefore it is very important that the dams are cleaned from debris blocking the flow through the V-notches. Most of the corrections made to measurements according discharge have been made because the V-notches periodically have been obstructed by ice, leaves or debris floating in the water. At discharge stations, using a natural cross section most corrections of measured water levels are made during the time of ice break up. Ice in the watercourse is then building ice jams and measured water levels are not representative for discharge calculations. The water level in such situations have been interpolated between the level before and after the occasion of the peak caused by the ice jam.

At 2006-10-01 the rating curves for all discharge stations were determined, and discharge recalculated from station start through quality checked water level data. See the rating curves in Appendix 2. All discharge data was sent to SKB 2006-10-05. However, an important remark regarding data quality has to be made. Most rating curves still have too few control measurements of discharge to be regarded as reliable, especially at higher water levels. Further measurements are therefore strongly recommended to make the rating curves reach an approved level of quality.

Measurements of water temperature at the discharge stations seem so far to work well. Even here, only a few measured values have been corrected when making quality check of data.

Measurements of electrical conductivity, EC, have also worked quite well. However, more corrections according to obviously strange values have been necessary to make than for other measured parameters. It has turned out that it seems to be very important that the temperature and conductivity sensors are kept clean. During the vegetation period, the sensors seem to be covered with organic material and for that reason, it is necessary to clean the sensors at some occasions during this period. The smallest watercourses dry up a great part of the season and the sensors must be cleaned during such periods. Otherwise, there is a risk of erroneous values when the water starts to flow again.

#### 5.1.1 Discharge

##### ***PSM000341, PSM000343, PSM000345, PSM000347 and PSM000365***

The quality checked values of discharge from the five stations with constructed dams are presented in Figures 5-1 and 5-2. Adjustment of measurements has been made to all stations, except for PSM000347, at several occasions because the V-notches have been blocked.

##### ***PSM000348, PSM000353, PSM000364 and PSM000368***

At four stations discharge is measured by using a natural cross-section in the watercourse, i.e. no dams are constructed. In last report only the water level was presented because the rating curves were not established yet. All rating curves are now established and the discharge



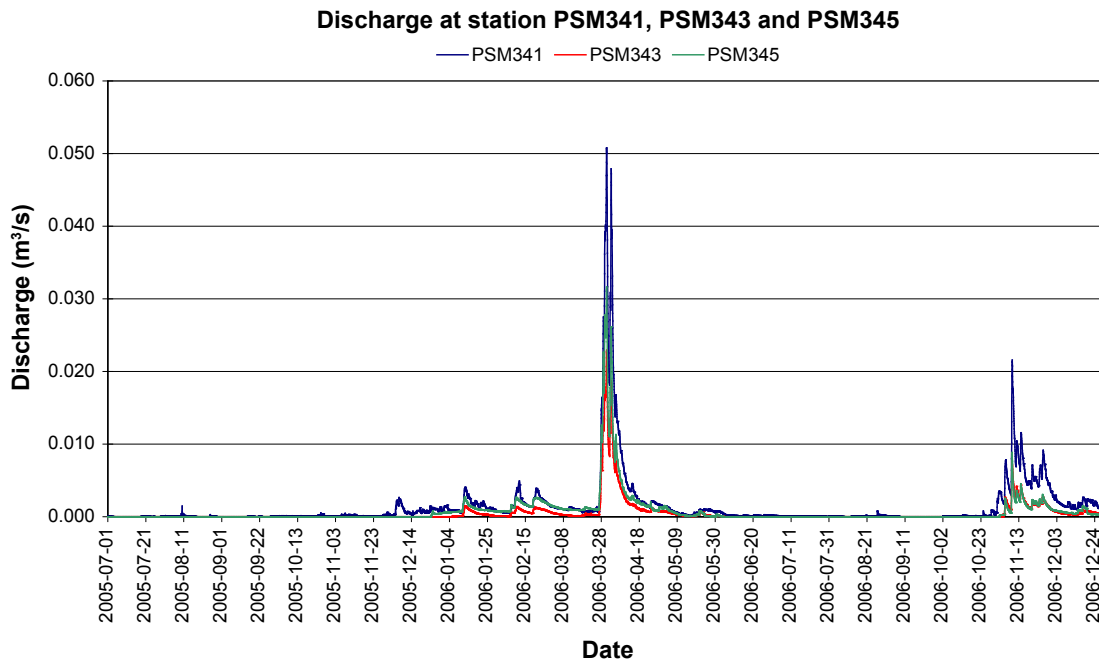


Figure 5-1. Quality assured discharge,  $m^3/s$ , at stations PSM000341, PSM000343 and PSM000345.

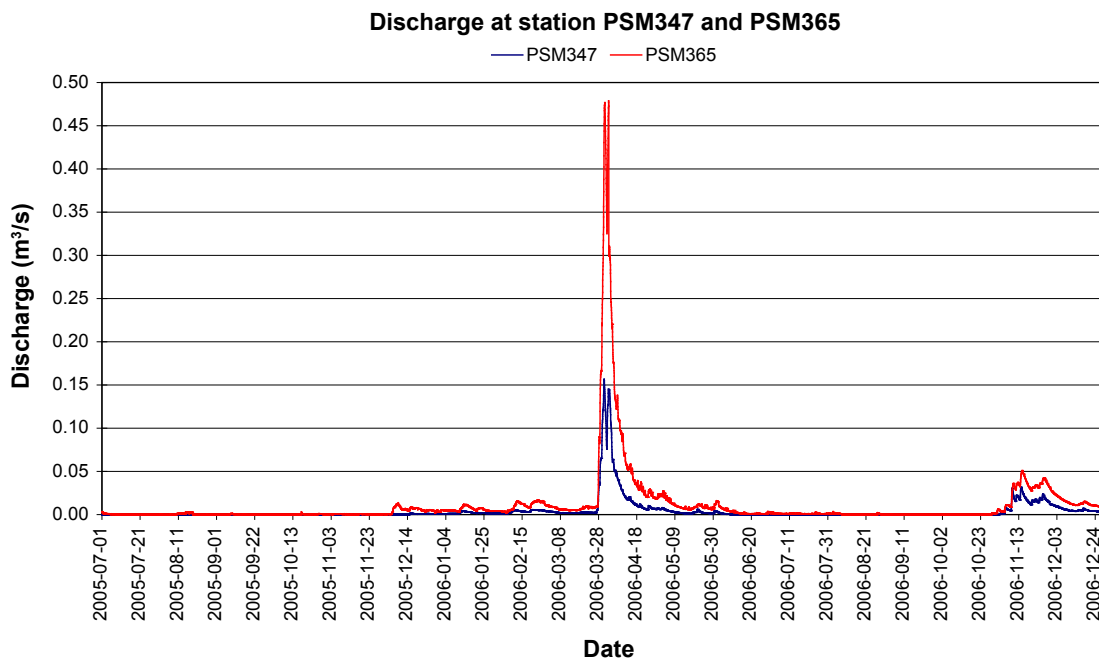


Figure 5-2. Quality assured discharge,  $m^3/s$ , for station PSM000347 and PSM000365.

is presented from station start. At station PSM000348 the discharge represents the outflow from lake Frisksjön. At all other places discharge is measured in the creek. The quality checked discharge from measurements of water level made during the period could be seen in Figures 5-3 to 5-5. Adjustment of measurements has been made to PSM000368 at several occasions because the V-notch has been blocked.

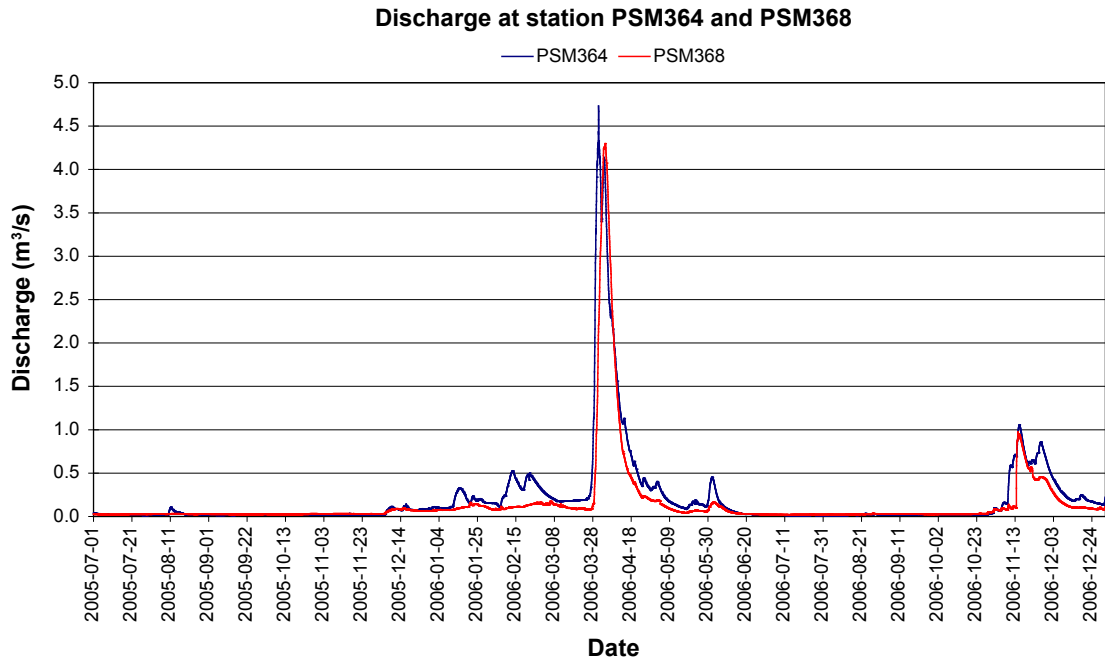


Figure 5-3. Quality assured discharge, m<sup>3</sup>/s, for stations PSM000364 and PSM000368.

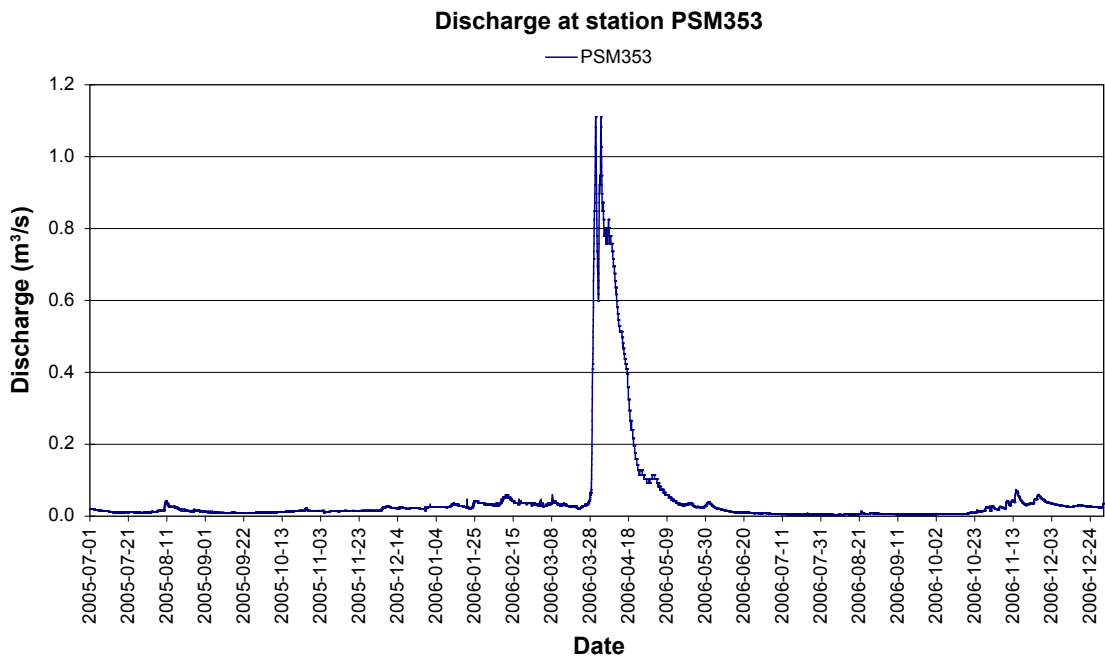


Figure 5-4. Quality assured discharge, m<sup>3</sup>/s, for station PSM000353.

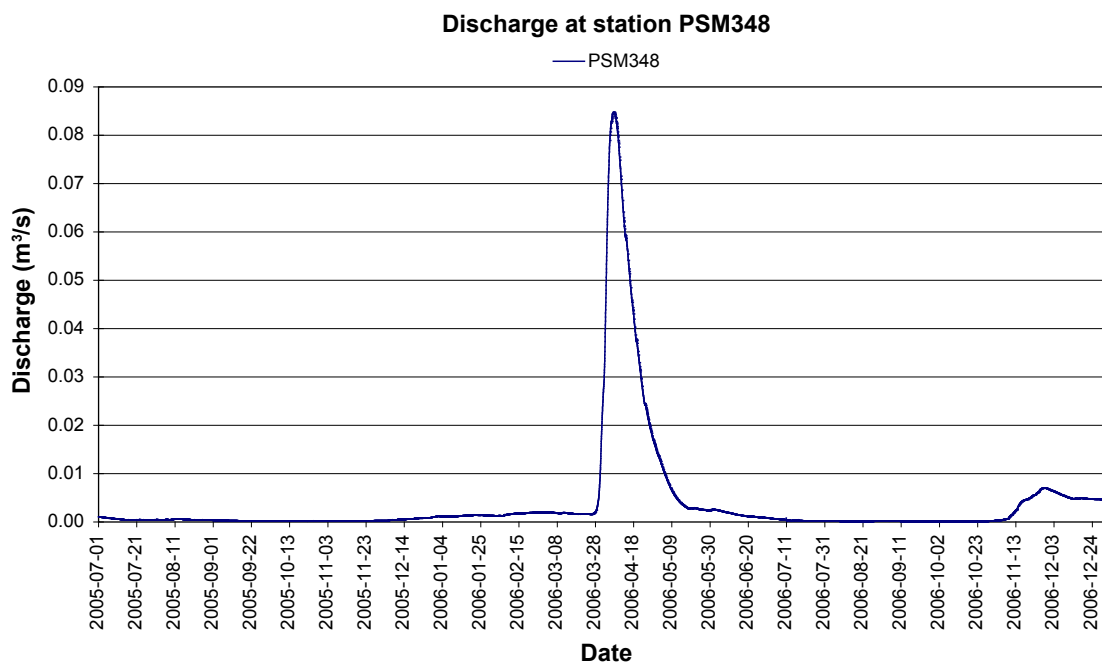


Figure 5-5. Quality assured discharge, m³/s, for station PSM000348.

## 5.1.2 Water level

### Sea water level

Sea water level is measured at three places in the surroundings of Äspö. The stations are PSM000369, PSM000370 and PSM000371. Measurements are made in elevation system RT90-RHB70 and expressed as metre above sea level (m.a.s.l.). The similarity between measurements at the three stations is good. The results are presented in Figure 5-6. It has not been necessary to make any corrections of measured values during time of measurements.

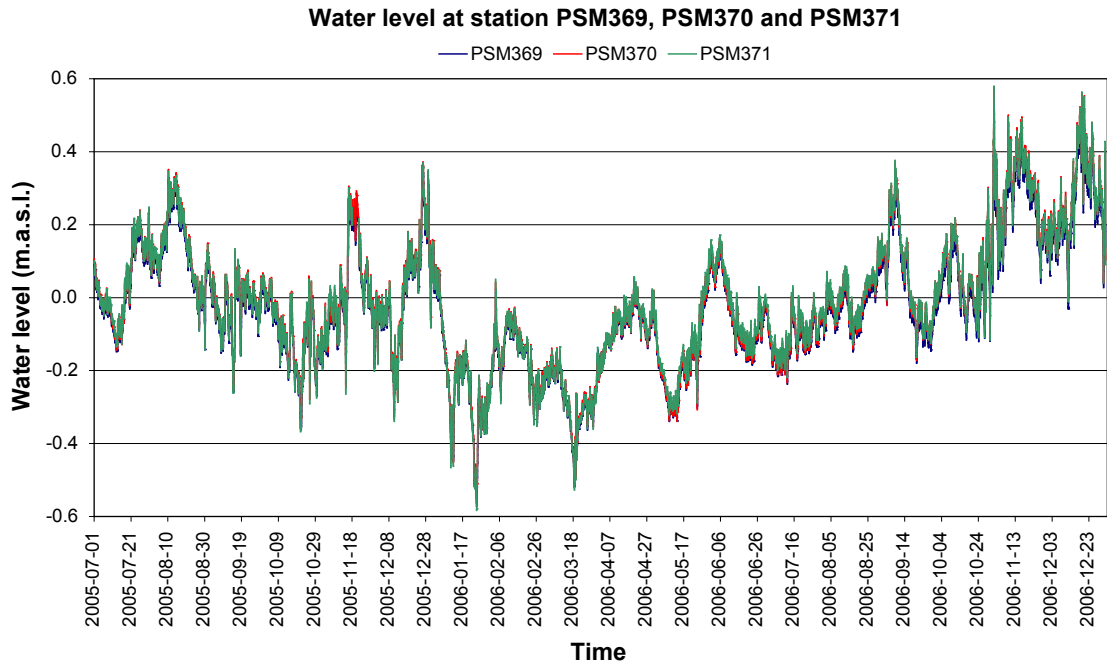
### Water level measured in lakes and reservoirs

Water level is also taken at station PSM000342 and PSM000344. At PSM000342 water level is measured in lake Jämsen and at station PSM000344 in lake Plittorpsgöl. All measurements are in elevation system RT90-RHB70. It has not been necessary to make any corrections of data at all during this period. The measured water levels can be seen in Figure 5-7.

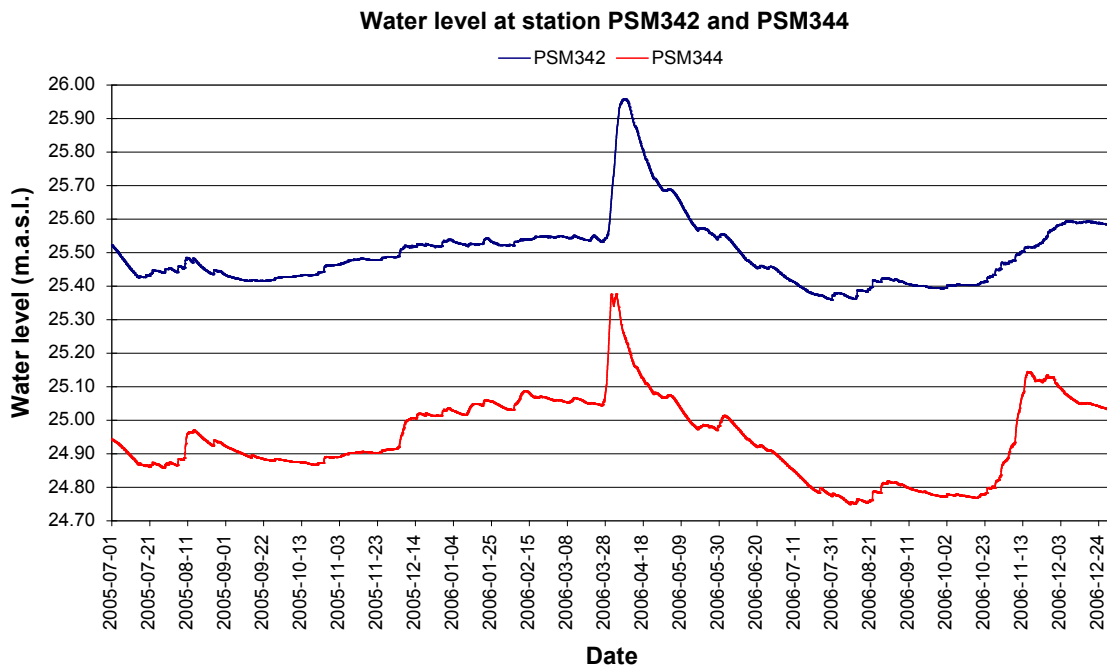
At station PSM000359 water level is taken in the reservoir at Sörå. Measurements are in metre above sea level (m.a.s.l.), in elevation system RT90-RHB70. The measured water level can be seen in Figure 5-8. Due to maintenance work the water level was low during 2006-09-04 to 2006-11-28; these values have been deleted.

