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Quality control of regional geochemical stream water samples collected in 2005 in Northern Ireland for the Tellus project

Geological Survey of Northern Ireland Programme

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COMMISSIONED REPORT CR/06/200N

Quality control of regional geochemical stream water samples collected in 2005 in Northern Ireland for the Tellus project

E L Ander

The Irish National Grid and other Ordnance Survey of Northern Ireland data are used in accordance with the Northern Ireland Mapping Agreement.

Keywords

Quality control; geochemistry; geochemical survey

Front cover

Monitor Site MSS2, Rostrevor, County Down. © EL Ander, 2005

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Maps and diagrams in this book use topography based on Ordnance Survey of Northern Ireland mapping.

Keyworth, Nottingham British Geological Survey 2009

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Foreword

This report gives details of the quality control work undertaken on the stream water samples collected for the purpose of regional geochemical mapping in Northern Ireland in 2005. These data are assessed as to whether they are fit-for-purpose, with additional comment made as to any extra provisos that are considered applicable to specific samples, or analytes, during any detailed follow-up work on small areas/ groups of samples. Methods used are those of the G-BASE project of the British Geological Survey, following on from the adoption of G-BASE sampling protocols.

Comparison with the samples collected in the period 1994-1996 by the G-BASE project do not form part of this work.

Acknowledgements

Dr Simon Chenery (BGS) is thanked for undertaking a thorough technical review of this document. Andrea Mills is thanked for help with the report formatting.

The outline image of Northern Ireland is used under the Northern Ireland Mapping Agreement (NIMA), courtesy of Ordnance Survey Northern Ireland (OSNI).

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Stream water samples were collected at a total of 3069 individual sites in the 2005 sampling campaign in Northern Ireland. These were submitted, with a full complement of control samples, for analysis for a suite of 57 analytes. Analysis was performed under contract by ALcontrol Laboratories NV, of the Netherlands. ALcontrol subcontracted some of the analyses to the Geological Survey of Finland (GTK). The data reported for these analytes have been considered by reference to their abundance in relation to the detection limit of the method, and in comparison with various control samples which were ‘blind’ to the analysts, submitted as part of the routine batches.

These checks have produced information on the quality of the data, and any causes of increased uncertainty which should be recognised in the presentation and interpretation of results. Levelling was applied to the Ba and Sr data (described in section 7.2). It has been found that, with a few exceptions, the data is fit-for-purpose and checks using provisional geochemical images have confirmed this. A summary of this information, listed by analyte, is provided below:

Analytes with no significant limitations identified in this report (n = 47):	Al, As, B, Ba, Be, Br, Ca, Cd, Cl, Co, Conductivity, Cr, Cs, Cu, DOC, F, Fe, HCO_3, Ho, K, La, Li, Mg, Mn, Mo, Na, Ni, NO_2, NO_3, P, Pb, pH, Rb, Sb, Si, SO_4, Sr, Th, Ti, Tl, Total alkalinity, U, V, W, Y, Zn, Zr
Analytes where most (>99%) sample site data is below the detection limit:	Ag, Au, Bi, Pd, Pt, Rh, Se
Analyte where blank water concentrations compromise sample site data:	Sn
Analyte with no measurable data by a semi-quantitative analytical method:	Hg

1 Introduction

This report describes the quality control of laboratory analysis of stream waters collected in Northern Ireland in 2005 under the Tellus projects at the Geological Survey of Northern Ireland (GSNI). The project was undertaken for, and financed by, the Department of Enterprise, Trade and Investment (DETI). The analytical work was undertaken by ALcontrol Laboratories of the Netherlands, under a contract awarded by open tender through the Northern Ireland Central Procurement Directorate. Further details of the field campaign can be found in Knights (2007).

All methods of sample collection and field-office procedures were as detailed in Johnson (2005). An additional sample was collected in the field. This unfiltered 30 ml sample was collected for the benefit of researchers in Queens University Belfast, concentrating on isotope analysis, and will not be discussed in this document. A non-conformity occurred in the storage and transport of samples after they left the field team. The samples were removed from the re-sealable plastic bag in which they are normally stored (Johnson, 2005, section 14.4), and stood on the shelf of the fridge in the Carrickfergus store. This store was also used for the storage and drying of stream sediment and soil samples, and the storage of field equipment. This may have increased the potential for random or systematic contamination. The water samples were then transported in a bulk container (F/A and F/UA) to the receiving laboratory in the Netherlands (ALcontrol). It is not clear how the F/A samples were transported to the GTK Laboratory from the Netherlands.

The methods used in this report follow the protocol of the Geochemical Baseline Survey of the Environment (G-BASE) project (Ander, in prep.), with the exception of using CRMs, which are not inserted by G-BASE. The SRM/CRMs were submitted whilst the samples were in Carrickfergus core store, rather than by the field teams.

Sample checklists were not dispatched in either paper or digital form with the samples when they were sent to ALcontrol (for forwarding to GTK in the case of F/A samples). These were compiled and sent directly to both laboratories as part of the QC process, and were updated for the samples collected in October and November when they were dispatched to ALcontrol.

2 Samples submitted

A total of 3322 stream water samples were collected in 2005, the location of which are shown in Figure 1. These were from 37 ‘hundreds’, with the numbers of samples submitted in each ‘hundred’ shown in Table 1; the spatial location of these ‘hundreds’ is shown in Figure 2. In addition blank waters and standard reference materials were added to the samples for analysis, as part of the quality assurance methodology.

Of all the drainage sites sampled, 63 were ‘dry sites’ (Figure 1), with stream sediment and panned concentrate sampling carried out as detailed in Johnson (2005), but with no stream waters occurring at the time of sampling.

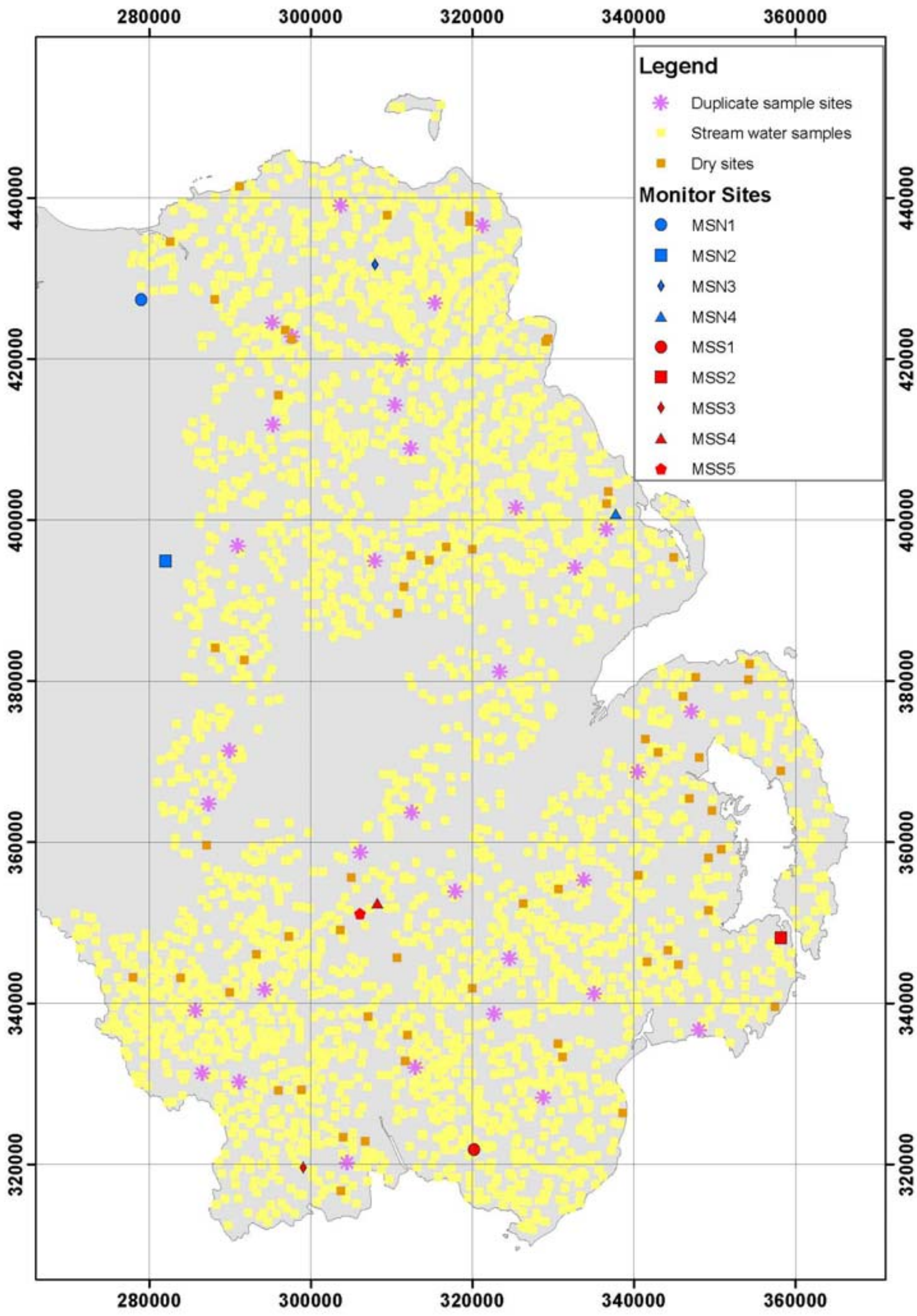


Figure 1 Location of stream sample sites, showing the location of monitor, duplicate and dry-sites

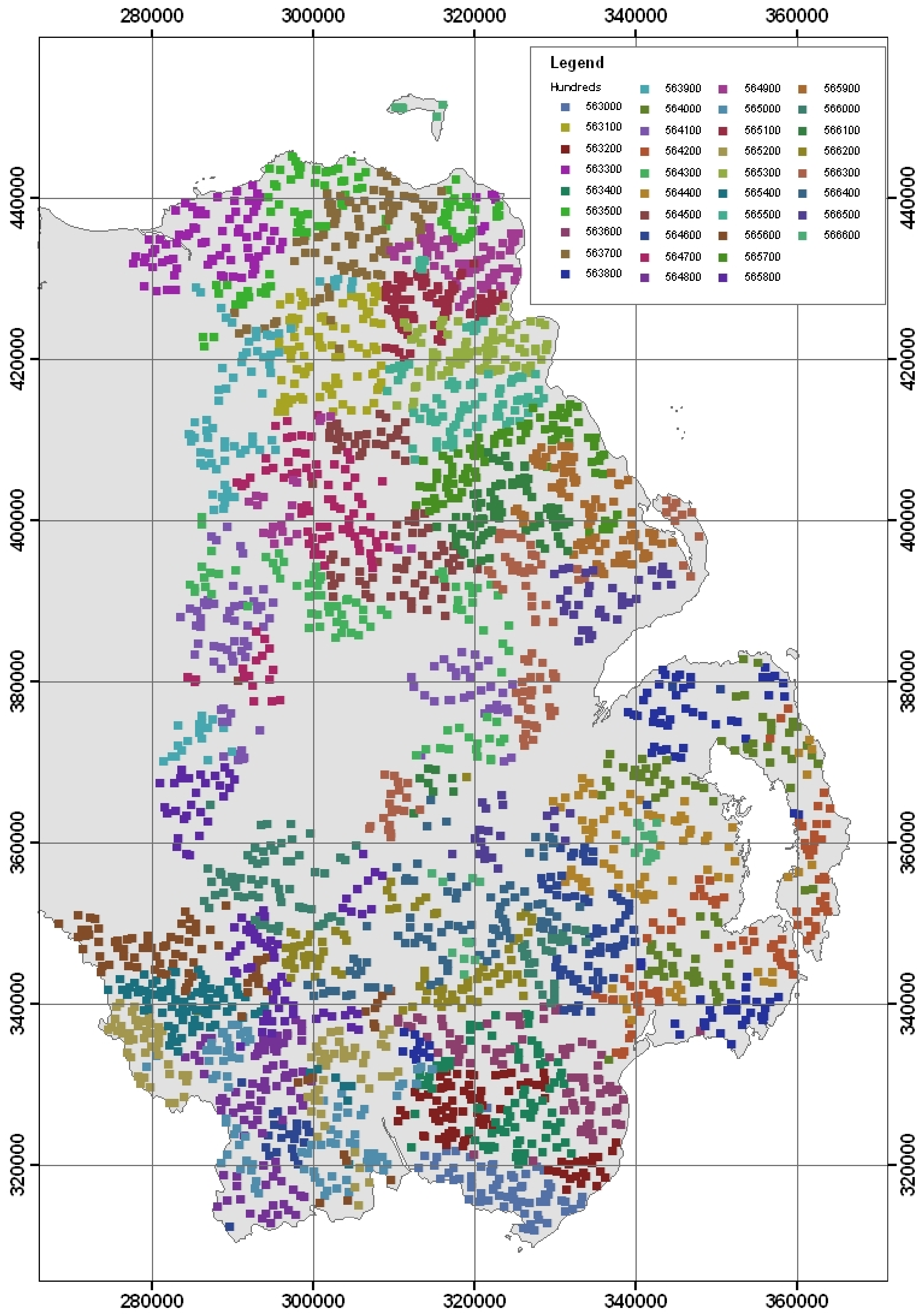


Figure 2: Location of the sampling ‘hundreds’

Table 1: Summary of aqueous samples by sampling batch

Hundred	Total number	Stream water sample sites	Duplicate site* samples	Blank waters	Standards	Monitor sites	Start date of sampling	Last date of sampling
563000	96	64	0	4	23	5	05/05/2005	10/05/2005
563100	98	87	4	2	3	2	04/07/2005	07/07/2005
563200	100	84	4	2	3	7	04/07/2005	13/07/2005
563300	97	81	4	2	3	7	06/07/2005	14/07/2005
563400	99	82	4	2	3	8	10/07/2005	19/07/2005
563500	99	85	4	2	3	5	12/07/2005	19/07/2005
563600	98	84	4	2	3	5	18/07/2005	26/07/2005
563700	99	88	4	2	3	2	17/07/2005	21/07/2005
563800	92	80	4	2	3	3	22/07/2005	29/07/2005
563900	98	85	4	2	3	4	21/07/2005	27/07/2005
564000	93	81	4	2	3	3	27/07/2005	04/08/2005
564100	98	87	4	2	3	2	25/07/2005	30/07/2005
564200	100	87	4	2	3	4	31/07/2005	05/08/2005
564300	100	87	4	2	3	4	29/07/2005	03/08/2005
564400	95	81	4	2	3	5	05/08/2005	10/08/2005
564500	95	81	4	2	3	5	01/08/2005	09/08/2005
564600	99	88	4	2	3	2	10/08/2005	17/08/2005
564700	100	87	4	2	3	4	05/08/2005	10/08/2005
564800	98	85	4	2	3	4	15/08/2005	20/08/2005
564900	100	85	4	2	3	6	09/08/2005	19/08/2005
565000	97	85	4	2	3	3	19/08/2005	25/08/2005
565100	100	87	4	2	3	4	18/08/2005	23/08/2005
565200	100	85	4	2	3	6	23/08/2005	30/08/2005
565300	98	83	4	2	3	6	22/08/2005	29/08/2005
565400	97	83	4	2	3	5	28/08/2005	02/09/2005
565500	100	84	4	3	4	5	29/08/2005	02/09/2005
565600	98	85	4	2	3	4	01/09/2005	08/09/2005
565700	100	87	4	2	3	4	02/09/2005	09/09/2005
565800	98	86	4	2	3	3	07/09/2005	12/09/2005
565900	98	86	4	2	3	3	08/09/2005	13/09/2005
566000	100	88	4	2	3	3	10/09/2005	16/09/2005
566100	99	87	4	2	3	3	12/09/2005	16/09/2005
566200	97	81	4	2	3	7	14/09/2005	21/09/2005
566300	100	88	4	2	3	3	15/09/2005	20/09/2005
566400	98	88	4	2	3	1	18/09/2005	22/09/2005
566500	70	54	0	0	13	3	20/09/2005	22/09/2005
566600	74	30	0	3	40	1	22/09/2005	23/11/2005
Counts:								
37	3577	3034	76	136	179	152		

* Note that the ‘Duplicate A’ sample is also used as a normal sample site.

The sample number within the ‘hundred’ which are used by control samples are specified in Table 2 for the four random number lists used in 2005 sampling. In addition to these normal control sample positions, extra standards were inserted into sample positions in hundreds 503000 and 566500. The extra sample shown in Table 2 (-A), was reclassified to a normal sample number (as non-numeric fields are not allowed in the Geochemistry Database) and included in 566600, so this hundred also has control samples in sample site positions. The extra sample means that there can be a maximum of 101 samples in each ‘hundred’. Two filtered (<0.45 µm) water samples were collected at each drainage, or monitor, site. The sample contained in a Nalgene 60 ml HDPE bottle was labelled ‘F/A’ in addition to the sample number, and acidified to 1%v/v with Aristar HNO_3 on return to the field office in the evening. The sample contained in a Nalgene 30 ml bottle was labelled ‘F/UA’, in addition to the sample number, and stored in the fridge on return to the field office in the evening. Full details of the sampling and data recording methods employed in the field can be found in Johnson (2005).

Table 2: Stream water 2005 control samples

Random number list	**1**	**2**	**3**	**4**
Filtered blank water	10	62	44	03
Unfiltered blank water	75	14	75	32
Standards	11, 22, 68	28, 43, 80	17, 87, 91	30, 47, 96
Duplicate A	76	31	04	71
Sub-sample A	86	77	62	60
Duplicate B	81	37	96	66
Sub-sample B	78	58	53	34
‘Armoy’ sub-sample*	76-A	31-A	04-A	71-A

* An additional standard sample inserted into each aqueous ‘hundred’. Post-analysis these have been re-coded to form part of the 5666*xx* series, in order to permit these data to be incorporated into the Geochemistry Database raw data table.

3 Sample data receipt from the laboratories

3.1 GTK DATA

Once the samples had been received at GTK (which was delayed from the initial contract specification), they were sorted and analysed in numerical order as requested in the contract. The analytical data were supplied in timely fashion (to ALcontrol initially), in accordance with the revised timetable which was submitted by GTK once they had received the first dispatch of samples. Dr Eeva Kallio was the point of contact for queries, which were always addressed in timely and helpful fashion. Ongoing verification of the data suggested that it was of good quality, and this is borne out by the work presented in this report.

3.2 ALCONTROL DATA

After the initially late dispatch of samples ALcontrol failed to compile these into numerical order, and did not analyse in numerical order. Experience in the G-BASE project (although only on the scale of 100 samples in that case) shows that such an approach is far more likely to lead to sample number identification errors, especially when combined with an incomplete sample checklist.

In the early stages of data reporting several problems occurred which were identified in the data verification process as are summarised below. These difficulties were resolved by email communication, and fewer errors were observed as the project progressed.

- Data transposed into the wrong analyte column (anion data) for part of a data file (start and end of the file correct, middle in error). An example of this was the transposition of F and Cl data. Several of the other analytes were then corrected in later versions.
- Samples not analysed in numerical order (all data).
- Batches 87570-87574 of GTK data not forwarded on to GSNI until after the next reporting of 5 batches had been sent.
- Sample data reported for a series of samples which had previously been correctly identified by ALcontrol as missing from the number sequence.
- Over-range NO_3 data (due to the submission of SLRS-4 as an F/UA sample) were initially reported as below the detection limit. This raised concerns as to whether this could affect sample site data.
- No versioning of data reported, or inclusion of any batch/ laboratory number. Analysis dates were supplied but these were not in a format that could be easily read as a date by software.

4 Analytical methodologies

A summary of the analytes which were requested from the laboratories, and those determined by the field team, is given in Figure 3. This section describes the analyses undertaken on each aliquot collected, and the number of samples analysed.

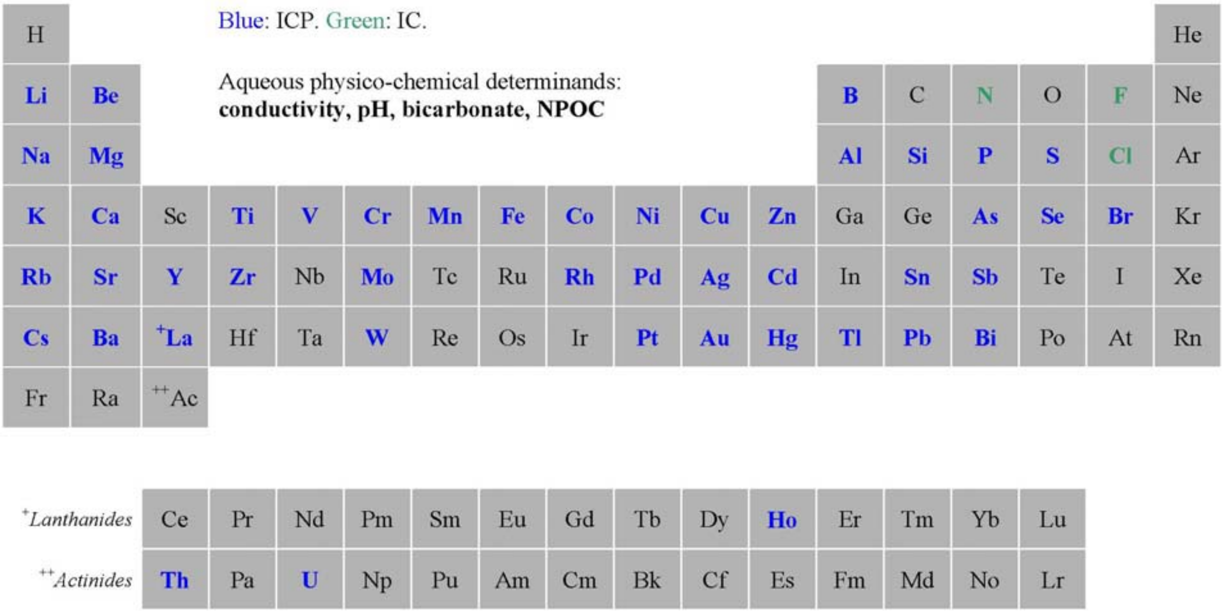


Figure 3: Periodic table showing the analytical suite on the 2005 Northern Ireland samples

4.1 UNFILTERED WATER SAMPLES

Unfiltered water samples were collected at each site to permit the determination of pH on the evening of collection and conductivity and total alkalinity the following morning. The pH sample was collected in a 30 ml bottle and that for conductivity and alkalinity in a 250 ml bottle. The samples were analysed according to the methods detailed in Johnson (2005). The detection limit for the alkalinity titration varies depending upon whether the titration is undertaken with 1.6N H_2SO_4 or 0.16N H_2SO_4. However, the titration should be repeated with 0.16N H_2SO_4 if it is below the detection limit of 1.6N H_2SO_4, thus the 0.16N H_2SO_4 detection limit is the value reported in Table 3. A summary of the sample numbers analysed for these parameters in the field is provided in Table 4. The ‘missing’ samples are as a result of samples not being collected, or the suspended solid content being too high to allow measurements to be taken. These absences of data affect 11 sites in total, with 3 having no field chemical data (563192, 565146, 566119).

Both the north and south field teams had considerable problems with pH meters during the early part of the field season, with pH analyses having to be held over by up to 6 days (08/07/05 to 15/07/05 in the ‘south team’ and 30/07/05 to 03/08/05 in the ‘north team’). The monitor site data is used to establish whether this could have had a systematic effect on the pH values subsequently measured. In all these cases pH samples and the calibration standards were stored in a fridge from the time of return to the field office, before being allowed to equilibrate to the temperature of the room, when they were analysed. The results of this are shown in Section 8.

Table 3: Field-based analytical methodologies with associated detection limits

Analyte	Analytical method	Accredited?	Units of measurement	Detection limit
pH	Probe	No	pH units	n/a
Conductivity	Probe	No	µS cm^{-1}	10
Alkalinity	Titration	No	mg l^{-1} $CaCO_3$	0.05

Table 4: Field-based analysis sample tally

Sample type	Sample count - pH	Sample count - conductivity	Sample count - alkalinity
Blank waters	n/a	n/a	n/a
Duplicate/replicate samples	68 (34 sites)	68 (34 sites)	68 (34 sites)
Monitor sites	151	151	151
Standards	n/a	n/a	n/a
Sample sites (excluding ‘Duplicate A’ sites)	3030	3025	3026
Sample sites	3065	3060	3061
‘Missing’ samples	4	9	8
Total analyses	3250	3245	3246

4.2 FILTERED WATER SAMPLES

The filtered water samples were submitted to ALcontrol Laboratories NV for analysis. ALcontrol subcontracted analysis of the F/A samples to the Geological Survey of Finland (GTK). The laboratories of GTK undertook analyses of the F/A sample by both inductively coupled plasma atomic emission spectrometry (ICP-AES) and inductively coupled plasma mass spectrometry (ICP-MS). Table 5 details the method of analysis used by GTK for each analyte, its reported detection limit and whether the method was accredited or not under ISO 17025.

Table 5: Analytical methods used by GTK, with associated detection limits

Analyte	Analytical method	Accredited?	Units of measurement	Detection limit
Ag	ICP-MS	Yes	µg l^{-1}	0.01
Al	ICP-MS	Yes	µg l^{-1}	0.5
As	ICP-MS	Yes	µg l^{-1}	0.05
Au	ICP-MS	No	µg l^{-1}	0.1
B	ICP-MS	Yes	µg l^{-1}	0.5
Ba	ICP-MS	Yes	µg l^{-1}	0.05
Ba	ICP-AES	Yes	µg l^{-1}	2
Be	ICP-MS	Yes	µg l^{-1}	0.05
Bi	ICP-MS	Yes	µg l^{-1}	0.02
Br	ICP-MS	Yes	µg l^{-1}	10
Ca	ICP-AES	Yes	mg l^{-1}	0.1
Cd	ICP-MS	Yes	µg l^{-1}	0.02
Co	ICP-MS	Yes	µg l^{-1}	0.02
Cr	ICP-MS	Yes	µg l^{-1}	0.2
Cs	ICP-MS	Yes	µg l^{-1}	0.01
Cu	ICP-MS	Yes	µg l^{-1}	0.1
Fe	ICP-AES	Yes	mg l^{-1}	0.01
Hg	ICP-MS	No	µg l^{-1}	n/a
Ho	ICP-MS	Yes	µg l^{-1}	0.001
K	ICP-MS	Yes	mg l^{-1}	0.01
K	ICP-AES	Yes	mg l^{-1}	0.5
La	ICP-MS	No	µg l^{-1}	0.001
Li	ICP-MS	Yes	µg l^{-1}	0.02
Mg	ICP-AES	Yes	mg l^{-1}	0.1
Mn	ICP-MS	Yes	µg l^{-1}	0.02
Mn	ICP-AES	Yes	µg l^{-1}	1
Mo	ICP-MS	Yes	µg l^{-1}	0.02
Na	ICP-AES	Yes	mg l^{-1}	0.2
Ni	ICP-MS	Yes	µg l^{-1}	0.05
P	ICP-MS	Yes	µg l^{-1}	10
P	ICP-AES	Yes	µg l^{-1}	50
Pb	ICP-MS	Yes	µg l^{-1}	0.05
Pd	ICP-MS	No	µg l^{-1}	0.1
Pt	ICP-MS	No	µg l^{-1}	0.02
Rb	ICP-MS	Yes	µg l^{-1}	0.01
Rh	ICP-MS	No	µg l^{-1}	0.01
Sb	ICP-MS	Yes	µg l^{-1}	0.02
Se	ICP-MS	Yes	µg l^{-1}	0.5
Si	ICP-AES	Yes	mg l^{-1}	0.06
Sn	ICP-MS	Yes	µg l^{-1}	0.05
SO4	ICP-AES	Yes	mg l^{-1}	0.3
Sr	ICP-MS	Yes	µg l^{-1}	0.1
Th	ICP-MS	Yes	µg l^{-1}	0.01
Ti	ICP-MS	No	µg l^{-1}	0.5
Tl	ICP-MS	Yes	µg l^{-1}	0.01
U	ICP-MS	Yes	µg l^{-1}	0.01
V	ICP-MS	Yes	µg l^{-1}	0.05
W	ICP-MS	No	µg l^{-1}	0.01
Y	ICP-MS	No	µg l^{-1}	0.001
Zn	ICP-MS	Yes	µg l^{-1}	0.2
Zr	ICP-MS	No	µg l^{-1}	0.03

A total of 3570 Tellus samples were analysed by GTK, plus their own quality control samples (blanks and standards). Table 6 illustrates the number of different Tellus samples analysed according to sample type. Of the ‘missing’ samples, 3 were actually impossible to filter and so a F/A sample was never provided (although ‘field’ chemical data exists), and 3 F/A samples were lost at some point between sample collection and sample analysis.

Table 6: F/A sample analysis tally by sample tally

Sample type	Sample count
Blank waters	76
Duplicate/replicate samples	136 (34 sites)
Monitor sites	150
Standards	179
Sample sites (excluding ‘Duplicate A’ sites)	3029
Sample sites	3063
‘Missing’ sample sites	6
Total analyses	3570

Table 7 lists the number of analytical results reported for each sample hundred, providing information on the laboratory batch number and any missing/ lost samples giving rise to total sample number differences with respect to the number of original samples collected (Table 1). GTK ran the samples in batches which reflected the ‘hundred’, and thus Figure 2 illustrates the analytical batches, with the exception of 5666*xx* which was run in two separate batches.

The F/UA sample was analysed by ALcontrol Netherlands laboratories. Analysis was by ion chromatography (IC) for selected anionic species in solution, and non-purgeable organic carbon (NPOC) was measured by TIC/TOC analyser. NPOC is approximately equivalent to dissolved organic carbon (DOC) in these filtered water samples. Table 8 lists the analytes, analytical method, detection limits and whether the method was accredited. Table 9 then lists the numbers of analyses reported for each control sample type and for sample sites.

The data summary provided for ICP in Table 5 has not been repeated for the anion and NPOC analyses as the laboratory did not analyse the samples in numerical order (despite requests to do so), and did not provide any form of laboratory number / order number relating to groups of sample numbers, or order of analysis. However, the location of samples by reporting batch (not necessarily closely related in analysis date) are shown in Figure 4. Thus, whilst the raw data tables do contain information on what order the samples were analysed in, it is too confused to be able to provide a simple summary in this document. Table 10, therefore, only shows the total number of samples reported by ALcontrol Netherlands for each hundred. The sample numbers are lower than those for the F/A samples because one of the standards submitted had been acidified (SLRS-4) and the additional samples submitted in each hundred (-A) (Section 2) were not run at all. There was not seen to be any benefit in requesting that these were subsequently run, as the purpose of standards is that they permit an understanding of sources of bias in the data, and estimates of uncertainty, by being run in numerical order with the rest of the samples.

