R-07-59

Oskarshamn site investigation

Programme for long-term observations of geosphere and biosphere after completed site investigation

Svensk Kärnbränslehantering AB

December 2008

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Preface

Since the beginning of 2002, Svensk Kärnbränslehantering AB (the Swedish Nuclear Fuel and Waste Management Co) has been conducting site investigations at the Simpevarp-Laxemar area in the municipality of Oskarshamn and at Forsmark in the municipality of Östhammar, for siting of a final repository for spent nuclear fuel. The major part of the investigations was completed during 2007 at both sites, in June 2007 at Forsmark and in December 2007 at Oskarshamn. The investigations have resulted in a detailed characterization of the geosphere and biosphere of the two sites, and the site descriptive data are used for modelling geoscientific and ecological conditions and processes.

SKB submitted a programme for the initial site investigations in Oskarshamn in spring 2002. A programme for the completion of the site investigations was presented early in 2005. The investigations that were included in the first programme were completed during 2004, whereas the investigations specified in the latter programme are now in their final stage. During the site investigations, long-term observations, so called monitoring, of certain geoscientific parameters and ecological objects have been initiated in order to obtain time series. The monitoring is planned to continue at least until SKB has selected the site for licence application in 2009. After that, a decision will be made regarding the scope of continued monitoring. This report describes the programme for subsequent monitoring starting in 2008.

The monitoring programme has been elaborated based on the experiences from the site investigations. The main objectives of prolonged monitoring is to establish the undisturbed conditions prevailing at the Laxemar investigation area prior to construction of a potential repository, and to enhance the knowledge about the inherent time dependent variations and dynamics of the geoscientific and ecological systems studied. It will also benefit the production of the environmental impact statement that must accompany the application for permits to site and build a deep repository.

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Abstract

The site investigation in Oskarshamn will be terminated at the end of 2007. Hundreds of investigations have been conducted during a period of more than five years. Monitoring of a number of geoscientific parameters and biological objects has been one important part of the site investigation programme. Monitoring is defined as recurrent measurements of the same parameters/objects, so that time series are generated. Long-term monitoring of for example weather parameters, surface water discharge in brooks, and the groundwater head in a large number of boreholes has been conducted during the site investigations. Furthermore, repeated sampling of precipitation, surface water and groundwater in soil and rock for hydrochemical analyses has been carried out, and the groundwater flow in isolated borehole sections has been measured several times. Besides, some biological objects, for example rare bird species, have been invented each year of the site investigation.

The measured parameters and the invented objects are characterized by a certain degree of time dependent variability, which is also site-specific. The aim of the monitoring is primarily to establish the "undisturbed" conditions, the so called "baseline". If a deep repository is sited at Laxemar in Oskarshamn, many site-specific conditions will change, due to natural causes as well as to the construction works. Knowledge about the undisturbed conditions strengthens the ability to reveal and quantify such changes and to distinguish natural changes from those caused by the human activities.

Another object of monitoring is to, by the study of the variability pattern of the monitored parameters, elevate the knowledge about the underlying, often complex causes governing the variations. In this way the description of site-specific conditions may be more precise and the prospects of modelling important processes are improved.

After completion of the site investigations, a period of about two years will follow, when the investigation results from the investigations will be further analysed. A long-term safety assessment based on geoscientific and ecological modelling will be made, and the Laxemar site will in this respect and from other aspects be compared with the Forsmark site situated in the municipality of Östhammar, which has been investigated simultaneously with the site investigation in Oskarshamn. SKB will then, probably during 2009, give preference to one of the two sites in order to prepare and submit an application under the Environmental Code and the Nuclear Activities Act to localize and build a final repository for spent nuclear fuel at that site. This application must be accompanied by an environmental impact statement, the production of which will profit much from a conscientiously performed monitoring programme.

A continued monitoring programme for the period January 2008–2009 has been decided, and the extent and execution of that programme is presented in this report. This will generate longer time series than have been achieved during the site investigations, which will serve as an improved scientific basis to be used in the site selection process. Broadly speaking, the monitoring programme initiated during the site investigations is suggested to continue after the end of 2007. However, this programme has been successively expanded during the site investigation period, and some monitoring equipment will not be installed until just before or after completion of the site investigations. Also the recent installations will be included in the continued monitoring programme, which hence, with a few exceptions, will be more extensive than the current programme.

Sammanfattning

Platsundersökningen i Oskarshamn kommer i huvudsak att avslutas i december 2007. Bland de hundratals aktiviteter som bedrivits under de 5½ år som platsundersökningen har pågått ingår monitering av ett antal geovetenskapliga parametrar och biologiska objekt. Med monitering avses upprepade mätningar av samma parametrar/objekt, så att tidsserier skapas. Bl a har långtidsregistrering av väderparametrar, ytavrinning i bäckar samt av grundvattenytans nivå i ett flertal borrhål i jord och berg utförts under platsundersökningen. Vidare har prover tagits regelbundet på nederbörd, ytvatten och grundvatten för hydrokemisk analys, och grundvattenflödet i avgränsade borrhålssektioner har mätts upprepade gånger. Slutligen har ett antal biologiska objekt, bl a skyddsvärda fågelarter, inventerats återkommande under platsundersökningen.

De parametrar som har mätts och de objekt som inventerats inom moniteringsprogrammet karaktäriseras av viss tids- och platsberoende variabilitet. Syftet med monitering är för det första att fastlägga de ”ostörda” förhållandena på platsen. Om ett slutförvar byggs i Laxemar kommer många platsspecifika förhållanden att förändras, både av naturliga orsaker och som en följd av byggnadsverksamheten. Kännedom om de ostörda förhållandena ger en möjlighet att upptäcka och kvantifiera sådana förändringar liksom att skilja mellan naturliga förändringar och sådana som beror av mänsklig verksamhet.

Ett annat syfte med moniteringen är att genom studium av de moniterade parametrarnas variationsmönster förbättra kunskapen om bakomliggande, ofta komplexa orsakssamband. Därigenom ökar precisionen vid beskrivningen av de platsspecifika förhållandena och förbättras möjligheterna att modellera viktiga processer.

Efter att platsundersökningen avslutats följer en period av ca två år, då undersökningsresultaten från Laxemar analyseras ytterligare och modellering av de geovetenskapliga och ekologiska förhållandena utförs. Resultaten kommer att ligga till grund för en långsiktig säkerhetsanalys, och Laxemar kommer att ur olika aspekter jämföras med det parallellt undersökta Forsmarksområdet i Östhammars kommun. SKB kommer därefter, sannolikt under 2009, att prioritera en av de två platserna, för vilken en tillståndsansökan enligt miljöbalken och kärntekniklagen för lokalisering och bygge av ett slutförvar för använt kärnbränsle kommer att skrivas. En sådan ansökan måste åtföljas av en miljökonsekvensbeskrivning. Framtagandet av en sådan kommer att underlättas mycket om den kan baseras på ett omsorgsfullt utfört moniteringsprogram.

Det har beslutats att ett fortsatt moniteringsprogram skall genomföras under perioden 2007 till 2009, så att längre tidsserier kan erhållas och därmed ett förbättrat vetenskapligt underlag inför valet av plats. Programmet, som presenteras i denna rapport, innebär i stort att de moniteringsaktiviteter som initierats under platsundersökningen fortsätter från och med januari 2008. Emellertid har det under hela platsundersökningen pågått en successiv utbyggnad av moniteringsverksamheten, och viss moniteringsutrustning kommer inte att vara installerad förrän strax innan eller strax efter att platsundersökningen avslutas. Även de nyinstallerade mätpunkterna kommer att ingå i det fortsatta programmet, vilket därmed, med några få undantag, kommer att ha större omfattning än moniteringsprogrammet under platsundersökningen.

Contents

1 Introduction

SKB initiated site investigations for a repository for spent nuclear fuel in two Swedish municipalities, Östhammar and Oskarshamn during 2002. An area south-east of the nuclear power facilities at Forsmark was selected for the site investigations in Östhammar, whereas the site investigations in Oskarshamn have been performed on the peninsula of Simpevarp as well as at the Laxemar area, situated a few kilometres west of Simpevarp, Figure 1-1. The site investigations were completed in June 2007 at Forsmark and in December 2007 at Oskarshamn. A few supplementary activities have been performed in Oskarshamn during 2008 and are foreseen to continue until the summer of 2009.

The overall goal of the site investigations is to obtain the permits required to site and construct the repository at one of the investigated sites. The site investigations must therefore provide the data required for an evaluation of the suitability of the respective investigated sites for a repository. Hence, the material must be comprehensive enough to enable assessment of the long-term safety, the construction related aspects, as well as the impact on the environment and society of the repository.

Data must also be of such structure and quality that comparison of the investigated sites is possible. Based on this, one of the sites will be selected and an application will be submitted under the Environmental Code and the Nuclear Activities Act for locating the repository within the site.

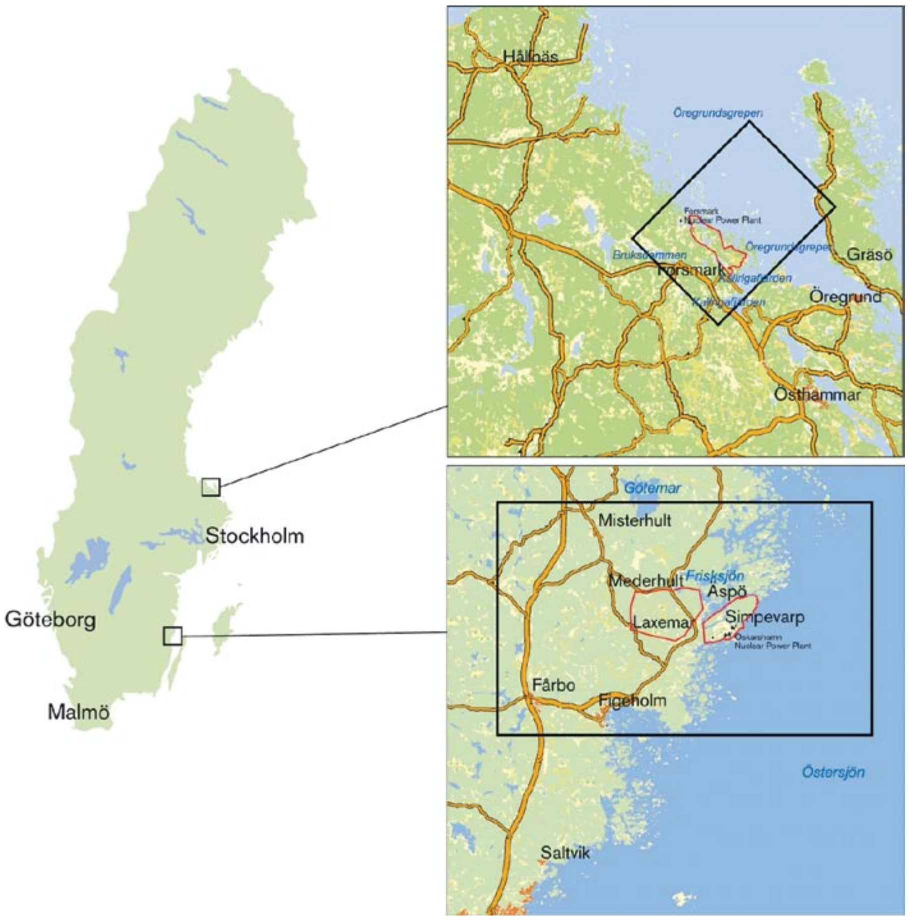

Figure 1-1. *The Forsmark and Oskarshamn site investigation areas. Black rectangles represent the respective regional model areas (about 168 km² at Forsmark and 273 km² at Oskarshamn, respectively), whereas the areas inside red borders show the focused investigation areas.*

The site investigations, which have comprised hundreds of investigation activities covering several geoscientific and biological-ecological disciplines, have resulted in a detailed mapping of the geosphere and the biosphere within the investigated areas. Examination of the biosphere, soil layers and the shallow part of the bedrock has been combined with investigations of the deeper parts of the bedrock. The bedrock has been studied down to about 1,000 m vertical depth by drilling and investigation of boreholes, whereas some geophysical methods applied have had an investigation range of several kilometres vertical depth.

The site investigations have been performed in compliance with a number of comprehensive programme documents. Regarding the site investigations in Oskarshamn these documents are:

- a generic site investigation programme /1/,
- a site specific investigation programme for the Simpevarp area relating to the entire site investigation, however with emphasis on the initial site investigation phase /2/,
- a site specific framework programme for the initial part of the complete site investigation phase in Laxemar /3/,
- a site specific investigation programme relating to the final part of the site investigation /4/.

The investigations at Forsmark have been conducted in accordance with a corresponding set of governing programme documents.

Some of the activities carried out have been singular investigations, whereas other activities have been repeated. A set of specially selected borehole investigation methods has been applied in every new borehole. Some of these measurements are repeated with a regular time interval in what is called a monitoring programme. Such measurements are also made on ground surface. Monitoring of e.g. meteorological, hydrological, hydrogeological and hydrogeochemical parameters, as well as of some wild animal species, is described in the programme documents referred to above, and hence monitoring activities have been part of the site investigations.

A need for continued monitoring after completion of the site investigations has been identified already in previous SKB reports, e.g. /5/. Hence, the monitoring programme for Laxemar initiated during the site investigation will continue, however modified. The objectives, scope and execution of this programme, which is planned to start immediately after completed site investigations in January 2008, are given in the present report. The monitoring according to this programme is planned to be continued until SKB has selected one of the two investigated sites in 2009. After that, new decisions about monitoring will be made for both sites.

The geological and ecological characteristics of the Laxemar investigation area are exhaustively described in a large number of reports published during the site investigations as well as in the comprehensive site descriptions written /6, 7, 8/. A summary of some main characteristics of the site is also given in Chapter 3 in this report.

2 Monitoring – background and objectives

Geoscientific and biological-ecological parameters are measured over time. Time intervals are site specific. Some time dependent changes, e.g. those caused by mineralogical processes in the rock types are extremely slow, whereas other parameters may display rapid and large changes, e,g, ecological, hydrological, hydrogeological and hydrogeochemical parameters measured close to the ground surface.

Many of the observed variations are cyclic. Cyclic processes may display a diurnal character, like some meteorological and geohydrological parameters, or show seasonal variations like the majority of meteorological and biological-ecological parameters. However, other, more unpredictable phenomena may also exist, like long-term variations such as climatic trends. The dynamics of geoscientific and biological-ecological systems is often dependent on several, superimposed cyclic and/or acyclic processes. One illustrative example is the groundwater level in soil and bedrock, where variations are generated by e.g. precipitation, plant respiration, barometric variations and gravitational effects from the moon and the sun. The type of variations created is, in this case, also depending on site-specific conditions, like the hydraulic transmissivity of the soil layer or bedrock formation. Finally, also human activities, like some of the investigations performed during the site investigations, for example pumping, or construction works in soil and rock may have an influence on many geoscientific and biological-ecological parameters.

To interpret and understand the variations with time of different parameters is part of the efforts to establish the “baseline data” of the site, i.e. the data representing “undisturbed” conditions prevailing at the site prior to construction of a repository. The monitoring activities performed are therefore an essential part of the site investigations. With sufficient time series of monitoring data as a reference, changes due to construction of the repository may be revealed, thereby enabling differentiation between natural changes and variations in time and space caused by human activities.

A second objective of the monitoring is to elevate the understanding of the processes governing the variations by analysing the variability pattern.

A third aim of monitoring is to provide a platform for an environmental impact statement of the Laxemar site, which will accompany a future application for permits to site and build a deep repository for spent nuclear fuel.

The understanding of geoscientific and biological-ecological processes studied by creating time series within a specific location, may be improved if results from this location can be compared with monitoring data from other sites, especially if data are acquired during roughly the same period of time. The sites which provide comparative data may be called “reference areas”. SKB performs monitoring of several parameters both at Laxemar and Forsmark. Most of the monitored parameters are identical, and therefore these two areas may, in some respects, serve as reference areas for each other, Comparisons can also be made with other long-term monitoring databases such as Swedish Meteorological and Hydrological Institute, SMHI meteorological and hydrological data or the Swedish Geological Survey water well database.

The monitoring programme during the site investigations has yielded time series covering a maximum of about five years. However, monitoring of for instance hydrogeological and hydrogeochemical conditions is depending on access to boreholes and technical installations in those. Because boreholes have been drilled during almost the entire site investigation period, monitoring in the latest completed holes is planned to start in February 2008.

The major part of the monitoring programme presented in this report will be running until SKB has selected one of the sites. This will provide time series of approximately two years for those boreholes in which monitoring has started very late, and up to seven years for the earliest monitored holes.

After the site selection there will follow a period when the authorities are reviewing the SKB application. The duration of this period can be estimated to about 2–3 years. The monitoring at the site not selected by SKB is planned to be gradually dismantled.

A continued programme for long-term observations and surveillance is also planned to be conducted during the entire construction and operation period /5/. This later programme will be designed based on experiences from all previous monitoring and results from modelling the impact of repository construction and operation.

3 The site

When the site investigation started in the beginning of 2002 the candidate area covered an approximate area of 60 square kilometres. The investigations started with surface based inventories of the ecosystem and airborne geophysics, and covered major parts of the area. In 2002 drilling also started at the Simpevarp peninsula, later defined as the Simpevarp subarea. In the western part of candidate area, the Laxemar subarea was selected as the other potential repository site. After the completion of the initial site investigation stage the Laxemar subarea was prioritized and the complete site investigation was concentrated to Laxemar.

With respect to the monitoring programme, most monitoring objects are situated to the Laxemar subarea even if the monitoring also includes objects at the Simpevarp subarea and a number of objects in the regional surroundings, see Figure 3-1.

The Laxemar-Simpevarp area is gently sloping towards the Baltic Sea in the east. The area is relatively flat with a few small lakes and some wetland. Annual precipitation in the area during the period July 2004 to December 2006 amounted to 550 millimetres. There are two main catchment areas, the Kärrviksån and Laxemarån rivers and their tributaries. The total volume of precipitation in one year in the catchment area for Kärrviksån is 15 million cubic metres and for Laxemarån 22 million cubic metres.

