

**P-05-85**

**Oskarshamn site investigation**  
**Hydrochemical logging in KLX06**

Cecilia Berg, Geosigma AB

September 2005

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*Keywords:* Core drilled borehole, Groundwater, Water sampling, Chemical analyses.

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

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## Abstract

Hydrochemical logging, or so called tube sampling, has been performed in the core drilled borehole KLX06. The method is a fast and simple sampling technique for obtaining information about the chemical composition of the water along an open borehole. The equipment consists of an approximately 1,000 m long polyamide tube divided into units of 50 m.

The water content in each tube unit constituted one sample. Every other sample, starting with the uppermost tube unit, was analysed according to SKB chemistry class 3 (no options included). Samples for isotope determination were collected at the time of sampling and stored in a freezer (tritium ( $^3\text{H}$ ) and carbon isotopes in a refrigerator);  $\delta^{18}\text{O}$ , deuterium ( $\delta\text{D}$ ),  $^{10}\text{B}$ , tritium,  $\delta^{37}\text{Cl}$  and  $^{87}\text{Sr}$  from odd-numbered tube units and  $\delta^{34}\text{S}$  and carbon isotopes from even-numbered tube units.

The content of flushing water remaining in the borehole after drilling was quite high in the deeper parts of the borehole. The maximum amount of flushing water was found at approximately 940 m where it was 60%. The relative charge balance error exceeded the acceptable limit of  $\pm 5\%$  in two out of ten analysed samples, no 7982 ( $-5.33\%$ ) from section 0–40 m and no 7994 ( $8.21\%$ ) from section 590–640 m along the borehole. The charge balance error was just outside the acceptable limit for the first of the two samples above.

## Sammanfattning

Hydrokemisk loggning, eller så kallad slangprovtagning, har utförts i det kärnborrade borrhålet KLX06. Metoden är snabb och enkel att använda för att erhålla information om den kemiska sammansättningen hos grundvattnet längs ett öppet borrhål. Utrustningen består av en cirka 1 000 m lång polyamidslang uppdelad i enheter om vardera 50 m.

Innehållet i en slangenhet utgör ett prov. Varannan slangenhet, med start från den översta, analyserades enligt SKB kemiklass 3 (exklusive tillval). Prover för bestämning av isotop-tillvalen togs ut vid provtagningstillfället och sparades i frys (tritium ( $^3\text{H}$ ) och kolisotoper i kylskåp);  $\delta^{18}\text{O}$ , deuterium ( $\delta\text{D}$ ),  $^{10}\text{B}$ , tritium,  $\delta^{37}\text{Cl}$  och  $^{87}\text{Sr}$  ur udda enheter,  $\delta^{34}\text{S}$  och kolisotoper ur jämna enheter.

Halten kvarvarande spolvatten i borrhålet efter borrning var ganska hög i de djupare sektionerna. Den högsta spolvattenhalten uppmättes till just över 60 % i botten på borrhålet. Det relativa felet i jonbalansen översteg den acceptabla nivån av  $\pm 5\%$  i två av tio analyserade prover, nummer 7982 ( $-5,33\%$ ) från sektion 0–40 meter samt nummer 7994 ( $8,21\%$ ) från sektion 590–640 meter längs borrhålet. Jonbalansfelet var just utanför den acceptabla gränsen i det första av de två fallen.

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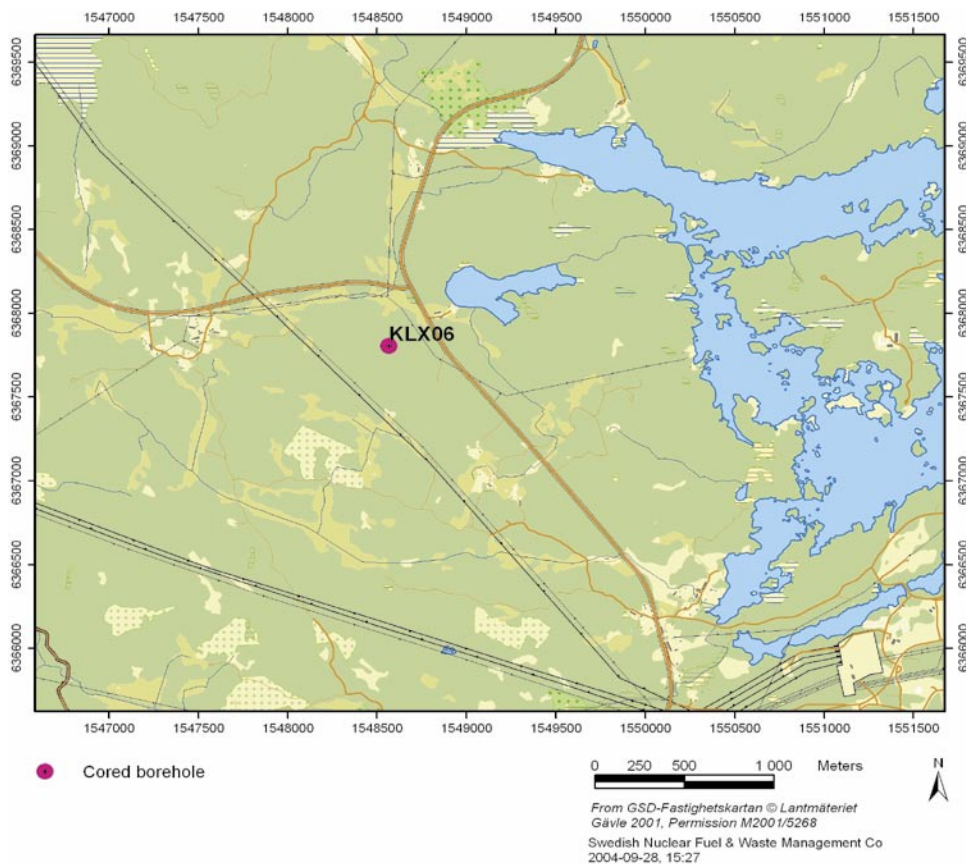
# 1 Introduction

This document reports the performance and results from hydrochemical logging in borehole KLX06. The hydrochemical logging is one of the activities performed within the site investigation at Oskarshamn /1/. The work was carried out in accordance with activity plan SKB AP PS 400-04-109 (SKB internal controlling document). The controlling documents for the performance of this activity are listed in Table 1-1. The obtained data from the activity are reported to the database SICADA.