Table 7: F/A sample analysis tally by ‘hundred’

Hundred	GTK analytical batch	Samples analysed	Samples missing
563000	87565	96	
563100	87566	98	
563200	87567	100	
563300	87568	97	
563400	87569	99	
563500	87570	99	
563600	87571	98	
563700	87572	99	
563800	87573	92	
563900	87574	98	
564000	87575	92	1
564100	87576	98	
564200	87577	100	
564300	87578	100	
564400	87579	93	2
564500	87580	95	
564600	87581	98	1
564700	87582	100	
564800	87583	98	
564900	87584	100	
565000	87585	96	1
565100	87586	100	
565200	87587	99	1 (monitor site)
565300	87588	98	
565400	87589	97	
565500	87590	100	
565600	87591	98	
565700	87592	100	
565800	87593	98	
565900	87594	98	
566000	87595	100	
566100	87596	99	
566200	87597	97	
566300	87598	100	
566400	87599	97	1
566500	87600	70	
566600*	87600	73	
		Total = 3570	7

* includes Armoy extra samples (-A) re-numbered post-analysis

Table 8: ALcontrol Netherlands analytical methods and associated detection limits

Analyte	Analytical method	Accredited?	Units of measurement	Detection limit
F	Ion chromatography	Yes	mg l^{-1}	0.01
Cl	Ion chromatography	Yes	mg l^{-1}	0.05
Br	Ion chromatography	Yes	mg l^{-1}	0.02
NO_2	Ion chromatography	Yes	mg l^{-1}	0.01
NO_3	Ion chromatography	Yes	mg l^{-1}	0.02
P	Ion chromatography	Yes	mg l^{-1}	0.1
SO_4	Ion chromatography	Yes	mg l^{-1}	0.05
NPOC (DOC)	TIC/TOC analyser	Yes	mg l^{-1}	0.5

Table 9: F/UA sample analysis tally, by sample type

Sample type	Sample count (Ion chromatography)	Sample count (TIC/TOC analyser)
Blank waters	75	74
Duplicate/replicate samples	136 (34 sites)	136 (34 sites)
Monitor sites	150	150
Standards	151	142
Sample sites (excluding 'Duplicate A' sites)	3026	3026
Sample sites	3060	3060
'Missing' sample sites	9	9
Total analyses	3538	3528

Table 10: Tally of samples analysed at ALcontrol laboratories, by hundred

Hundred	Anions	NPOC (DOC)
563000	96	96
563100	98	98
563200	100	100
563300	96	97
563400	97	98
563500	99	99
563600	97	98
563700	96	97
563800	91	92
563900	97	98
564000	92	93
564100	97	98
564200	99	100
564300	99	100
564400	92	93
564500	94	95
564600	98	98
564700	99	100
564800	96	97
564900	98	99
565000	95	96
565100	100	100
565200	99	100
565300	98	98
565400	96	97
565500	99	100
565600	97	98
565700	99	99
565800	96	98
565900	97	98
566000	100	100
566100	98	99
566200	96	97
566300	99	100
566400	97	98
566500	70	70
566600	36	37

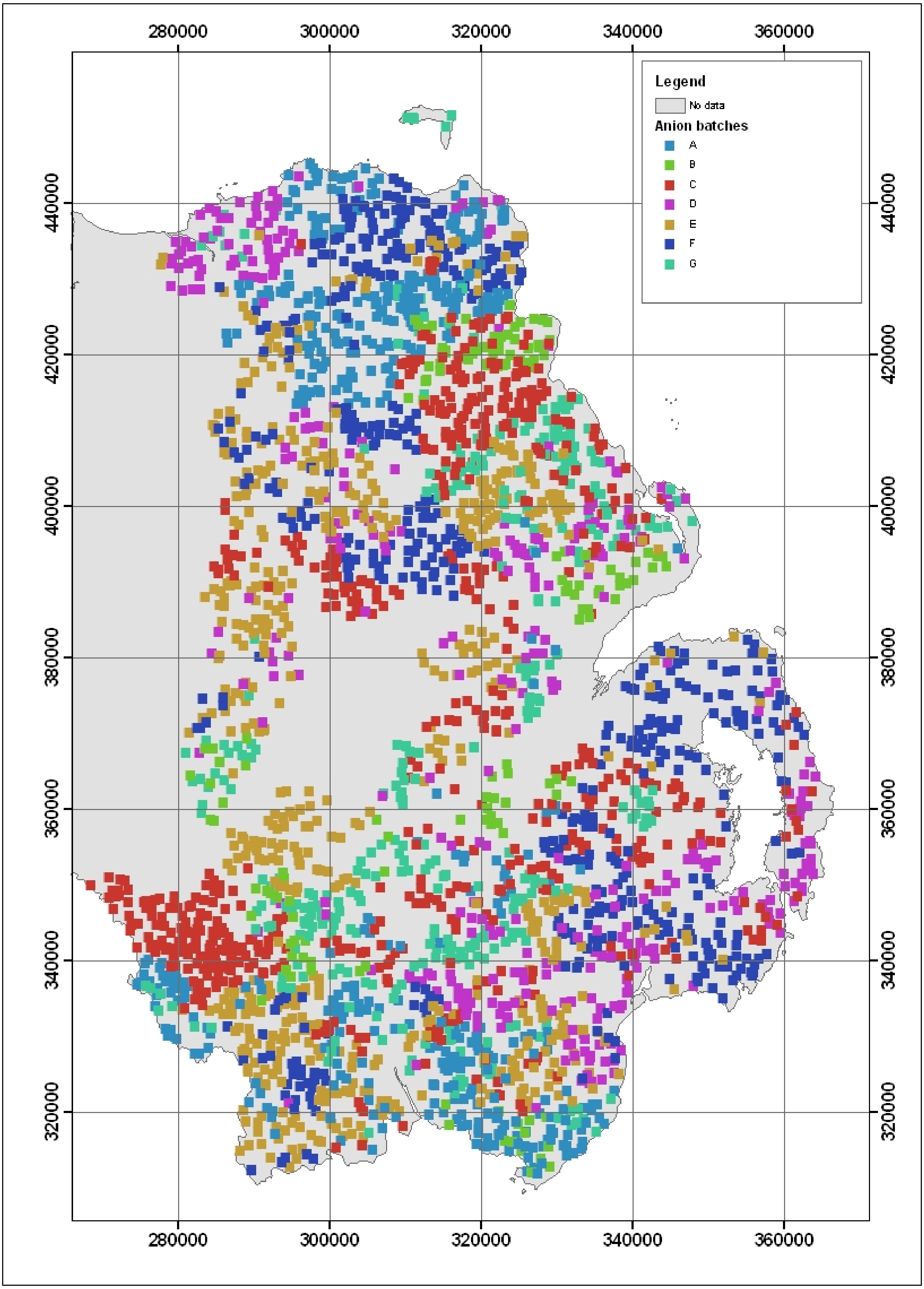


Figure 4: Sample location of the analytical batches reported by ALcontrol laboratories

4.3 ANALYTES EXCLUDED FROM FURTHER CONSIDERATION

The sample collection and preservation method used for the F/A bottles are not appropriate to the quantitative determination of Hg concentrations in water (as noted by GTK). Thus no detection limit is quoted by the laboratories (Table 5), and no samples had detectable Hg in the F/A sample split.

Also, preliminary inspection of the data showed that several analytes had natural abundances that are at, or below, the detection limit for almost every sample analysed. These have not been considered any further in this document. The criteria for this selection has been that >90% of the sample data are below the detection limit, and that the maximum concentration is <5x the detection limit value. Additionally a preliminary inspection of the location of those samples where concentrations are detectable was undertaken to ensure that useful information on baseline concentrations was not being lost. Thus most of the parameters shown in Table 11 have been excluded, but Be (148 samples > 0.05 µg l^{-1}) and W (211 samples > 0.01 µg l^{-1}) have been included. Great care should be taken in undertaking anything more than a generalised interpretation of much of the Be and W data, despite their inclusion, as most of these are very close to the detection limit and hence have inherently greater uncertainty than data more than 10x above the detection limit. Data for Be, Bi, Rh, Se, W are shown in Appendix 1, in order to illustrate the decision process. It should be noted that data was reported to the same number of significant figures as given for the detection limit value, hence samples sites may have concentrations which are numerically identical to the detection limit. A very high proportion of the nitrite and phosphate data by IC are below the detection limit.

Table 11: Summary of ICP-MS analytes with most analyses below the detection limit

Analyte	Detection limit (µg l^{-1})	Sample sites analysed (n)	Samples sites < detection limit (n)	Samples sites = detection limit (n)	Sample sites > detection limit (n)
Ag	0.01	3063	2990	72	1
Au	0.1	3063	3063	0	0
Be	0.05	3063	2887	28	148
Bi	0.02	3063	3027	30	6
Hg	n/a*	3063	3063	0	0
Pd	0.1	3063	3063	0	0
Pt	0.02	3063	3063	0	0
Rh	0.01	3063	2613	433	17
Se	0.02	3063	3050	0	13
W	0.01	3063	2100	752	211

* see notes on methodology above

5 Blank waters

Blank waters were inserted into each ‘hundred’ in two positions, one of which was filtered in the same way as the samples, the other of which not filtered (Table 2), to allow identification of filtering artefacts. These samples are labelled as F/A or F/UA irrespective of this, to allow such procedural checks to be ‘blind’ to the analyst. Each F/A sample was acidified using the Aristar HNO_3 in use in that week, whilst the F/UA sample was left unmodified. More detail on these procedures can be found in Johnson (2005). This type of control sample only relates to analyses undertaken post-fieldwork, and thus is not relevant to pH, conductivity and bicarbonate analyses.

The total number of blank waters submitted for analysis are shown below (Table 12). No blank waters were inserted into the 5665*xx* ‘hundred’, thus the ICP and IC methods have reported all the blank waters dispatched. Data for one blank water sample has not been reported by NPOC. In interpreting the data, it should be borne in mind that the blank water samples for 5630*xx* appear to have been inserted some months later, and thus the acid used may not relate to that used in the F/A samples.

Table 12: Blank water analysis summary

Analytical methods	Number of analyses	Number of analytes	Problem analytes
ICP	72	46	Sn (major) Cr, Cu, V, Zn (minor)
IC	72	7	-
TIC/TOC analyser	71	1	NPOC (DOC)

The analytes with which there are considered to be problems arising from the analysis of blank water samples are identified in Table 12, with the full data shown for the ICP analytes of most concern in Appendix 2. For these analytes the data reported are generally above the detection limit (reported by the laboratories) of the method. An understanding of the significance of this is even more critical where the detection limit is significant with respect to the natural abundance of the analyte in stream waters over the survey area, or the concentration in the blank waters is a substantial proportion of the concentration of the natural samples.

Several elements (Al, Ba, K, Mn, Rb) have blank samples which were measurable, but these concentrations were either close to the detection limit, or insignificant in relation to the natural abundance of the element in stream waters (gauged by looking at the concentrations in relation to the 5th percentile of the dataset). For these 5 elements, no systematic contamination could be observed which would warrant any kind of blank correction to be applied. Other elements determined by ICP which had greater problems were Cr, Cu, Sn, V and Zn.

In the case of Cr, 13 analyses were above the detection limit, with 7 of these being above the dataset median value ($0.33\ \mu g\ l^{-1}$). However, no systematic variations could be observed that relate either to filtration, field team or analytical sequence of the samples. Thus, no blank subtraction has been undertaken, but it should be noted that samples could be affected by isolated contamination.

Copper data shows that of the 15 samples above the detection limit, 6 were greater than the 10th percentile of the dataset ($0.1\ \mu g\ l^{-1}$). As with Cr, no systematic variation in the data that could explain the results, or validate and blank subtraction exercise, could be observed. The natural abundance of Cu in stream waters is somewhat higher than that of Cr, and thus whilst contamination may occur it is likely to be isolated in nature and may be of less significance that any contamination of samples by Cr.

Vanadium data shows 16 samples over the detection limit, with 8 being above the 5th percentile. The comments made relating to Cu (above) apply equally to V. The Zn data shows the greatest contamination, apart from Sn, with 22 samples above the detection limit, and 14 of those above the 5th percentile of the dataset. Once again, these data are not systematic in their nature, and as for Cr, it must be borne in mind that some isolated samples may be affected by Zn contamination.

Tin is the greatest problem in terms of the concentration of the analyte in the blank water samples. A statistical summary of the results (Table 13) shows the concentrations in the blank waters are greater than the detection limit in all but 11 of the 76 blank water samples. This is a problem common to other projects of this nature (Ander, in prep.): the source of the contamination is not clear and could relate to the acid used or the bottles. It is not thought to relate to the 18 MΩ water provided by the BGS Keyworth laboratory, as this is also used by them for their reagent blanks, which are not affected by Sn contamination. If 0.194 µg l^{-1} Sn is taken as the detection limit calculated from the field blank waters (Miller and Miller, 1993), as opposed to the laboratory blanks used by GTK, 98% of the data is below that concentration. This indicates that the blank water concentrations are so large in relation to the sample concentrations that it is not possible to correct for it using blank subtraction, and thus the Sn concentration data for sample sites should not be used for any interpretation purposes. As a final check on this method of comparison, the closeness of the median and the mean suggest that these assumptions are not greatly affected by a skewed dataset.

Table 13: Concentration of tin in blank water samples

Summary values	Sn (µg/l)
median	0.080
mean	0.084
standard deviation (σ)	0.037
3σ	0.110
mean+3σ	0.194

The analytes measured by ion chromatography were satisfactory, with one apparently spurious result for Cl (18.9 mg l^{-1}: 563410), which could be an analytical error, or the mis-identification of a sample number (as occurs in the duplicate samples). The NO_3 concentration was above the detection limit in 16 of the blank water samples, with 7 being above the 15th percentile of the dataset (0.09 mg l^{-1}). None of the concentrations are sufficiently high in the context of the overall dataset (median 3.8 mg l^{-1}) to give cause for concern.

6 Duplicate and replicate analyses

Samples from 34 duplicate sites (Figure 1) were submitted for analysis, giving a total of 136 analyses. Initially the data for all analytes were examined by plotting the data using an excel macro (Lister and Johnson, 2005). These graphs permit the rapid inspection of the data, and removal of data which is clearly in ‘catastrophic’ error. This obviously biases the data set and is one of the subjective decisions made in the process. An example of this is given using the Ni duplicate/ replicate data in Figure 5; the relationship of the duplicates and replicates (subsamples) to each other is described in Figure 6. Conditional formatting of the data-file is also used to rapidly show whether data are at or below the detection limit.

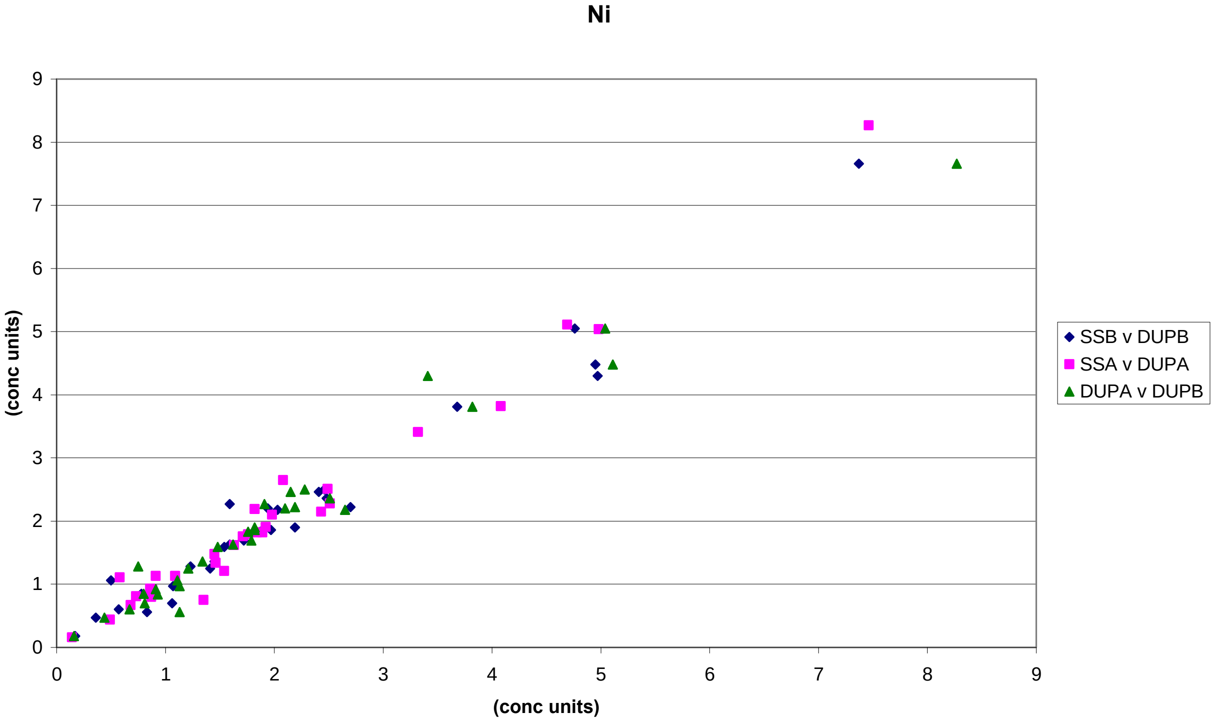


Figure 5: Example output of the duplicate-replicate plotting: Nickel in stream waters

The method of analysis of the suite of duplicate and replicate sample data from each site is to use the method of ‘fully nested analysis of variance’ (ANOVA). The suite of samples are shown schematically in Figure 6 and the method of collection is described by Johnson (2005). Figure 6a illustrates the relationship between samples and the ANOVA output for all laboratory data, Figure 6b shows this information for the field chemical parameters (pH, conductivity, HCO_3) where replicates are not available. The value of such an approach is further described by Ramsey (1998). The ANOVA analysis used includes a log-transformation step (except for pH), as many such datasets are log-normal, and has been undertaken using an ‘in-house’ macro which allows rapid batch processing of the data (Johnson, 2002); this code has been validated against commercially available statistical software to ensure that it gives the same results. It is suggested that the suggested maximum technical (sampling + analytical) variance is 20% for most geochemical purposes (Ramsey, 1998).

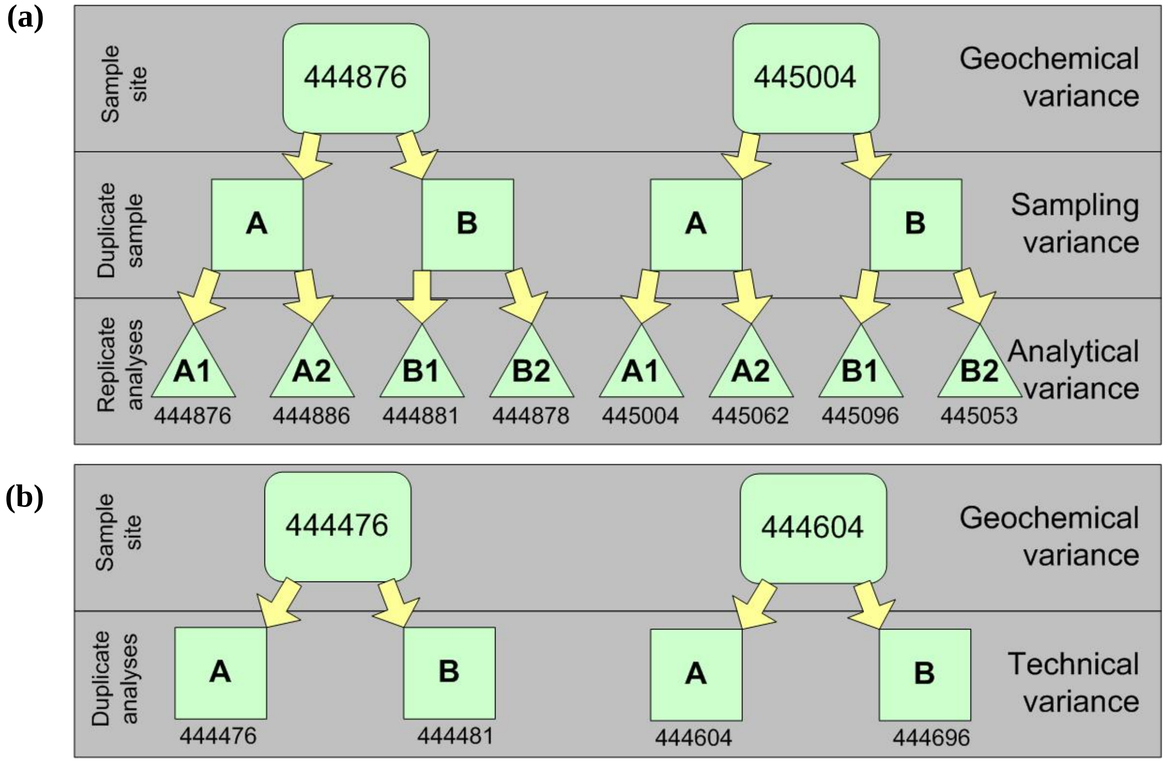


Figure 6: Relationship of duplicate and replicate (sub-) samples; (a) where subsamples can be created; (b) where only duplicates are collected and no subsamples are created

Of the 38 ICP analytes remaining for consideration (see sections above), Table 14 indicates those excluded from ANOVA analysis, because insufficient samples were above the detection limit to allow the analysis to provide statistically significant data. Samples sites with any data reported as negative numbers (as the procedure uses a log-transformation), or where data for a site were all reported as identical values (and below the detection limit) were removed from the data set.

Table 14: Analytes excluded from ANOVA analysis

Analyte	Duplicate/ replicate sets analysed	Duplicate/ replicate sets > DL	Duplicate/ replicate sets < DL
Be	34	1	33
Cd	34	5	29
Th	34	4	30
Tl	34	4	30
W	34	3	31

The analysis for the field data (where no replicates are collected) were run using Minitab (version 13), with the duplicates providing an overall technical variance compared to the geochemical (between site) variance. The results of ANOVA analysis for pH, conductivity and HCO_3 can be seen to be very good (Table 15), and these data show no limitation of the use of the data in regional geochemical mapping.

The ANOVA analysis was conducted on the remaining 32 analytes using an Excel macro (Johnson, 2002). The results summarised in Table 15, include information on the sources of variance in the data, and the number of sample sites used in running the ANOVA analysis.

Table 15: ANOVA results

	Element	Between Site %	Between Sample %	Within Sample %	Number of sites used
		Geochemical variance	Technical variance		
Field analytes:					
	pH	99	1		34
	Conductivity	99	1		34
	HCO3	100	0		34
ICP analytes:					
	Al	93	4	3	34
	As	95	0	5	34
	B	91	0	9	34
	Ba	98	0	2	34
	Br	96	0	4	34
	Ca	100	0	0	34
	Co	92	5	2	33
	Cr	67	11	22	22
	Cu	95	2	3	32
	Fe	98	2	0	34
	Ho	97	0	3	31
	K	99	0	1	34
	La	91	1	8	34
	Li	97	0	3	34
	Mg	100	0	0	34
	Mn	86	12	2	34
	Mo	100	0	0	34
	Na	100	0	0	34
	Ni	97	0	3	31
	P	99	0	1	33
	Pb	94	3	3	31
	Rb	100	0	0	34
	Sb	99	0	1	34
	Si	100	0	0	34
	SO4	100	0	0	34
	Sr	100	0	0	34
	Ti	86	8	6	34
	U	99	0	1	34
	V	97	1	2	32
	Y	99	0	0	34
	Zn	85	8	7	34
	Zr	91	0	9	33
IC analytes:					
	Br	64	13	23	30
	Cl	100	0	0	33
	F	97	0	2	33
	P	74	0	26	17
	NO3	93	3	4	31
	SO4	100	0	0	33
TIC/TOC analyser:					
	NPOC (DOC)	96	0	4	28

It can be seen that Br^- by IC has a greater technical variance contribution than is generally considered desirable. Bromine data can be used from the ICP-MS analysis, as this appears to be higher quality data. The number of analytical pairs is reduced by one for all analytes, as there was clearly a mis-identification/ very poor analysis of one sample, as shown in Figure 7. However, in order to undertake ANOVA analysis further sets of data had to be removed from P and NO_3 where results were either reported as negative or zero values (and thus cannot be log-transformed). It can be seen that the P data is very poor, this is likely to relate to both loss of the soluble HPO_4 in solution between sampling and analysis, and the proximity of data to the detection limit. The NPOC data is produced from only 28 sites, because two included values of zero, and four were very poor replicates. These very poor replicates suggest a source of error above and beyond the systematic errors associated and quantified by most QC methods. These four sites could have been affected by mis-identification of sample numbers (which experience shows to be more likely if samples are not sorted into numerical sequence prior to analysis), degradation of the organic carbon by bacterial activity or sorption, or contamination in storage, transit or the laboratories. The data are all plotted in Figure 8.

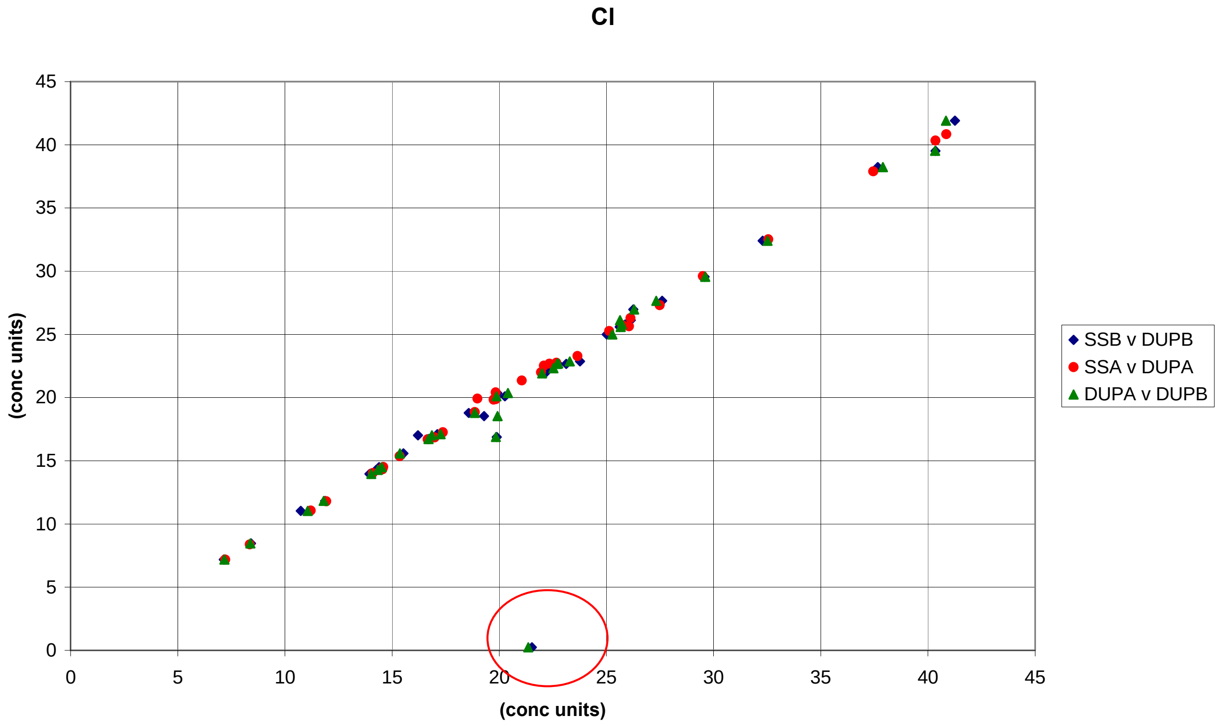


Figure 7: Duplicate-replicate comparison of chloride data

Analytes by ICP are occasionally affected by negative values being included in the dataset, and in this case the number of sites used has been decreased. Whilst the technical variance of Mn, Ti and Zn is greater than most of the analytes, the only element of concern is Cr. The Cr data are illustrated in Figure 9. In the case of Cr, interpretation of the data must include an understanding of the greater uncertainties associated with the dataset, than is the case for many other analytes. This understanding of uncertainty also needs to take account of the low natural abundance of Cr in relation to the detection limit, and must be reflected in the presentation of regional geochemical data particularly with the class intervals which are appropriate to use in interpolated images.

