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Hydrochemical monitoring of near surface groundwater and surface waters

Results from the sampling period January–December 2016

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Sveriges Vattenekologer

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Abstract

This report presents the hydrochemical monitoring of near surface groundwaters and surface waters in Forsmark during the sampling period January to December 2016.

Near surface groundwaters were sampled and analysed four times during this period. First the samples were collected from shallow soil monitoring wells and one BAT-pipe. In August 2016 the sampling program was changed, adding new soil pipes and excluding the BAT-pipe in the sampling program.

Sampling of surface waters (sea, streams and lakes) was performed once per month (except July) in the four streams and once per season (four times) in the sea and lakes included in the monitoring programme. Water from an extra sampling location (the outlet of Lake Biotestsjön) was collected once per month (except in July) for tritium analyses in order to check for possible tritium contamination from the nuclear power plant. Starting in August 2016 the monitoring program was extended to include not only tritium but also ordinary water sampling from the outlet of Lake Biotestsjön as well as a few new sampling locations in the sea to be able to reveal possible nitrogen contamination later on when the underground construction starts.

The results from the near surface groundwater and surface water monitoring include field measurements of redox potential (ORP), pH, dissolved oxygen, electrical conductivity and water temperature, as well as chemical analyses of major constituents, nutrient salts, trace metals and isotopes. For surface waters, the field measurements also include depth and turbidity.

Generally, the new data confirm the knowledge and conclusions from the earlier investigation periods. The characters of the near surface groundwaters in the monitoring programme generally remain unchanged also this year.

Surface waters in the lakes and streams in the Forsmark area are well buffered with high alkalinity, high pH and high calcium concentrations. The proportions of the major ions in the sampled freshwaters and the shallow sea bay were similar to previous years, showing no major changes. Also, the concentrations of total nitrogen and total phosphorus were similar to previous years. However, a slightly elevated concentration of Na^+ and Cl^- indicate salt water inflow into Bolundsfjärden. Previous data indicates periodic tritium contamination from the adjacent nuclear power plant in water samples from near the cooling water outlet. In 2016, elevated tritium concentration was measured in November and December.

Sammanfattning

Rapporten dokumenterar den hydrokemiska övervakningen av ytnära grundvatten och ytvatten i Forsmarksområdet under provtagningsperioden januari till december 2016.

Provtagning och analyser av ytnära grundvatten utfördes vid fyra tillfällen under 2016. I januari och april provtogs vatten från fem jordborrhål och ett BAT-rör. I augusti omformades provtagningsprogrammet vilket innebar att BAT-röret ströks och nya jordborrhål lades till i programmet.

Ytvatten provtogs en gång per månad (utom i juli) i fyra bäckar samt fyra gånger per år (en gång per årstid) i tre sjöar och i havet. En extra provpunkt vid utloppet av Biotestsjön provtogs en gång per månad (utom i juli) i syfte att kontrollera eventuell kontaminering av tritium från kärnkraftverket. Även detta förändrades med start i augusti 2016. Från augusti provtogs provpunkten vid utloppet av Biotestsjön enligt samma tillvägagångssätt som övriga ytvattenprover (d.v.s. mer utförlig provtagning och analys). Dessutom lades nya havspunkter till i programmet.

De erhållna resultaten från ytnära grundvatten och ytvatten omfattar fältmätningar av ORP (redox-potential), pH, löst syre, elektrisk konduktivitet och vattentemperatur samt kemiska analyser av huvudkomponenter, närsalter, kolföreningar, spårelement och isotoper. För ytvatten mäts även djup och turbiditet.

Årets data bekräftar generellt slutsatser från tidigare undersökningsperioder. Ytvattnet i sjöar och bäckar i Forsmarksområdet är väl buffrade med hög alkalinitet, högt pH och höga kalciumkoncentrationer. Koncentrationen av de vanligaste jonerna i de provtagna sötvattnen och havspunkten liknade föregående år och visar därmed inga större förändringar under året. Något förhöjda koncentrationer av natrium- och kloridjoner indikerar dock saltvattensinflöde i Bolundsfjärden. Förhöjda halter av tritium uppmättes i proverna nära kylvattenutsläppet från kärnkraftverket (Biotestsjön) vid provtagningarna i november och december.

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1 Introduction

The site investigations in Forsmark were finished in June 2007 (SKB 2001, 2005) and a less intensive phase commenced when a prolonged monitoring programme was established (SKB 2007). This document reports the performance and results for near surface groundwater and surface waters during the period January to December 2016. The monitoring has been ongoing, in one form or another, since 2001 and is today performed according to the monitoring programme from 2007 (SKB 2007).

The sampling objects for near surface groundwater in soil include shallow monitoring wells and wells/pipes equipped with BAT-filter tips (a special sampling system described in Section 2.3.3). The different sampling objects are presented in Table 2-1 and a map showing their location is presented in Figure 2-1. The surface water sampling sites include lakes, streams and sea bays in the Forsmark area. The sampling locations are presented in Figure 3-1 and Table 3-1.

The monitoring activities include sampling and chemical analyses as well as field measurements. The controlling documents for the activities are listed in Table 1-1. The activity plans and method descriptions are SKB's internal controlling documents. Original data from the reported activities are stored in the primary database Sicada. Data are traceable in Sicada by the activity plan numbers (AP SFK 10-082 and AP SFK 16-023). Only data in the database are accepted for further interpretation and modelling. The results presented in this report are regarded as copies of the original data. Data in the database may be revised, if needed. However, such revision of the database will not necessarily result in a revision of this report.

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

Activity plans	Number	Version
Hydrokemisk monitoringsprogram för gölar, ytvatten och ytnära grundvatten januari 2015 till juni 2016.	AP SFK 10-082	1.0
Hydrokemiskt övervakningsprogram för ytvatten, ytnära grundvatten och gölar. Augusti till och med december 2016.	AP SFK 16-023	1.0
Method descriptions	Number	Version
Metodbeskrivning för ytvattenprovtagningar vid platsundersökningar.	SKB MB 900.004	2.0
Provtagning och Provhantering	SKB MD 452.001	11.0

Water sampling and measurement procedures are also described in SKB PIR-04-09 "Metodik för provtagning av ekologiska parametrar i hav", SKB PIR-04-06, "Metodik för provtagning av ekologiska parametrar i sjöar och vattendrag", and SKB PIR-04-12, "Översikt över provhanterings- och analysrutiner för vattenprov" (SKB internal documents).



Figure 1-1. Sampling at Norra bassängen (PFM000097) in February 2016.

2 Near surface groundwaters

2.1 Objectives and scope

An extensive, two-year-long sampling campaign designed to characterise near surface groundwaters in different types of environments within the candidate area (SKB 2001) was followed by a reduced monitoring programme in July 2005 (SKB 2005). The site investigation of the candidate area was concluded in June 2007 but the monitoring programme (SKB 2007) will continue until the construction of the repository for spent nuclear fuel starts and during the construction and operation phase. This in order to monitor the water composition and obtain long time-series of data, first to create a base-line describing the natural variations and second to follow changes caused by the construction and operation of the repository.

During the reported period, January–December 2016, the sampling locations (stand pipes) within the monitoring programme were sampled at four occasions, in January, April, August and October. The sampling was conducted from shallow soil monitoring wells and one BAT-pipe. In August 2016 the sampling program was changed, adding three new soil pipes and excluding the BAT-pipe in the sampling program. The different sampling objects are presented in Table 2-1 and a map showing their location is presented in Figure 2-1.

The activity includes water sampling for chemical analysis as well as direct measurements in the field of parameters such as ORP (redox potential), pH, dissolved oxygen, electrical conductivity (EC) and water temperature. The analytical protocol includes major constituents, nutrient salts, silica, carbon species as well as isotopes and trace metals, see Tables 2-2 and 2-3.

2.2 Sampling objects

The monitoring programme for near surface groundwater includes stand pipes and one BAT-pipe. The wells/pipes are of the following types:

1. Single stand pipes made of HDPE located close to drill sites.
2. Double and single stand pipes made of HDPE. Double pipes means that one of the pipes is equipped with a permanently installed sensor for logging the groundwater pressure and the other pipe is intended for hydrochemical sampling.
3. Stand pipes installed in the sediment below the water layer in Lake Bolundsfjärden (Figure 1-1). These pipes are made of ordinary, non-stainless iron. Stand pipes located in till below fen are of the same type.
4. Pipes equipped with BAT-filter tips as described in Section 2.3.3.

For pipe types 1) to 3), the positions of the filter/screen part, and for type 4) the position of the BAT-filter tip, correspond to the upper and lower section limits (Secup and Seclow) in the Sicada database. The section limits refer to the top of the stand pipe (Top Of Casing/TOC).

The sampled monitoring wells and their stand pipe types are listed in Table 2-1. The locations of the different sampling objects are displayed in Figure 2-1.

Table 2-1. List of sampling objects, type of sampling and type of pipe.

Idcode	Comments on sampled object	Pipe type	Comment on monitoring
SFM0001	Stand pipe connected to drill site	Plastic	
SFM0023	Stand pipe in sediment below water surface	Iron	
SFM0032	Double-pipe for chemistry	Plastic	
SFM0037	Double-pipe for chemistry	Plastic	
SFM0049	Double-pipe for chemistry	Plastic	
SFM0051	BAT-system, drill site 1	BAT	Excluded from August 2016
SFM0002	Double-pipe for chemistry	Plastic	Included from August 2016
SFM0011	Double-pipe for chemistry	Plastic	Included from August 2016
SFM0057	Double-pipe for chemistry	Plastic	Included from August 2016

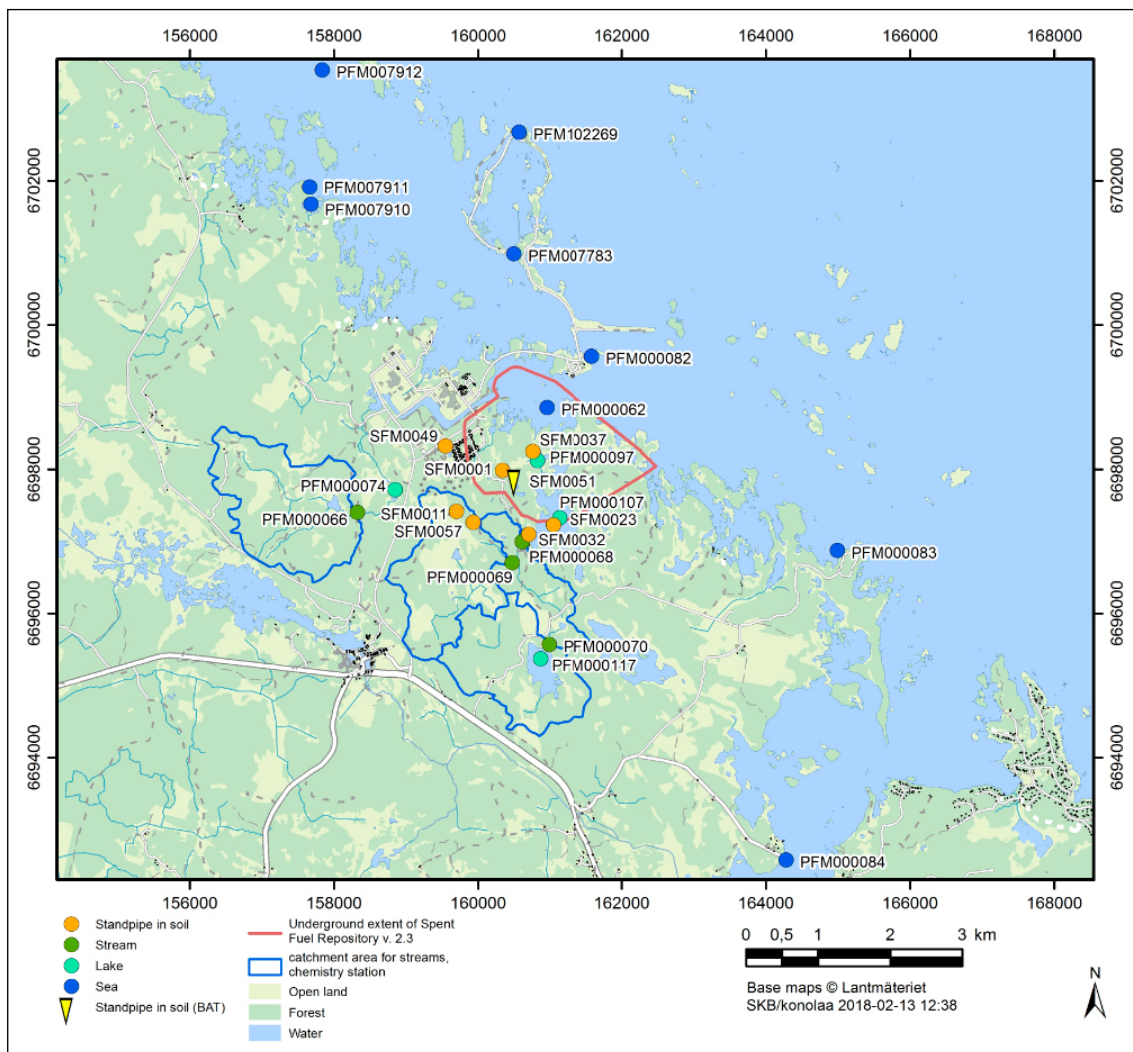


Figure 2-1. Sampling locations within the monitoring programme for surface and near surface waters in Forsmark during 2016. One location constitutes an alternative for a regular sampling position (see Table 3-1) and PFM007910–7912 are sampling points planned to be included in the programme 2017.

2.3 Equipment

2.3.1 Sampling equipment

Groundwater samples from the shallow monitoring stand pipes in soil were collected using pump setups, each one consisting of a submersible electrical pump (12V, Awimex) connected to a 5–10 m long polyamide-tube (Tecalan) of 8 mm diameter. Manually operated electrical regulators were used to adjust the water flow to a maximum of 0.5 litre/minute. Disposable filters (0.45 μm , $\varnothing = 22$ mm) were used for filtration of some sample portions. The filters were fitted to 60 ml syringes. A separate pump set-up was used for the stand pipe made from standard iron, i.e. pipe SFM0023, in order to minimize the risk of contaminating other samples.

2.3.2 Multi-parameter sondes

Field measurements were conducted with a multi-parameter sonde, InSitu Troll9500 (Figure 2-2). A hand held PC is connected to the sonde through a cable for logging and initial field control of data.

The measured parameters in near surface groundwaters included pH, water temperature, oxygen, ORP (redox potential) as well as electrical conductivity. Measurements were conducted in a flow-through cell, Figure 2-2.

2.3.3 BAT-equipment

Water sampling in the stand pipe equipped with a BAT-filter tip was performed with a GeoN BAT-type groundwater sampler. The sampler carries an evacuated and hermetically closed glass sample container, 500 mL, and a vial. The vial is fitted with a cap with a rubber disc, similar to the disc in the filter tip. The needle of the sampler, which is “double-ended”, penetrates through the two rubber discs, thus connecting the filter tip to the vial cap, see Figure 2-3. Due to the vacuum in the vial, water will be sucked from the aquifer, through the filter and the needle, into the vial.

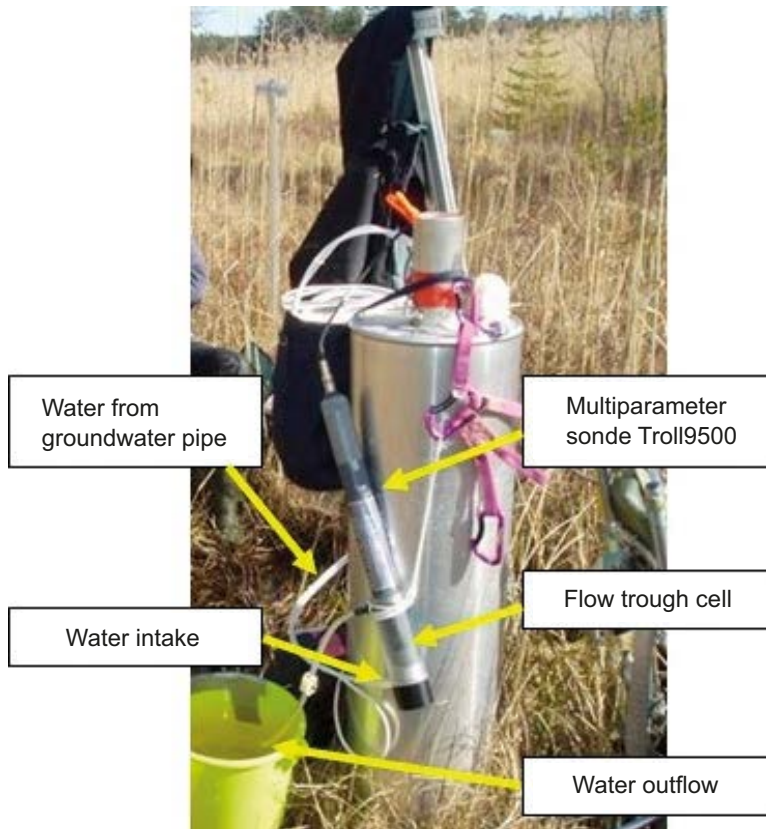


Figure 2-2. The multi parameter sonde used in 2016, Troll9500.

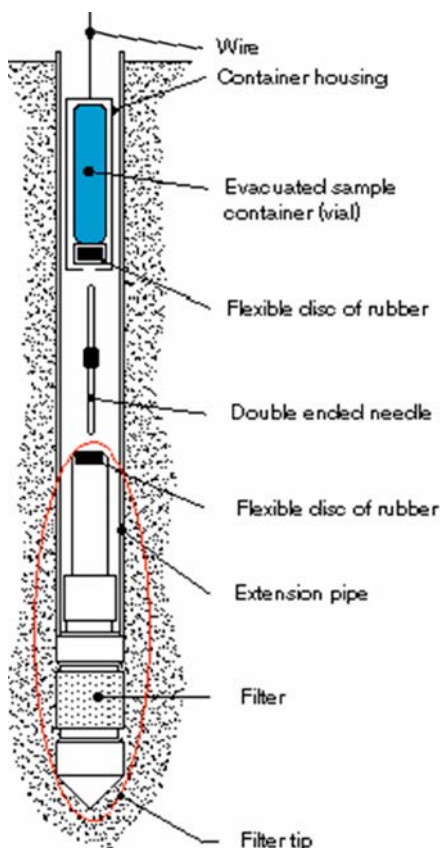


Figure 2-3. Outline of BAT-sampler system and the BAT-filter tip.

2.4 Performance

2.4.1 Sampling programme

Sampling schedule

The sampling schedule for the sampling programme is given in Table 2-2. Bottles were filled and the analyses performed according to the different SKB chemical classes (class 3 and class 5, respectively) as summarised in Table 2-3.

Presampling preparations

Prior to the sampling campaigns, sample bottles were labelled and packed in insulated boxes/bags. Acid additions were made in advance to bottles intended for trace metal and iron analyses as well as acidified archive samples. Bottles with added nitric acid were put in a separate plastic bag and kept outside the box away from the other sample bottles in order to avoid contamination. The pump setups were washed and rinsed with deionised water before use and all parts of equipment were kept well protected in plastic bags or in tight containers. Calibration of the sonde was performed according to the measurement system description (the operator's manual for TROLL9500, Rev. 007, 2009).

Table 2-2. Sampling schedule January–December 2016.

Year	Month	Week	Sampling objects	Sampling and analysis class
2016	January	3	Shallow monitoring wells BAT-pipe	SKB class 5 SKB class 5
2016	April	16	Shallow monitoring wells BAT-pipe	SKB class 3 SKB class 3
2016	August	32	Shallow monitoring wells	SKB class 5
2016	October	41	Shallow monitoring wells	SKB class 3

Table 2-3. Sample portions/bottles and preparation procedures for class 3 and class 5.

