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## **Oskarshamn site investigation**

### **Hydrochemical logging in KLX05**

#### **Results from isotope determinations ( $\delta^3\text{H}$ , $\delta^2\text{D}$ and $\delta^{18}\text{O}$ )**

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January 2006

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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 KLX05. The method is a fast and simple sampling technique to obtain information of 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 unit, was analysed according to SKB chemistry class 3 (excluding isotope options). The performance and results from this sampling has been reported in a previous report /1/. This report gives the results from the performed isotope determinations of tritium ( $^3\text{H}$ ), deuterium ( $\delta\text{D}$ ) and  $\delta^{18}\text{O}$ . Samples for isotope determinations were collected at the sampling occasion and stored in a freezer (tritium in a refrigerator) for approximately four months before they were sent to the consulted laboratories for analysis.

# Sammanfattning

Hydrokemisk loggning, även kallad slangprovtagning, har utförts i kärnborrhålet KLX05. Hydrokemisk loggning är en snabb och enkel provtagningsteknik för att erhålla information om vattenpelarens kemiska sammansättning längs ett öppet borrhål. Utrustningen utgörs av en cirka 1 000 m lång polyamid slang uppdelad i enheter om vardera 50 m.

Innehållet i en slangenhet utgör ett prov. Varannan enhet, med start från den översta, analyserades i enlighet med SKB kemiklass 3 utan tillägg i direkt anslutning till provtagningstillfället. Utförande och resultat från denna provtagning har rapporterats i en tidigare primärdatarapport /1/. Denna rapport redovisar resultaten från utförda isotopanalyser av tritium ( $^3\text{H}$ ), deuterium ( $\delta\text{D}$ ) och  $\delta^{18}\text{O}$ . Isotopprover togs ut i samband med provtagningen och sparades i frys respektive kyl (tritium) i cirka fyra månader innan de sändes iväg för analys till de konsulterade laboratorierna.

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# 1 Introduction

This document reports isotope results from the Hydrochemical logging in borehole KLX05, which is one of the activities performed within the site investigation at Oskarshamn /2/. The work was carried out in accordance with activity plan SKB AP PS 400-05-003. In Table 1-1 controlling documents for performance of this activity are listed. Both activity plan and method descriptions are SKB's internal controlling documents.

This report is a complement to the previous report regarding the Hydrochemical logging in KLX05 /1/, which documented the performance and results from analyses of major constituents, anions, flushing water content, electric conductivity, pH and hydrogen carbonate. The data from the activity is reported to the database SICADA.

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

<b>Activity plan</b>	<b>Number</b>	<b>Version</b>
Hydrokemisk loggning i KLX05	AP PS 400-05-003	1.0
<b>Method descriptions</b>	<b>Number</b>	<b>Version</b>
Metodbeskrivning för hydrokemisk loggning	SKB MD 422.001	1.0

## 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 KLX05. The technique used for sampling is fast and simple even at great depth.

The analysis program has previous been carried out according to SKB chemistry class 3 without isotope options and reported in a previous report /1/. The isotopes reported in this report were sent to be analysed approximately four months after the sampling occasion i.e. in the beginning of August 2005. Until they were sent for analyses they were stored in a freezer (tritium in a refrigerator). The conducted isotope determinations include tritium,  $\delta^{18}\text{O}$  and deuterium. For samples with high content of remaining flushing water, the isotope determinations are omitted (limit for flushing water content is determined by SKB at each logging occasion, for the present occasion the limit was set at approximately 25%).

## 3 Performance

### 3.1 Hydrochemical logging

The hydrochemical logging in KLX05 was performed April 6, 2005, according to the controlling documents for the activity (see Table 1-1).

The performance of the activity is described in a previous report regarding the hydrochemical logging in KLX05 /1/.

### 3.2 Sample treatment and chemical analysis

An overview of sample treatment and analysis routines is given in Appendix 1.