The Quaternary cover is dominated by till. The soil cover is typically thin, but can reach significant thickness in the valleys. Peat and fine-grained water laid deposits are the dominating surface deposits in the valleys. The total thickness of soil is often several metres in the valleys. The groundwater table in the soil layers is generally located about a metre below the ground surface. Bedrock outcrop is common, particularly in the northern part of Laxemar.

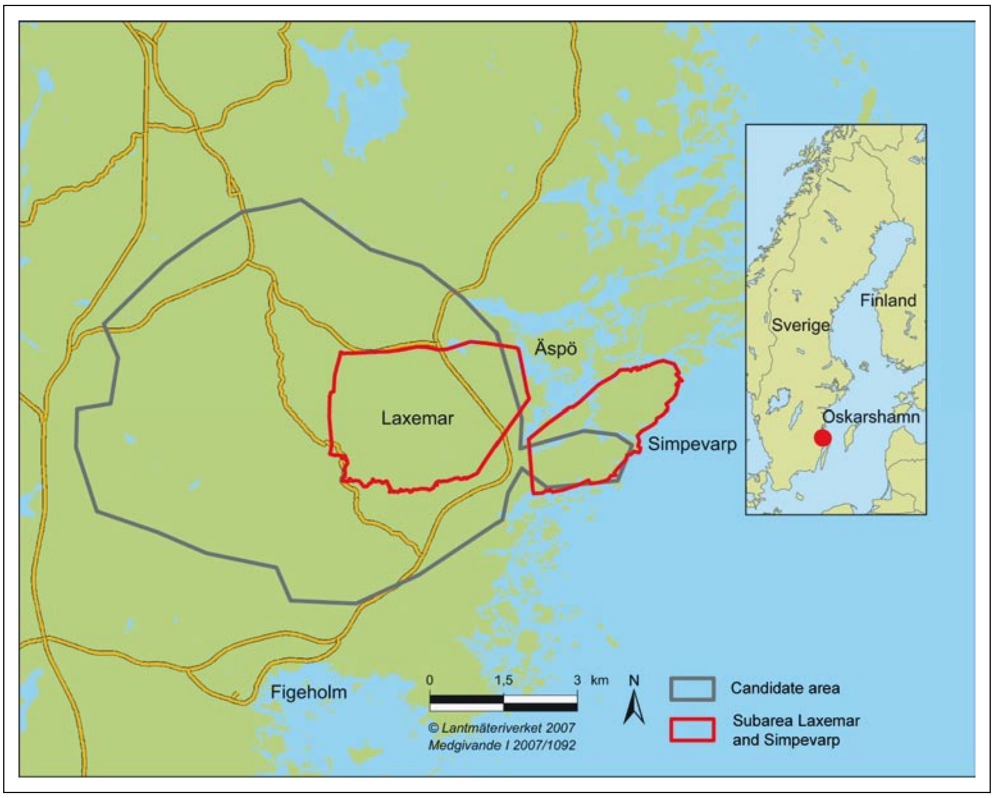

Figure 3-1. The candidate area in Oskarshamn and the Laxemar and Simpevarp subareas where the major part of the site investigations were performed.

The bedrock in Laxemar is dominated by two rock types: Ävrö granite and quartz monzodiorite. Besides these two very common rock types there are minor constituents of other igneous rocks grading in composition from felsic to mafic. A geological map of the bedrock in the Laxemar-Simpevarp area is given in Appendix 1, according to Site descriptive model 2.2.

There are deformation zones in the Laxemar area that extend beyond the investigation area. These are called regional deformation zones. Deformation zones with more than a kilometre in length are visible in topographic and magnetic maps. The geometry and properties of deformation zones have been determined through drilling and geological investigations. Minor deformation zones and individual fractures can not be investigated individually but has to be characterized through studying a subset of the features and subsequently treating the data statistically.

The bedrock is often more fractured and its hydraulic conductivity is higher near the surface than at greater depth. At depths below 400 metres the water-conducting fractures are less frequent and hydraulic conductivity is at least one order of magnitude lower. In Figure 3-2 it can be seen that the median value of the hydraulic conductivity in the rock matrix and deformation zones at depth is about 10^{-9} m/s.

The Laxemar subarea is confined by some large deformation zones which have a major control on the regional groundwater flow. The east-west trending deformation zone (EW007) that cuts through the central part of the Laxemar area has high hydraulic conductivity in its upper parts down to 200 metres.

The hydraulic properties of the northern deformation zone (EW002) are not as well characterized but test have shown a mean transmissivity of one order of magnitude lower than EW007. The southern deformation zone (NW042) does not appear to be water-conducting along its entire length. The zone is conductive in the upper sections of its western and central parts, The eastern part appears to be relatively impermeable, however. The deformation zone has been defined on geological grounds and is interpreted as a geological unit. This does not necessarily mean that its hydraulic properties are uniform everywhere in the zone.

To the west the Laxemar subarea is bounded by a deformation zone (NS001) consisting of dolerite, which is a mafic igneous rock that has intruded into the surrounding rock. The dolerite appears to be hydraulically non-conductive, but the contact between dolerite and the surrounding rock on both sides is water-conducting.

The compilation of chemical data in the model confirms that at least four different waters of different ages can be distinguished in the bedrock:

- deep saline groundwater
- glacial water
- marine water
- rainwater (meteoric water)

The meteoric water dominates in the upper bedrock in the west, while a mixture of meteoric and marine water (Baltic Sea water) is found in the east. At greater depth older marine water from the Littorina Sea and brines of deeper source can be found. The origin of the water can be revealed by its chloride content, isotope composition and dissolved cations. The chloride concentration increases at greater depths, and it is possible to see how the saline deep water mixes with both meteoric water and smaller quantities of glacial water, see Figure 3-3.

It is possible to identify fractions of the water that percolated down into the bedrock after the most recent ice age, even though they are mixed with the early marine inflows from the precursors of the Baltic Sea, such as water from the Littorina Sea. The residence time of these waters naturally varies and is influenced by the ongoing process of land uplift and the hydrological situation in the area.

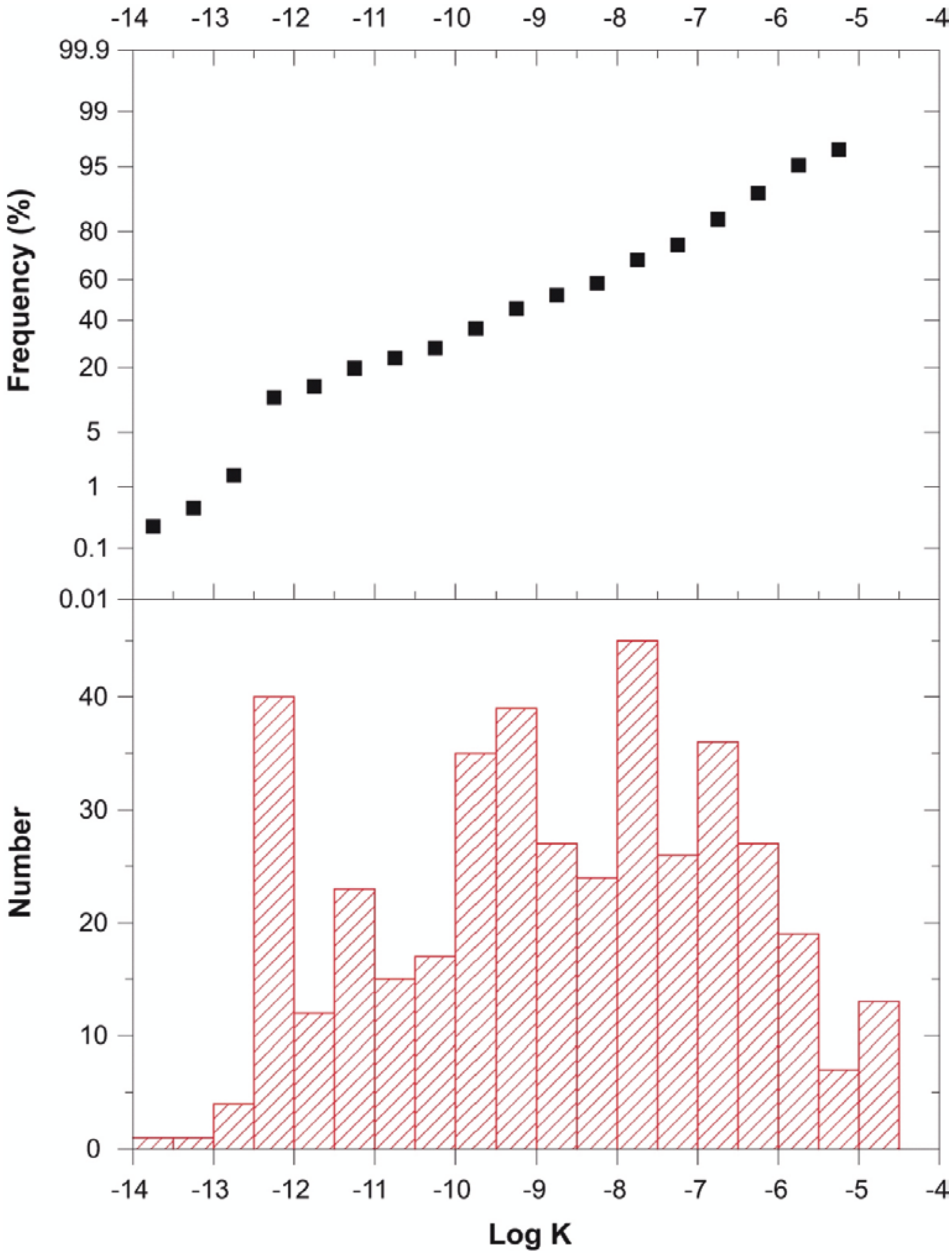

Figure 3-2. *Frequency plot of 411 tests of hydraulic conductivity in 20 metre sections from 12 cored boreholes in Laxemar. The measurements are made both in rock matrix and in deformation zones and were made in all different rock types (from SKB 2007 /9/).*

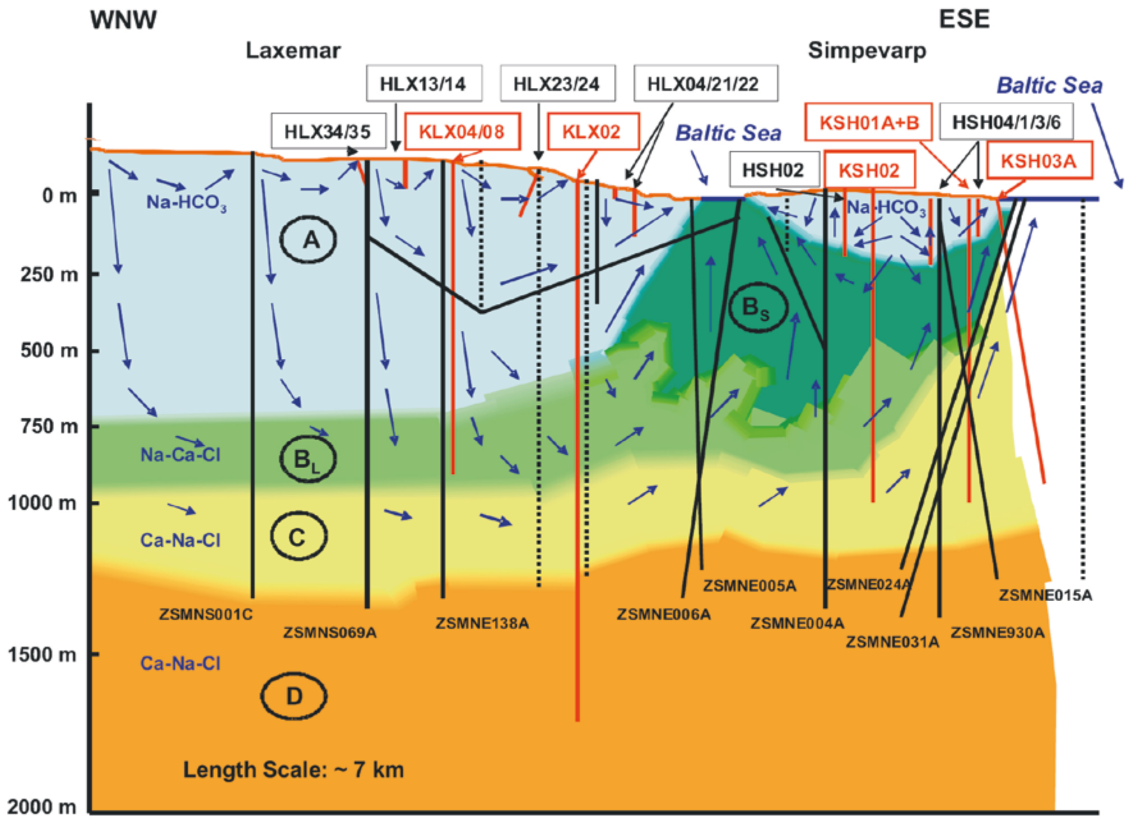

Figure 3-3. *Schematic 2-D visualisation along a WNW-ESE transect of the Oskarshamn site investigation area integrating the major structures, the major groundwater flow directions and the variation in groundwater chemistry from the sampled boreholes. Sampled borehole sections are indicated in red, major structures are indicated in black (full lines = confident; dashed lines = less confident) and the major groundwater types A–D are also indicated. Type A is shallow water of mainly meteoric origin. Type B is shallow to intermediate depth groundwater with contents of Littorina Sea water, glacial water and deep saline components. Type C is intermediate to deep saline groundwaters originating from mixture of glacial water and deep saline brine. Type D is deep highly-saline and brine groundwater. The blue arrows are estimated groundwater flow directions; short arrows low flow rates, long arrows greater flow rates (taken from SKB 2006 /10/).*

4 Programme for long-term observations

The monitoring comprises several disciplines and a multitude of parameters which are described in the chapters that follows. Basic data from this monitoring will be reported recurrently in different reports as given in Table 4-1.

4.1 Seismic monitoring

4.1.1 Background and monitoring during the site investigation

According to an agreement with SKB, the Department of Earth Sciences at the Uppsala University, has during the last years carried out observations of seismic activity in Sweden within the programme of the Swedish National Seismic Network (SNSN). The university has also constructed several new observation stations. The goal is to complement the existing regional seismic network to establish a local seismic network that also permits registration of small earthquakes in order to obtain relatively long time series and thereby gain a better understanding of the causes of seismic events in the site investigation areas.

The SNSN network consists today of 61 stations, see Figure 4-1, of which one station is located within the Laxemar subarea close to borehole KLX03.

Fundamental information about the seismic events, including origin time, hypocenter location and information about the source parameters are given after every three months /11/.

The sensitivity of the network allows for complete recording of all earthquakes down to a magnitude of lower than 0.5 within the network and down to magnitude 0.0 near SKB´s investigation sites at Forsmark and Oskarshamn.

Table 4-1 Type of monitoring undertaken.

Monitoring type	Chapter describing the monitoring	Monitored parameters	Monitoring frequency	Reporting period
Seismicity	4.1	Location and magnitude of earthquakes in Sweden	Every second	Every third month
Meteorology, winter parameters and hydrology	4.2, 4.3 and 4.4	Meteorology: Precipitation, pressure, temperature, wind speed and direction, rel. humidity, global radiation Winter parameters: frost in ground, snow depth/water content and ice cover/break-up Hydrology: Water level, discharge, temperature and electric conductivity	Every ten minutes to once a week	Annually October–September
Groundwater head in Quaternary deposits and in bedrock	4.5 and 4.6	Hydraulic head	Once every two hours + event trigger	Annually October–September
Hydrochemistry of precipitation, surface water and groundwater	4.7 and 4.8	Water chemistry and analytical parameters	Once per year to once per month	Every four months
Groundwater flow in bedrock	4.9	Groundwater velocity	Once a year	Report for each annual measurement campaign
Ecology	4.10	Birds, elk and surface water. Monitoring of ecological parameter in surface waters are treated in Section 4.7	Once a year	Reported annually

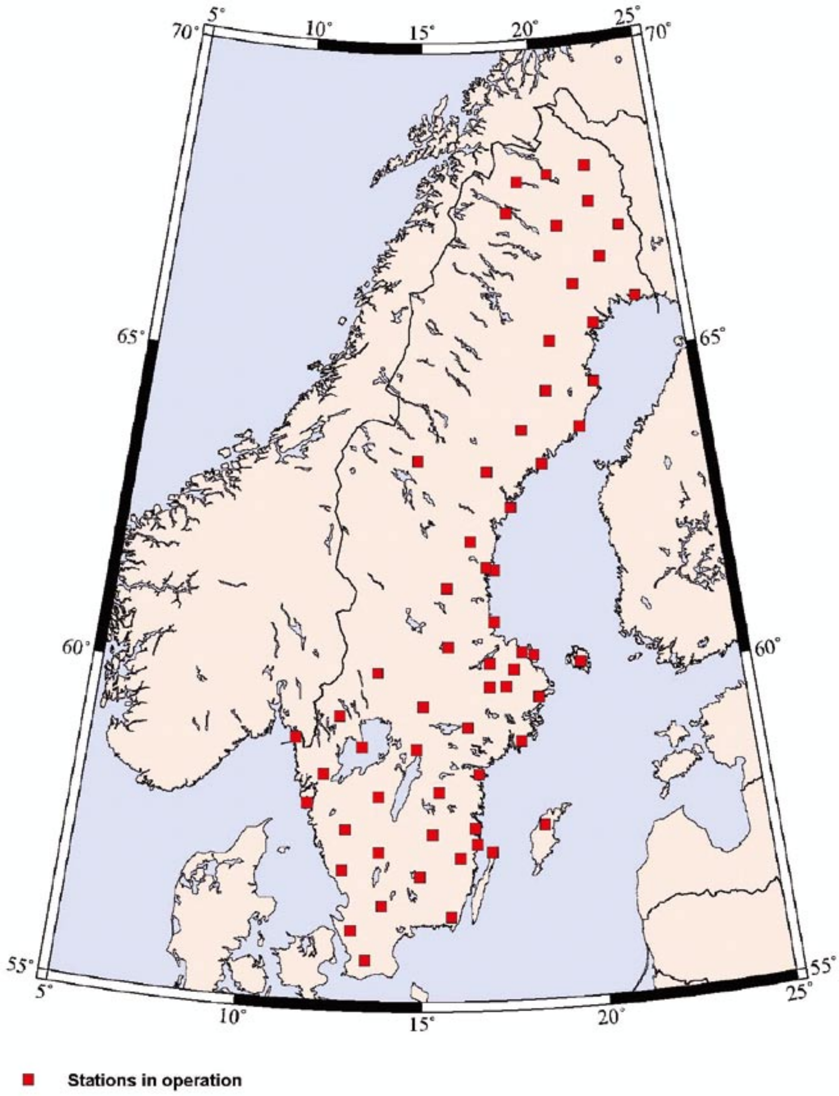

Figure 4-1. The present Swedish National Seismic Network.