Borehole KLX06 is a 997.98 m long telescopic borehole, drilled within the site investigation in the Oskarshamn area. The percussion borehole HLX20 served as the source of flushing water for the drilling of KLX06. The location of KLX06 is shown in Figure 1-1.

**Table 1-1. SKB internal controlling documents for the performance of the activity.**

| Activity plan                             | Number           | Version |
|---|------------------|---------|
| Hydrokemisk loggning i KLX06              | AP PS 400-04-109 | 1.0     |
| Method descriptions                       | Number           | Version |
| Metodbeskrivning för hydrokemisk loggning | SKB MD 422.001   | 1.0     |



**Figure 1-1.** Location of the core drilled borehole KLX06 within the site investigation in the Oskarshamn area.

## 2 Objective and scope

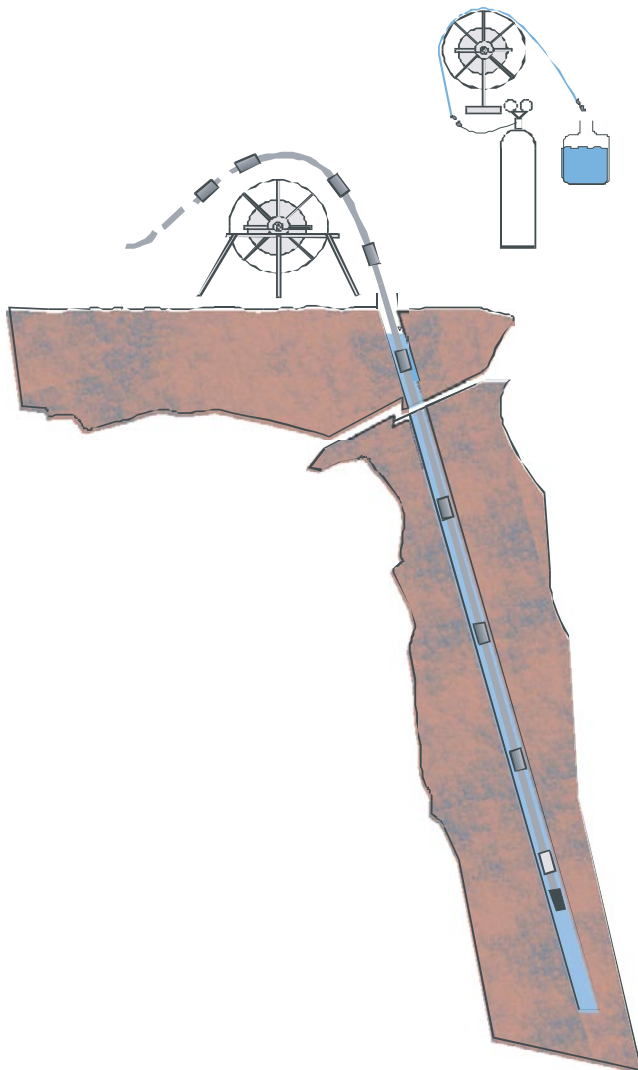
Hydrochemical logging was performed in order to obtain an overview of the chemical composition of the water along the open borehole KLX06. The technique used for sampling is fast and simple, even at great depth.

The analysis program was carried out according to SKB chemistry class 3 except for optional isotopes. Sample portions intended for isotope analyses were collected at the time of sampling, but have not been analysed. The samples are stored in a freezer at SKB (except the samples collected for determination of tritium and carbon isotopes; these samples were stored in a refrigerator) until further notice. If samples from the activity are analysed for isotopes, the results from those analyses will be presented in a separate report.

### 3 Sampling equipment

For the hydrochemical logging an approximately 1,000 m long polyamide tube, divided into units of 50 m, was used. The equipment is described in the method description, see Table 1-1.

A schematic picture of the equipment used for the hydrochemical logging is shown in Figure 3-1. The tube units are connected using couplings. The length of each tube unit is given in Table 3-1. The first tube lowered down the borehole has a non-return valve at the bottom to prevent water outflow while lifting the tube units. The external and internal diameters of the tube units are 10 and 8 mm, respectively. The water content in each tube unit constitutes one sample, and the volume of each sample is approximately two and a half litres. At the lower end of the tube array, a weight is added in order to stretch the array and thereby prevent fastening.



**Figure 3-1.** Equipment for hydrochemical logging in boreholes. At the lower end of the tube array there is a check valve and a weight connected. Each tube unit is 50 m long.



**Table 3-1. Length of tube units used for the hydrochemical logging in KLX06.**

| <b>Unit</b>           | <b>Length (m)</b> |
|-----------------------|-------------------|
| 1                     | 49.71             |
| 2                     | 50.08             |
| 3                     | 49.77             |
| 4                     | 49.28             |
| 5                     | 49.97             |
| 6                     | 50.01             |
| 7                     | 49.85             |
| 8                     | 49.87             |
| 9                     | 49.57             |
| 10                    | 49.72             |
| 11                    | 49.67             |
| 12                    | 50.25             |
| 13                    | 50.62             |
| 14                    | 49.70             |
| 15                    | 49.22             |
| 16                    | 49.20             |
| 17                    | 49.30             |
| 18                    | 49.63             |
| 19                    | 49.62             |
| 20                    | 49.87             |
| Sum:                  | 994.91            |
| Couplings             | 2.812             |
| Weight                | 0.817             |
| Total tube<br>length: | 998.539           |

## 4 Performance

### 4.1 Hydrochemical logging

The hydrochemical logging in KLX06 was performed on December 21, 2004.

The lowering of the tube units started at 08:17. The tubes were lowered down the borehole at a rate of about five metres/minute. The equipment was lowered to a depth of 990 m, i.e. the length of the borehole subtracted by 8 m, in order to avoid sedimentation of drilling debris at the bottom of the borehole, and thereby decrease the risk of fastening. The lifting of the tubes started at 12:03, and the last tube unit was retrieved at 13:29. The tube unit at the top of the tube array was lowered to 40 m of its length. This and a ground water level at the logging occasion resulted in a not completely filled tube unit. Pressurized nitrogen gas was used to empty the tube units and the water samples were portioned into sample bottles. Each tube unit represents one sample.