An overview showing the samples obtained at the logging occasion is given in Table 3-1. The sample portions for isotope analyses were stored in a freezer at SKB (tritium in a refrigerator) at the time of the hydrochemical logging. Samples collected for determination of tritium,  $\delta^{18}\text{O}$  and deuterium were analysed at the consulted laboratories approximately four months after the sampling occasion. Due to high flushing water content in some of the samples, only samples no 10208–10224 (even numbers) was sent for analysis. Remaining isotope samples collected are still stored in a freezer. The data from the hydrochemical logging are stored in the database SICADA. The SKB sample numbers are 10208-10227.

Due to the lack of water in the first tube unit, archive samples from the second tube unit were not obtained. Water intended for archive samples in the second unit were used to fill sample bottles for analyses of  $\delta^{37}\text{Cl}$ ,  $\delta\text{D}$  and  $\delta^{18}\text{O}$ ,  $^{10}\text{B}/^{11}\text{B}$  and  $^{87}\text{Sr}$  from the first section (0–40 m).



**Table 3-1. Overview of samples collected at the *Hydrochemical logging* in KLX05. Filled cells represent collected samples. Dark (blue) filling represents samples reported in a previous report /1/, light (yellow) filling represents isotope samples that have been analysed. Dashed yellow filling represents samples stored in a freezer (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 Const.	Ura- nine	An- ions	<sup>3</sup> H	$\delta$ D $\delta^{18}$ O	$\delta^{37}$ Cl	<sup>10</sup> B	<sup>87</sup> Sr	$\delta^{34}$ S	C- isotopes	Filtered 2×250 mL
1	0-40	10208	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Yellow	Light Yellow	Dashed Yellow	Dark Blue	Dashed Yellow			
2	90	10209										Dashed Yellow	Dashed Yellow	
3	140	10210	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Yellow	Light Yellow	Dashed Yellow	Dark Blue	Dashed Yellow			
4	190	10211										Dashed Yellow	Dashed Yellow	Dashed Purple
5	240	10212	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Yellow	Light Yellow	Dashed Yellow	Dark Blue	Dashed Yellow			
6	290	10213										Dashed Yellow	Dashed Yellow	Dashed Purple
7	340	10214	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Yellow	Light Yellow	Dashed Yellow	Dark Blue	Dashed Yellow			
8	390	10215										Dashed Yellow	Dashed Yellow	Dashed Purple
9	440	10216	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Yellow	Light Yellow	Dashed Yellow	Dark Blue	Dashed Yellow			
10	490	10217										Dashed Yellow	Dashed Yellow	Dashed Purple
11	540	10218	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Yellow	Light Yellow	Dashed Yellow	Dark Blue	Dashed Yellow			
12	590	10219										Dashed Yellow	Dashed Yellow	Dashed Purple
13	640	10220	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Yellow	Light Yellow	Dashed Yellow	Dark Blue	Dashed Yellow			
14	690	10221										Dashed Yellow	Dashed Yellow	Dashed Purple
15	740	10222	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Yellow	Light Yellow	Dashed Yellow	Dark Blue	Dashed Yellow			
16	790	10223										Dashed Yellow	Dashed Yellow	Dashed Purple
17	840	10224	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Yellow	Light Yellow	Dashed Yellow	Dark Blue	Dashed Yellow			
18	890	10225										Dashed Yellow	Dashed Yellow	Dashed Purple
19	940	10226	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dashed Yellow	Dashed Yellow	Dashed Yellow	Dark Blue	Dashed Yellow			
20	990	10227										Dashed Yellow	Dashed Yellow	Dashed Purple

⌘ filled with sample water from tube unit two.

### 3.3 Data handling

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

Several constituents are determined by more than one method and/or laboratory.