## 5.1.3 Water temperature and electrical conductivity, (EC)

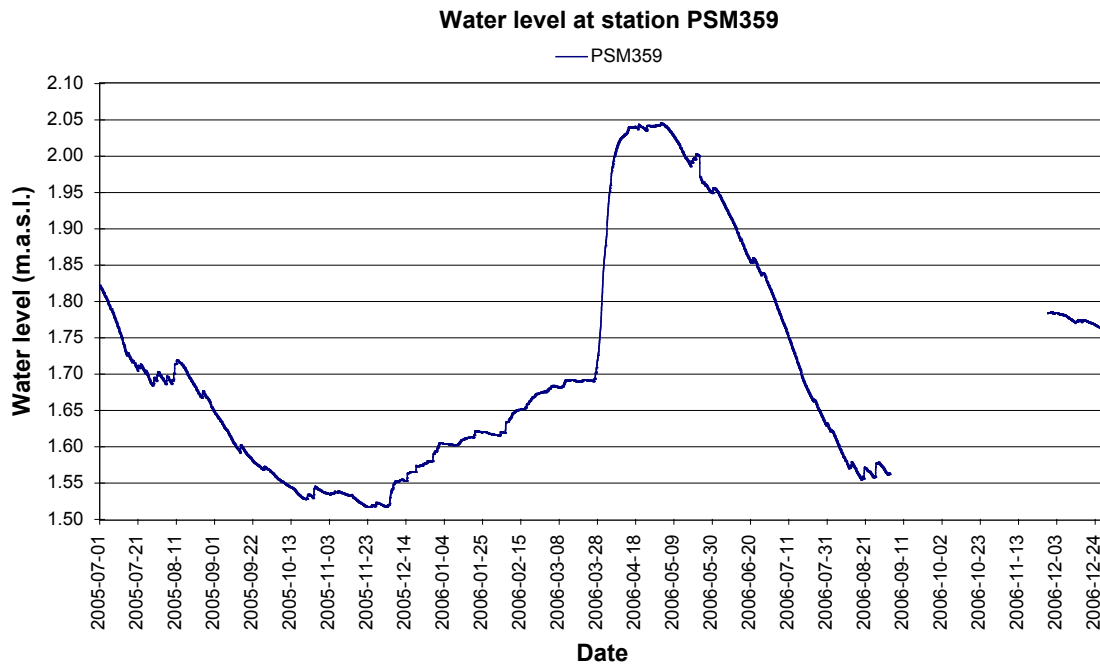
At all stations monitoring discharge the water temperature and electrical conductivity, EC, are measured. At the stations PSM000341, PSM000343 and PSM000345 where constructed dams are made, temperature and EC is measured in the small basin upstream the concrete dam. During drought, in periods when discharge in creeks equals zero, the water temperature in the basins will increase and the logged temperature and EC values will therefore not be representative. For this reason, all quality checked temperature and EC values are deleted when the discharge equals zero. Temperature measurements have worked well except for when a thermometer went out of order at PSM000341 2006-09-18 (replaced 2006-09-25).



*Figure 5-6. Sea water level measured at station PSM000369, PSM000370 and PSM000371. All measurements made in elevation system RT90-RHB70.*



*Figure 5-7. Water level measured at station PSM000342 and PSM000344. The blue line shows the development of water level for lake Jämsen and the red line for lake Plittorpsgöl. Measurements made in metre above sea level (m.a.s.l.).*



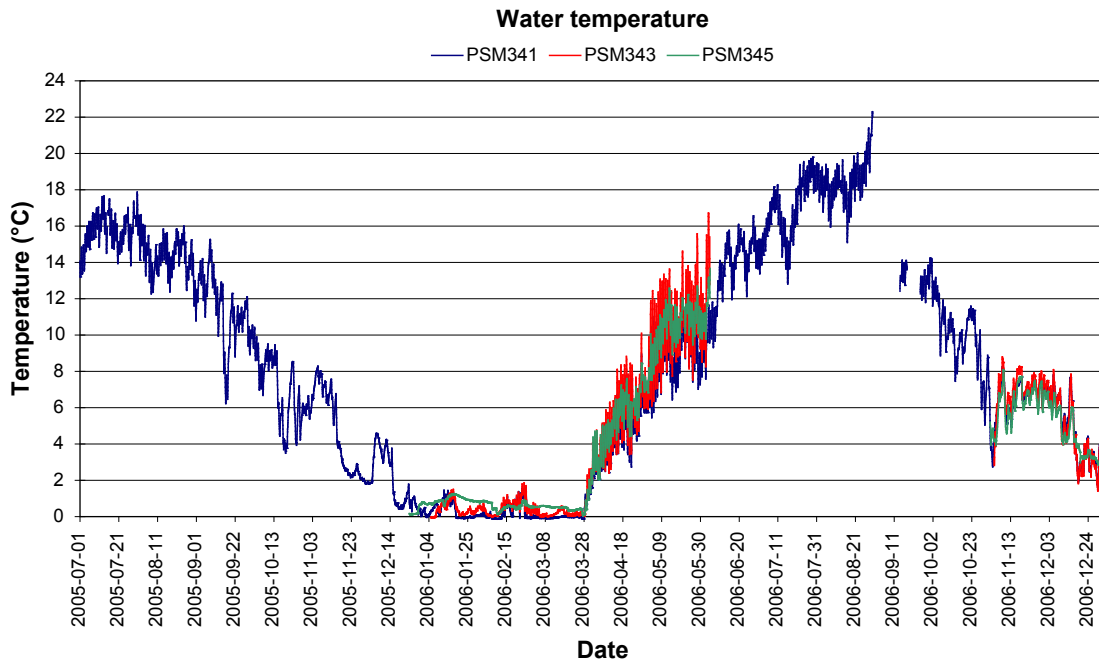
**Figure 5-8.** Water level measured in m.a.s.l. at station PSM000359. The blue line shows the development of water level in the reservoir at Sörå. Due to maintenance work there were nonconformities at the end of the period and this data has been deleted.

No other temperature adjustments have been made. However, quite high temperatures have been registered at PSM000364 and PSM000353 in June and August 2006 respectively. In order to prevent eventual malfunction, the thermometers should be checked.

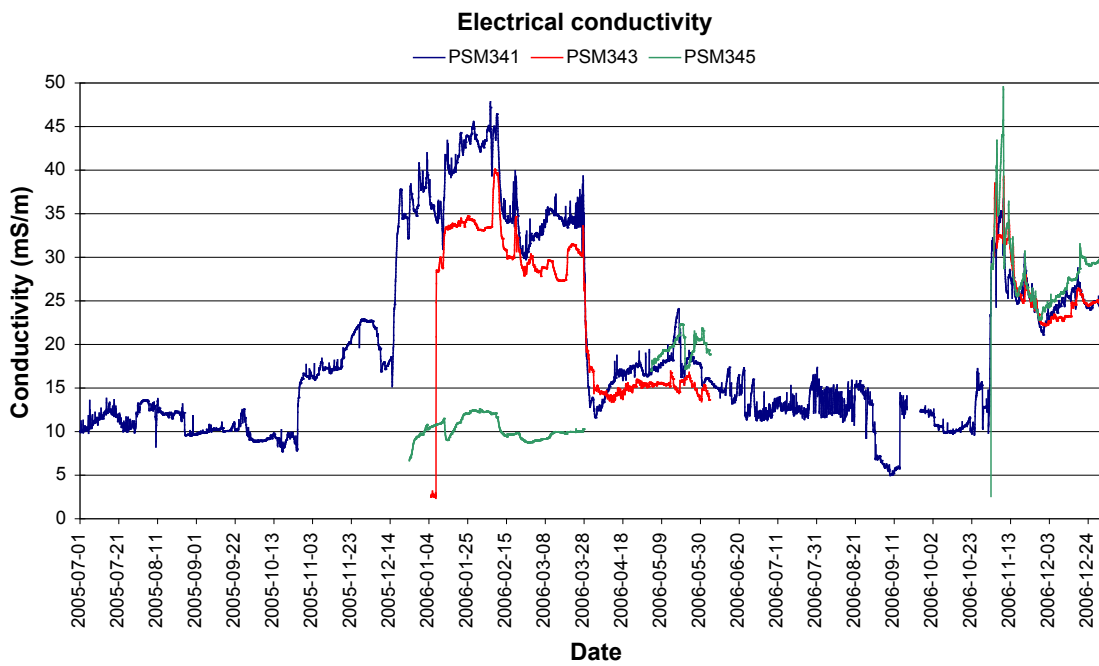
It has been necessary to adjust conductivity measurements at PSM000341 and PSM000345 when some deviating values occurred. At stations PSM000348, PSM000353, PSM000364 and PSM000368 all sensors are situated in a creek or in a lake. Also here adjustments of conductivity has been necessary to make when some strange and deviating values occurred. The sensors seem to be covered with organic material during the vegetation period when the biological activity is high. Because of this, it is very important to keep the sensor clean during this part of season. All adjustments made have likely been caused by increasing growth of organic material on sensors. After cleaning the sensors, they have showed correct values. Quality checked measurements are presented in Figures 5-9 to 5-16.

## 5.2 Meteorological monitoring

Figure 4-2 shows where the two monitoring stations Plittorp and Äspö are situated. The figure also shows where the SMHI's regional precipitation stations presented in this report below are located.



**Figure 5-9.** Water temperature measured at stations PSM000341, PSM000343 and PSM000345. Values are deleted during periods when the discharge equals zero or when the watercourse is dried up.



**Figure 5-10.** Electrical conductivity, EC, measured at stations PSM000341, PSM000343 and PSM000345. Values are deleted during periods when the discharge equals zero or when the watercourse is dried up.

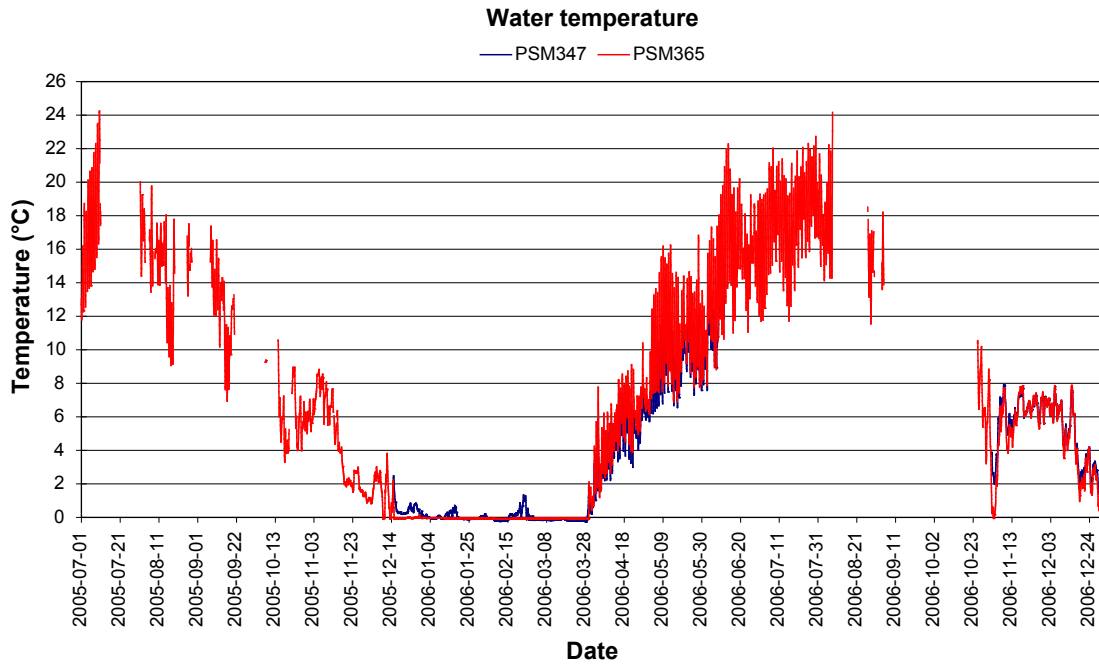


Figure 5-11. Water temperature measured at stations PSM000347 and PSM000365. Values are deleted during periods when the discharge equals zero or when the watercourse is dried up.

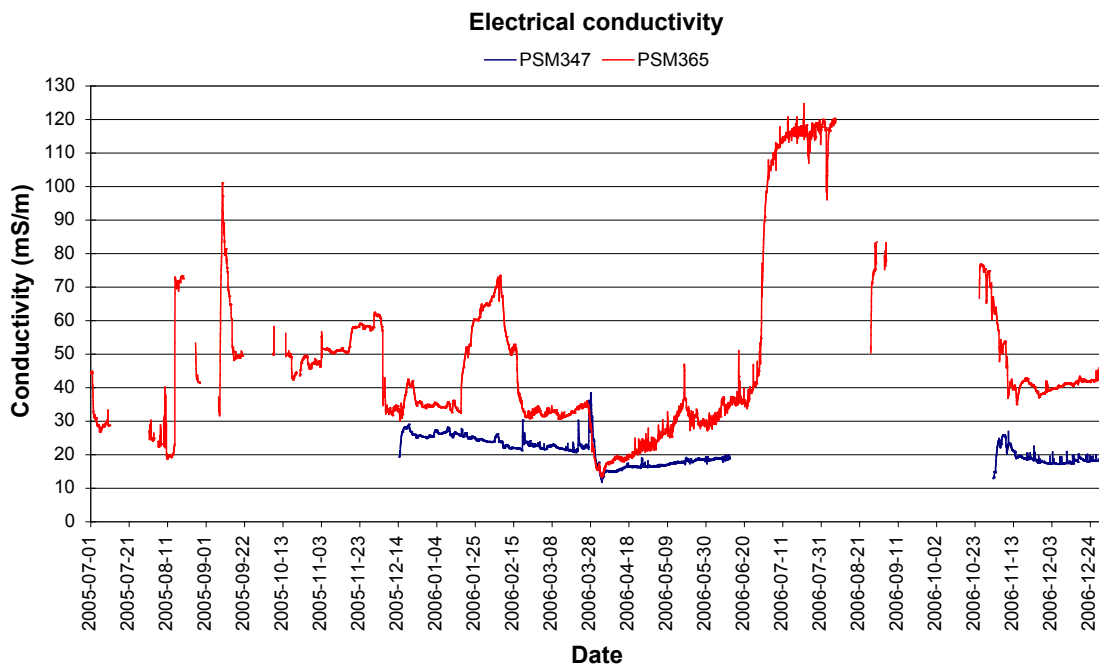


Figure 5-12. Electrical conductivity, EC, measured at stations PSM000347 and PSM000365. Values are deleted during periods when the discharge equals zero or when the watercourse is dried up.

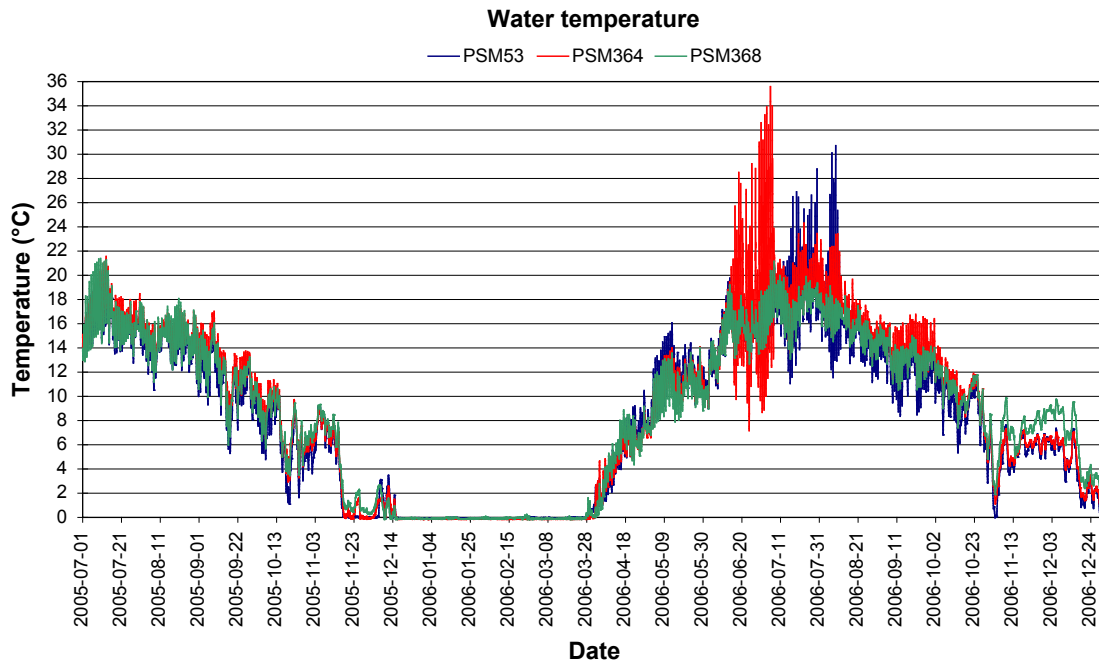


Figure 5-13. Water temperature measured at stations PSM000353, PSM000364 and PSM000368.

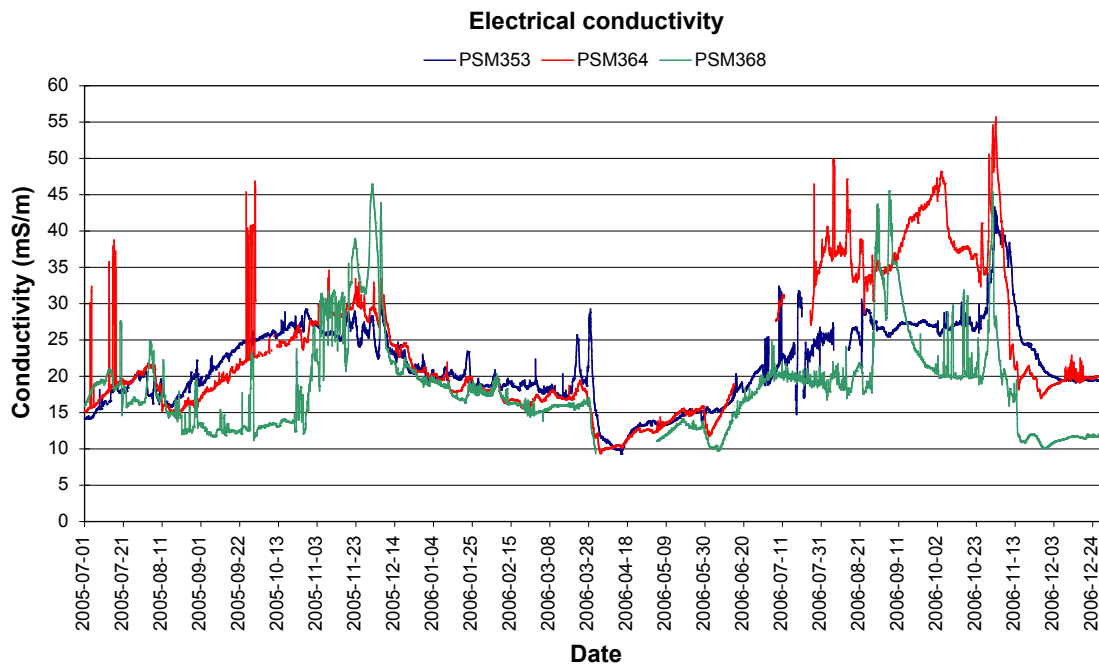


Figure 5-14. Electrical conductivity measured at station PSM000353, PSM000364 and PSM000368.