The ground water level before and after completed logging was 5.90 m and 5.96 m, respectively, measured from the top of the casing.

### 4.2 Sample treatment and chemical analysis

An overview of sample treatment and analysis routines is given in Appendix 1. The routines are applicable irrespectively of sampling object or sampling method.

An overview showing the samples obtained at the logging occasion is given in Table 4-1. Sample portions intended for isotope analyses were collected at the sampling occasion but not sent for analysis. These samples are stored in a freezer at SKB (except the sample collected for tritium determination which is stored in refrigerator). The collected samples intended for isotope analysis may be sent for analysis, and in that case, the results will be presented in a separate report. The data from the hydrochemical logging are stored in the database SICADA. The SKB sample numbers are 7982–7999 and 10000–10001.

The uppermost tube unit was not completely filled, see Section 4.1. All other tube units seemed, by visual inspection, to be fully filled with sample water; only small bubbles of gas was observed during lifting. Due to the lack of water in the first tube unit, see above, archive samples from the second tube unit was not obtained. Water intended for archive samples in the second unit were used to fill sample bottles for analyses of  $\delta^{37}\text{Cl}$ ,  $^{10}\text{B}/^{11}\text{B}$  and  $^{86}\text{Sr}/^{87}\text{Sr}$  from the first section (0–40 m).

**Table 4-1. Overview of samples collected at the hydrochemical logging in KLX06. Filled cells represent collected samples. Dark (blue) filling represents samples that has been analysed, light (yellow) filling represents samples collected and stored in a freezer (tritium and carbon isotopes in a refrigerator) and dashed (purple) cells represent archive samples.**

| Sample information |            |        | Collected sample portions |            |         |         |                |                      |                    |                 |                  |                   | Archive    |                   |
|--------------------|------------|--------|---------------------------|------------|---------|---------|----------------|----------------------|--------------------|-----------------|------------------|-------------------|------------|-------------------|
| Tube unit          | Length (m) | SKB no | Cond, pH, alk             | Major Comp | Uranine | An-ions | <sup>3</sup> H | δD/δ <sup>18</sup> O | δ <sup>37</sup> Cl | <sup>10</sup> B | <sup>87</sup> Sr | δ <sup>34</sup> S | C-isotopes | Filtered 2×250 mL |
| 1                  | 0-40       | 7982   |                           |            |         |         |                |                      | Ж                  | Ж               | Ж                |                   |            |                   |
| 2                  | 90         | 7983   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 3                  | 140        | 7984   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 4                  | 190        | 7985   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 5                  | 240        | 7986   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 6                  | 290        | 7987   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 7                  | 340        | 7988   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 8                  | 390        | 7989   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 9                  | 440        | 7990   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 10                 | 490        | 7991   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 11                 | 540        | 7992   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 12                 | 590        | 7993   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 13                 | 640        | 7994   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 14                 | 690        | 7995   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 15                 | 740        | 7996   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 16                 | 790        | 7997   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 17                 | 840        | 7998   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 18                 | 890        | 7999   |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 19                 | 940        | 10000  |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |
| 20                 | 990        | 10001  |                           |            |         |         |                |                      |                    |                 |                  |                   |            |                   |

Ж Filled with sample water from tube unit 2.

### 4.3 Data handling

The following routines for quality control and data management are generally applied for hydrogeochemical analysis data, irrespectively of sampling method or sampling object.

All analytical results were stored in the SICADA database. The applied hierarchy path “Hydrochemistry/Hydrochemical investigation/Analyses/Water in the database” contains two types of tables, raw data tables and primary data tables (final data tables).

Data from **basic water analyses** are inserted into raw data tables for further evaluation. The evaluation results in a final data set for each sample. These data sets are compiled in a primary data table named “water\_composition”. The evaluation is based on:

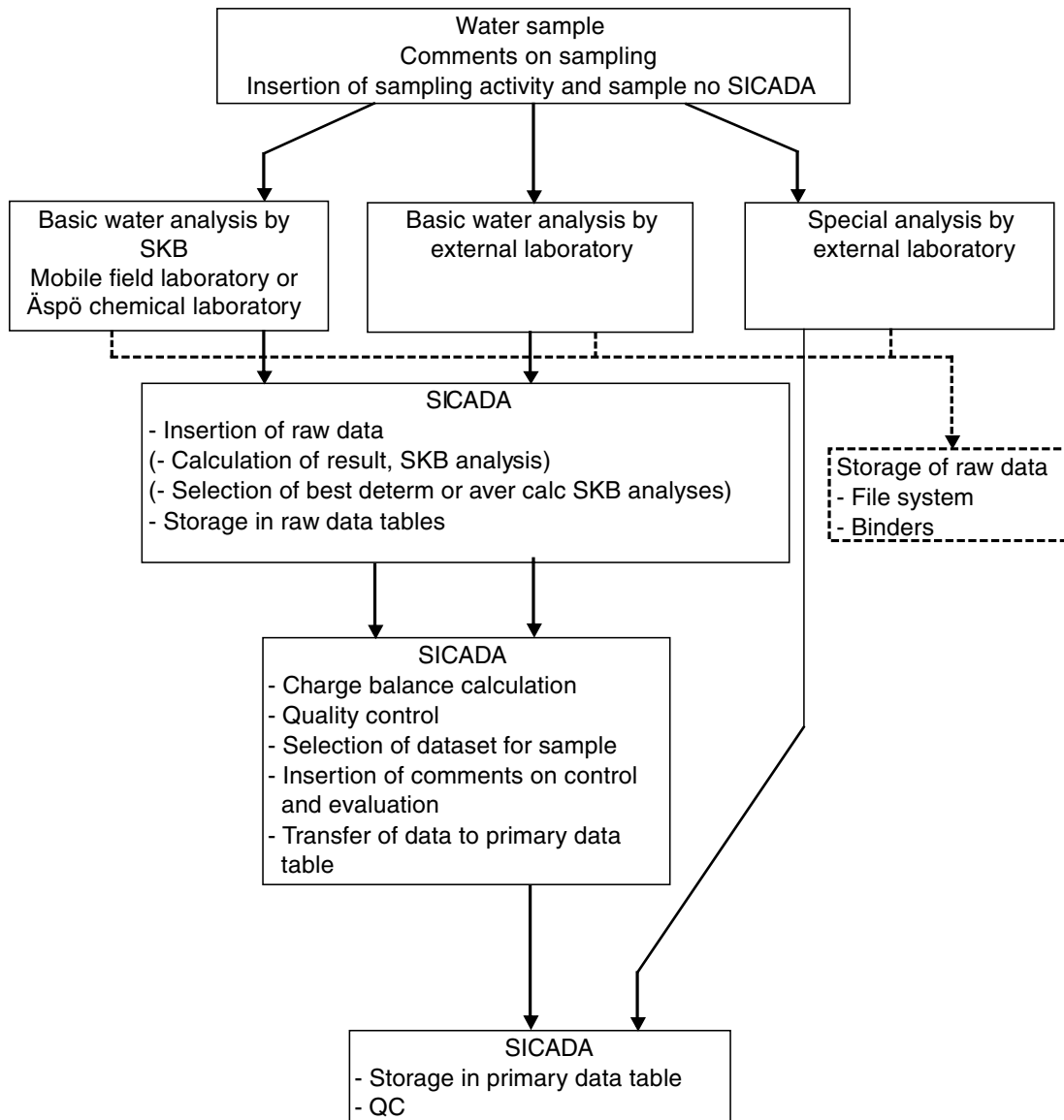
- Comparison of the results from different laboratories and/or methods. The analyses are repeated if a large disparity is noted (generally more than 10%).
- Calculation of charge balance errors. Relative errors within  $\pm 5\%$  are considered acceptable (in surface waters  $\pm 10\%$ ).