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

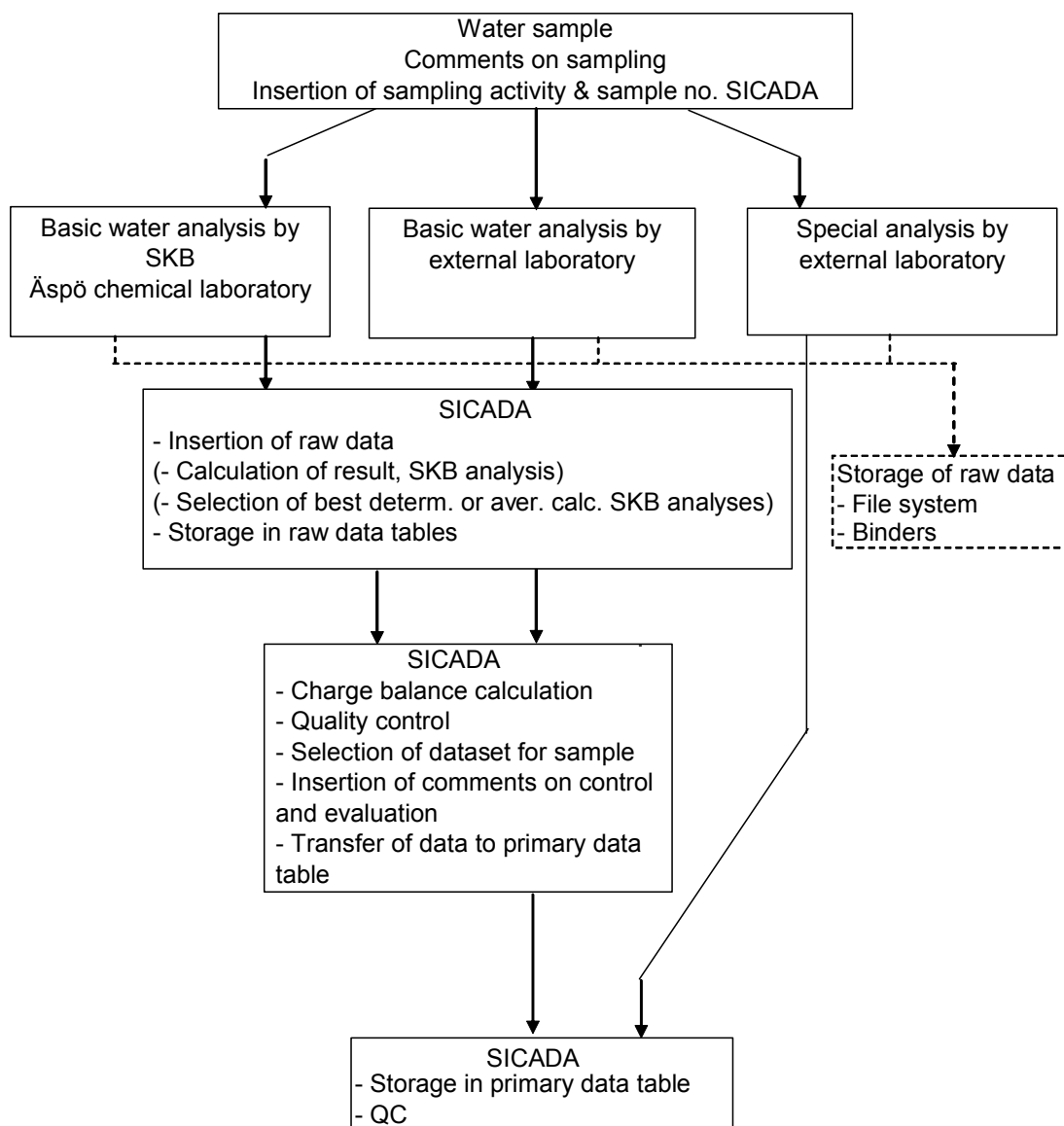
- Comparison of the results from different laboratories and/or methods. The analyses are repeated if a large disparity is noted (generally more than 10%).
- Calculation of charge balance errors. Relative errors within  $\pm 5\%$  are considered acceptable (in surface waters  $\pm 10\%$ ).

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

- 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 those cases where the analyses are repeated or performed by more than one laboratory, a “best choice” notation will indicate those results which are considered most reliable.

An overview of the data management is given in Figure 3-1.



**Figure 3-1.** Overview of data management for hydrogeochemical data. This report only handles the “Special analyses by external laboratory”. (The basic water analyses are reported in a previous report /1/).