The seismic monitoring is managed by the PU department at SKB, i.e. not by the site investigation managements at Forsmark and Oskarshamn, respectively. However, data handling and reporting are following the same routines as applied at the site investigations at Forsmark and Oskarshamn. Data, which are stored in Sicada, are also reported quarterly in SKB P-reports.

4.1.2 Monitoring programme after the site investigation

The SNSN monitoring programme will continue as described in Section 4.1.1 until 2011. The same routines as today for data handling and reporting will be applied.

4.2 Meteorological monitoring

4.2.1 Background and monitoring during the site investigation

Two meteorological stations were established for the site investigation, one at Äspö and one at Plittorp, see Figure 4-2. The locations were chosen to cover the east-west trending topographical gradient and main catchments so that the stations could represent a coastal site and a more elevated inland site. This was judged to provide optimal coverage of climatological parameters.

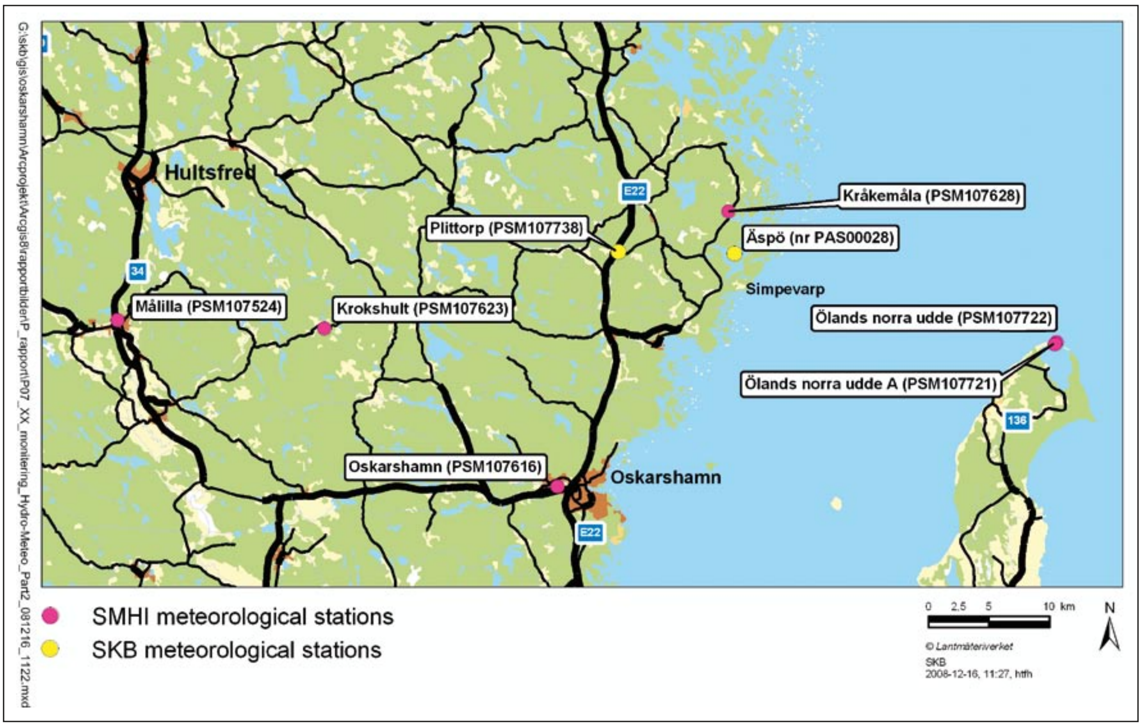

Figure 4-2. *Map showing objects of meteorological monitoring stations. The two SKB meteorological stations are PAS00028 at Äspö) and PSM107738 (Plittorp), shown with yellow dots. NB The SMHI station at Gladhammar (PSM107642) located 45 km north of Oskarshamn is not shown on the map.*

In the early stage of the site investigation the existing meteorological station at Äspö was upgraded and an additional station further west, at Plittorp, was constructed, see Table 4-2. The parameters measured are listed in Table 4-3. The station locations are shown in Figure 4-2 along with surrounding national network station of the Swedish Meteorological and Hydrological Institute (SMHI).

The wind was measured at 10 m above ground level, the other parameters at 2 m.

Table 4-2. SKB and SMHI meteorological stations.

Identity code	Location	Data available at SKB from
SKB stations		
PAS000028	Äspö	August 2003
PSM107738	Plittorp	July 2004
SMHI stations		
PSM107524	Målilla	January 1994
PSM107623	Krokshult	January 1994
PSM107616	Oskarshamn	January 1987
PSM107628	Kråkemåla	January 1994
PSM107721	Öland norra A	August 1991
PSM107722	Öland norra	January 1987
PSM107642	Gladhammar	August 1995

Table 4-3. Equipment used for collection of meteorological data at the meteorological 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, only at Äspö	Kipp&Zonen CM21 with warming and fan

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

- Precipitation: Accumulated sum of precipitation every 30 minutes. The 30-minutes precipitation value is the difference between two adjacent accumulated precipitation sums.
- Temperature: 30-minutes mean of one-second values.
- Barometric pressure: 30-minutes mean of one-second values.
- Wind speed and wind direction: The latest 10-minutes mean value for the actual 30 minutes. Hence, for the 10:00 data the measurement is from 09:51 to 10:00.
- Relative humidity: 30-minutes mean of one-second values.
- Global radiation: 30-minutes mean of one-second values.

4.2.2 Monitoring programme after the site investigation

Field performance

The main purpose with the monitoring after the site investigations is to provide additional baseline time series data with the spatial coverage same or similar as during the site investigations. This monitoring may also serve to support complementary investigations that may arise.

The measurements at the Äspö meteorological station, which have been running since September 2003 and at the Plittorp meteorological, which have been running from July 2004, will continue also after the site investigation, with measuring programme as described in Section 4.2.1.

Data handling and processing

Unchecked data should be transferred to the SKB Hydro Monitoring System (HMS) database /12/ every four hours via FTP (File Transfer Protocol). HMS is the SKB central database for storing and retrieving hydrogeological time series data. The data logger at the station has internal memory to secure the data in case of communication disturbances.

Every week a primary check for missing and incorrect values is to be performed, and every four month all HMS-data from the previous period shall be quality checked before transfer to the site characterisation database, Sicada. In connection with the delivery of the quality assured data, corrected precipitation according to Alexandersson, 2005 /13/ and potential evapotranspiration from the Penman equation as described in detail by Eriksson, 1981 /14/ should be calculated and delivered to SKB for storage in Sicada.

Documentation

Reporting is based on the hydrological year, October 1 to September 30.

Every four months, in connection with the quality assurance, an SKB internal report (PIR) shall be written, in which all quality checks are described, as well as the changes on raw data that these checks resulted in. HMS-adjusted diaries shall be delivered at the same time.

A comprehensive public report, in the P-series, should be delivered annually in October covering the previous reporting period up to September according to the format specified by SKB. This report shall include meteorological and hydrological data, see Section 4.4, as well as winter parameters, see Section 4.3. All measurements and calculations, documented and presented in graphs of daily and monthly values shall form part of that report. Annual means and sums should be calculated as well. The annual reports shall also include data from the nearby stations of the SMHI. These are delivered in digital form in SKB Excel table format. Nonconformities compared with the monitoring programme must be specified.

The first P-report after the site investigations will cover the monitoring period September 1, 2007 to September 30, 2008.

4.3 Winter parameter monitoring

4.3.1 Background and monitoring during the site investigation

During the site investigation, frost in ground, snow depth/water content and ice cover/ice break-up have been measured at the stations shown in Figure 4-3 and listed in Table 4-4.The measurements have been performed weekly during the winter season. The winter parameters consist of:

- Frost in ground
- Snow depth and water content in snow
- Ice cover and break-up

The measurements are made according to /12/.

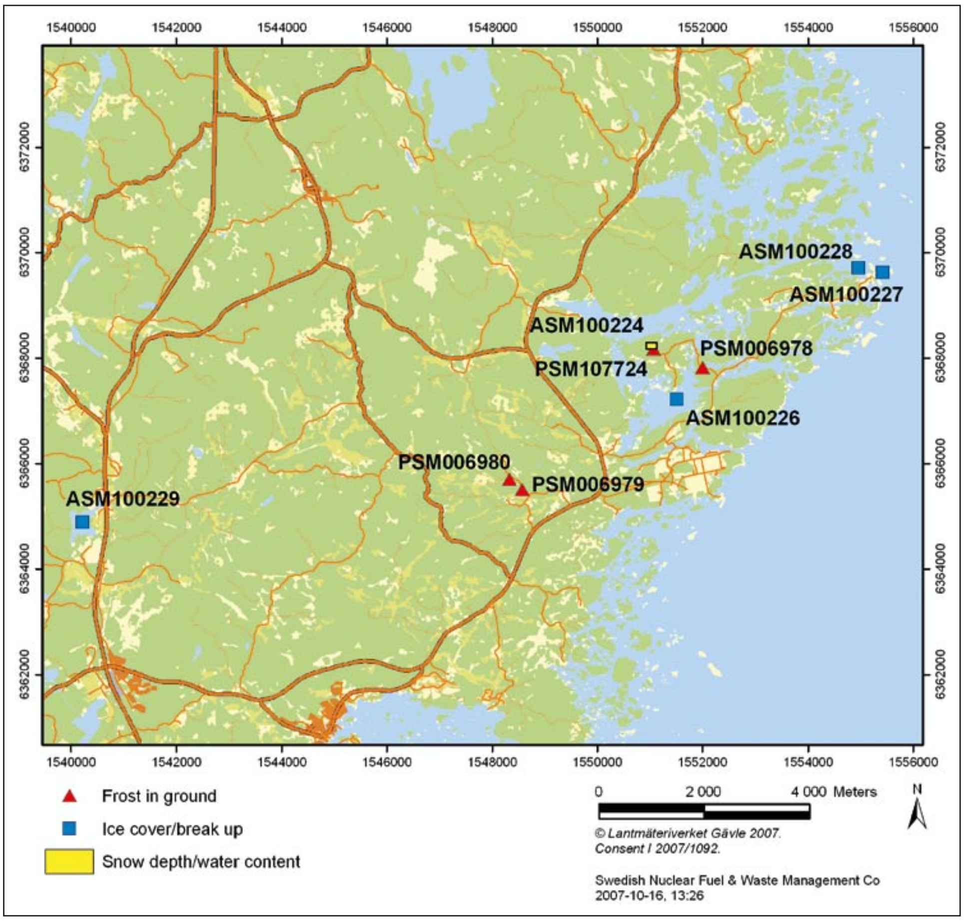

Figure 4-3. Locations of frost in ground and snow depth/water content measurement stations and the ice cover/ice break-up observation points.

Table 4-4. Winter parameter stations.

Parameter	ID-code	Place name	Measurement start
Frost in ground	PSM107724	Grillplatsen	December 2002
	PSM006978	Löv1	
	PSM006979	Grindstugan	
	PSM006980	Åker	
Snow depth/water content	ASM100224	Grillplatsen	December 2002
Ice cover/break up	ASM100226	Äspö brygga	November 2002
	ASM100227	Kråkelund, yttre	
	ASM100228	Kråkelund, inre	
	ASM100229	Lake Jämsen	

4.3.2 Monitoring programme after site investigation

Field performance

The main purpose with the monitoring after the site investigations is to provide additional baseline time series data with the spatial coverage same as during the site investigations. This monitoring may also serve to support complementary investigations that may arise.

The monitoring programme performed during the site investigation, as described in Section 4.3.1, will continue, except for snow depth measurements at PSM 107724 at Äspö which will be discontinued.

Data handling and processing

After every weekly measurement, data should be delivered to SKB in digital form in an Excel table format specified by SKB. The data shall be quality assured prior to delivery to the site characterisation database, Sicada.

Documentation

Reporting is based on the hydrological year, October 1 to September 30.

Winter parameters are quality assured directly in the database twice a year in connection with delivery to the database which is done in January and May. No separate Quality Assurance document is produced.

Results are reported in the same annual report as the meteorological, see Section 4. 2 and hydrological data, see Section 4.4. This is a report in the P-series, delivered in October covering the previous reporting period up to September according to the format specified by SKB.

The first P-report after the site investigations will cover the monitoring period September 1, 2007 to September 30, 2008.

4.4 Hydrological monitoring

4.4.1 Background and monitoring during site investigation

During the site investigation, surface water levels have been measured in different type of basins i.e. in the Baltic sea (three locations), in three lakes (four locations), in one stream (two locations) and in one man-made reservoir. Additionally, water levels are also measured at nine locations in streams for the purpose to calculate the discharge rate.

The location of gauging stations for water level and discharge is shown in Figure 4-4. Surface water discharge, electrical conductivity (EC) and water temperature (T) are monitored at nine gauging stations as shown with yellow triangles in Figure 4-4. Basic information for the gauging stations is listed in Table 4-5.

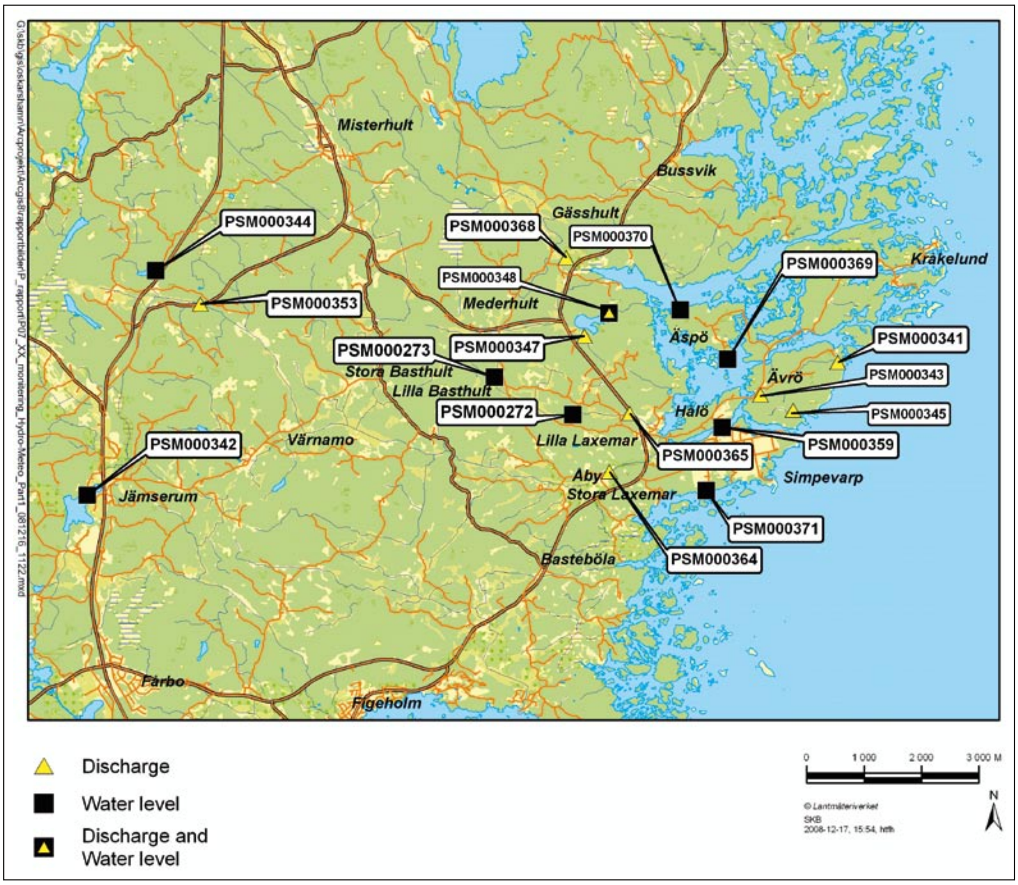

Figure 4-4. Map showing the location of all hydrological monitoring (gauging) stations.

Table 4-5. Hydrological gauging stations included in the monitoring programme.

Station Id	Location	Type of basin	Measured variables	Start date of measurements	Catchment area discharging into the sea	
					Size (km^2)	Id code
PSM000341	Ävrö NE	Stream	Discharge, Temperature, EC	2004-03-18 00:00	0.307	Simpevarp 23
PSM000342	Jämsen	Lake	Water level	2004-07-24 15:00		
PSM000343	Ävrö SW	Stream	Discharge, Temperature, EC	2004-03-18 00:00	0.131	Simpevarp 25
PSM000344	Plittorpsgöl	Lake	Water level	2004-07-24 15:00		
PSM000345	Ävrö SE	Stream	Discharge, Temperature, EC	2004-03-18 00:00	0.165	Simpevarp 26
PSM000347	Frisksjön(in)	Lake, Stream	Discharge, Temperature, EC	2004-11-30 13:00		
PSM000348	Frisksjön (out)	Lake, Stream	Discharge, Water level, Temperature, EC	2004-07-24 01:00	2.1	Simpevarp 7
PSM000353	Laxemarån (upper)	Stream	Discharge, Temperature, EC	2004-09-02 15:00	Not defined	
PSM000359	Sörå-magasinet	Man made reservoir	Water level	2004-01-28 17:00		
PSM000364	Laxemarån (lower)	Stream	Discharge, Temperature, EC	2004-09-02 11:00	41.0	Simpevarp 10
PSM000365	Ekerumsån	Dam	Discharge, Temperature, EC	2005-02-01 13:00	2.8	Simpevarp 9
PSM000368	Kärrviksån	Stream	Discharge, Temperature, EC	2004-07-24 10:00	27.2	Simpevarp 5
PSM000369	Äspö S	Sea	Water level	2004-01-28 17:00		
PSM000272	Ekerumsån	Stream	Water level	2007-02-07 17:00	Not defined	
PSM000273	Ekerumsån	Stream	Water level	2007-06-08 17:00	Not defined	
PSM000370	Äspö N	Sea	Water level	2004-01-28 17:00		
PSM000371	Clab	Sea	Water level	2004-01-28 17:00		

Water levels in sea and lakes are recorded every two hours and all gauges are linked to a SMHI server via GSM. The data are transferred every day to the HMS. The exceptions are stations PSM000272 and PSM000273 measuring stream water level in Ekerumsån which are equipped with stand-alone loggers, manually dumped by SKB and delivered to HMS. Stream water levels and discharge are recorded every 60 minutes. Also electrical conductivity and temperature are recorded once every 60 minutes.