Bottle volume (mL)	Number of bottles	Components	Preparation
100	1	Br, I	
100	1	Deuterium ² H, ¹⁸ O	–
250	2	Anions (Br, SO ₄ , Cl, F), Alkalinity, pH, Electric conductivity	–
500	1	Tritium, ³ H	–
100	1	Tot-N, Tot-P	–
100	1	TOC	–
250	2	Archive samples	–
25	4	Ammonia, NO _x , Silicate, Phosphate	Filtering with syringe/0.4 µm filter
100	2	DOC, DIC	Filtering with syringe/0.4 µm filter
125	1	Major constituents; cations ^{1a} and S, Si. Environmental metals ^{*1b} , trace metals ^{*1c}	Acid addition (1 mL conc. HNO ₃) Filtering with syringe/0.4 µm,
100	2	Archive samples	Acid addition (1 mL conc. HNO ₃) Filtering with syringe 0.4 µm,
250	1	Fe(II)/Fetot	Acid addition (2.5 mL conc. HCl) Filtering with 0.4 µm filter,
Winkler bottles 125	2	HS*	0.5 ml ZnAc + 0.5 ml NaOH and mix

1a) Na, K, Ca, Mg, Si, Fe, Mn, Li, Sr.

1b) Al, As, Ba, B, Cd, Co, Cr, Cu, Hg, Mo, Ni, P, Pb, V, Zn (only class 5 samples).

1c) Sc, Rb, Y, Zr, I, Sb, Cs, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, U, Th (only class 5 samples).

* Only class 5 samples.

Class 3 and 5
 Class 5

Sampling and measurements

The groundwater sampling procedure described below was generally applied in the groundwater pipes and wells, except for the BAT-pipe.

First, the groundwater level in the pipe was established by sounding and the water volume of the pipe was calculated. The pump with its connected tube was lowered carefully in order to prevent dirt from entering the pipe. The water inlet of the submersible pump was lowered to the filter/screen section of the pipe or just above. Pumping was then performed at a maximum flow rate of 0.5 litre per minute. The pumped water was disposed of at least 10 m away from the sampling object where it filtrated back into the ground. The pumping phases were as follows:

- *Exchange of water volume in pipe and tubes:* The water volume was exchanged three to five times (depending on the exchange/recovery time) prior to the actual sampling.
- *Field measurement:* A flow-through cell was connected to the pump setup and measurements were performed with the multi parameter sonde. The results were recorded when the electrodes and sensors in the flow-through cell showed stable values (minimum 10 minutes). A judgement of the plausibility of the values was made in the field and accepted values were noted in the field protocol and logged on the hand held PC.
- *Sampling:* All sample bottles, except the ones with added acid, were rinsed three times with sample water before they were filled. Disposable filters were used for filtration of water portions for major components, trace metals, Fe, nutrients and DOC/DIC. Each filter was rinsed with sample water (approx. 20 mL) before the sample portion/filtrate was collected. Bottles containing acid were the last ones to be filled in order to prevent acid contamination in the other sample portions. Disposable plastic gloves were used during the sampling. The samples were transported back from the field in insulated boxes/bags.

Sampling performance using the BAT-system

Sampling of the BAT-filter tip pipe followed the sampling schedule for the regular shallow soil pipes. The approximate time to fill one 500 mL container in pipe SFM0051 was 15 minutes.

A total of four or five sample containers were filled from the BAT-pipe in order to obtain enough water for the analyses. In order to exchange the water volume in the BAT-pipe before sampling, the first sample container filled was not used for any analyses. The use of the sample volumes and the analyses performed are listed in Table 2-5.

2.4.2 Sample handling and analyses

Table 2-4 lists the collected samples during the reported period. Measurements/analyses of $pH_{(lab)}$, electrical conductivity_(lab) and alkalinity as well as spectrophotometric analyses of total iron and ferrous iron (Fe+II) were conducted immediately at the site laboratory. An overview of sample treatments and analytical routines for major constituents, minor anions, trace metals and isotopes is given in Appendix 1. The routines are applicable independent of sampling method or type of sampling object.

Table 2-4. List of collected samples during the period January to December 2016 (X = collected sample).

Id code	Week/Year				Sum (X)
	3/16	16/16	32/16	41/16	
Soil wells					
SFM 0001	X	X	X	X	4
SFM 0023	X				1
SFM 0032	X	X	X	X	4
SFM 0037	X	X	X	X	4
SFM 0049	X	X	X	X	4
SFM 0002			X	X	2
SFM 0011			X	X	2
SFM 0057			X	X	2
BAT pipes					
SFM0051	X	X			2
Sum (X)	6	5	7	7	25

Table 2-5. Sample containers and analyses, bat pipe SFM0051.

Sample container no.	Analyses and determinations			Total volume
1-2	Chloride, bromide, fluoride and sulphate by IC. (200 mL+50 mL)	Alkalinity titr, pH and EC. (150 mL)	δ^2H , $\delta^{18}O$ (100 mL)	500 mL
3	Tritium (500 mL)			Approx. 500 mL
4	Fe (+II), (Fe(tot) (200 mL)	Major constituents, trace elements, $^{10}B/^{11}B$ by ICP AES/MS (125 mL)	5 mL of HCl was added to the container prior to sampling.	325 mL

2.4.3 Nonconformities

Due to problems with the pipe, site SFM0023 was only sampled in January 2016. This is due to unreliable data. The exclusion of this data is due to highly variable water quality both during the sampling and between sample occasions. The differences in water quality can e.g. be observed during the sampling. The water colour can shift from clear to black. Also, the charge balance error is rarely acceptable. The bad water quality is probably due to the corroded iron pipe used in this site. A new pipe was added at the SFM0023 site in 2016. However, this new pipe did not work during 2016 and the sampling site must be fixed before reliable samples can be obtained.

No sampling was performed in the private wells (PFM000001, PFM000009 and PFM006382) during this sampling period (2016).

2.5 Results

2.5.1 Field measurements

The pH, electrical conductivity, dissolved oxygen, oxygen saturation, water temperature and redox potential (ORP) results from the field measurements are presented in Appendix 2.

pH-measurement

Field measurements of pH are plotted against the corresponding laboratory values in Figure 2-4. The data show good agreement between field and laboratory measurements although some deviation is expected due to different water temperatures and the time delay between field and laboratory measurements. However, in one case, the disagreement seems to be too large. This is from the only sampling occasion at the site SFM0023 in Lake Bolundsfjärden, where large differences between field and laboratory values are common. This well yields little water and the inflow is very slow (the exchange of the pipe volume takes ca 24 h), which means that field measurements must be performed the day before the water is sampled for laboratory analyses. This may explain the large differences in pH-values illustrated by the point disagreeing most from the red line in Figure 2-4.

Electrical conductivity

Electrical conductivity values from the field are plotted versus corresponding laboratory values in Figure 2-5. The values show good agreement between field and laboratory measurements.

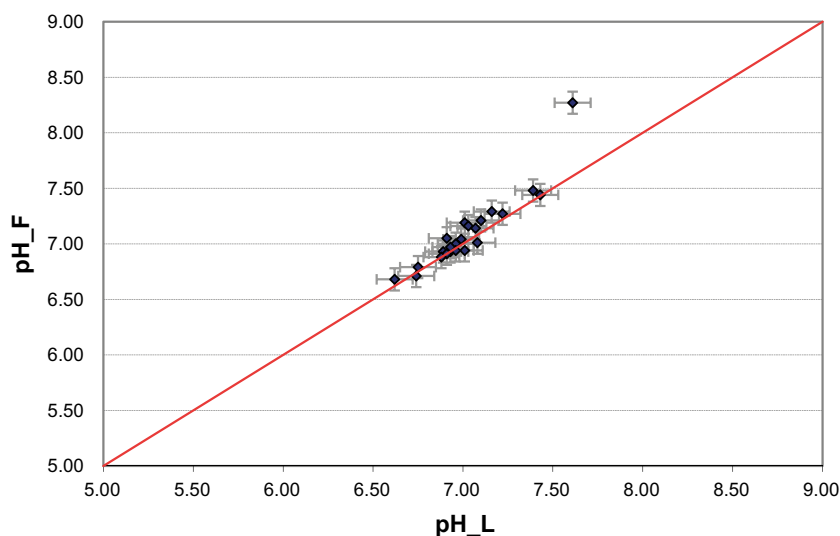


Figure 2-4. Field-pH (pH_F) values versus laboratory-pH (pH_L) values. Field-pH and laboratory-pH values are measured at prevailing water temperature and at 25 °C respectively. The measurement uncertainty (Appendix 1) is shown as error bars.

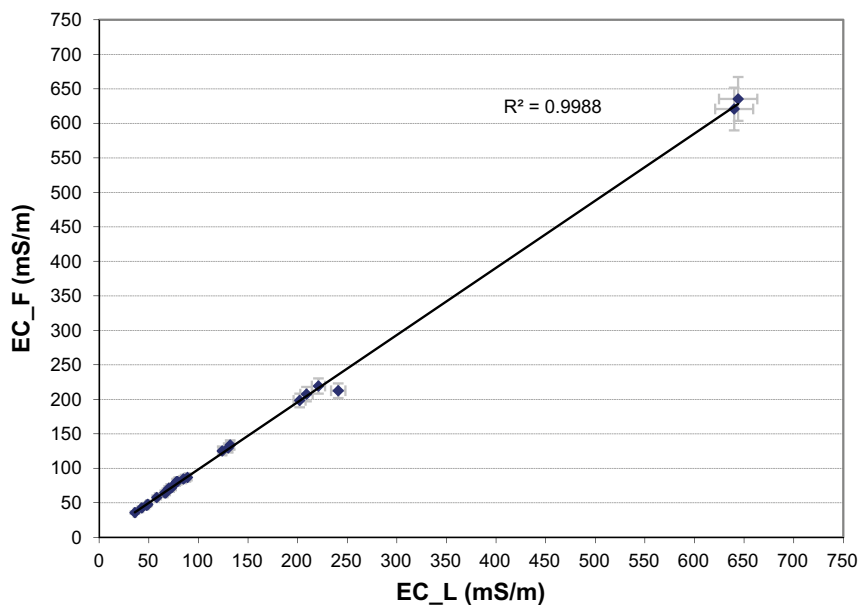


Figure 2-5. Electrical conductivity (25 °C). Field measurements (EC_F) versus laboratory values (EC_L). The measurement uncertainty (Appendix 1) is shown as error bars.

Dissolved oxygen

The field measurements of dissolved oxygen were checked in April 2005 by comparison to results from laboratory analyses (Nilsson and Borgiel 2005). This control showed that, generally, the field measurement values were somewhat higher, especially at oxygen concentrations below 4 mg/L. Field measurements of dissolved oxygen are presented in Appendix 2.

ORP-measurements and redox conditions

ORP-measurements (Oxidation Reduction Potential) have been conducted using the multipurpose measurement sonde. The recorded ORP-values should be used with great caution and merely considered as an indication of the redox conditions in the waters. Measured ORP-values are presented in Appendix 2.

2.5.2 Water analyses

Basic components

The basic water analyses include the major constituents Na, K, Ca, Mg, Sr, S, SO₄²⁻, Cl⁻, Si and HCO³⁻ as well as the minor constituents Fe, Li, Mn, Br, F, I and HS⁻. Furthermore, batch measurements of pH and electrical conductivity are included. The basic water analysis data are compiled in Appendix 2. The charge balance error provides an indication of the quality and uncertainty of the analyses of major constituents and, the charge balance error was calculated for all samples according to the formula below.

$$rel.error(\%) = 100 \times \frac{\sum cation(equivalents) - \sum anions(equivalents)}{\sum cation(equivalents) + \sum anion(equivalents)}$$

Relative errors within 5 % are considered acceptable. All samples collected in 2016 showed acceptable errors (less than/within ± 5 %).

Differences in flow rate may result in different water characteristics in the duplicate samples which may result in a large charge balance error. Duplicate analyses by a second laboratory or another method are conducted regularly for some of the analysed constituents as a further check of the reliability of the analyses.

The bromide analyses are often uncertain, for example the detection limit of bromide by ion chromatography (< 0.2 mg/L) is often too high for fresh waters. Therefore, duplicate analyses by ICP (bromine) have been performed for most samples.

Surface water supplements

Shallow groundwater analysis includes the surface water supplements/options $\text{NH}_4\text{-N}$, $\text{NO}_2\text{-N}$, $\text{NO}_3\text{-N}+\text{NO}_2\text{-N}$, $\text{NO}_3\text{-N}$, tot-N, tot-P, $\text{PO}_4\text{-P}$, TOC, DOC and DIC. The analytical data are compiled in Appendix 2. The DIC values should be used with care and bicarbonate values (by alkalinity titration) are considered more reliable.

The concentrations of the different nitrogen, phosphorous and carbon compounds may show seasonal variation depending on decomposition processes and varying redox conditions also in shallow groundwater, however, this variation is more pronounced in surface waters. The graphs in Figure 2-7 show the variations of total nitrogen, ammonium and phosphate in the sampled groundwater from the five soil-pipes included in the long-term monitoring programme.

The results from 2016 show concentrations within the previously recorded variations for each sampling location, except for well SFM0023. In the well SFM0023 the concentrations of total nitrogen was higher during January 2016 compared to previous years (Figures 2-7). Results from the new soil pipes (SFM0002, SFM0011 and SFM0057) are available in Appendix 2.

Trace metals

The analyses of trace and rare earth elements include Al, As, Sc, Cd, Cr, Cu, Co, Hg, Ni, Zn, Pb, V, U, Th, Rb, Y, Zr, Mo, In, Sb, Cs, Ba, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Se and Lu. The trace element data are compiled in Appendix 2.

These elements are generally present at low concentrations in the groundwater and the risk for contamination is high. Especially data on common metals such as Al, Cr, Cu, Co, Ni and Zn must be used with caution. Trace metals are not analysed for the iron stand pipe SFM0023 in Lake Bolundsfjärden because of the risk for contamination from the iron pipe.

Isotopes

Isotope determinations including the stable isotopes δD , and $\delta^{18}\text{O}$ as well as the radioactive isotope ^3H (TU) are compiled in Appendix 2.



Figure 2-6. Sampling of near surface groundwater at the sampling well SFM0001 in October 2015.

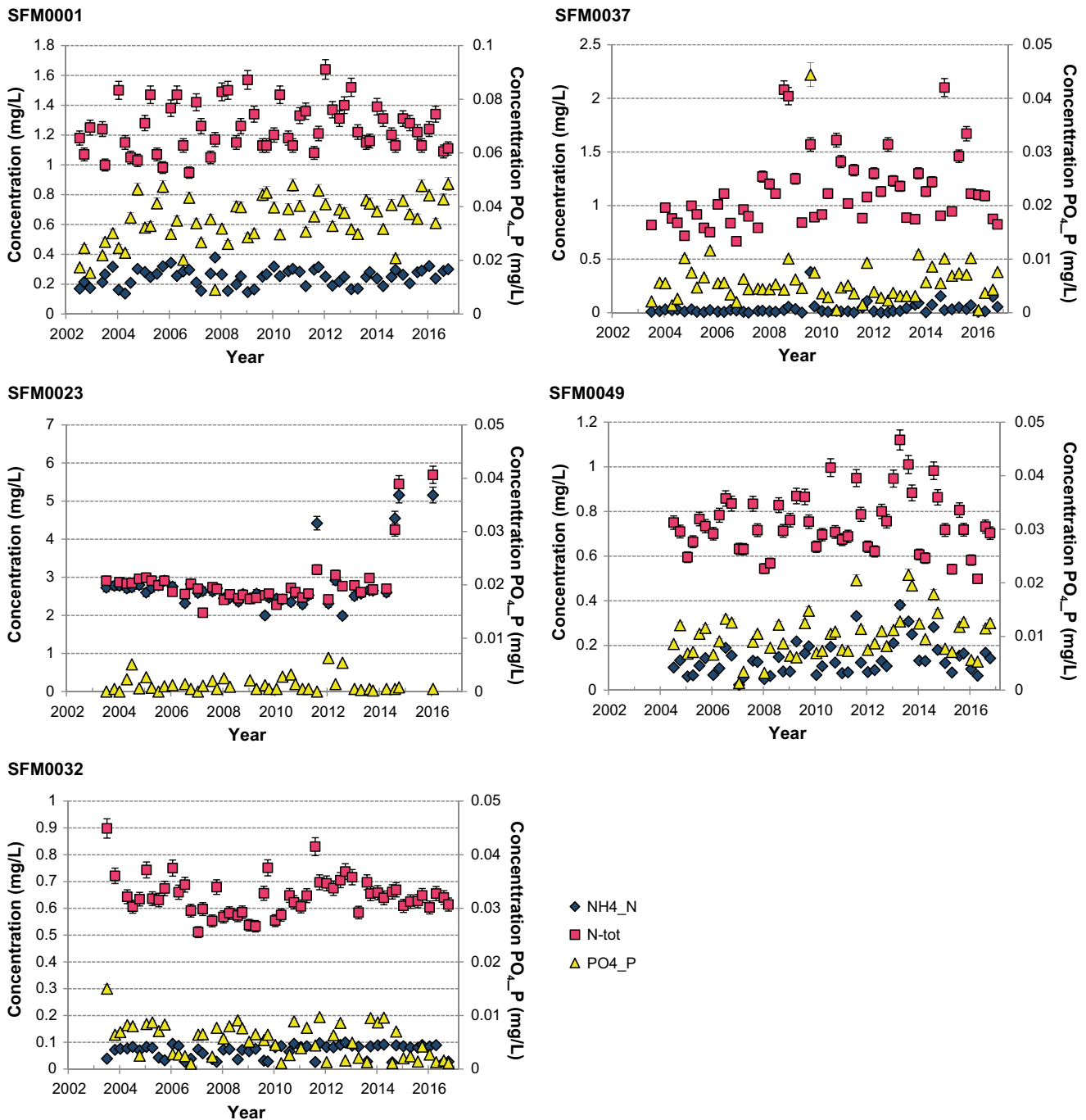


Figure 2-7. Ammonium, total nitrogen and phosphate concentrations plotted versus sampling date for the sampling wells SFM0001, SFM0023, SFM0032, SFM0037 and SFM0049. Note the different scales and that the phosphate concentration is given on the secondary Y-axis. The measurement uncertainty is shown as error bars.

2.6 Summary and discussion

The characters of the near surface groundwater in the sampling locations included in the monitoring programme generally remain unchanged. The chemical investigation routines for near surface groundwater are well established after several years of field work, reporting and data administration and this year of the long-term monitoring programme has passed without any major nonconformities or surprises. However, only one sample was collected from stand pipe in Lake Bolundsfjärden (SFM0023) during 2016. The reason for this is the bad condition of the iron pipe used in the well.

With start in August 2016, three new soil pipes were included and the BAT-pipe was excluded from the monitoring program.

3 Surface waters

3.1 Objectives and scope

Sampling and analyses of surface waters in the Forsmark area began in 2002 during the site investigation phase. After the site investigations, the surface water monitoring programme continued and focused on sampling locations in the prioritised north-western part of the Forsmark candidate area (SKB 2007). The monitoring programme was reviewed and modified in 2010. The modifications of the programme have resulted in reduced sampling frequency in the lakes and the sea and fewer isotope determinations. However, the analytical programme was also extended in the streams adding environmental metals to the analytical programme at every sampling occasion.

The main objectives are to obtain long time-series of data to create a base-line, describing the natural variations. This in order to allow identification of eventual perturbation effects from SKB activities during the future construction and operation of the repository for nuclear waste.

The programme includes sampling of water for chemical analysis as well as direct field measurements of physical and chemical parameters such as ORP (Oxidation Reduction Potential), pH, dissolved oxygen, EC, measurement depth, turbidity and water temperature.

Analyses of major constituents, surface water supplements (nutrient salts etc) and trace elements were conducted frequently (once a month) while extended analyses, including also isotopes were performed once per season, i.e. in January, April, August and October.

3.2 Sampling locations and sampling schedule

The monitoring programme included four lakes, one shallow sea bay location and four streams. The extent of the sampling varied at different occasions. The streams were sampled at eleven occasions (once per month, except for July) and the lake and sea sampling locations at four occasions (once per season) during the reported time period. Water from an extra sampling object (the outlet of Lake Biotestsjön) was also collected once per month (except July) for tritium analyses in order to check for possible tritium contamination from the nuclear power plant.



Figure 3-1. Field sampling at PFM000069 in April 2016.

Starting in August 2016 the monitoring program was extended to include ordinary water sampling from the outlet of Lake Biotestsjön along with three new sampling points in the sea.

The sampling locations are presented in Figure 2-1. Table 3-1 lists the location id-codes, the coordinates and the names together with clarifying comments. The sampling schedule for 2016 is given in Table 3-2.

Table 3-1. Sampling locations (Id-code, coordinates, name and comments).