$$\text{Relative error (\%)} = 100 \times \frac{\sum \text{cations(equivalents)} - \sum \text{anions(equivalents)}}{\sum \text{cations(equivalents)} + \sum \text{anions(equivalents)}}$$

- General expert judgement of plausibility based on earlier results and experiences.

All results from **special analyses of trace metals and isotopes** are inserted directly into primary data tables. In cases where the analyses are repeated or performed by more than one laboratory, a “best choice” notation will indicate the results considered most reliable.

An overview of the data management is given in Figure 4-1.



*Figure 4-1. Overview of data management for hydrogeochemical data.*

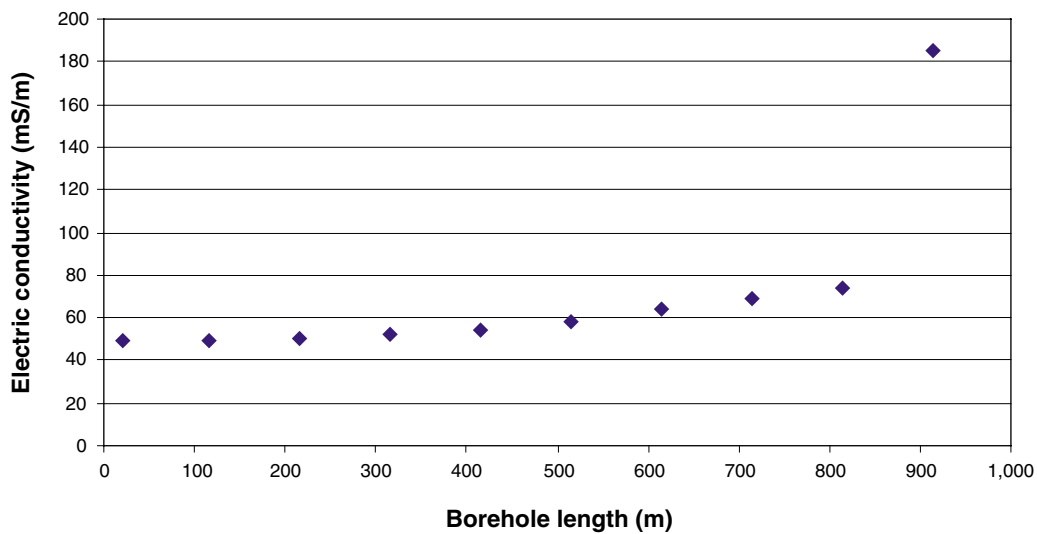
#### 4.4 Nonconformities

The activity was performed according to the controlling documents without any deviations that can affect the quality of the data.