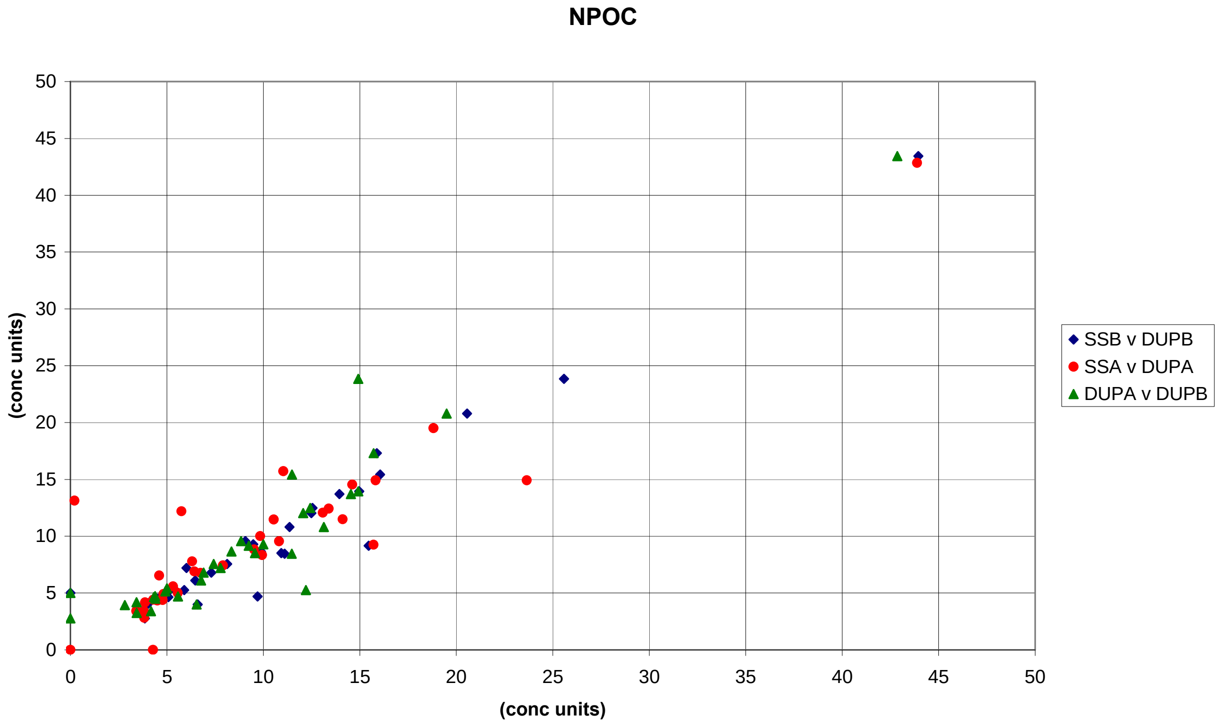


Figure 8: Duplicate-replicate comparison of NPOC data

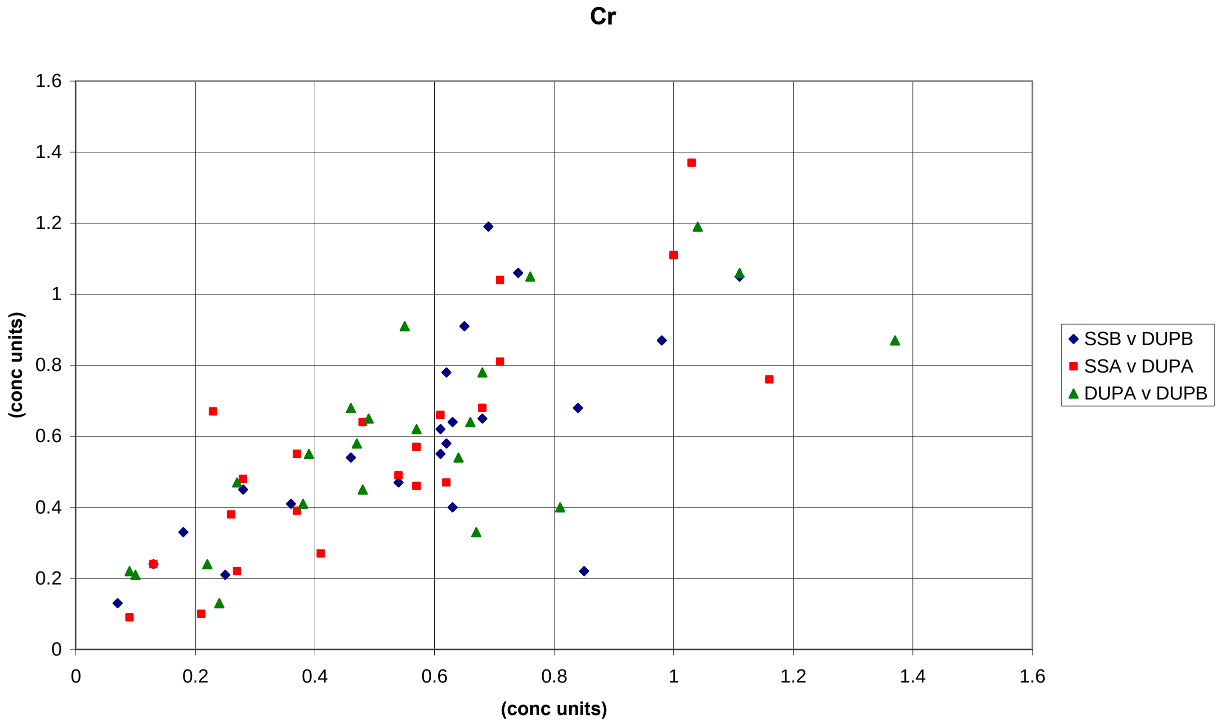


Figure 9: Duplicate-replicate comparison of the chromium data

7 Reference material data

In each 'hundred' four standards were inserted (Table 2) in fixed positions according to the random number list in use (Johnson, 2005). The results of these analyses, in sequence with the sample site data, can be used to ascertain whether significant shifts have occurred between analytical batches. Failure to correct for such bias between batches can lead to differences between sampling regions which are artefacts of the analysis rather than due to geochemical variability. Graphs illustrating the results for these analyses are given in Appendix 3.

Three of the standards inserted were collected in bulk in Northern Ireland from separate locations to provide secondary reference materials (SRM). One of the samples used is SLRS-4 from the National Research Council Canada, which is an internationally recognised Certified Reference Material (CRM) (National Research Council Canada, 1998). This allows a check on the precision as well as the trueness of the data, leading to a better understanding of the overall uncertainty (for terminology see AMC (2003)). Certified reference materials have also been run by the laboratories concerned. The reference materials on which data have been reported are summarised in Table 16. It can be seen that SLRS-4 has been used by both Tellus as a project CRM, and GTK as one of their quality control samples, thus 3 results are reported for SLRS-4 for each hundred. These data are presented for those parameters for which there is a certified value in Appendix 4. The value of this presentation is to establish whether there are any systematic offsets between the GTK QC samples and those of Tellus, and to establish if there is a significant lack of trueness of the overall sample site dataset which would need to be corrected for, particularly in order to compare the data with regulatory standards. ALcontrol did not report data for the Armoy SRM, and SLRS-4 is acidified with HNO_3, so where data has been reported it is not appropriate to use information from samples which have had to undergo such significant dilution prior to analysis.

Table 16: Reference materials reported for the 2005 Tellus stream water samples

Name of reference material	Source of reference material	Type of reference material	Analyses reported (n)	Notes
Armoy	Tellus project	SRM	48	Reported by GTK only
Car	Tellus project	SRM	47	Reported by GTK and ALcontrol
Pal	Tellus project	SRM	47	Reported by GTK and ALcontrol
SLRS-4	National Research Council Canada (1998)	CRM	111	Reported by GTK only; used by the project as a blind sample and by GTK as a laboratory CRM
NIST 1640	National Institute of Standards & Technology (2006)	CRM	72	Reported by GTK only
SPS SW2	Spectrapure Standards, Norway	SRM	72	Reported by GTK only
QDW	not recorded	SRM	157	Reported by ALcontrol only

7.1 ANION AND NPOC DATA

The ALcontrol data has been presented in two formats, as shown in Figure 10a,b. Firstly in numerical order (which would allow identification of any problems resulting from changes in the SRMs with time) and by sequence (A-G) in which the data were reported (although it is not always clear if this exactly the same as analytical sequence). Studying the data in analytical sequence allows any artefacts between batches to be established.

Chloride, sulphate and fluoride can be seen to be very good. No assessment can be made of trueness using these data as they are all from SRMs. The one spurious value is likely to represent a mis-identified sample number. Nitrate data is not as good as the other analytes in the Pal SRM, whilst that reported at lower concentrations for Car is very good (with a precision of ±10% at a mean of 0.66 mg l^{-1}). The mean concentration of 7.1 mg l^{-1} for the Pal SRM data which looks like a coherent dataset is clearly exceeded in 10 of the 47 samples. This is shown in Figure 10, where the mean ±2 standard deviations is also plotted for the 37 samples which look sensible by visual inspection. It is noticeable that the data which is in error occurs in two regions of the sample numbers, but has no relation to the sequence in which data was reported. It thus seems that there is a problem with the samples, but that this cannot be related to analysis directly, and thus is not suitable for correction. It is also not a baseline shift in the calibration, as that would be reflected in the Car data. What is apparent is that it is the data at the end of batches A, B, C, and E that account for most of the uncertainty. An example plot comparing these data for batch A with the sample site data is given in Figure 11. There does not seem to be any systematic population shift, which also lends weight to the suggestion that there is no error correction process which should be undertaken as a result of these data. As with all control samples affected by unexplained sources of uncertainty, this information should be borne in mind when undertaking interpretation of the data.

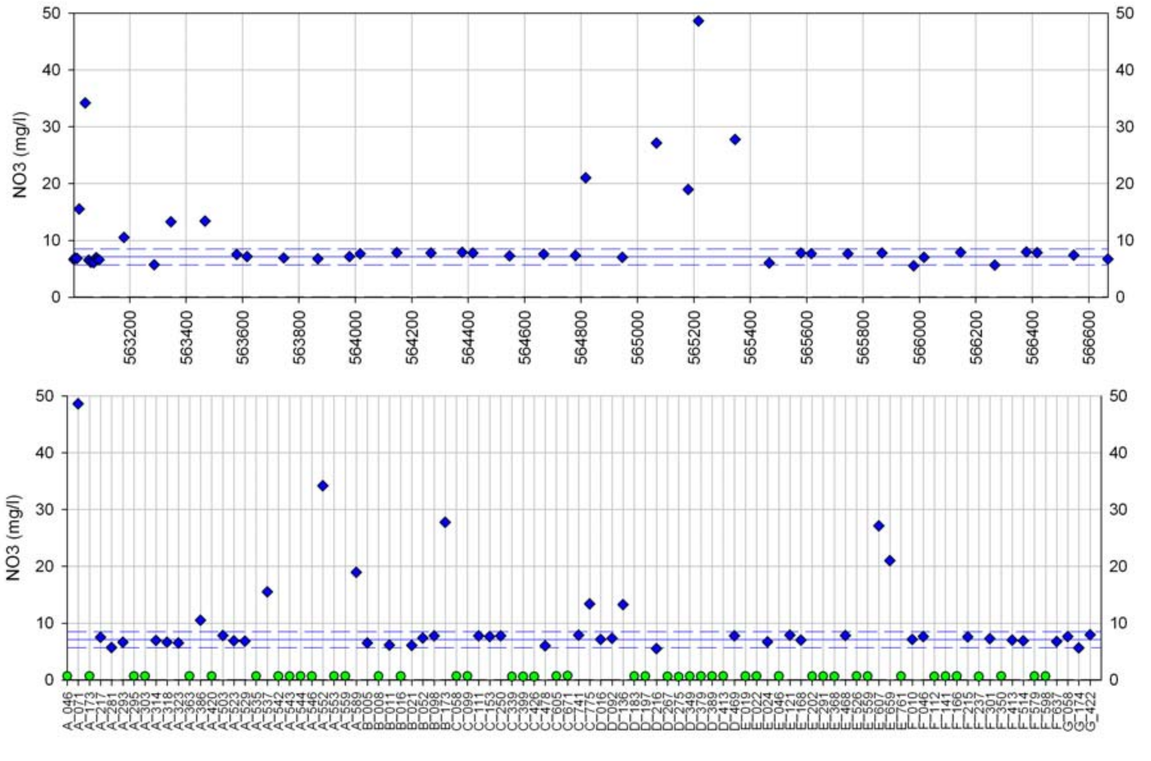


Figure 10: Secondary reference material data for nitrate (a) data plotted in numerical order (b) data plotted in reporting sequence

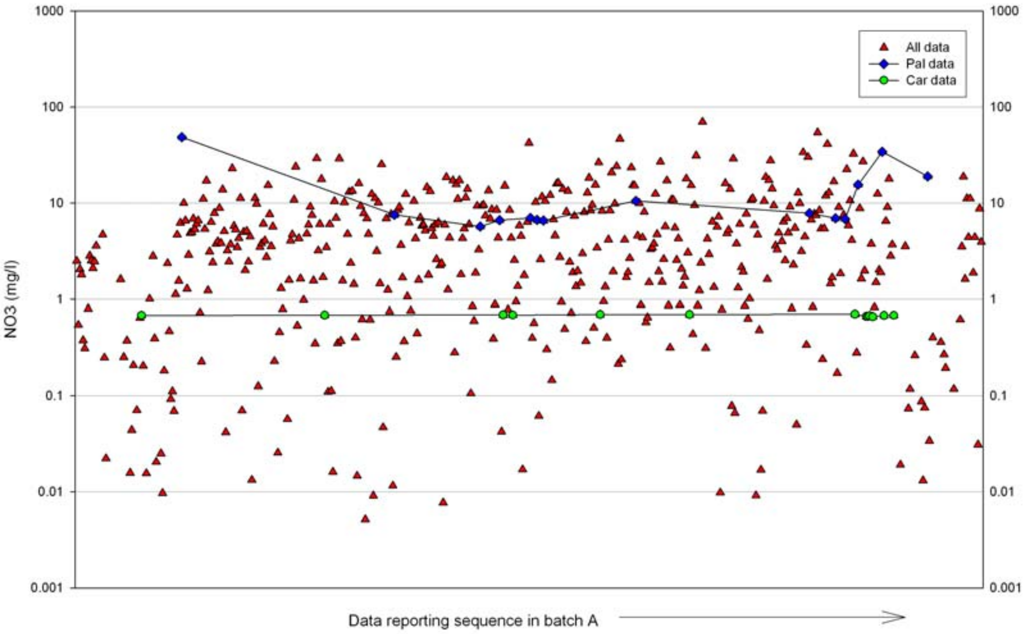


Figure 11: Comparison of nitrate concentrations in samples and secondary reference materials for reporting batch ‘A’.

The NPOC (DOC) data are also subject to not being run in numerical order and have two graphs as for the anion data (Appendix 3). These data show a major positive displacement of some of the extra standards inserted into hundred 5631*xx* in both Pal and Car SRMs (Figure 12), but there is no systematic pattern that can be discerned from the RNL sequence, the numerical sequence or the analytical run sequence (Appendix 3). Additionally the Car data appear to show a baseline shift in the ‘f’ batch, however, the concentrations in Car are close to the detection limit and will thus be affected by greater uncertainties. In batch ‘f’ there do not appear to be similar shifts in the Pal SRM data. There is also a potential positive shift in the batch ‘c’ data for Car, but not in Pal. The Pal SRM data appears to be affected by a positive shift in batch ‘a’ in comparison to subsequent data, that is not reflected in the Car data. In light of these conflicting perturbations, corrections have not been made. The data for smaller subsets of samples should be investigated carefully in any follow-up studies from the regional geochemical mapping.

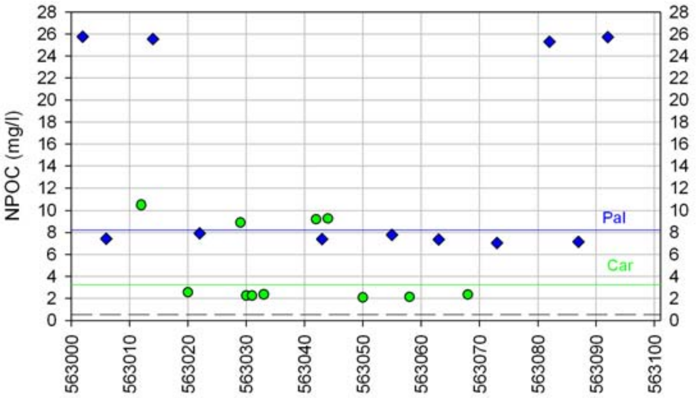


Figure 12: Secondary reference material data for NPOC in ‘hundred’ 5631*xx*

7.2 ICP DATA

The ICP data are presented in Appendix 3, with information on the certified value of SLRS-4 (where relevant) and the sample site data interquartile range, to establish some idea of the relative importance of the 3 SRMs and 1 CRM to the dataset. For each reference material the mean of the dataset is plotted as a control line on the plot in the same colour as the data points for that reference material. In Appendix 4, the data are presented for the 16 analytes for which SLRS-4 has certified values, and the Tellus CRM samples are compared with those inserted by GTK (2 per hundred). For these plots the certified value and 95% confidence limits are plotted, and the mean of the dataset is also drawn. These allow a form of visual t-test approach to be taken, where it can rapidly be established if there are significant differences between the sample data and the certified values, and any similarly whether any within batch variation is likely to be significant and require further testing.

The analytes which show possible bias between batches are investigated further below, and the other data shown in Appendix 3 and 4 do not show such variations.

7.2.1 BARIUM

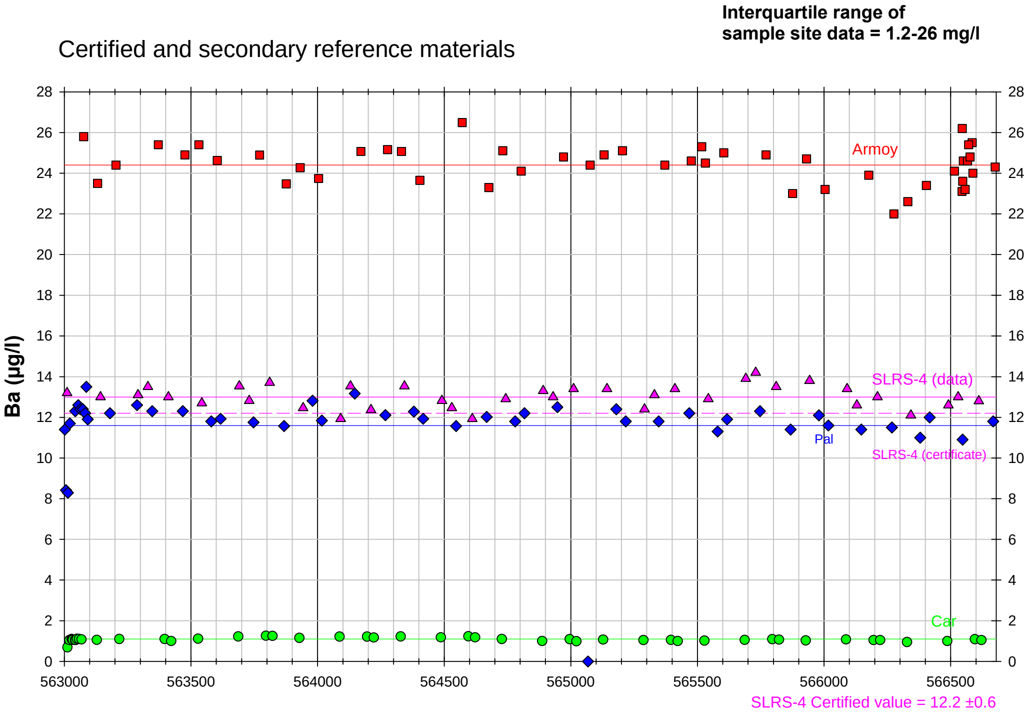
There would appear to be a systematic offset in the data between batches 87571-87581 (inclusive) from those preceding and following these batches (Appendix 3). Summary statistic calculation of the mean concentrations of the 36 samples between these laboratory numbers compared with the rest of the samples are summarised in Table 17.

A regression equation of $\mathbf{Y = 0.130 + (0.889X)}$ has been derived by taking the data for the 36 samples outwith the batches of concern as the 'accepted values' and the mean concentration of the 11 samples in batches 87571 – 87581 as the biased data. The regression was run in Minitab software. These 11 lab numbers have a total of 1046 analyses of Ba by ICP-MS, including 935 sample sites. The results of applying this equation to the reference materials are shown in the final column of Table 17 and in the corrected results in Figure 13. The sample sites affected by this transformation are shown in Figure 14. When interpolated images (using the standard G-BASE 10 classes) are compared the greatest difference is observed in the higher concentrations in the Ards area of County Down, some of which move to lower percentile classes.

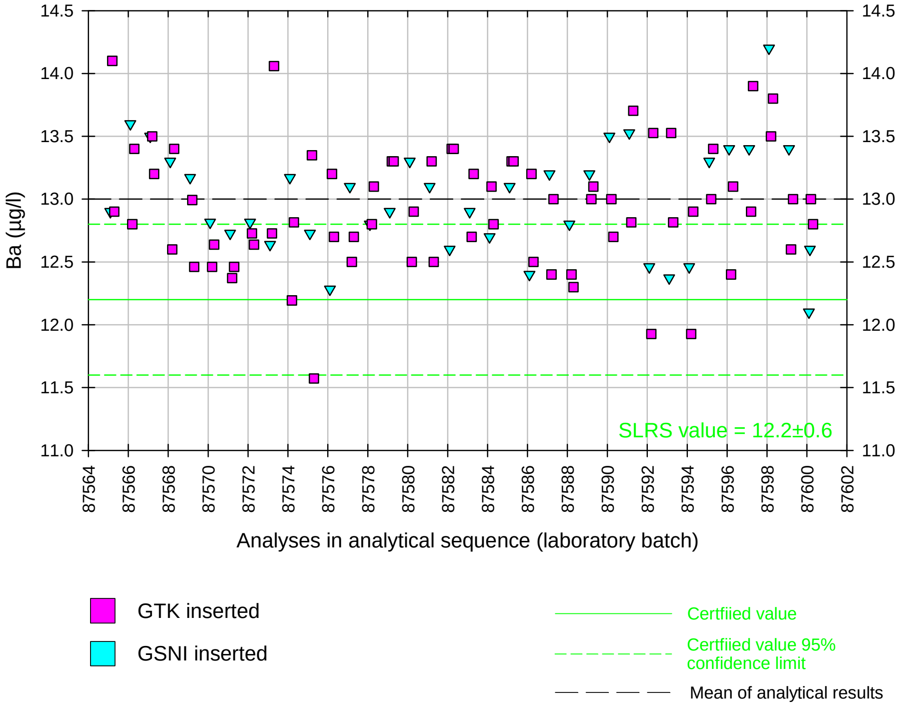
Thus the correction is satisfactory and the correction applied to the sample site data is retained.

Table 17: Summary statistics of Ba in reference materials between batch groups

Standard	**Lab batch <87571 or >87581**	**Lab batch ≥87571 and ≤87581**	**Lab batch ≥87571 and ≤87581 - corrected**
	mean concentration ($\mu g\ l^{-1}$)		
Car	1.05	1.13	1.14
Pal	11.8	13.4	12.0
SLRS-4 (all data)	13.0	14.0	12.9
Arm	24.4	27.4	24.5



(a) Routine reference materials



(b) SLRS-4 data

Figure 13: Corrected Ba concentrations in reference materials

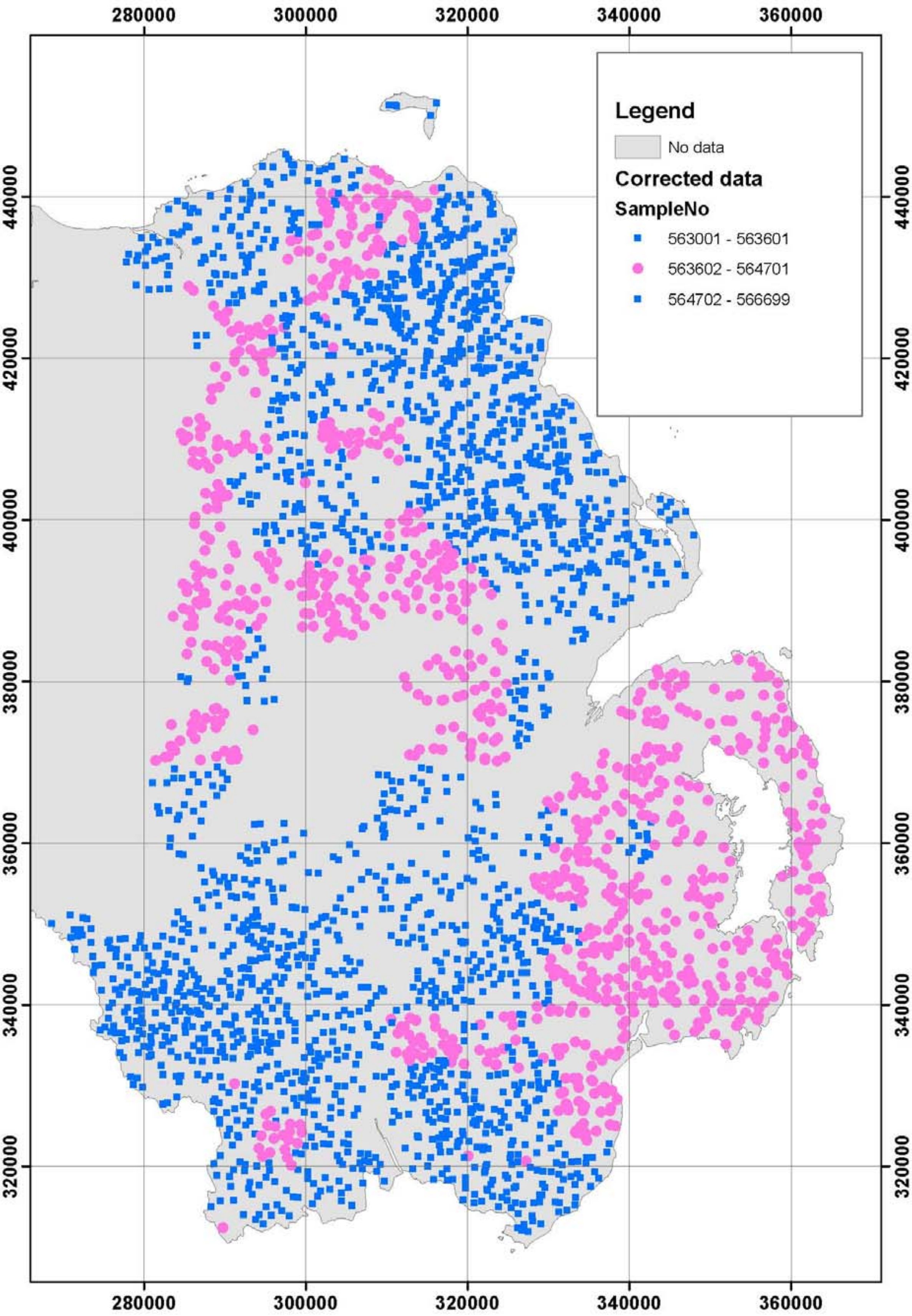


Figure 14: Location of the corrected Ba sample site data

7.2.2 CALCIUM

The calcium concentrations in the SRMs shown in Appendix 3 show excellent accuracy, with no apparent systematic between batch variation. However, Appendix 4 confirms that the SLRS-4 concentrations, whilst accurate, are systematically lower than the certified reference value. This offset from the value and 95% confidence limits of SLRS-4 is a very low actual concentration (mean of 5.8 mg l^{-1}, compared with a certified value of 6.2 ±0.2 mg l^{-1}). If the same uncertainty is applied to the GTK data as quoted by NRC (which should be a 'best case scenario'), then it can be seen that the upper limit of the GTK data is coincident with the lower value of the NRC values. Combining that information with the natural abundance of Ca in stream waters in the 2005 survey area (interquartile range of 24 – 50 mg l^{-1}) suggests that it would not be appropriate or necessary at this stage to make adjustment to the Ca concentrations.

The only rider to this assessment will be upon combination of the Ca data with that from the 1990s survey, when analysis was undertaken at the BGS Keyworth laboratories, which will have it's own uncertainty associated with it.

7.2.3 SODIUM

As is the case for Ca, Appendix 3 illustrates SRM data with a very high accuracy. As is also the case with Ca, the SLRS-4 data shown in Appendix 4 confirms the apparent negative bias of the data. In this case application of the confidence limits values of the NRC data to the GTK mean value gives a greater overlap between data distributions than occurs with the Ca data. As is the case with the Ca data, the concentrations of Na in SLRS-4 are very low compared to the interquartile range of the overall dataset (11-17 mg l^{-1}). As a result of this further assessment of the data, no adjustment has been made to Na concentrations, with the same rider as that attached to the Ca data.

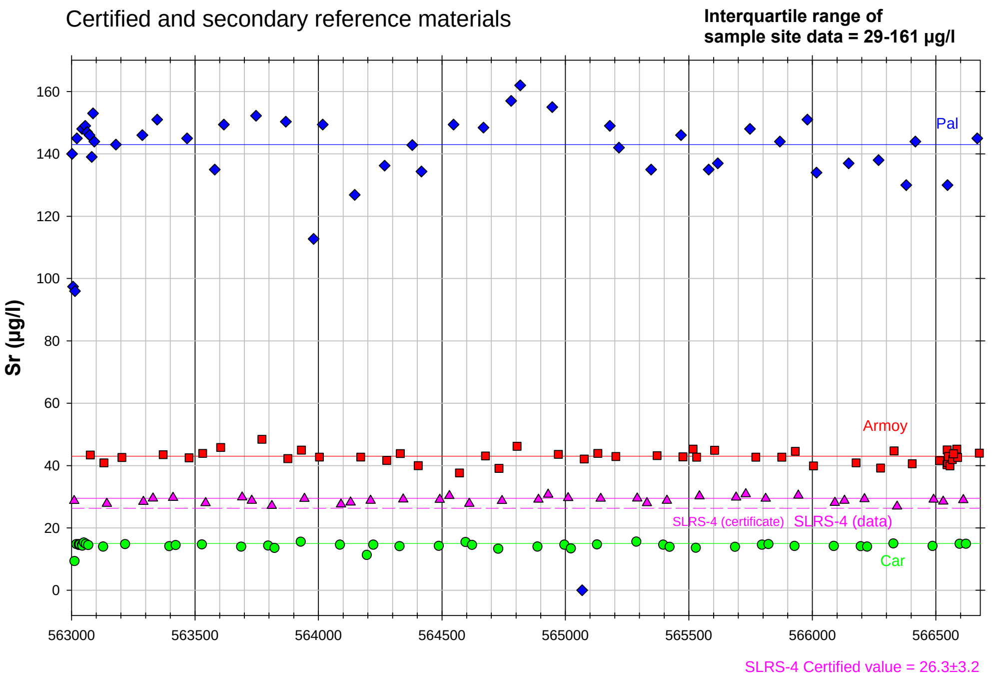
7.2.4 STRONTIUM

There would appear to be a systematic offset in the data between batches 87571-87581 (inclusive) from those preceding and following these batches (Appendix 3). Summary statistic calculation of the mean concentrations of the 36 samples between these laboratory numbers compared with the rest of the samples are summarised in Table 18.

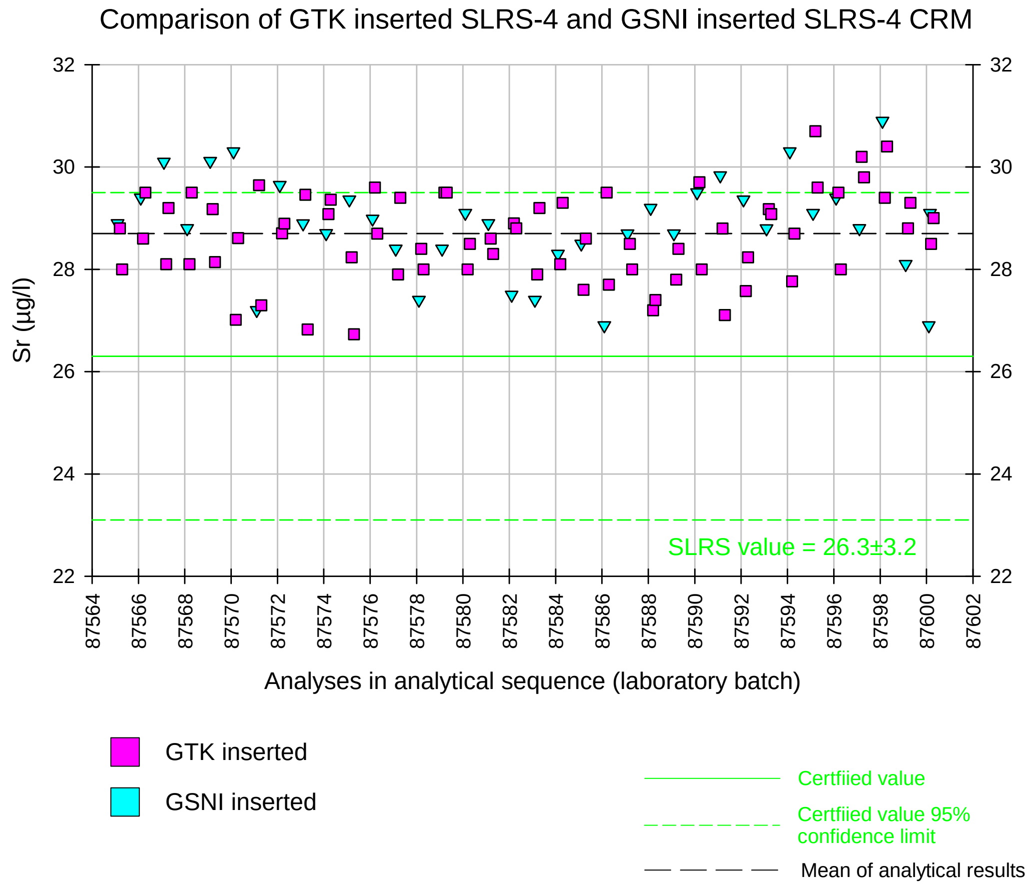
A regression equation of **Y = -0.059 + (0.940X)** has been derived by taking the data for the 35 samples outwith the batches of concern as the 'accepted values' and the mean concentration of the 11 samples in batches 87571 – 87581 as the biased data. The regression was run in Minitab software. These 11 lab numbers have a total of 1074 analyses of Sr by ICP-MS, including 950 sample sites. The results of applying this equation to the reference materials are shown in the final column of Table 18 and in the corrected results in Figure 15. The sample sites affected by this transformation are shown in Figure 14. When interpolated images (using the standard G-BASE 10 classes) are compared the greatest difference is observed in isolated regions of the Ards district, with some concentrations dropping into lower percentile classes (as for Ba). Thus the correction is satisfactory and the correction applied to the sample site data is retained.