Sampling locations	Coordinates (RT90 RHB70)	Name	Comments
Lakes			
PFM000074	16 29 854, 66 99 393	Labboträsket	
PFM000097*	16 31 814, 66 99 868	Norra bassängen	* Only field measurements
PFM000107	16 32 065, 66 99 031	Bolundsfjärden	
PFM000117	16 31 946, 66 97 118	Eckarfjärden	
Shallow sea bays and sea location			
PFM000062	16 31 921, 67 00 605	SV Forslingens grund	
PFM000082	16 32 528, 67 01 336		Alternative to PFM00062
PFM102269	16 31 405, 67 04 412	Cooling water outlet, Lake Biotestsjön	Check of tritium contamination. Full sampling starting in August 2016.
PFM000083	16 36 023, 66 98 757	Kallrigafjärden	Included from August 2016. First sampled in October 2016.
PFM000084	16 35 455, 66 94 442	Olandsån	Included from August 2016. First sampled in October 2016.
PFM007783	16 31 390, 67 02 724	Uppströms böjen, Lake Biotestsjön	Included from August 2016. First sampled in August 2016.
Streams			
PFM000066	16 29 343, 66 99 064	Öster Gunnarsboträsket	
PFM000068	16 31 641, 66 98 735	Kungsträsket	
PFM000069	16 31 510, 66 98 440	Bolundsskogen	
PFM000070	16 32 061, 66 97 319	Norr Eckarfjärden	

Table 3-2. Surface water sampling schedule from January to December 2016.

Year	Month	Week	Programme type*	Sampling comment
2016	January	3	E	All sampling points
2016	February	7	M	Streams and Lake Biotestsjön
2016	March	11	M	Streams and Lake Biotestsjön
2016	April	16	E	All sampling points
2016	May	21	M	Streams and Lake Biotestsjön
2016	June	26	M	Streams and Lake Biotestsjön
2016	August	32	E	All sampling points
2016	September	35	M	Streams and Lake Biotestsjön
2016	October	41	E	All sampling points
2016	November	45	M	Streams and Lake Biotestsjön
2016	December	49	M	Streams and Lake Biotestsjön

* M = main programme (SKB class 3 including surface water supplements), E = extended programme (SKB class 5 including surface water supplements).

3.3 Equipment

3.3.1 Sampling equipment

Water samples were collected using a pump setup consisting of an electrical peristaltic pump system, Solinst, model 410, connected to 4–8 m long Teflon-tubes (FEP 140) of 5 mm inner diameter. The sampling equipment is presented in Figure 3-2.

3.3.2 Multi-parameter sondes

Field measurements were conducted with a multi-parameter sonde, InSitu Troll9500. The parameters measured in field that are summarised in Table 3-3. A hand held PC is connected to the sonde through a cable for logging and initial field control of data.

Table 3-3. Parameters measured by the sonde TROLL9500.

Parameter	TROLL9500
Date/time	Yes
Temperature (°C)	Yes
pH	Yes
Dissolved oxygen (mg/L, %)	Yes
ORP (Redox potential, mV)	Yes
Electrical conductivity (mS/cm)	Yes
Depth (m)	Yes
Turbidity (NTU)	Yes



Figure 3-2. Winter sampling of surface water using the peristaltic pump system (PPS). A schematic presentation of the PPS is shown below the photo. Photo from the sampling at PFM00062.

3.3.3 General field equipment

- Ruttner samplers were used as back up if the portable pump system should fail.
- The exact positions of the sampling locations were determined using a GPS (Garmin GPSmap 78s) with an average accuracy of ± 0.5 – 1.0 m.
- Water depth in the lakes and sea was measured using an echo sounder (Plastimo, Echotest, LCD digital sounder) with an accuracy of ± 0.05 m.
- Water transparency was estimated using a Secchi disc and an aqua scope.
- Disposable filters (Millipore, $0.40\ \mu\text{m}$, $\varnothing = 22$ mm) were used together with 60 mL syringes to filter specific sample portions of the sampled water in the field.
- Stopwatch, a water-filled plastic bottle (50 mL) and measuring-tape were used for flow/runoff estimates in stream waters.

3.4 Performance

3.4.1 Presampling preparations

Prior to sampling, the sample bottles were labelled and packed in insulated boxes/bags. Acid additions were made in advance to bottles intended for iron and trace metal analyses as well as acidified archive samples. The bottles with added acid were placed in separate plastic bags outside the box/bag to avoid contamination. The peristaltic pump system, including the Teflon tubes, was washed using acid (0.5 M HCl) and rinsed with deionised water before use. The equipment was kept well protected in plastic bags or in tight containers. Calibration of the sonde was performed according to the measurement system description (the operator's manual for TROLL9500 Rev.007, 2009).

3.4.2 Water sampling

Water samples were collected using the peristaltic pump system. Lake and sea water samples were collected close to the surface at 0.5 m depth. When the lake and sea sampling locations were covered with ice, water was also collected from approximately 0.5 m above the lake or sea bottom, in order to sample water both above and below the stratification. Stream water samples were collected at approximately 0.1 m depth. The peristaltic pump and sample bottles were rinsed with water from the sampling locations prior to collecting samples, except for bottles with acid additions. The disposable filters were rinsed with sample water before filtering and sampling commenced. The field crew wore rubber gloves to avoid contamination and great care was taken not to contaminate bottles or equipment. Bottles and samples with added acid were handled and stored separately to avoid contaminating other sample portions.

Each sample consists of several sample portions labelled with the same sample number. The preparation of the sample portions in the field differs depending on their use. Details on collected sample portions, components to be analysed and sample preparations are summarised in Table 3-4.

3.4.3 Field measurements

The multi parameter sonde was used for measurements of pH, water temperature, ORP, turbidity, electrical conductivity and dissolved oxygen. Light penetration was measured at lake and sea sampling locations with a Secchi disc according to the Swedish standard BIN SR 111. Photo documentation of stream waters was performed to facilitate evaluation of the investigation data. Photos were taken at each stream water sampling location. At the lakes and one sea sampling location field measurements were taken in a depth profile, with measurements logged at every metre from the surface to the bottom, see Table 3-5.

Table 3-4. Sample volumes, components and preparation of samples.

Bottle volume (mL)	Number of bottles	Analyses	Comments	Preparation in field
250	1	pH, EC, Alkalinity, color determination		
250	1	Cl, SO ₄ , Br, F		
100	1	Br		
125	1	Major cations, SO ₄ -S, Si, Environmental metals	Acid washed	Filtering with syringe/0.4 µm filter
2 000	1	PON, POP, POC, Chlorophyll a, c and pheophytin	Filtrated in laboratory	
100	1	Tot-N, tot-P		
100	2	DIC, DOC		Filtering with syringe/0.4 µm filter
100	1	TOC		
25	2	Nutrients: NH ₄ , NO ₂ , NO ₃ , PO ₄		Filtering with syringe/0.4 µm filter
1 000	1	Suspended matter		
100	1	I	The same bottle as for Br above.	
125	1	Trace metals	Acid washed, the same bottle as for major cations above.	
25	3	Nutrients: NH ₄ , NO ₂ , NO ₃ , PO ₄		Filtering with syringe/0.4 µm filter
100	1	Deuterium, ¹⁸ O		
500	1	Tritium, ³ H		
100	2	Archives	Acid washed	Filtering with syringe/0.4 µm filter
250	2	Archives		
5 000	1	Archives *		

* Archives sample to compensate for cancelled isotope analyses.

Main programme, eleven times per year in streams, four times per year in lakes and sea.

Extended programme four times per year.

Table 3-5. Logging depths at sampling locations in lakes and the shallow sea bay.

Sampling locations	Name	Logging depth (m)					
		0.5	1	1.5	2	2.5	3
Lakes							
PFM000074	Labboträsket	X					
PFM000097	Norra bassången	X					
PFM000107	Bolundsfjärden	X	X				
PFM000117	Eckarfjärden	X	X	X			
Shallow sea bays							
PFM000062	SV Forslingens grund	X	X		X		X

A simple “floating bottle” method (Johansson 2005) was used to measure water flow/runoff in the streams as a complement to the regular method using discharge weirs and gauges. The cross-section mean area of the stream was estimated, forming a rectangle, see Figure 3-4. The time for the bottle (close to neutral in weight in water) to float the distance (L) from point A to B was measured with a stopwatch. This procedure was repeated three times in each stream. The average water velocity (m/s) multiplied with the average area (m²) resulted in a rough water runoff estimate (m³/s).



Figure 3-3. On the way to the sampling site at Labboträsket (PFM000074).

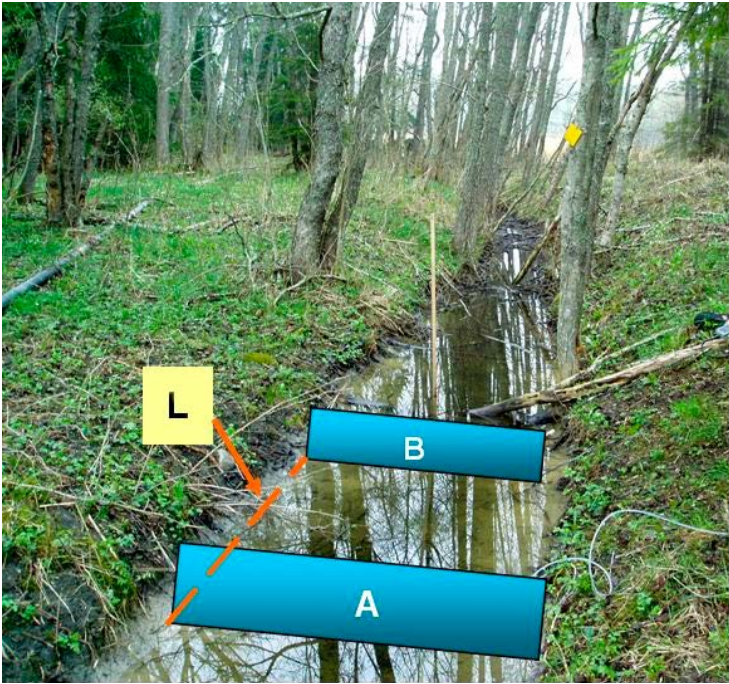


Figure 3-4. Schematic presentation for estimating water runoff in natural stream waters (see text for explanation).

3.4.4 Sample treatment and chemical analyses

An overview of sample treatment and analytical methods is given in Appendix 1. The routines are applicable independently of sampling method or type of sampling object.

3.4.5 Data handling/post processing

A field protocol established during sampling/measuring contains metadata (idcode, date, time, sample no., field crew etc.), a few measured data and weather observations as well as other comments on field conditions that may influence the analytical results. The field protocols supply the basic information for creating activities and activity comments in the Sicada database and also information that describes the sampling conditions for further storage in database tables. Furthermore, eventual deviations from the sampling programme or from the normal routines are also documented in special reports/comment files. The comment files are stored in the Sicada file archive Table 3-6.

Field measurement data

The logged data from field measurements are exported digitally from the hand held PC to the specified Sicada data table. The original data file, as well as photographs and comments on sampling and measurements, are stored in the Sicada file archive, Table 3-6.

Table 3-6. File types stored in the Sicada file archive.

Type of file	Example of file name	No. per sampling session
Data file	YTv41_16_data.xls	1
Comments	Noterat V41-16.doc	1
Photography	PFM66.jpg	1-4



Figure 3-5. Sampling in the cooling water outlet (PFM102269).

Other relevant information and data

Information about weather conditions and related parameters describing the sampling conditions are compiled in a separate Table in Sicada called “Weather_data” which contains the following columns below. These data are not presented in this report but are useful information when evaluating data. Furthermore, additional complementary information from other measurement activities within the monitoring programme are also available.

Air temperature	Wind velocity	Runoff/Water flow
Cloudiness	Wind direction	Water depth
Precipitation	Light penetration (lakes and sea)	Snow/ice depth

3.4.6 Nonconformities

Some nonconformities have been reported during this sampling period, January–December 2016. The flow measurements in the streams were not always performed due to the ice, dry conditions or too much water vegetation. Collected samples and reasons for deviations from the programme are compiled in Tables 3-7 and 3-8.

During 2016 there were problems with both the ordinary and backup Troll sondes. The problems were mainly connected to the O₂ probes. Unreliable O₂-values was recorded in the weeks 3, 7 and 11. During the service of the sondes (in the weeks 16, 21, 26 and 32) another Troll sonde (AquaTroll) was borrowed from the service centre and used during field measurements. This sonde covered the variables from the ordinary sondes and the O₂-values were good. However, when the ordinary sondes returned from service the O₂-values were still poor which is why unreliable O₂-values was recorded in the weeks 35, 41, 45 and 49.

Table 3-7. Collected samples and conducted measurements. Explanations and abbreviations:

	Year	16	16	16	16	16	16	16	16	16	16	16	Sum
	Week	3	7	11	16	21	26	32	35	41	45	49	
Sea													
	Name												
PFM000062	SV-Forslingen	C			X			X		X			3
PFM000082	Alt PFM62												
PFM102269	Utlopp Biotesten	Y*	Y*	Y*	Y*	Y*	Y*	X	X	X	X	X	11
PFM000083	Kallrigafjärden									X			1
PFM000084	Olandsån									X			1
PFM007783	Böjen Biotestsjön							X		X			2
Stream													
PFM000066	Ö-Gunnarsbo	X	X	X	X	X	X	G	X	G	X	X	9
PFM000068	Kungsträsket	X	X	X	X	X	X	G	X	G	X	X	9
PFM000069	Bolundsskogen	X	X	X	X	X	X	G	X	G	X	X	9
PFM000070	N-Eckarfjärden	X	X	X	X	X	X	G	X	G	X	X	9
Lakes													
PFM000074	Labboträsket	X			X			X		X			4
PFM000097	N. bassängen	B	B	B	B	B	B	B	B	B	B	B	
PFM00107	Bolundsfjärden	XX			X			X		X			5
PFM00117	Eckarfjärden	XX			X			X		X			5
Sum water samples		10	5	5	9	5	5	6	5	8	5	5	68

Y: Sample taken, no field measurements.

X: Sample and field measurements taken.

B: No sample, only field measurements with sonde.

C: No measurement due to weak ice.

G: Dry conditions, no measurements or samples.

*: Only tritium and anions samples.

Table 3-8. Comments on measurements/water sampling.

	Year	16	16	16	16	16	16	16	16	16	16	16
	Week	3	7	11	16	21	26	32	35	41	45	49
Sea												
	Name											
PFM000062	SV-Forslingen											
PFM000082	Alt PFM62											
PFM102269	Utlopp Biotesten											
PFM000083	Kallrigafjärden											
PFM000084	Olandsån											
PFM007783	Böjen Biotestsjön											
Stream												
PFM000066	Ö-Gunnarsbo	C						G	F	G	C	
PFM000068	Kungsträsket	C	C			F	F	G	F	G	C	C
PFM000069	Bolundsskogen	C						G	F	G	C	
PFM000070	N-Eckarfjärden	C				F	F	G	F	G	C	C
Lakes												
PFM000074	Labboträsket											
PFM000097	N. bassängen											
PFM00107	Bolundsfjärden	A										
PFM00117	Eckarfjärden	A										

Explanations to codes/abbreviations:

A: Two samples collected. Surface and bottom water sampled separately due to winter stagnation in lake.

C: Frozen water, no flow measurement.

F: Flow rate too low, no flow measurement.

G: Dry conditions, no measurements or samples.

3.5 Results

3.5.1 General

The surface water investigation period from January to December 2016 includes 68 water samples and 92 field loggings of measurements from the regular sampling locations in streams, lakes and sea including the samples from Lake Biotestsjön. Furthermore, the accompanying field documentation is quite extensive. The data are compiled in the attached Appendices and stored in the Sicada database where they are traceable by the activity plan number.

Fresh waters in the Forsmark area are well buffered with high alkalinity, high pH and high calcium concentrations. In addition, waters affected or recently affected by brackish sea water still show high sodium chloride concentrations. The relationship between the position of the coastline and the salinity of the water samples collected at the sampling locations in the area has been demonstrated in Nilsson et al. (2003). Furthermore, a detailed evaluation of surface water data from March 2002 to March 2004 was presented in Sonesten (2005). A summary of the results from the surface water monitoring during 2005–2009 is available in Nilsson et al. (2010).

The results presented and compiled in this section are restricted to field work performed between January and December 2016.

3.5.2 Water analyses

Major components

The basic water analyses include the major constituents Na, K, Ca, Mg, Sr, S, SO₄²⁻, Cl⁻, Si and alkalinity as well as the minor constituents Fe, Li, Mn, Br, F⁻, and I. Furthermore, batch measurements of pH and EC are included. The basic water analysis data are compiled together with field measurements of pH and water temperature in Appendix 3.

The charge balance errors, see section 2.5.2 for calculation formula, give an indication of the quality and uncertainty of the analyses of major constituents. All samples were within the acceptable errors for surface water ($\pm 10\%$).

Surface water supplements

The surface water supplements include $\text{NH}_4\text{-N}$, $\text{NO}_2\text{-N}$, $\text{NO}_3\text{-N}+\text{NO}_2\text{-N}$, $\text{NO}_3\text{-N}$, tot-N, tot-P, $\text{PO}_4\text{-P}$, TOC, DOC and DIC. The analytical data are compiled in Appendix 3. The DIC values should be used with care and bicarbonate values, by alkalinity titration, are considered more reliable.

Isotopes

The isotope data including the stable isotopes δD , $\delta^{18}\text{O}$, as well as the radioactive isotope tritium (^3H) are compiled in Appendix 3.

Tritium

It is suspected that the adjacent nuclear power plant may have increased the natural content of tritium and ^{14}C isotopes (Nilsson and Borgiel 2005). Very high tritium concentrations, above 100 TU, have previously been recorded in samples from the cooling water outlet PFM102269 in July 2005, January and May 2008, October 2010 and April 2011. Slightly elevated values have also been noted in 2006, 2007, 2009, 2011, 2013 and 2015. In 2016, elevated tritium concentration was measured in November and December, Figure 3-6.

Tritium contents was analysed in water from the regular stream, lake and sea sampling locations in January, April, August and October. Tritium content in the water from near the cooling water outlet (PFM102269) ranged from 2.20 – 88.99 TU compared to the other regular sampling points ranging from 5.82–10.52 TU (8.0 ± 0.41 TU; mean $\pm 95\%$ confidence interval).

Comparison of tritium contents from the samplings in January, April, August and October show that the lowest mean tritium contents were found at the stream site, PFM000068, and at the sea sites, PFM000062 and PFM007783, as well as at the site close to the cooling water outlet, PFM102269, Figure 3-7.

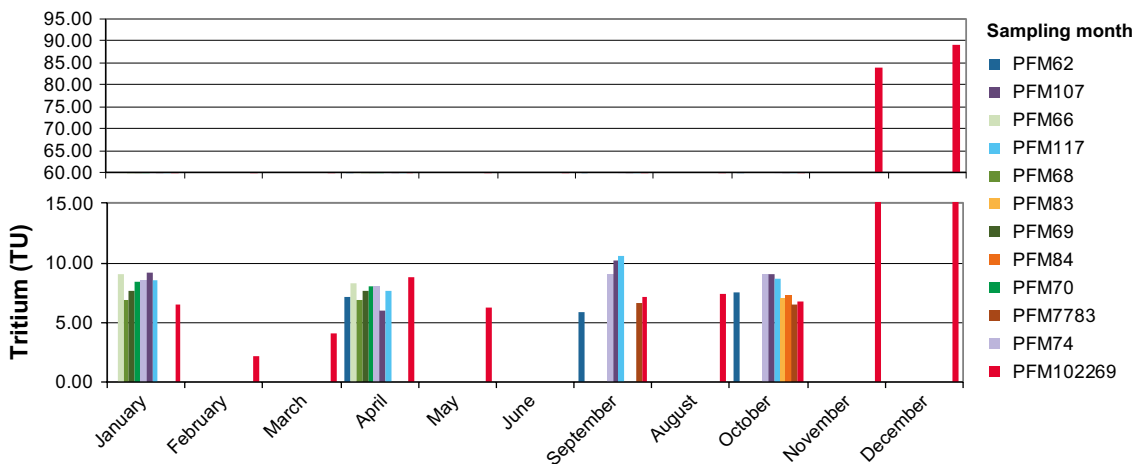


Figure 3-6. Results from tritium analyses sampled during 2016. The red bar represents the sampling location near the cooling water outlet, PFM102269.