### 3.4 Nonconformities

Samples for <sup>10</sup>B were analysed. The results from those analyses are reported in a previous report /1/ and in Appendix 2. Except from that, no deviation from the controlling documents for the activity is reported.

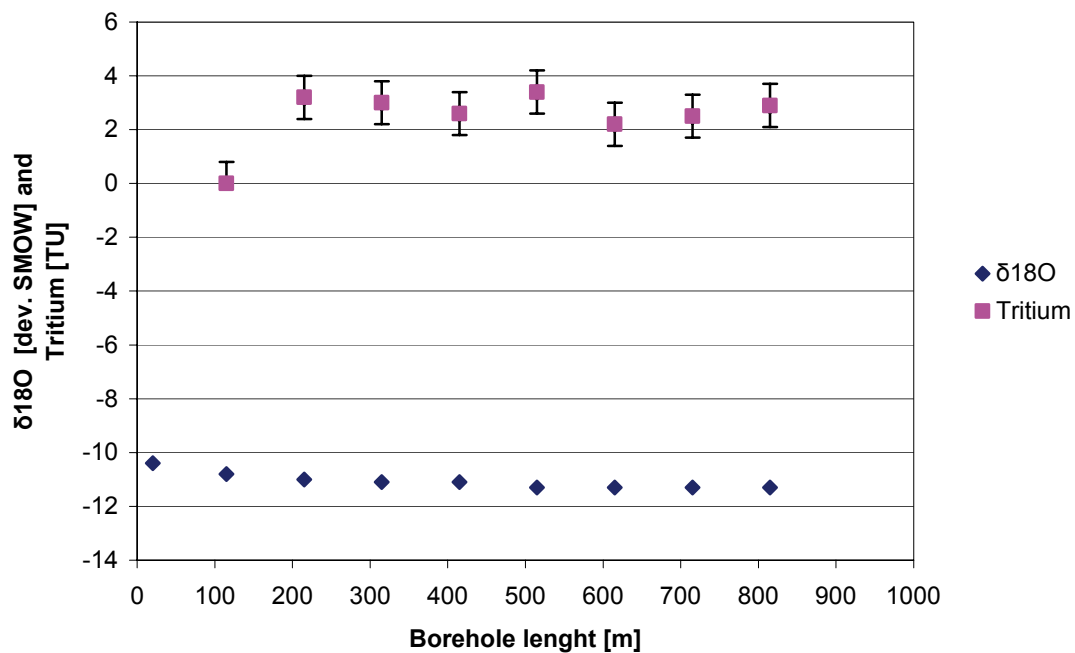
## 4 Results

### 4.1 Analysis results

The results from the conducted isotope determinations are given in Appendix 2. Diagrams showing the tritium and  $\delta^{18}\text{O}$  values along the borehole received from the hydrochemical logging are presented in Figure 4-1. Sample no 10208 (from section 0–40 m) is lacking tritium result, the sample “blew up” during analyse at the consulted laboratory. Results from deuterium determinations are shown in Table 4-1. Results are plotted for the mid-length of each tube unit, for example the first tube is plotted at 20 m.

**Table 4-1. Deuterium determinations for samples collected at the hydrochemical logging in KLX05.**

Sample SKB:no	$\delta\text{D}$ (dev. SMOW)
10208	-76.3
10210	-77.2
10212	-79.1
10214	-80.0
10216	-80.6
10218	-80.7
10220	-81.6
10222	-82.5
10224	-81.3



**Figure 4-1.** Tritium and  $\delta^{18}\text{O}$  data from samples collected in the core drilled borehole KLX05 at the hydrochemical logging.

## 5 References

- /1/ **Berg C, 2005.** Oskarshamn site investigation. Hydrochemical logging in KLX05. SKB P-05-195, Svensk Kärnbränslehantering AB.
- /2/ **SKB, 2001.** Generellt genomförande program för platsundersökningar. SKB R 01-10, Svensk Kärnbränslehantering AB.