Table 18: Summary statistics of Sr in reference materials between batch groups

Standard	Lab batch <87571 or >87581 (n = 36)	Lab batch ≥87571 and ≤87581 (n = 11)	Lab batch ≥87571 and ≤87581 - corrected values
	mean concentration (µg l^{-1})		
Car	14.3	15.2	14.2
SLRS-4 (all data)	28.7	30.4	28.7
Arm	42.7	45.8	43.0
Pal	141	150	141



(a) all routine reference materials



(b) SLRS-4 data

Figure 15: Corrected Sr data in reference materials

7.2.5 ZINC

There is a large deviation apparent in the data for laboratory batches >565800 for the Car and Pal SRMs. Isolated Arm samples are likewise affected, but there is no such effect on the SLRS-4 CRM material in either the GTK or the Tellus samples. Thus it is likely that the problem is related to contamination of the SRMs towards the end of the period of storage and use (either via contamination of the material itself or the sample bottles into which it was decanted for insertion into the field sample batches). The problem is not likely to be related to evaporation, as that would increase all parameters. Also, inhomogeneity problems would be expected to be reflected in more than one analyte. On the basis of this evidence, no adjustment to sample site data is proposed.

8 Monitor site data

Samples were collected on a daily basis at a 'monitor site' from each field base, as described in Johnson (2005). These stream sites are chosen on the basis of representivity of the region being sampled from a field base and ease of access for daily sampling by field team leaders; their location is shown in Figure 1, and details of each site are summarised in Table 19. Much of the data is plotted and shown in Appendix 5, The purpose of sample collection at these sites is to assist with determining whether any short term weather events (particularly heavy rainfall) could affect the regional hydrogeochemical data, and result in artefacts on the interpolated geochemical images. Another variable occurs in the pH data, where failure of pH meters occurred once in each field team, leading to delays in analysis whilst spares were posted out from BGS Keyworth (see Section 4). These data affected are highlighted in the plot in Appendix 5, and shown in more detail in Figure 16. It can be seen that little interpretation can be made of the variations, although it is possible that after two days storage there is a decrease in pH. This variation is not large enough to warrant any form of post-analysis correction to the data. The sample site data is plotted in Figure 17 by date, to show the locations with which most care should be taken in any future use of the data, but comparison of the location of these data with the provisional interpolated pH map (Figure 18) indicates that any systematic errors are not sufficiently large to affect the spatial data distribution.

Table 19 shows the dates on which heavy rainfall is recorded in the field chemistry book, and are thus most likely to have an influence on stream water chemistry. Some of these do appear to tie in with minor perturbations in the monitor site data, such as that of pH at MSN2 around the 29th July, which is also reflected in the Ca and HCO_3 data. However, in all cases these fluctuations are small in relation to the overall dataset, and there is no indication from inspection of the graphs that there was any weather event which affects the suitability of the data for regional geochemical mapping.

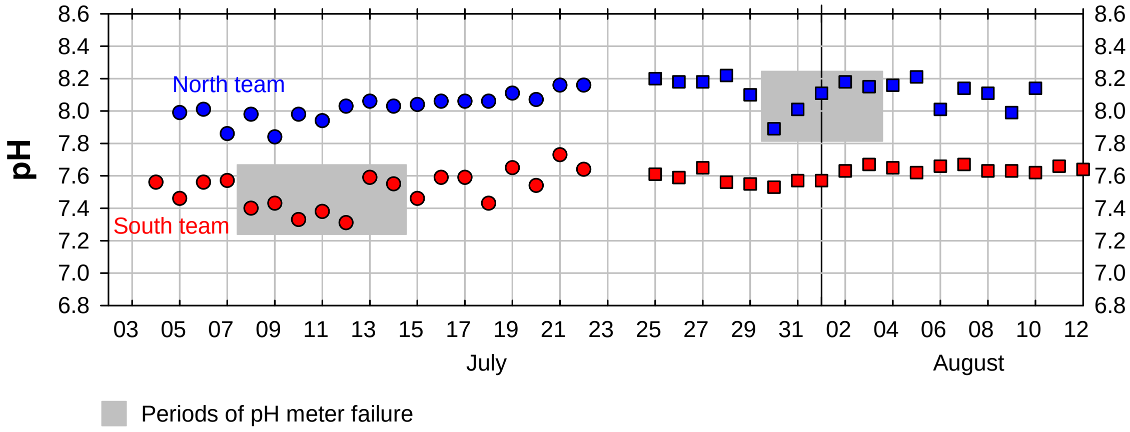


Figure 16: pH data affected by meter failure

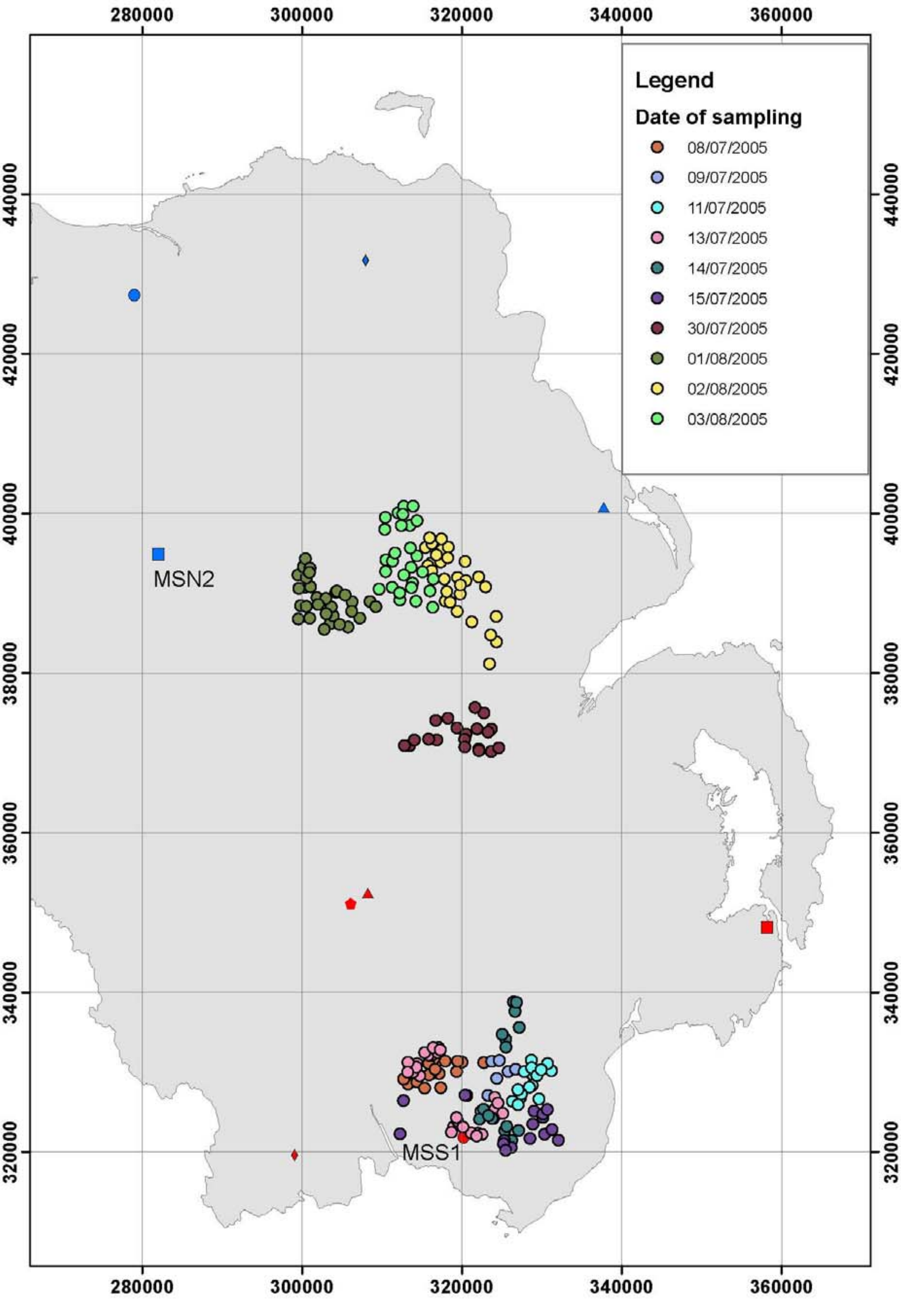


Figure 17: Location and data of samples collected during pH meter malfunction periods

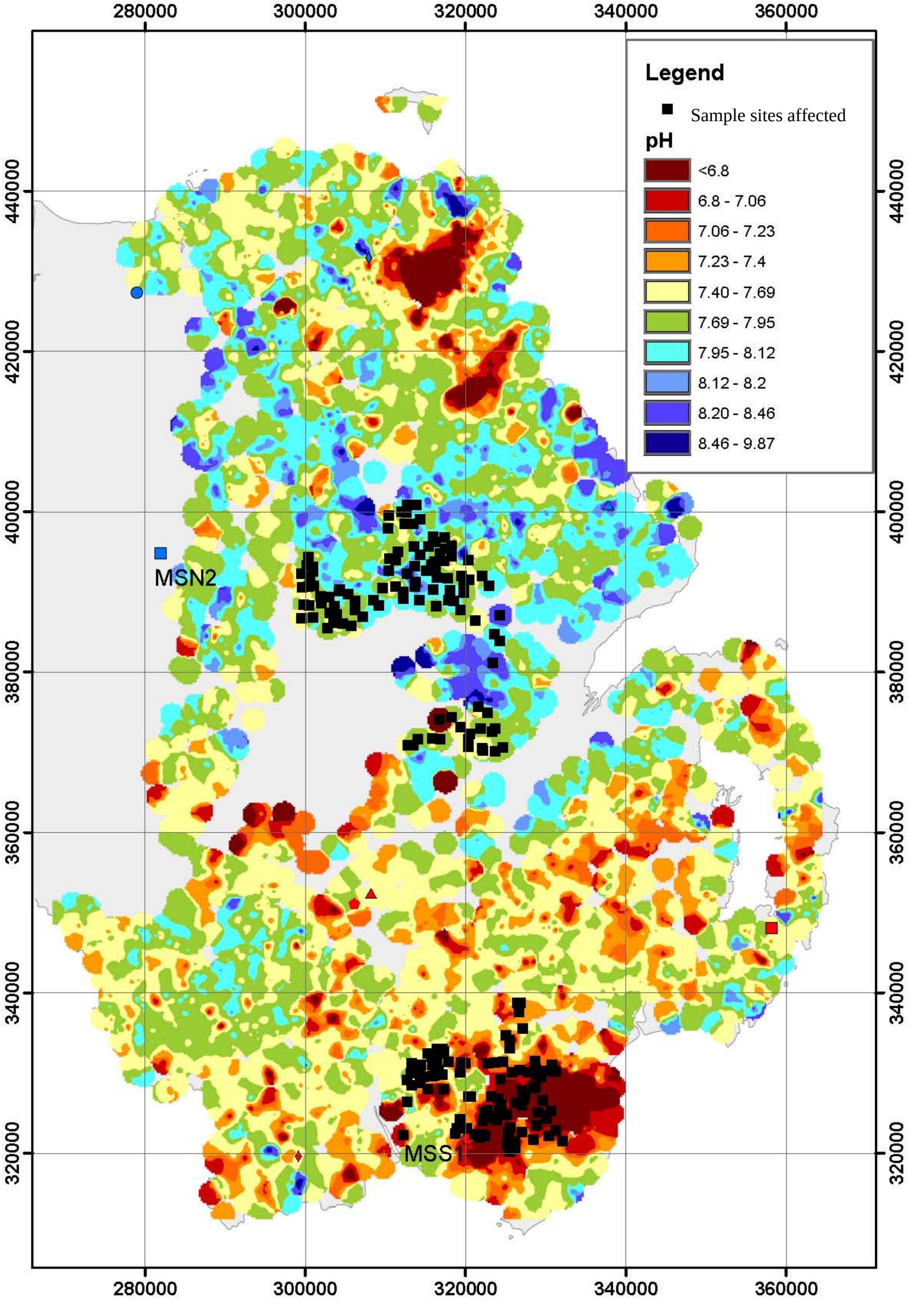


Figure 18: Location of samples collected during pH meter malfunction and comparison with the provisional interpolated image

Table 19: Details of the monitor sites

(a) Location and dates

Monitor Site	Easting	Northing	Sample count	Start date	End date
M1	320209	321837	5	06/05/2005	10/05/2005
MSN1	279001	427356	18	05/07/2005	22/07/2005
MSN2	281979	394859	17	25/07/2005	10/08/2005
MSN3	307948	431724	21	13/08/2005	02/09/2005
MSN4	337784	400813	16	05/09/2005	22/09/2005
MSS1	320209	321838	19	04/07/2005	22/07/2005
MSS2	358203	348084	19	25/07/2005	12/08/2005
MSS3	299082	319609	18	15/08/2005	02/09/2005
MSS4	308219	352423	6	05/09/2005	10/09/2005
MSS5	306084	351166	12	11/09/2005	22/09/2005

(b) Stream environment information and observations.

Monitor Site	Stream order	Drainage type	Drainage condition	Landuse	Mapped geology (1:250,000)
M1	1	‘Small stream’	‘Moderate flow’	Rough grazing	Granite
MSN1	2	‘Small stream’	‘Moderate flow’	Rough grazing	Basalt
MSN2	1	‘Small stream’	‘Low flow’	Rough grazing	Sandstone
MSN3	2	‘Small stream’	‘Low flow’	Pasture	Quartzite
MSN4	3	‘Stream’	‘Strong flow’	Rough grazing	Basalt
MSS1	1	‘Small stream’	‘Moderate flow’	Rough grazing	Granite
MSS2	3	‘Small stream’	‘Low flow’	Arable	Sandstone
MSS3	1	‘Drain’	‘Low flow’	Pasture	Granodiorite
MSS4	2	‘Small stream’	‘Low flow’	Pasture	Basalt
MSS5	2	‘Small stream’	‘Moderate flow’	Rough grazing	Basalt

Codes and translations for these information are provided in Johnson (2005)

(c) Additional information

Monitor Site	Notes
M1	Training week; location re-used for MSS1.
MSN1	Heavy showers 5th, 7th, 14th and 18th July
MSN2	Heavy showers 28th July and 2nd August
MSN3	Heavy showers 21st, 22nd, 31st August and 1st September
MSN4	Heavy showers 5th and 9th September
MSS1	Heavy showers 5th and 6th July
MSS2	Heavy showers 28th July and 4th August
MSS3	Heavy showers 19th, 21st, 24th, 25th and 31st August
MSS4	Heavy showers 9th September
MSS5	Heavy showers 15th September

9 Charge balance data

Charge balance is calculated as shown below (Equation 1). This relationship follows from the essential condition of electro-neutrality in water and the fact that the eight major ions comprise >95% of the total dissolved ions in most natural stream waters (Appelo and Postma, 1994).

$$\text{Charge balance} = \frac{(sum\ of\ \ cations - sum\ of\ \ anions)}{(sum\ of\ \ anions + sum\ of\ \ cations)} \times 100 \qquad \text{Equation 1}$$

Where ‘cations’ represents Ca, Mg, Na and K. ‘Anions’ represents HCO_3, SO_4, Cl, NO_3, all converted to milli-equivalents per litre.

Convention dictates that with modern analytical techniques, there should be no greater charge balance error than ±5%. However, for the purposes of regional geochemical mapping acceptance of data with a charge balance error of ±10% proves perfectly adequate. It should be noted that if sites are to be studied further at a local scale, the results of this calculation may need to be revisited. Additionally, where the total of the cations or anions is <1 meq l^{-1}, then the charge balance errors have been accepted irrespective of their value. This is because the analytical errors will be much larger at such low concentrations. As long as visual inspection of this data confirms that there do not appear to be errors on the scale of orders of magnitude, the concentrations are fit-for-purpose for regional geochemical mapping. Applying these criteria, some 107 samples had charge balance errors greater than ±10% which warranted further inspection which are reported in Appendix 6. These data are represented in Figure 19, and the distribution of areas with very low total dissolved major ions are shown in Figure 20.

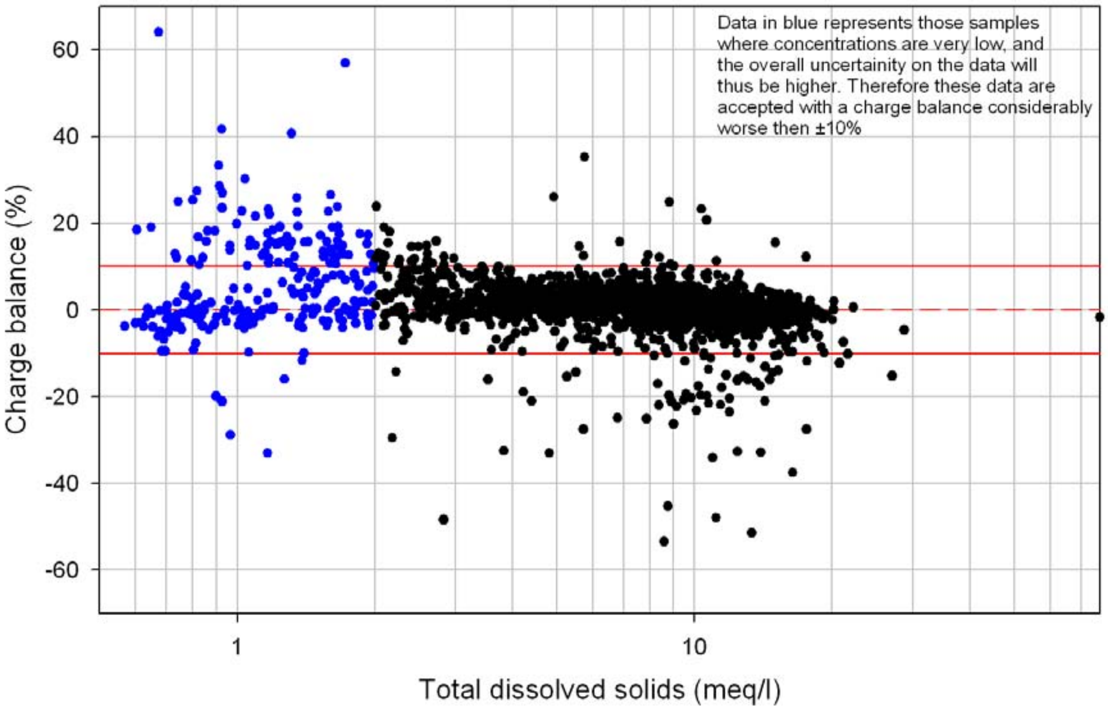


Figure 19: Comparison of charge balance errors with TDS concentrations

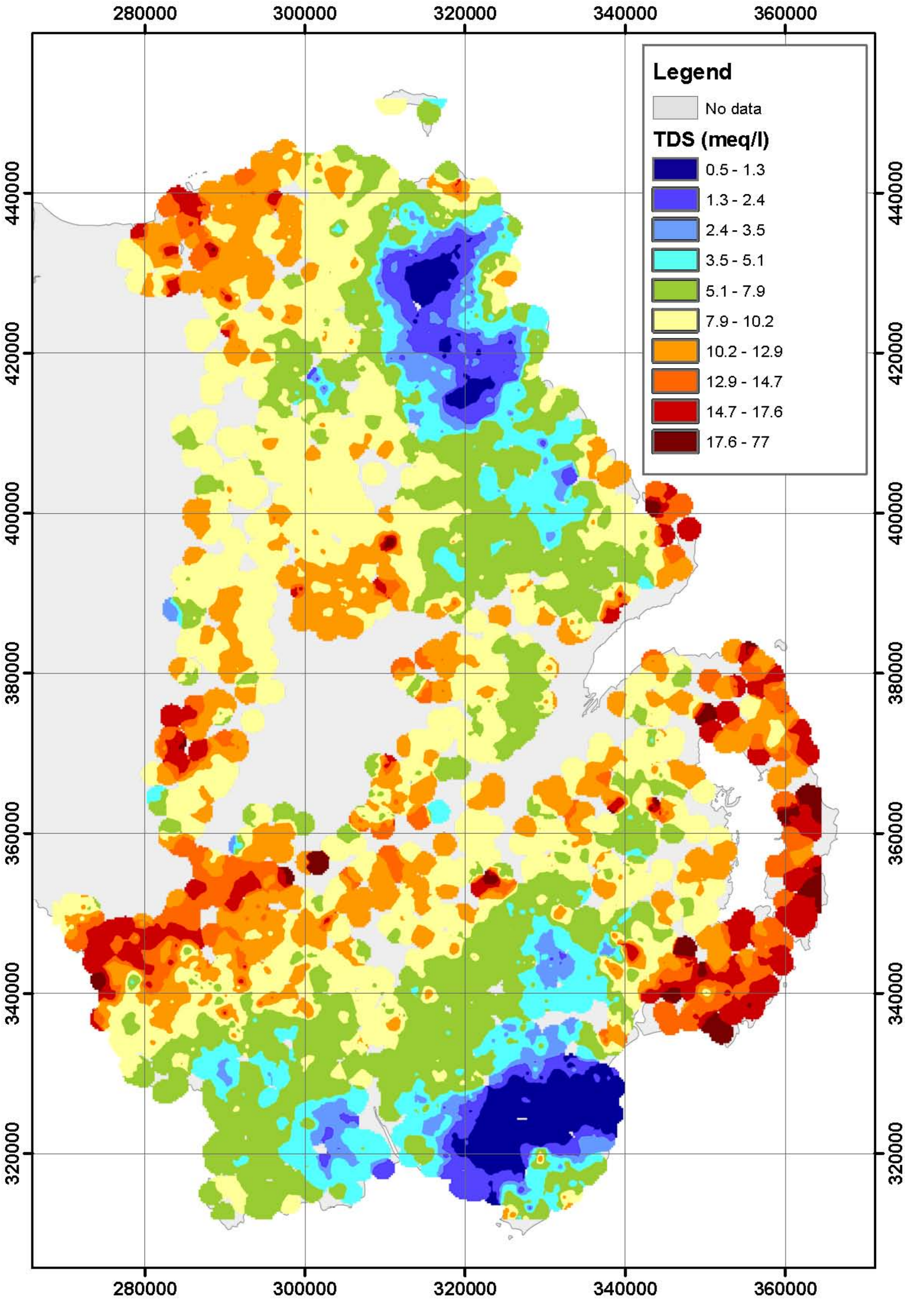


Figure 20: Provisional image of total dissolved solids in streamwater of Northern Ireland

Plotting the location of these 107 (Figure 21) samples illustrates that most of them are isolated, and generally exhibit no particular relationship to geology or sampling campaign boundaries. The exception to this is the region of north-east Co. Antrim, where the is a cluster of samples which are >10% charge balance error. Inspection of the provisional images for these areas indicate very low major ion concentrations, but these samples also have high concentrations of dissolved organic carbon (DOC). The exclusion of which from the charge balance calculation could lead to an underestimate of negatively charged ions. Additionally it was noticed that some data where the SO_4 concentrations appear to be the source of the charge balance error (Appendix 6), these occur around north-east Co. Antrim as illustrated in Figure 21. Thus the decision has been altered, and these data have been retained as a result of inspection of the provisional SO_4 image, although they have had a qualifier attached to their reliability if used in detail rather than for regional geochemical mapping. These data are also coincident with elevated DOC concentrations.

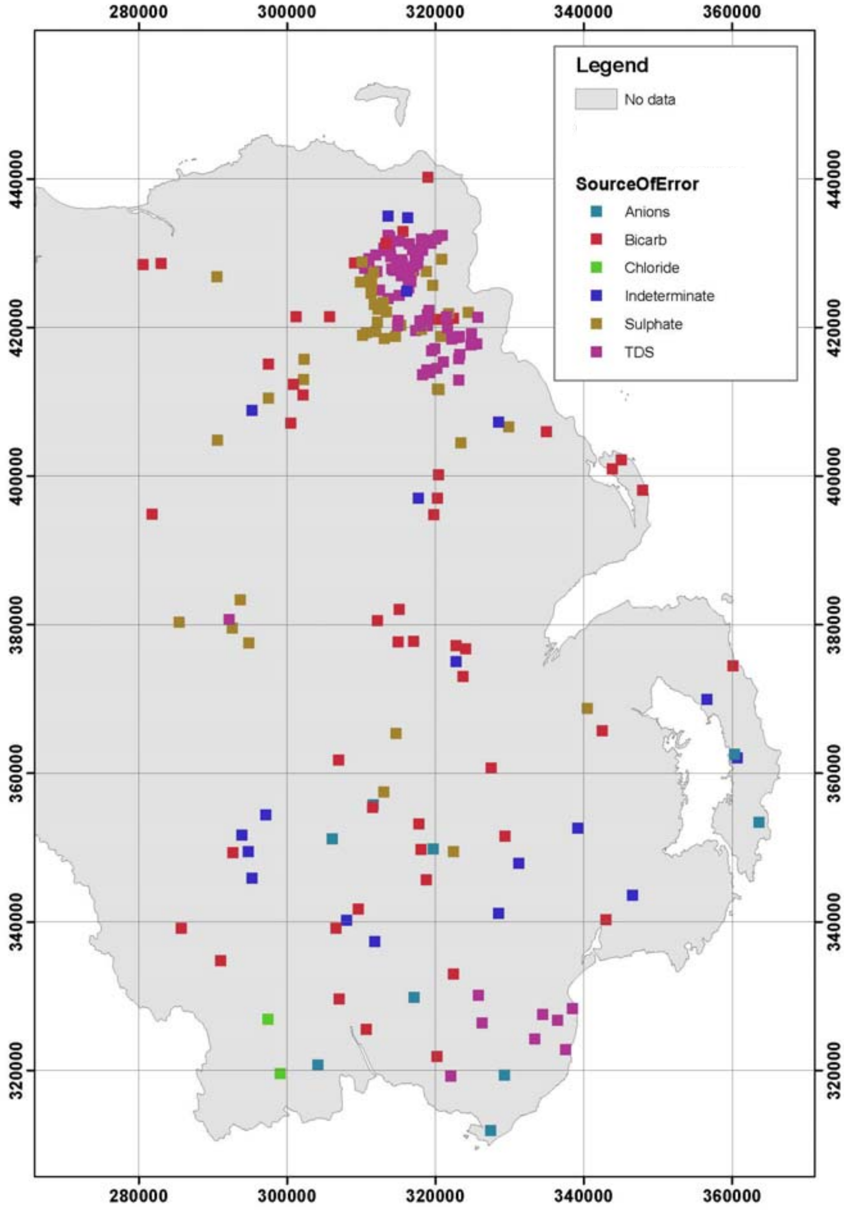


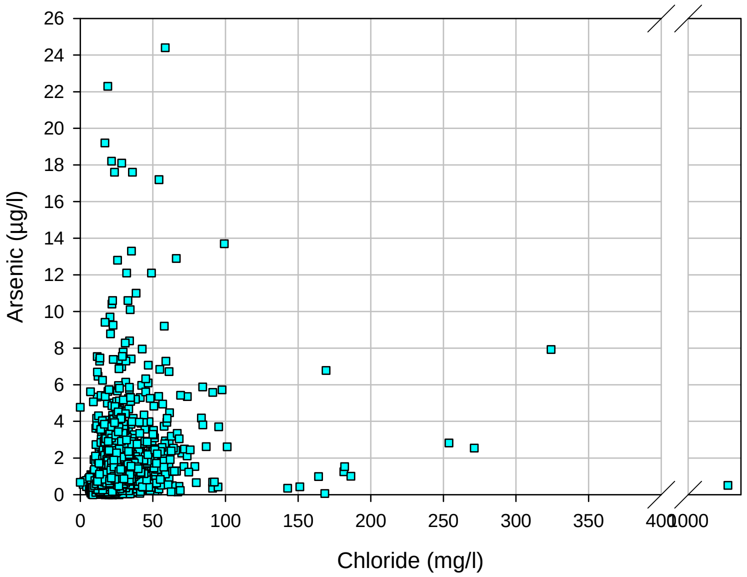
Figure 21: Distribution of different causes of high charge balance errors in streamwaters

10 Analytical interferences and overlap analytes

10.1 CHECK ON ICP INTERFERENCES

Analytical interferences are corrected as part of the laboratory QC procedure. However, as a final check, plots are made of selected element pairs which are known to be subject to interferences. This is particularly useful in order to confirm that any positive anomalies recognised during mapping are not artefacts of an interference.

Figure 22 illustrate the comparisons undertaken for this report. These plots are for Ni-Ca, Zn-Ca, As-Cl, Cr-NPOC(DOC). It can be seen than none of them show a strong positive correlation, suggesting that sample site data is not subject to under-corrected interferences.