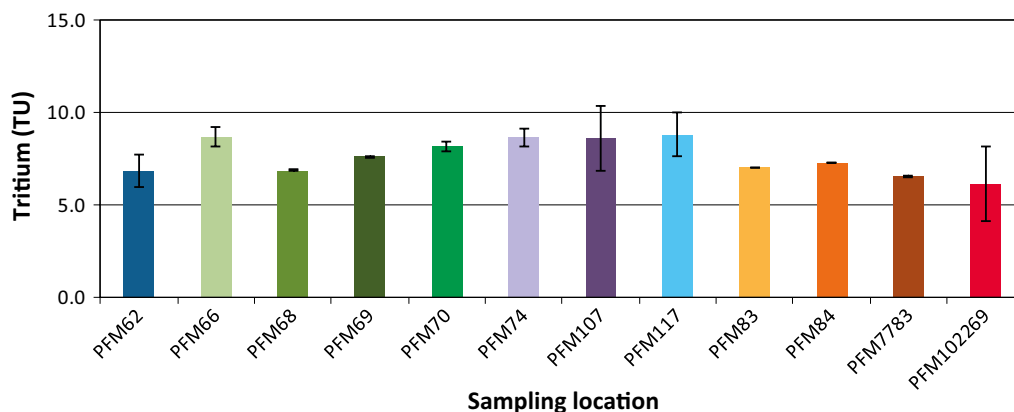


Figure 3-7. Tritium content per sampling location based on the sampling in January, April, August and October 2016 (mean \pm 95 % confidence interval). The red bar represents the sampling location near the cooling water outlet, PFM102269. PFM000062, 83, 84 and 7783 are sea sites and PFM000074, PFM000107 and PFM000117 are the lakes. PFM000066, PFM000068, PFM000069 and PFM000070 are streams.

Trace metals

The analyses of trace and rare earth elements include Al, As, Sc, Cd, Cr, Cu, Co, Hg, Ni, Zn, Pb, V, U, Th, Rb, Y, Zr, Mo, In, Sb, Cs, Ba, La, Hf, Tl, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Se and Lu. The trace element data are compiled in Appendix 3.

These elements are generally present at low concentrations in the water and the risk for contamination is high. Especially data on common metals like Al, Cr, Cu, Co, Ni and Zn must be used with caution. Generally, the distribution of data is location specific but outliers do exist.

3.5.3 Field measurements

The field measurement data including redox potential, pH, dissolved oxygen, electrical conductivity, measurement depth, turbidity and water temperature are compiled in Appendix 3. The water flow rate estimations by the float method (Johansson 2005) are of low accuracy compared to measurements using discharge weirs and gauges. They were performed in order to allow comparison between early data obtained when there was no other available method and new data from installed measurement stations, Appendix 3.

3.5.4 Water composition

The major cations in freshwater and sea water are generally calcium, magnesium, sodium and potassium. Sulphate and chloride are the major anions in sea water and in freshwater also bicarbonate gives a large contribution. The relative proportions between these major constituents differ between sea water and freshwater and also between different freshwater bodies, Figures 3-8 and 3-9. Comparisons of the mean concentrations of these ions at the different sampling locations during year 2008–2016 generally show little variation, Figure 3-10 and 3-11.

The largest variation in these major constituents is seen in Lake Bolundsfjärden, PFM000107, especially for the ions Na^+ and Cl^- . Lake Bolundsfjärden is characterised by irregular inflow of saltwater, which explains the larger variations in these two ions. The concentrations of ions Na^+ and Cl^- were comparatively high in 2008 indicating a recent influx of saltwater. Also, in 2012, 2015 and 2016 the concentrations were higher indicating saltwater inflow.

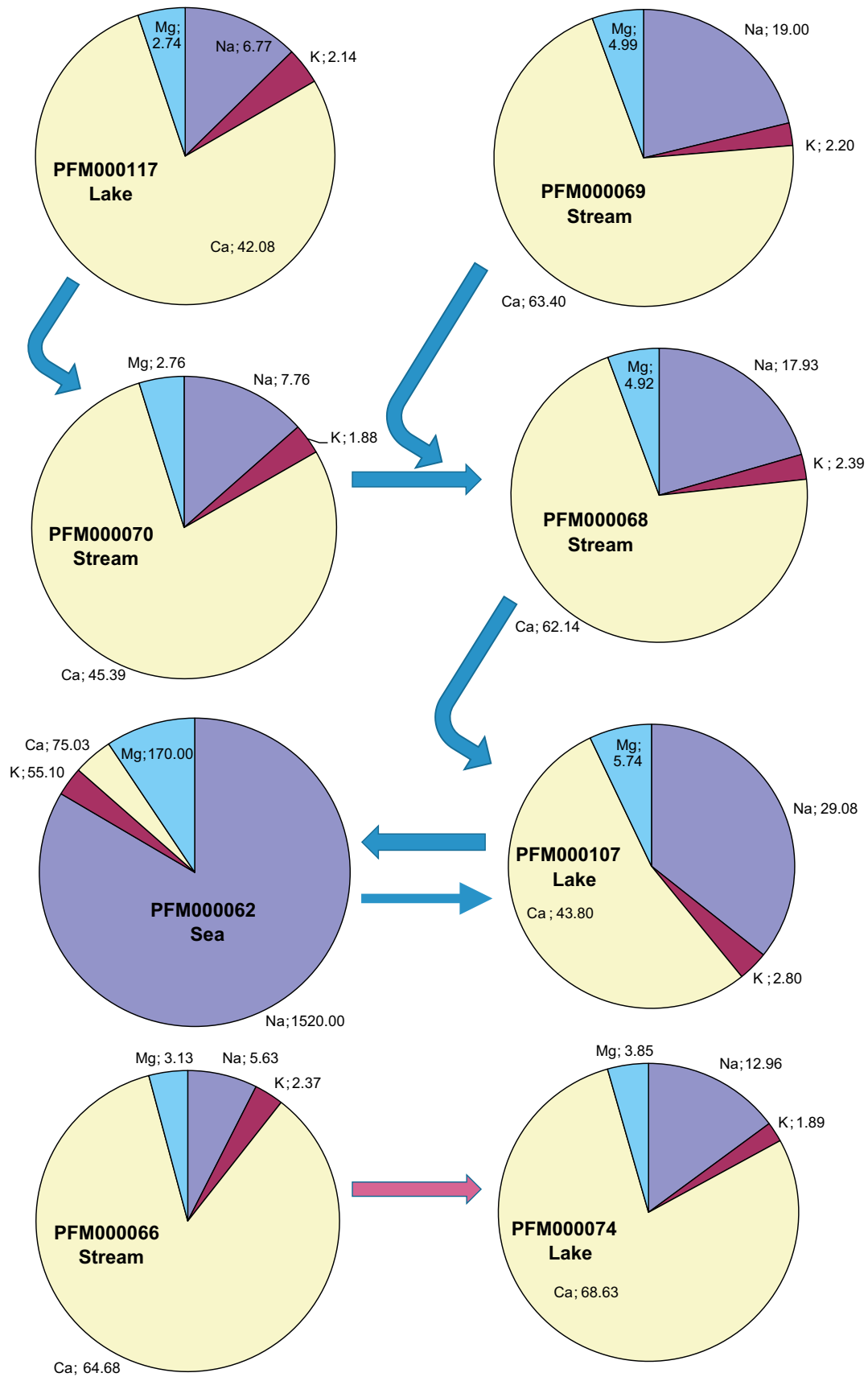


Figure 3-8. Relative proportions of the cations Na^+ , K^+ , Ca^{2+} , Mg^{2+} based on average values during the sampling period 2016. The average values (mg/L) are displayed behind each cation in the diagrams. The arrows show the path of the surface water between the lakes and streams. Occasional inflow of sea water into Lake Bolundsfjärden (PFM 000107) is indicated by a dashed arrow. The Lake Labbotträsket (PFM000074) and the stream PFM000066 belong to a different catchment area.

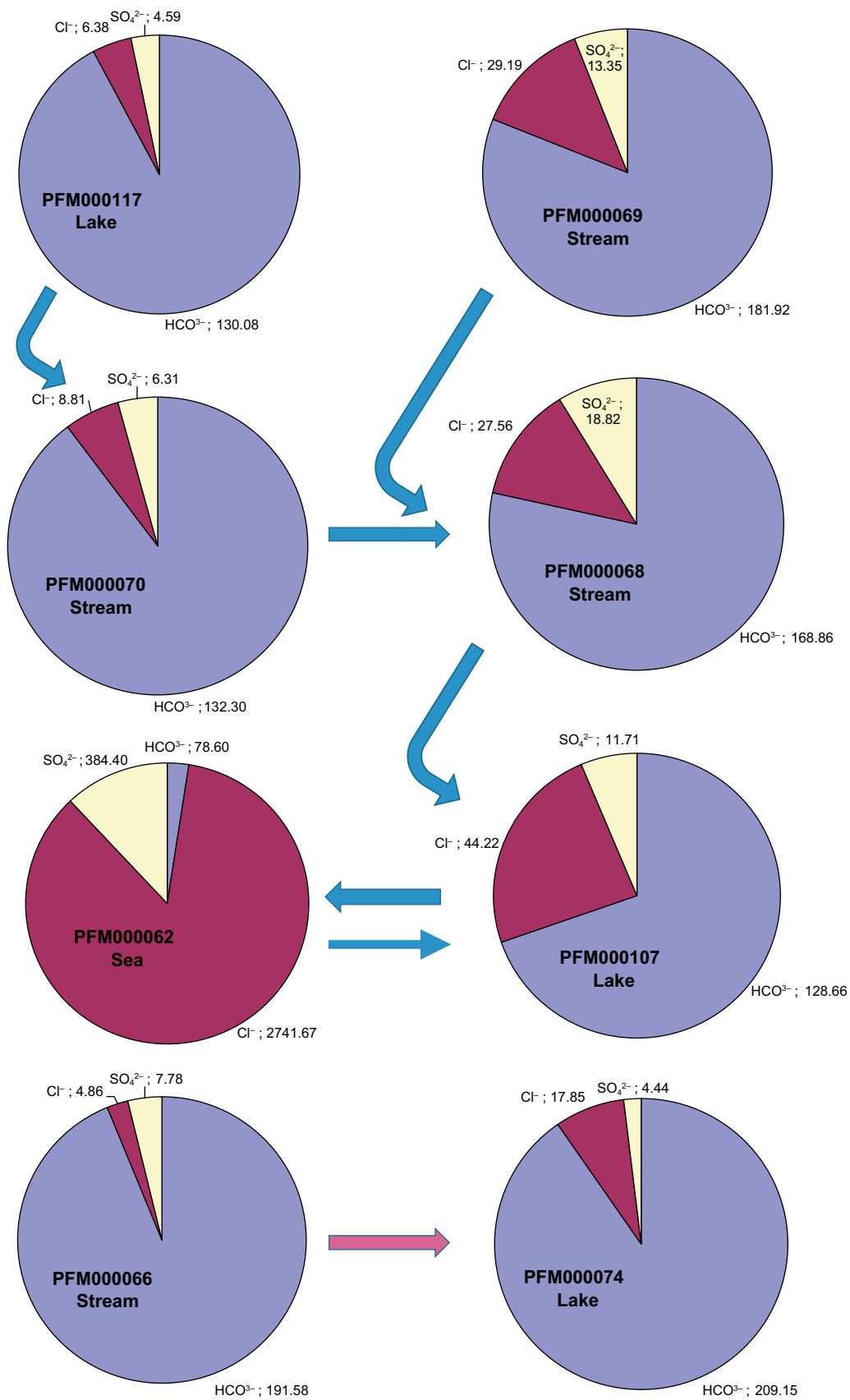


Figure 3-9. Relative proportions of the anions Cl^- , HCO_3^- and SO_4^{2-} based on the average values (given in the diagrams in mg/L) during the sampling period 2016. The arrows show the path of the surface water between the lakes and streams. Occasional inflow of sea water into Lake Bolundsfjärden (PFM 000107) is indicated by a dotted arrow. The Lake Labboträsket (PFM000074) and the stream PFM000066 belong to a different catchment area.

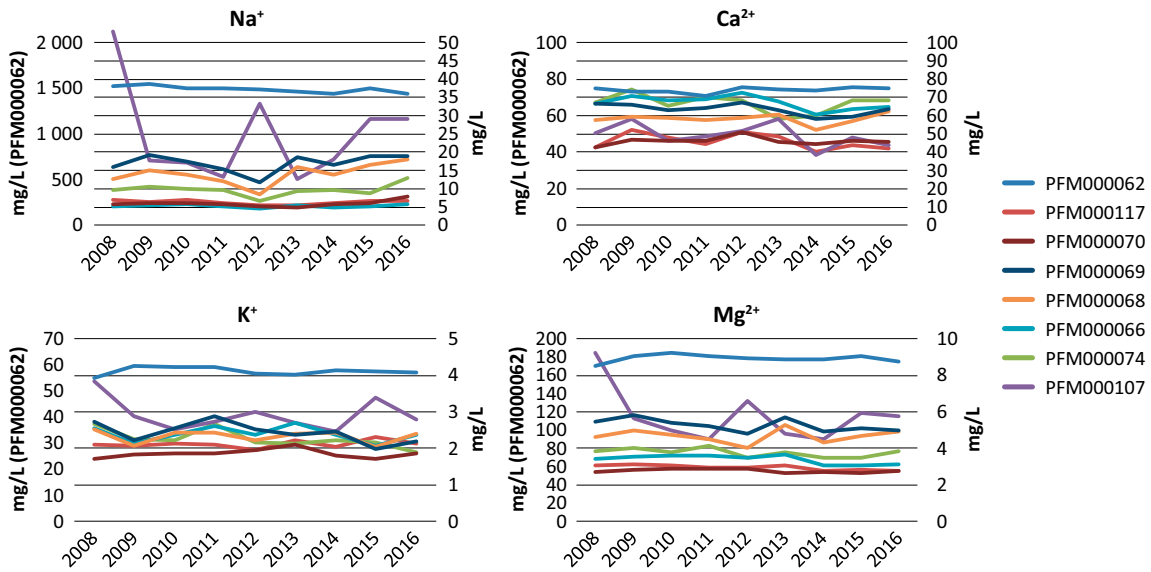


Figure 3-10. Mean concentrations of the cations Na^+ , K^+ , Ca^{2+} , Mg^{2+} during the years 2008–2016 at the sampling locations in the three lakes (PFM000074, PFM000107 and PFM000117) the four streams (PFM000066, PFM000068, PFM000069 and PFM000070) and the sea (PFM000062).

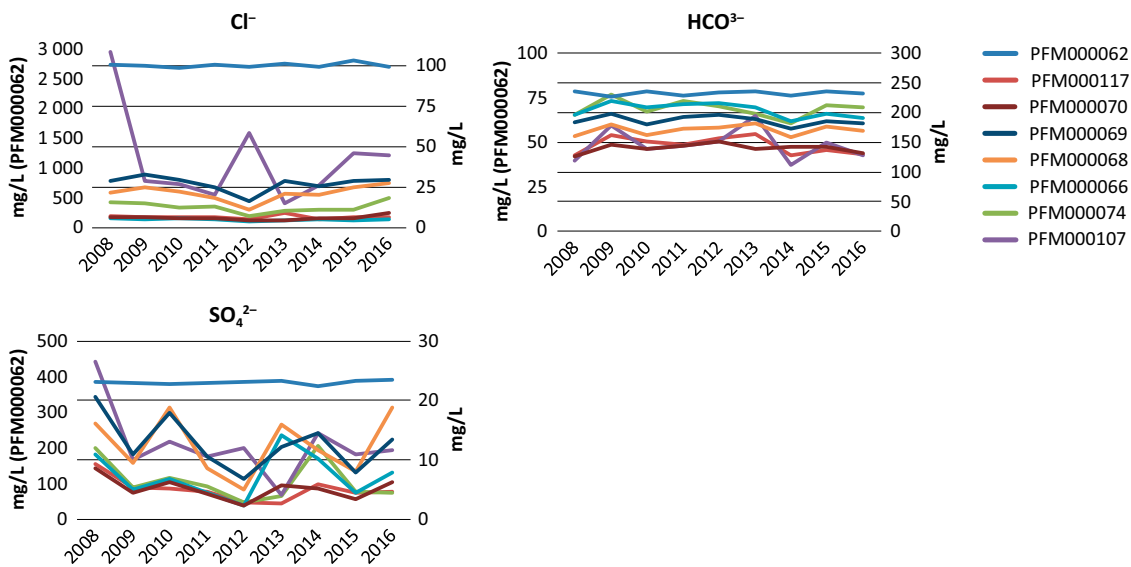


Figure 3-11. Mean concentrations of the anions Cl^- , HCO_3^- and SO_4^{2-} during the years 2008–2016 at the sampling locations in the three lakes (PFM000074, PFM000107 and PFM000117) the four streams (PFM000066, PFM000068, PFM000069 and PFM000070) and the sea (PFM000062).



Figure 3-12. Field measurements at site PFM000068.

3.5.5 The NP-ratio in the surface water

The nutrients, nitrogen and phosphorus, are often the limiting factors for the primary production. Primary producers, such as plants and phytoplankton, use nitrogen and phosphorus in a ratio of about 16 mol nitrogen to 1 mol phosphorus, also known as the Redfield ratio, or 7:1 in terms of mass. A ratio deviating from 16 (or 7) indicates that the primary production is limited by either nitrogen or phosphorus. When nitrogen is present in excess the ratio will be higher than 16, indicating that lack of phosphorus is limiting the growth. Whereas lower ratios indicate nitrogen limitations, which may favour growth of blue green algae able to use nitrogen from the air. In fresh water, phosphorus is usually the limiting nutrient whereas in the oceans it is usually nitrogen.

Figure 3-13 shows the relationship between nitrogen and phosphorus in the surface water of the investigated streams, lakes and coastal bays in the Forsmark area. The lakes and streams are phosphorus limited with high concentrations of nitrogen. The coastal bays in the Baltic Sea, PFM000062, PFM000083, PFM000084 and PFM007783 are also phosphorus limited although the ratio is much lower.

Comparisons of the mean concentrations of total nitrogen and total phosphorus during years 2008–2016 generally show little variation between years, Figure 3-14. The largest variation is seen for phosphorus in Lake Eckarfjärden, PFM000117, but there is no increasing or decreasing trend over the years.

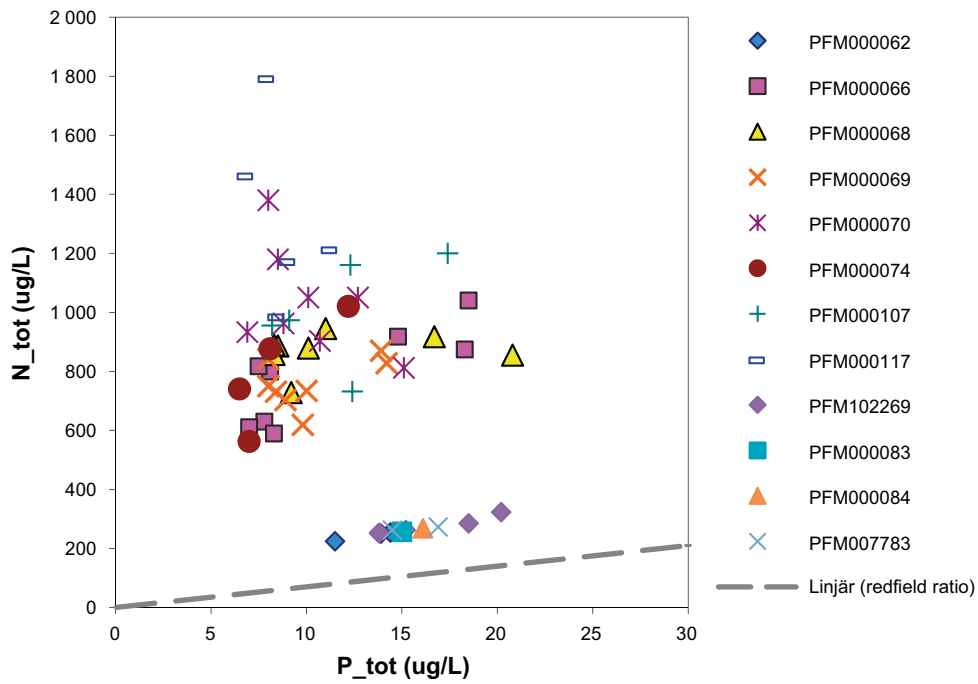


Figure 3-13. The relationship between nitrogen and phosphorus in the surface water of the investigated streams, lakes and coastal bays in the Forsmark area. The Redfield ratio (7:1) is indicated. Values above and below the line indicate phosphorus limitation and nitrogen limitation, respectively.