The catchment areas with positions for the gauging stations measuring discharge in the Laxemar subarea to the Baltic Sea, are shown in Figure 4-5. A photo example of a gauging station, PSM000365, is shown in Figure 4-6.

4.4.2 Hydrological monitoring programme after the site investigation

The monitoring programme performed during the site investigation shall continue as described in Section 4.4.1.

Field performance

The main purpose with the monitoring after the site investigations is to provide additional baseline time series data with the spatial coverage same or similar as during the site investigations. This monitoring may also serve to support complementary investigations that may arise.

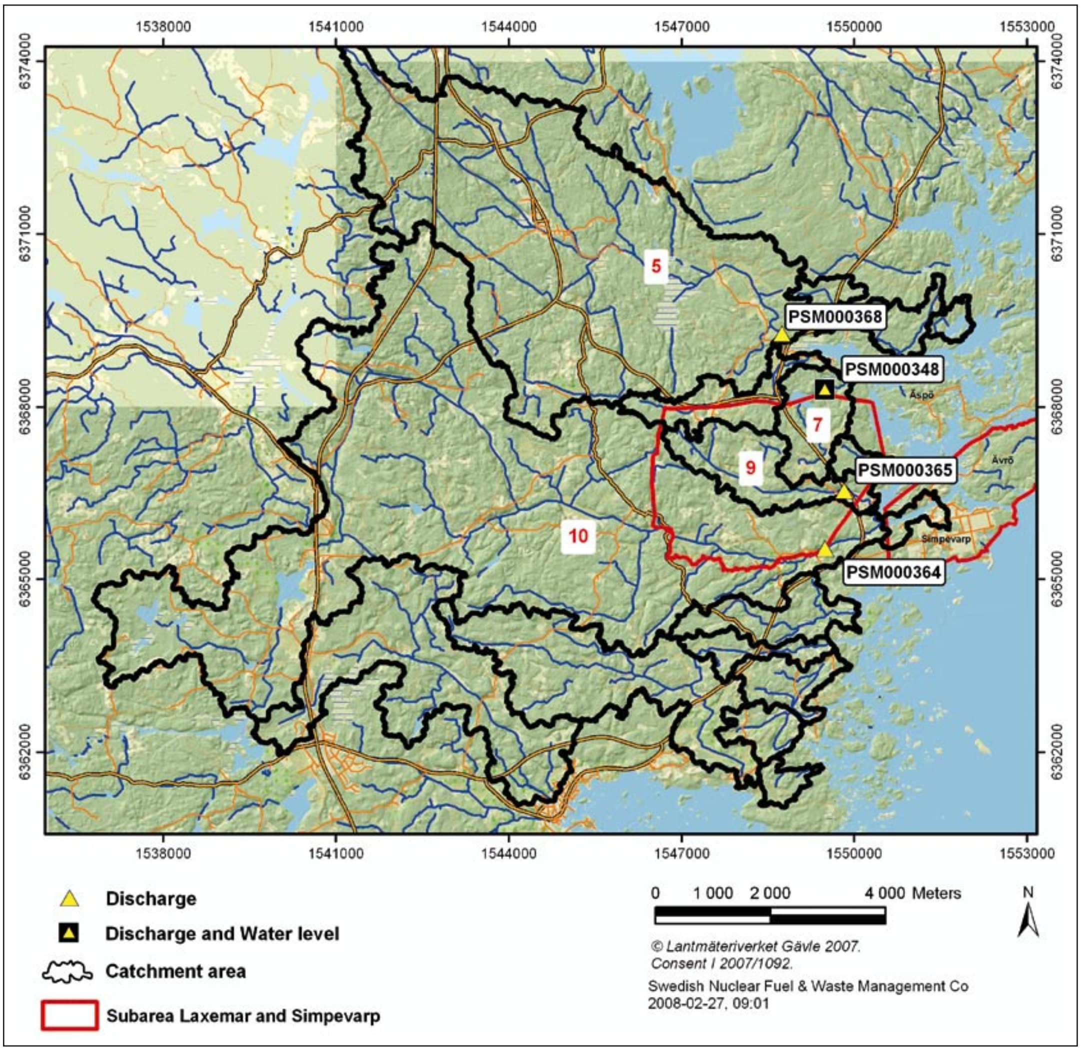

Figure 4-5. *Catchment areas and location of the four related surface water gauging stations in the Laxemar area.*

Figure 4-6. Discharge station PSM000365 during spring flood in recession on April 6, 2006. At this time the flow is 0.15m³/s (9,000 L/min). A 45° V-notch weir made of concrete with impermeable geotextile upstream. The pipes in the middle of the stream are holding the pressure gauge and the combined temperature/electrical conductivity sensor. The pipe to the left is holding the data logger and GSM transmitter.

The flow measurements conducted in order to establish a rating curve for the discharge stations will continue in order to provide a sufficient level of confidence in the established rating relationships. These field measurements are performed by SKB. Checking and cleaning the measurement stations is done on a monthly basis while calibration and control of sensor is done annually.

Data handling and processing

The water level, electrical conductivity and temperature data is being automatically transferred to HMS. A weekly check of the data is performed and every four months the data shall be quality checked, and if necessary the automatic recordings be adjusted based on the manual measurements. After the quality check, data shall be transferred to the SKB Sicada database.

For the discharge calculation, the quality assured level data from the discharge gauging stations in the HMS are utilised. The resulting quality assured flow data is stored in the HMS. If necessary, data considered as likely erroneous should be excluded in the discharge calculations. After the flow calculation, discharge data should be delivered to Sicada. Level data excluded in the calculations are specified as "Comments" in Sicada.

Documentation

Reporting is based on the hydrological year, October 1 to September 30.

Every four months a SKB-internal PIR-report will be written accounting for the Quality Assurance. All measurements shall be documented and presented in graphs.

A comprehensive primary data report (P-report) should be delivered annually in October covering the previous reporting period until the end of September in the report format specified by SKB. This report shall include meteorological, see Section 4.4 and hydrological data as well as winter parameters, see Section 4.5. All measurements and calculations, documented and presented in graphs of daily and monthly values shall form part of that report.

The first P-report after the site investigations will cover the monitoring period September 1, 2007 to September 30, 2008.

4.5 Groundwater head monitoring in Quaternary deposits

4.5.1 Background and monitoring during site investigation

Hydrogeological monitoring serves as a basis for describing groundwater head and infer flow distribution and their variations with time in the Quaternary deposits and in the rock mass. The system actually measures the level of the groundwater in the hole or section, either above a pressure transducer or below the top of casing. This level is converted into a point water head and expressed as meter above sea level. The natural groundwater level variations prior to a possible future construction of a deep repository are measured to establish a baseline. The monitoring equipment is also used to register pressure responses during drilling and hydraulic testing e g single-hole pumping tests and interference tests. At a later stage, the monitoring system may also be used to measure pressure responses during tunnelling for the deep repository at the selected site.

This section presents groundwater monitoring in the Quaternary deposits, i.e. in the soil layers, by the use of monitoring equipment installed in boreholes penetrating the soil layer and supplied with screened groundwater stand-pipes. Usually the friable material, such as sand and till, is screened. For some soil wells also the underlying rock is screened thus constituting the soil/rock transition zone measurements.

In total, groundwater levels are monitored in 70 wells in Quaternary deposits. The locations of the monitoring wells (SSM-numbers) are shown in Figure 4-7 and the wells are listed in Appendix 2. Measurements of the groundwater level in soil wells were normally made with five-minute intervals.

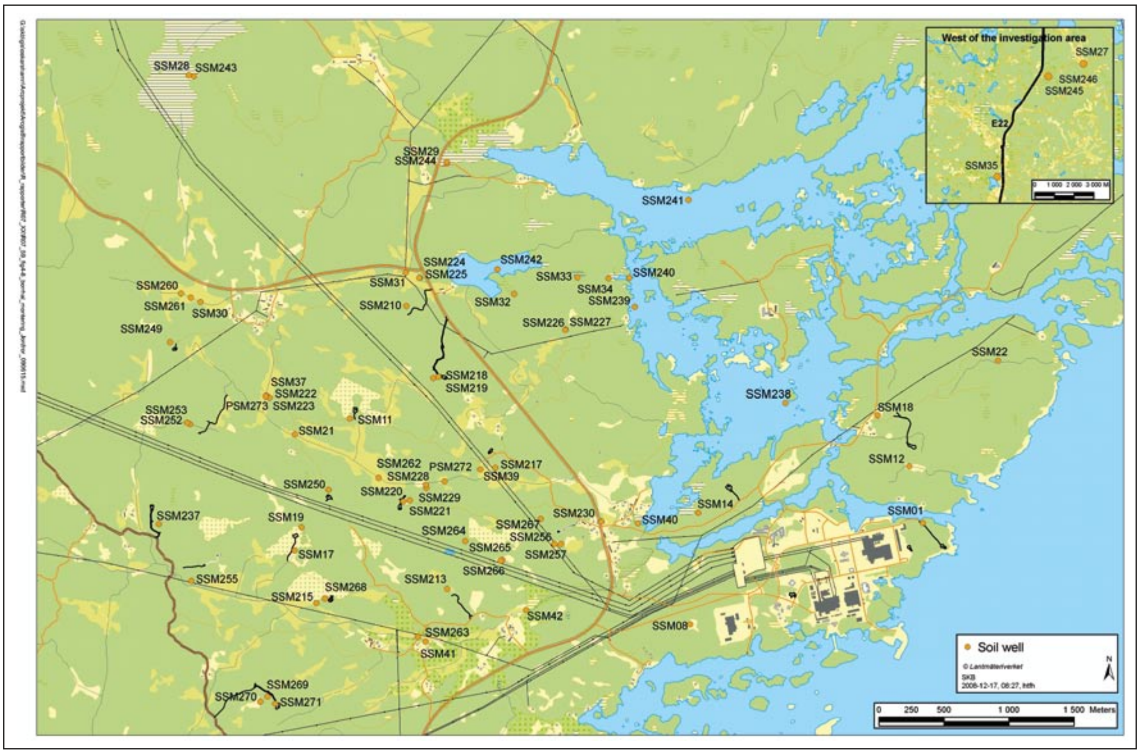

Figure 4-7. Location of groundwater monitoring wells (soil pipes).

A reading of the groundwater level is stored at least every two hours. Logger readings will be stored if they differ from the previously stored value by more than 0.05 m.

The monitoring equipment consists of a pressure transducer connected to a data logger. Eight of the 70 monitoring wells are linked to the HMS-system via GSM, whereas the others have stand-alone loggers.

4.5.2 Monitoring programme after the site investigation

Field performance

The main purpose with the monitoring after the site investigations is to provide additional baseline time series data with the spatial coverage same or similar as during the site investigations. This monitoring may also serve to support complementary investigations that may arise.

The monitoring programme performed during the site investigation will continue as described in Section 4.5.1.

Data handling and processing

The groundwater levels from the monitoring wells are automatically transferred to the SKB hydrogeological monitoring database, HMS /15/. The system measure the level of the groundwater in the hole or section, either above a pressure transducer or below the top of casing. This level is converted into a point water head and expressed as meter above sea level. A weekly check of the data is performed as a quality control measure. Manual sounding of the levels should be performed monthly in order to calibrate the transducer data. Every four months the data shall be quality checked, and if necessary the automatic recordings are adjusted based on the manual soundings. After the quality check, data shall be transferred to the SKB Sicada database.

Documentation

Reporting is based on the hydrological year, October 1 to September 30.

Every four months a SKB-internal PIR-report will be written addressing quality assurance issues.

A comprehensive primary data report (P-report) should be delivered annually in October covering the previous reporting period up to September 30 according to the format specified by SKB. This report shall include monitoring of groundwater head in the bedrock, see Section 4.6. All measurements and calculations, documented and presented in graphs of daily and monthly values shall form part of that report.

4.6 Groundwater head monitoring in bedrock

4.6.1 Background and monitoring during site investigation

This section presents groundwater head monitoring in bedrock by the use of monitoring equipment installed in percussion drilled and core drilled boreholes. The system actually measures the level of the groundwater in the hole or section, either above a pressure transducer or below the top of casing. This level is converted into a point water head and expressed as meter above sea level.

Monitoring may be performed in an open borehole supplied with a pressure transducer and a data logger. However, deep boreholes in crystalline rock penetrate fractures at different levels in the rock mass, and an open borehole constitutes a short-circuited connection between these fracture systems. In order to permit groundwater level monitoring of fractures at different depths, borehole equipment which serves to isolate the respective fracture systems from each other has to be installed, thereby preventing an uncontrolled mixing of groundwater from different levels, possibly with different hydraulic head and hydrochemical composition.

The groundwater monitoring measurement system

The preparations made to enable monitoring in isolated sections in deep core drilled or percussion drilled boreholes at the SKB investigation sites involve sectioning off the boreholes by means of one or several hydraulically expandable rubber packers, so that the groundwater level can be measured in each section, see Figure 4-8.

With the SKB pressure monitoring system, the diameter in Ø 76 mm cored boreholes is large enough to permit isolation of up to ten sections for pressure monitoring, but the number of sections in boreholes with only a few hydraulically conductive fractures and fracture zones may be considerably less. Small plastic tubing connects each borehole section with a water level pipe of larger diameter in the upper part of the borehole. In most cored boreholes at Oskarshamn the upper 100 m have a diameter of 200 mm to provide more space for *in-the-hole* equipment. These holes are called telescopic boreholes. Pressure sensors, installed at a certain depths in the water level pipes and connected to a data logger, register the groundwater pressure in each section which is converted to hydraulic head in the HMS database. Mini-packers installed in the water level pipes ensure rapid responses when pressure changes occur in the respective borehole sections. Figure 4-9 shows installation of monitoring equipment in a core drilled borehole.

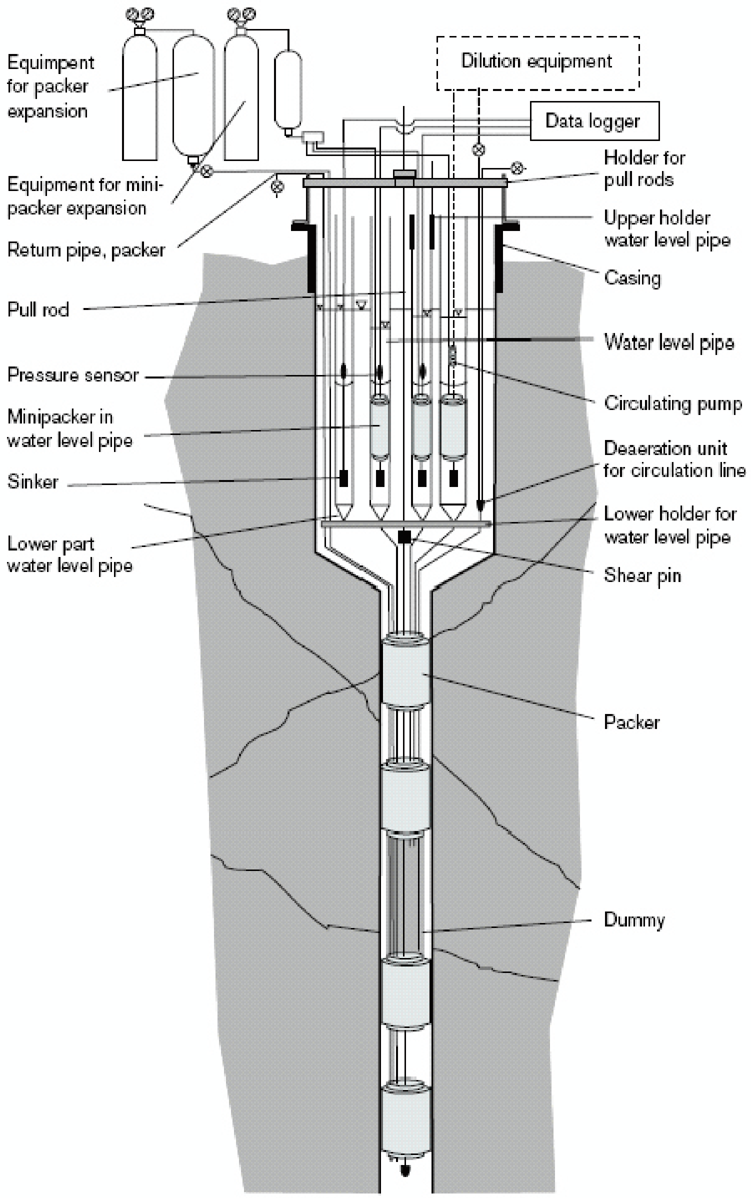

***Figure 4-8.** Principle of the SKB system for monitoring of groundwater levels in sectioned boreholes.*

Figure 4-9. *Installation of equipment for groundwater level monitoring in a core drilled borehole.*

Two out of the ten pressure sections can be supplied with equipment for groundwater sampling, see Section 4.8 and/or circulation of the groundwater in the section, see Section 4.9. Groundwater circulation is achieved by connecting two extra hoses and by installing a portable pump, see Figure 4-8. One of the hoses opens at the bottom of the section and the other at the top. With the water circulation equipment the flow through the packed-off section may be determined by adding a tracer and measuring its dilution with time. The circulation sections also provide tracer injection points or sampling points to be used in cross-hole tracer tests. After completed installations, the borehole collar housing is provided by a container, which serves to protect the above ground equipment from wind and weather as well as from other kinds of damage, see Figure 4-10.