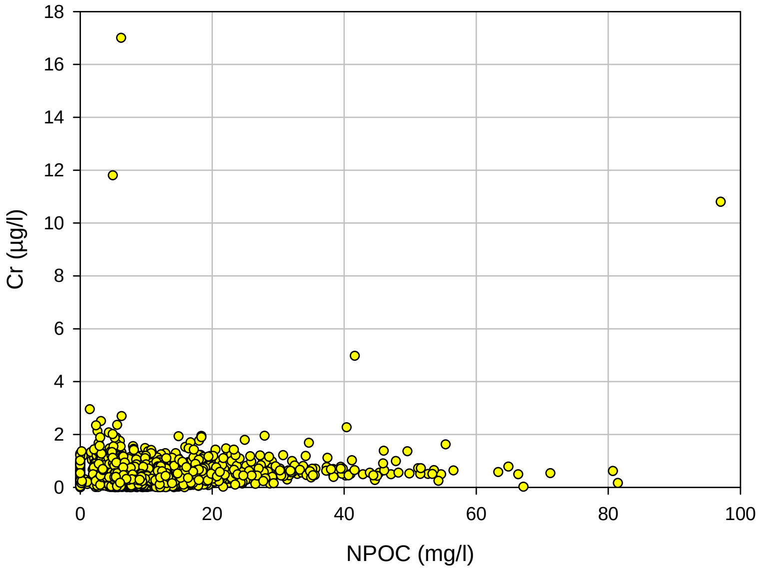
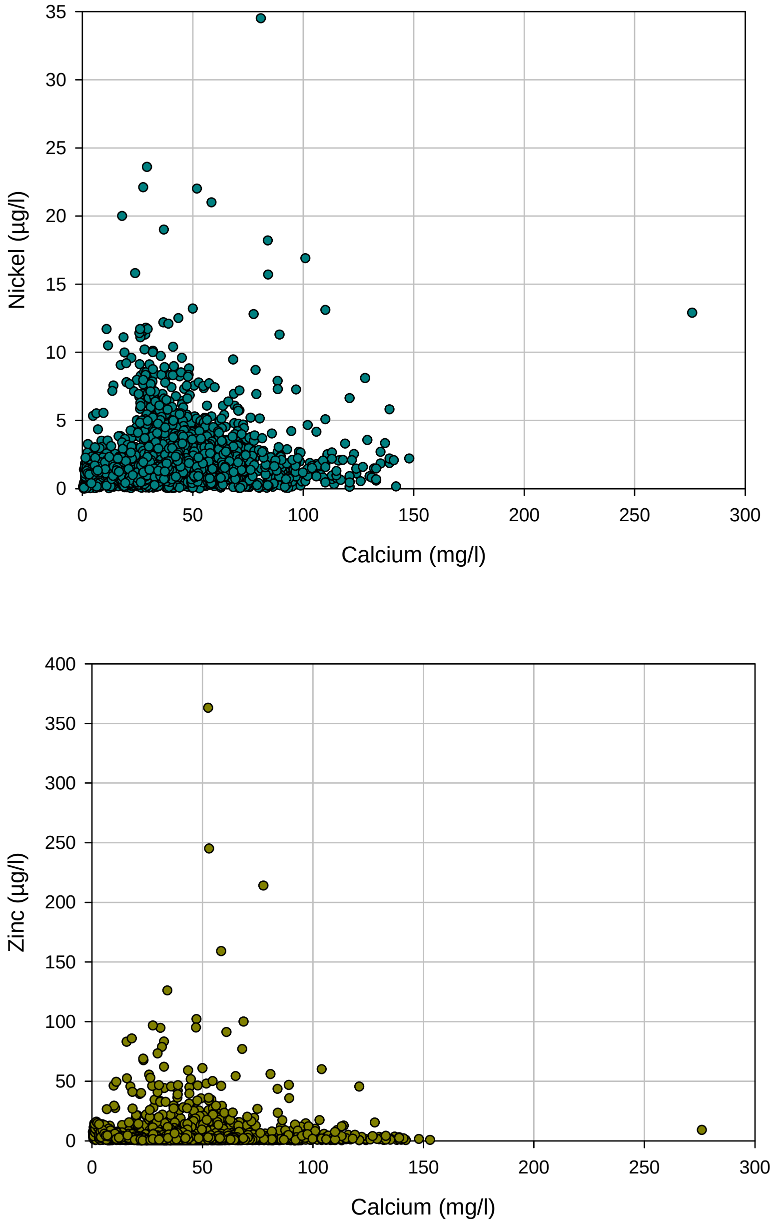


Figure 22: Comparison of data with potential interferences by ICP

(a) Chloride on arsenic (b) NPOC on chromium



cont.. Figure 22: Comparison of data with potential interferences by ICP

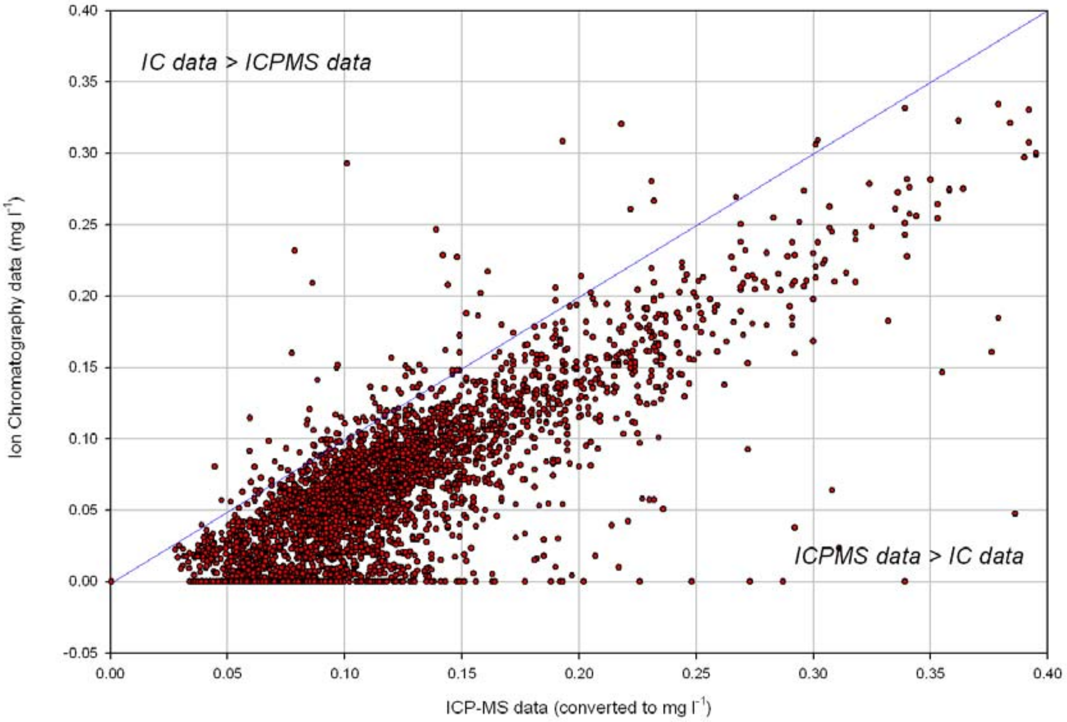
(c) Calcium on nickel (d) Calcium on zinc

10.2 BROMINE/ BROMIDE

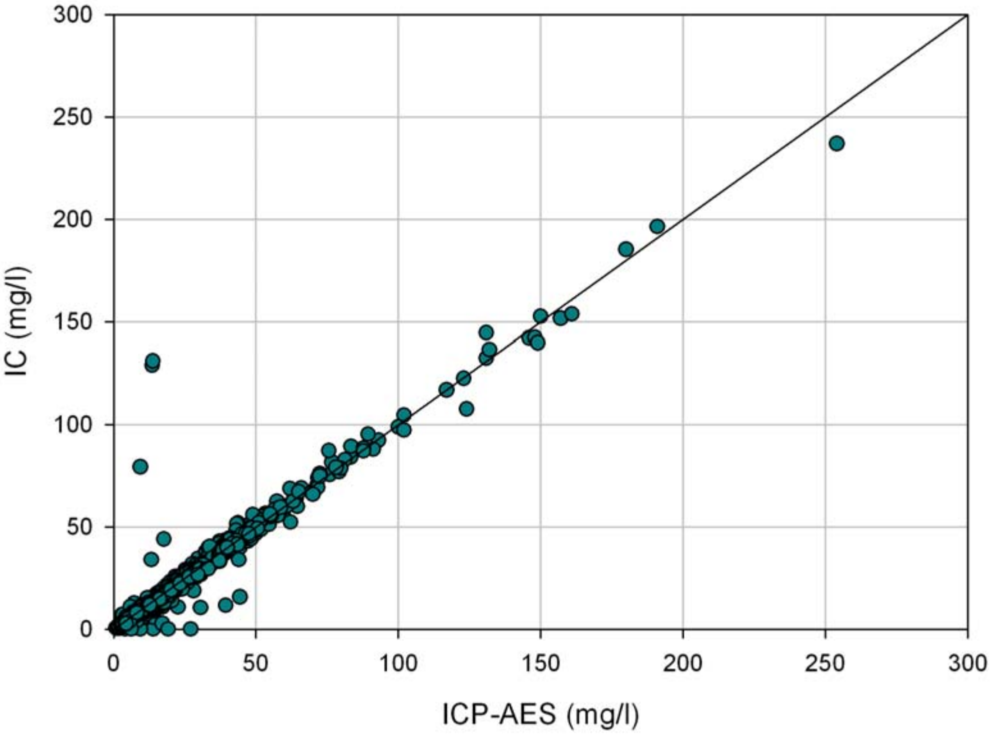
Figure 23a illustrates the systematic bias between the ICP and IC methods of analysis. The ICP-MS data have been used in this study because the overall uncertainties on the data appear to be less than those from IC. It should be noted that the two methods are technically measuring different parameters, as the ICP-MS is measuring total Br, whilst the IC is measuring Br^-.

10.3 SULPHATE

Figure 23b illustrates the systematic bias between the ICP and IC methods of analysis. The ICP-AES data have been used in this study in order to avoid systematic bias between the 1994-1996 data and these data when the data sets are combined for whole Northern Ireland presentation.



(a)



(b)

Figure 23: Comparison of (a) bromide and (b) sulphate measured by two different techniques

11 Statistical summary of data acquired from the 2005 samples

The data shown in Table 20 is a summary of all the data included in this report, with percentile values provided appropriate to those included in the standard BGS geochemical regional mapping presentations.

Table 20: Summary statistics of 2005 sample site data after quality control inspection

(Field measurements, IC and TIC/TOC analyser, analytical methods)

Analyte	pH	Conductivity	Alkalinity	F	Cl	Br (IC)	NO_2	NO_3	P	SO_4 (IC)	DOC
Units	-	µS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Detection limit (DL)	-	10	0.05	0.01	0.05	0.02	0.01	0.02	0.1	0.05	0.5
Minimum value	2.6	<10	<0.05	<0.01	<0.05	<0.02	<0.01	<0.02	<0.1	<0.05	<0.5
Percentiles: 5	6.8	68	16	0.018	8.5	<0.02	<0.01	<0.02	<0.1	1.7	2.7
10	7.1	114	43	0.023	10	<0.02	<0.01	0.02	<0.1	2.8	3.6
15	7.2	164	69	0.027	12	<0.02	<0.01	0.09	<0.1	3.8	4.4
25	7.4	233	104	0.035	15	0.028	<0.01	0.64	<0.1	6.0	5.5
50	7.7	356	171	0.067	21	0.064	<0.01	3.8	<0.1	12	8.3
75	8.0	472	229	0.101	28	0.099	0.014	8.6	<0.1	19	12.6
90	8.1	579	304	0.135	38	0.147	0.066	16	0.20	29	18.7
95	8.2	643	349	0.174	47	0.191	0.17	22	0.45	38	26.0
99	8.5	817	438	0.317	74	0.325	1.10	40	1.7	79	53.9
Maximum value	9.9	3400	1289	15	1076	9.8	30	80	24	237	97
Mean	7.6	359	174	0.116	24	0.079	0.075	6.2	0.10	15	10.7
Count (n)	3065	3060	3061	3060	3060	3060	3059	3060	3060	3060	3060
Samples ≤DL (n)	n/a	1	18	15	2	619	2185	318	2580	4	76
Samples ≤DL (%)	n/a	<1%	1%	<1%	<1%	20%	71%	10%	84%	<1%	2%

cont.. Table 20: Summary statistics of 2005 sample site data after quality control inspection

(ICP analytical methods)

Analyte	Ag	Al	As	Au	B	Ba (ICP-MS)	Ba (ICP-AES)	Be	Bi	Br	Ca	Cd	Co
Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	µg/l	µg/l
Detection limit (DL)	0.01	0.5	0.05	0.1	0.5	0.05	2	0.05	0.02	10	0.1	0.02	0.02
Minimum value	<0.01	<0.5	<0.05	<0.1	2.1	<0.05	239	<0.05	<0.02	29	0.4	<0.02	<0.02
Percentiles: 5	<0.01	3.4	0.12	<0.1	4.9	0.25	267	<0.05	<0.02	55	4.3	<0.02	0.03
10	<0.01	4.7	0.17	<0.1	5.8	0.40	295	<0.05	<0.02	63	9.5	<0.02	0.05
15	<0.01	5.9	0.20	<0.1	6.5	0.63	323	<0.05	<0.02	70	16	<0.02	0.06
25	<0.01	7.9	0.28	<0.1	7.9	1.2	374	<0.05	<0.02	86	24	<0.02	0.10
50	<0.01	14	0.59	<0.1	13	8.6	429	<0.05	<0.02	111	38	<0.02	0.19
75	<0.01	28	1.3	<0.1	22	25	444	<0.05	<0.02	144	50	<0.02	0.39
90	<0.01	86	2.4	<0.1	34	66	479	<0.05	<0.02	199	70	0.03	0.84
95	<0.01	151	3.4	<0.1	44	107	519	<0.05	<0.02	244	88	0.05	1.4
99	<0.01	263	7.5	<0.1	96	215	552	0.66	<0.02	392	121	0.17	4.7
Maximum value	0.05	2186	24	<0.1	475	669	560	2.8	0.1	4856	276	1.6	27
Mean	<0.01	33	1.1	<0.1	19	24	407	<0.05	<0.02	128	40	<0.02	0.44
Count (n)	3063	3063	3063	3063	3063	3055	8	3063	3063	3063	3063	3063	3063
Samples ≤DL (n)	3062	3	37	3063	0	2	0	2915	3057	0	0	2604	123
Samples ≤DL (%)	>99%	<1%	1%	100%	<1%	<1%	<1%	95%	>99%	<1%	<1%	85%	4%

cont.. Table 20: Summary statistics of 2005 sample site data after quality control inspection

Analyte	Cr	Cs	Cu	Fe	Ho	K (ICP-MS)	K (ICP-AES)	La	Li	Mg	Mn (ICP-MS)	Mn (ICP-AES)
Units	µg/l	µg/l	µg/l	mg/l	µg/l	mg/l	mg/l	µg/l	µg/l	mg/l	µg/l	µg/l
Detection limit (DL)	0.2	0.01	0.1	0.01	0.001	0.01	0.5	0.001	0.02	0.1	0.02	1
Minimum value	<0.2	<0.01	<0.1	<0.01	<0.001	<0.01	0.7	<0.001	<0.02	0.4	0.09	129
Percentiles: 5	<0.2	<0.01	<0.1	0.01	<0.001	0.22	1.1	0.004	0.05	2.1	2.1	196
10	<0.2	<0.01	0.23	0.02	<0.001	0.35	1.5	0.005	0.08	4.3	4.0	232
15	<0.2	<0.01	0.36	0.03	<0.001	0.60	1.6	0.006	0.11	5.9	6.4	258
25	<0.2	<0.01	0.55	0.06	0.002	1.2	3.2	0.009	0.20	8.2	12	310
50	0.34	<0.01	1.0	0.14	0.003	3.2	27	0.023	0.74	14	33	672
75	0.59	<0.01	1.7	0.38	0.005	6.9	50	0.065	1.6	20	101	1841
90	0.86	0.05	2.7	0.94	0.010	11	84	0.18	2.9	23	280	4239
95	1.0	0.08	3.5	1.8	0.020	16	128	0.34	4.3	26	632	6547
99	1.5	0.20	6.3	5.6	0.052	30	148	0.89	8.8	31	2622	7710
Maximum value	17	1.3	14	33	0.14	55	163	4.4	27	66	38958	9406
Mean	0.33	0.02	1.3	0.48	0.005	5.1	35	0.077	1.2	14	185	1523
Count (n)	3063	3063	3063	3063	3063	2999	64	3063	3063	3063	2910	153
Samples ≤DL (n)	1108	2356	184	104	688	1	0	14	42	0	0	0
Samples ≤DL (%)	36%	77%	6%	3%	22%	<1%	0%	<1%	1%	0%	0%	0%

cont.. Table 20: Summary statistics of 2005 sample site data after quality control inspection

Analyte	Mo	Na	Ni	P (ICP-MS)	P (ICP-AES)	Pb	Pd	Pt	Rb	Rh	Sb	Se	Si
Units	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l
Detection limit (DL)	0.02	0.2	0.05	10	50	0.05	0.1	0.02	0.01	0.01	0.02	0.5	0.06
Minimum value	<0.02	4.0	<0.05	<10	<50	<0.05	<0.1	<0.02	0.03	<0.01	<0.02	<0.5	0.38
Percentiles: 5	<0.02	6.6	0.1	<10	<50	<0.05	<0.1	<0.02	0.27	<0.01	<0.02	<0.5	2.2
10	0.03	7.8	0.3	<10	80	<0.05	<0.1	<0.02	0.49	<0.01	<0.02	<0.5	3.1
15	0.03	8.8	0.4	<10	110	<0.05	<0.1	<0.02	0.73	<0.01	0.03	<0.5	3.6
25	0.06	11	0.7	23	154	<0.05	<0.1	<0.02	1.1	<0.01	0.04	<0.5	4.5
50	0.20	14	1.4	85	230	<0.05	<0.1	<0.02	2.4	<0.01	0.07	<0.5	6.3
75	0.57	19	2.3	225	482	0.12	<0.1	<0.02	4.8	<0.01	0.14	<0.5	9.2
90	0.93	24	3.8	522	3821	0.34	<0.1	<0.02	8.2	<0.01	0.24	<0.5	11
95	1.2	29	5.3	852	4719	0.69	<0.1	<0.02	11	<0.01	0.32	<0.5	12
99	2.7	46	10.1	2345	17734	1.8	<0.1	<0.02	27	<0.01	0.69	<0.5	15
Maximum value	28	698	34.5	12569	27800	44	<0.1	<0.02	273	0.05	3.4	1.0	20
Mean	0.43	16	1.9	233	1424	0.17	<0.1	<0.02	4.0	<0.01	0.12	<0.5	6.8
Count (n)	3063	3063	3063	3016	48	3063	3063	3063	3063	3063	3063	3063	3063
Samples ≤DL (n)	265	0	117	462	0	1687	3063	3063	0	3046	328	3050	0
Samples ≤DL (%)	9%	0%	4%	15%	0%	55%	100%	100%	0%	99%	11%	>99%	0%

cont.. Table 20: Summary statistics of 2005 sample site data after quality control inspection

Analyte	Sn[$]	SO_4	Sr	Th	Ti	Tl	U	V	W	Y	Zn	Zr
Units	µg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Detection limit (DL)	0.05	0.3	0.1	0.01	0.5	0.01	0.01	0.05	0.01	0.001	0.2	0.03
Minimum value	<0.05	1.0	3.0	<0.01	<0.5	<0.01	<0.01	<0.05	<0.01	<0.001	<0.2	<0.03
Percentiles: 5	<0.05	2.6	7.7	<0.01	0.9	<0.01	<0.01	0.12	<0.01	0.02	0.5	<0.03
10	<0.05	3.5	11.9	<0.01	1.1	<0.01	0.02	0.22	<0.01	0.03	0.7	<0.03
15	<0.05	4.5	16.3	<0.01	1.3	<0.01	0.03	0.31	<0.01	0.04	0.8	<0.03
25	0.06	6.7	29.4	<0.01	1.7	<0.01	0.06	0.52	<0.01	0.05	1.0	0.05
50	0.07	12	87.0	<0.01	2.4	<0.01	0.15	1.1	<0.01	0.07	1.8	0.08
75	0.09	20	157	<0.01	3.4	<0.01	0.38	2.2	<0.01	0.14	3.5	0.15
90	0.12	30	234	0.03	4.5	0.02	0.80	3.6	<0.01	0.28	8.5	0.23
95	0.15	38	300	0.05	5.6	0.02	1.3	4.7	0.02	0.53	15	0.30
99	0.23	76	492	0.15	12	0.04	2.6	7.1	0.10	1.6	48	0.55
Maximum value	4.3	254	2612	0.46	83	0.22	8.4	20	2.5	4.9	363	3.0
Mean	0.08	16	112	0.01	2.9	<0.01	0.34	1.6	<0.01	0.15	4.5	0.11
Count (n)	3063	3063	3063	3063	3063	3063	3063	3063	3063	3063	3063	3063
Samples ≤DL (n)	740	0	0	2541	23	2447	260	74	2852	3	4	490
Samples ≤DL (%)	24%	0%	0%	83%	1%	80%	8%	2%	93%	<1%	<1%	16%

[$] See section 5 describing QC problems with these data that should restrict their use.

Glossary

Term	Explanation
ANOVA	Analysis of variance (a statistical test)
CRM	Certified reference material
DOC	Dissolved organic carbon.
F/A	Filtered and acidified (a sample type)
F/UA	Filtered, unacidified (a sample type)
GTK	Geological Survey of Finland (Geologian Tutkimuskeskus)
IC	Ion chromatography (an analytical instrument)
ICP-AES	Inductively coupled atomic emission spectrometry (an analytical instrument)
ICP-MS	Inductively coupled plasma mass spectrometry (an analytical instrument)
NPOC	Non-purgeable organic carbon. The name under which DOC is reported, but includes analytical method information, so is not strictly an analyte.
RNL	Random number list.
SRM	Secondary reference material
TDS	Total dissolved solids. Measured in this report by summation of the major ions in solution.