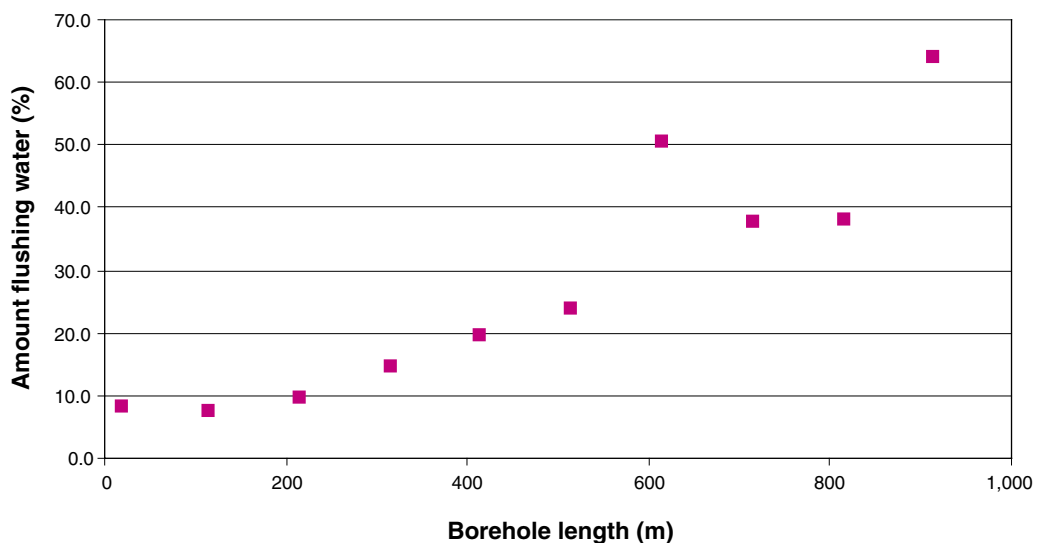
# 5 Results

## 5.1 Analysis results

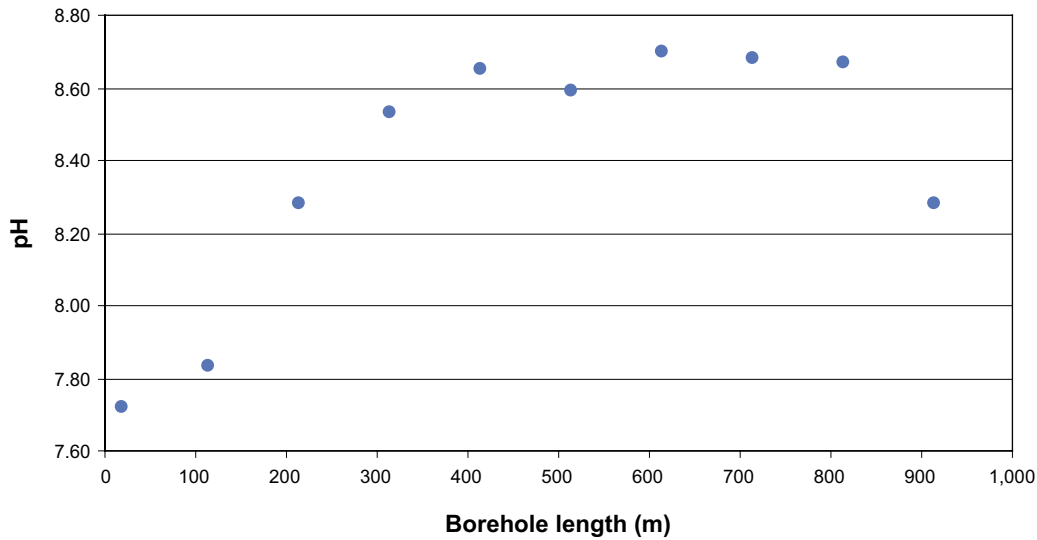
Results from the chemical analysis are given in Appendix 2. Diagrams showing the flushing water content and the electric conductivity along the borehole, at the time of the hydrochemical logging, are presented in Figures 5-1 and 5-2. Results from analyses of pH, some of the major constituents (Na, Ca and Cl<sup>-</sup>) and sulphate (SO<sub>4</sub><sup>2-</sup>) are shown in Figures 5-3 to 5-5, respectively. Results are plotted for the mid-length of each tube unit. For example, the first tube is plotted at 20 m.



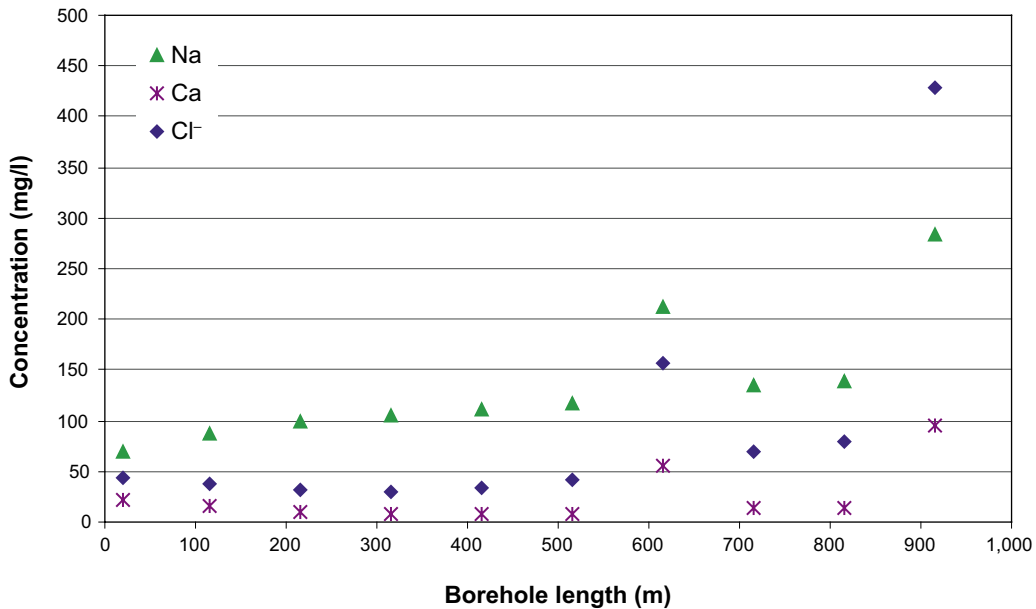
*Figure 5-1. Amount of flushing water remaining at different borehole lengths at the time of the hydrochemical logging in KLX06.*



*Figure 5-2. Electric conductivity values along the borehole KLX06 obtained from the hydrochemical logging.*



**Figure 5-3.** Results from pH measurements obtained from the hydrochemical logging in KLX06.



**Figure 5-4.** Results from analysis of the constituents Na, Ca and Cl<sup>-</sup> in water samples obtained from hydrochemical logging in KLX06.

Sulphate (SO<sub>4</sub><sup>2-</sup>) analysed by using ion chromatography (IC) is compared with sulphate determined as total sulphur using inductively coupled plasma atomic emission spectrometry (ICP-AES) in Figure 5-5. The values obtained from ICP-AES are higher than from IC in all samples.