## Sampling and analysis methods

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> <sup>-</sup> pH(lab) cond (lab)	Plastic	250	No	No	Titration Pot. meas, Cond. meas	Äspö's chemistry lab.	The same day – maximum 24 hours
Anions 2	Cl <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup> , Br <sup>-</sup> , F <sup>-</sup>	Plastic	250	Yes (in connection with analysis)	No	Titration (Cl <sup>-</sup> ) IC (Cl <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup> , Br <sup>-</sup> , F <sup>-</sup> )	Äspö's chemistry 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	Yes (1 mL HNO <sub>3</sub> )	ISE (F <sup>-</sup> ) ICP-AES 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), or plastic	100×4	No	–	(A)MS	Univ. Of Waterloo The Angström laboratory, Uppsala	A few days
Sulphur isotopes	<sup>34</sup> S	Plastic	1000	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	250×2 **	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 chromatography
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.**

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**Äspö waterchemical laboratory (SKB)**

Analytica AB  
Aurorum 10  
977 75 Luleå  
(Nytorsvägen 16  
Box 511  
183 25 Täby)

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Environmental Isotope Laboratory  
Dep. Of earth sciences  
University of Waterloo  
Waterloo, Ontario  
N2L 3G1 CANADA

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Institutt for energiteknik (IFE)  
Instituttveien 18  
P.O Box 40  
2027 Kjeller  
NORGE

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The Ångström laboratory  
Box 534  
Se-751 21 Uppsala

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## Isotopes, compilation of H- and O-isotopes

Compilation January 2006.

Idcode	Secup m	Seclow m	Sample no	$\delta^2\text{H}$ dev SMOW	$\delta^{18}\text{O}$ dev SMOW	$^3\text{H}$ TU	$\delta^{37}\text{Cl}$ dev SMOC	$^{10}\text{B}/^{11}\text{B}$ no unit	$^{87}\text{Sr}/^{86}\text{Sr}$ no unit	$\delta^{34}\text{S}$ dev CDT	$\delta^{13}\text{C}$ dev PDB	$^{14}\text{C}$ pmC
KLX05	0	40	10208	-76.3	-10.4	xx	xxx	0.2375	xxx	-	-	-
KLX05	40	90	10209	-	-	-	-	-	-	xxx	xxx	xxx
KLX05	90	140	10210	-77.2	-10.8	-0.8	xxx	0.2382	xxx	-	-	-
KLX05	140	190	10211	-	-	-	-	-	-	xxx	xxx	xxx
KLX05	190	240	10212	-79.1	-11.0	3.2	xxx	0.2371	xxx	-	-	-
KLX05	240	290	10213	-	-	-	-	-	-	xxx	xxx	xxx
KLX05	290	340	10214	-80.0	-11.1	3.0	xxx	0.2364	xxx	-	-	-
KLX05	340	390	10215	-	-	-	-	-	-	xxx	xxx	xxx
KLX05	390	440	10216	-80.6	-11.1	2.6	xxx	0.2363	xxx	-	-	-
KLX05	440	490	10217	-	-	-	-	-	-	xxx	xxx	xxx
KLX05	490	540	10218	-80.7	-11.3	3.4	xxx	0.2362	xxx	-	-	-
KLX05	540	590	10219	-	-	-	-	-	-	xxx	xxx	xxx
KLX05	590	640	10220	-81.6	-11.3	2.2	xxx	0.2353	xxx	-	-	-
KLX05	640	690	10221	-	-	-	-	-	-	xxx	xxx	xxx
KLX05	690	740	10222	-82.5	-11.3	2.5	xxx	0.2351	xxx	-	-	-
KLX05	740	790	10223	-	-	-	-	-	-	xxx	xxx	xxx
KLX05	790	840	10224	-81.3	-11.3	2.9	xxx	0.2357	xxx	-	-	-
KLX05	840	890	10225	-	-	-	-	-	-	xxx	xxx	xxx
KLX05	890	940	10226	xxx	xxx	xxx	xxx	0.2375	xxx	-	-	-
KLX05	940	990	10227	-	-	-	-	-	-	xxx	xxx	xxx

- = 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.