In percussion drilled boreholes, which at Oskarshamn have a nominal diameter of 140 mm, the SKB monitoring system permits the use of up to three packers, which means that groundwater pressure data, when re-calculated to levels, can be measured in four sections, one of which can also be a equipped to function as a circulation section. The pressure registration and data storage follow the same principles as for core drilled boreholes. The housing used for percussion drilled boreholes is shown in Figure 4-11.

Monitoring during the site investigation

Specifications of the sections monitored during the site investigation is given in Appendix 3 (percussion drilled holes are named HXXxx, and core drilled holes are named KXXxx). Appendix 4 presents a graph showing the period during which the individual boreholes have been monitored during the site investigations.

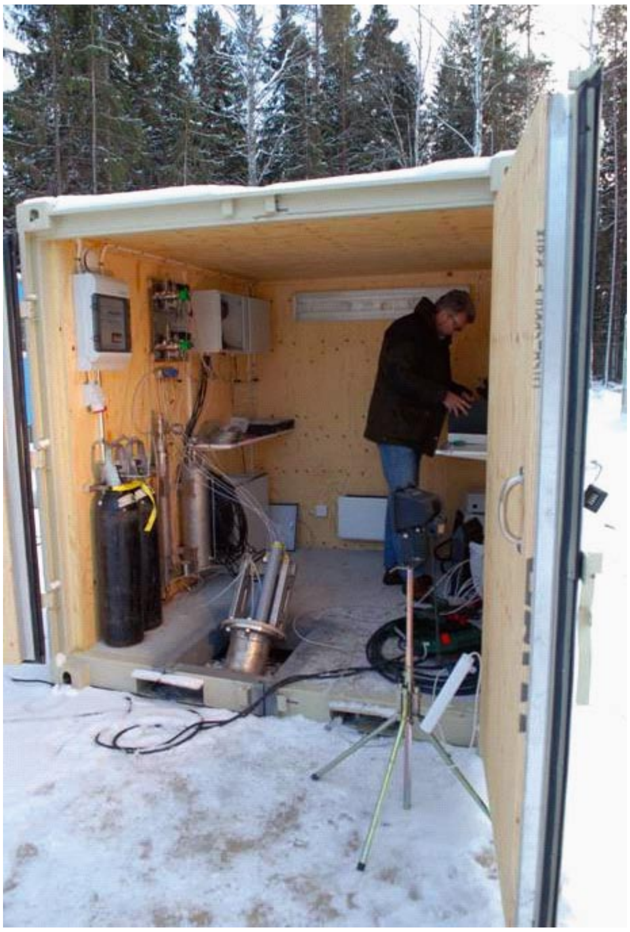

Figure 4-10. Interior of container used as borehole collar shelter after installation of groundwater level monitoring equipment in a core drilled borehole of telescopic type.

Figure 4-11. Interior of two housings used as borehole collar shelters after installation of groundwater level monitoring equipment in percussion drilled boreholes.

Measurements of the groundwater level were normally made with one-minute intervals for percussion and core boreholes.

Measured values are not stored unless they differ from the previously stored value by more than 0.1 m for percussion and core boreholes (called event logging). Regardless, a value is stored every two hours.

During interference tests other measuring frequencies and threshold values have been used.

4.6.2 Monitoring programme after the site investigation

Field performance

The monitoring programme will carry on as described in Section 4.6.1, and Appendix 3. Appendix 3 presents all core and percussion drilled boreholes included in the current monitoring programme as well as those intended to be included, in the monitoring programme after the site investigation. The position of the holes is presented in Figure 4-12.

Installation of monitoring equipment in boreholes for including in the monitoring programme has been successively carried out as new boreholes have been drilled and investigated during the site investigation. The last installations will not be completed until after the end of the site investigations, i.e. spring 2008. The groundwater level monitoring programme for the post site investigation period will continue at least until the end of 2009. This monitoring may also serve to support complementary investigations that may arise.

The main purpose with the monitoring after the site investigations is to provide additional baseline time series data with the spatial coverage same or similar as during the site investigations.

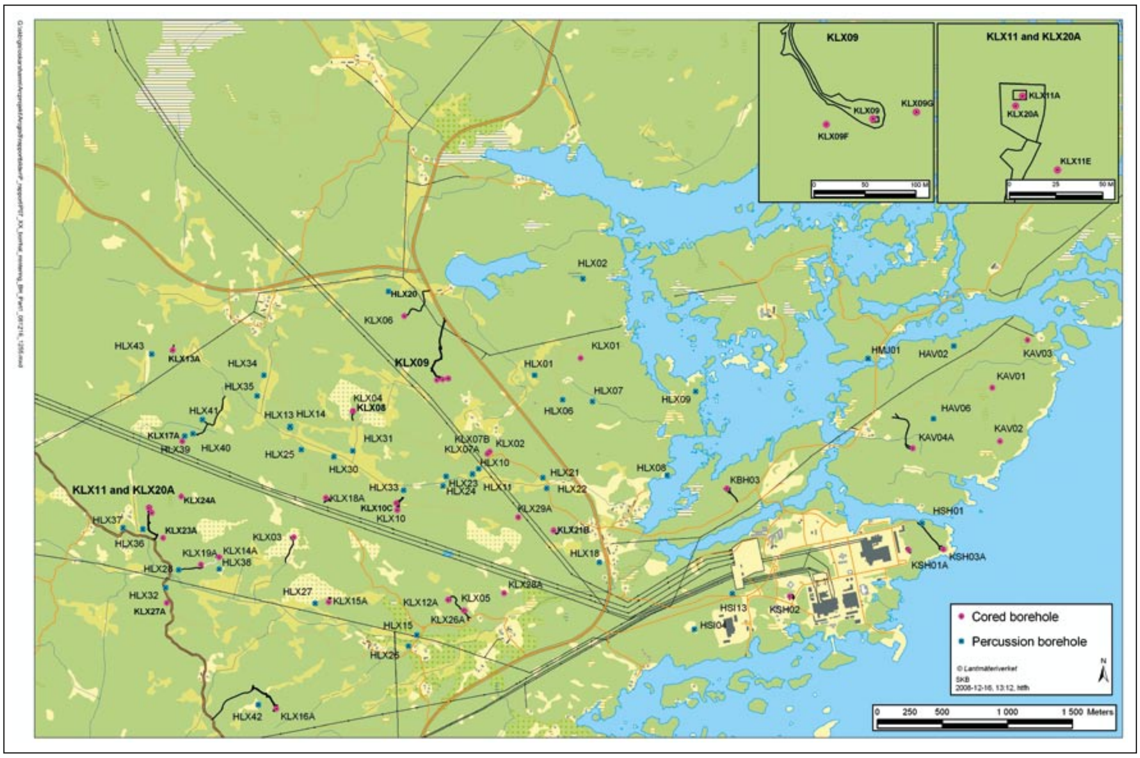

Figure 4-12. *Locations of groundwater monitoring boreholes. HLXxx are percussion drilled boreholes and KLXxx are core drilled boreholes monitored in spring 2008.*

Data handling and processing

Some of the measured groundwater levels from both soil wells, core- and percussion drilled boreholes will be automatically transferred on-line to the SKB HMS database while some are fetched manually from the stand-alone data loggers /15/. Manual levelling of all sections is normally made once every month, in order to calibrate the registrations from the data loggers.

The logger data is transformed to water levels by subtracting the air pressure since all transducers give the absolute pressure. The groundwater level is measured in the hole or section, either above a pressure transducer or below the top of casing. This level is converted into a point water head and expressed as meter above sea level. Converted logger data are then compared with results from manual levelling. If the two differs, calibration constants are adjusted until an acceptable agreement is obtained.

Every four months the data are quality checked and, if necessary, the automatic recordings are adjusted based on the manual soundings. After the quality check, data shall be transferred to the SKB database Sicada three times a year.

Documentation

Reporting is based on the hydrological year, October 1 to September 30.

Every four months a SKB-internal PIR-report will be written addressing quality assurance issues.

A comprehensive primary data report (P-report) should be delivered annually in October covering the previous reporting period up to September 30 in a format specified by SKB. This report shall include monitoring of groundwater head in the Quaternary deposits, see Section 4.5. All measurements and calculations, documented and presented in graphs shall form part of that report. Nonconformities compared with the monitoring programme must be specified.

4.7 Hydrochemical monitoring in precipitation, surface water and near-surface groundwater

4.7.1 Background and monitoring during the site investigation

The hydrochemical monitoring programme includes sampling and field analyses as well as laboratory analyses of water samples collected from precipitation, surface waters, near surface groundwater and groundwater from percussion and core drilled boreholes. The monitoring also includes determination of parameters for the surface ecosystem monitoring programme, see Section 4.10. The surface water monitoring has therefore been coordinated between the two programmes.

Samples from precipitation have been collected and analysed since the start of the site investigation in 2002. The performance and results have been documented in /16, 17/. Comprehensive chemical investigation of surface waters also started 2002 while the characterisation of near surface groundwater (from soil pipes) started in 2004 /18, 19, 20, 21, 22/.

These initial characterization programmes was followed by less extensive long-term monitoring programmes. The hydrochemical monitoring program for precipitation and surface water was initiated in 2005 /23, 24/. For near surface groundwater the monitoring programme in the Simpevarp subarea was initiated in 2005 and in the Laxemar subarea in 2006.

A summary of sampling points for the hydrochemical monitoring programme are listed in Table 4-10. Samples for analysis of surface ecology parameters are taken in conjunction with hydrochemical sampling. The analytical parameters and the sampling frequencies are given in Table 4-11.

For each sea and lake location sampling is performed at the surface and then at one metre depth intervals. The measurements in streams are conducted at one depth only, and near surface groundwater are pumped through a simple measurement cell, where the measurements take place.

Table 4-10. Summary of sampling points for the long-term monitoring program for precipitation, surface waters and near surface groundwaters.

ID code	Locality	Type	Northing	Easting
PSM001514	Äspö	Precipitation	6368197	1551079
PSM001515	Äspö	Precipitation	6368194	1551080
PSM001516	Äspö	Precipitation	6368195	1551082
PSM001517	Äspö	Precipitation	6368192	1551081
PSM001518	Äspö	Precipitation	6368192	1551087
PSM007097	Borholmsfjärden	Sea	6367120	1551440
PSM002064	Granholmsfjärden	Sea	6368620	1550520
PSM002065	Frisksjön	Lake	6368100	1549010
PSM000347	Frisksjön(inlopp)	Stream	6367901	1549042
PSM002079	Kvarnstugan	Stream	6365829	1546762
PSM002083	Smedtorpet	Stream	6369140	1548891
PSM002085	Ekerum	Stream	6366571	1549890
PSM002087	Ekhyddan	Stream	6365716	1550156
PSM002086	Basteböla	Stream	6363730	1548505
PSM107795	Uthammar	Stream	6361748	1548073
SSM000030			6367907	1546986
SSM000228			6366503	1548718.
SSM000022			6367457	1553120
SSM000041			6365332	1548655
SSM000042			6365540	1549487
SSM000014			6366286	1550812
SSM000240			6368093	1550283
SSM000241			6368694	1550738

Table 4-11. Summary of analytical parameters i.e.laboratory analyses and field measurements.

Parameters	Frequency (samples/year) Precipit. ation	Lakes	Sea bays	Streams	Near-surface groundwater
Major constituents (Na, K, Ca, Mg, SO_4–S, Si, Li, Sr,)	6	12	12	12	4
Major consituents (HCO_3, Cl, SO_4, Br, F, pH_lab, EC_lab)	52	12	12	12	4
Surface water supplements for surface ecology (NO_3, NO_2+NO_3, PO_4, NH_4, absorbance at 436 nm, TOC, DOC, DIC, POC, PON , POP, Chlorofphyll a och c, pheopigment, Tot-N, Tot-P, SiO_4, suspended matter		12	12	12[1]	4[2]
Field measurements 1 (pH, ORP, EC, water temperature, dissolved oxygen) Field measurements 2 (turbidity, chlorophyll, light)		12	12		
O_2, temp				12	
pH, El Cond and temp					4[3]
Fe^{2+} and Fe_{tot}, HS^-		1	1	1	4
Fe, Mn,, Environmental metals (Al, Zn, Ba, Cr, Mo, Pb, Cd, Hg, Co, V, Cu, Ni, P, As)		4[8]	4[8]	4[8]	4[4]
Trace metals (La, Ce, Pr, Nd, Sm. Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, SC, In, Th, Rb, Zr, Sb, Cs, Tl, Y, Hf, U)		4	4	4	4[5]
Isotopes 1 (^{3}H, δ^{2}H, δ^{18}O)	10	4[6]	4[6]	4[6]	4
Isotopes 2 (δ^{37}Cl, δ^{13}C, ^{14}C (pmC), ^{10}B/^{11}B, ^{87}Sr/^{86}Sr, δ^{34}S, ^{238}U, ^{234}U, ^{230}Th, ^{226}Ra, ^{222}Rn)		4[6]	4[6]	4[6]	1[7]

1) Chlorophyll a and c, pheopigment are only measured in two of seven streams (PSM002083 and PSM002087).
2) DIC, Si, suspended material, Chlorophyll a and c, pheopigment are not analysed in near-surface ground water.
3) El Cond is analysed in two of the soil pipes (SSM000240and SSM000241).
4) As not analysed in near-surface groundwater.
5) In not analysed in near-surface groundwater.
6) Only archive samples are taken i.e.no analytical work is done on the samples.
7) One analysis of δ^{37}Cl is made per year (SSM000241).
8) ^{10}B/^{11}B is analysed once per year.

The position of precipitation collectors is shown in Figure 4-13. The location for most of the surface water sampling points is given in Figure 4-14. The location of the all soil pipes, including the ones used for near surface groundwater sampling is given in Figure 4-7. The coordinates for soil pipes (SSMnnnnnn) used for near surface groundwater sampling are given in Table 4-10. Collectors for rain and snow can be seen in Figure 4-15.

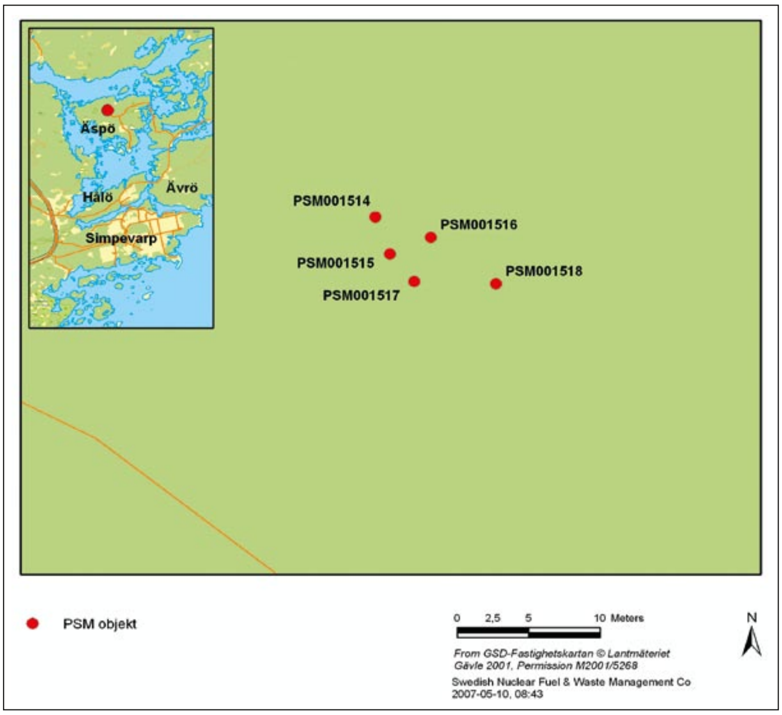

Figure 4-13. Locations for the precipitation collectors PSM001514-18 on the island of Äspö. The collectors have been in use from 2007, replacing the previous collector PSM002170 at the same location.

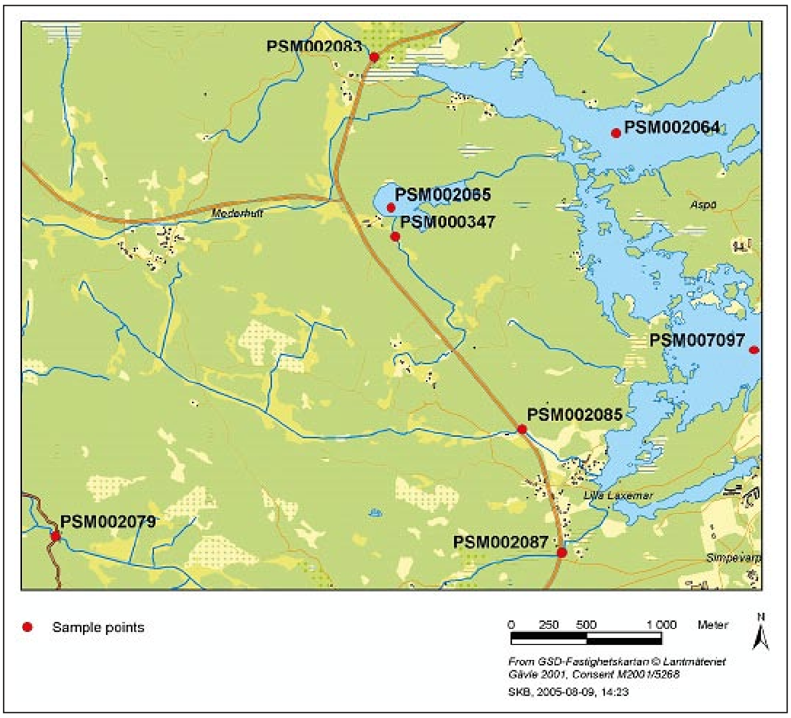

Figure 4-14. Locations of surface water sampling points in lakes, streams and sea from 2005 and onwards. PSM002086 and PSM107795 are located further west and not shown on the map.

Figure 4-15. Sample collectors for precipitation at Äspö. The two collectors to the left are for rain and the ones in the picture to the right are for snow. The construction aims to prevent evaporation.