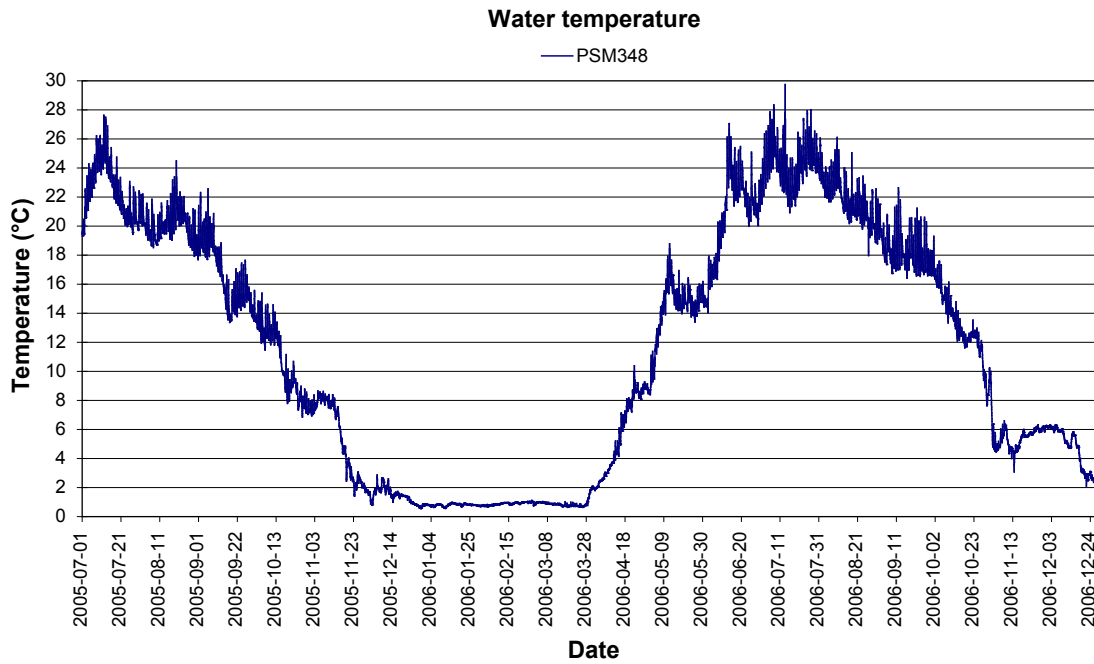


Figure 5-15. Water temperature measured at Lake Frisksjön station PSM000348.

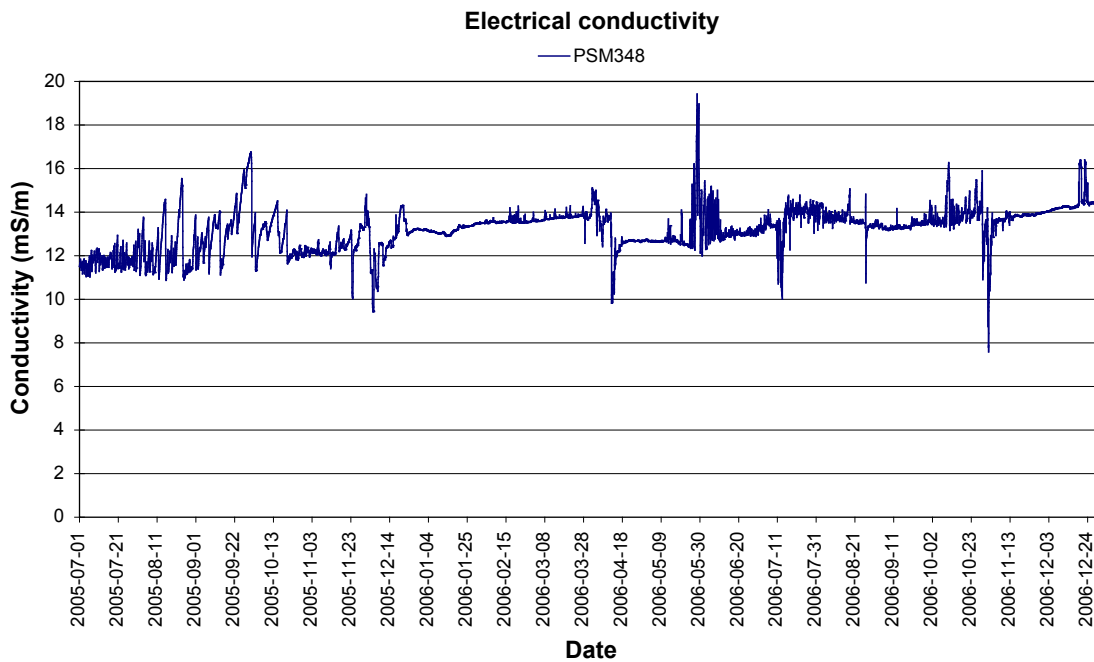


Figure 5-16. Electrical conductivity measured at Lake Frisksjön station PSM000348.

### 5.2.1 Precipitation

The monthly precipitations for SMHI's stations are presented in Table 5-2 and Figure 5-17 below. "Ölands Norra Udde A" and "Gladhammar A" are automatic stations and the others are manual stations. These precipitation values are all controlled and approved by SMHI. There are no correction for wind errors, wetting and evaporation in these values in Table 5-2a but in Table 5-2b corrected values are presented. We see that the precipitation differs a lot between stations and between months.

The correction of precipitation is listed below in Table 5-1.

**Table 5-1. Corrections in percent of SMHI's stations according to /5/.**

|                     | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| Målilla             | 7   | 9   | 6   | 8   | 7   | 8   | 6   | 7   | 7   | 6   | 6   | 6   | 7    |
| Oskarshamn          | 6   | 6   | 6   | 8   | 8   | 11  | 8   | 7   | 7   | 7   | 6   | 6   | 7    |
| Krokshult           | 9   | 11  | 9   | 8   | 10  | 12  | 9   | 10  | 8   | 8   | 8   | 8   | 9    |
| Kråkemåla           | 7   | 9   | 9   | 8   | 9   | 10  | 8   | 9   | 8   | 8   | 7   | 6   | 8    |
| Ölands Norra Udde A | 18  | 22  | 16  | 16  | 13  | 16  | 15  | 16  | 16  | 16  | 18  | 18  | 17   |
| Ölands Norra Udde   | 13  | 14  | 17  | 12  | 13  | 16  | 15  | 11  | 12  | 14  | 11  | 11  | 13   |
| Gladhammar A        | 13  | 15  | 14  | 14  | 22  | 12  | 13  | 13  | 13  | 12  | 13  | 16  | 13   |

**Table 5-2a. Monthly precipitation in mm at SMHI's stations, uncorrected.**

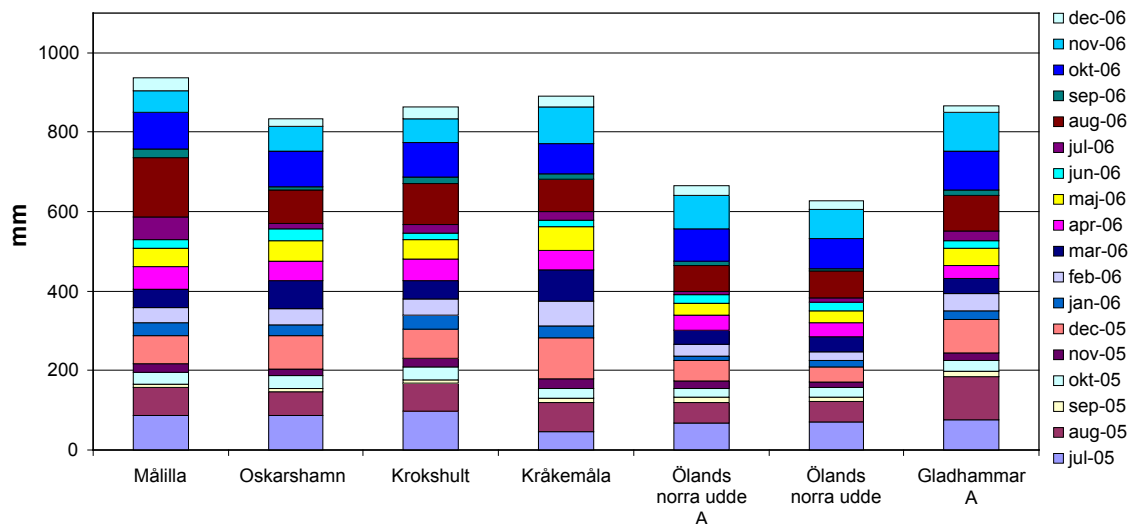
|                     | jul -05 | aug -05 | sep -05 | okt -05 | nov -05 | dec -05 | jan -06 | feb -06 | mar -06 | apr -06 |
|---------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Målilla             | 87.4    | 71.1    | 7.5     | 30.6    | 20.4    | 72.2    | 31.3    | 38.2    | 45.0    | 58.3    |
| Oskarshamn          | 88.2    | 59.7    | 8.1     | 32.6    | 16.2    | 83.8    | 26.5    | 41.9    | 68.1    | 50.1    |
| Krokshult           | 97.8    | 71.4    | 7.6     | 31.4    | 22.9    | 73.8    | 35.4    | 40.0    | 45.4    | 53.7    |
| Kråkemåla           | 47.1    | 73.2    | 11.2    | 23.3    | 23.4    | 104.5   | 29.3    | 62.9    | 77.6    | 50.1    |
| Ölands Norra Udde A | 68.4    | 52.0    | 11.7    | 24.0    | 16.9    | 51.7    | 12.6    | 28.1    | 37.2    | 35.8    |
| Ölands Norra Udde   | 70.1    | 51.7    | 11.3    | 25.6    | 12.3    | 37.7    | 16.0    | 21.8    | 38.0    | 36.4    |
| Gladhammar A        | 76.5    | 109.5   | 12.4    | 27.5    | 19.3    | 84.3    | 21.9    | 42.8    | 38.7    | 31.2    |

|                     | maj -06 | jun -06 | jul -06 | aug -06 | sep -06 | okt -06 | nov -06 | dec -06 | Total |
|---------------------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
| Målilla             | 45.6    | 20.9    | 58.7    | 149.0   | 21.0    | 91.9    | 55.6    | 32.9    | 937.6 |
| Oskarshamn          | 51.3    | 30.9    | 14.2    | 83.3    | 7.5     | 89.2    | 62.4    | 19.8    | 833.8 |
| Krokshult           | 50.3    | 16.0    | 23.0    | 101.5   | 15.7    | 88.0    | 58.9    | 30.3    | 863.1 |
| Kråkemåla           | 58.7    | 17.6    | 22.5    | 80.1    | 13.3    | 77.6    | 91.3    | 25.9    | 889.6 |
| Ölands Norra Udde A | 31.9    | 19.9    | 8.4     | 66.6    | 10.7    | 80.1    | 84.7    | 25.4    | 666.1 |
| Ölands Norra Udde   | 30.7    | 21.5    | 8.7     | 67.9    | 7.8     | 74.8    | 74.4    | 19.6    | 626.3 |
| Gladhammar A        | 43.6    | 19.4    | 23.3    | 90.5    | 13.2    | 98.9    | 96.5    | 16.9    | 866.4 |

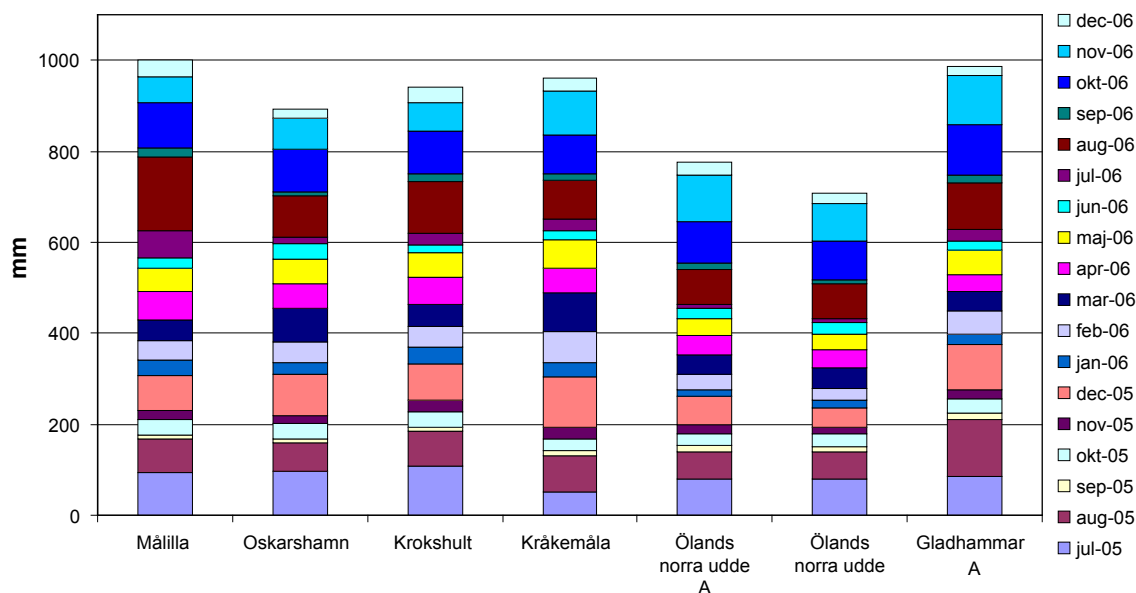
**Table 5-2b. Monthly precipitation in mm at SMHI's stations, corrected.**

|                     | jul -05 | aug -05 | sep -05 | okt -05 | nov -05 | dec -05 | jan -06 | feb -06 | mar -06 | apr -06 |
|---------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Målilla             | 92.6    | 76.1    | 8.0     | 32.4    | 21.6    | 76.5    | 33.5    | 41.6    | 47.7    | 63.0    |
| Oskarshamn          | 95.3    | 63.9    | 8.7     | 34.9    | 17.2    | 88.8    | 28.1    | 44.4    | 72.2    | 54.1    |
| Krokshult           | 106.6   | 78.5    | 8.2     | 33.9    | 24.7    | 79.7    | 38.6    | 44.4    | 49.5    | 58.0    |
| Kråkemåla           | 50.9    | 79.8    | 12.1    | 25.2    | 25.0    | 110.8   | 31.4    | 68.6    | 84.6    | 54.1    |
| Ölands Norra Udde A | 78.7    | 60.3    | 13.6    | 27.8    | 19.9    | 61.0    | 14.9    | 34.3    | 43.2    | 41.5    |
| Ölands Norra Udde   | 80.6    | 57.4    | 12.7    | 29.2    | 13.7    | 41.8    | 18.1    | 24.9    | 44.5    | 40.8    |
| Gladhammar A        | 86.4    | 123.7   | 14.0    | 30.8    | 21.8    | 97.8    | 24.7    | 49.2    | 44.1    | 35.6    |

|                     | maj -06 | jun -06 | jul -06 | aug -06 | sep -06 | okt -06 | nov -06 | dec -06 | Total   |
|---------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Målilla             | 48.8    | 22.6    | 62.2    | 159.4   | 22.5    | 97.4    | 58.9    | 34.9    | 1,003.2 |
| Oskarshamn          | 55.4    | 34.3    | 15.3    | 89.1    | 8.0     | 95.4    | 66.1    | 21.0    | 892.2   |
| Krokshult           | 55.3    | 17.9    | 25.1    | 111.7   | 17.0    | 95.0    | 63.6    | 32.7    | 940.8   |
| Kråkemåla           | 64.0    | 19.4    | 24.3    | 87.3    | 14.4    | 83.8    | 97.7    | 27.5    | 960.8   |
| Ölands Norra Udde A | 36.0    | 23.1    | 9.7     | 77.3    | 12.4    | 92.9    | 99.9    | 30.0    | 779.3   |
| Ölands Norra Udde   | 34.7    | 24.9    | 10.0    | 75.4    | 8.7     | 85.3    | 82.6    | 21.8    | 707.7   |
| Gladhammar A        | 53.2    | 21.7    | 26.3    | 102.3   | 14.9    | 110.8   | 109.0   | 19.6    | 979.0   |



Figur 5-17a. Monthly precipitation in mm at SMHI's stations, uncorrected.



Figur 5-17b. Monthly precipitation in mm at SMHI's stations, corrected.

The precipitation at Plittorp and Äspö are presented in Table 5-4. "001" in the table means originally measured value from the Geonor precipitation gauge, "COR" means corrected and approved value by SMHI, "KOR" is an estimation of the true precipitation, "BUC" means values from a precipitation gauge of the type tipping bucket and "MES" means analysed values from Mesan. ALX is the new correction for wind errors, wetting and evaporation. "BUC"-data is from another gauge and are not a part of this project. SMHI is not responsible for this instrument.

During the year a new method for estimating the true precipitation were implemented (ALX). It is based on photographs of the surroundings and maps of the stations and the same method is used as for the other SMHI stations. It gives higher values than the old method KOR-method described below. The Table 5-3 below gives the corrections in percent for each month. More information about the estimated true precipitation can be found in /5/ and /6/.

**Table 5-3. Corrections in percent of SKB's stations according to /6/.**

|          | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| Äspö     | 21  | 21  | 19  | 16  | 14  | 14  | 14  | 14  | 14  | 16  | 17  | 20  | 17   |
| Plittorp | 12  | 13  | 12  | 10  | 10  | 9   | 9   | 10  | 10  | 10  | 10  | 12  | 11   |

**Table 5-4. Monthly precipitation in mm at SKB's stations. "001" in the table means originally measured value, "COR" means corrected and approved value by SMHI and "MES" means analysed values from Mesan. ALX is the new estimation of the true precipitation and "BUC" means values from a precipitation gauge of the type tipping bucket.**

|              | jul -05 | aug -05 | sep -05 | okt -05 | nov -05 | dec -05 | jan -06 | feb -06 | mar -06 | apr -06 |
|--------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Äspö 001     | 41.5    | 70.7    | 10.0    | 22.0    | 20.0    | 93.3    | 23.9    | 48.9    | 53.8    | 46.6    |
| Äspö COR     | 41.7    | 70.5    | 10.3    | 22.1    | 20.0    | 68.4    | 23.9    | 48.9    | 53.4    | 46.6    |
| Äspö MES     | 35.1    | 41.5    | 6.1     | 19.0    | 14.1    | 44.7    | 19.1    | 20.2    | 44.2    | 32.8    |
| Äspö ALX     | 47.5    | 80.4    | 11.7    | 25.6    | 23.4    | 82.1    | 28.9    | 59.2    | 63.5    | 54.1    |
| Äspö BUC     | 48.4    | 75.6    | 11.6    | 24.0    | 19.0    | 42.4    | 5.8     | 21.6    | 19.0    | 19.2    |
| Plittorp 001 | 43.2    | 92.7    | 15.4    | 21.7    | 16.8    | 82.4    | 29.7    | 48.7    | 54.2    | 46.8    |
| Plittorp COR | 43.3    | 92.7    | 15.4    | 21.7    | 16.9    | 74.4    | 29.6    | 48.7    | 53.8    | 46.8    |
| Plittorp ALX | 47.2    | 102.0   | 16.9    | 23.9    | 18.6    | 83.3    | 33.2    | 55.0    | 60.3    | 51.5    |

|              | maj-06 | jun-06 | jul-06 | aug-06 | sep-06 | okt-06 | nov-06 | dec-06 | Total |
|--------------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| Äspö 001     | 45.5   | 18.1   | 10.6   | 68.4   | 8.4    | 67.1   | 91.3   | 29.6   | 769.7 |
| Äspö COR     | 45.5   | 18.3   | 10.6   | 68.2   | 8.4    | 67.1   | 91.3   | 21.0   | 736.2 |
| Äspö MES     | 40.5   | 19.0   | 10.3   | 76.9   | 6.7    | 45.7   | 53.2   | 10.3   | 539.4 |
| Äspö ALX     | 51.9   | 20.9   | 12.1   | 77.7   | 9.6    | 77.8   | 106.8  | 25.2   | 858.5 |
| Äspö BUC     | 0.0    | 1.4    | 3.4    | 0.2    | 0.0    | 1.0    | 113.4  | 35.0   | 441.0 |
| Plittorp 001 | 57.9   | 15.0   | 22.1   | 97.4   | 7.9    | 61.0   | 81.6   | 20.1   | 814.6 |
| Plittorp COR | 58.0   | 15.1   | 21.5   | 97.3   | 8.0    | 61.1   | 81.5   | 20.1   | 805.9 |
| Plittorp ALX | 63.8   | 16.5   | 23.4   | 107.0  | 8.6    | 67.2   | 89.6   | 22.5   | 890.5 |

The old method for estimating the true precipitation (KOR), i.e. precipitation corrected for wind errors, wetting and evaporation, is not presented. For this site and instrument, was assumed to be 10% more than the measured if the temperature is below +1°C, or else 6% more.