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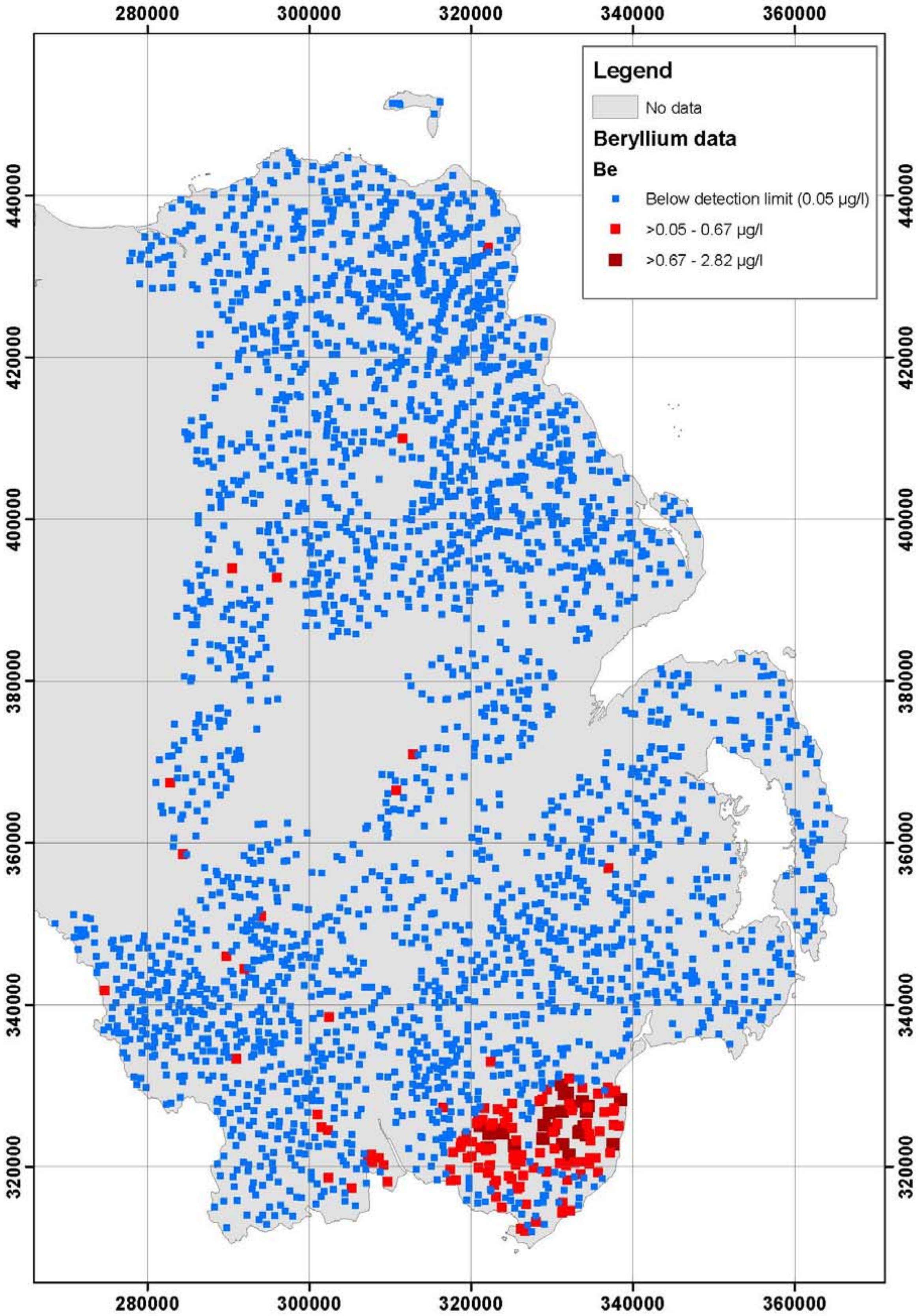
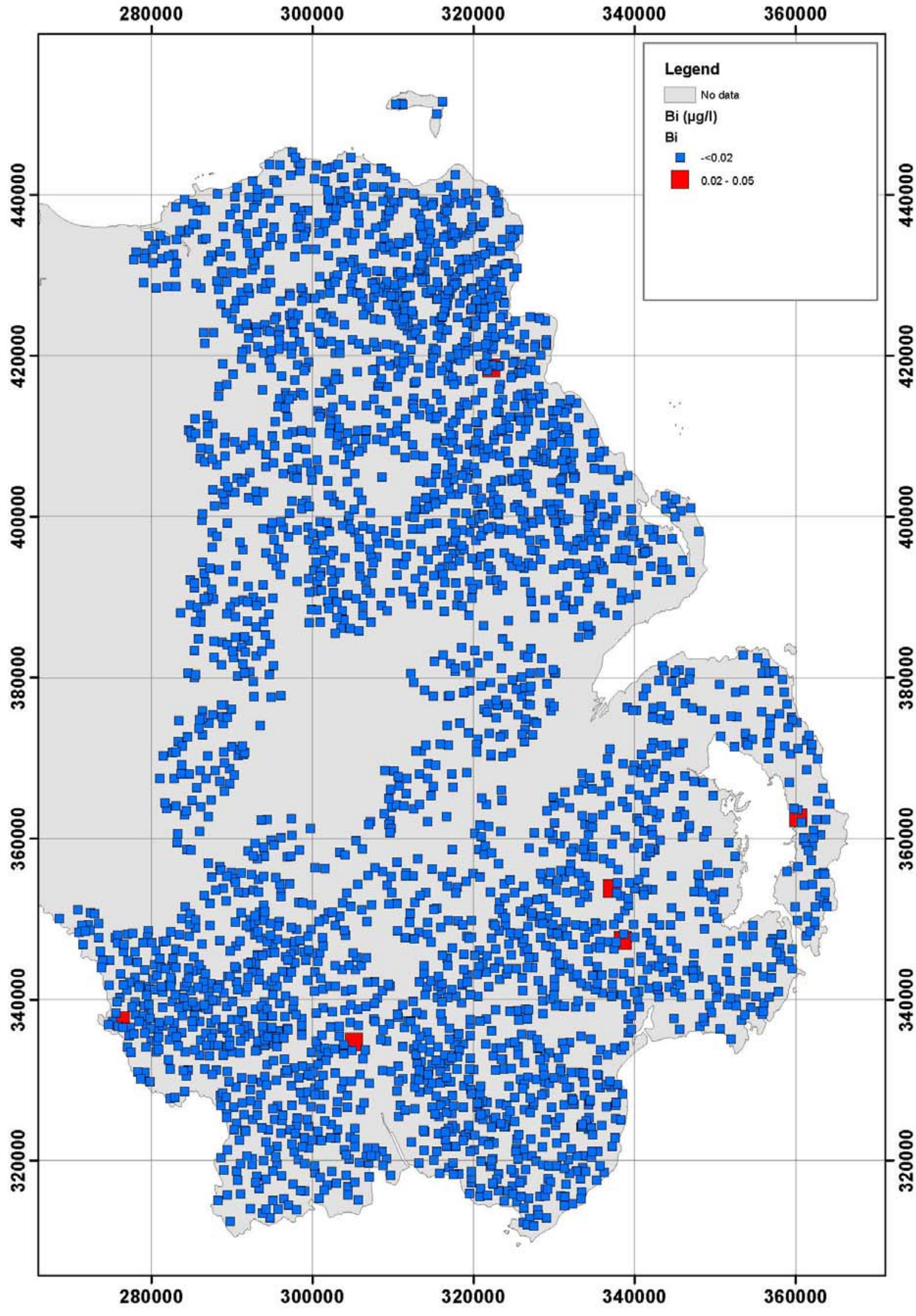
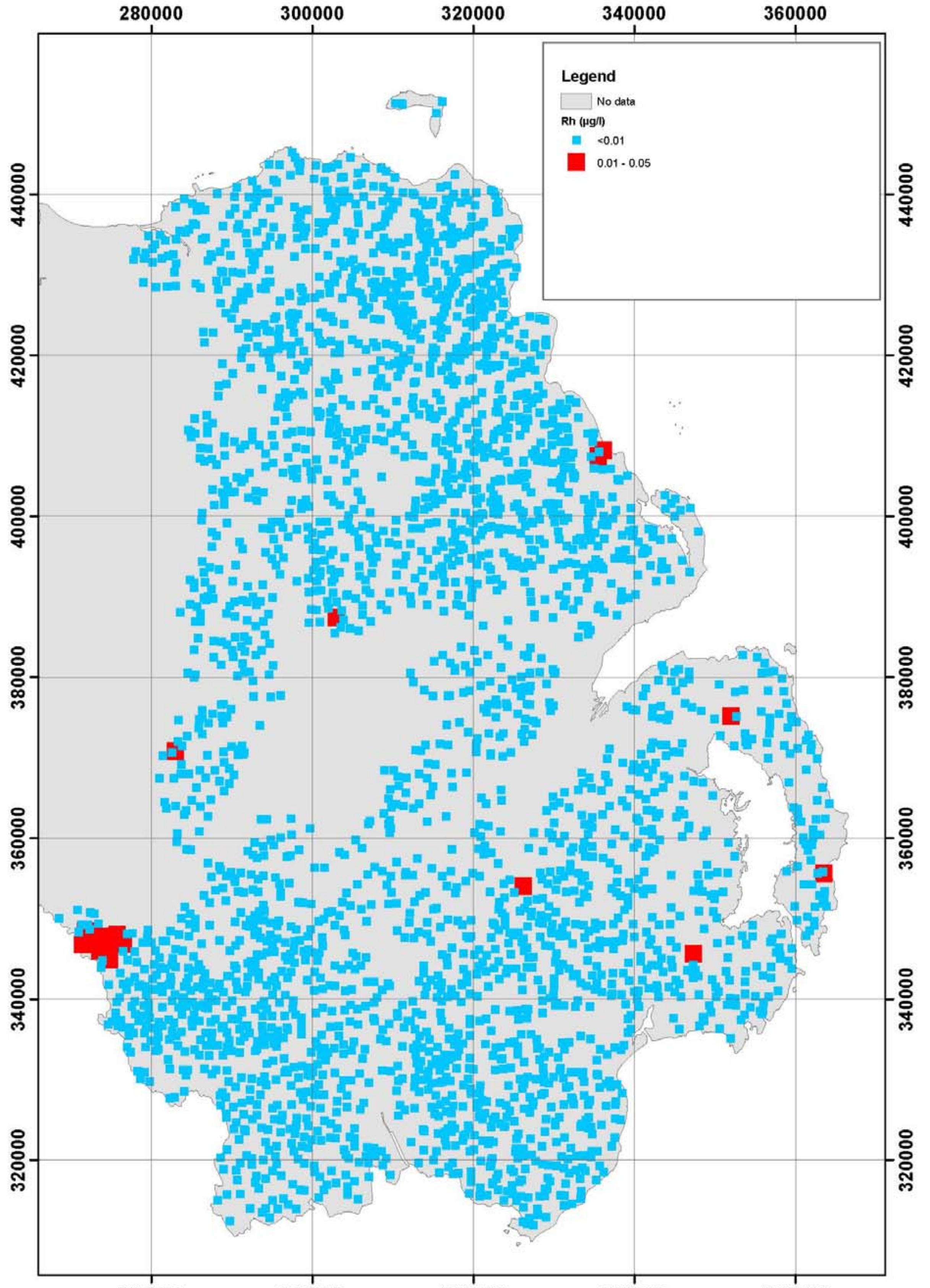
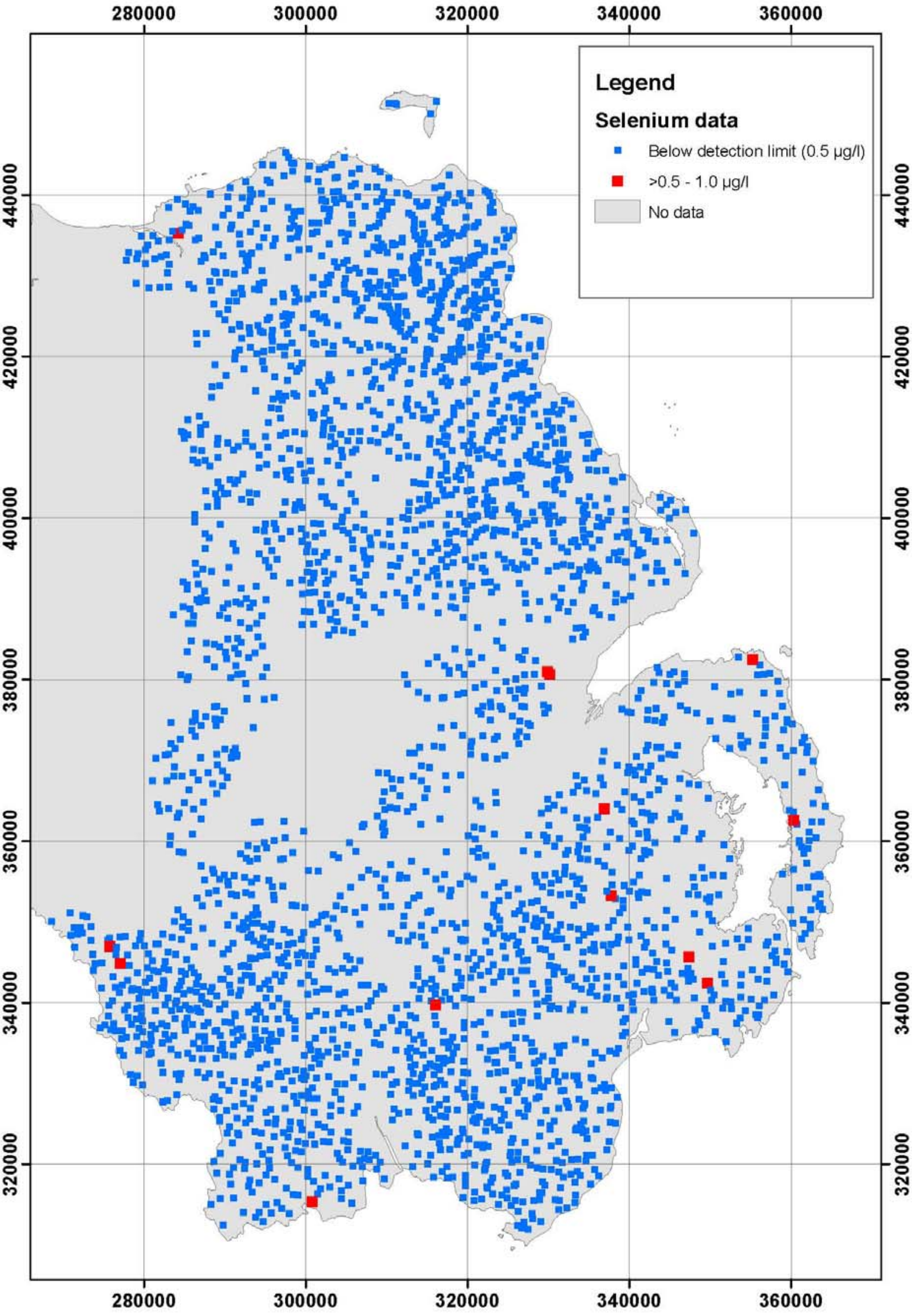
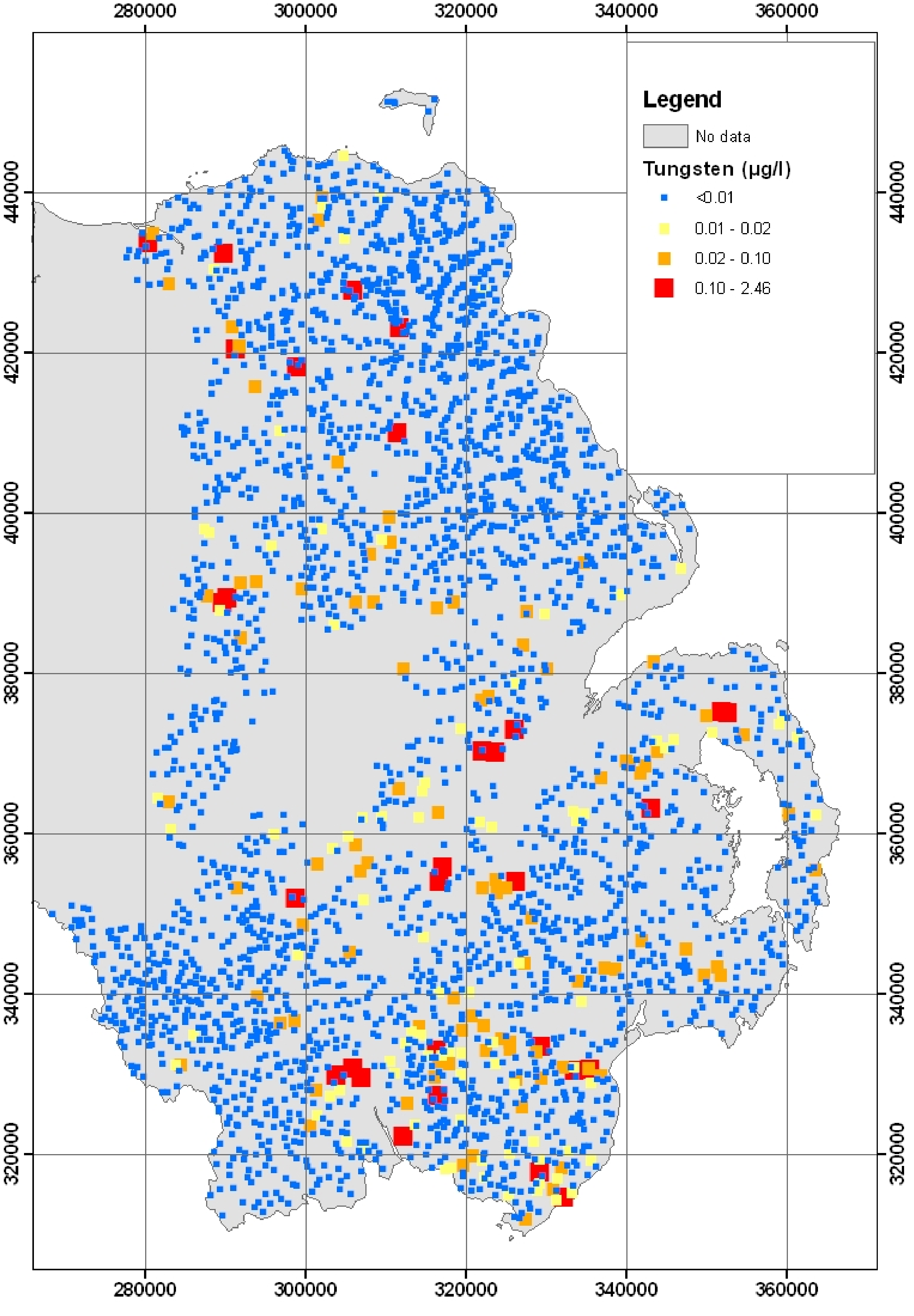
Appendix 1 – Maps of Be, Bi, Rh, Se and W reported data




280000
300000
320000
340000
360000
440000
420000
400000
380000
360000
340000
320000
Legend
No data
Bi (µg/l)
Bi
-<0.02
0.02 - 0.05


280000
300000
320000
340000
360000
440000
420000
400000
380000
360000
340000
320000
Legend
No data
Rh (µg/l)
<0.01
0.01 - 0.05


280000
300000
320000
340000
360000
440000
420000
400000
380000
360000
340000
320000
Legend
Selenium data
Below detection limit (0.5 µg/l)
>0.5 - 1.0 µg/l
No data


280000
300000
320000
340000
360000
440000
420000
400000
380000
360000
340000
320000
Legend
No data
Tungsten (µg/l)
<0.01
0.01 - 0.02
0.02 - 0.10
0.10 - 2.46

Appendix 2 – Blank water concentrations

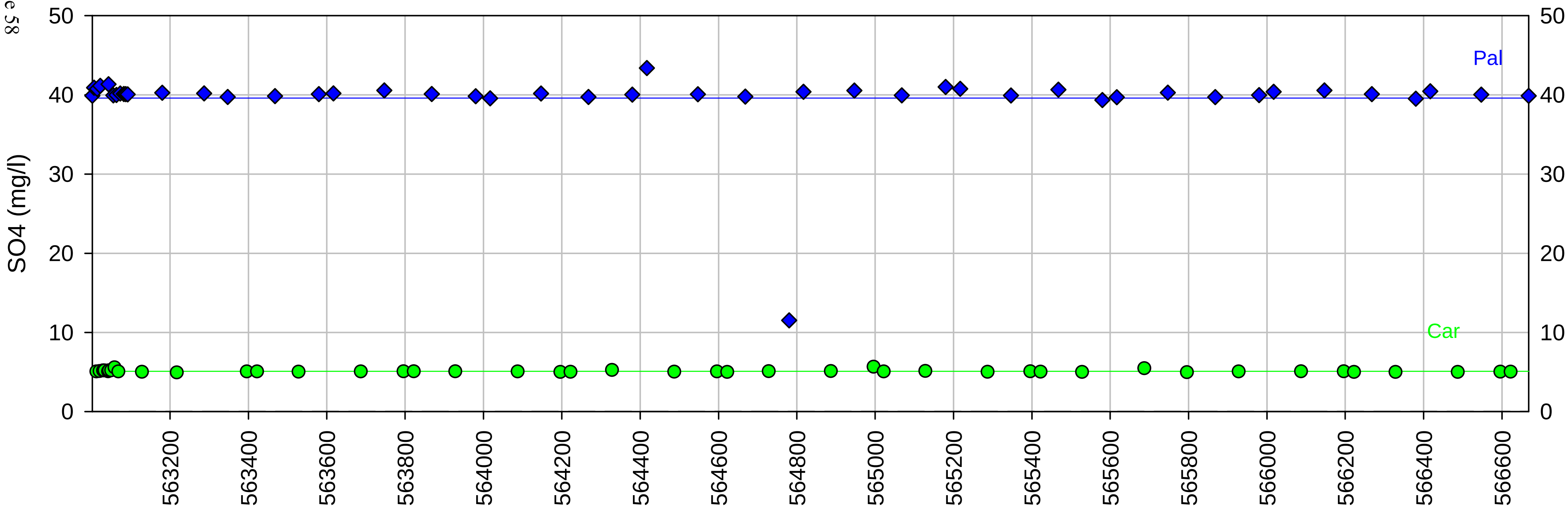
Red data are below the detection limit shown in row 2. All concentrations in µg l^{-1}.

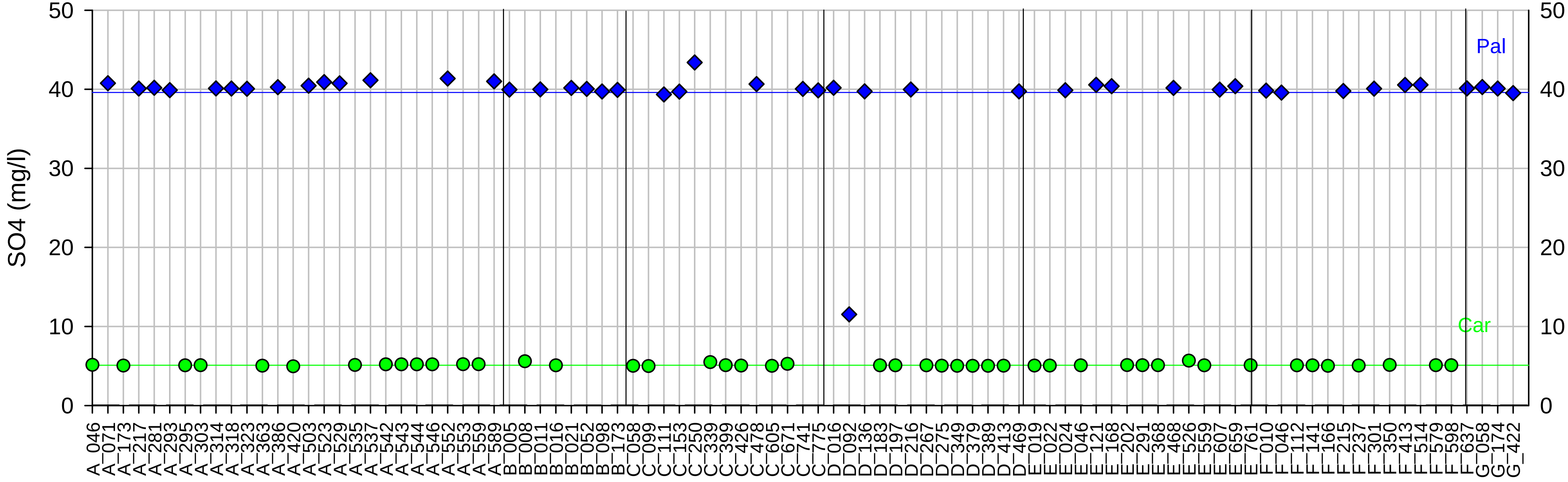
Sample Number	Standard type	GTK Batch	Cr	Cu	Sn	V	Zn
			0.2	**0.1**	**0.05**	**0.05**	**0.2**
563010	BW	First	-0.2	-0.1	0.16	0.05	0.59
563075	BW	First	-0.2	-0.1	0.11	-0.05	0.73
563114	BW	First	0.53	-0.1	0.05	-0.05	-0.2
563162	BW	First	0.28	-0.1	0.07	-0.05	-0.2
563244	BW	First	-0.2	-0.1	0.08	-0.05	-0.2
563275	BW	First	-0.2	-0.1	0.1	-0.05	-0.2
563303	BW	First	-0.2	-0.1	0.06	-0.05	-0.2
563332	BW	First	-0.2	0.1	0.05	0.05	-0.2
563410	BW	First	-0.2	-0.1	0.09	-0.05	-0.2
563475	BW	First	-0.2	-0.1	0.12	-0.05	-0.2
563514	BW	Third	0.02	0.04	0.1	0.01	0.12
563562	BW	Third	0.06	0.03	0.09	0.01	0.21
563644	BW	Third	-0.03	0.03	0.06	0	0.18
563675	BW	Third	0.17	0.03	0.06	0.06	0
563703	BW	Third	0.08	0.08	0.08	0.03	0.3
563732	BW	Third	0.14	0.1	0.09	0.05	0.15
563810	BW	Third	0.28	0.01	0.07	0.1	0.08
563875	BW	Third	0.42	0.06	0.06	0.13	0.32
563914	BW	Third	0.06	0.02	0.05	0.05	-0.09
563962	BW	Third	0.23	0.03	0.08	0.08	0.05
564044	BW	Second	0.11	0.03	0.07	0.16	0.08
564075	BW	Second	-0.09	0.16	0.1	-0.03	0.16
564103	BW	Second	0.06	0.06	0.08	0.03	0.03
564132	BW	Second	0.09	0.03	0.08	0.03	-0.11
564210	BW	Second	0.05	0.04	0.1	0.02	0.02
564275	BW	Second	0.45	0.02	0.06	0.14	-0.22
564314	BW	Second	0.45	0.04	0.13	0.17	0.06
564362	BW	Second	0.13	0.13	0.12	0.03	0.59
564444	BW	Second	0.32	0.03	0.05	0.12	-0.02
564475	BW	Second	0.43	0.01	0.04	0.15	-0.1
564503	BW	Fourth	0.21	0.12	0.03	0.13	0.31
564532	BW	Fourth	-0.03	0.02	0.09	0.01	0.13
564610	BW	Fourth	0.08	0.02	0.08	0.03	0.1
564675	BW	Fourth	0.06	0.02	0.14	0.03	0.07

Sample Number	Standard type	GTK Batch	Cr	Cu	Sn	V	Zn
564714	BW	Fourth	0.12	0.24	0.08	0.04	0.13
564762	BW	Fourth	0.04	0.37	0.08	0.02	0.06
564844	BW	Fifth	0.08	0.04	0.08	0.04	-0.05
564875	BW	Fifth	0.09	0.02	0.06	0.03	-0.08
564903	BW	Fifth	0.13	0.3	0.23	0.04	1.81
564932	BW	Fifth	0.04	0.09	0.13	0.01	0.67
565010	BW	Fifth	0.16	0.07	0.15	0.05	1.71
565075	BW	Fifth	0.08	0.03	0.13	0.03	-0.01
565114	BW	Fifth	0.03	0.07	0.13	0.02	0.47
565162	BW	Fifth	0.09	0.04	0.08	0.04	-0.03
565244	BW	Sixth	0.25	0.05	0.06	0.1	0.16
565275	BW	Sixth	0.19	0.04	0.06	0.05	0.05
565303	BW	Fifth	0.12	0.35	0.05	0.05	1.1
565332	BW	Fifth	0.11	0.01	0.03	0.04	0.07
565410	BW	Sixth	0.14	0.07	0.08	0.05	0.2
565475	BW	Sixth	0.21	0.07	0.07	0.07	0.12
565514	BW	Seventh	0.05	0.03	0.06	0.04	0.05
565562	BW	Seventh	0.04	0.17	0.06	0.01	0.79
565644	BW	Sixth	-0.07	0.04	0.07	0.07	0.05
565675	BW	Sixth	0.01	0.05	0.06	0.08	0.14
565703	BW	Sixth	0.14	0.17	0.08	0.05	0.86
565732	BW	Sixth	0.1	0.32	0.06	0.03	-0.08
565810	BW	Seventh	0.18	0.1	0.08	0.06	0.2
565875	BW	Seventh	0.45	0.03	0.07	0.17	0
565914	BW	Sixth	0.06	0.03	0.06	0.02	0.06
565962	BW	Sixth	0	0.13	0.12	0.01	0.66
566044	BW	Seventh	-0.01	0.04	0.05	0	0.11
566075	BW	Seventh	0.1	0.03	0.06	0.04	0.09
566103	BW	Seventh	0.03	0.09	0.1	0.02	0.45
566132	BW	Seventh	0.03	0.13	0.09	0.02	0.52
566210	BW	Eighth	0.06	0.07	0.12	0.03	0.36
566275	BW	Eighth	0.11	0.44	0.1	0.04	1.17
566314	BW	Eighth	0.05	0.02	0.1	0.02	0.09
566362	BW	Eighth	0.01	0.04	0.11	0.01	0.24
566444	BW	Eighth	0.19	0.17	0.01	0.05	0.67
566475	BW	Eighth	0.11	0.15	0	0.04	1.94
566610	BW	Eighth	0.05	0.03	0.17	0.03	0.11
566675	BW	Eighth	0.09	0.02	0.11	0.04	0.07