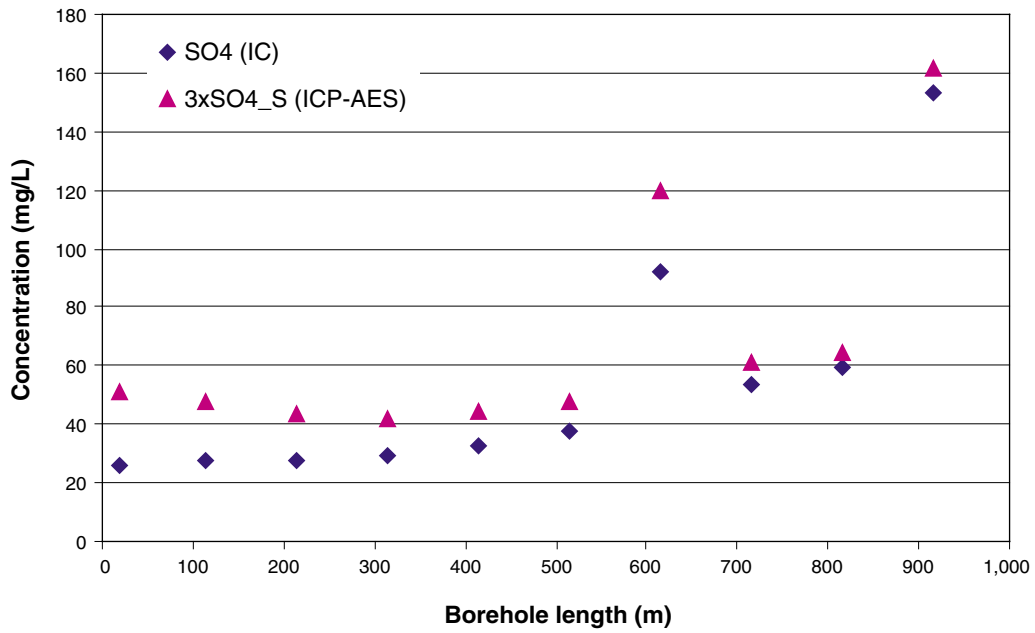


Figure 5-5. Sulphate (IC) compared to total sulphur (ICP-AES).

## 5.2 Quality of the analyses

The charge balance errors give an indication of the quality and uncertainty of the analyses of major constituents. The relative charge balance errors were calculated for the selected sets of data, see Appendix 2. If the relative errors are within  $\pm 5\%$  they are considered acceptable. The errors did exceed 5% in two out of ten cases, no 7982 ( $-5.33\%$ ) and 7994 ( $8.21\%$ ). Sample 7994 indicates an error larger than the 8.21% charge balance error.



## 6 Conclusions

At the hydrochemical logging in KLX06, the following chemical conditions were found:

- The amount of remaining flushing water at the time of the hydrochemical logging was increasing down the borehole. The maximum was found at the bottom of the borehole where it was just above 60%.
- The charge balance error, giving an indication of the quality and uncertainty of the analyses, exceeded the acceptable level in two cases, sample no 7982 (charge balance -5.33%) from section 0–40 m and sample no 7994 (charge balance 8.21%) from section 590–640 m.
- The electric conductivity and the chloride concentration increased only slightly down the borehole. The highest values were 190 mS/m and 430 mg/L, respectively (both values from the deepest part measured along the borehole).
- Sample no 7994 is somewhat deviating from the other samples with its charge balance error and deviation from the trend of increasing values for content of flushing water and major components down the borehole. The deviation may partly be explained by the higher amount of flushing water compared to the adjacent sections, but the electric conductivity is not lower in sample 7994 than in nearby sections as would be expected if that was the case. The results for this sample are questionable and error during sampling and/or analyses can not be excluded even if no deviations of such are reported.

## 7 References

- /1/ **SKB, 2001.** Generellt genomförande program för platsundersökningar.  
SKB R-01-10, Svensk Kärnbränslehantering AB.

## Sampling and analysis method

Table A1-1. Overview of general sample handling routines and analysis methods.

| Component group                            | Component/element   | Sample container (material)               | Volume (mL) | Filtering              | Preparation/conservation*                      | Analysis method   | Laboratory***   | Analysis within – or delivery time to lab |
|--|---|---|-------------|------------------------|--|---|---|---|
| Anions 1                                   | HCO <sub>3</sub><br>pH(lab)<br>cond (lab)                               | Plastic                                   | 250         | No                     | No   | Titration<br>Pot. meas,<br>Cond. meas   | Åspö's chemistry<br>lab                                 | The same day<br>– maximum 24 hours        |
| Anions 2                                   | Cl, SO <sub>4</sub> , Br <sup>-</sup> , F <sup>-</sup> , I <sup>-</sup> | Plastic                                   | 250         | Yes (not in the field) | No   | Titration (Cl <sup>-</sup> )<br>IC (Cl <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup> , Br <sup>-</sup> , F <sup>-</sup> )<br>ISE (F <sup>-</sup> ) | Åspö's chemistry<br>lab                                 | Not critical (month)                      |
| Cations, Si and S according to SKB class 3 | Na, K, Ca, Mg, S(tot), Si(tot), Li, Sr                                  | Plastic (at low conc acid washed bottles) | 100         | Yes (not in the field) | Yes (not in the field, 1 mL HNO <sub>3</sub> ) | ICP-AES<br>ICP-MS   | Analytica AB  | Not critical (month)                      |
| Environmental isotopes                     | <sup>2</sup> H, <sup>18</sup> O   | Plastic                                   | 100         | No                     | –  | MS  | IFE   | Not critical (month)                      |
| Tritium,                                   | <sup>3</sup> H (enhanced.)  | Plastic (dry bottle)                      | 500         | No                     | –  | LSC   | Univ Of Waterloo  | Not critical (month)                      |
| Chlorine-37                                | Chlorine-37   | Plastic                                   | 500         | No                     | –  | ICP MS  | Univ Of Waterloo  | Not critical (month)                      |
| Carbon isotopes                            | <sup>13</sup> C, <sup>14</sup> C  | Glass (brown)                             | 100x2       | No                     | –  | (A)MS   | Univ Of Waterloo<br>The Ångström<br>laboratory, Uppsala | A few days                                |
| Sulphur isotopes                           | <sup>34</sup> S   | Plastic                                   | 500–1,000   | No                     | –  | Combustion, ICP MS  | IFE   | No limit                                  |
| Strontium-isotopes                         | <sup>87</sup> Sr/ <sup>86</sup> Sr                                      | Plastic                                   | 100         | No                     | –  | TIMS  | IFE   | Days or Week                              |
| Boron isotopes                             | <sup>10</sup> B   | Plastic                                   | 100         | Yes                    | Yes (1 mL HNO <sub>3</sub> )                   | ICP – MS  | Analytica AB  | No limit                                  |
| Archive samples without acid               | –   | Plastic                                   | 250x2 **    | Yes                    | No   | –   | –   | Storage in freeze                         |

\* Suprapur acid is used for conservation of samples.