The registered 30-minutes precipitation values have to be filtered before storing. That is because the instrument is very sensitive and registers incorrect small values of precipitation.

If we compare the corrected values from Plittorp and Äspö (806 and 736 mm), with the values from the closest SMHI stations Kråkemåla and Oskarshamn (890 mm and 834 mm) we see that they correspond quite well with each other.

Figure A5-1 in Appendix 5 shows the accumulated sum of precipitation during the period. From the figure, we see that the precipitation gauge was emptied in December 2005 and in August 2006. From the figure you can see that a wrong value was reported in the middle of July from Plittorp. However this wrong value is taken away before calculating the precipitation.

### **5.2.2 Barometric pressure**

Graphs of the barometric pressure are presented in Figure A5-2 in Appendix 5. Values from Plittorp, Äspö and Mesan-values are presented. Figure A5-10 shows 30-min values for January 2006 where we can see that the measured value from Plittorp is lower than the Mesan-value, which is valid for the sea surface. The pressure decreases in theory about 1 hPa per 8 metres and the value from Plittorp is therefore correct. Note that there is a notch in the curve 2006-01-12 (Figure A5-10) that comes from Mesan and not from the measurements at Plittorp and Äspö.

### **5.2.3 Air temperature**

Graphs of daily temperature are presented in Figure A5-3 in Appendix 5. Values from Plittorp, Äspö and Mesan-values are presented. We see that the three curves follow each other very well.

Figure A5-11 shows 30-min values for January 2006. We notice that Äspö is more influenced of the sea because the lowest temperatures are several degrees higher compared to Plittorp

### **5.2.4 Relative humidity**

Graphs of daily relative humidity are presented in Figure A5-4 in Appendix 5. Values from Plittorp, Äspö and Mesan-values are presented. We see that the three curves follow each other very well. In Figure A5-12, 30-min values for January 2006 are presented.

### **5.2.5 Wind speed**

Graphs of the wind speed (daily mean) are presented in Figure A5-5 in Appendix 5. Values from Plittorp, Äspö and Mesan-values are presented. We see that the wind speeds are higher at Äspö compared to Plittorp but that the curves follow each other quite well.

The measured wind speed at Plittorp is clearly lower than the Mesan analysis. This depends on the surroundings of the site (not very open area) and that Mesan overestimates the wind speed at sites close to the sea. The measured wind speed at Plittorp is also lower than the values from Äspö. The reason is of course that Äspö is closer to the sea.

Figure A5-13 shows measurements for January 2006 for the 30-min mean wind speed. We notice the peak of the wind speed the night 8–9 January when the severe storm was ravaging. The gust wind speed is approximately 2–3 times higher than the mean wind speed presented here. The gust wind speed is not presented in the figure.

### **5.2.6 Wind direction**

Graphs of the wind direction are presented in Figure A5-6 in Appendix 5. Values from Äspö, Plittorp and Mesan-values are presented. We see that the two curves follow each other very well. Figure A5-14 shows 30-min values for January 2006.

### **5.2.7 Global radiation**

Graphs of the daily sum of global radiation are presented in Figure A5-7 in Appendix 5. Global radiation is measured only at Äspö. Values from Äspö and Strång-values are presented. Analysed global radiation from the SMHI radiation model Strång, which uses data from Mesan, corresponds well to measured global radiation at Äspö. 30-min values for January 2006 are presented in Figure A5-15.

## 5.2.8 Calculated evapotranspiration

The potential evapotranspiration  $E_p$  “new calculation method” is derived from the Penman equation:

$$E_p = \left( \frac{\Delta \cdot (R_n - G)}{(\Delta + \gamma) \cdot L} + \frac{\gamma \cdot f(u) \cdot (e_s - e)}{(\Delta + \gamma)} \right) \cdot tstep$$

where

|          |                                |
|----------|--------------------------------|
| $\Delta$ | proportionality constant       |
| $R_n$    | net radiation flux density     |
| $G$      | heat flux density into ground  |
| $\gamma$ | psychrometric constant         |
| $f(u)$   | function of wind speed         |
| $e_s$    | saturated water vapor pressure |
| $e$      | water vapor pressure           |
| $L$      | latent heat of vaporization    |
| $tstep$  | time step                      |

The method is described in detail in /4/. Measured data every 30-minutes of temperature, relative humidity, wind speed and global radiation were required as input data to the equation to calculate the potential evapotranspiration. The wind speed was measured at 10 m above the ground but for the estimation of potential evapotranspiration the wind speed was re-calculated to a value representing 2 m above the ground by multiplying by a factor 0.8. The net radiation was calculated from the measured global radiation and the albedo was set to 0.12 when the ground was not covered in snow and to 0.5 when there was a snow cover. The applied method included heat storage in the ground.

Graph of the potential evapotranspiration is presented in the Figure A5-8 in Appendix 5. The 30-min values for January 2006 are presented in Figure A5-1 in Appendix 5.

## 5.3 Winter parameters

### 5.3.1 Snow depth

The average snow depth at the one station for snow depth measurement is shown in Figure 5-18. The complete set of primary data is presented in Appendix 3, Table A3-1.

### 5.3.2 Frost in ground

The frost in ground together with snow depth at “Grillplatsen” (PSM107724) is shown in Figure 5-19. The complete sets of primary data is shown in Appendix 4, Table A4-1 and A4-2.

### 5.3.3 Ice cover

Ice conditions observed in the Oskarshamn area are shown in Table 5-5.

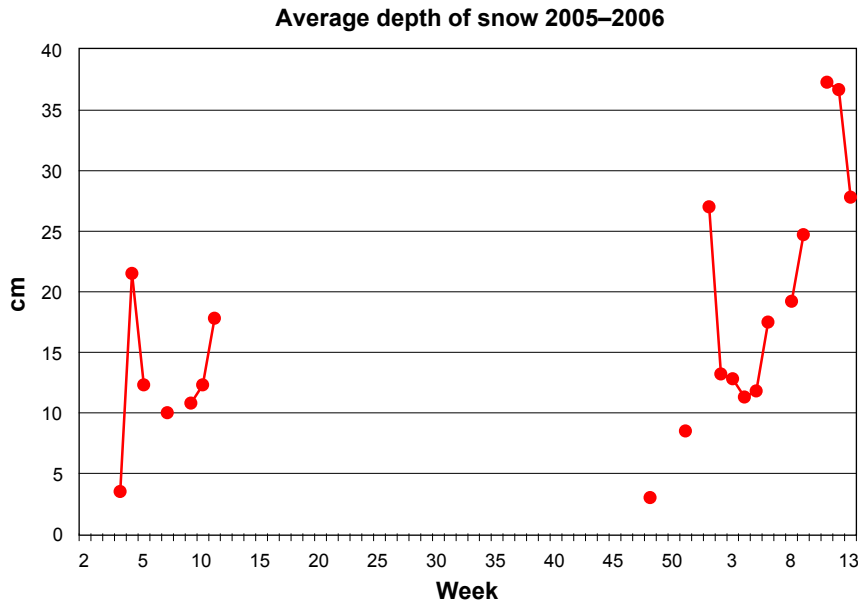


Figure 5-18. Average snow depth at Äspö 2 (ASM100224) during the winter 2005/2006.

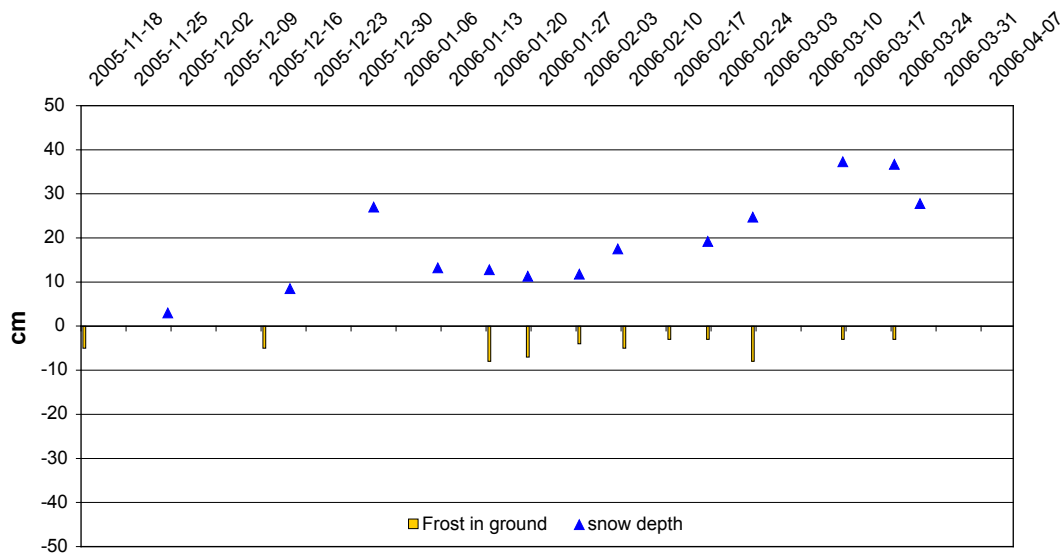


Figure 5-19. Calculated frost in ground and snow depth at PSM107724 during 2005 and 2006.

**Table 5-5. Time for ice freeze up and ice break up in a lake and sea at the Oskarshamns area<sup>1</sup>.**

| Site                        | Ice freeze up                        | Ice break up | Period with ice cover (days) |
|-----------------------------|--------------------------------------|--------------|------------------------------|
| Äspös brygga (ASM10226)     | 2002-12-19                           | 2003-03-27   | 99                           |
|                             | 2004-01-07                           | 2004-03-10   | 62                           |
|                             | 2005-03-08                           | 2005-04-01   | 25                           |
|                             | 2005-12-20                           | 2006-04-18   | 119                          |
| Kråkelund yttre (ASM100227) | <i>no ice cover during 2003–2004</i> |              |                              |
|                             | <i>no ice cover during 2004–2005</i> |              |                              |
|                             | <i>no ice cover during 2005–2006</i> |              |                              |
| Kråkelund inre (ASM100228)  | 2003-01-10                           | 2003-03-21   | 71                           |
|                             | <i>no ice cover during 2004–2005</i> |              |                              |
|                             | 2006-01-02                           | 2006-01-12   | 10                           |
|                             | 2006-01-26                           | 2006-02-03   | 8                            |
|                             | 2006-03-17                           | 2006-03-29   | 12                           |
| Jämsen (ASM100229)          | 2002-11-19                           | 2002-11-22   | 3                            |
|                             | 2002-12-19                           | 2003-03-28   | 100                          |
|                             | 2004-01-07                           | 2004-03-10   | 64                           |
|                             | 2004-11-22                           | 2005-03-30   | 129                          |
|                             | 2005-11-22                           | 2006-04-18   | 147                          |

<sup>1</sup>This table replaces Table 5-3 in report P-06-19 and Table 5-3 in report P-05-227 due to error in ice cover data for ASM100227 (Kråkelund yttre).



## References

- /1/ **SMHI/Naturvårdsverket, 1979.** Vattenföringsbestämning vid vattenundersökningar.
- /2/ **SMHI.** Handbok för observatörer. Internt document.
- /3/ **SKB, 2002.** Instruktion för inmätning och avvägning av objekt. SKB MD 110.001, Svensk Kärnbränslehantering AB.
- /4/ **Eriksson B, 1981.** Den ”potentiella” evapotranspirationen i Sverige. Eriksson, B. (1981) RMK28.
- /5/ **Alexandersson, 2003.** Meteorologi, Nr111. Korrektion av nederbörd enligt enkel klimatologisk metodik.
- /6/ **Alexandersson, 2005.** Enkel bedömning av nederbördsrätningsförluster på fyra automatstationer.
- /7/ **SMHI.** Handbok för observatörer. Internt document.
- /8/ **SKB, 2002.** Instruktion för inmätning och avvägning av objekt. SKB MD 110.001, Svensk Kärnbränslehantering AB.

## Hydrological monitoring stations

| Station Id | Object               | Place                       | Variables        | Instrumentation   | Time interval of measurements                           | QC_OK |
|------------|----------------------|-----------------------------|------------------|---|---|-------|
| PSM000341  | Ävrö NE              | Dam                         | Discharge, T, EC | Logger:<br>Campbell CR10X<br>Pressure sensor:<br>DRUCK PDCR 1830<br>Temp. and EC:<br>Campbell CS547 | Start:<br>2004-03-18 00:00<br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000342  | Jämsen               | Lake                        | Water level      | Logger:<br>Campbell CR510<br>Pressure sensor:<br>DRUCK PDCR 1830                                    | Start:<br>2004-07-24 15:00<br>Stop:<br>2007-01-01-00:00 | OK    |
| PSM000343  | Ävrö SW              | Dam                         | Discharge, T, EC | Logger:<br>Campbell CR10X<br>Pressure sensor:<br>DRUCK PDCR 1830<br>Temp. and EC:<br>Campbell CS547 | Start:<br>2004-03-18 00:00<br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000344  | Plittorpsgöl         | Lake                        | Water level      | Logger:<br>Campbell CR510<br>Pressure sensor:<br>DRUCK PDCR 1830                                    | Start:<br>2004-07-24 15:00<br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000345  | Ävrö SE              | Dam                         | Discharge, T, EC | Logger:<br>Campbell CR10X<br>Pressure sensor:<br>DRUCK PDCR 1830<br>Temp. and EC:<br>Campbell CS547 | Start:<br>2004-03-18 00:00<br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000347  | Frisksjön (in)       | Dam                         | Discharge, T, EC | Logger:<br>Campbell CR10X<br>Pressure sensor:<br>DRUCK PDCR 1830<br>Temp. and EC:<br>Campbell CS547 | Start:<br>2004-11-30 13:00<br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000348  | Frisksjön (out)      | Lake,<br>Natural<br>section | Discharge, T, EC | Logger:<br>Campbell CR10X<br>Pressure sensor:<br>DRUCK PDCR 1830<br>Temp. and EC:<br>Campbell CS547 | Start:<br>2004-07-24 01:00<br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000353  | Laxemarån<br>(upper) | Natural<br>section          | Discharge, T, EC | Logger:<br>Campbell CR10X<br>Pressure sensor:<br>DRUCK PDCR 1830<br>Temp. and EC:<br>Campbell CS547 | Start:<br>2004-09-02 15:00<br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000359  | Sörå-<br>magasinet   | Lake                        | Water level      | Logger:<br>Campbell CR510<br>Pressure sensor:<br>DRUCK PDCR 1830                                    | Start:<br>2004-01-28 17:00<br>Stop:<br>2007-01-01 00:00 | OK    |

| Station Id | Object               | Place              | Variables           | Instrumentation   | Time interval of measurements                               | QC_OK |
|------------|----------------------|--------------------|---------------------|---|---|-------|
| PSM000364  | Laxemarån<br>(lower) | Natural<br>section | Discharge,<br>T, EC | Logger:<br>Campbell CR10X<br><br>Pressure sensor:<br>DRUCK PDCR 1830<br><br>Temp. and EC:<br>Campbell CS547 | Start:<br>2004-09-02 11:00<br><br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000365  | Ekerumsån            | Dam                | Discharge,<br>T, EC | Logger:<br>Campbell CR10X<br><br>Pressure sensor:<br>DRUCK PDCR 1830<br><br>Temp. and EC:<br>Campbell CS547 | Start:<br>2005-02-01 13:00<br><br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000368  | Kärrviksån           | Natural<br>section | Discharge,<br>T, EC | Logger:<br>Campbell CR10X<br><br>Pressure sensor:<br>DRUCK PDCR 1830<br><br>Temp. and EC:<br>Campbell CS547 | Start:<br>2004-07-24 10:00<br><br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000369  | Äspö S               | Sea                | Water level         | Logger:<br>Campbell CR510<br><br>Pressure sensor:<br>DRUCK PDCR 1830  | Start:<br>2004-01-28 17:00<br><br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000370  | Äspö N               | Sea                | Water level         | Logger:<br>Campbell CR510<br><br>Pressure sensor:<br>DRUCK PDCR 1830  | Start:<br>2004-01-28 17:00<br><br>Stop:<br>2007-01-01 00:00 | OK    |
| PSM000371  | Clab                 | Sea                | Water level         | Logger:<br>Campbell CR510<br><br>Pressure sensor:<br>DRUCK PDCR 1830  | Start:<br>2004-01-28 17:00<br><br>Stop:<br>2007-01-01 00:00 | OK    |

## Rating curves for hydrological stations

### Rating curves where concrete V-notch is used

After a number of control measurements have been made by personnel from SKB and SMHI, the following rating curves are suggested for the present for the SKB hydrological stations with concrete V-notch weirs. The rating curves were determined 2006-10-01. The names of the five stations are: PSM000341, PSM000343, PSM000345, PSM000347 and PSM000365.

For all stations the discharge has been theoretically calculated as:

$$Q = 8/15 \cdot \mu \cdot (2g)^{1/2} \cdot h^{5/2} \cdot \tan \alpha / 2$$

Q Discharge (m<sup>3</sup>/s)

μ Coefficient approximately constant

g Constant of gravity (9.815 m/s<sup>2</sup>)

h Water level above V-notch (m)

α opening angle

#### PSM000341

The rating angle is 45° and μ is set to 0.7. This value of μ is somewhat high because the water speed is high through the dam. The diagram below shows how the control measurements fit to the theoretically calculated discharge Q.

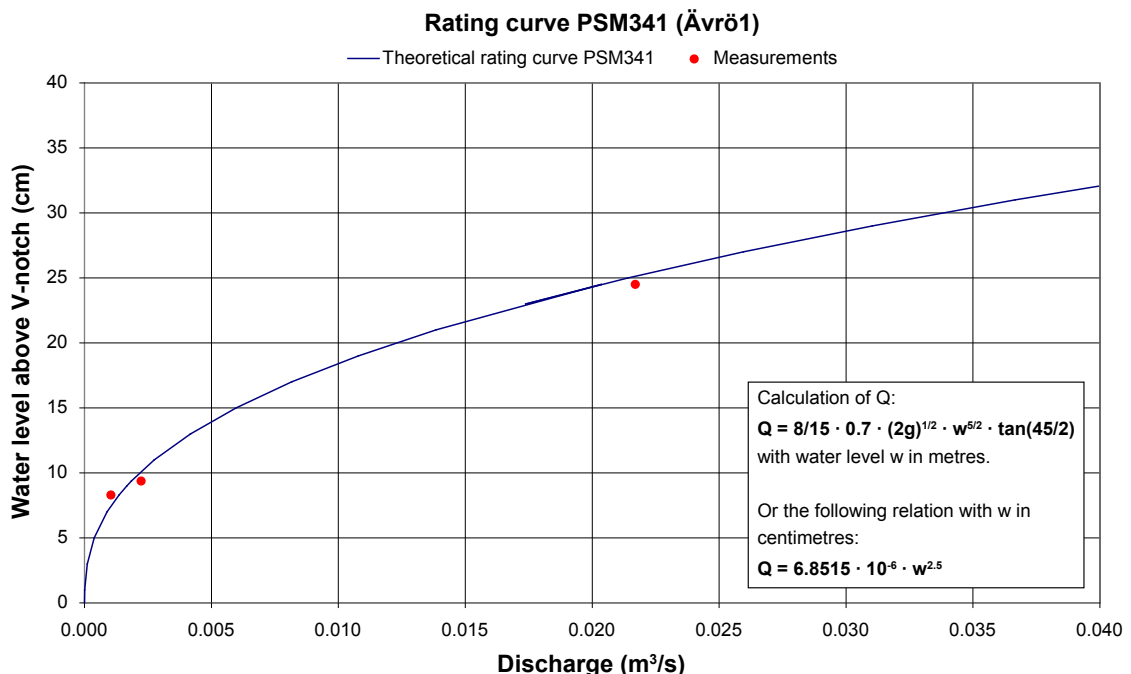


Figure A2-1. Made control measurements in relation to the theoretically calculated discharge.