4.7.2 Monitoring programme after the site investigation

Field performance

Sampling and analyses of precipitation, surface water and near surface water will continue as specified in section 4.7.1.

Data handling and processing

Analytical results from field measurements and from external laboratories are transferred to Sicada by SKB personnel at the latter laboratory.

Documentation

The sampling and analyses of precipitation, surface water and near surface groundwater are documented yearly in three separate P-reports.

4.8 Hydrochemical monitoring of water in bedrock

4.8.1 Background and monitoring during the site investigation

Groundwater in bedrock comprises water sampled in percussion and core drilled boreholes.

A hydrochemical monitoring programme for groundwater from core drilled boreholes has been running since 2005 as part of the site investigations /25, 26, 27/. Since 2007 percussion boreholes are also included in the monitoring program. The monitored boreholes are equipped with straddle packers in order to isolate different borehole sections for long-term pressure monitoring, see Section 4.6.1. Some of these sections are so called circulation sections designed also for tracer tests, water sampling, and groundwater flow measurements, cf. Sections 4.6.1 and 4.9. The boreholes and sections included in the monitoring programme are listed in Table 4-12. A map showing the location of cored boreholes and percussion drilled boreholes is given in Figure 4-12.

Table 4-12. Boreholes and borehole sections included in the monitoring programme for percussion and core drilled boreholes.

Borehole and section number	Section interval From-to (m)	2005	2006	2007	Spring 2008	Autumn 2008–2010 (planned)
KAV01:3	391–434	x	x			
KSH02:1	955–963	x	x			
KSH02:4	411–439	x	x			
KSH01A:4	532–572	x	x			
KSH01A:7	238–277	x	x			
KLX01:3	171–190		x			
KLX02:5	452–494		x			
KLX02:2	1,145–1,164		x	x		
KLX03:1	965–971		x			
KLX03:4	729–751		x			
KLX04:5	507–530		x	x	x	
KLX04:2	870–897		x		x	
KLX05:3	625–633		x	x		
KLX05:7	241–255		x	x	x	
KLX06:6	256–275		x			
KLX06:3	554–570		x			
KLX07A.2	753–780		x	x	x	
KLX08:3	626–683			x	x	
KLX08:4	594–625			x	x	x
KLX10A:5	351–368		x	x	x	x
KLX10A:2	689–710		x	x	x	x
KLX12A:2	535–545		x	x	x	x
KLX15A:3	623–640			x	x	x
KLX15A:6	260–272				x	x
KLX18A:3	472–489			x	x	x
KLX19A:3	509–517			x	x	x
KLX20A:2	260–296				x	
HLX20:2	71–80			x		
HLX28:2	70–90					x
HLX35:2	120–130					x
HLX37:1	150–200					x
HLX39:1	187–199					x

The sampling in 2005 and 2006 was performed twice a year according to SKB class 5 and class 3. A summary of the parameters included in the different analytical classes is given in Table 4-13 and a full definition of SKB chemistry classes 3 and 5 is given in /1/.

Starting in 2007 the sampling procedure was changed. The sampling frequency was still twice a year but the number of samples per section was increased. The sampling is now done with several samples taken over a period of a week or more. The procedure is called time series sampling and is schematically explained for cored boreholes in Figure 4-17. The change to time series sampling is also reflected in the smaller number of sections included in the monitoring in 2007, see Table 4-12. The locations of the boreholes monitored from the autumn 2008 and onwards are shown in Figure 4-16. The time series procedure improves the quality of the final class 5 sample. For sampling in percussion drilled boreholes a simplified procedure is used. Only one class 5 sample is taken when the electrical conductivity is stable.

Table 4-13. Summary of analytical parameters in SKB chemistry class 3, reduced class 5 and full class 5.

Analytical parameter	class 3	reduced class 5	full class 5	Laboratory
pH, conductivity, alkalinity	x	x	x	Äspö/Field
F^-, Br^-, Cl^-, SO_4^{2-}	x	x	x	Äspö/Field
Uranine	x	x	x	Äspö/Field
Density	x	x	x	Äspö
Na, K, Ca, Mg, SO_4^{2-}_S, Si, Li, Sr and more	x	x	x	External lab
Deuterium, O-18	x	x	x	External lab
Tritium	x	x	x	External lab
Fe II + Fe tot		x	x	Äspö/Field
NH_4			x	Äspö/Field
HS^-		x	x	Äspö
B-10			x	External lab
As, In			x	External lab
Environmental metals			x	External lab
Lantanoids			x	External lab
Other trace elements			x	External lab
I^-			x	External lab
Nutrients (NO_3^-, NO_2^-, (NO_3^- + NO_2^-), PO_4^{3-}			x	External lab
DOC		x	x	External lab
TOC		x	x	External lab
Sr-87			x	External lab
Cl-37			x	External lab
C-13, PMC			x	External lab
S-34			x	External lab
U-, Th-isotopes			x	External lab
Ra-, Rn-isotopes			x	External lab

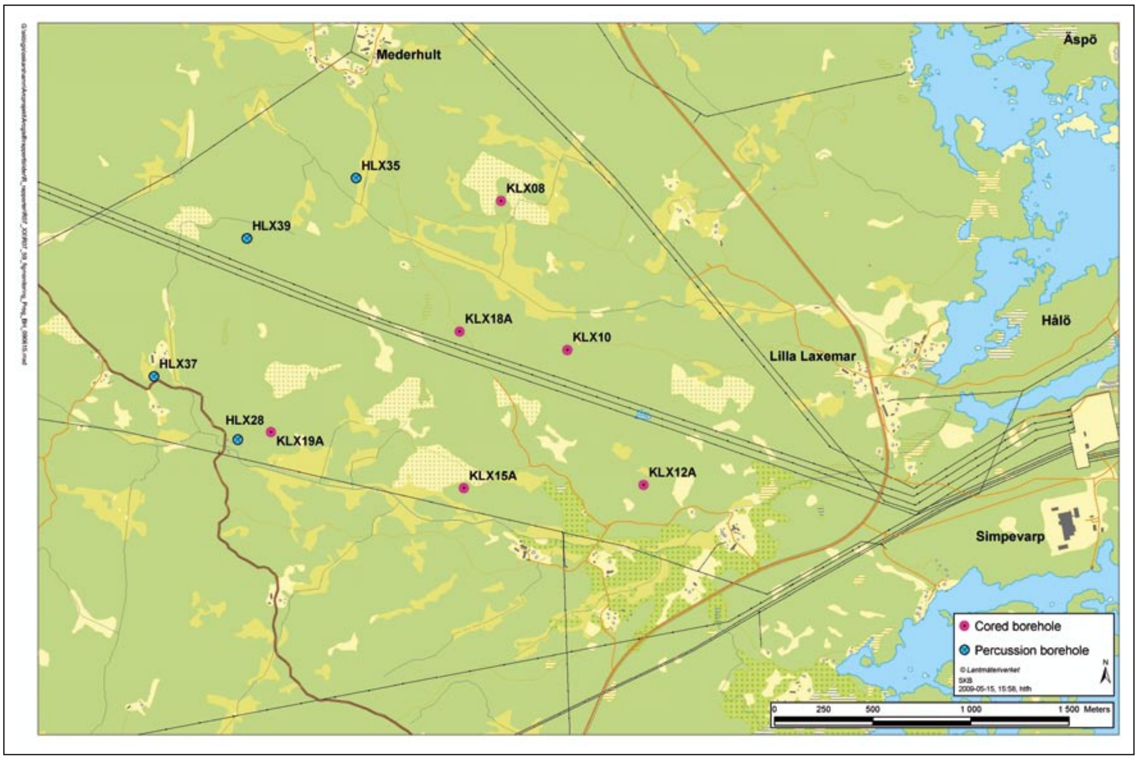

Figure 4-16. Boreholes planned for hydrochemical monitoring of water in bedrock, autumn 2008 and onwards.

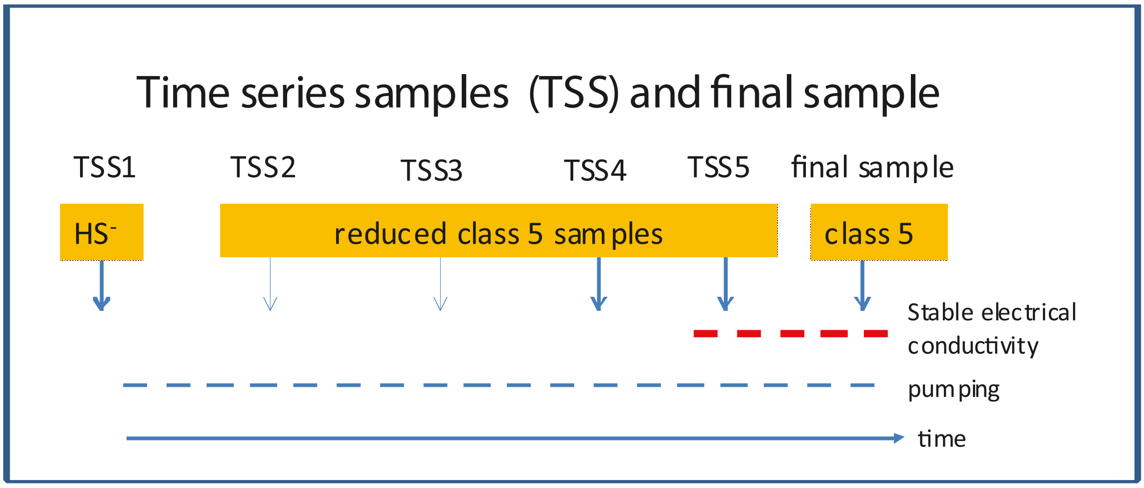

Figure 4-17. *Sketch of time series sampling and the final sampling in cored boreholes. Typically a sampling series could last for over a week. The first time series sample (TSS1) is taken before pumping and water removal starts in the section. The first sample is only analysed for sulphide (HS^-). The following time series samples 2, 3 and 4 are taken as water equivalent to between three to five times the water volume in the section is pumped out. The time series samples 2, 3 and 4 are analysed for reduced class 5 parameters. A fifth time series sample is taken when the electrical conductivity has become stable in the pumped water. The final, full class 5 sample, is taken after water with stable electrical conductivity has been pumped for a period of time ranging from a few hours to a few days.*

4.8.2 Monitoring programme after the site investigation

Field performance

The monitoring programme for percussion and core drilled boreholes will continue according to specifications given in Section 4.8.1. Borehole sections are specified in Table 4-12. The sampling methods and analyzed parameters will remain unchanged in monitored sections in percussion and core drilled boreholes, in the coming monitoring phase.

Data handling and processing

Analytical results from field measurements and from external laboratories are transferred to Sicada by SKB personnel at the latter laboratory.

Documentation

The sampling and analyses of groundwater sampled from percussion and core drilled boreholes are documented yearly in a separate P-report as specified by SKB.

4.9 Groundwater flow monitoring

4.9.1 Background and monitoring during site investigation

The monitoring programme for groundwater flow in boreholes is closely linked to the programme for groundwater sampling in core and percussion drilled boreholes. The two activities include the same borehole sections and partly the same equipment is used. In 2009, after the end of the site investigation 44 borehole sections in 32 boreholes will be equipped for groundwater flow measurements, see Table 4-15.

Measurements within the current monitoring programme, using the tracer dilution technique, have been performed once a year since November 2005, cf. Table 4-15. A few borehole sections have also been measured in connection with hydraulic interference tests during the summers 2005 and 2006.

Table 4-15. Monitored borehole sections.

Borehole and section number	Section interval From–to (m)	measurements until 2007	2008	2009–2010 plan	Section with low priority
HLX14:1	96–116		x	x	
HLX20:2	70–80	x	x	x	Low prio
HLX28:2	70–90			x	
HLX32:2	20–30	x		x	
HLX35:2	120–135	x	x	x	
HLX37:1	150–200			x	
HLX38:3	28–40			x	
HLX39:1	187–199	x	x	x	
HLX43:1	135–147	x	x	x	
KAV01:3	391–434	x		x	Low prio
KLX01:3	171–190	x	x	x	Low prio
KLX02:2	1,145–1,164	x	x	x	
KLX02:5	452–494	x	x	x	
KLX03:1	965–971	x	x	x	
KLX03:4	729–751	x	x	x	
KLX04:2	870–897	x		x	Low prio
KLX04:5	507–530	x		x	Low prio
KLX05:7	241–255	x	x	x	
KLX06:3	554–570	x		x	Low prio
KLX06:6	256–275	x		x	Low prio
KLX07A:2	753–780	x	x	x	
KLX08:3	626–683	x	x	x	
KLX08:4	594–625	x	x	x	
KLX10:2	689–710	x	x	x	
KLX10:5	351–368	x	x	x	
KLX11A:3	573–586	x		x	
KLX11A:7	256–272	x		x	
KLX12A:2	535–545	x	x	x	
KLX13A:2	490–507		x	x	
KLX15A:3	623–640	x	x	x	
KLX15A:6	260–272	x	x	x	
KLX17A:2	419–434		x	x	
KLX17A:6	180–219		x	x	
KLX18A:3	472–489	x	x	x	
KLX19A:3	509–517	x		x	
KLX20A:2	260–293	x		x	
KLX20A:5	103–144	x		x	
KLX21B:3	558–572		x	x	
KLX27A:6	220–259			x	
KLX27A:1	640–651			x	
KSH01A:4	532–572	x		x	Low prio
KSH01A:7	238–277	x		x	Low prio
KSH02:1	955–963	x		x	Low prio
KSH02:4	411–439	x		x	Low prio

Table 4-15 shows currently monitored borehole sections with respect to groundwater flow as well as boreholes and borehole sections planned to be monitored for groundwater flow in 2008, 2009 and 2010. Some sections have a lower priority for measurement. The decision whether to measure these or not is taken in the activity plan.

4.9.2 Monitoring programme after site investigation

Field performance

The monitoring programme for percussion and core drilled boreholes will continue according to specifications given in Section 4.9.1. Borehole sections are specified in Table 4-15. The plan is to continue with the same measurement frequency, i.e. one measurement per year, and at the same time of the year (late autumn).

The main purpose with the monitoring after the site investigations is to provide additional baseline time series data with the spatial coverage same or similar as during the site investigations. This monitoring may also serve to support complementary investigations that may arise.

Data handling and processing

Data and measurement protocols should be delivered immediately after each field campaign to SKB in digital form in an Excel table format as specified by SKB for storage, together with processed data, in Sicada.

Documentation

The results should be documented annually in an SKB P-report. If monitored sections are discarded, the motives for this should be accounted for in the report. An example of a complete documentation is given in /28/.

4.10 Ecology

4.10.1 Background and monitoring during the site investigation

The surface ecosystem monitoring programme currently performed in the site investigations includes three different activities:

- yearly inventories of sensitive bird species,
- yearly acquisition of data regarding elk demography and reproduction in cooperation with local hunters,
- recurrent sampling, laboratory and field analyses of surface waters.

The two first monitoring activities are further described in the text below, whereas the monitoring of surface waters is performed in coordination with the hydrochemical monitoring programme and is described in Section 4.7.

The three investigations all comprise parameters which vary over time, and therefore long time series of site specific data are valuable. The parameters registered may also be sensitive to nearby environmental changes such as construction and operation of a repository for radioactive waste. For all three investigations, monitoring programmes have already been in operation during the site investigation.

Monitoring of sensitive bird species

Monitoring of bird species has been performed in the Oskarshamn area from the start of the site investigation in 2002 /29/. Since 2003 special attention has been paid to sensitive and listed species within the regional model area, see Figure 4-18.

The activity comprises an inventory of occurrence and breeding success of a number of selected bird species (all listed according to Swedish or EU authorities). The first priority is to follow up already known territories and, if resources are available, efforts are made to find other territories. The selected species are listed in Table 4-16. The investigation follows the breeding season and starts in spring each year. The field work is completed during late summer.

Monitoring of elk (Alces alces) demography and reproduction in cooperation with local hunters.

Acquisition of data from elk in the Oskarshamn area regarding demography and reproduction has been performed in cooperation with local hunters since the hunting season 2002/2003 /30, 31/.

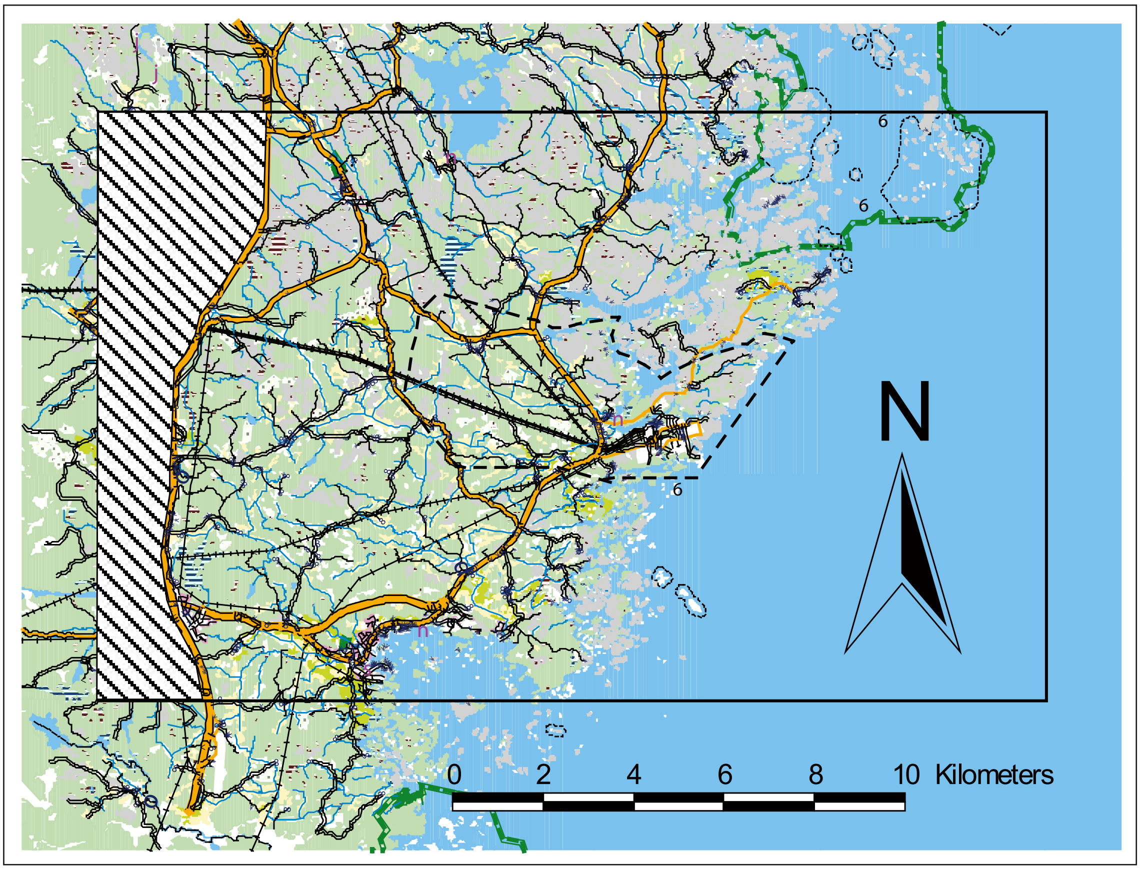

Figure 4-18. Monitoring of selected bird species is performed in the regional model area, i.e. the black rectangle outlined in the map.