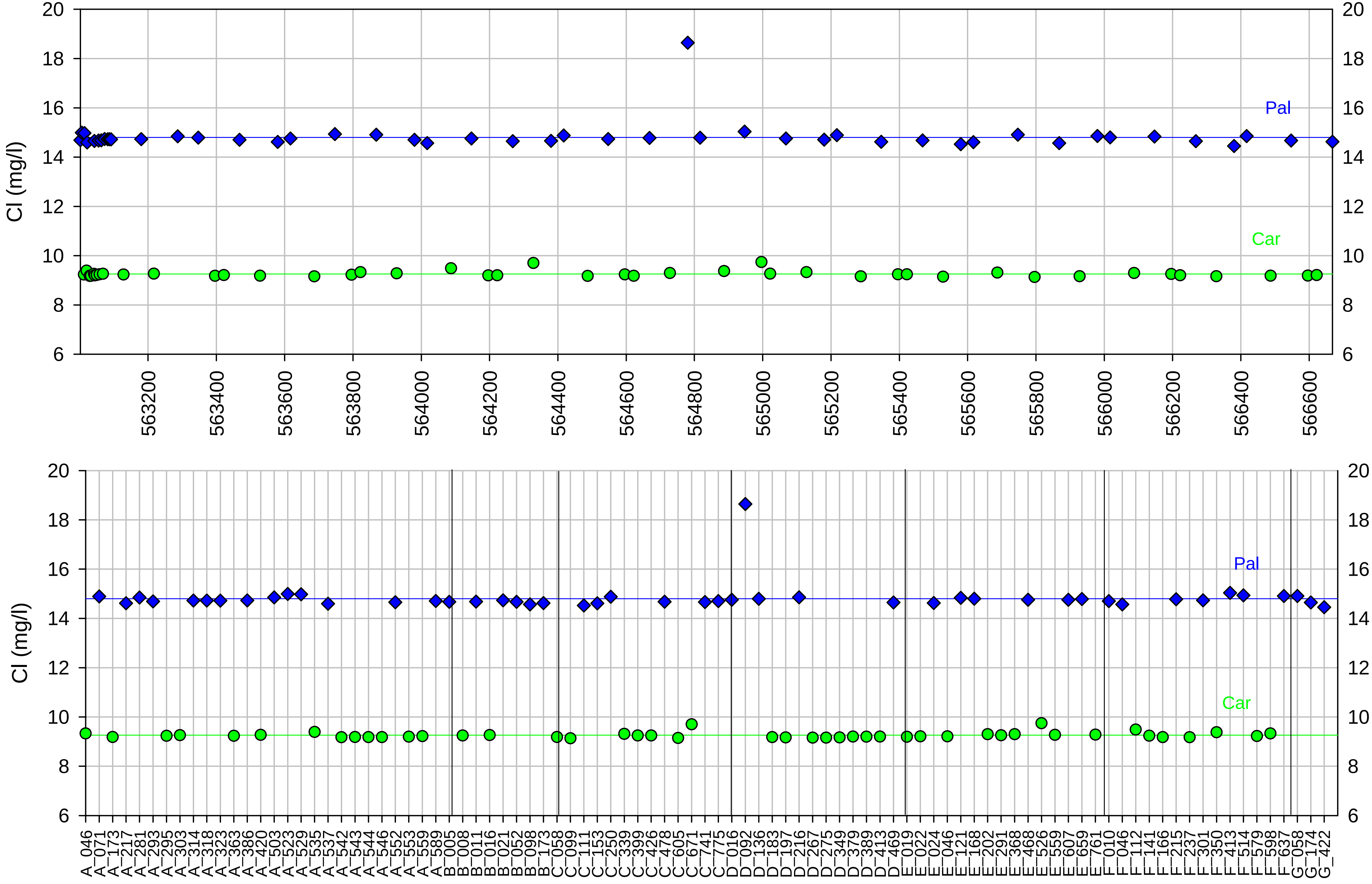
Appendix 3 – Reference Material plots

Sulphate control samples: SRMs

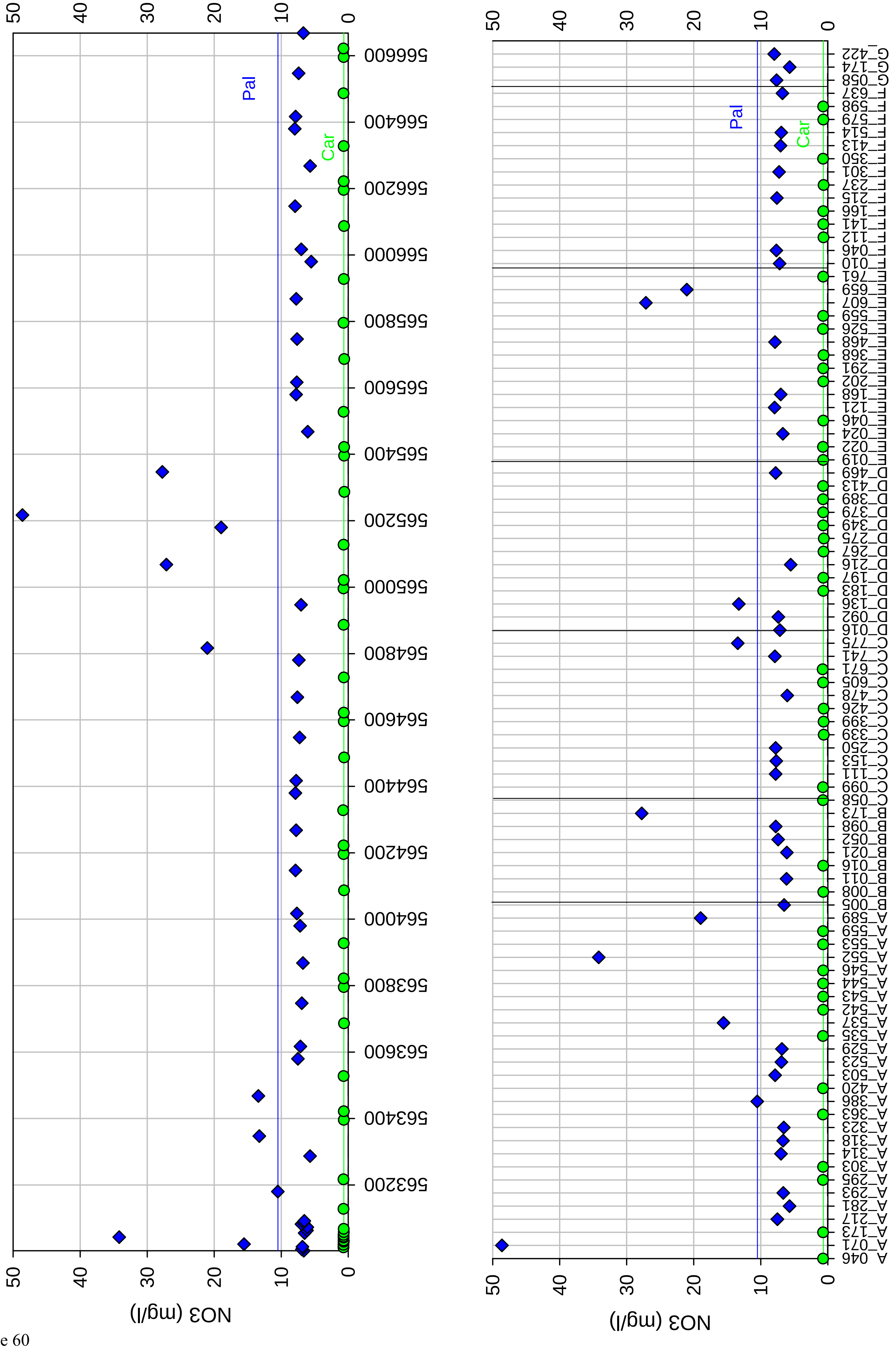




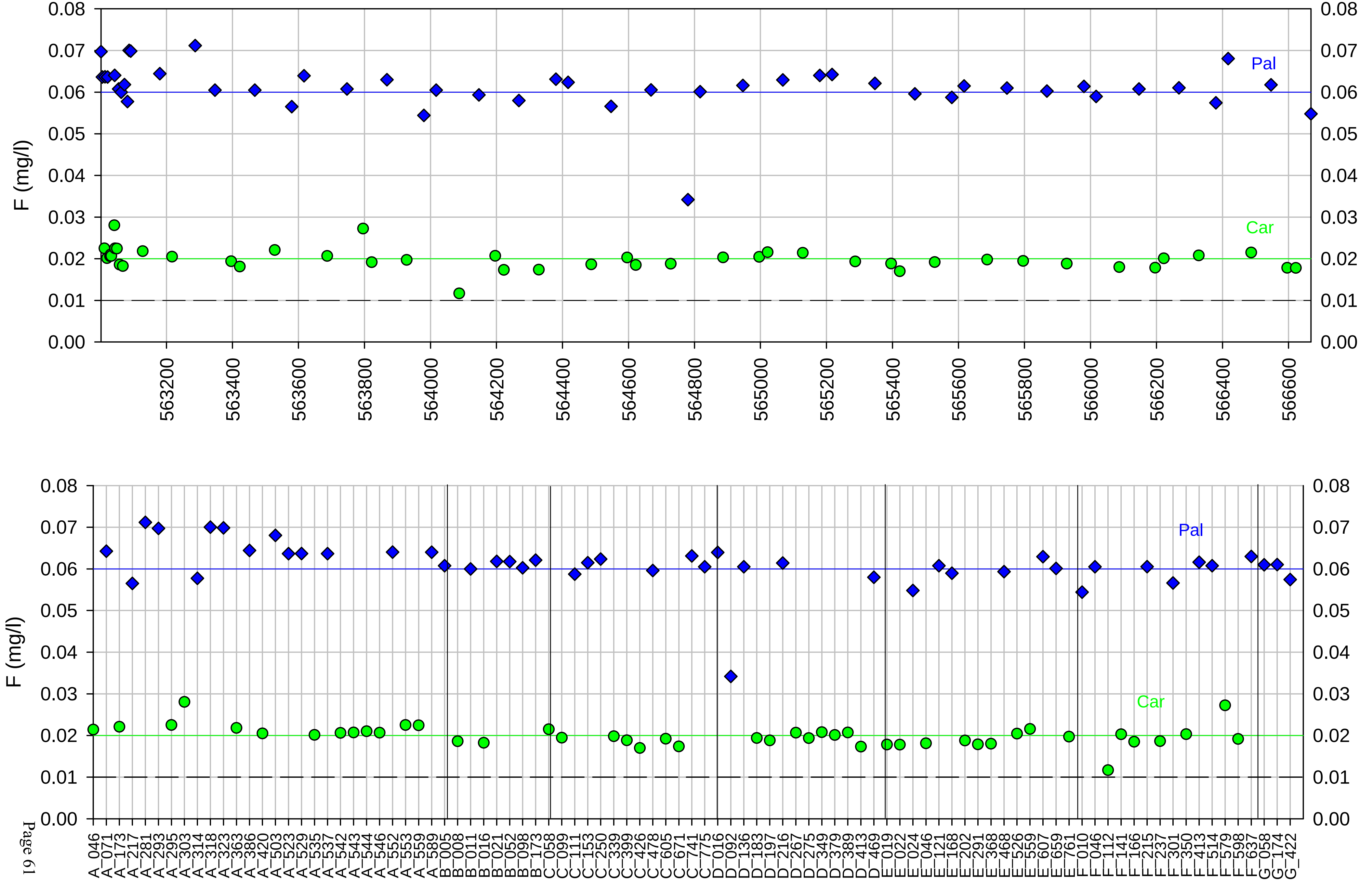
Chloride control samples: SRMs

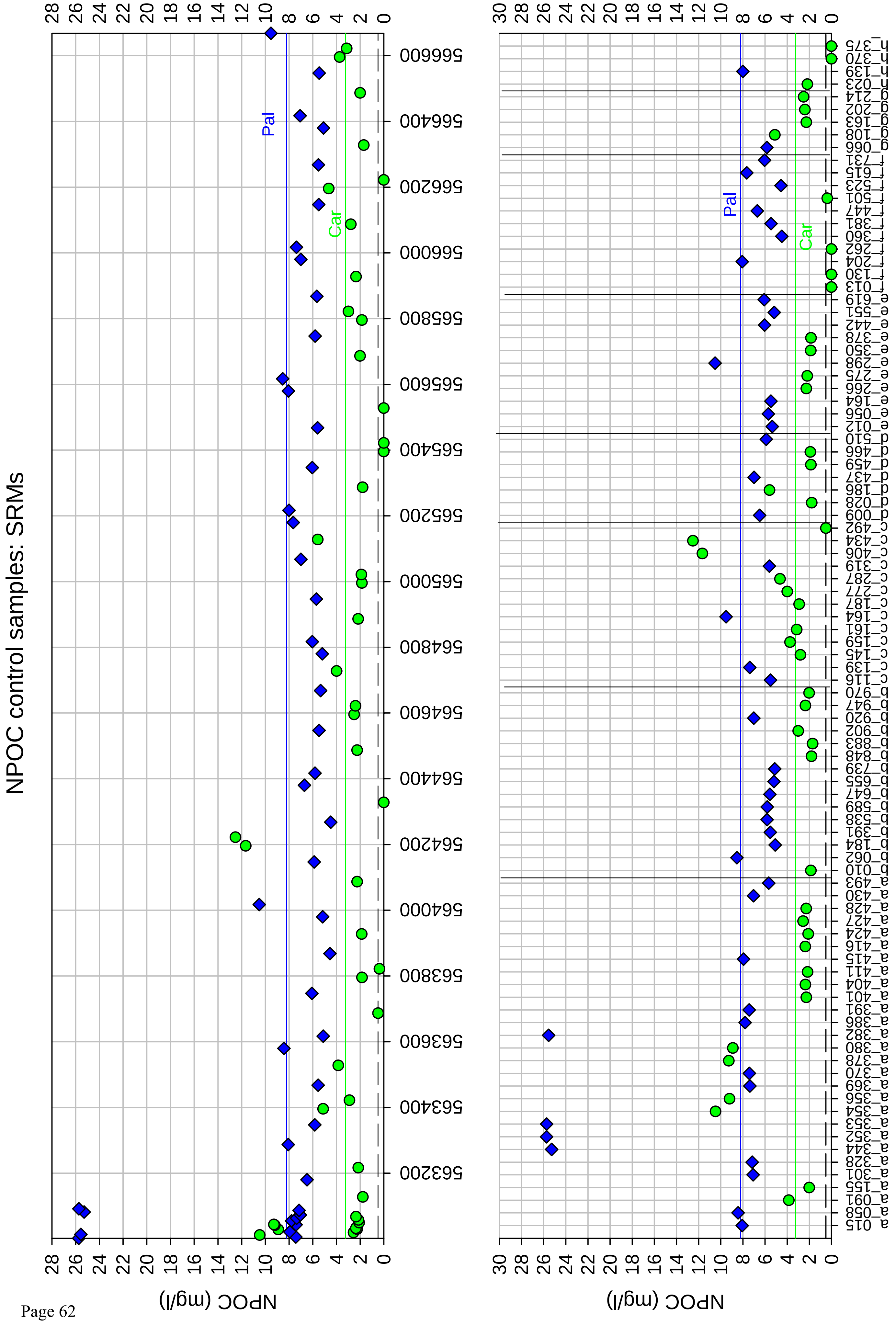


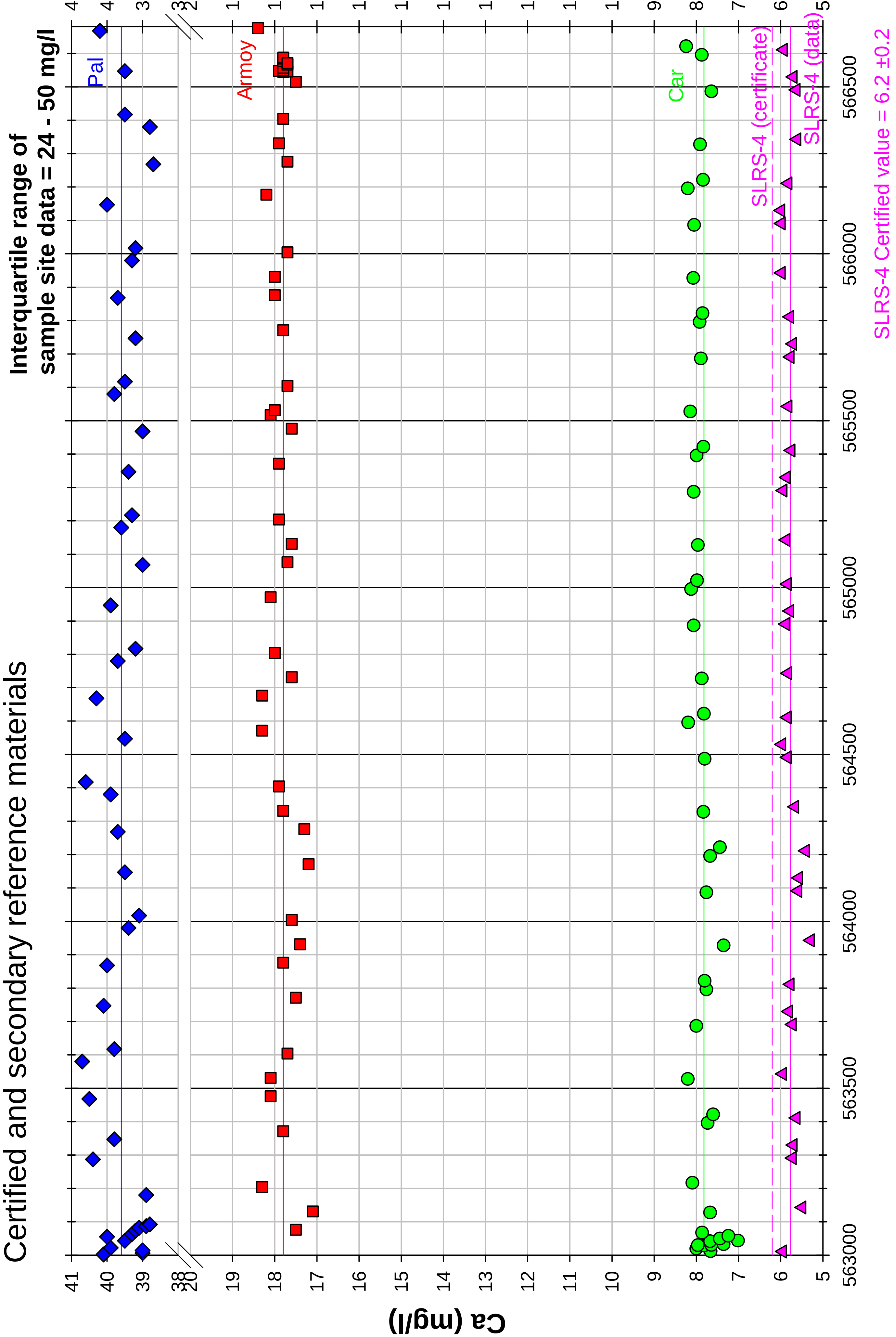
Nitrate control samples: SRMs



Fluoride control samples: SRMs

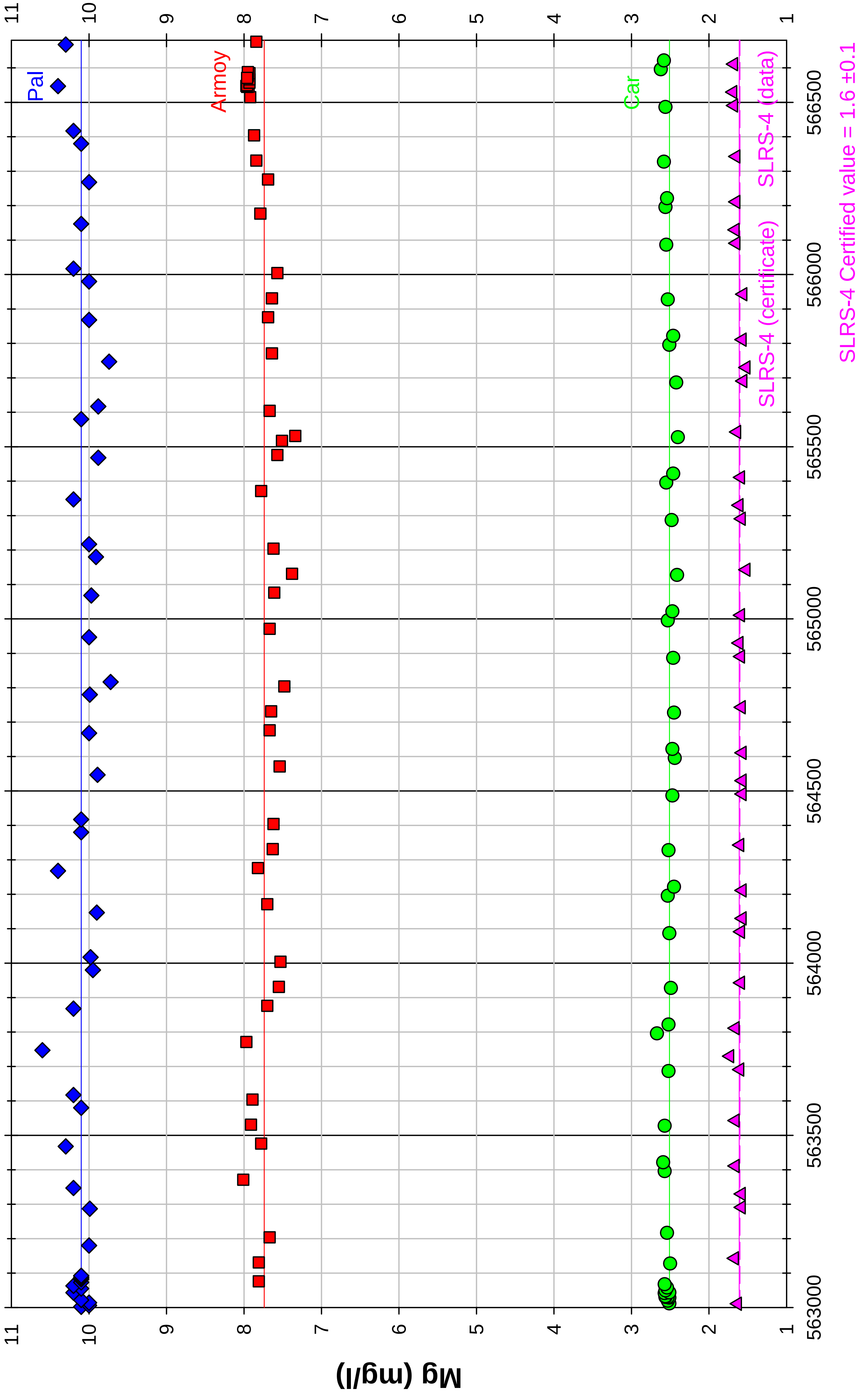


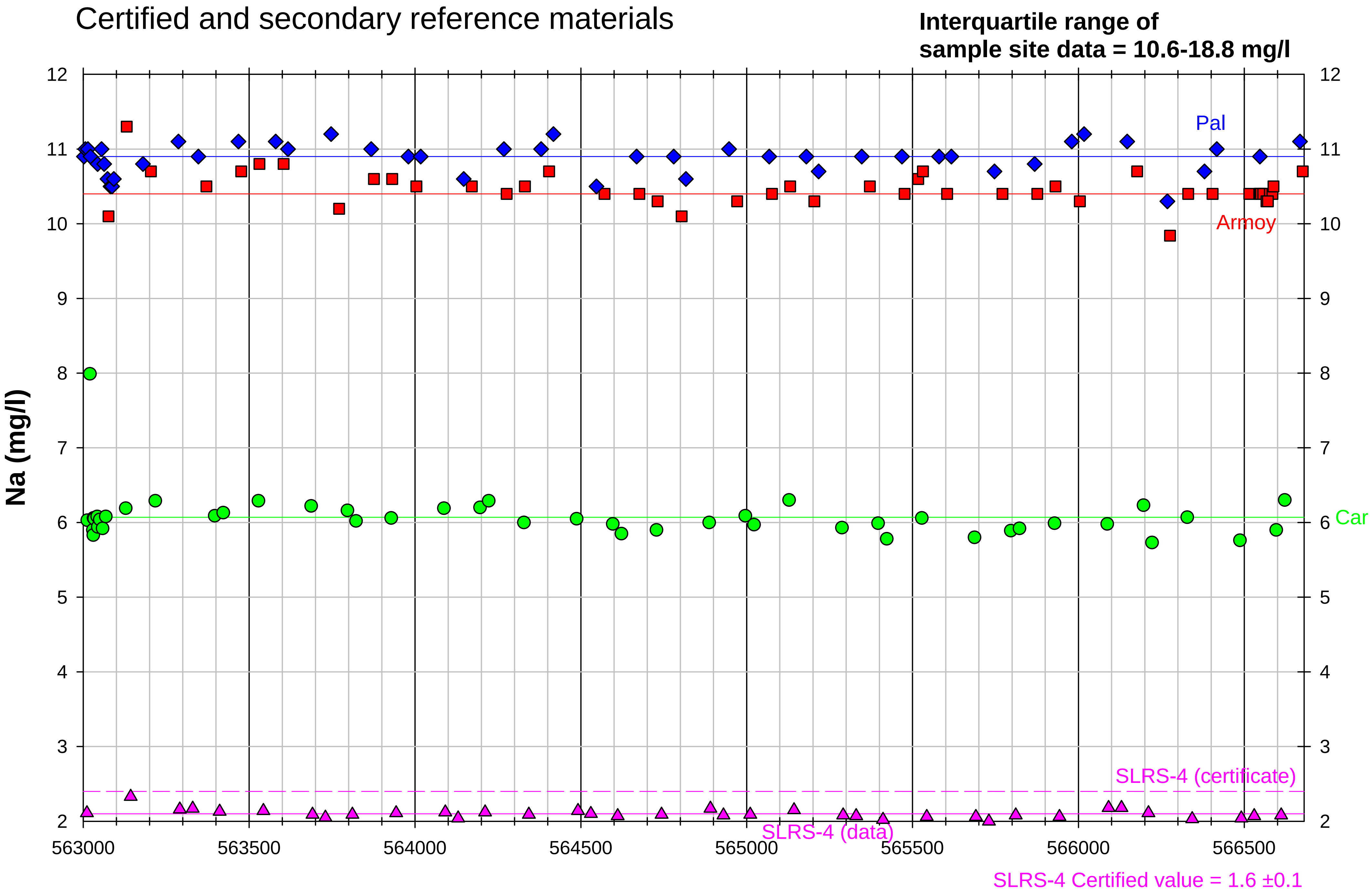

NPOC control samples: SRMs
NPOC (mg/l)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Pal
Car
563200
563400
563600
563800
564000
564200
564400
564600
564800
565000
565200
565400
565600
565800
566000
566200
566400
566600
a_015
a_058
a_091
a_155
a_301
a_328
a_344
a_352
a_353
a_354
a_356
a_369
a_370
a_378
a_380
a_382
a_386
a_391
a_401
a_404
a_411
a_415
a_416
a_424
a_427
a_428
a_430
a_493
b_010
b_062
b_184
b_391
b_538
b_589
b_647
b_655
b_739
b_848
b_883
b_902
b_920
b_947
b_970
c_116
c_139
c_145
c_159
c_161
c_164
c_187
c_277
c_287
c_319
c_406
c_434
c_492
d_009
d_028
d_186
d_437
d_459
d_466
d_510
e_012
e_056
e_164
e_266
e_275
e_298
e_350
e_378
e_442
e_551
e_619
f_013
f_130
f_204
f_262
f_360
f_381
f_447
f_501
f_523
f_615
f_731
g_066
g_108
g_163
g_202
g_214
h_023
h_139
h_370
h_375


Certified and secondary reference materials
Interquartile range of sample site data = 24 - 50 mg/l
Ca (mg/l)
Pal
Armoy
Car
SLRS-4 (certificate)
SLRS-4 (data)
SLRS-4 Certified value = 6.2 ±0.2
41
40
39
38
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
563000
563500
564000
564500
565000
565500
566000
566500

Certified and secondary reference materials

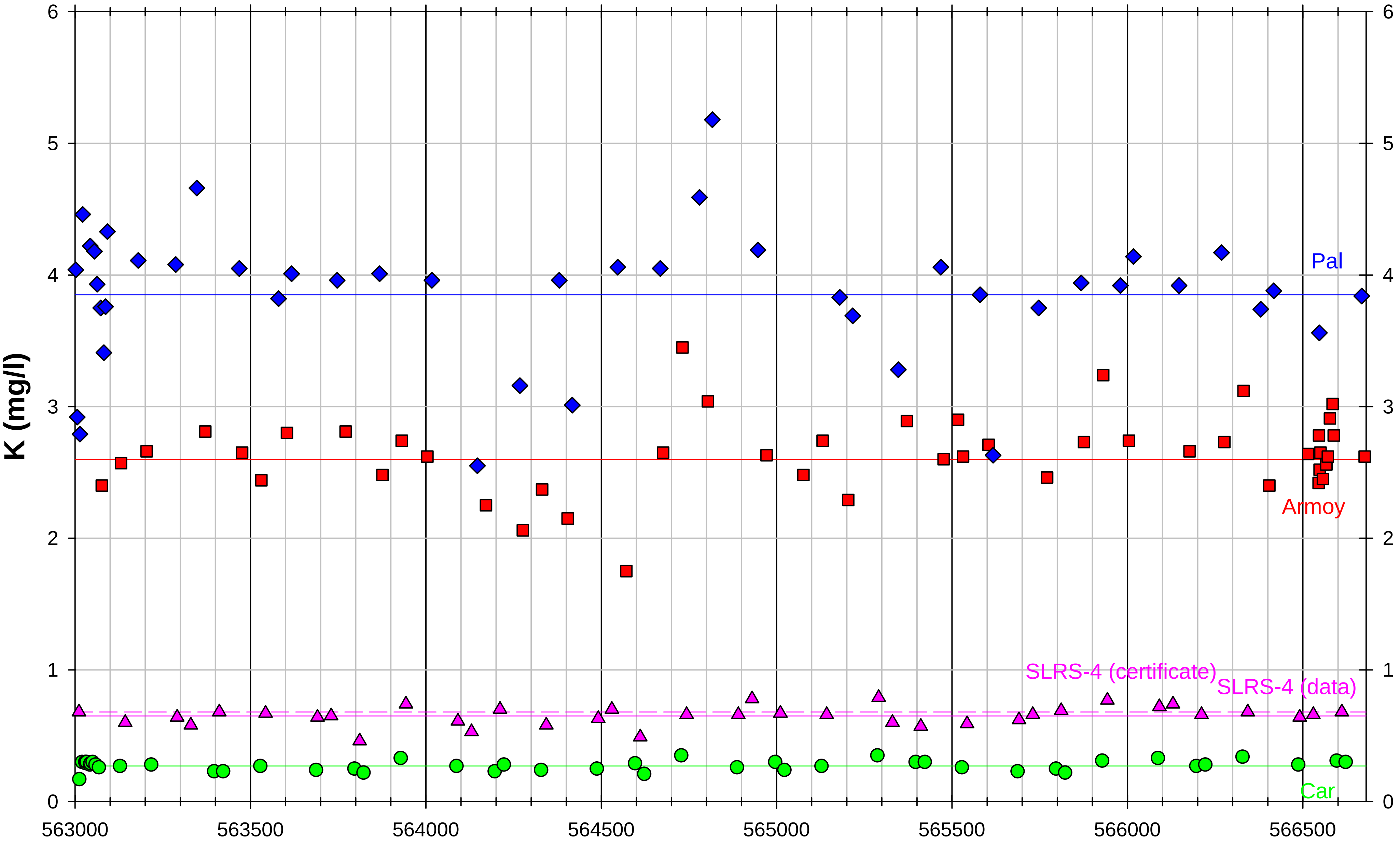
Interquartile range of sample site data = 8.2-20 mg/l




Certified and secondary reference materials

Certified and secondary reference materials

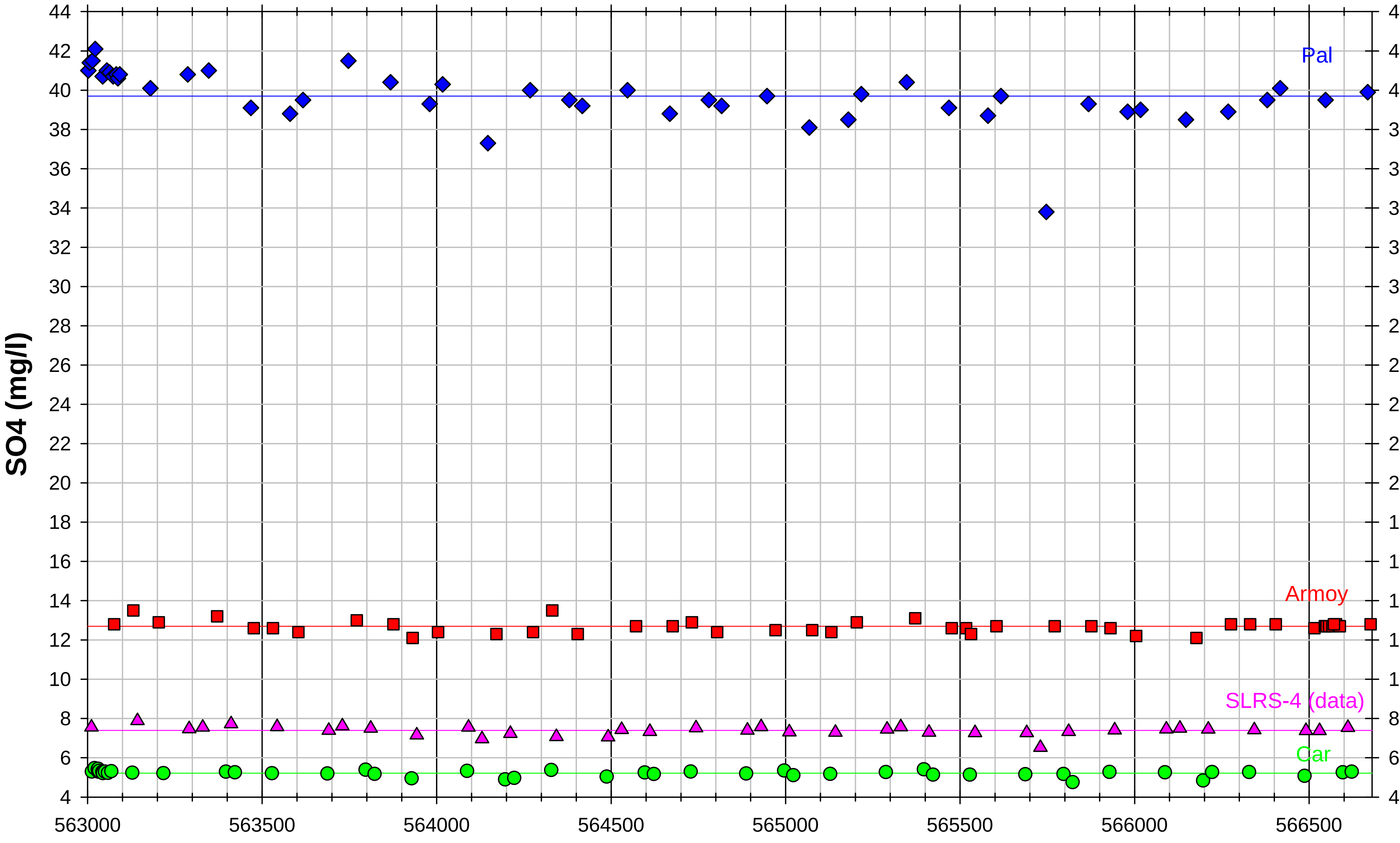
Interquartile range of sample site data = 1.23-6.94 mg/l



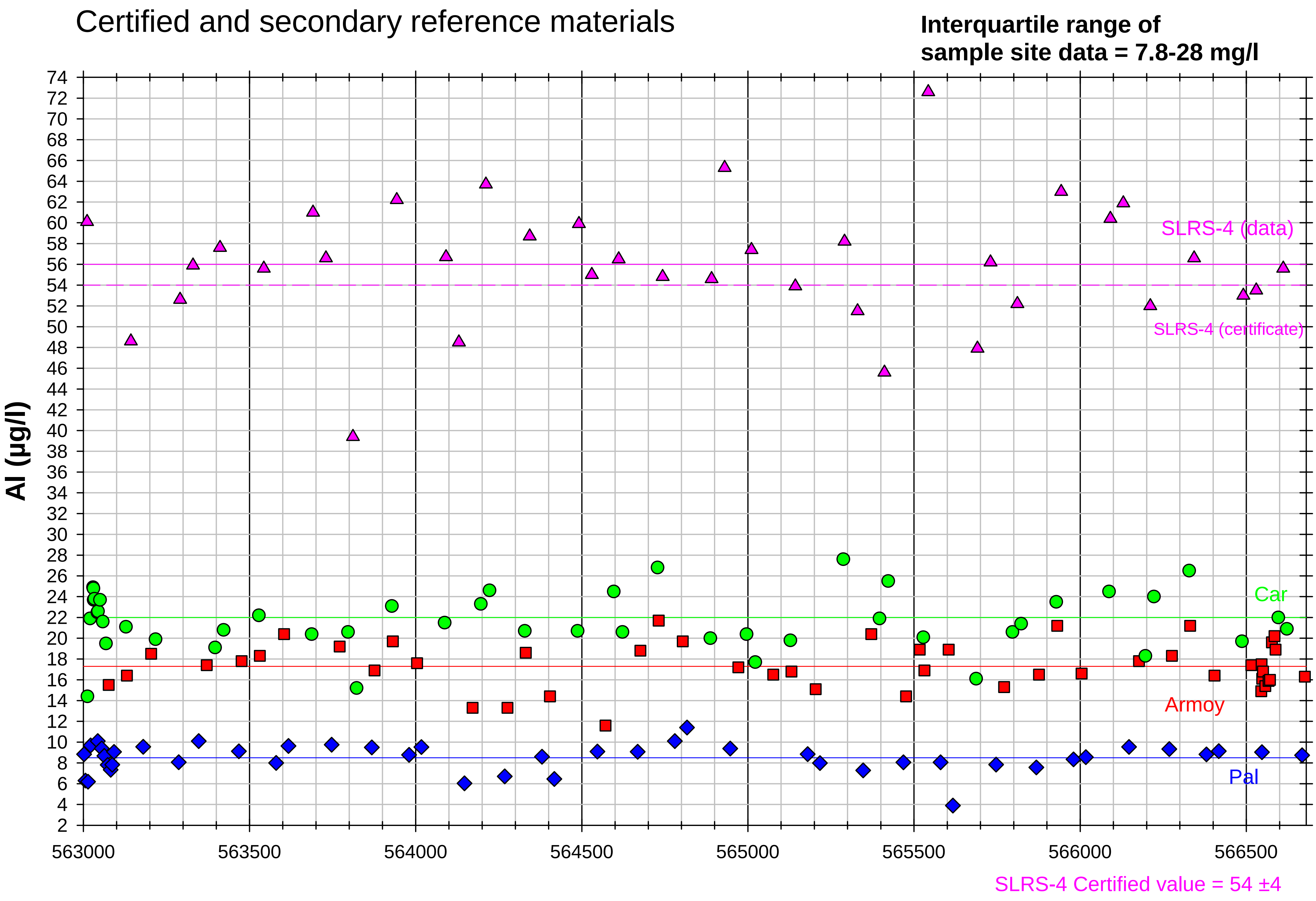
SLRS-4 Certified value = 1.6 ±0.1

Certified and secondary reference materials

Interquartile range of sample site data = 6.6-19.5 mg/l

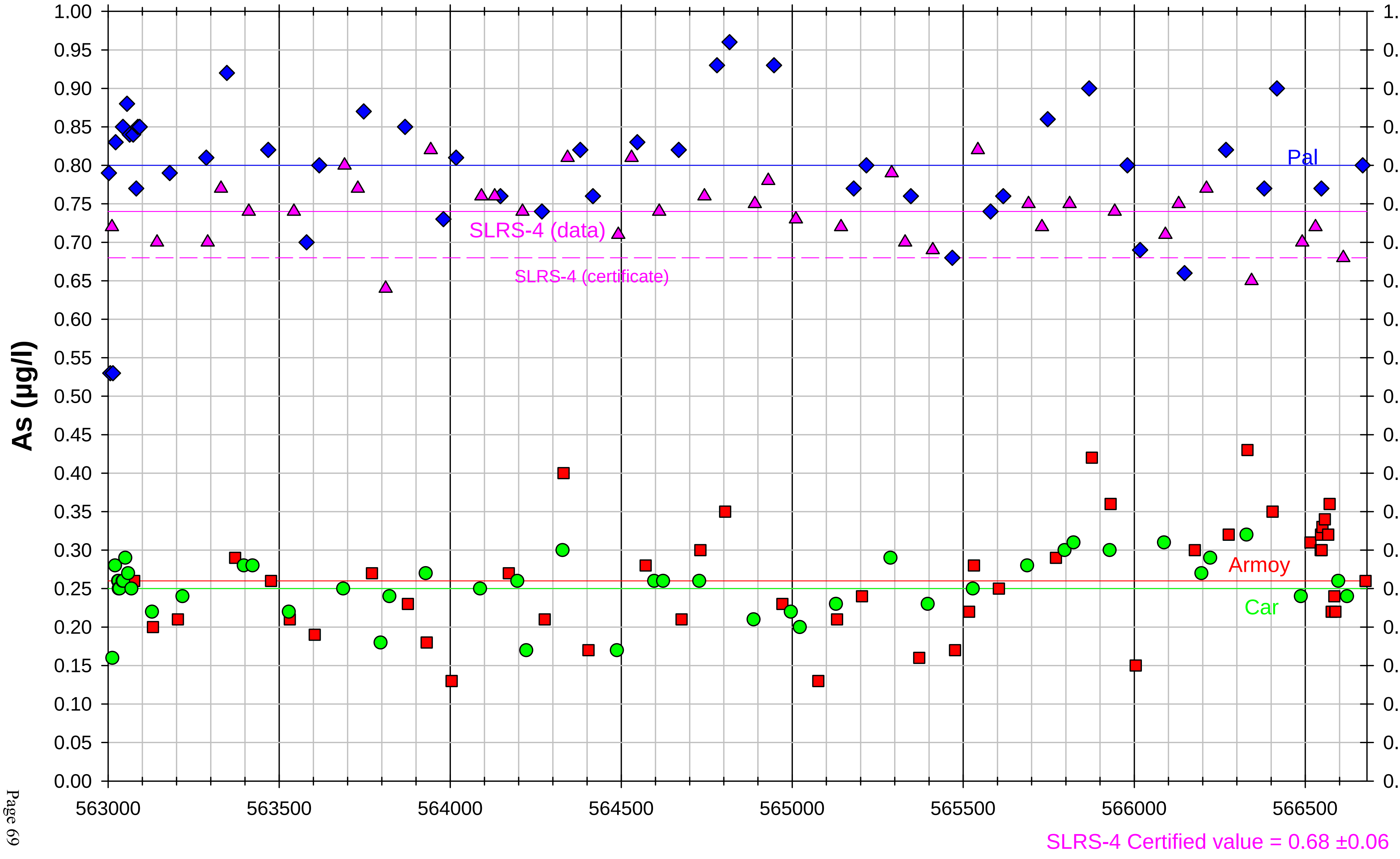


SLRS-4 Certified value = (no value)