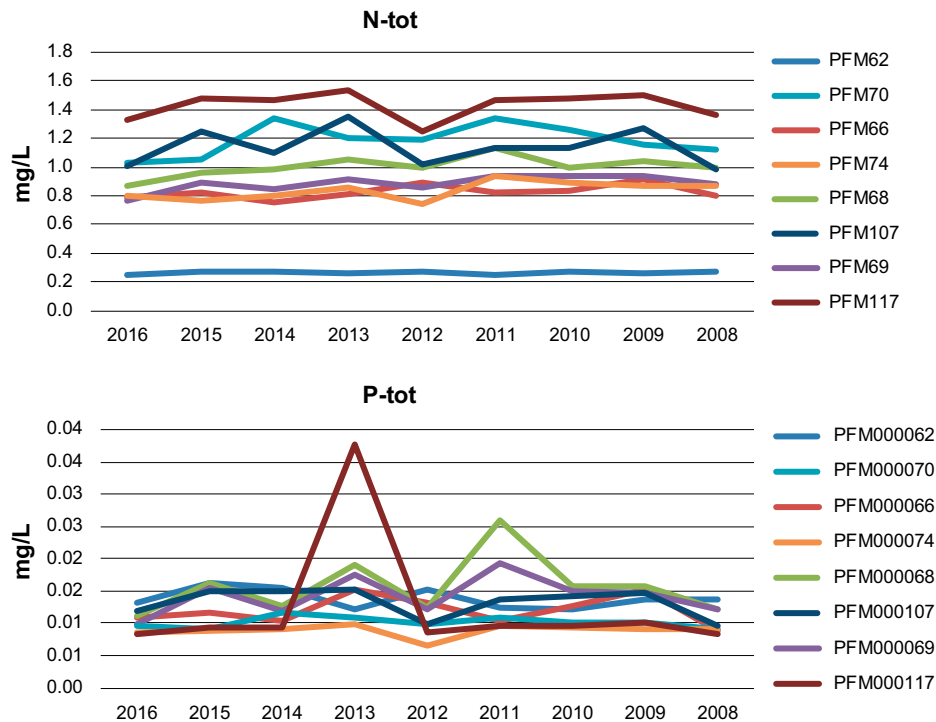


Figure 3-14. Mean concentrations of total nitrogen (N-tot) and total phosphorus (P-tot) during the years 2008–2016 at the sampling locations in the sea bay (PFM000062), four streams (PFM000066, PFM000068, PFM000069 and PFM000070) and three lakes (PFM000074, PFM000107 and PFM000117).

3.6 Summary and discussion

The chemical investigation routines for surface waters are well established and this period of the long-term surface water monitoring programme has passed without any major nonconformities or surprises.

The main experiences and conclusions from surface water sampling and analyses during the sampling period January to December 2016 are summarised below:

- Previous data indicates periodic tritium contamination from the adjacent nuclear power plant in water samples from near the cooling water outlet. In 2016, elevated tritium concentration was measured in November and December.
- The proportions of the major ions in the sampled freshwaters and the shallow sea bay were similar to previous years. However, in 2015 and 2016 the concentration of Na^+ and Cl^- in Lake Bolundsfjärden, PFM000107, were higher compared to 2013 and 2014, indicating saltwater inflows.
- The concentrations of total nitrogen and total phosphorus in the sampled freshwaters and shallow sea bay were similar to previous years.

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Appendix 1

Sampling and analytical methods

Component	Method ¹	Reporting limits (RL), detection limits (DL) or range ²	Unit	Measurement uncertainty ³
pH	Potentiometric	3–10	pH unit	±0.1
EC	Electrical Conductivity meas.	2–150 150–10 000	mS/m	5 % 3 %
HCO ₃	Alkalinity titration	2	mg/L	4 %
Cl ⁻	Mohr-titration	≥ 70	mg/L	5 %
Cl ⁻	IC	0.5 – 70		8 %
SO ₄	IC	0.5	mg/L	12 %
Br ⁻	IC	DL 0.2, RL 0.5	mg/L	15 %
Br	ICP SFMS	0.001, 0.004, 0.010 ⁴	mg/L	25 % ⁵
F ⁻	IC	DL 0.2, RL 0.5	mg/L	13 %
F ⁻	Potentiometric	DL 0.1, RL 0.2		12 %
I ⁻	ICP SFMS	0.001, 0.004, 0.010 ⁴	mg/L	25 % ⁵
Na	ICP AES	0.1	mg/L	13 %
K	ICP AES	0.4	mg/L	12 %
Ca	ICP AES	0.1	mg/L	12 %
Mg	ICP AES	0.09	mg/L	12 %
S(tot)	ICP AES	0.16	mg/L	12 %
Si(tot)	ICP AES	0.03	mg/L	14 %
Sr	ICP AES	0.002	mg/L	12 %
Li	ICP AES	0.004	mg/L	12.2 %
Fe	ICP AES	0.02	mg/L	13.3 % ⁶
Fe	ICP SFMS	0.0004, 0.002, 0.004 ⁴	mg/L	20 % ⁶
Mn	ICP AES	0.003	mg/L	12.1 % ⁵
Mn	ICP SFMS	0.00003, 0.00004, 0.0001 ⁴	mg/L	53 % ⁶
Fe(II), Fe(tot)	Spectrophotometry	DL 0.006, RL 0.02	mg/L	0.005 (0.02–0.05 mg/L) 9 % (0.05–1 mg/L) 7 % (1–3 mg/L)
HS ⁻	Spectrophotometry, SKB	SKB DL 0.006, RL 0.02	mg/L	25 %
HS ⁻	Spectrophotometry, external laboratory	0.01	mg/L	0.02 (0.01–0.2 mg/L) 12 % (>0.2 mg/L)
NO ₂ as N	Spectrophotometry	0.1	µg/L	2 %
NO ₃ as N	Spectrophotometry	0.2	µg/L	5 %
NO ₂ +NO ₃ as N	Spectrophotometry	0.2	µg/L	0.2 (0.2–20 µg/L) 2 % (> 20 µg/L)
NH ₄ as N	Spectrophotometry, SKB	11	µg/L	30 % (11–20 µg/L) 25 % (20–50 µg/L) 12 % (50–1 200 µg/L)
NH ₄ as N	Spectrophotometry external laboratory	0.8	µg/L	0.8 (0.8–20 µg/L) 5 % (> 20 µg/L)
PO ₄ as P	Spectrophotometry	0.7	µg/L	0.7 (0.7–20 µg/L) 3 % (> 20 µg/L)
SiO ₄	Spectrophotometry	1	µg/L	2.5 % (>100 µg/L)
O ₂	Iodometric titration	0.2 – 20	mg/L	5 %
Chlorophyll a, c pheopigment ⁷	/1/	0.5	µg/L	5 %
Component	Method ¹	Reporting limits (RL), detection limits (DL) or range ²	Unit	Measurement uncertainty ³
PON ⁷	/1/	0.5	µg/L	5 %
POP ⁷	/1/	0.1	µg/L	5 %
POC ⁷	/1/	1	µg/L	4 %
Tot-N ⁷	/1/	10	µg/L	4 %
Tot-P ⁷	/1/	0.5	µg/L	6 %
Al,	ICP SFMS	0.2, 0.3, 0.7 ⁴	µg/L	17.6 % ⁶
Zn	ICP SFMS	0.2, 0.8, 2 ⁴	µg/L	15.5, 17.7, 25.5 % ⁶
Ba, Cr, Mo,	ICP SFMS	0.01, 0.04, 0.1 ⁴	µg/L	Ba 15 % ⁴ , Cr 22 % ⁵ Mo 39 % ⁶
Pb	ICP SFMS	0.01, 0.1, 0.3 ⁴	µg/L	15 % ⁶

Component	Method ¹	Reporting limits (RL), detection limits (DL) or range ²	Unit	Measurement uncertainty ³
Cd	ICP SFMS	0.002, 0.02, 0.5 ⁴	µg/L	15.5 % ⁵
Hg	ICP AFS	0.002	µg/L	10.7 % ⁶
Co	ICP SFMS	0.005, 0.02, 0.05 ⁴	µg/L	25.9 % ⁶
V	ICP SFMS	0.005, 0.03, 0.05 ⁴	µg/L	18.1 % ⁶
Cu	ICP SFMS	0.1, 0.2, 0.5 ⁴	µg/L	14.4 % ⁶
Ni	ICP SFMS	0.05, 0.2, 0.5 ⁴	µg/L	15.8 % ⁶
P	ICP SFMS	1, 5, 40 ⁴	µg/L	16.3 % ⁶
As	ICP SFMS	0.01 (520 mS/m)	µg/L	59.2 % ⁶
La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu	ICP SFMS	0.005, 0.02, 0.05 ⁴	µg/L	20 %, 20 %, 25 % ⁶
Sc, In, Th	ICP SFMS	0.05, 0.2, 0.5 ⁴	µg/L	25 % ⁶
Rb, Zr, Sb, Cs	ICP SFMS	0.025, 0.1, 0.25 ⁴	µg/L	15 %, 20 %, 20 % ⁵ 25 % ⁶
Tl	ICP SFMS	0.025, 0.1, 0.25 ⁴	µg/L	14.3 % ^{5 and 6}
Y, Hf	ICP SFMS	0.005, 0.02, 0.05 ⁴	µg/L	15 %, 20 %, 20 % ⁵ 25 % ⁶
U	ICP SFMS	0.001, 0.005, 0.01 ⁴	µg/L	13.5 %, 14.3 %, 15.9 % ⁵ 19.1 %, 17.9 %, 20.9 % ⁶
DOC	UV oxidation, IR Carbon analysator	0.5	mg/L	8 %
TOC	UV oxidation, IR Carbon analysator	0.5	mg/L	10 %
δ ² H	MS	2	‰ SMOW ⁷	0.9 (one standard deviation)
δ ¹⁸ O	MS	0.1	‰ SMOW ⁷	0.1 (one standard dev.)
³ H	LSC	0.8	TU ⁸	0.8
δ ³⁷ Cl	A (MS)	0.2	‰ SMOC ¹⁰	0.2 ¹⁷
δ ¹³ C	A (MS)	–	‰ PDB ¹¹	0.3 ¹⁷
¹⁴ C pmc	A (MS)	–	PMC ¹²	0.4 ¹⁷
δ ³⁴ S	MS	0.2	‰ CDT ¹³	0.4 (one standard dev.)
⁸⁷ Sr/ ⁸⁶ Sr	TIMS	–	No unit (ratio) ¹⁴	0.00002
¹⁰ B/ ¹¹ B	ICP SFMS	–	No unit (ratio) ¹⁴	–
²³⁴ U, ²³⁵ U, ²³⁸ U, ²³² Th, ³⁰ Th	Alfa spectr.	0.0001	Bq/L ¹⁵	≤5 % (Counting statistics uncertainty)
²²² Rn, ²²⁶ Ra	LSS	0.015	Bq/L	≤5 % (Count. stat. uncert.)

- Many elements may be determined by more than one ICP technique depending on concentration range. The most relevant technique and measurement uncertainty for the concentrations normally encountered in groundwater are presented. In cases where two techniques were frequently used, both are displayed.
- Reporting limits (RL), generally 10×standard deviation, if nothing else is stated. Measured values below RL or DL are stored as negative values in SICADA (i.e. –RL value and –DL value).
- Measurement uncertainty reported by the laboratory, generally as ± percent of measured value in question at 95 % confidence interval.
- Reporting limits at electrical cond. 520 mS/m, 1440 mS/m and 3810 mS/m respectively.
- Measurement uncertainty at concentrations 100×RL.
- Measurement uncertainty at concentrations 10×RL.
- Determined only in surface waters. PON, POP and POC refers to Particulate Organic Nitrogen, Phosphorous and Carbon, respectively.
- Per mille deviation¹⁶ from SMOW (Standard Mean Oceanic Water).
- TU = Tritium Units, where one TU corresponds to a tritium/hydrogen ratio of 10⁻¹⁸ (1 Bq/L Tritium = 8.45 TU).
- Per mille deviation¹⁶ from SMOC (Standard Mean Oceanic Chloride).
- Per mille deviation¹⁶ from PDB (the standard PeeDee Belemnite).
- The following relation is valid between pmC (percent modern carbon) and Carbon-14 age: pmC = 100 × e^{((1950-y-1.031)/8274)} where y = the year of the C-14 measurement and t = C-14 age.
- Per mille deviation¹⁶ from CDT (the standard Canyon Diablo Troilite).
- Isotope ratio without unit.
- The following expressions are applicable to convert activity to concentration, for uranium-238 and thorium-232:
1 ppm U = 12.4 Bq/kg²³⁸U, 1 ppm Th = 3.93 Bq/kg²³²Th.
- Isotopes are often reported as per mill deviation from a standard. The deviation is calculated as:
δ‰ = 1000 × (K_{sample} - K_{standard}) / K_{standard}, where K = the isotope ratio and ‰ = ²H, ¹⁸O, ³⁷Cl, ¹³C or ³⁴S etc.
- SKB estimation from duplicate analyses by the contracted laboratory.

Near surface groundwater

Table A2-1. Field measurements.

Idcode	Measuring date yyyy/mm/dd hh:mm	Sample no	Water temp. (°C)	pH	EC (mS/m)	ORP (mV)	O ₂ diss. (mg/L)	Oxygen (%)
SFM0001	2016/01/20 09:10	30712	6.05	7.21	219.2	-180	-0.16	-1.3
SFM0001	2016/04/19 15:15	30754	5.03	7.19	133.7	-240	0.06	0.5
SFM0001	2016/08/08 11:30	30896	8.20	7.27	198.3	-260	-0.01	-0.1
SFM0001	2016/10/14 10:04	30934	8.59	7.29	207.4	-190	0.13	1.1
SFM0002	2016/08/12 11:45	30902	9.68	7.04	71.8	-140	0.01	0.1
SFM0002	2016/10/14 10:44	30935	9.39	7.05	72.2	-90	0.53	4.7
SFM0011	2016/08/11 12:37	30901	8.69	7.48	620.7	-110	0.00	0.0
SFM0011	2016/10/12 15:32	30931	8.66	7.44	635.3	-100	0.08	0.7
SFM0023	2016/01/21 09:00	30714	6.60	8.27	212.5	-260	0.03	0.3
SFM0032	2016/01/20 12:05	30713	4.22	7.16	84.5	-130	-0.16	-1.2
SFM0032	2016/04/20 14:35	30755	4.45	7.14	80.8	-170	0.77	6.1
SFM0032	2016/08/08 15:45	30898	11.07	6.93	80.6	-240	-0.02	-0.2
SFM0032	2016/10/13 14:48	30933	9.47	7.00	86.8	-150	0.01	0.1
SFM0037	2016/01/19 10:54	30710	1.93	6.68	64.3	-150	0.22	1.6
SFM0037	2016/04/19 09:49	30753	5.20	7.01	70.8	-100	1.07	9.0
SFM0037	2016/08/08 17:44	30899	11.77	6.94	125.2	-120	2.28	21.3
SFM0037	2016/10/12 10:16	30930	9.47	6.94	129.5	-90	0.73	6.4
SFM0049	2016/01/19 14:00	30711	3.58	6.93	46.2	-210	-0.19	-1.4
SFM0049	2016/04/18 15:43	30752	3.63	6.91	35.7	-160	0.13	1.0
SFM0049	2016/08/08 14:17	30897	12.10	6.71	47.8	-260	-0.01	-0.1
SFM0049	2016/10/13 11:08	30932	10.97	6.79	42.6	-190	0.06	0.5
SFM0057	2016/08/11 10:09	30900	8.13	6.97	57.7	-30	-0.01	-0.1
SFM0057	2016/10/11 15:10	30929	8.93	6.88	64.4	80	0.10	0.8

Table A2-2a. Water composition.

Idcode	Secup m	Seclow m	Date yyyy-mm-dd	Sample No.	RCB %	Na mg/L	K mg/L	Ca mg/L	Mg mg/L	HCO ³ mg/L	Cl mg/L	SO ₄ mg/L	SO ₄ -S mg/L	Br mg/l	F- mg/L	Si mg/L	Fe mg/L	Mn mg/L	Li mg/L	Sr mg/L	pH (lab)	EC (lab) mS/m	HS ⁻ mg/L	F ⁻ mg/L
SFM0001	3.95	4.95	2016/01/20	30712	1.9	302.0	20.90	114.0	45.40	552.5	335.0	179.30	61.30	1.620	0.65	8.06	3.560	0.250	0.021	0.472	7.10	221.0	0.141	0.0172
SFM0001	3.95	4.95	2016/04/19	30754	2.0	159.0	14.50	87.7	28.20	403.5	162.4	105.20	36.70	0.683	0.63	7.08	2.900	0.193	0.014	0.306	7.01	132.0	0.083	0.0105
SFM0001	3.95	4.95	2016/08/08	30896	3.4	309.0	19.10	92.0	38.80	502.2	303.0	165.60	56.70	1.240	0.74	7.42	2.760	0.199	0.019	0.374	7.22	202.0	0.087	0.0118
SFM0001	3.95	4.95	2016/10/14	30934	2.9	319.0	20.90	101.0	41.50	518.0	322.6	174.80	64.70	1.130	0.81	8.23	2.920	0.218	0.021	0.401	7.16	209.0	0.083	0.0099
SFM0002	4.21	5.21	2016/08/12	30902	0.7	10.7	3.91	125.0	9.17	353.4	52.8	11.80	4.05	0.183	0.48	5.65	3.030	0.150	0.004	0.169	6.99	73.0	0.029	0.0057
SFM0002	4.21	5.21	2016/10/14	30935	1.8	10.7	4.07	129.0	9.22	355.7	52.1	11.90	4.25	0.178	0.49	5.91	3.150	0.157	0.004	0.172	6.91	73.0		0.0055
SFM0011	3.50	4.50	2016/08/11	30901	-0.1	1100.0	26.90	159.0	73.80	316.0	1841.0	253.40	88.40	7.060	0.89	6.38	0.828	0.230	0.031	1.160	7.39	640.0	0.048	0.0243
SFM0011	3.50	4.50	2016/10/12	30931	-1.9	1050.0	26.60	163.0	72.00	330.7	1830.0	244.10	89.40	6.790	0.95	6.61	0.868	0.251	0.031	1.130	7.43	644.0		0.0186
SFM0023	4.42	5.42	2016/01/22	30714	-6.3	248.0	12.90	84.5	41.10	308.1	562.3	13.40	4.84	2.700	0.27	8.73			0.012	0.587	7.61	241.0		0.0486
SFM0032	3.00	4.00	2016/01/20	30713	3.2	30.9	6.05	139.0	10.50	371.5	58.5	48.90	16.70	0.481	0.62	6.29	2.690	0.221	0.007	0.238	7.03	85.0	0.035	0.0071
SFM0032	3.00	4.00	2016/04/20	30755	2.0	27.3	5.71	131.0	9.75	365.7	48.0	44.10	15.30	0.331	0.63	6.00	2.730	0.207	0.008	0.224	7.07	79.0	0.043	0.0052
SFM0032	3.00	4.00	2016/08/08	30898	1.1	26.4	5.79	129.0	9.25	333.0	42.2	68.30	27.50	0.261	0.66	6.91	2.510	0.203	0.009	0.220	6.93	78.0	0.103	0.0041
SFM0032	3.00	4.00	2016/10/13	30933	-1.2	25.6	5.72	152.0	10.10	342.0	40.8	130.20	51.80	0.257	0.36	6.96	2.570	0.229	0.009	0.248	6.96	89.0		0.0039
SFM0037	2.00	3.00	2016/01/19	30710	2.4	22.4	2.99	105.0	11.10	271.1	20.8	85.60	29.40	0.174	0.35	6.77	0.426	0.183	0.006	0.185	6.62	67.0	0.031	0.0044
SFM0037	2.00	3.00	2016/04/19	30753	3.7	23.0	4.48	119.0	12.20	328.2	18.9	74.30	25.40	0.146	0.52	6.22	1.050	0.159	0.007	0.207	7.08	70.0	0.060	0.0053
SFM0037	2.00	3.00	2016/08/08	30899	-1.4	87.9	7.70	144.0	23.00	510.7	99.6	104.10	36.40	0.416	0.71	7.18	2.080	0.235	0.014	0.343	7.01	124.0	0.070	0.0054
SFM0037	2.00	3.00	2016/10/12	30930	1.1	102.0	8.36	151.0	25.10	510.5	119.5	104.60	35.70	0.450	0.67	7.24	1.390	0.257	0.015	0.366	6.96	130.0		0.0047
SFM0049	4.00	5.00	2016/01/19	30711	2.5	18.5	2.84	73.3	5.60	227.0	29.2	5.25	3.43	0.088	0.31	4.98	0.519	0.103	0.002	0.100	6.89	48.0	0.202	0.0039
SFM0049	4.00	5.00	2016/04/18	30752	6.6	15.1	2.82	59.4	4.48	170.0	21.5	6.46	2.65	0.057	0.33	4.56	0.405	0.087	-0.004	0.079	6.91	36.0	0.145	0.0026
SFM0049	4.00	5.00	2016/08/08	30897	0.6	21.0	3.11	74.1	5.32	244.4	29.2	1.90	3.96	0.076	0.36	3.52	0.705	0.115	0.002	0.101	6.74	49.0	0.390	0.0046
SFM0049	4.00	5.00	2016/10/13	30932	-0.2	17.8	2.83	67.4	4.49	203.6	28.0	7.74	7.61	0.061	0.36	3.83	0.602	0.109	0.002	0.087	6.75	43.0		0.0027
SFM0051	5.09	5.25	2016/01/18	30715	5.34	7.7	4.32	129.0	7.61	360.9	20.4	14.20	5.23	0.142	0.51	7.18	5.780	0.236	0.005	0.175	7.16	65.0		0.0093
SFM0051	5.09	5.25	2016/04/18	30757	3.4	7.3	9.10	124.0	7.48	369.0	23.3	14.20	5.18	0.126	0.51	6.68	5.550	0.227	0.005	0.165	7.19	65.0		0.0090
SFM0057	3.55	4.55	2016/08/11	30900	1.2	7.9	2.99	110.0	5.69	352.6	8.2	9.88	3.26	0.059	0.23	4.41	0.041	0.044	0.001	0.159	6.93	58.0	< 0.019	0.0040
SFM0057	3.55	4.55	2016/10/11	30929	1.6	9.0	3.52	127.0	6.40	390.9	11.6	18.00	6.04	0.074	0.24	4.48	0.033	0.042	0.002	0.182	6.88	66.0		0.0024

RCB % = Relative charge balance error %
EC = Electrical Conductivity

Table A2-2b. Surface water supplements.