**PSM000343**

The rating angle is 45° and μ is set to 0.6. The diagram below shows how the control measurements fit to the theoretically calculated discharge Q.

**PSM000345**

The rating angle is 45° and μ is set to 0.6. The diagram below shows how the control measurements fit to the theoretically calculated discharge Q.

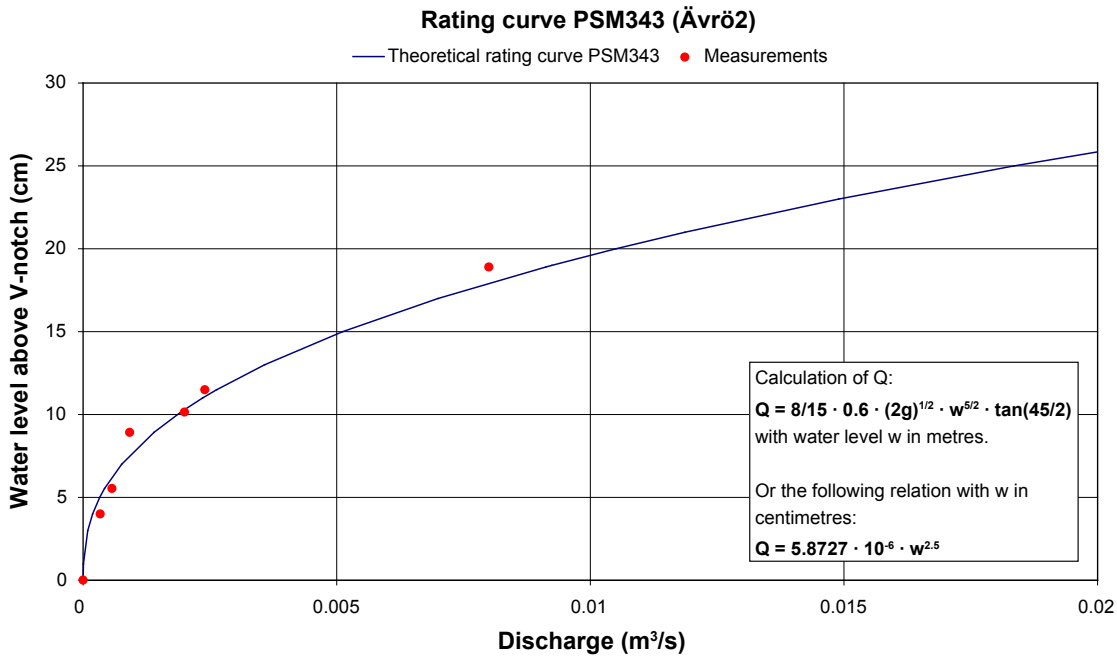


Figure A2-2. Made control measurements in relation to the theoretically calculated discharge.

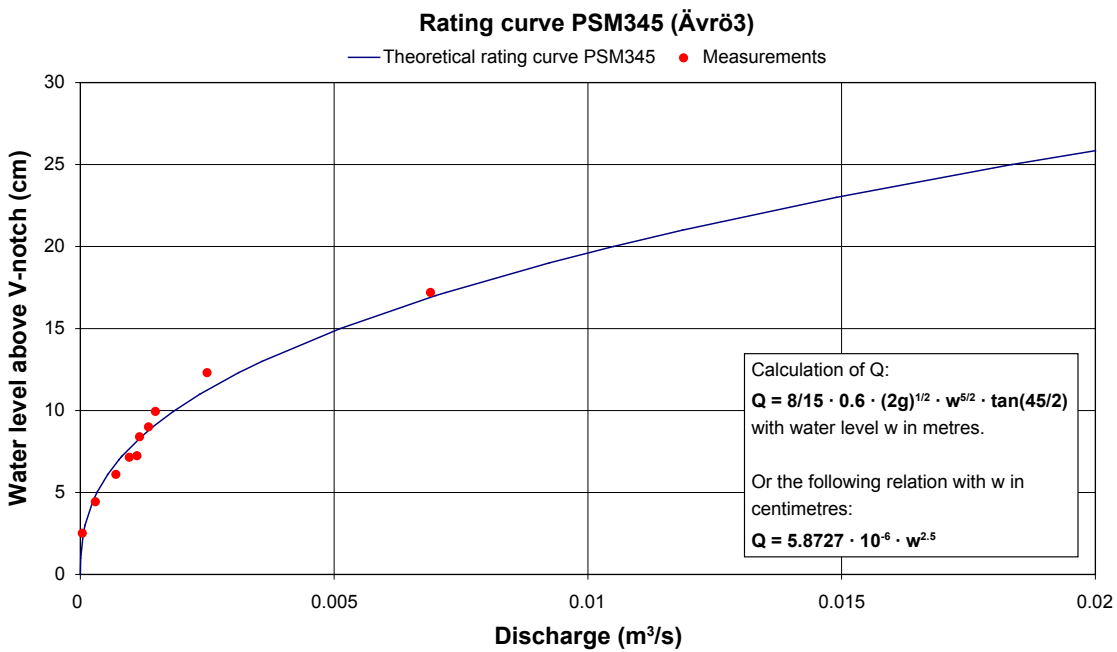


Figure A2-3. Made control measurements in relation to the theoretically calculated discharge.

### PSM000347

The rating angle is 60° and  $\mu$  is set to 0.6. The diagram below shows how the control measurements fit to the theoretically calculated discharge Q.

### PSM000365

The rating angle is 120° and  $\mu$  is set to 0.6. The diagram below shows how the control measurements fit to the theoretically calculated discharge Q.

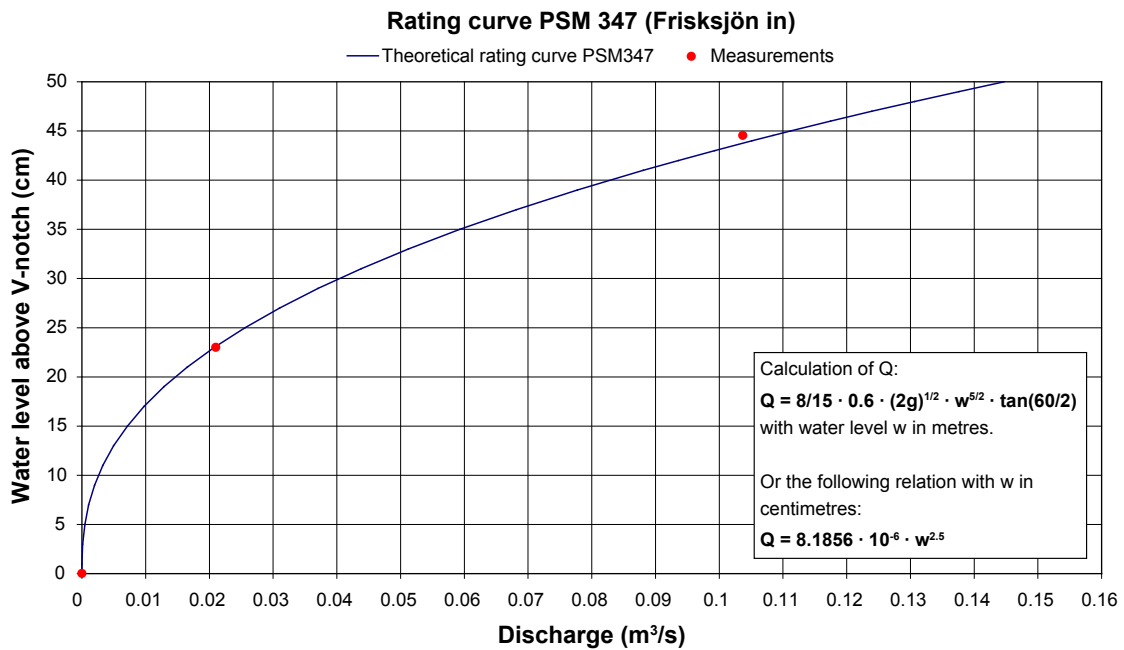


Figure A2-4. Made control measurements in relation to the theoretically calculated discharge.

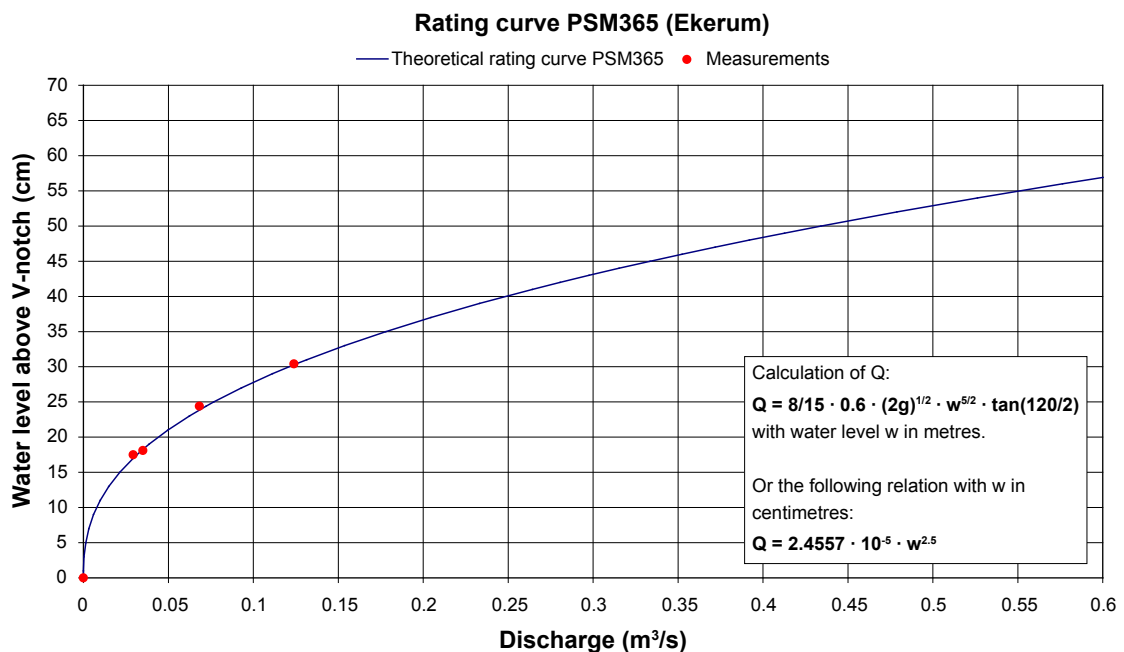


Figure A2-5. Made control measurements in relation to the theoretically calculated discharge.

### Rating curves where natural cross section is used

After a number of control measurements have been made by personnel from SKB and SMHI, the following rating curves are suggested for the present for the SKB hydrological stations where a natural cross section in the watercourse is used. The rating curves were determined 2006-10-01. The names of the four stations are PSM000348, PSM000353, PSM000364 and PSM000368. Further control measurements of discharge are required at these stations to increase the accuracy in the discharge calculations.

#### PSM000348

The discharge from lake Frisksjön is determined by using the lake's natural outlet as cross section. The rating curve below has been established based on control measurements made up to now.

#### PSM000353

The discharge in Laxemarån upper is determined by using the natural sections (Equation 1) and the contraction made by the road culvert just downstream the station (Equation 2). The discharge is for the present calculated with two rating equations. The first is valid up to the water level +10.23 metres above sea level and the other for higher levels. The following rating curves have been established based on control measurements made up to now.

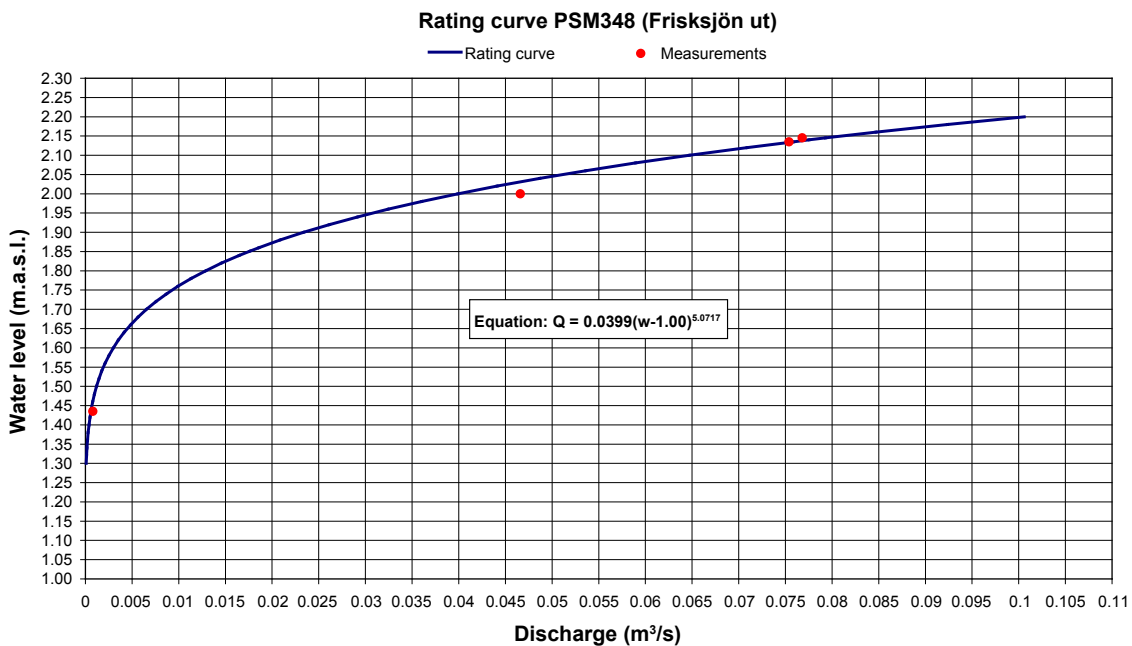
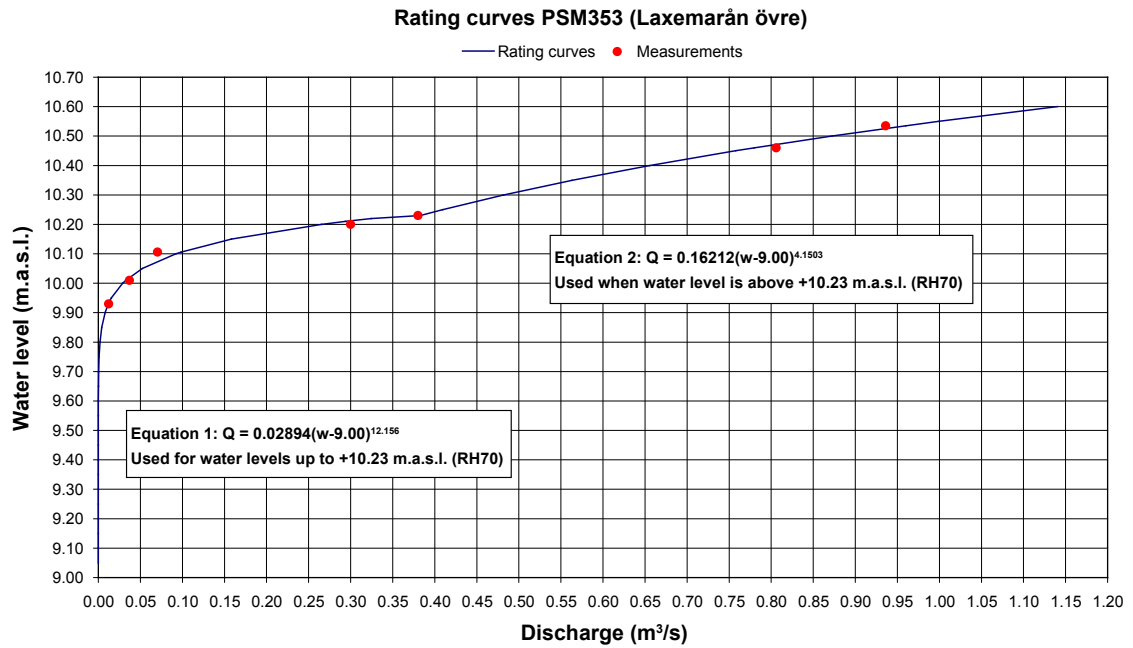


Figure A2-6. Rating curve for lake Frisksjön based on made control measurements.



*Figure A2-7. Rating curve for lake Frisksjön based on control measurements made up to now.*

#### **PSM000364**

The discharge in Laxemarån lower is determined by using the threshold and contraction made by the earlier concrete construction. The discharge is for the present calculated by the following rating curve.

#### **PSM000368**

The discharge in Kärrviksån is determined by using downstream sections and contractions in the watercourse. The discharge is for the present calculated by two rating curves, since control measurements have shown that different sections is determining the discharge in different rating registers. The first is valid up to water level +1.94 metre above sea level and the other for higher water levels. The following rating curve has been established based on control measurements made up to now.



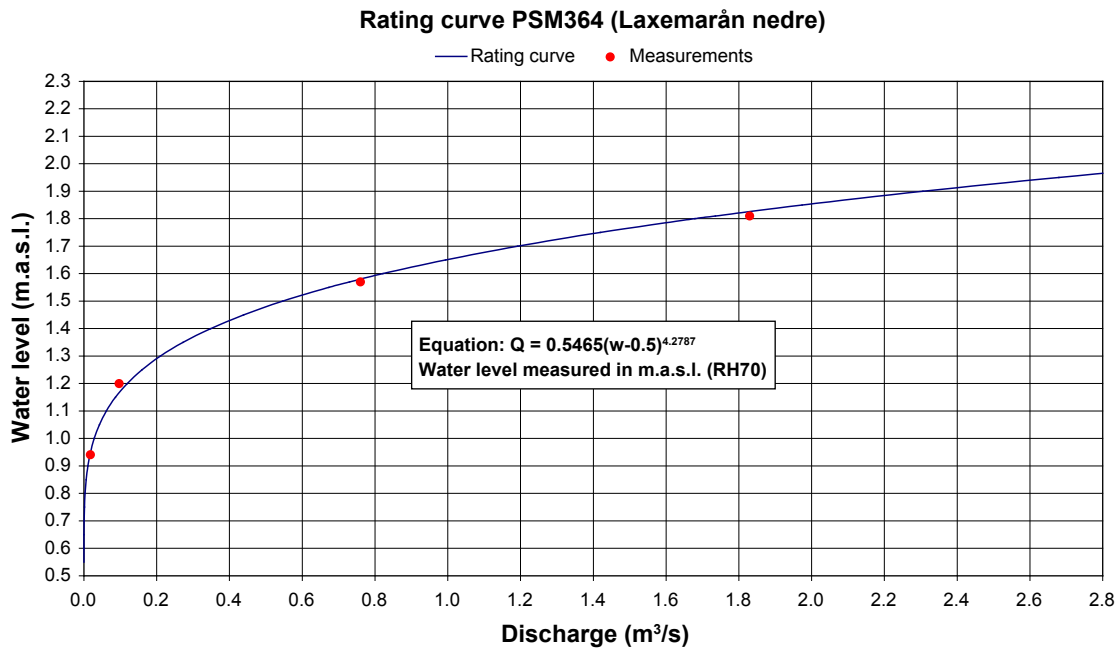


Figure A2-8. Rating curve for lake Frisksjön based on control measurements made up to now.