\*\* Minimum number, the number of archive samples can vary depending on how many similar samples that are collected at the same occasion.

\*\*\* Full name and address is given in Table A1-2.

**Abbreviations and definitions:**

|         |   |
|---------|---|
| IC      | Ion chromatograph                                       |
| ISE     | Ion selective electrode                                 |
| ICP-AES | Inductively Coupled Plasma Atomic Emission Spectrometry |
| ICP-MS  | Inductively Coupled Plasma Mass Spectrometry            |
| INAA    | Instrumental Neutron Activation Analysis                |
| MS      | Mass Spectrometry                                       |
| LSC     | Liquid Scintillation Counting                           |
| (A)MS   | (Accelerator) Mass Spectrometry                         |
| GC      | Gas Chromatography                                      |

**Table A1-2. Consulted laboratories, full name and address.**

---

|                                     |
|-------------------------------------|
| Åspö waterchemical laboratory (SKB) |
| Analytica AB                        |
| Aurorum 10                          |
| 977 75 Luleå                        |
| (Nytorpsvägen 16                    |
| Box 511                             |
| 183 25 Täby)                        |
| Environmental Isotope Laboratory    |
| Dep Of Earth Sciences               |
| University of Waterloo              |
| Waterloo, Ontario                   |
| N2L 3G1 CANADA                      |
| Institutt for energiteknik (IFE)    |
| Insituttveien 18                    |
| P.O Box 40                          |
| 2027 Kjeller                        |
| NORGE                               |
| The Ångström laboratory             |
| Box 534                             |
| Se-751 21 Uppsala                   |

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## Appendix 2

### Water composition

Compilation April 2005

| Icode | Secup<br>m | Seclow<br>m | Sample<br>no | Charge<br>Bal % | Na<br>mg/L | K<br>mg/L | Ca<br>mg/L | Mg<br>mg/L | HCO <sub>3</sub> <sup>-</sup><br>mg/L | Cl <sup>-</sup><br>mg/L | SO <sub>4</sub> <sup>2-</sup><br>mg/L | SO <sub>4</sub> -S<br>mg/L | Br <sup>-</sup><br>mg/L | F <sup>-</sup><br>mg/L | Si<br>mg/L | Fe<br>mg/L | Mn<br>mg/L | Li<br>mg/L | Sr<br>mg/L | pH   |
|-------|------------|-------------|--------------|-----------------|------------|-----------|------------|------------|---------------------------------------|-------------------------|---------------------------------------|----------------------------|-------------------------|------------------------|------------|------------|------------|------------|------------|------|
|       |            |             |              |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |
| KLX06 | 0          | 40          | 7982         | -5.33           | 69.1       | 2.13      | 22.8       | 3.5        | 157                                   | 42.9                    | 26.2                                  | 17.0                       | < 0.20                  | 3.09                   | 6.61       | 0.084      | 0.208      | 0.014      | 0.174      | 7.72 |
| KLX06 | 40         | 90          | 7983         |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |
| KLX06 | 90         | 140         | 7984         | -4.80           | 87.5       | 1.74      | 15.4       | 2.6        | 188                                   | 37.5                    | 27.4                                  | 15.8                       | < 0.20                  | 3.99                   | 6.85       | 0.569      | 0.121      | 0.016      | 0.163      | 7.84 |
| KLX06 | 140        | 190         | 7985         |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |
| KLX06 | 190        | 240         | 7986         | -3.78           | 98.8       | 1.53      | 10.8       | 1.9        | 207                                   | 31.5                    | 27.5                                  | 14.4                       | < 0.20                  | 4.77                   | 5.87       | 0.038      | 0.055      | 0.014      | 0.155      | 8.28 |
| KLX06 | 240        | 290         | 7987         |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |
| KLX06 | 290        | 340         | 7988         | -2.96           | 106.0      | 1.63      | 8.5        | 1.5        | 216                                   | 29.5                    | 29.5                                  | 14.0                       | < 0.20                  | 5.26                   | 5.68       | 0.060      | 0.030      | 0.016      | 0.152      | 8.53 |
| KLX06 | 340        | 390         | 7989         |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |
| KLX06 | 390        | 440         | 7990         | -2.44           | 112.0      | 1.73      | 7.9        | 1.4        | 218                                   | 32.7                    | 32.5                                  | 14.7                       | < 0.20                  | 5.44                   | 5.63       | 0.054      | 0.024      | 0.018      | 0.161      | 8.66 |
| KLX06 | 440        | 490         | 7991         |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |
| KLX06 | 490        | 540         | 7992         | -1.86           | 118.0      | 1.90      | 8.7        | 1.4        | 215                                   | 40.9                    | 37.7                                  | 15.9                       | < 0.20                  | 5.49                   | 5.68       | 0.086      | 0.024      | 0.020      | 0.183      | 8.59 |
| KLX06 | 540        | 590         | 7993         |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |
| KLX06 | 590        | 640         | 7994         | 8.21            | 212.0      | 3.43      | 55.6       | 5.3        | 213                                   | 156.0                   | 92.1                                  | 39.9                       | 0.93                    | 4.77                   | 4.50       | 0.139      | 0.102      | 0.034      | 1.030      | 8.70 |
| KLX06 | 640        | 690         | 7995         |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |
| KLX06 | 690        | 740         | 7996         | -1.35           | 135.0      | 2.44      | 13.0       | 1.7        | 209                                   | 68.7                    | 53.6                                  | 20.4                       | 0.33                    | 5.23                   | 5.38       | 0.029      | 0.027      | 0.022      | 0.255      | 8.68 |
| KLX06 | 740        | 790         | 7997         |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |
| KLX06 | 790        | 840         | 7998         | -1.96           | 139.0      | 2.74      | 14.7       | 1.8        | 209                                   | 78.9                    | 59.7                                  | 21.6                       | 0.33                    | 5.43                   | 5.54       | 0.151      | 0.032      | 0.024      | 0.279      | 8.67 |
| KLX06 | 840        | 890         | 7999         |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |
| KLX06 | 890        | 940         | 10000        | -1.64           | 283.0      | 3.48      | 94.7       | 8.6        | 169                                   | 429.0                   | 153.0                                 | 53.8                       | 3.43                    | 3.83                   | 3.38       | 0.100      | 0.169      | 0.042      | 1.740      | 8.28 |
| KLX06 | 940        | 990         | 10001        |                 |            |           |            |            |                                       |                         |                                       |                            |                         |                        |            |            |            |            |            |      |