Id code	Secup m	Seclow m	Date yyyy-mm-dd	Sample No.	NH ₄ -N mg/L	NO ₂ -N mg/L	NO ₃ -N+NO ₂ -N mg/L	NO ₃ -N mg/L	N-tot mg/L	P-tot mg/L	PO ₄ -P mg/L	SiO ₂ -Si mg/L	TOC mg/L	DOC mg/L	DIC mg/L
SFM0001	3.95	4.95	2016/01/20	30712	0.321	0.0005	0.0009	0.0003	1.240	0.051	0.0442	8.18	29.3	29.4	103.9
SFM0001	3.95	4.95	2016/04/19	30754	0.239	0.0004	0.0006	< 0.0003	1.340	0.044	0.0339	7.30	35.8	35.8	77.0
SFM0001	3.95	4.95	2016/08/08	30896	0.288	0.0003	0.0005	< 0.0003	1.090	0.048	0.0427	7.74	26.9	26.8	88.8
SFM0001	3.95	4.95	2016/10/14	30934	0.300	< 0.0002	<0.0003	< 0.0003	1.110	0.051	0.0485	8.02	26.4	26.4	94.0
SFM0002	4.21	5.21	2016/08/12	30902	0.061	< 0.0002	0.0005	0.0006	0.435	0.007	0.0010	5.88	15.1	15.3	64.6
SFM0002	4.21	5.21	2016/10/14	30935	0.063	< 0.0002	0.0003	< 0.0003	0.458	0.008	0.0017	6.08	15.4	15.3	63.0
SFM0011	3.50	4.50	2016/08/11	30901	0.760	0.0003	0.0015	0.0012	0.950	0.079	0.0012	6.43	6.0	6.7	53.2
SFM0011	3.50	4.50	2016/10/12	30931	0.812	< 0.0002	0.0006	0.0004	1.000	0.039	0.0012	6.49	5.9	5.9	42.8
SFM0023	4.42	5.42	2016/01/22	30714	5.160	0.0003	0.0024	0.0020	5.690	0.138	< 0.0005	9.19			
SFM0032	3.00	4.00	2016/01/20	30713	0.085	< 0.0002	0.0011	0.0009	0.603	0.012	0.0027	6.42	17.6	17.7	73.4
SFM0032	3.00	4.00	2016/04/20	30755	0.089	< 0.0002	<0.0003	< 0.0003	0.655	0.013	0.0013	6.14	19.2	19.2	76.8
SFM0032	3.00	4.00	2016/08/08	30898	0.027	< 0.0002	0.0004	0.0004	0.640	0.010	0.0016	7.24	20.5	20.5	61.9
SFM0032	3.00	4.00	2016/10/13	30933	0.028	< 0.0002	<0.0003	< 0.0003	0.614	0.010	0.0011	7.15	18.1	17.8	55.9
SFM0037	2.00	3.00	2016/01/19	30710	0.009	0.0003	0.0011	0.0008	1.100	0.069	< 0.0005	6.95	27.5	26.6	65.0
SFM0037	2.00	3.00	2016/04/19	30753	0.013	0.0004	0.0008	0.0004	1.090	0.033	0.0037	6.39	30.6	29.1	64.6
SFM0037	2.00	3.00	2016/08/08	30899	0.149	< 0.0002	0.0004	< 0.0003	0.875	0.078	0.0043	7.74	22.6	22.1	88.6
SFM0037	2.00	3.00	2016/10/12	30930	0.055	0.0003	<0.0003	< 0.0003	0.824	0.056	0.0076	7.56	22.3	22.0	87.5
SFM0049	4.00	5.00	2016/01/19	30711	0.094	0.0004	0.0041	0.0036	0.582	0.013	0.0056	5.20	16.7	16.6	49.6
SFM0049	4.00	5.00	2016/04/18	30752	0.064	0.0004	0.0095	0.0090	0.498	0.011	0.0053	4.52	14.9	14.9	33.7
SFM0049	4.00	5.00	2016/08/08	30897	0.167	< 0.0002	< 0.0003	< 0.0003	0.732	0.018	0.0115	3.75	20.0	19.9	43.3
SFM0049	4.00	5.00	2016/10/13	30932	0.142	< 0.0002	< 0.0003	< 0.0003	0.703	0.017	0.0125	4.04	18.6	18.7	44.3
SFM0051	5.09	5.25	2016/04/18	30757						0.018					
SFM0057	3.55	4.55	2016/08/11	30900	0.014	< 0.0002	0.0003	< 0.0003	0.310	0.006	0.0039	4.68	10.1	10.1	71.6
SFM0057	3.55	4.55	2016/10/11	30929	0.004	0.0098	0.0225	0.0127	0.418	0.008	0.0035	4.75	11.9	12.0	67.8

< "value" = result below detection or reporting limit.

RCB % = Relative charge balance error %.

EC = Electrical Conductivity.

Table A2-2c. Isotopes I.

Id code	Secup m	Seclow m	Date yyyy-mm-dd	Sample No.	δ D (‰ SMOW)	Tritium (TU)	$\delta^{18}\text{O}$ (‰ SMOW)
SFM0001	3.95	4.95	2016/01/20	30712	-71.2	6.82	-10.12
SFM0001	3.95	4.95	2016/04/19	30754	-72.5	7.67	-11.12
SFM0001	3.95	4.95	2016/08/08	30896	-75.4	6.85	-10.73
SFM0001	3.95	4.95	2016/10/14	30934	-73.8	5.33	-10.60
SFM0002	4.21	5.21	2016/08/12	30902	-82.9	7.34	-12.11
SFM0002	4.21	5.21	2016/10/14	30935	-80.6	6.17	-11.78
SFM0011	3.50	4.50	2016/08/11	30901	-70.6	1.64	-9.82
SFM0011	3.50	4.50	2016/10/12	30931	-68.0	1.31	-9.53
SFM0023	4.42	5.42	2016/01/22	30714	-60.7	7.37	-7.80
SFM0032	3.00	4.00	2016/01/20	30713	-78.9	8.25	-11.53
SFM0032	3.00	4.00	2016/04/20	30755	-79.9	7.19	-11.88
SFM0032	3.00	4.00	2016/08/08	30898	-80.4	7.26	-11.60
SFM0032	3.00	4.00	2016/10/13	30933	-75.2	7.26	-10.92
SFM0037	2.00	3.00	2016/01/19	30710	-70.4	7.80	-10.16
SFM0037	2.00	3.00	2016/04/19	30753	-66.8	8.45	-10.42
SFM0037	2.00	3.00	2016/08/08	30899	-72.1	7.88	-10.35
SFM0037	2.00	3.00	2016/10/12	30930	-67.0	6.99	-9.65
SFM0049	4.00	5.00	2016/01/19	30711	-70.7	8.70	-9.88
SFM0049	4.00	5.00	2016/04/18	30752	-67.8	9.95	-10.67
SFM0049	4.00	5.00	2016/08/08	30897	-71.0	6.85	-9.46
SFM0049	4.00	5.00	2016/10/13	30932	-61.5	8.91	-8.14
SFM0051	5.09	5.25	2016/01/18	30715	-80.3	8.98	-12.21
SFM0051	5.09	5.25	2016/04/18	30757	-81.5	6.94	-11.96
SFM0057	3.55	4.55	2016/08/11	30900	-82.8	7.05	-11.96
SFM0057	3.55	4.55	2016/10/11	30929	-76.6	7.42	-11.03

Table A2-2d. Trace metals I.

IDCODE	Secup m	Seclow m	Date yyyy/mm/dd	Sample No.	Al µg/L	Cd µg/L	Cr µg/L	Cu µg/L	Co µg/L	Hg µg/L	Ni µg/L	Zn µg/L	Pb µg/L	V µg/L	Mo µg/L	Ba µg/L	Se µg/L
SFM0001	3.95	4.95	2016/01/20	30712	28.6	0.003	0.423	0.192	0.135	< 0.002	0.605	2.050	0.048	2.490	1.200	66.3	< 0.5
SFM0001	3.95	4.95	2016/04/19	30754													< 0.5
SFM0001	3.95	4.95	2016/08/08	30896	17.9	0.003	0.333	0.911	0.127	< 0.002	0.427	25.300	0.020	2.270	1.570	56.9	< 0.5
SFM0001	3.95	4.95	2016/10/14	30934	17.0	0.005	0.275	0.262	0.116	< 0.002	0.484	2.420	0.043	2.350	1.670	62.1	< 0.5
SFM0002	4.21	5.21	2016/08/12	30902	22.3	0.002	0.326	0.108	0.076	< 0.002	0.378	1.550	0.013	2.470	1.130	97.6	< 3
SFM0002	4.21	5.21	2016/10/14	30935	22.0	0.009	0.350	0.485	0.070	< 0.002	0.502	5.380	0.045	2.570	1.210	101.0	< 0.5
SFM0011	3.50	4.50	2016/08/11	30901	1.0	< 0.02	< 0.04	< 0.2	0.210	< 0.002	0.230	5.020	< 0.1	0.297	7.740	50.9	< 3
SFM0011	3.50	4.50	2016/10/12	30931	1.2	0.014	0.052	0.151	0.249	< 0.002	0.853	4.930	0.050	0.317	9.010	50.9	< 0.5
SFM0023	4.42	5.42	2016/01/22	30714	0.6	0.013	0.185	1.320	0.530	< 0.002	0.864	1.420	0.030	0.101	0.704	96.8	< 0.5
SFM0032	3.00	4.00	2016/01/20	30713	15.4	0.002	0.269	0.249	0.109	< 0.002	0.679	1.220	0.039	1.570	2.460	65.6	< 0.5
SFM0032	3.00	4.00	2016/04/20	30755													< 0.5
SFM0032	3.00	4.00	2016/08/08	30898	15.4	0.003	0.300	0.102	0.057	< 0.002	0.432	< 0.2	0.019	1.630	5.180	63.8	< 0.5
SFM0032	3.00	4.00	2016/10/13	30933	12.7	0.007	0.286	< 0.1	0.053	< 0.002	0.472	1.590	0.022	1.480	2.820	70.5	< 0.5
SFM0037	2.00	3.00	2016/01/19	30710	36.7	0.023	0.282	1.240	0.772	< 0.002	1.900	6.860	0.528	1.240	0.876	53.1	< 0.5
SFM0037	2.00	3.00	2016/04/19	30753													< 0.5
SFM0037	2.00	3.00	2016/08/08	30899	25.1	0.005	0.420	0.924	0.150	< 0.002	0.893	1.240	0.179	2.610	1.140	100.0	< 0.5
SFM0037	2.00	3.00	2016/10/12	30930	24.2	0.018	0.448	0.326	0.267	< 0.002	1.790	3.310	0.516	3.390	1.020	116.0	< 0.5
SFM0049	4.00	5.00	2016/01/19	30711	11.3	< 0.002	0.101	0.214	0.056	< 0.002	0.143	0.613	0.204	0.404	0.107	33.7	< 0.5
SFM0049	4.00	5.00	2016/04/18	30752													< 0.5
SFM0049	4.00	5.00	2016/08/08	30897	25.9	< 0.002	0.218	0.109	0.078	< 0.002	0.159	29.200	0.041	0.957	0.063	37.2	< 0.5
SFM0049	4.00	5.00	2016/10/13	30932	29.8	0.004	0.203	< 0.1	0.048	< 0.002	0.123	1.040	0.052	0.853	0.111	31.9	< 0.5
SFM0051	5.09	5.25	2016/01/18	30715	211.0	0.006	1.310	0.679	0.162	< 0.002	0.795	3.420	0.400	3.100	0.599	85.5	< 0.5
SFM0051	5.09	5.25	2016/04/18	30757	90.7	0.007	1.030	9.060	0.104	< 0.002	0.712	1.160	0.219	2.420	1.380	79.2	< 0.5
SFM0057	3.55	4.55	2016/08/11	30900	28.5	0.014	0.174	2.470	0.201	< 0.002	0.734	0.961	0.071	0.357	0.552	57.8	< 0.5
SFM0057	3.55	4.55	2016/10/11	30929	24.4	0.028	0.219	7.100	0.212	0.002	1.400	1.660	0.100	0.557	0.713	69.2	< 0.5

< "value" = below reporting limit.

Table A2-2e. Trace metals II.

Idcode	Secup m	Seclow m	Date yyyy/mm/dd	Sample No.	U µg/L	Th µg/L	Sc µg/L	Rb µg/L	Y µg/L	Zr µg/L	Sb µg/L	Cs µg/L	La µg/L	Hf µg/L	Ti µg/L	Ce µg/L	Pr µg/L	Nd µg/L	Sm µg/L	Eu µg/L	Gd µg/L	Tb µg/L	Dy µg/L	Ho µg/L	Er µg/L	Tm µg/L	Yb µg/L	Lu µg/L
SFM0001	3.95	4.95	2016/01/20	30712	4.300	0.343	0.156	4.390	3.060	< 10	0.055	0.073	1.760	0.469	< 0.01	4.340	0.452	2.000	0.425	0.043	0.450	0.067	0.442	0.098	0.302	0.041	0.295	0.023
SFM0001	3.95	4.95	2016/08/08	30896	3.420	0.171	0.116	3.660	2.320	9.250	0.047	< 0.03	1.340	0.147	< 0.01	3.320	0.324	1.420	0.294	0.034	0.327	0.047	0.328	0.067	0.214	0.028	0.208	0.030
SFM0001	3.95	4.95	2016/10/14	30934	3.230	0.176	0.097	4.460	2.220	9.650	0.051	0.047	1.400	0.136	< 0.01	3.680	0.326	1.450	0.306	0.031	0.327	0.044	0.309	0.061	0.206	0.027	0.194	0.032
SFM0002	4.21	5.21	2016/08/12	30902	2.880	0.210	0.142	1.640	2.560	8.190	0.029	< 0.03	0.932	0.186	< 0.01	2.620	0.230	1.070	0.229	0.024	0.278	0.041	0.312	0.073	0.259	0.038	0.304	0.048
SFM0002	4.21	5.21	2016/10/14	30935	2.900	0.219	0.151	1.940	2.660	9.520	0.033	< 0.03	0.938	0.197	< 0.01	2.640	0.224	1.060	0.233	0.019	0.286	0.041	0.323	0.072	0.268	0.039	0.302	0.054
SFM0011	3.50	4.50	2016/08/11	30901	9.390	< 0.2	< 0.4	5.640	0.723	0.248	< 0.1	< 0.1	0.272	< 0.02	< 0.05	0.343	0.053	0.229	0.042	< 0.02	0.062	< 0.02	0.050	< 0.02	0.037	< 0.02	0.033	< 0.02
SFM0011	3.50	4.50	2016/10/12	30931	9.560	< 0.02	< 0.05	6.360	0.568	0.300	0.043	0.096	0.217	0.007	< 0.01	0.264	0.039	0.191	0.036	< 0.005	0.047	0.005	0.040	0.009	0.029	< 0.004	0.028	0.007
SFM0023	4.42	5.42	2016/01/22	30714	1.030	0.320	0.142	1.600	1.460	< 10	0.061	0.058	0.988	0.268	< 0.01	2.050	0.236	0.955	0.195	0.014	0.200	0.029	0.204	0.043	0.143	0.023	0.163	0.015
SFM0032	3.00	4.00	2016/01/20	30713	10.400	0.102	0.074	2.050	1.600	6.390	0.036	< 0.03	0.642	0.314	< 0.01	1.190	0.153	0.696	0.142	0.008	0.156	0.025	0.181	0.042	0.135	0.020	0.138	0.012
SFM0032	3.00	4.00	2016/08/08	30898	4.000	0.116	0.071	1.900	1.830	3.680	0.053	< 0.03	0.786	0.080	< 0.01	1.510	0.190	0.842	0.177	0.020	0.211	0.030	0.216	0.049	0.168	0.022	0.176	0.023
SFM0032	3.00	4.00	2016/10/13	30933	4.180	0.093	0.062	2.120	1.560	3.690	0.053	< 0.03	0.780	0.065	< 0.01	1.480	0.174	0.795	0.163	0.013	0.182	0.025	0.190	0.040	0.140	0.020	0.147	0.025
SFM0037	2.00	3.00	2016/01/19	30710	13.700	0.236	0.090	4.130	2.170	2.390	0.066	< 0.03	1.920	0.366	0.013	3.430	0.409	1.700	0.336	0.030	0.314	0.044	0.299	0.063	0.196	0.028	0.188	0.016
SFM0037	2.00	3.00	2016/08/08	30899	10.400	0.246	0.152	6.400	2.660	4.260	0.116	< 0.03	1.750	0.109	< 0.01	3.130	0.396	1.720	0.361	0.038	0.383	0.052	0.368	0.078	0.256	0.035	0.260	0.034
SFM0037	2.00	3.00	2016/10/12	30930	11.000	0.222	0.143	7.890	2.790	5.410	0.072	0.032	1.830	0.116	0.020	3.240	0.403	1.770	0.367	0.032	0.366	0.051	0.376	0.076	0.260	0.036	0.268	0.047
SFM0049	4.00	5.00	2016/01/19	30711	0.352	0.117	< 0.05	2.950	0.651	0.560	0.028	< 0.03	0.724	0.184	< 0.01	1.350	0.162	0.685	0.132	0.013	0.118	0.016	0.101	0.021	0.063	0.009	0.061	< 0.005
SFM0049	4.00	5.00	2016/08/08	30897	0.241	0.122	0.086	4.020	0.891	0.486	0.026	< 0.03	1.030	0.023	< 0.01	2.010	0.236	0.978	0.190	0.023	0.174	0.023	0.149	0.028	0.089	0.012	0.087	0.009
SFM0049	4.00	5.00	2016/10/13	30932	0.176	0.117	0.055	4.120	0.967	0.536	0.020	< 0.03	1.070	0.018	< 0.01	2.080	0.238	1.020	0.200	0.021	0.179	0.023	0.153	0.029	0.095	0.013	0.088	0.015
SFM0057	3.55	4.55	2016/08/11	30900	7.320	0.117	0.152	3.220	1.640	1.340	0.109	< 0.03	1.210	0.036	0.023	2.280	0.268	1.200	0.235	0.031	0.239	0.032	0.224	0.046	0.146	0.019	0.137	0.015
SFM0057	3.55	4.55	2016/10/11	30929	11.200	0.109	0.131	4.200	1.850	1.670	0.193	< 0.03	1.380	0.037	0.028	2.510	0.288	1.290	0.254	0.028	0.261	0.035	0.238	0.047	0.157	0.021	0.146	0.033

< "value" = below reporting limit.