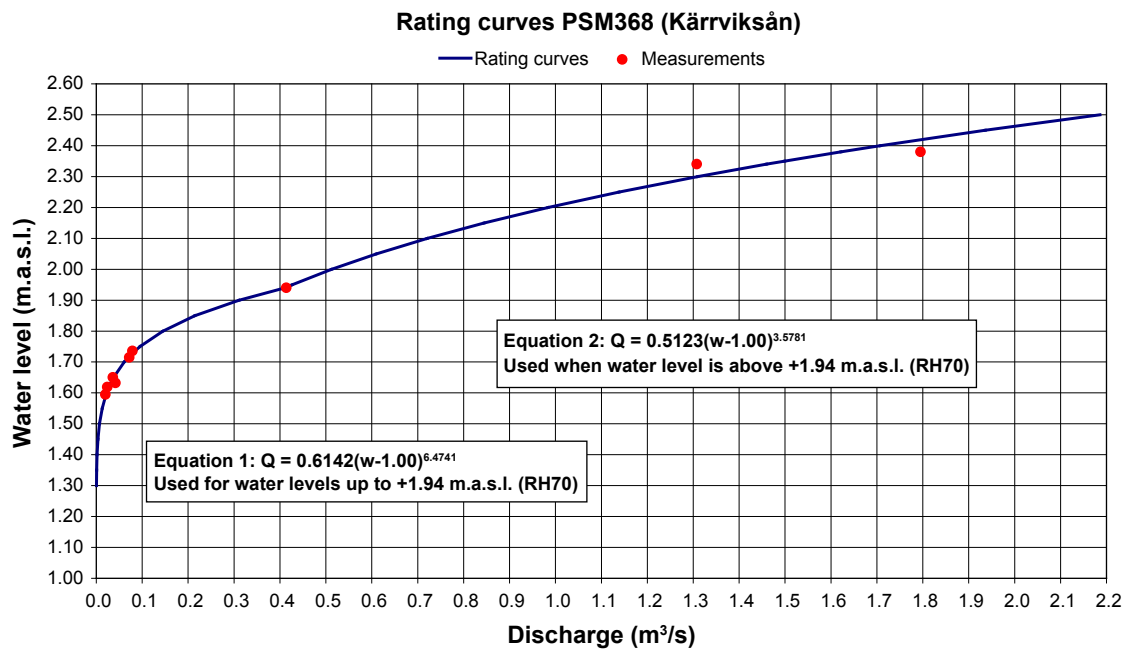


Figure A2-9. Rating curve for Kärrviksån based on control measurements made up to now.

## Measurements of snow cover

### Primary data from snow depth measurements during the winter 2005/2006

The data collected during the snow depth measurements are presented below as individual measurements as well as the calculated average snow depth and a visual estimate of the coverage degree. S = completely or almost covered ground, SB=more than half of the ground snow covered but not completely covered, BS=more than half of the ground free of snow but not completely, B = the ground completely or almost completely free of snow.

**Table A3-1. Snow depth at “Grillplatsen” (ASM100224) during the winter 2005/2006.**

| Start date | Stop date  | Point 1<br>(cm) | Point 2<br>(cm) | Point 3<br>(cm) | Point 4<br>(cm) | Point 5<br>(cm) | Point 6<br>(cm) | Average snow<br>cover (cm) | Snow<br>coverage |
|------------|------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------------------|------------------|
| 2005-11-14 | 2005-11-14 |                 |                 |                 |                 |                 |                 |                            | B                |
| 2005-11-28 | 2005-11-28 |                 |                 |                 |                 |                 |                 |                            | BS               |
| 2005-12-01 | 2005-12-01 | 3               | 3               | 4               | 3               | 2               | 3               | 3                          | S                |
| 2005-12-16 | 2005-12-16 | 7               | 7               | 10              | 9               | 9               | 9               |                            | B                |
| 2005-12-20 | 2005-12-20 |                 |                 |                 |                 |                 |                 | 8.5                        | S                |
| 2006-01-02 | 2006-01-02 | 27              | 27              | 27              | 27              | 29              | 25              | 27                         | S                |
| 2006-01-12 | 2006-01-12 | 13              | 13              | 12              | 12              | 14              | 15              | 13.2                       | S                |
| 2006-01-20 | 2006-01-20 | 11              | 13              | 10              | 13              | 17              | 13              | 12.8                       | S                |
| 2006-01-26 | 2006-01-26 | 13              | 9               | 10              | 12              | 12              | 12              | 11.3                       | S                |
| 2006-02-03 | 2006-02-03 | 10              | 11              | 12              | 12              | 13              | 13              | 11.8                       | S                |
| 2006-02-09 | 2006-02-09 | 19              | 16              | 13              | 21              | 19              | 17              | 17.5                       | S                |
| 2006-02-23 | 2006-02-23 | 15              | 20              | 20              | 20              | 20              | 20              | 19.2                       | S                |
| 2006-03-02 | 2006-03-02 | 16              | 20              | 19              | 30              | 29              | 34              | 24.7                       | S                |
| 2006-03-16 | 2006-03-16 | 37              | 25              | 37              | 37              | 43              | 45              | 37.3                       | S                |
| 2006-03-24 | 2006-03-24 | 35              | 38              | 33              | 33              | 43              | 38              | 36.7                       | S                |
| 2006-03-28 | 2006-03-28 | 31              | 26              | 23              | 25              | 27              | 35              | 27.8                       | S                |
| 2006-04-11 | 2006-04-11 |                 |                 |                 |                 |                 |                 |                            | B                |

## Measurements of ground frost

### Primary data from measurement of frost in the ground during the winter 2005/2006

The data collected during the measurements of ground frost are presented below. As the whole device was not situated within the ground, the levels for ground surface are above the 0-level. The upper registration is the level of the upper border of the ground frost read from the device whereas the lower registration is the lower border. The upper and lower levels of ground frost are calculated using the level of the ground surface and the upper and lower registrations, respectively. From these two levels the distribution of ground frost has been calculated.

**Table A4-1. Frost in ground during the winter 2005/2006 at Grillplatsen (PSM007724).**

| Start date | Stop date  | Ground surface (cm) | Upper reg (cm) | Lower reg (cm) | Upper level of ground frost (cm) | Lower level of ground frost (cm) | Ground frost distribution (cm) |
|------------|------------|---------------------|----------------|----------------|----------------------------------|----------------------------------|--------------------------------|
| 2005-11-14 | 2005-11-14 | 100                 |                |                |                                  |                                  |                                |
| 2005-11-18 | 2005-11-18 | 100                 | 0              | 110            | 0                                | 10                               | 10                             |
| 2005-11-29 | 2005-11-29 | 100                 | 0              | 111            | 0                                | 11                               | 11                             |
| 2005-12-16 | 2005-12-16 | 100                 | 0              | 112            | 0                                | 12                               | 12                             |
| 2005-12-20 | 2005-12-20 | 100                 | 0              | 113            | 0                                | 13                               | 13                             |
| 2006-01-12 | 2006-01-12 | 100                 |                |                |                                  |                                  |                                |
| 2006-01-20 | 2006-01-20 | 100                 | 0              | 110            | 0                                | 10                               | 10                             |
| 2006-02-03 | 2006-02-03 | 100                 | 0              | 103            | 0                                | 3                                | 3                              |
| 2006-02-09 | 2006-02-09 | 100                 | 81             | 114            | 0                                | 14                               | 14                             |
| 2006-02-17 | 2006-02-17 | 100                 | 0              | 105            | 0                                | 5                                | 5                              |
| 2006-02-23 | 2006-02-23 | 100                 | 90             | 103            | 0                                | 3                                | 3                              |
| 2006-03-02 | 2006-03-02 | 100                 | 0              | 109            | 0                                | 9                                | 9                              |
| 2006-03-17 | 2006-03-17 | 100                 | 0              | 106            | 0                                | 6                                | 6                              |
| 2006-03-24 | 2006-03-24 | 100                 | 0              | 110            | 0                                | 10                               | 10                             |
| 2006-03-28 | 2006-03-28 | 100                 |                |                |                                  |                                  |                                |
| 2006-04-11 | 2006-04-11 | 100                 |                |                |                                  |                                  |                                |

**Table A4-2. Frost in ground during the winter 2005/2006 at Äspö (PSM6978).**

| Start date | Stop date  | Ground surface (cm) | Upper reg (cm) | Lower reg (cm) | Upper level of ground frost (cm) | Lower level of ground frost (cm) | Ground frost distribution (cm) |
|------------|------------|---------------------|----------------|----------------|----------------------------------|----------------------------------|--------------------------------|
| 2005-11-18 | 2005-11-18 | 95                  | 0              | 100            | 0                                | 5                                | 5                              |
| 2005-11-29 | 2005-11-29 | 95                  | 0              | 95             | 0                                | 0                                | 0                              |
| 2005-12-16 | 2005-12-16 | 95                  | 0              | 100            | 0                                | 5                                | 5                              |
| 2005-12-20 | 2005-12-20 | 95                  | 0              | 101            |                                  |                                  |                                |
| 2006-01-04 | 2006-01-04 | 95                  |                |                |                                  |                                  |                                |
| 2006-01-12 | 2006-01-12 | 95                  |                |                |                                  |                                  |                                |
| 2006-01-20 | 2006-01-20 | 95                  | 0              | 103            | 0                                | 8                                | 8                              |
| 2006-01-26 | 2006-01-26 | 95                  | 0              | 102            | 0                                | 7                                | 7                              |
| 2006-02-03 | 2006-02-03 | 95                  | 0              | 99             | 0                                | 4                                | 4                              |
| 2006-02-10 | 2006-02-10 | 95                  | 76             | 100            | 0                                | 5                                | 5                              |
| 2006-02-17 | 2006-02-17 | 95                  | 0              | 98             | 0                                | 3                                | 3                              |
| 2006-02-23 | 2006-02-23 | 95                  | 71             | 98             | 0                                | 3                                | 3                              |
| 2006-03-02 | 2006-03-02 | 95                  | 0              | 103            | 0                                | 8                                | 8                              |
| 2006-03-16 | 2006-03-16 | 95                  | 0              | 98             | 0                                | 3                                | 3                              |
| 2006-03-24 | 2006-03-24 | 95                  | 0              | 98             | 0                                | 3                                | 3                              |
| 2006-03-28 | 2006-03-28 | 95                  | 79             | 95             | 0                                | 0                                | 0                              |
| 2006-04-11 | 2006-04-11 | 95                  |                |                |                                  |                                  |                                |

**Table A4-3. Frost in ground during the winter 2005/2006 at Grindstugan (PSM6979).**

| Start date | Stop date  | Ground surface (cm) | Upper reg (cm) | Lower reg (cm) | Upper level of ground frost (cm) | Lower level of ground frost (cm) | Ground frost distribution (cm) |
|------------|------------|---------------------|----------------|----------------|----------------------------------|----------------------------------|--------------------------------|
| 2005-11-14 | 2005-11-14 | 100                 |                |                |                                  |                                  |                                |
| 2005-11-18 | 2005-11-18 | 100                 | 0              | 102            | 0                                | 2                                | 2                              |
| 2005-11-29 | 2005-11-29 | 100                 | 0              | 77             | 0                                | 0                                | 0                              |
| 2005-12-16 | 2005-12-16 | 100                 | 0              | 64             | 0                                | 0                                | 0                              |
| 2005-12-20 | 2005-12-20 | 100                 |                |                |                                  |                                  |                                |
| 2005-12-21 | 2005-12-21 | 100                 |                |                |                                  |                                  |                                |
| 2006-01-02 | 2006-01-02 | 100                 | 0              | 95             | 0                                | 0                                | 0                              |
| 2006-01-12 | 2006-01-12 | 100                 | 84             | 91             | 16                               | 0                                | 0                              |
| 2006-01-20 | 2006-01-20 | 100                 |                |                |                                  |                                  |                                |
| 2006-01-26 | 2006-01-26 | 100                 |                |                |                                  |                                  |                                |
| 2006-02-27 | 2006-02-27 | 100                 |                |                |                                  |                                  |                                |
| 2006-03-02 | 2006-03-02 | 100                 |                |                |                                  |                                  |                                |
| 2006-03-17 | 2006-03-17 | 100                 | 0              | 98             | 0                                | 2                                | 2                              |
| 2006-03-24 | 2006-03-24 | 100                 |                |                |                                  |                                  |                                |
| 2006-03-28 | 2006-03-28 | 100                 |                |                |                                  |                                  |                                |
| 2006-04-11 | 2006-04-11 | 100                 |                |                |                                  |                                  |                                |

**Table A4-4. Frost in ground during the winter 2005/2006 at Åkern (PSM6980).**

| Start date | Stop date  | Ground surface (cm) | Upper reg (cm) | Lower reg (cm) | Upper level of ground frost (cm) | Lower level of ground frost (cm) | Ground frost distribution (cm) |
|------------|------------|---------------------|----------------|----------------|----------------------------------|----------------------------------|--------------------------------|
| 2005-11-14 | 2005-11-14 | 92                  |                |                |                                  |                                  |                                |
| 2005-11-18 | 2005-11-18 | 92                  | 0              | 100            | 0                                | 8                                | 8                              |
| 2005-11-29 | 2005-11-29 | 92                  | 0              | 97             | 0                                | 5                                | 5                              |
| 2005-12-16 | 2005-12-16 | 92                  |                | 100            |                                  | 8                                | 8                              |
| 2005-12-20 | 2005-12-20 | 92                  | 0              | 101            | 0                                | 9                                | 9                              |
| 2006-01-02 | 2006-01-02 | 92                  | 0              | 92             |                                  |                                  |                                |
| 2006-01-09 | 2006-01-09 | 92                  |                |                |                                  |                                  |                                |
| 2006-01-20 | 2006-01-20 | 92                  | 0              | 100            | 0                                | 8                                | 8                              |
| 2006-01-26 | 2006-01-26 | 92                  | 0              | 96             | 0                                | 4                                | 4                              |
| 2006-02-03 | 2006-02-03 | 92                  | 0              | 95             | 0                                | 3                                | 3                              |
| 2006-02-09 | 2006-02-09 | 92                  | 71             | 97             | 0                                | 5                                | 5                              |
| 2006-02-17 | 2006-02-17 | 92                  | 0              | 94             | 0                                | 2                                | 2                              |
| 2006-02-23 | 2006-02-23 | 92                  | 73             | 93             | 0                                | 1                                | 1                              |
| 2006-03-02 | 2006-03-02 | 92                  | 0              | 99             | 0                                | 7                                | 7                              |
| 2006-03-17 | 2006-03-17 | 92                  | 0              | 95             | 0                                | 3                                | 3                              |
| 2006-03-24 | 2006-03-24 | 92                  |                |                |                                  |                                  |                                |
| 2006-03-28 | 2006-03-28 | 92                  |                |                |                                  |                                  |                                |

Meteorological monitoring

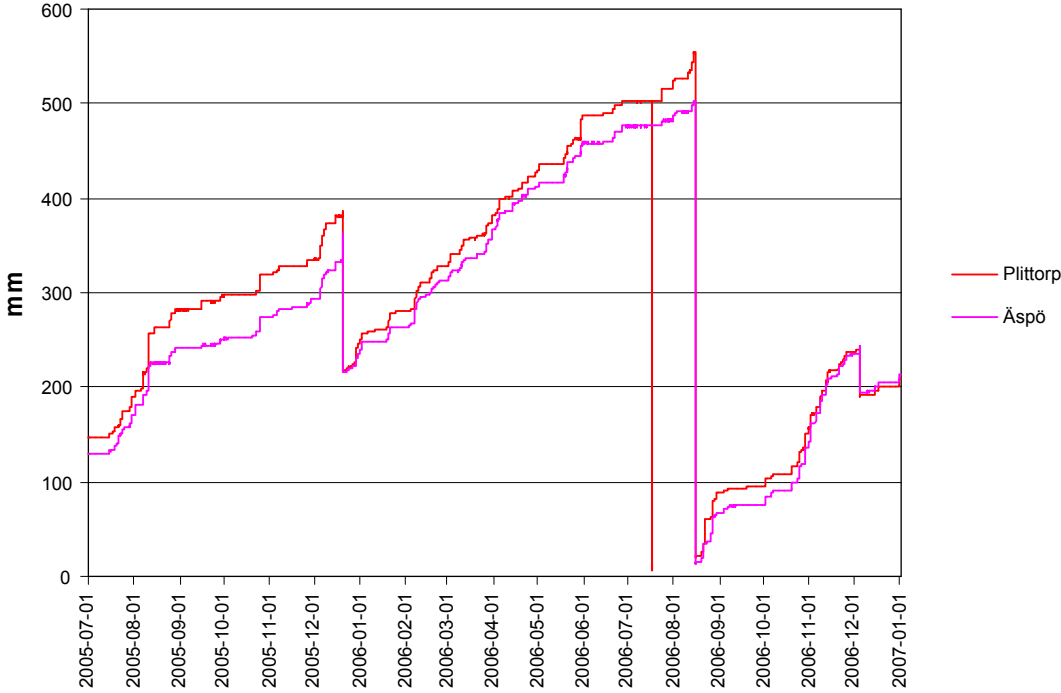


Figure A5-1. Precipitation in mm, 30 min values. July 2005–December 2006.