Table 4-16. Bird species included in the monitoring programme.

English name	Swedish name	Latin name	Listing*
Honey Buzzard	Bivråk	Pernis apivorus	(Sw, EU)
White-tailed Eagle	Havsörn	Haliaeetus albicilla	(Sw, EU)
Osprey	Fiskgjuse	Pandion haliaetus	(EU)
Eagle Owl	Berguv	Bubo bubo	(Sw, EU)
Wryneck	Göktyta	Jynx torquilla	(Sw)
Lesser spotted Woodpecker	Mindre hackspett	Dendrocopus minor	(Sw)
Nightjar	Nattskärra	Caprimulgus europaeus	(Sw, EU)
Red-backed shrike	Törnskata	Lanius collurio	(EU)

* EU = listed according to European Commission Birds Directive, Sw = listed according to the Swedish Red list i.e. list of threatened species.

The hunters gather different kinds of information about observed and shot individuals of elk. This is reported on a website (www.jaktwebb.se). After hunting, jaws and uteruses from the shot elk individuals are frozen and later sent for analysis in order to estimate age and reproductivity, and from these data estimates of the demography and reproductivity of the local elk population are made.

The activity follows the hunting season and starts in October each year. The observations of live animals and acquisition of anatomical samples from shot individuals are performed during hunting, which for elk commences in October and ends in January the next year. When the hunting is over the samples of jaws and uteruses are collected and then analysed.

Monitoring of surface waters

See Section 4.7.

4.10.2 Monitoring programme after the site investigation

Field performance

Monitoring of sensitive bird species will continue after the site investigations with the same frequency and by applying the same methodology, as specified in Section 4.10.1.

Monitoring of elk demography and reproduction will after the site investigations be performed in the same way as during the site investigations.

The programme for surface water monitoring is presented in Section 4.7.

Data handling and processing

As concerns monitoring of sensitive bird species, data shall be delivered to SKB during October. The data delivery includes paper protocols as well as two Excel files. One contains a list of all field observations and the other processed information about breeding success (a file which is extended for each year). All this material contains data for which there are access restrictions, and data are therefore not saved in Sicada. The breeding success data are incorporated in the SKB GIS database, also in this case with restrictions on the availability of data. The complete data delivery is sent to SKB Oskarshamn and is stored in a special archive.

Data from monitoring of elk data should be delivered to SKB in May each year and shall include a raw data file as well as the processed data (both Excel files) for storage in Sicada.

Regarding data from monitoring of surface water, see Section 4.7.

Documentation

The activity monitoring of sensitive bird species shall be documented in a P-report delivered to SKB in November, presenting the investigation and the results according to earlier reports.

Documentation of monitoring of elk demography and reproduction shall be documented in a P-report, in Swedish. This report, which will be written by the company making the analyses, shall be delivered to the local hunters by SKB. The P-report shall be in the format specified by SKB and present method and results as well as nonconformities compared to the programme specified.

4.11 Quality assurance

The monitoring shall be performed according to the SKB system for quality assurance. Each activity is conducted in compliance with an Activity Plan (AP) and appropriate SKB Method Documents (MD), when applicable. Field activities shall, apart from laws, regulations and ordinances, follow SKB´s existing procedures. Furthermore, data shall be treated and delivered to SKB and reports written according to SKB routines.

Contractors engaged by SKB for performance of activities must issue a quality plan for each assignment and carry out and document internal quality controls. With fieldwork, it is of outmost importance that activities are carried out with satisfactory safety as regards humans and environment. The Contractor must therefore in his quality plan include a risk assessment regarding safety, security, health and environment.

5 Future changes of the scope of the monitoring programme

After completion of the site investigations in Oskarshamn by the end of 2007, a new project will start which will manage the monitoring programme and additional investigations during the period until SKB during 2009 has selected the site for final repository. The scope of the monitoring programme at the beginning of this new project is presented in this report. However, the extent and performance may be changed with time. This may be due mainly to three reasons:

- monitoring equipment may be malfunctioning,
- supplementary investigations may be initiated, which, for example if new boreholes are drilled, may entail expansion of the monitoring programme,
- changes in the monitoring programme may be motivated by scientific considerations not linked to supplementary investigations.

These possible situations are discussed below.

5.1 Consequenses for the monitoring programme if monitoring equipment is malfunctioning

If a component in the monitoring borehole equipment fails, irrespective of what kind of equipment, fault-tracing will be initiated as soon as possible after the error is observed. When the malfunctioning component is localized, a decision is made whether it is worthwhile mending or exchanging the component, or if that part of the monitoring shall be terminated.

The Activity Leader for Hydrogeology will prepare the issue, after consultation with the Activity Leaders for Hydrochemistry and Transport properties and advice from the Project Manager for SKB Site modelling. The Oskarshamn Project Manager makes the decision, which shall be carefully documented including motives for the decision.

5.2 Consequenses for the monitoring programme in case of supplementary investigations

After completion of the site investigations in December 2007, analysis of the investigation results will continue. The extended and deepened analyses of the site investigation results may possibly reveal some gaps and imperfections in the data material, and hence demands may be called for supplementary investigations. The extent of supplementary data needed is not known in advance. However, if supplementary investigations will be performed, they should preferably be held together in one single field campaign, in which as many activities as possible are carried out simultaneously, all in order to limit the investigation time as much as possible. Consideration must however be taken to potential hydraulic interferences so as not to jeopardize the quality of the data from the supplementary investigations.

However, if such investigations take place, they may have some implications on the monitoring programme. The monitoring of natural trends might temporarily be disturbed, for example if a new borehole is drilled, whereby pumping activities may cause a drawdown, which possibly may influence monitoring in nearby situated boreholes. Supplementary investigations may also entail a change in the scope of the monitoring programme. An obvious example is that if one or several new boreholes are drilled, they might be included in the monitoring programme. A decision to do so will be made by the Oskarshamn Project Manager after preparation of the issue by the Activity Leader concerned and after consulting SKB´s Site modelling Project Manager. The decision will be documented, including the motives for expansion of the monitoring programme.

5.3 Other scientific reasons for changing the monitoring programme

The continued analysis of site investigation data including monitoring data may motivate changes in the scope and/or performance of the monitoring programme. If a need for expansion of the monitoring programme is demonstrated, the decision-making should then be according to Section 5.2.

The analysis of monitoring data may, however, also lead to a decision to reduce the monitoring programme, for example if several objects turn out to monitor the same feature, so that data are closely correlated. The Project Manager may then, after the Activity Leader concerned has prepared the issue, and after taking advise from SKB´s Site modelling Project Manager, decide that one or several monitoring objects may be excluded from the programme. Also in this case the decision shall be documented, including motivation for reducing the monitoring programme.

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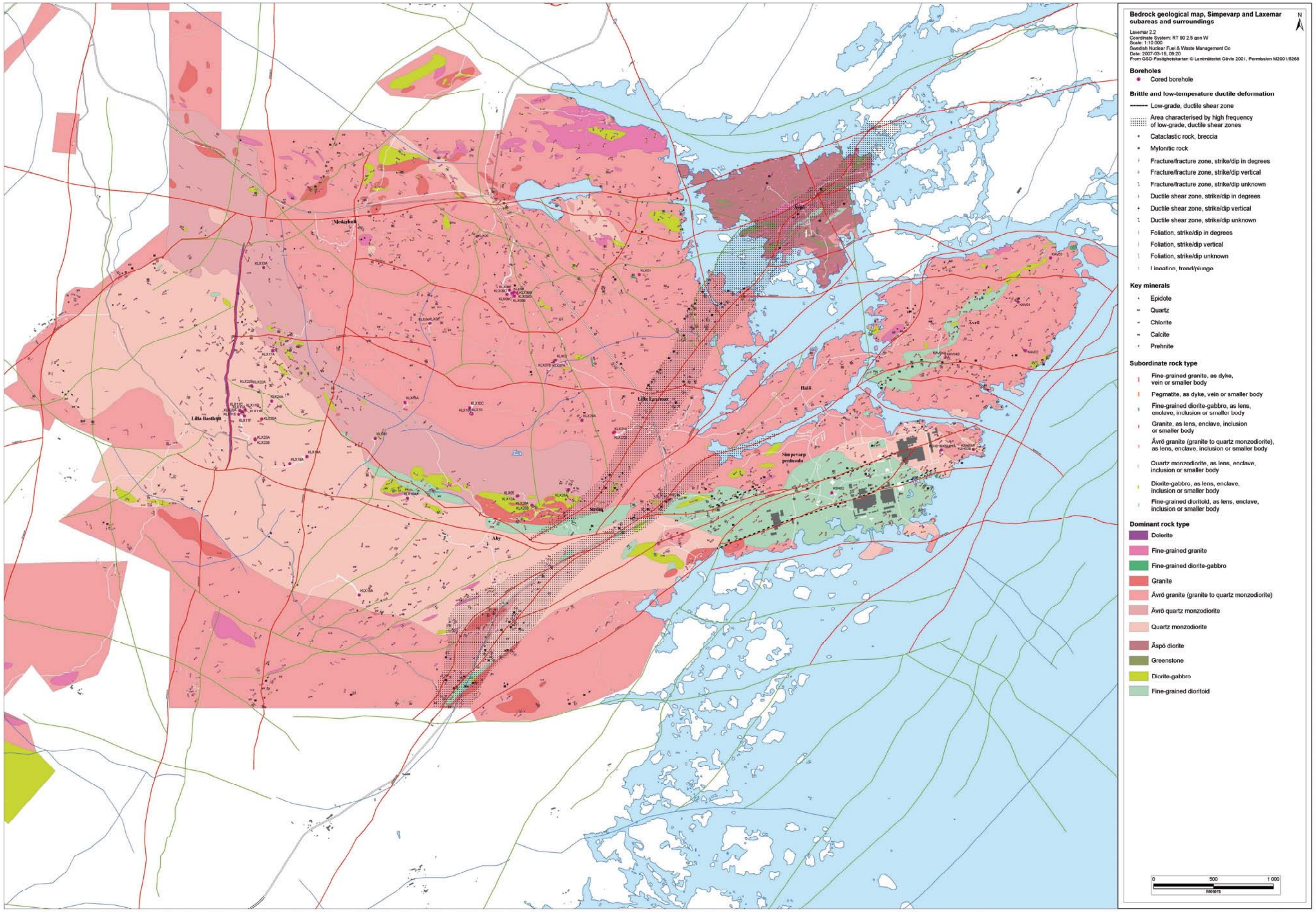
Bedrock geology in the Laxemar/Simpevarp area



Appendix 2

Monitored soil wells

Borehole	Section	Installation date	Section interval from (m)	to (m)	Screen interval from (m)	to (m)
SSM000001	1	2002-10-08	0.0	3.1	2.0	3.0
SSM000008	1	2003-12-08	0.0	5.1	3.0	5.0
SSM000011	1	2004-01-29	0.0	3.1	1.0	3.0
SSM000012	1	2004-01-22	0.0	6.1	5.0	6.0
SSM000014	1	2003-12-09	0.0	3.1	2.0	3.0
SSM000017	1	2004-05-04	0.0	2.1	1.0	2.0
SSM000018	1	2003-12-11	0.0	3.1	2.0	3.0
SSM000019	1	2004-05-04	0.0	3.1	2.0	3.0
SSM000021	1	2004-05-04	0.0	4.1	3.0	4.0
SSM000022	1	2004-01-12	0.0	7.1	5.0	7.0
SSM000027	1	2004-06-28	0.0	5.1	3.0	5.0
SSM000028	1	2004-06-09	0.0	3.1	2.0	3.0
SSM000029	1	2004-06-08	0.0	7.1	5.0	7.0
SSM000030	1	2004-09-10	0.0	5.1	4.0	5.0
SSM000031	1	2004-06-10	0.0	4.1	3.0	4.0
SSM000032	1	2004-06-15	0.0	4.1	3.0	4.0
SSM000033	1	2004-06-15	0.0	2.1	1.0	2.0
SSM000034	1	2004-06-16	0.0	4.1	3.0	4.0
SSM000035	1	2004-06-09	0.0	4.1	3.0	4.0
SSM000037	1	2004-06-22	0.0	4.1	3.0	4.0
SSM000039	1	2004-06-21	0.0	5.1	3.0	5.0
SSM000040	1	2004-06-14	0.0	3.1	2.0	3.0
SSM000041	1	2004-07-07	0.0	4.1	2.0	4.0
SSM000042	1	2004-06-17	0.0	5.1	3.0	5.0
SSM000210	1	2004-06-28	0.0	4.1	2.0	4.0
SSM000213	1	2004-07-06	0.0	2.1	1.0	2.0
SSM000215	1	2004-12-03	0.0	4.1	2.0	4.0
SSM000217	1	2004-12-02	0.0	4.1	2.0	4.0
SSM000218	1	2005-06-02	0.0	3.1	2.0	3.0
SSM000219	1	2005-06-01	0.0	5.1	4.0	5.0
SSM000220	1	2005-05-31	0.0	3.1	2.0	3.0
SSM000221	1	2005-05-30	0.0	3.1	2.0	3.0
SSM000222	1	2005-08-22	0.0	5.1	4.0	5.0
SSM000223	1	2005-08-24	0.0	8.1	6.0	8.0
SSM000224	1	2005-08-29	0.0	17.0	16.0	17.0
SSM000225	1	2005-09-14	0.0	10.0	9.0	10.0
SSM000226	1	2005-09-14	0.0	5.1	4.0	5.0
SSM000227	1	2005-09-14	0.0	2.1	1.0	2.0
SSM000228	1	2005-09-19	0.0	7.1	6.0	7.0
SSM000229	1	2005-09-20	0.0	4.1	3.0	4.0
SSM000230	1	2005-09-21	0.0	5.1	4.0	5.0
SSM000237	1	2005-10-31	0.0	3.1	2.0	3.0
SSM000238	1	2006-02-21	0.0	12.0	11.0	12.0
SSM000239	1	2006-02-22	0.0	5.1	4.0	5.0
SSM000240	1	2006-02-23	0.0	6.1	5.0	6.0
SSM000241	1	2006-02-15	0.0	33.0	32.0	33.0
SSM000242	1	2006-02-07	0.0	18.0	17.0	18.0
SSM000243	1	2006-02-13	0.0	12.0	11.0	12.0
SSM000244	1	2006-02-28	0.0	12.0	11.0	12.0

SSM000245	1	2006-02-02	0.0	5.1	4.0	5.0
SSM000246	1	2006-02-02	0.0	4.1	3.0	4.0
SSM000249	1	2006-01-26	0.0	3.1	2.0	3.0
SSM000250	1	2006-01-27	0.0	4.1	2.0	4.0
SSM000252	1	2006-07-13	0.0	7.7	5.0	7.0
SSM000253	1	2006-07-12	0.0	4.1	3.0	4.0
SSM000255	1	2006-05-16	0.0	6.1	4.0	6.0
SSM000256	1	2006-07-11	0.0	5.1	3.0	5.0
SSM000257	1	2006-07-10	0.0	4.1	3.0	4.0
SSM000260	1	2006-10-25	0.0	9.6	7.45	9.45
SSM000261	1	2006-10-24	0.0	10.0	9.2	10.2
SSM000262	1	2006-10-30	0.0	15.0	11.7	14.7
SSM000263	1	2006-11-02	0.0	8.6	6.3	8.3
SSM000264	1	2006-11-16	0.0	8.0	3.0	5.0
SSM000265	1	2006-11-08	0.0	5.8	3.58	5.58
SSM000266	1	2006-11-08	0.0	4.3	3.01	4.01
SSM000267	1	2006-11-07	0.0	6.3	4.0	6.0
SSM000268	1	2006-11-15	0.0	4.3	3.03	4.03
SSM000269	1	2006-11-15	0.0	4.6	1.0	1.8
SSM000270	1	2006-11-15	0.0	3.2	2.0	3.0
SSM000271	1	2006-11-14	0.0	1.5	0.99	1.49

Monitored sections in core and percussion drilled boreholes

Borehole	Section No	Section interval from (m) to (m)		monitored during site investigation	monitored after site investigation
HAV02	1	17.0	163.0	x	x
HAV06	1	17.0	100.0	x	x
	2	0.0	16.0	x	x
HLX01	1	16.0	100.0	x	x
HLX02	1	0.0	132.0	x	x
HLX06	1	0.0	100.0	x	x
HLX07	1	16.0	100.0	x	x
HLX08	1	0.0	40.0	x	x
HLX09	1	17.0	151.0	x	x
	2	0.0	16.0	x	x
HLX11	1	14.0	70.0	x	x
	2	0.0	13.0	x	x
HLX13	1	0.0	202.2	x	x
HLX14	1	0.0	115.9	x	x
HLX14	1	96.0	115.9	x	x
	2	0.0	95	x	x
HLX15	1	0.0	115.6	x	x
HLX18	1	91.0	181.2	x	x
	2	0.0	90.0	x	x
HLX20	1	81.0	202.0		x
	2	70.0	80.0		x
	3	0.0	69.0		x
HLX21	1	73.0	150.3	x	x
	2	0.0	72.0	x	x
HLX22	1	0.0	163.2	x	x
HLX23	1	61.0	160.2	x	x
	2	0.0	60.0	x	x
HLX24	1	41.0	175.2	x	x
	2	0.0	40.0	x	x
HLX25	1	61.0	202.5	x	x
	2	0.0	60.0	x	x
HLX26	1	11.0	151.2	x	x
HLX27	1	153.0	164.7		x
	2	0.0	152.0		x
HLX28	1	91.0	154.4	x	x
	2	70.0	90.0	x	x
	3	7.5	69.0	x	x
	4	0.0	6.5	x	x
HLX30	1	101.0	164.4	x	x
	2	0.0	100.0	x	x
HLX31	1	0.0	133.5	x	x
HLX32	1	31.0	162.6	x	x
	2	20.0	30.0	x	x
	3	0.0	19.0	x	x
HLX33	1	50.0	202.1	x	x
	2	0.0	49.0	x	x
HLX34	1	0.0	151.8	x	x