Appendix 3

Surface waters

Table A3-1. Field measurements.

Idcode	Measuring date yyyy-mm-dd hh:mm	Measured depth (m)	Water depth (m)	Sno	Temp. (°C)	pH	EC (mS/m)	Turb (NTU)	O ₂ diss. (mg/l)	O ₂ sat. (%)	ORP (mV)
PFM000062	16/04/19 09:00	0.50	3.90	30772	4.26	8.24	875.4	1.6	13.10	107.2	206
PFM000062	16/04/19 09:08	1.00	3.90		4.08	8.13	880.3	2.7	13.16	108.0	209
PFM000062	16/04/19 09:15	2.00	3.90		3.97	8.18	883.3	1.8	13.17	108.4	210
PFM000062	16/04/19 09:23	3.00	3.90		3.95	8.19	879.8	1.5	13.28	109.3	211
PFM000062	16/08/10 08:52	0.50	3.90	30915	11.32	7.62	856.9	1.8	9.10	81.8	102
PFM000062	16/08/10 08:58	1.00	3.90		10.85	7.56	879.2	1.7	9.27	83.4	99
PFM000062	16/08/10 09:03	2.00	3.90		10.73	7.52	885.9	1.6	9.31	83.9	99
PFM000062	16/08/10 09:07	3.00	3.90		10.70	7.55	879.2	1.6	9.34	84.3	96
PFM000062	16/10/11 09:45	0.50	3.70	30950	10.92	8.05	874.8	1.9			190
PFM000062	16/10/11 10:02	1.00	3.70		10.90	7.93	876.5	1.9			190
PFM000062	16/10/11 10:06	2.00	3.70		10.89	7.92	876.9	2.0			180
PFM000062	16/10/11 10:09	3.00	3.70		10.89	7.92	877.5	2.4			180
PFM000066	16/01/19 13:00	0.10	0.20	30730	0.01	7.10	41.4	2.5	4.75	32.6	60
PFM000066	16/02/15 13:30	0.10	0.40	30739	0.22	6.86	32.1	1.0			120
PFM000066	16/03/16 14:15	0.10	0.30	30748	1.71	7.13	36.3	0.8			90
PFM000066	16/04/18 11:45	0.10	0.42	30768	7.19	7.28	30.9	1.4	7.90	69.0	224
PFM000066	16/05/23 15:00	0.10	0.25	30817	17.64	7.55	32.8	3.5	6.91	70.8	146
PFM000066	16/06/27 13:20	0.10	0.17	30894	17.86	7.55	32.2	1.4	4.79	49.8	89
PFM000066	16/08/09 12:00	0.10									
PFM000066	16/09/04 10:30	0.10	0.21	30922	11.88	7.31	28.2	2.6	0.60	5.5	130
PFM000066	16/10/09 16:20	0.10									
PFM000066	16/11/07 13:45	0.10	0.18	30956	0.82	7.45	31.3	1.1	7.26	51.0	240
PFM000066	16/12/06 13:20	0.10	0.28	30971	0.52	7.18	33.4	19.3	1.09	7.6	210
PFM000068	16/01/18 16:20	0.10	0.50	30729	0.02	7.49	42.9	1.4	6.77	46.5	180
PFM000068	16/02/15 11:50	0.10	0.50	30738	0.03	6.53	31.4	1.2			160
PFM000068	16/03/16 11:20	0.10	0.51	30745	0.40	6.98	33.1	1.0			120
PFM000068	16/04/18 11:05	0.10	0.75	30767	6.15	7.07	29.7	1.5	7.41	62.9	211
PFM000068	16/05/23 13:20	0.10	0.61	30814	15.30	7.45	33.2	2.9	7.45	72.9	92
PFM000068	16/06/27 10:45	0.10	0.59	30891	15.14	7.21	40.8	1.4	5.42	54.3	133
PFM000068	16/08/09 08:52	0.10									
PFM000068	16/09/04 08:30	0.10	0.47	30919	12.10	7.83	50.2	0.6	0.07	0.6	170
PFM000068	16/10/09 15:50	0.10									
PFM000068	16/11/07 11:35	0.10	0.48	30954	0.28	6.69	50.6	0.7	8.97	62.0	290
PFM000068	16/12/06 10:45	0.10	0.60	30968	0.85	6.40	42.7	13.7	0.91	6.4	170
PFM000069	16/01/21 11:40	0.10	0.10	30732	0.03	7.58	53.0	1.2			50
PFM000069	16/02/15 15:30	0.10	0.33	30741	0.06	7.20	39.0	0.6			140
PFM000069	16/03/16 11:50	0.10	0.21	30746	0.59	7.05	43.5	0.8			100
PFM000069	16/04/18 16:30	0.10	0.20	30771	8.20	7.26	34.1	0.9	5.99	53.4	119
PFM000069	16/05/23 13:45	0.10	0.10	30815	14.89	7.30	39.9	1.2	6.94	67.7	144
PFM000069	16/06/27 11:20	0.10	0.11	30892	14.87	7.16	40.1	1.2	5.89	58.1	89
PFM000069	16/08/09 09:05	0.10									
PFM000069	16/09/04 09:05	0.10	0.06	30920	11.67	7.49	47.9	1.0	0.95	8.7	140
PFM000069	16/10/09 16:00	0.10									
PFM000069	16/11/07 12:10	0.10	0.10	30955	0.06	7.01	47.6	1.0	10.14	69.7	270
PFM000069	16/12/06 11:15	0.10	0.19	30969	0.80	6.83	42.9	13.5	0.50	3.5	190
PFM000070	16/01/21 12:20	0.10	0.20	30733	0.06	8.14	27.8	0.8			40
PFM000070	16/02/15 14:20	0.10	0.30	30740	0.54	7.22	22.6	3.0			140
PFM000070	16/03/16 12:30	0.10	0.20	30747	2.74	7.24	23.5	0.4			120
PFM000070	16/04/18 15:45	0.10	0.21	30770	10.60	7.80	0.1	0.9	9.05	84.9	99

Idcode	Measuring date yyyy-mm-dd hh:mm	Measured depth (m)	Water depth (m)	Sno	Temp. (°C)	pH	EC (mS/m)	Turb (NTU)	O ₂ diss. (mg/l)	O ₂ sat. (%)	ORP (mV)
PFM000070	16/05/23 14:20	0.10	0.09	30816	19.59	7.22	25.6	1.1	5.10	54.5	154
PFM000070	16/06/27 12:00	0.10	0.10	30893	19.00	7.22	24.4	1.1	5.65	60.7	151
PFM000070	16/08/09 09:20	1.00									
PFM000070	16/09/04 09:50	0.10	0.08	30921	12.23	7.34	23.4	1.7	0.63	5.9	110
PFM000070	16/10/09 15:40	0.10									
PFM000070	16/11/07 15:30	0.10	0.07	30957	0.36	7.73	24.2	0.4	8.65	59.9	130
PFM000070	16/12/06 11:45	0.10	0.11	30970	0.30	7.12	22.4	13.7	1.71	11.8	200
PFM000074	16/01/21 10:55	0.50	0.70	30731	1.03	7.90	59.4	2.1			-50
PFM000074	16/04/19 11:20	0.50	1.15	30773	7.17	7.62	34.6	1.2	6.56	58.1	132
PFM000074	16/08/09 13:50	0.50	0.70	30911	16.96	8.11	39.8	1.3	9.37	95.0	129
PFM000074	16/10/10 09:45	0.50	0.52	30945	8.34	7.90	39.4	0.4			150
PFM000083	16/10/09 13:45	0.50		30943	11.18	7.06	880.9	2.7			220
PFM000084	16/10/09 14:40	0.50		30944	9.08	7.53	882.6	2.5			200
PFM000097	16/01/19 10:45	0.50	0.65		1.88	6.91	140.2	5.4	1.76	12.7	-130
PFM000097	16/02/16 10:25	0.50	0.80		1.77	7.84	53.1	0.7			170
PFM000097	16/03/17 10:05	0.50	0.90		4.59	8.23	56.1	0.7			130
PFM000097	16/04/19 10:20	0.50	0.99		8.98	8.48	31.2	1.4	10.58	97.5	87
PFM000097	16/05/24 09:40	0.50	0.89		18.29	8.55	35.2	1.8	9.35	97.9	125
PFM000097	16/06/28 09:50	0.50	0.90		20.23	8.16	30.5	1.2	8.22	89.9	120
PFM000097	16/08/09 10:00	0.50	0.80		16.34	9.21	51.2	1.8	10.06	100.0	125
PFM000097	16/09/03 17:30	0.50	0.68		17.58	8.35	55.1	1.9	9.08	95.4	140
PFM000097	16/10/13 08:20	0.50	0.72		6.73	8.40	80.1	1.5			220
PFM000097	16/11/08 08:35	0.50									
PFM000097	16/12/07 09:00	0.50	0.60		3.45	7.74	71.5	1.3	4.20	31.7	100
PFM000107	16/01/18 13:30	0.50	1.80	30726	1.56	6.64	50.0	0.3	10.37	74.4	230
PFM000107	16/01/18 13:45	1.00	1.80	30725	2.40	6.74	51.2	0.3	4.58	33.6	240
PFM000107	16/04/19 14:05	0.50	1.70	30774	8.67	8.52	31.5	1.1	11.11	101.8	150
PFM000107	16/04/19 14:13	1.00	1.70		8.72	8.49	31.4	1.5	11.10	101.5	152
PFM000107	16/08/10 10:39	0.50	1.60	30916	15.97	9.47	29.6	1.8	9.09	90.7	64
PFM000107	16/08/10 10:45	1.00	1.60		15.98	9.42	28.8	1.9	9.21	92.0	71
PFM000107	16/10/13 11:15	0.50	1.50	30952	7.10	8.39	32.8	0.8			110
PFM000107	16/10/13 11:26	1.00	1.50		7.10	8.37	32.8	0.8			110
PFM000117	16/01/18 15:00	0.50	2.30	30727	1.33	7.54	27.7	0.5	13.91	99.0	210
PFM000117	16/01/18 15:17	1.00	2.30		1.77	7.55	28.3	0.7	14.30	103.1	210
PFM000117	16/01/18 15:19	1.50	2.30	30728	2.43	7.49	29.9	0.6	11.87	87.1	220
PFM000117	16/04/18 14:45	0.50	2.30	30769	9.70	8.44	25.8	1.5	11.85	108.9	156
PFM000117	16/04/18 14:52	1.00	2.30		9.58	7.94	26.0	1.5	11.95	110.1	187
PFM000117	16/04/18 14:58	1.50	2.30		9.45	7.89	24.8	1.4	12.01	110.4	58
PFM000117	16/08/09 17:50	0.50	2.10	30914	18.85	9.15	17.8	1.9	9.92	103.8	104
PFM000117	16/08/09 17:57	1.00	2.10		18.85	8.87	17.9	2.1	9.91	103.8	154
PFM000117	16/08/09 18:05	1.50	2.10		18.84	8.85	17.9	1.9	9.92	103.9	168
PFM000117	16/10/13 09:45	0.50	2.00	30951	7.66	8.48	19.0	1.1			90
PFM000117	16/10/13 09:58	1.00	2.00		7.62	8.52	19.0	1.4			90
PFM000117	16/10/13 10:04	1.50	2.00		7.47	8.53	19.1	1.0			90
PFM007783	16/08/11 16:50	0.50	1.30	30917	16.07	8.17	843.5	1.8	9.77	96.7	94
PFM007783	16/10/10 13:40	0.50		30948	9.18	7.99	884.5	1.0			180
PFM102269	16/01/21 13:25	0.50		30724							
PFM102269	16/08/09 10:50	0.50	1.50	30910	13.67	7.55	862.7	1.9	8.56	81.6	126
PFM102269	16/09/04 11:20	0.50		30918	24.70	7.59	862.3	0.7	12.90	160.0	130
PFM102269	16/10/10 14:15	0.50		30949	18.79	7.83	878.9	2.2			180
PFM102269	16/11/07 14:35	0.50		30953	5.99	7.44	905.1	3.1	15.69	130.4	240
PFM102269	16/12/06 14:25	0.50		30967	13.26	7.18	875.7	5.3	9.68	95.5	240

Sno = Corresponding water sample no.
EC = Electrical conductivity.
NTU = Nephelometric Turbidity Unit.
ORP = Oxidising Reducing Potential.

Table A3-2. Water flow measurements.

Idcode	Start date	Stop date	Simple flow rate (m³/s)	Code/Comment
PFM000062	2016/01/21 12:15	2016/01/21 12:15		N
PFM000062	2016/04/19 09:00	2016/04/19 09:07		N
PFM000062	2016/04/19 09:08	2016/04/19 09:14		N
PFM000062	2016/04/19 09:15	2016/04/19 09:22		N
PFM000062	2016/04/19 09:23	2016/04/19 09:28		N
PFM000062	2016/08/10 08:52	2016/08/10 08:57		N
PFM000062	2016/08/10 08:58	2016/08/10 09:02		N
PFM000062	2016/08/10 09:03	2016/08/10 09:06		N
PFM000062	2016/08/10 09:07	2016/08/10 09:15		N
PFM000062	2016/10/11 09:45	2016/10/11 10:01		N
PFM000062	2016/10/11 10:02	2016/10/11 10:05		N
PFM000062	2016/10/11 10:06	2016/10/11 10:08		N
PFM000062	2016/10/11 10:09	2016/10/11 10:12		N
PFM000066	2016/01/19 13:00	2016/01/19 13:20		F
PFM000066	2016/02/15 13:30	2016/02/15 13:50	0.100	L
PFM000066	2016/03/16 14:15	2016/03/16 14:35	0.071	L
PFM000066	2016/04/18 11:45	2016/04/18 12:05	0.067	L
PFM000066	2016/05/23 15:00	2016/05/23 15:20	0.027	L
PFM000066	2016/06/27 13:20	2016/06/27 13:40	0.009	L
PFM000066	2016/08/09 12:00	2016/08/09 12:20		G
PFM000066	2016/09/04 10:30	2016/09/04 10:50		F
PFM000066	2016/10/09 16:20	2016/10/09 16:25		G
PFM000066	2016/11/07 13:45	2016/11/07 14:05		C
PFM000066	2016/12/06 13:20	2016/12/06 13:40	0.019	L
PFM000068	2016/01/18 16:20	2016/01/18 16:40		C
PFM000068	2016/02/15 11:50	2016/02/15 12:10		C
PFM000068	2016/03/16 11:20	2016/03/16 11:40	0.240	L
PFM000068	2016/04/18 11:05	2016/04/18 11:25	0.360	L
PFM000068	2016/05/23 13:20	2016/05/23 13:40		F
PFM000068	2016/06/27 10:45	2016/06/27 11:05		F
PFM000068	2016/08/09 08:52	2016/08/09 08:53		G
PFM000068	2016/09/04 08:30	2016/09/04 08:50		F
PFM000068	2016/10/09 15:50	2016/10/09 15:55		G
PFM000068	2016/11/07 11:35	2016/11/07 11:55		C
PFM000068	2016/12/06 10:45	2016/12/06 11:05		D
PFM000069	2016/01/21 11:40	2016/01/21 12:00		F
PFM000069	2016/02/15 15:30	2016/02/15 15:50	0.100	L
PFM000069	2016/03/16 11:50	2016/03/16 12:10	0,056	L
PFM000069	2016/04/18 16:30	2016/04/18 16:50	0.071	L
PFM000069	2016/05/23 13:45	2016/05/23 14:00	0.022	L
PFM000069	2016/06/27 11:20	2016/06/27 11:40	0.026	L
PFM000069	2016/08/09 09:05	2016/08/09 09:06		G
PFM000069	2016/09/04 09:05	2016/09/04 09:25		F
PFM000069	2016/10/09 16:00	2016/10/09 16:05		G
PFM000069	2016/11/07 12:10	2016/11/07 12:30		C
PFM000069	2016/12/06 11:15	2016/12/06 11:30	0.024	L
PFM000070	2016/01/21 12:20	2016/01/21 12:40		F
PFM000070	2016/02/15 14:20	2016/02/15 14:40	0.135	L
PFM000070	2016/03/16 12:30	2016/03/16 12:50	0.033	L
PFM000070	2016/04/18 15:45	2016/04/18 16:05	0.052	L
PFM000070	2016/05/23 14:20	2016/05/23 14:40		F
PFM000070	2016/06/27 12:00	2016/06/27 12:20		B
PFM000070	2016/08/09 09:20	2016/08/09 09:21		G
PFM000070	2016/09/04 09:50	2016/09/04 10:10		B
PFM000070	2016/10/09 15:40	2016/10/09 15:45		G
PFM000070	2016/11/07 15:30	2016/11/07 15:50		C
PFM000070	2016/12/06 11:45	2016/12/06 12:05		D

Idcode	Start date	Stop date	Simple flow rate (m³/s)	Code/Comment
PFM000074	2016/01/21 10:55	2016/01/21 11:15		N
PFM000074	2016/04/19 11:20	2016/04/19 11:40		N
PFM000074	2016/08/09 13:50	2016/08/09 14:10		N
PFM000074	2016/10/10 09:45	2016/10/10 10:05		N
PFM000083	2016/10/09 13:45	2016/10/09 14:05		N
PFM000084	2016/10/09 14:40	2016/10/09 15:00		N
PFM000097	2016/01/19 10:45	2016/01/19 10:55		N
PFM000097	2016/02/16 10:25	2016/02/16 10:40		N
PFM000097	2016/03/17 10:05	2016/03/17 10:15		N
PFM000097	2016/04/19 10:20	2016/04/19 10:40		N
PFM000097	2016/05/24 09:40	2016/05/24 10:00		N
PFM000097	2016/06/28 09:50	2016/06/28 10:10		N
PFM000097	2016/08/09 10:00	2016/08/09 10:10		N
PFM000097	2016/09/03 17:30	2016/09/03 17:40		N
PFM000097	2016/10/13 08:20	2016/10/13 08:40		N
PFM000097	2016/11/08 08:35	2016/11/08 08:50		N
PFM000097	2016/12/07 09:00	2016/12/07 09:20		N
PFM000107	2016/01/18 13:30	2016/01/18 13:45		N
PFM000107	2016/01/18 13:45	2016/01/18 14:00		N
PFM000107	2016/04/19 14:05	2016/04/19 14:12		N
PFM000107	2016/04/19 14:13	2016/04/19 14:23		N
PFM000107	2016/08/10 10:39	2016/08/10 10:44		N
PFM000107	2016/08/10 10:45	2016/08/10 10:55		N
PFM000107	2016/10/13 11:15	2016/10/13 11:25		N
PFM000107	2016/10/13 11:26	2016/10/13 11:30		N
PFM000117	2016/01/18 15:00	2016/01/18 15:17		N
PFM000117	2016/01/18 15:17	2016/01/18 15:19		N
PFM000117	2016/01/18 15:19	2016/01/18 15:40		N
PFM000117	2016/04/18 14:45	2016/04/18 14:46		N
PFM000117	2016/04/18 14:52	2016/04/18 14:53		N
PFM000117	2016/04/18 14:58	2016/04/18 14:59		N
PFM000117	2016/08/09 17:50	2016/08/09 17:56		N
PFM000117	2016/08/09 17:57	2016/08/09 18:04		N
PFM000117	2016/08/09 18:05	2016/08/09 18:10		N
PFM000117	2016/10/13 09:45	2016/10/13 09:57		N
PFM000117	2016/10/13 09:58	2016/10/13 10:03		N
PFM000117	2016/10/13 10:04	2016/10/13 10:08		N
PFM007783	2016/08/11 16:50	2016/08/11 17:10		N
PFM007783	2016/10/10 13:40	2016/10/10 14:00		N
PFM102269	2016/01/21 13:25	2016/01/21 13:35		N
PFM102269	2016/08/09 10:50	2016/08/09 11:20		N
PFM102269	2016/09/04 11:20	2016/09/04 11:40		N
PFM102269	2016/10/10 14:15	2016/10/10 14:35		N
PFM102269	2016/11/07 14:35	2016/11/07 14:55		N
PFM102269	2016/12/06 14:25	2016/12/06 14:45		N