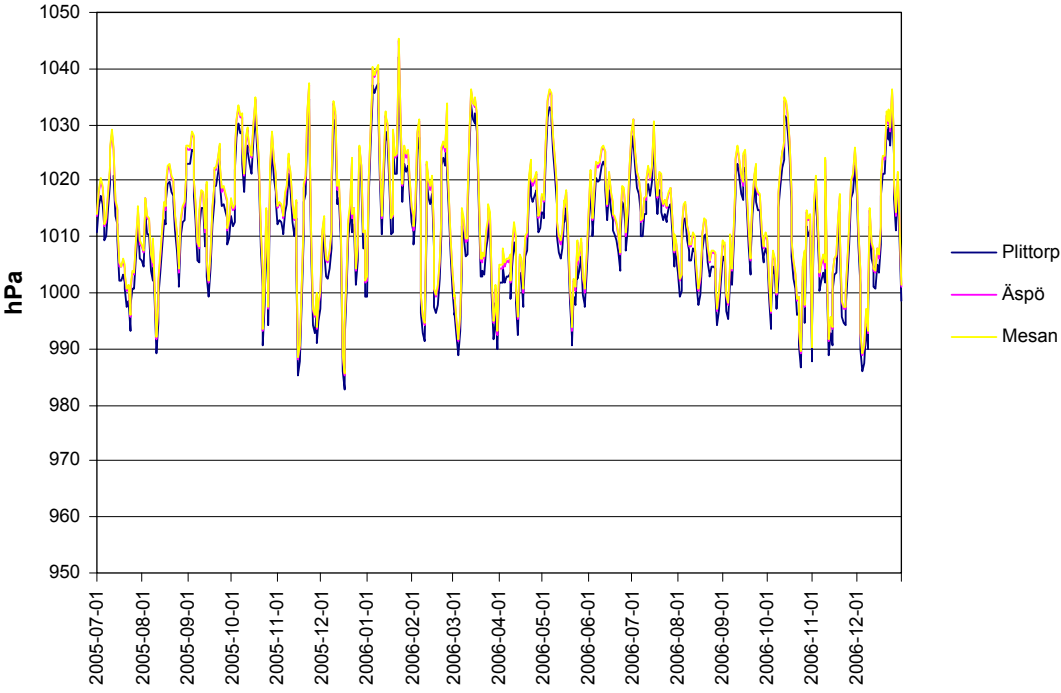
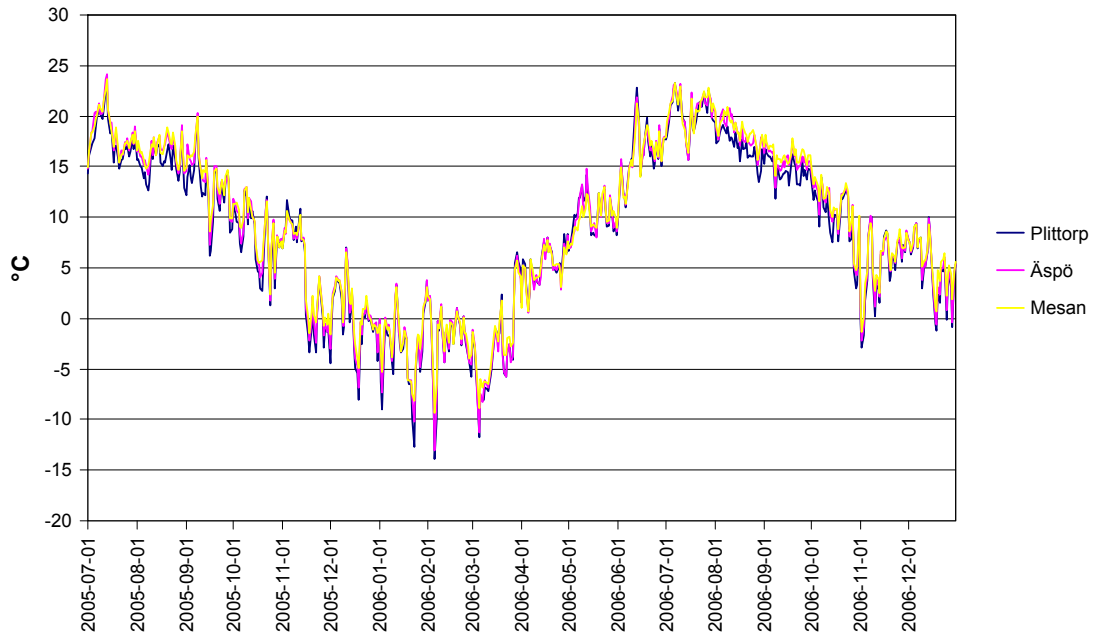
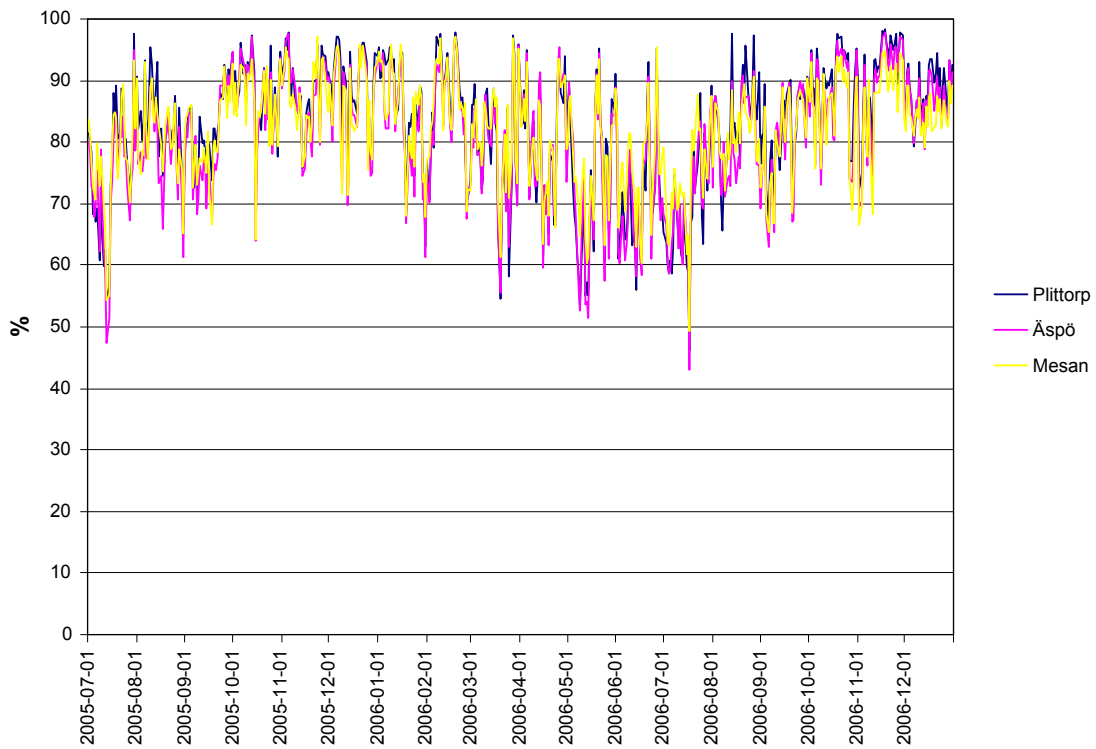


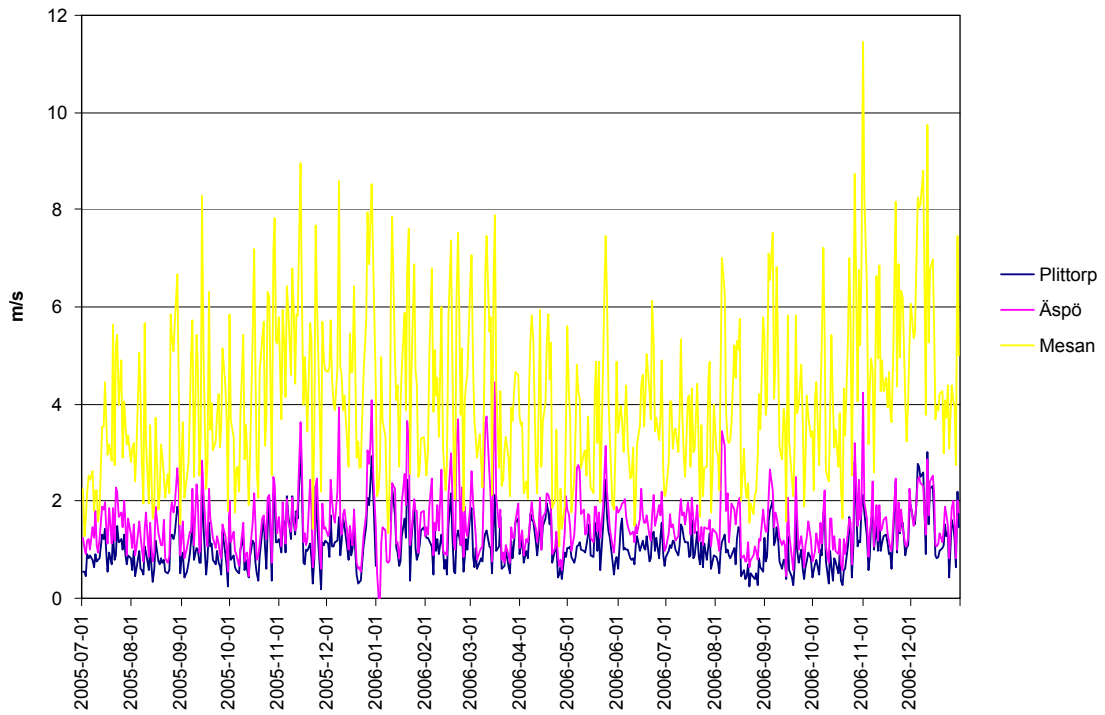
Figure A5-2. Barometric pressure in hPa, daily values. July 2005–December 2006.



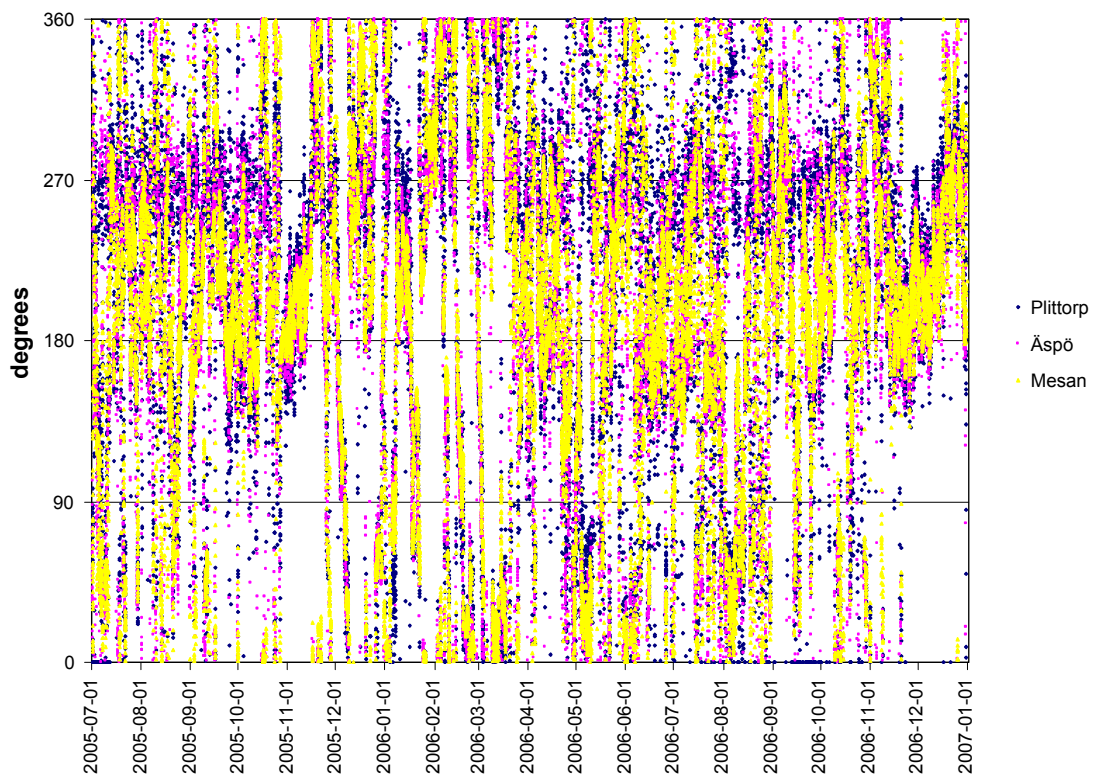
*Figure A5-3. Temperature in °C, daily values. July 2005–December 2006.*



*Figure A5-4. Relative humidity in %, daily values. July 2005–December 2006.*



**Figure A5-5.** Wind speed in m/s, daily values. July 2005–December 2006.



**Figure A5-6.** Wind direction in  $^{\circ}$ , 30-min values. July 2005–December 2006.



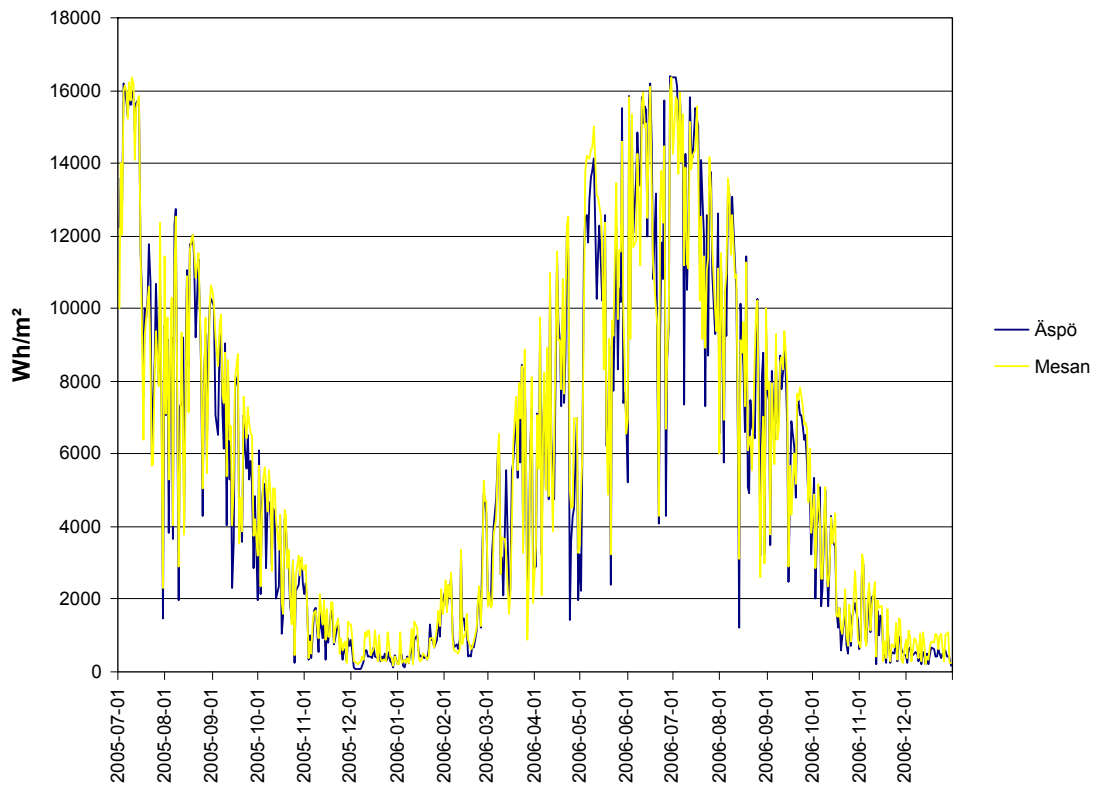


Figure A5-7. Global radiation in  $Wh/m^2$ , daily sum. July 2005–December 2006.

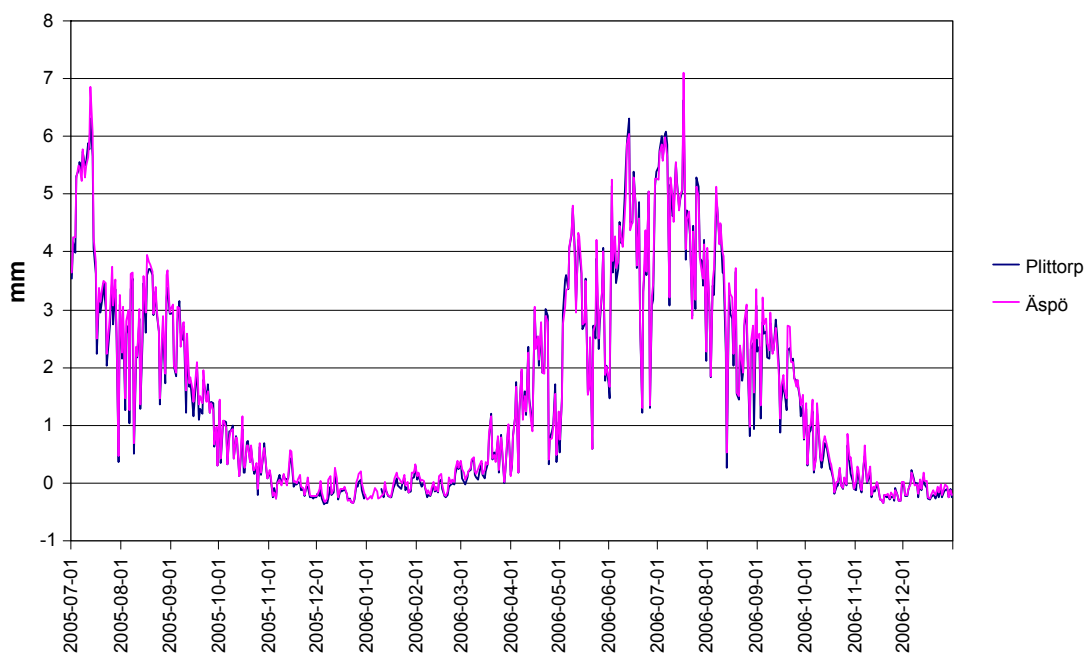
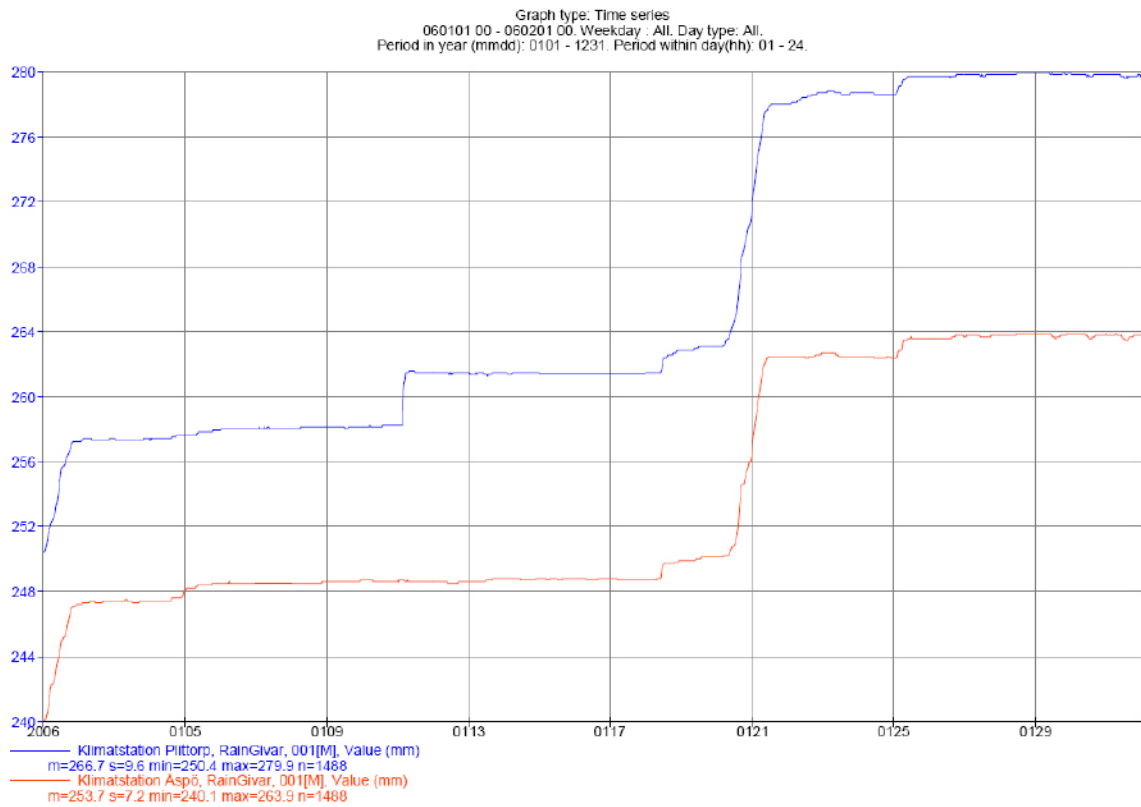
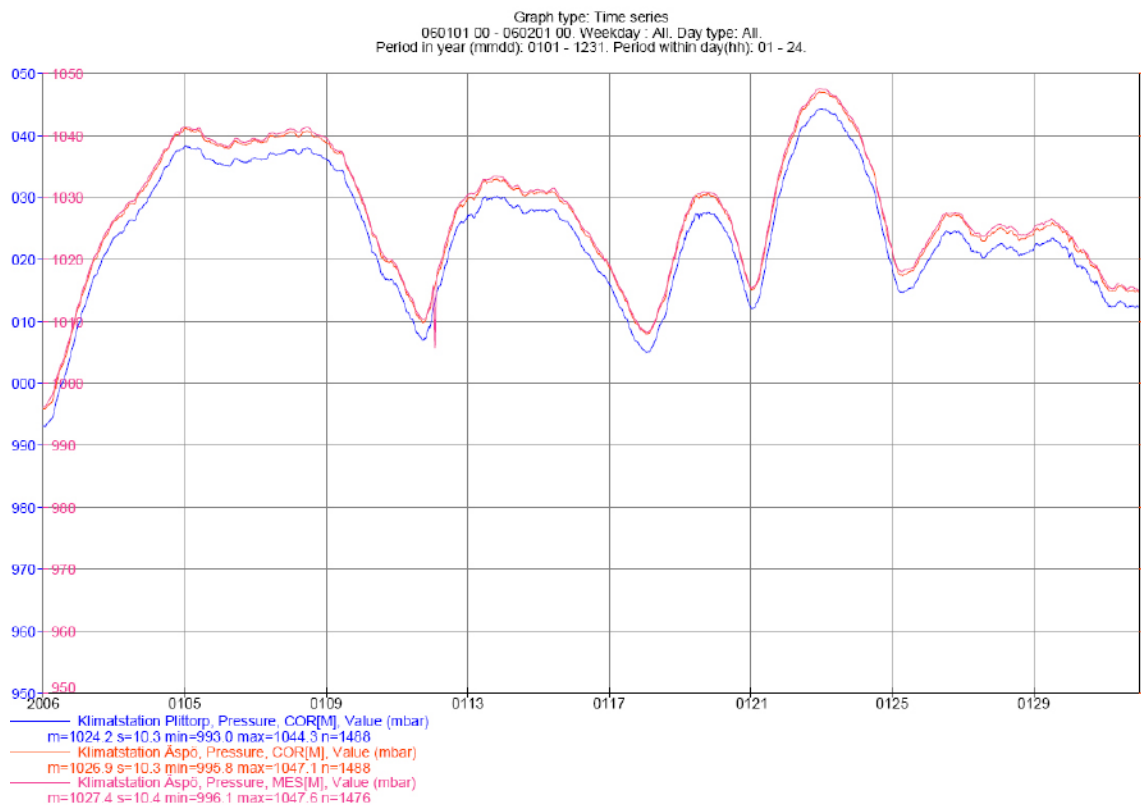


Figure A5-8. Evapotranspiration in mm, daily sum. July 2005–December 2006.