HLX35	1	136.0	151.8		x
	2	120.0	135.0		x
	3	0.0	119.0		x
HLX36	1	50.0	199.8	x	x
	2	0.0	49.0	x	x
HLX37	1	150.0	199.8		x
	2	111.0	149.0		x
	3	94.0	110.0		x
	4	13.25	93.0		x
	5	0.0	12.25		x
HLX38	4	0.0	27.0		x
	3	28.0	40.0		x
	2	41.0	80.0		x
	1	81.0	199.5		x
HLX39	1	187.0	199.0		x
	2	51.0	186.0		x
	3	0.0	50.0		x
HLX40	1	40.0	199.5	x	x
HLX41	1	0.0	199.5	x	x
HLX42	1	30.0	152.6	x	x
	2	0.0	29.0	x	x
HLX43	1	148.0	170.6		x
	2	135.0	147.0		x
	3	75.0	134.0		x
	4	30.0	74.0		x
	5	0.0	29.0		x
HMJ01	1	32.9	46.0	x	x
	2	0.0	31.9	x	x
HSH01	1	25.0	200.0	x	x
	2	0.0	24.0	x	x
HSI04	1	0.0	37.0	x	x
HSI13	1	0.0	4.0	x	x
KAV01	1	582.93	742.93	x	x
	2	434.93	581.93	x	x
	3	390.93	433.93	x	x
	4	108.93	306.93	x	x
	5	0.0	107.93	x	x
KAV02	1	0.0	97.1	x	x
KAV03	1	16.0	248.4	x	x
KAV04A	1	675.0	1,000.0	x	x
	2	440.0	674.0	x	x
	3	214.0	439.0	x	x
	4	0.0	213.0	x	x
KBH03	1	0.0	100.43	x	x
KLX01	1	705.0	1,077.99	x	x
	2	191.0	704.0	x	x
	3	171.0	190.0	x	x
	4	0.0	170.0	x	x
KLX02	1	1,165.0	1,700.0	x	x
	2	1,145.0	1,164.0	x	x
	3	718.0	1,144.0	x	x
	4	495.0	717.0	x	x
	5	452.0	494.0	x	x
	6	348.0	451.0	x	x
	7	209.0	347.0	x	x
	8	0.0	208.0	x	x

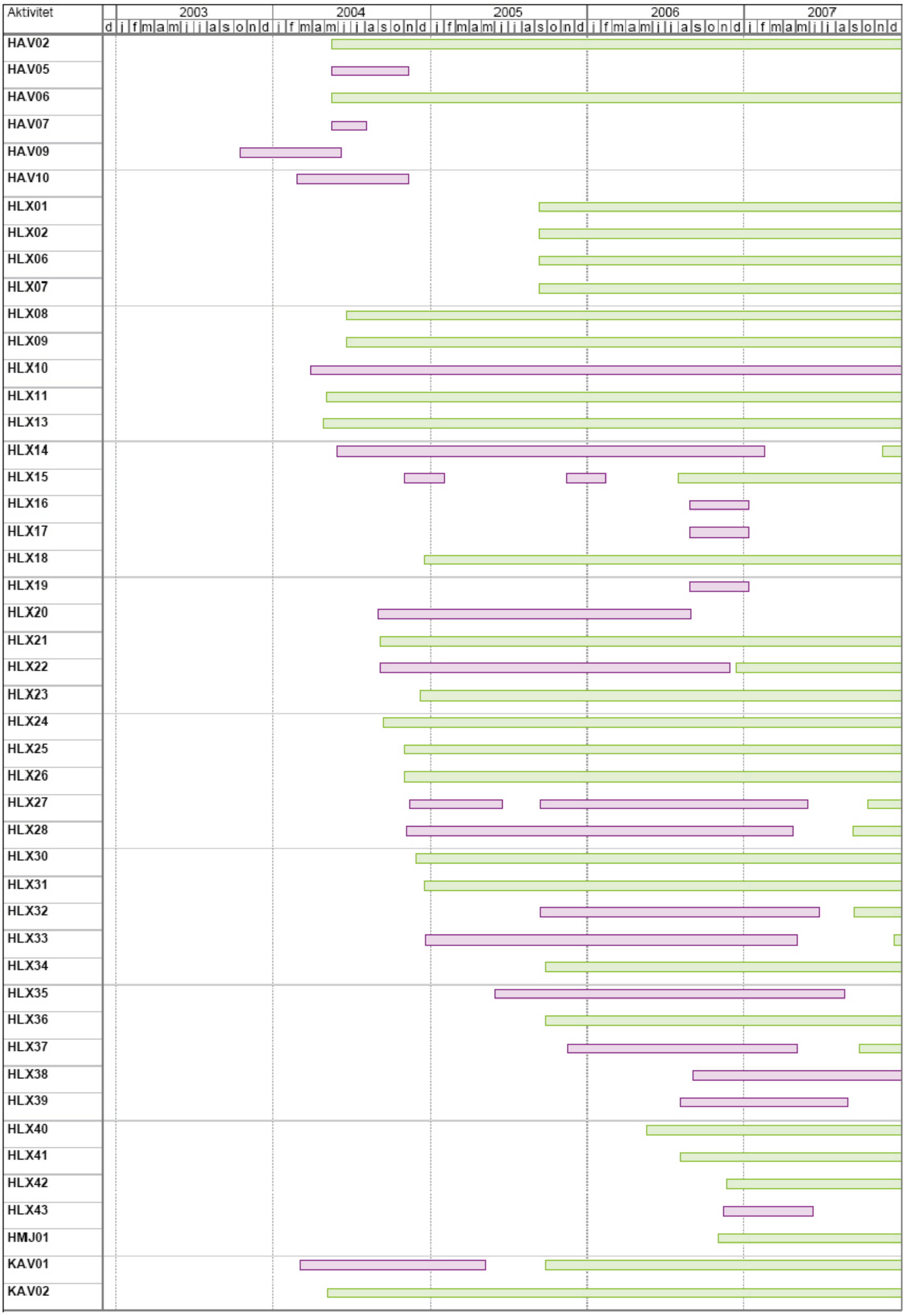
KLX03	1	965.0	971.0	x	x
	2	830.0	964.0	x	x
	3	752.0	829.0	x	x
	4	729.0	751.0	x	x
	5	652.0	728.0	x	x
	6	465.0	651.0	x	x
	7	349.0	464.0	x	x
	8	199.0	348.0	x	x
	9	193.0	198.0	x	x
	10	0.0	192.0	x	x
KLX04	1	898.0	1,000.0	x	x
	2	870.0	897.0	x	x
	3	686.0	869.0	x	x
	4	531.0	685.0	x	x
	5	507.0	530.0	x	x
	6	231.0	506.0	x	x
	7	163.0	230.0	x	x
	8	0.0	162.0	x	x
KLX05	1	721.0	1,000.0	x	x
	2	634.0	720.0	x	x
	3	625.0	633.0	x	x
	4	501.0	624.0	x	x
	5	361.0	500.0	x	x
	6	256.0	360.0	x	x
	7	241.0	255.0	x	x
	8	220.0	240.0	x	x
	9	128.0	219.0	x	x
	10	0.0	127.0	x	x
KLX06	1	761.0	1,000.0	x	x
	2	571.0	760.0	x	x
	3	554.0	570.0	x	x
	4	411.0	553.0	x	x
	5	276.0	410.0	x	x
	6	256.0	275.0	x	x
	7	146.0	255.0	x	x
	8	0.0	145.0	x	x
KLX07A	1	781.0	844.73	x	x
	2	753.0	780.0	x	x
	3	612.0	752.0	x	x
	4	457.0	611.0	x	x
	5	333.0	456.0	x	x
	6	204.0	332.0	x	x
	7	104.0	203.0	x	x
	8	0.0	103.0	x	x
KLX07B	1	95.0	200.0	x	x
	2	0.0	94.0	x	x
KLX08	1	894.0	1,000.41	x	x
	2	684.0	839.0	x	x
	3	626.0	683.0	x	x
	4	594.0	625.0	x	x
	5	497.0	593.0	x	x
	6	355.0	496.0	x	x
	7	243.0	354.0	x	x
	8	160.0	242.0	x	x
	9	102.0	159.0	x	x
	10	0.0	101.0	x	x

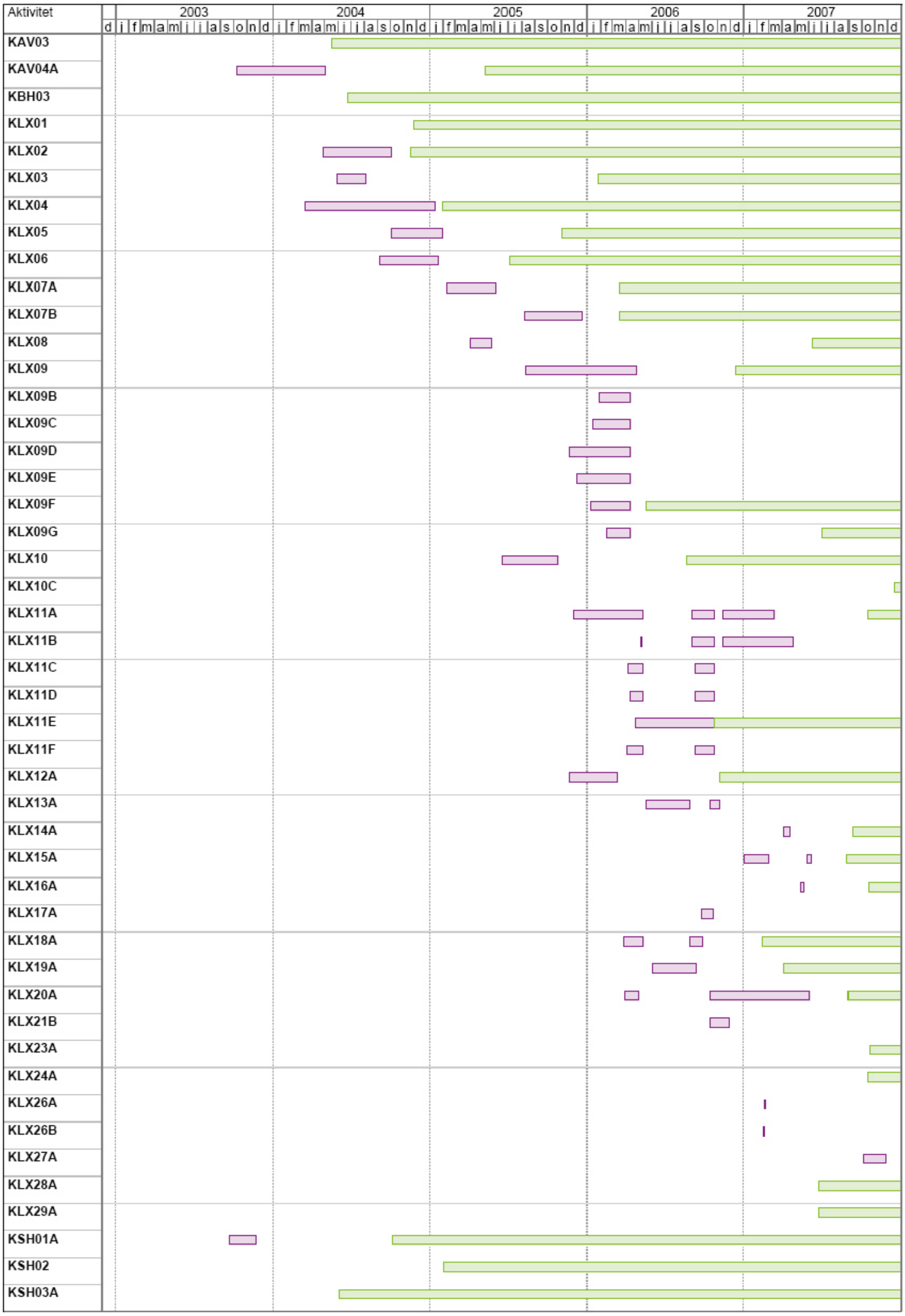
KLX09	1	564.0	880.38	x	x
	2	470.0	563.0	x	x
	3	199.0	469.0	x	x
	4	104.0	198.0	x	x
	5	0.0	103.0	x	x
KLX09F	1	0.0	152.3	x	x
KLX09G	1	0.0	100.1	x	x
KLX10	1	711.0	1,001.0	x	x
	2	689.0	710.0	x	x
	3	465.0	688.0	x	x
	4	369.0	464.0	x	x
	5	351.0	368.0	x	x
	6	291.0	350.0	x	x
	7	131.0	290.0	x	x
	8	0.0	130.0	x	x
KLX10C	1	66.0	146.0	x	x
	2	32.0	65.0	x	x
	3	0.0	31.0	x	x
KLX11A	1	703.0	992.29	x	x
	2	587.0	702.0	x	x
	3	573.0	576.0	x	x
	4	495.0	572.0	x	x
	5	315.0	494.0	x	x
	6	273.0	314.0	x	x
	7	256.0	272.0	x	x
	8	180.0	255.0	x	x
	9	103.0	179.0	x	x
	10	0.0	102.0	x	x
KLX11E	1	0.0	121.3	x	x
KLX12A	1	546.0	602.3	x	x
	2	535.0	545.0	x	x
	3	426.0	534.0	x	x
	4	386.0	425.0	x	x
	5	291.0	385.0	x	x
	6	160.0	290.0	x	x
	7	142.0	159.0	x	x
	8	104.0	141.0	x	x
	9	0.0	103.0	x	x
KLX13A	1	508.0	596.0		x
	2	490.0	507.0		x
	3	341.0	489.0		x
	4	244.0	340. 0		x
	5	131.0	243.0		x
	6	0.0	130.0		x
KLX14A	1	123.0	176.27	x	x
	2	77.0	122.0	x	x
	3	0.0	76.0	x	x
KLX15A	1	902.0	1,000.43	x	x
	2	641.0	901.0	x	x
	3	623.0	640.0	x	x
	4	481.0	622.0	x	x
	5	273.0	480.0	x	x
	6	260.0	272.0	x	x
	7	191.0	259.0	x	x
	8	79.0	190.0	x	x
	9	0.0	78.0	x	x

KLX16A	1	327.0	433.55		x
	2	86.0	326.0		x
	3	0.0	85.0		x
KLX17A	1	435.0	710.0		x
	2	419.0	434.0		x
	3	343.0	418.0		x
	4	314.0	342.0		x
	5	220.0	313.0		x
	6	180.0	219.0		x
	7	70.0	179.0		x
	8	0.0	69.0		x
KLX18A	1	571.0	611.28	x	x
	2	490.0	570.0	x	x
	3	472.0	489.0	x	x
	4	315.0	471.0	x	x
	5	155.0	314.0	x	x
	6	104.0	154.0	x	x
	7	0.0	103.0	x	x
KLX19A	1	661.0	800.07	x	x
	2	518.0	660.0	x	x
	3	509.0	517.0	x	x
	4	481.5	508.0	x	x
	5	311.0	480.5	x	x
	6	291.0	310.0	x	x
	7	136.0	290.0	x	x
	8	0.0	135.0	x	x
KLX20A	1	294.0	457.92	x	x
	2	260.0	293.0	x	x
	3	181.0	259.0	x	x
	4	145.0	180.0	x	x
	5	103.0	144.0	x	x
	6	0.0	102.0	x	x
KLX21B	1	720.0	858.78		x
	2	573.0	719.0		x
	3	558.0	572.0		x
	4	441.0	557.0		x
	5	281.0	440.0		x
	6	171.0	280.0		x
	7	102.5	170.0		x
	8	0.0	101.5		x
KLX23A	1	49.0	100.15	x	x
	2	0.0	48.0	x	x
KLX24A	1	69.0	100.17	x	x
	2	41.0	68.0	x	x
	3	0.0	40.0	x	x
KLX26A	1	48.0	101.14		x
	2	22.0	47.0		x
	3	0.0	21.0		x
KLX26B	1	21.0	50.0		x
	2	0.0	20.0		x
KLX27A	1	640.0	650.56		x
	2	580.0	639.0		x
	3	490.0	579.0		x
	4	380.0	489.0		x
	5	260.0	379.0		x
	6	220.0	259.0		x
	7	115.0	219.0		x
	8	80.0	114.0		x
	9	0.0	79.0		x

KLX28A	1	0.0	80.23	x	x
KLX29A	1	0.0	60.25	x	x
KSH01A	1	800.0	1,003.0	x	x
	2	671.0	799.0	x	x
	3	573.0	670.0	x	x
	4	532.0	572.0	x	x
	5	331.0	531.0	x	x
	6	278.0	330.0	x	x
	7	238.0	277.0	x	x
	8	181.0	237.0	x	x
	9	0.0	180.0	x	x
KSH02	1	955.0	963.0	x	x
	2	649.0	954.0	x	x
	3	440.0	648.0	x	x
	4	411.0	439.0	x	x
	5	111.0	410.0	x	x
	6	91.0	110.0	x	x
	7	0.0	90.0	x	x
KSH03A	1	281.15	1,000.7	x	x
	2	180.65	280.15	x	x
	3	0.0	179.65	x	x

Time periods when groundwater level monitoring in core and percussion drilled holes has been made during the site investigations




Aktivitet
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KLX06
KLX07A
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