Code	Code description
A	Blocked flow; no measurement
B	Too much water vegetation, no measurement
C	Water completely frozen, no measurement
D	Too much ice, no measurement
E	Flow rate too high, no measurement
F	Flow rate too low, no measurement
G	Dry conditions, no measurements
H	Measurement not possible, estimated value
I	Measurement not possible, see protocol
K	Comment missing
L	Flow rate value available
M	Low water level
N	Lake, Sea, no measurement
O	Too much wind, no measurement
P	Stationary water

Idcode	Sample no.	Depth (m)	Sampling date (yyyy-mm-dd)	RCB (%)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	HCO ₃ ⁻ (mg/L)	Cl ⁻ (mg/L)	SO ₄ ²⁻ (mg/L)	SO ₄ -S (mg/L)	Br (mg/L)	F ⁻ (mg/L)	Si (mg/L)	Fe (mg/L)	Mn (mg/L)	Li (mg/L)	Sr (mg/L)	I ⁻ (mg/L)	pH_L	pH_F	Temp_F (°C)	EC_L (mS/m)
PFM000107	30916	0.50	2016/08/10	4.0	25.4	2.36	26.0	5.12	81.5	37.2	10.70	4.17	0.178	0.30	1.29	0.0320	0.0026	0.0029	0.070	0.0080	9.12	9.47	15.97	29
PFM000107	30952	0.50	2016/10/13	4.0	27.2	2.67	33.4	5.66	103.0	41.6	10.00	3.95	0.180	0.30	0.09	0.0256	0.0012	0.0032	0.077	0.0065	8.17	8.39	7.10	34
PFM000117	30727	0.50	2016/01/18	4.1	6.8	2.32	48.9	2.80	150.7	6.6	4.47	1.90	0.066	0.25	1.49	0.0116	0.0014	0.0015	0.057	0.0132	7.94	7.54	1.33	28
PFM000117	30728	1.50	2016/01/18	4.9	7.3	2.49	56.1	3.06	169.6	6.8	5.00	2.11	0.066	0.25	2.20	0.0501	0.1180	0.0014	0.063	0.0134	7.52	7.49	2.43	31
PFM000117	30769	0.50	2016/04/18	3.7	5.8	1.91	47.4	2.46	145.3	5.6	4.54	1.83	0.042	0.20	1.33	0.0270	0.0103	0.0012	0.050	0.0088	8.24	8.44	9.70	26
PFM000117	30914	0.50	2016/08/09	5.3	7.1	1.97	27.2	2.68	87.5	6.3	4.51	1.91	0.049	0.21	1.98	0.0042	0.0012	0.0013	0.045	0.0101	9.01	9.15	18.85	18
PFM000117	30951	0.50	2016/10/13	5.2	6.9	2.01	30.8	2.72	97.3	6.6	4.43	1.76	0.052	0.25	1.69	0.0024	0.0006	0.0015	0.047	0.0095	8.27	8.48	7.66	20
PFM007783	30917	0.50	2016/08/11	1.4	1580.0	54.70	72.2	170.00	76.1	2690.0	392.50	128.00	9.700	0.33	0.52	0.0034	0.0020	0.0254	1.070	0.0133	7.92	8.17	16.07	880
PFM007783	30948	0.50	2016/10/10	-2.6	1460.0	53.80	75.4	168.00	77.7	2741.0	393.30	130.00	8.860	0.37	0.43	0.0041	0.0017	0.0273	1.070	< 0.09	7.96	7.99	9.18	892
PFM102269	30910	0.50	2016/08/09	1.2	1610.0	55.60	73.7	173.00	77.7	2760.0	389.60	129.00	9.960	0.34	0.53	0.0037	0.0067	0.0257	1.090	0.0141	7.61	7.55	13.67	888
PFM102269	30918	0.50	2016/09/04	0.0	1540.0	55.60	76.2	174.00	76.7	2727.0	394.50	132.00	9.500	0.36	0.53	0.0024	0.0028	0.0254	1.090	0.0110	7.74	7.59	24.70	886
PFM102269	30949	0.50	2016/10/10	-2.7	1440.0	53.40	75.0	167.00	76.7	2717.0	378.40	128.00	9.170	0.36	0.53	< 0.002	0.0019	0.0263	1.060	< 0.09	7.92	7.83	18.79	886
PFM102269	30953	0.50	2016/11/07	-0.5	1550.0	53.80	73.8	169.00	80.2	2764.0	410.60	127.00	9.230	0.34	0.57	0.0028	0.0032	0.0253	1.060	< 0.09	7.79	7.44	5.99	898
PFM102269	30967	0.50	2016/12/06	0.3	1540.0	54.30	75.4	169.00	77.7	2697.0	383.80	130.00	9.170	0.28	0.63	< 0.002	0.0012	0.0307	1.070	< 0.02	7.85	7.18	13.26	876

< "value" = below reporting limit.

Idcode	Sample no.	Sampling date (yyyy-mm-dd)	Depth (m)	NH ₄ N (mg/L)	NO ₂ N (mg/L)	NO ₃ N+NO ₂ N (mg/L)	N TOT (mg/L)	P TOT (mg/L)	PO ₄ P (mg/L)	POP (mg/L)	PON (mg/L)	SiO ₂ SI (mg/L)	Chl. C (ug/L)	Chl. A (ug/L)	Pheop. (ug/L)	POC (mg/L)	TOC (mg/L)	DOC (mg/L)	DIC (mg/L)	Abs. coeff. (1/m)
PFM000107	30916	2016/08/10	0.50	0.0101	< 0.0002	< 0.0003	1.2000	0.0174	0.0020	0.0056	0.0595	1.360	0.200	2.50	0.60	0.4950	20.90	20.70	11.50	0.80
PFM000107	30952	2016/10/13	0.50	0.0184	< 0.0002	0.0003	1.1600	0.0123	0.0012	0.0039	0.0295	0.096	< 0.2	0.90	< 0.2	0.3840	21.50	21.10	15.90	0.62
PFM000117	30727	2016/01/18	0.50	0.3300	0.0007	0.0155	1.4600	0.0064	< 0.0005	0.0021	0.0350	1.580	0.600	2.40	1.30	0.4480	22.70	21.70	23.50	1.18
PFM000117	30728	2016/01/18	1.50	0.5470	0.0007	0.0162	1.7900	0.0075	< 0.0005	0.0043	0.0908	2.300	< 0.2	1.00	< 0.2	0.7430	23.50	23.20	27.30	1.56
PFM000117	30769	2016/04/18	0.50	0.0590	0.0006	0.0121	0.9830	0.0080	0.0007	0.0034	0.0664	1.440	0.300	0.80	0.60	0.5540	19.10	17.90	22.00	1.46
PFM000117	30914	2016/08/09	0.50	0.0064	< 0.0002	0.0004	1.2100	0.0108	0.0012	0.0047	0.0911	2.110	0.300	2.90	< 0.2	0.7670	22.70	21.60	12.50	0.82
PFM000117	30951	2016/10/13	0.50	0.0093	< 0.0002	0.0006	1.1700	0.0086	0.0009	0.0037	0.0753	1.790	0.300	2.20	0.30	0.6730	22.50	22.00	15.80	0.70
PFM007783	30917	2016/08/11	0.50	0.0010	< 0.0002	0.0009	0.2730	0.0169	0.0017	0.0083	0.0574	0.542	0.500	2.80	B	0.3250	4.60	4.30	14.60	0.28
PFM007783	30948	2016/10/10	0.50	0.0014	< 0.0002	0.0008	0.2620	0.0145	0.0012	0.0075	0.0606	0.433	0.500	2.60	0.80	0.4310	4.30	4.10	14.20	0.26
PFM102269	30910	2016/08/09	0.50	0.0045	0.0002	0.0034	0.2510	0.0138	0.0031	0.0049	0.0341	0.569	0.400	2.10	0.50	0.2350	4.30	4.40	15.30	0.24
PFM102269	30918	2016/09/04	0.50	0.0128	0.0004	0.0550	0.2530	0.0138	0.0038	0.0033	0.0196	0.561				0.1650	4.50	4.30	14.60	0.16
PFM102269	30949	2016/10/10	0.50	0.0130	0.0009	0.0171	0.2620	0.0152	0.0061	0.0034	0.0152	0.549	0.200	1.40	0.60	0.1530	4.10	4.00	14.10	0.22
PFM102269	30953	2016/11/07	0.50	0.0227	0.0019	0.0386	0.3230	0.0202	0.0066	0.0027	0.0136	0.670				0.1160	4.10	3.80	12.90	0.20
PFM102269	30967	2016/12/06	0.50	0.0059	0.0011	0.0382	0.2850	0.0185	0.0061	0.0044	0.0228	0.676				0.2180	4.20	3.90	14.80	0.16

A = Inget prov för Tot-NP samt DIC har ankommit till lab. Detta på grund av att provkärlet av misstag inte packades ner i provkit.

B = Resultat för Phepigment saknas, då prov gick förlorat.

< "value" = below reporting limit.

Table A3-3c. Isotopes I.

Idcode	Sample no.	Sampling date (yyyy-mm-dd)	Depth (m)	$\delta^{2}\text{H}$ ‰ SMOW	^3H TU	$\delta^{18}\text{O}$ ‰ SMOW
PFM000062	30772	2016/04/19	0.50	-57.4	7.13	-8.22
PFM000062	30915	2016/08/10	0.50	-59.2	5.82	-8.15
PFM000062	30950	2016/10/11	0.50	-58.3	7.58	-8.07
PFM000066	30730	2016/01/19	0.10	-74.5	9.06	-10.66
PFM000066	30768	2016/04/18	0.10	-72.1	8.34	-11.03
PFM000068	30729	2016/01/18	0.10	-68.3	6.90	-9.10
PFM000068	30738	2016/02/15	0.10			
PFM000068	30745	2016/03/16	0.10			
PFM000068	30767	2016/04/18	0.10	-70.4	6.85	-10.31
PFM000069	30732	2016/01/21	0.10	-76.5	7.63	-10.95
PFM000069	30771	2016/04/18	0.10	-74.4	7.62	-10.97
PFM000070	30733	2016/01/21	0.10	-56.3	8.35	-6.59
PFM000070	30770	2016/04/18	0.10	-58.8	7.98	-8.16
PFM000074	30731	2016/01/21	0.50	-74.8	8.57	-10.71
PFM000074	30773	2016/04/19	0.50	-76.0	8.01	-10.99
PFM000074	30911	2016/08/09	0.50	-58.9	9.00	-7.25
PFM000074	30945	2016/10/10	0.50	-54.1	9.07	-6.82
PFM000083	30943	2016/10/09	0.50	-57.0	7.01	-7.93
PFM000084	30944	2016/10/09	0.50	-58.0	7.30	-7.93
PFM000107	30726	2016/01/18	0.50	-57.5	9.20	-7.86
PFM000107	30725	2016/01/18	1.00	-61.2	8.23	-8.51
PFM000107	30774	2016/04/19	0.50	-67.7	6.04	-9.29
PFM000107	30916	2016/08/10	0.50	-43.6	10.18	-4.08
PFM000107	30952	2016/10/13	0.50	-38.3	9.00	-3.81
PFM000117	30727	2016/01/18	0.50	-54.1	8.51	-6.46
PFM000117	30728	2016/01/18	1.50	-57.3	8.30	-6.92
PFM000117	30769	2016/04/18	0.50	-59.5	7.60	-8.18
PFM000117	30914	2016/08/09	0.50	-47.8	10.52	-4.96
PFM000117	30951	2016/10/13	0.50	-43.8	8.61	-4.53
PFM007783	30917	2016/08/11	0.50	-59.5	6.59	-8.17
PFM007783	30948	2016/10/10	0.50	-57.1	6.56	-7.88
PFM102269	30724	2016/01/21	0.50		6.53	
PFM102269	30742	2016/02/15	0.50		2.20	
PFM102269	30749	2016/03/16	0.50		4.10	
PFM102269	30766	2016/04/19	0.50		8.78	
PFM102269	30818	2016/05/23	0.50		6.30	
PFM102269	30895	2016/06/27	0.50		C	
PFM102269	30910	2016/08/09	0.50	-61.0	7.19	-8.36
PFM102269	30918	2016/09/04	0.50	-58.9	7.34	-7.96
PFM102269	30949	2016/10/10	0.50	-57.9	6.73	-8.06
PFM102269	30953	2016/11/07	0.50	-58.1	84.00	-7.53
PFM102269	30967	2016/12/06	0.50	-60.8	88.99	-8.19

C = No tritium result due to delivery problems to contracted laboratory.

Idcode	Sample no.	Sampling date (yyyy-mm-dd)	Depth (m)	Al (ug/L)	Cd (ug/L)	Cr (ug/L)	Cu (ug/L)	Co (ug/L)	Hg (ug/L)	Ni (ug/L)	Zn (ug/L)	Pb (ug/L)	V (ug/L)	Mo (ug/L)	Ba (ug/L)	Se (ug/L)	U (ug/L)	TH (ug/L)	SC (ug/L)	RB (ug/L)	Y (ug/L)	ZR (ug/L)	SB (ug/L)	CS (ug/L)	LA (ug/L)	HF (ug/L)	TL (ug/L)	CE (ug/L)	PR (ug/L)	ND (ug/L)	SM (ug/L)	EU (ug/L)	GD (ug/L)	TB (ug/L)	DY (ug/L)	HO (ug/L)	ER (ug/L)	TM (ug/L)	YB (ug/L)	LU (ug/L)		
PFM000107	30726	2016/01/18	0.50	5.11	0.0027	0.0969	0.486	0.0413	< 0.002	0.282	1.330	0.0433	0.143	0.559	19.90	< 0.5	2.820	0.035	< 0.05	3.040	0.108	0.359	0.062	< 0.03	0.052	0.072	< 0.01	0.066	0.014	0.067	0.014	< 0.005	0.015	< 0.005	0.015	< 0.005	0.012	< 0.004	0.012	< 0.005		
PFM000107	30725	2016/01/18	1.00	8.21	0.0029	0.1070	0.589	0.0606	< 0.002	0.357	1.220	0.0427	0.182	0.654	23.50	< 0.5	3.880	0.050	< 0.05	3.060	0.148	0.527	0.068	< 0.03	0.079	0.078	< 0.01	0.101	0.019	0.090	0.018	< 0.005	0.021	< 0.005	0.020	< 0.005	0.015	< 0.004	0.015	< 0.005		
PFM000107	30774	2016/04/19	0.50	4.81	0.0038	0.0983	0.605	0.0376	< 0.002	0.305	0.710	0.0483	0.154	0.497	14.80	< 0.5	2.630	< 0.02	< 0.05	1.970	0.120	0.159	0.060	< 0.03	0.050	< 0.005	< 0.01	0.063	0.014	0.055	0.012	< 0.005	0.009	< 0.005	0.014	< 0.005	0.009	< 0.004	0.011	< 0.005		
PFM000107	30916	2016/08/10	0.50	12.80	0.0026	0.0843	0.553	0.0659	< 0.002	0.311	4.220	0.1110	0.418	0.677	12.00	< 0.5	2.130	< 0.02	< 0.05	2.530	0.045	0.083	0.108	< 0.03	0.032	0.010	< 0.01	0.041	0.008	0.035	0.007	< 0.005	0.008	< 0.005	0.007	< 0.005	< 0.005	< 0.004	< 0.005	< 0.005		
PFM000107	30952	2016/10/13	0.50	3.65	0.0034	0.0749	0.373	0.0393	< 0.002	0.105	1.570	0.0855	0.135	0.586	15.20	< 0.5	1.680	< 0.02	< 0.05	2.720	0.031	0.077	0.082	< 0.03	0.022	< 0.005	< 0.01	0.027	0.006	0.023	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.004	< 0.005	< 0.005	
PFM000117	30727	2016/01/18	0.50	2.57	< 0.002	0.0751	0.565	0.0443	< 0.002	0.258	0.704	0.0254	0.244	0.406	18.70	< 0.5	1.660	0.022	< 0.05	2.560	0.071	0.294	0.076	< 0.03	0.023	0.060	< 0.01	0.020	0.008	0.030	0.008	< 0.005	0.008	< 0.005	0.009	< 0.005	0.007	< 0.004	0.008	< 0.005		
PFM000117	30728	2016/01/18	1.50	7.48	< 0.002	0.1000	0.637	0.0650	< 0.002	0.320	1.760	0.0319	0.217	0.372	22.80	< 0.5	1.770	0.033	< 0.05	2.570	0.137	0.363	0.084	< 0.03	0.059	0.057	< 0.01	0.064	0.015	0.072	0.015	< 0.005	0.018	< 0.005	0.018	< 0.005	0.014	< 0.004	0.014	< 0.005		
PFM000117	30769	2016/04/18	0.50	5.18	0.0034	0.0915	0.699	0.0410	< 0.002	0.240	2.470	0.0329	0.215	0.311	16.30	< 0.5	1.480	< 0.02	< 0.05	2.060	0.119	0.172	0.077	< 0.03	0.036	< 0.005	< 0.01	0.037	0.010	0.048	0.011	< 0.005	0.011	< 0.005	0.014	< 0.005	0.010	< 0.004	0.012	< 0.005		
PFM000117	30914	2016/08/09	0.50	9.78	0.0057	0.0711	0.600	0.0641	< 0.002	0.179	23.200	0.0207	0.393	0.430	11.00	< 0.5	1.830	< 0.02	< 0.05	2.220	0.027	0.093	0.117	< 0.03	0.006	0.009	< 0.01	< 0.005	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.004	< 0.005	< 0.005
PFM000117	30951	2016/10/13	0.50	3.24	0.0021	0.0582	0.579	0.0422	< 0.002	< 0.05	1.200	0.0180	0.331	0.421	12.70	< 0.5	1.740	< 0.02	< 0.05	2.530	0.024	0.102	0.103	< 0.03	< 0.005	< 0.005	< 0.01	< 0.005	< 0.005	0.007	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.004	< 0.005	< 0.005
PFM007783	30917	2016/08/11	0.50	1.14	< 0.02	< 0.04	0.597	< 0.02	< 0.002	0.689	4.390	< 0.1	0.138	1.280	17.90	< 3	0.544	< 0.2	< 0.4	15.500	0.023	< 0.1	0.108	< 0.1	< 0.02	< 0.02	< 0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
PFM007783	30948	2016/10/10	0.50	0.54	< 0.02	0.1100	0.511	< 0.02	< 0.002	< 0.2	0.843	< 0.1	0.099	1.280	17.20	< 3	0.505	< 0.2	< 0.4	17.800	0.024	< 0.1	< 0.1	< 0.1	< 0.02	< 0.02	< 0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
PFM102269	30910	2016/08/09	0.50	1.68	< 0.02	0.0708	0.553	0.0307	< 0.002	0.897	27.300	< 0.1	0.181	1.530	16.80	< 3	0.538	< 0.2	< 0.4	17.400	0.027	< 0.1	0.113	< 0.1	< 0.02	< 0.02	< 0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.074
PFM102269	30918	2016/09/04	0.50	< 0.3	< 0.02	0.0760	0.854	< 0.02	< 0.002	0.888	5.440	< 0.1	0.206	1.710	18.20	< 3																										
PFM102269	30949	2016/10/10	0.50	1.05	< 0.02	0.0794	0.610	< 0.02	< 0.002	< 0.2	1.670	< 0.1	0.146	1.430	16.60	< 3	0.550	< 0.2	< 0.4	17.400	0.025	< 0.1	< 0.1	< 0.1	< 0.02	< 0.02	< 0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
PFM102269	30953	2016/11/07	0.50	1.16	0.0162	0.0531	0.581	0.0139	< 0.002	0.730	9.840	< 0.02	0.154	1.350	17.40	< 3																										
PFM102269	30967	2016/12/06	0.50	2.02	< 0.02	0.0494	1.020	< 0.02	< 0.002	0.727	6.500	< 0.1	0.246	1.510	17.00	6.35																										

< "value" = below reporting limit.

SKB is responsible for managing spent nuclear fuel and radioactive waste produced by the Swedish nuclear power plants such that man and the environment are protected in the near and distant future.

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