**Figure A5-9.** Precipitation in mm, 30 min values. January 2006.



**Figure A5-10.** Barometric pressure in Pa, 30 min-values. January 2006.

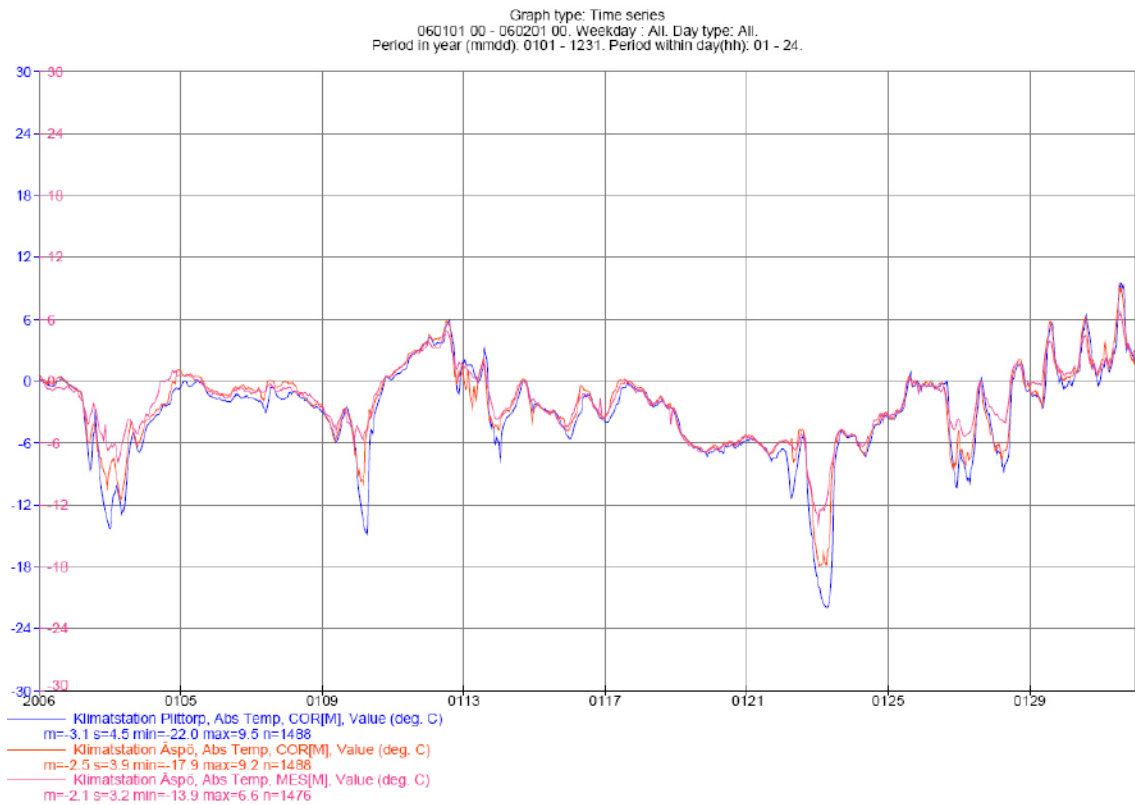


Figure A5-11. Temperature in °C, 30 min-values. January 2006.

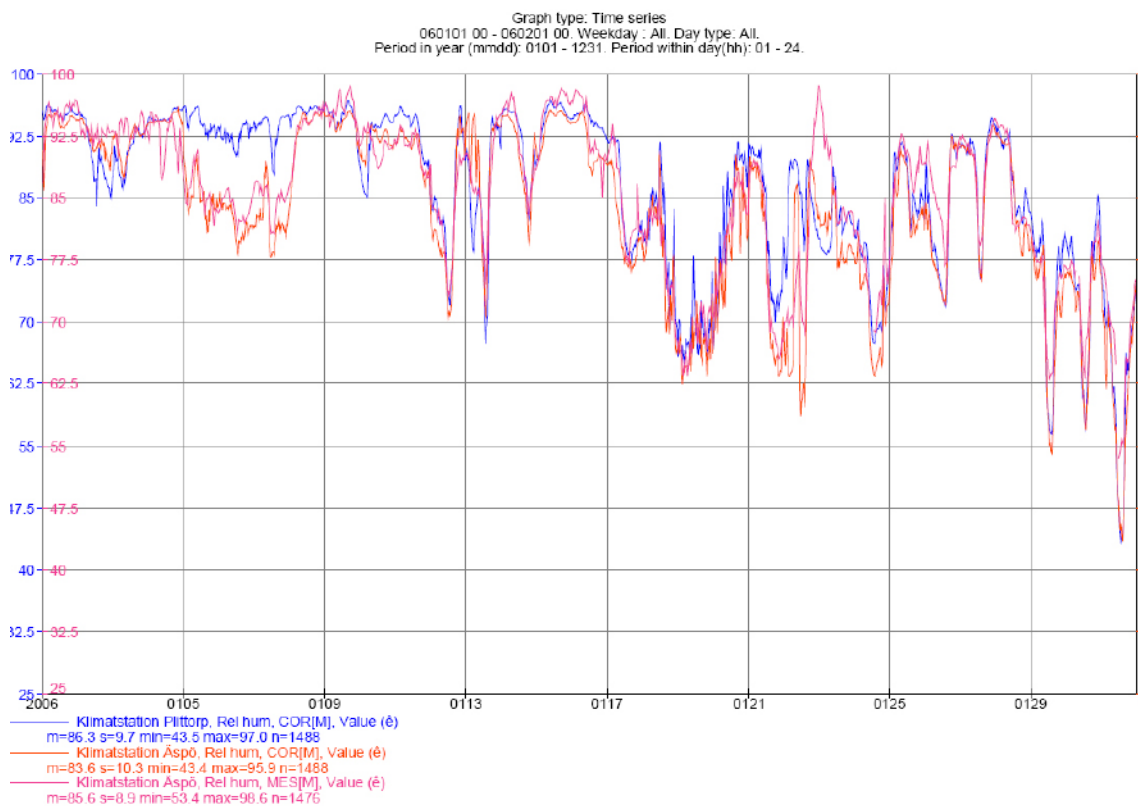
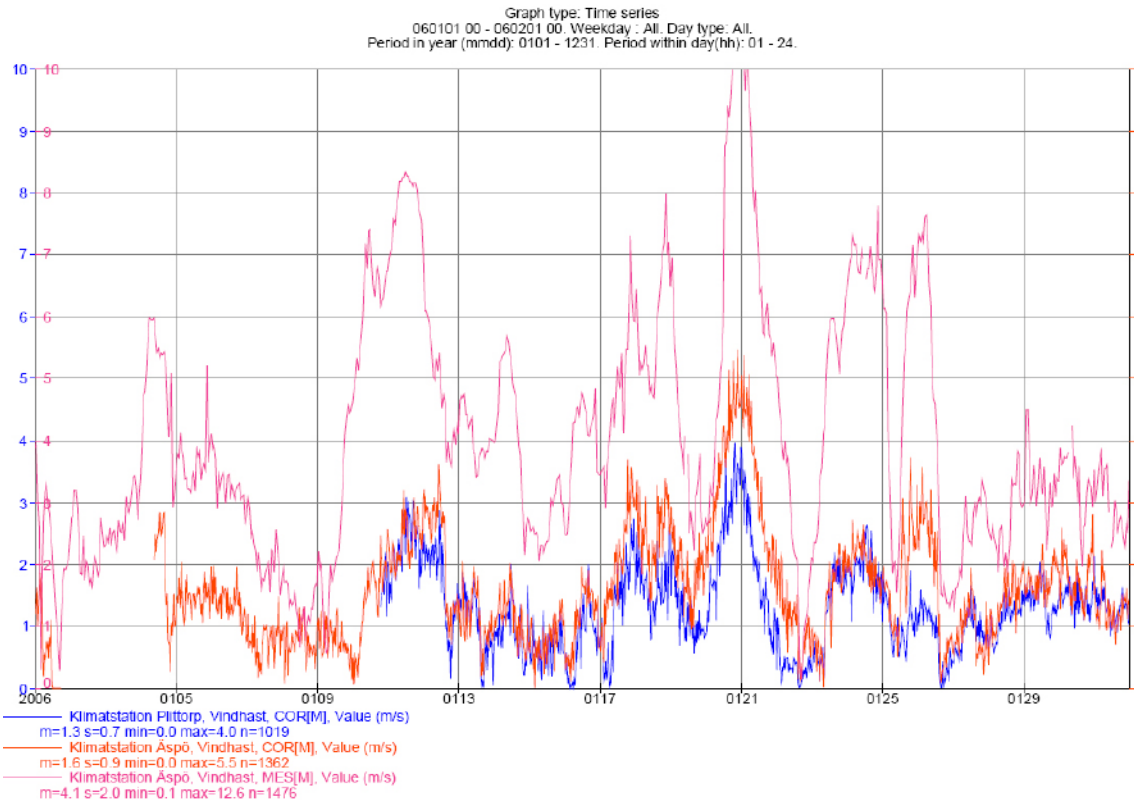
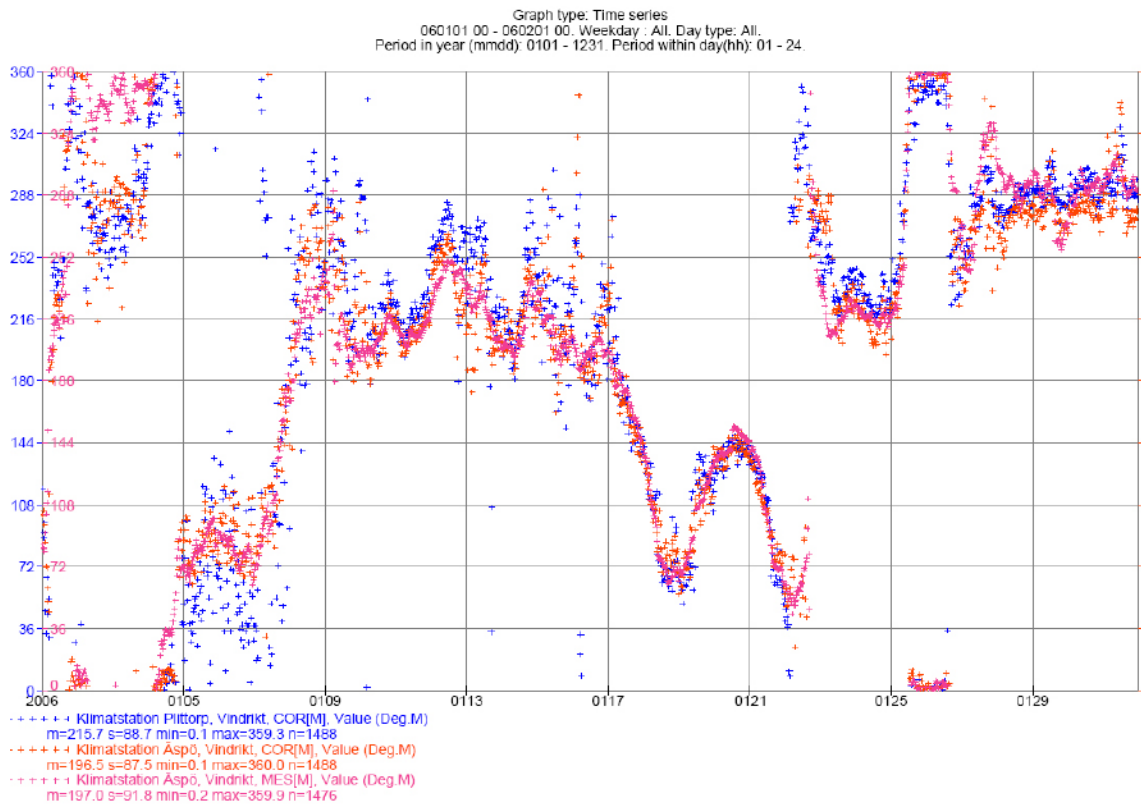


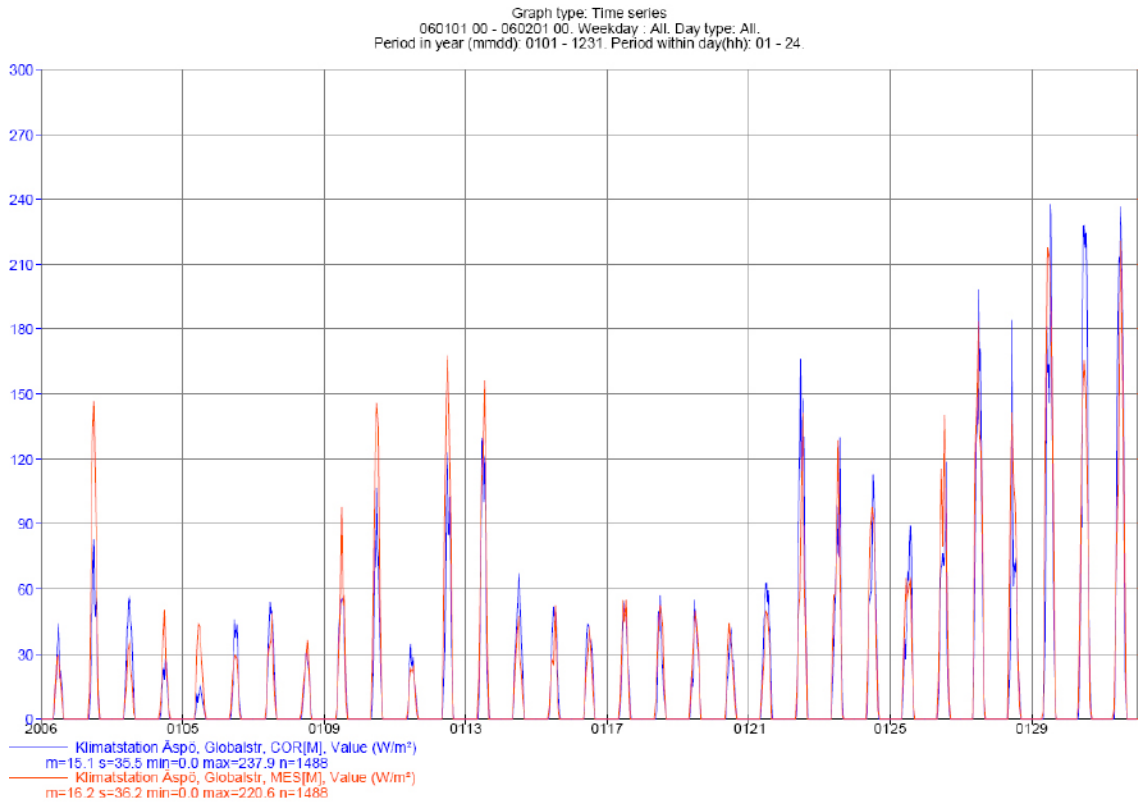
Figure A5-12. Relative humidity in %, 30 min-values. January 2006.



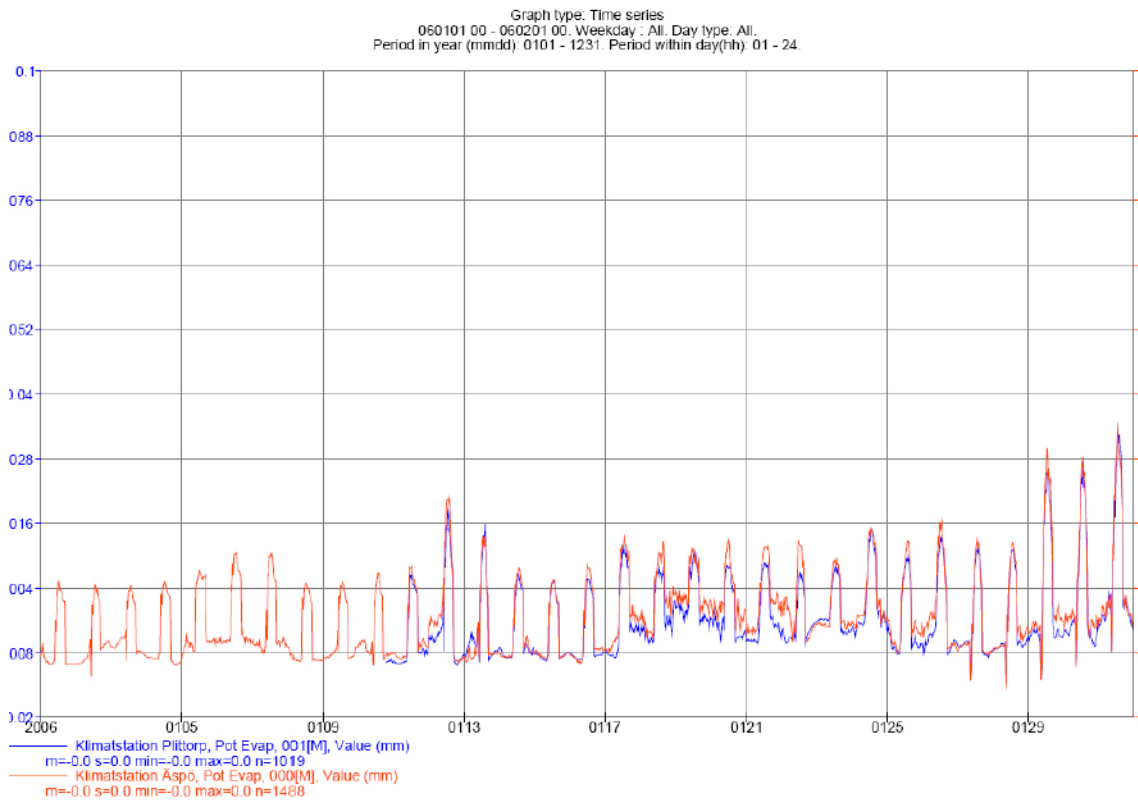
**Figure A5-13.** Wind speed in m/s, 30 min values. January 2006.



**Figure A5-14.** Wind direction in °, 30-min values. January 2006.



**Figure A5-15.** Global radiation in  $W/m^2$ , 30 min values. January 2006.



**Figure A5-16.** Evapotranspiration in mm, 30 min values. January 2006.