**Compilation April 2005**

| Idcode | Secup<br>m | Seclow<br>m | Sample<br>no | Drill_water<br>% | EICond<br>mS/m | δ 2H |      | δ 18O |      | 3H  |     | δ 37Cl |         | 10B/11B |     | 87Sr/86Sr |     | δ 34S |     | δ 13C |     | 14C<br>pmC |
|--------|------------|-------------|--------------|------------------|----------------|------|------|-------|------|-----|-----|--------|---------|---------|-----|-----------|-----|-------|-----|-------|-----|------------|
|        |            |             |              |                  |                | dev  | SMOW | dev   | SMOW | TU  | dev | SMOC   | no unit | no unit | dev | CDT       | dev | PDB   |     |       |     |            |
| KLX06  | 0          | 40          | 7982         | 8.1              | 48.7           | xxx  | xxx  | xxx   | xxx  | xxx | xxx | xxx    | xxx     | xxx     | xxx | xxx       | xxx | xxx   | xxx | xxx   | xxx | xxx        |
| KLX06  | 40         | 90          | 7983         | -                | -              | -    | -    | -     | -    | -   | -   | -      | -       | -       | -   | -         | -   | -     | -   | -     | -   | -          |
| KLX06  | 90         | 140         | 7984         | 7.5              | 48.5           | xxx  | xxx  | xxx   | xxx  | xxx | xxx | xxx    | xxx     | xxx     | xxx | xxx       | xxx | xxx   | xxx | xxx   | xxx | xxx        |
| KLX06  | 140        | 190         | 7985         | -                | -              | -    | -    | -     | -    | -   | -   | -      | -       | -       | -   | -         | -   | -     | -   | -     | -   | -          |
| KLX06  | 190        | 240         | 7986         | 9.6              | 50.2           | xxx  | xxx  | xxx   | xxx  | xxx | xxx | xxx    | xxx     | xxx     | xxx | xxx       | xxx | xxx   | xxx | xxx   | xxx | xxx        |
| KLX06  | 240        | 290         | 7987         | -                | -              | -    | -    | -     | -    | -   | -   | -      | -       | -       | -   | -         | -   | -     | -   | -     | -   | -          |
| KLX06  | 290        | 340         | 7988         | 14.4             | 52.0           | xxx  | xxx  | xxx   | xxx  | xxx | xxx | xxx    | xxx     | xxx     | xxx | xxx       | xxx | xxx   | xxx | xxx   | xxx | xxx        |
| KLX06  | 340        | 390         | 7989         | -                | -              | -    | -    | -     | -    | -   | -   | -      | -       | -       | -   | -         | -   | -     | -   | -     | -   | -          |
| KLX06  | 390        | 440         | 7990         | 19.4             | 54.4           | xxx  | xxx  | xxx   | xxx  | xxx | xxx | xxx    | xxx     | xxx     | xxx | xxx       | xxx | xxx   | xxx | xxx   | xxx | xxx        |
| KLX06  | 440        | 490         | 7991         | -                | -              | -    | -    | -     | -    | -   | -   | -      | -       | -       | -   | -         | -   | -     | -   | -     | -   | -          |
| KLX06  | 490        | 540         | 7992         | 23.9             | 58.1           | xxx  | xxx  | xxx   | xxx  | xxx | xxx | xxx    | xxx     | xxx     | xxx | xxx       | xxx | xxx   | xxx | xxx   | xxx | xxx        |
| KLX06  | 540        | 590         | 7993         | -                | -              | -    | -    | -     | -    | -   | -   | -      | -       | -       | -   | -         | -   | -     | -   | -     | -   | -          |
| KLX06  | 590        | 640         | 7994         | 50.4             | 63.8           | xxx  | xxx  | xxx   | xxx  | xxx | xxx | xxx    | xxx     | xxx     | xxx | xxx       | xxx | xxx   | xxx | xxx   | xxx | xxx        |
| KLX06  | 640        | 690         | 7995         | -                | -              | -    | -    | -     | -    | -   | -   | -      | -       | -       | -   | -         | -   | -     | -   | -     | -   | -          |
| KLX06  | 690        | 740         | 7996         | 37.6             | 69.4           | xxx  | xxx  | xxx   | xxx  | xxx | xxx | xxx    | xxx     | xxx     | xxx | xxx       | xxx | xxx   | xxx | xxx   | xxx | xxx        |
| KLX06  | 740        | 790         | 7997         | -                | -              | -    | -    | -     | -    | -   | -   | -      | -       | -       | -   | -         | -   | -     | -   | -     | -   | -          |
| KLX06  | 790        | 840         | 7998         | 37.9             | 73.5           | xxx  | xxx  | xxx   | xxx  | xxx | xxx | xxx    | xxx     | xxx     | xxx | xxx       | xxx | xxx   | xxx | xxx   | xxx | xxx        |
| KLX06  | 840        | 890         | 7999         | -                | -              | -    | -    | -     | -    | -   | -   | -      | -       | -       | -   | -         | -   | -     | -   | -     | -   | -          |
| KLX06  | 890        | 940         | 10000        | 64.0             | 185.0          | xxx  | xxx  | xxx   | xxx  | xxx | xxx | xxx    | xxx     | xxx     | xxx | xxx       | xxx | xxx   | xxx | xxx   | xxx | xxx        |
| KLX06  | 940        | 990         | 10001        | -                | -              | -    | -    | -     | -    | -   | -   | -      | -       | -       | -   | -         | -   | -     | -   | -     | -   | -          |

- = Not analysed  
A = results will be reported later  
x = No result due to sampling problems  
xx = No result due to analytical problems  
xxx = Stored in freezer/refrigerator  
< = result below detection limit  
Charge Bal % = Relative charge balance error %