Certified and secondary reference materials
Interquartile range of
sample site data = 7.8-28 mg/l
Al (µg/l)
SLRS-4 (data)
SLRS-4 (certificate)
Car
Armoy
Pal
SLRS-4 Certified value = 54 ±4
74
72
70
68
66
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
563000
563500
564000
564500
565000
565500
566000
566500

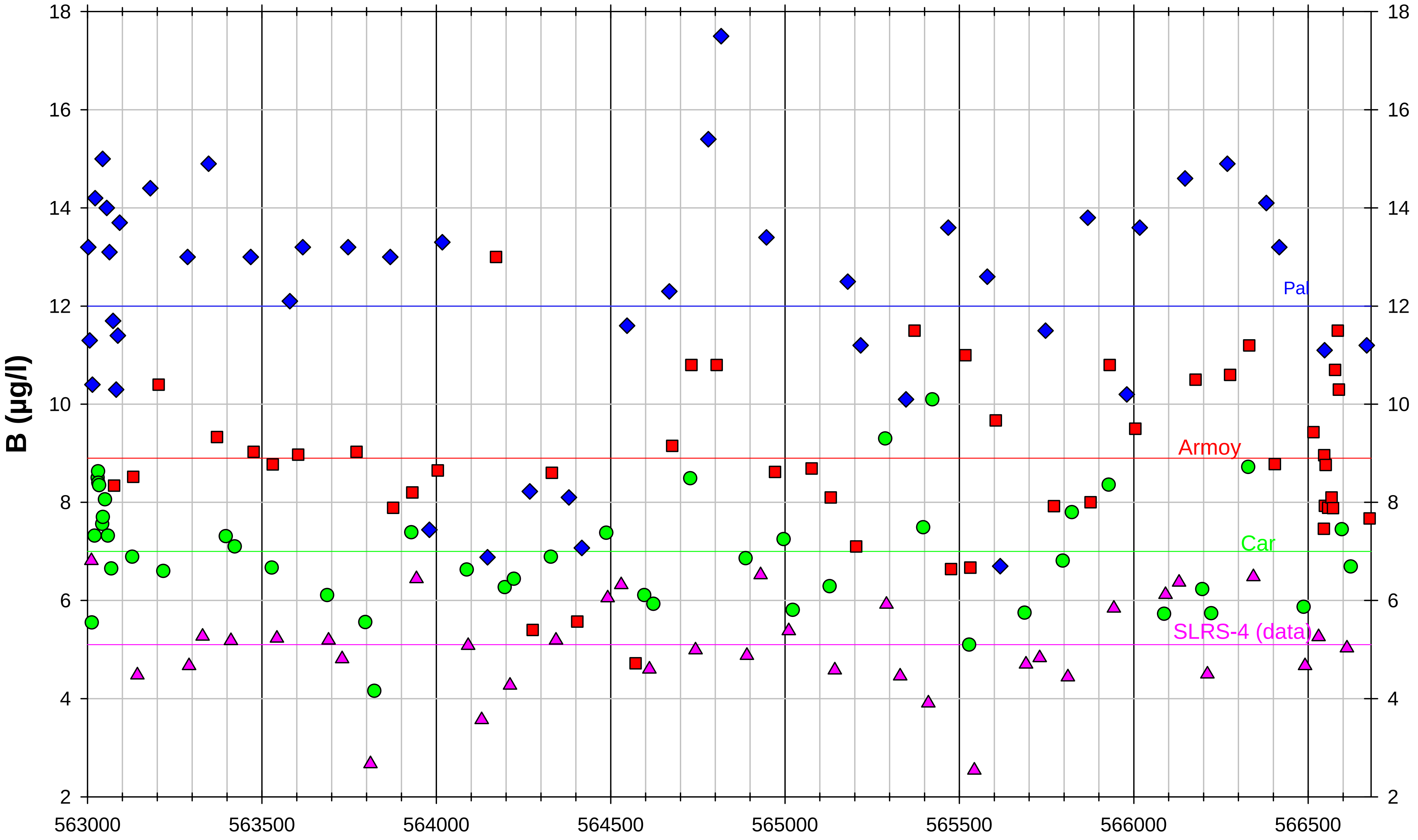
Certified and secondary reference materials

Interquartile range of sample site data = 0.28-1.27 mg/l



Certified and secondary reference materials

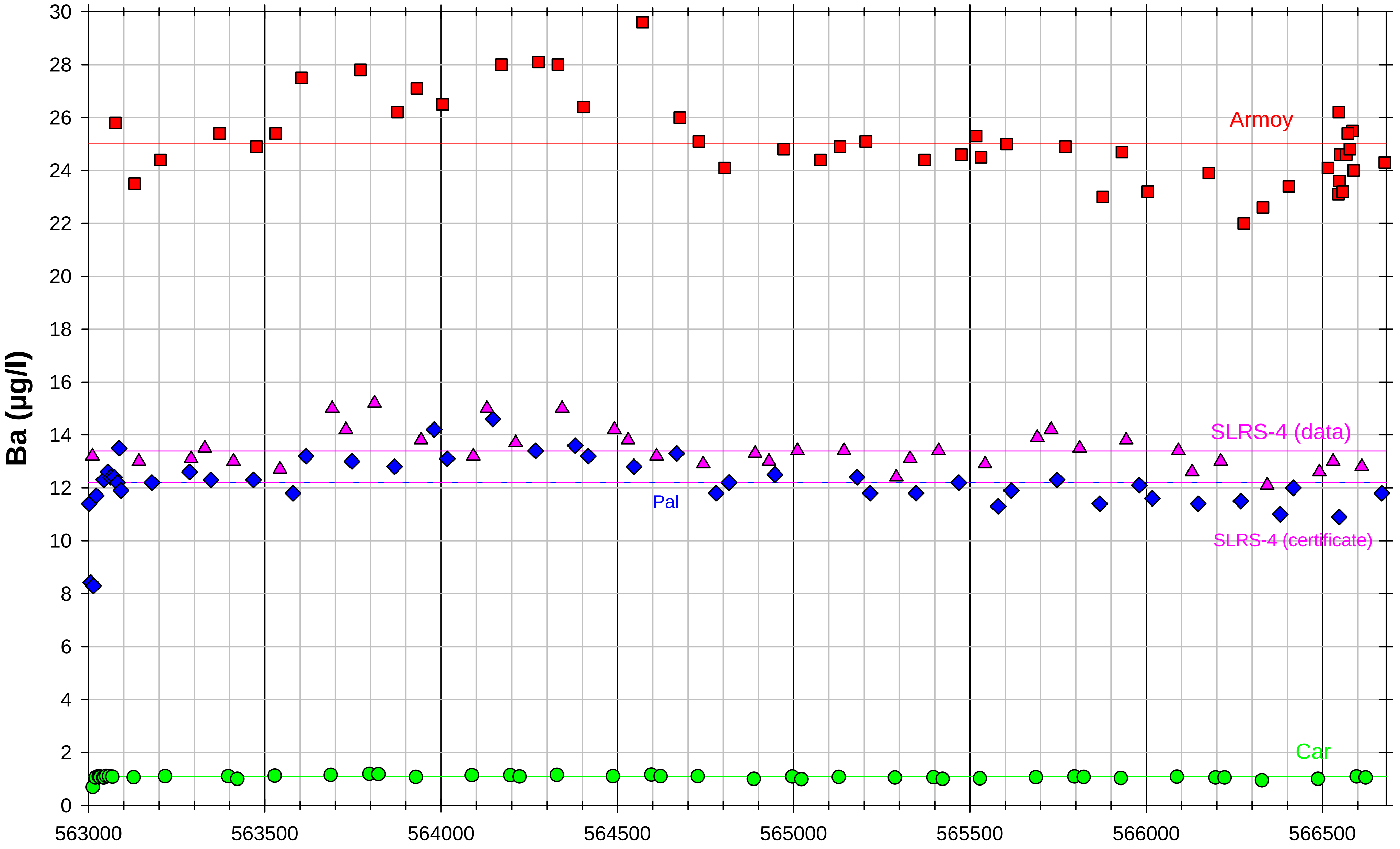
Interquartile range of sample site data = 7.8-28 mg/l



SLRS-4 Certified value = n/a

Certified and secondary reference materials

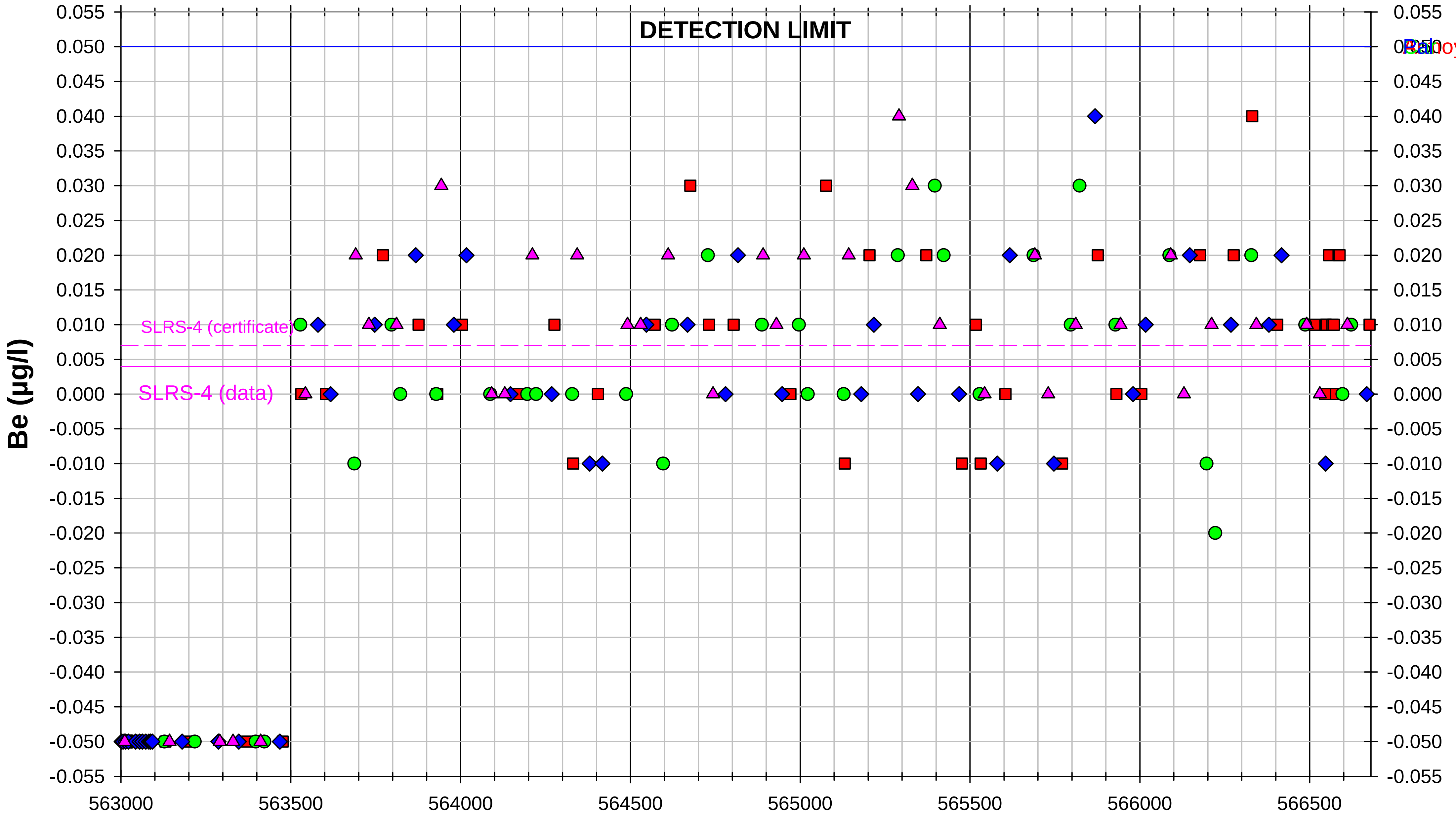
Interquartile range of sample site data = 1.2-26 mg/l



SLRS-4 Certified value = 12.2 ±0.6

Certified and secondary reference materials

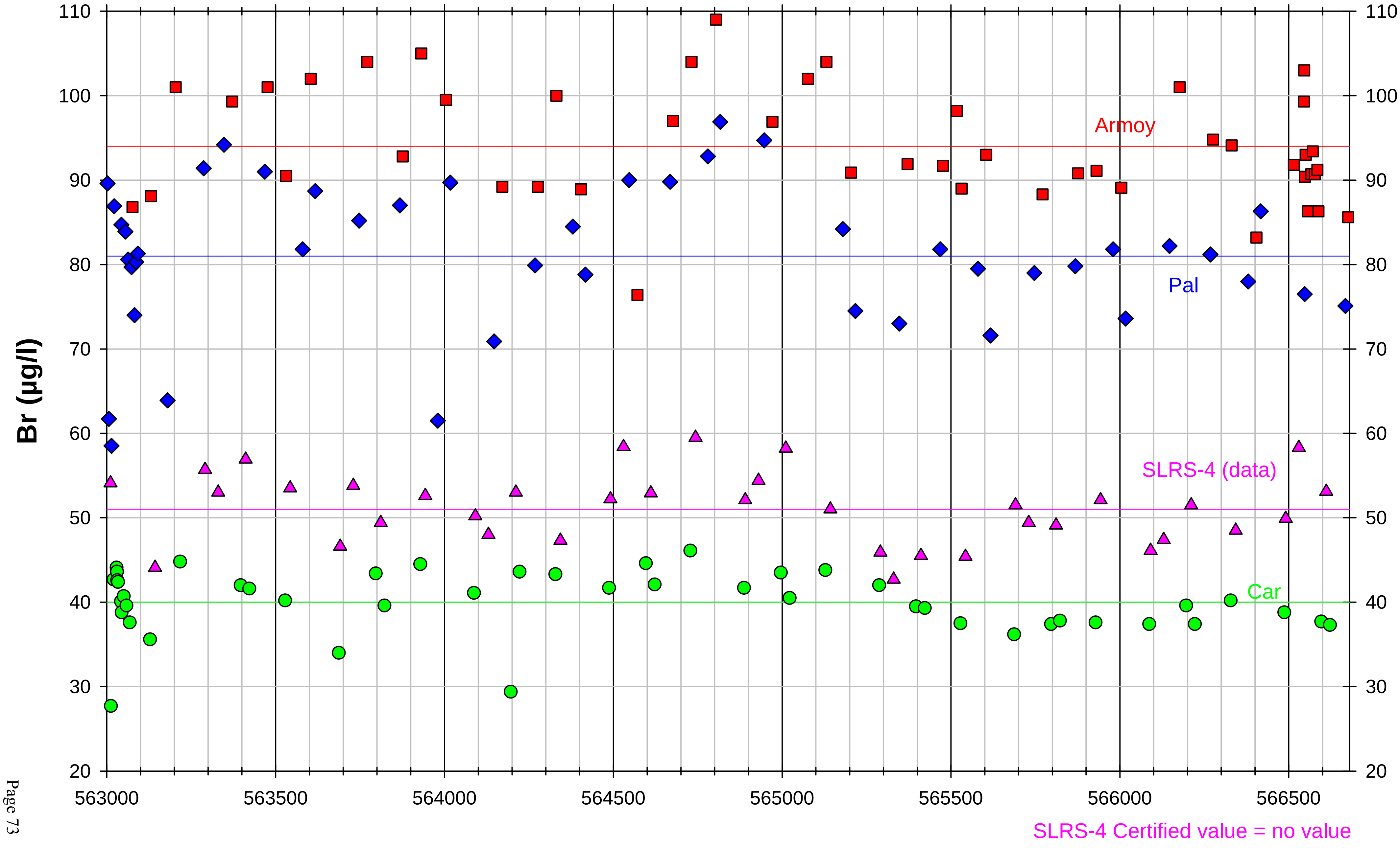
Interquartile range of sample site data = <0.05 mg/l

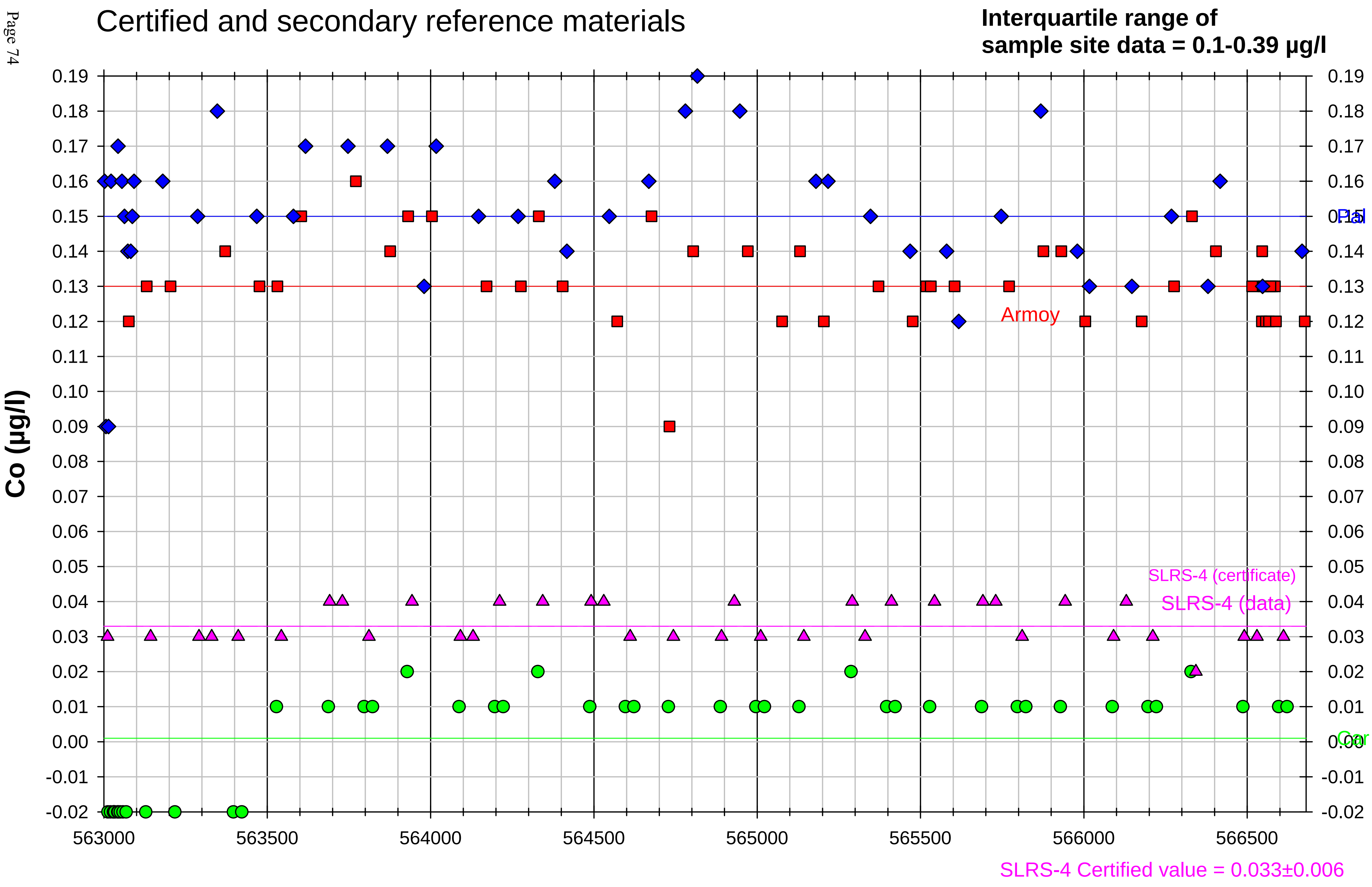


SLRS-4 Certified value = 0.007±0.002
(below the detection limit)

Certified and secondary reference materials

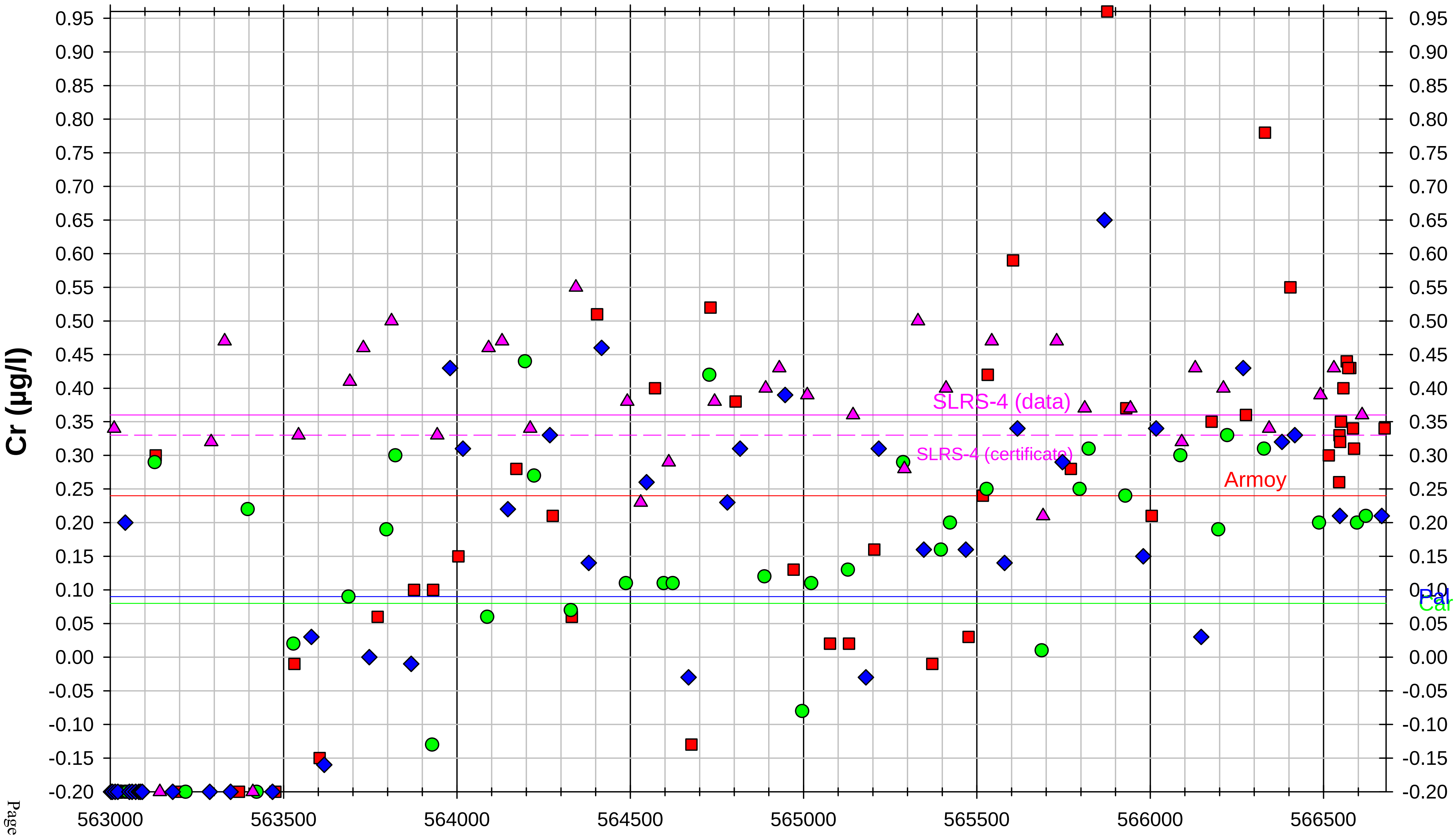
Interquartile range of sample site data = 86-144 µg/l




Certified and secondary reference materials
Interquartile range of
sample site data = 0.1-0.39 µg/l
Co (µg/l)
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
563000
563500
564000
564500
565000
565500
566000
566500
Pal
Armoy
SLRS-4 (certificate)
SLRS-4 (data)
Car
SLRS-4 Certified value = 0.033±0.006

Certified and secondary reference materials

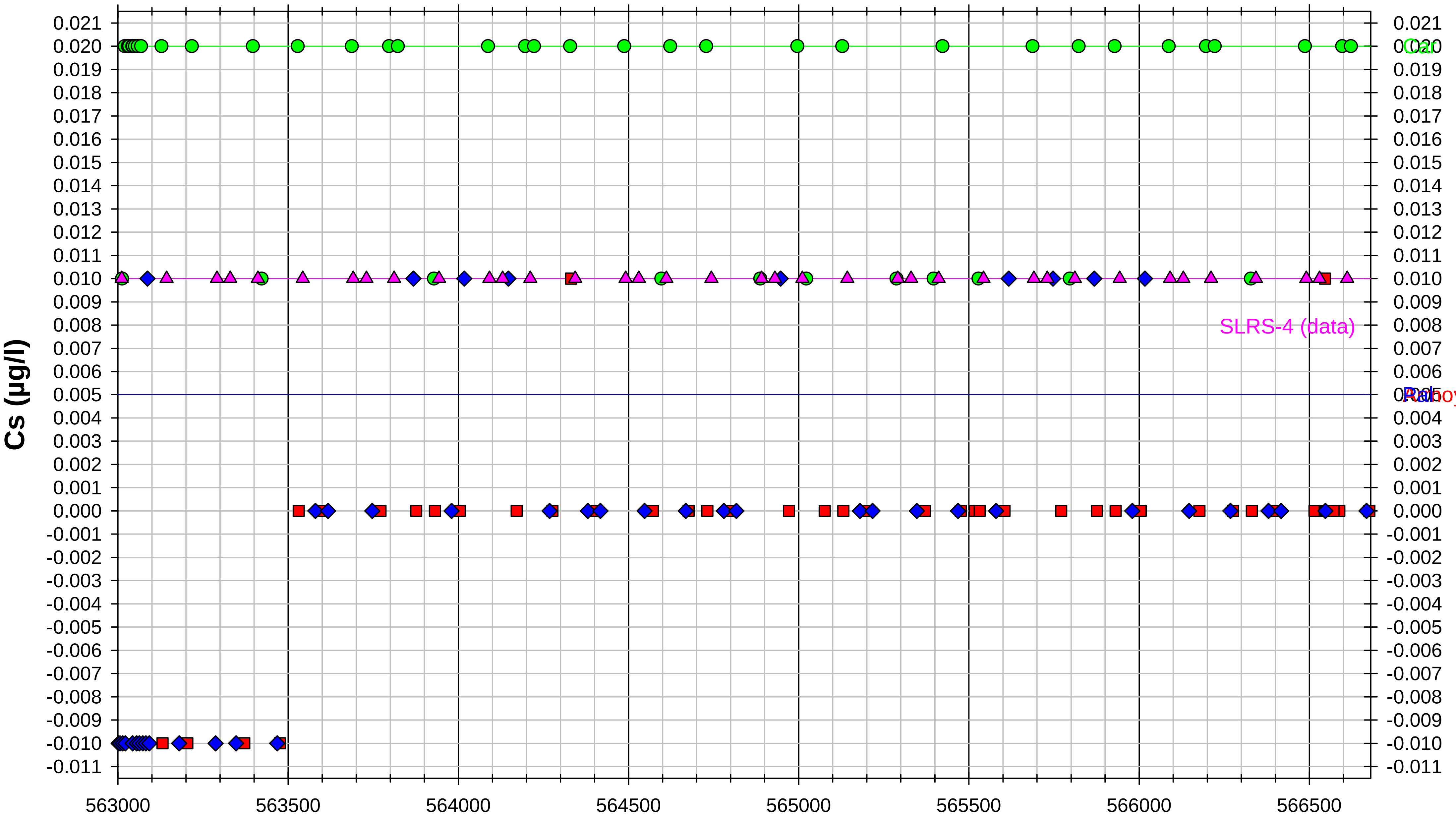
Interquartile range of sample site data = <0.2-0.6 µg/l



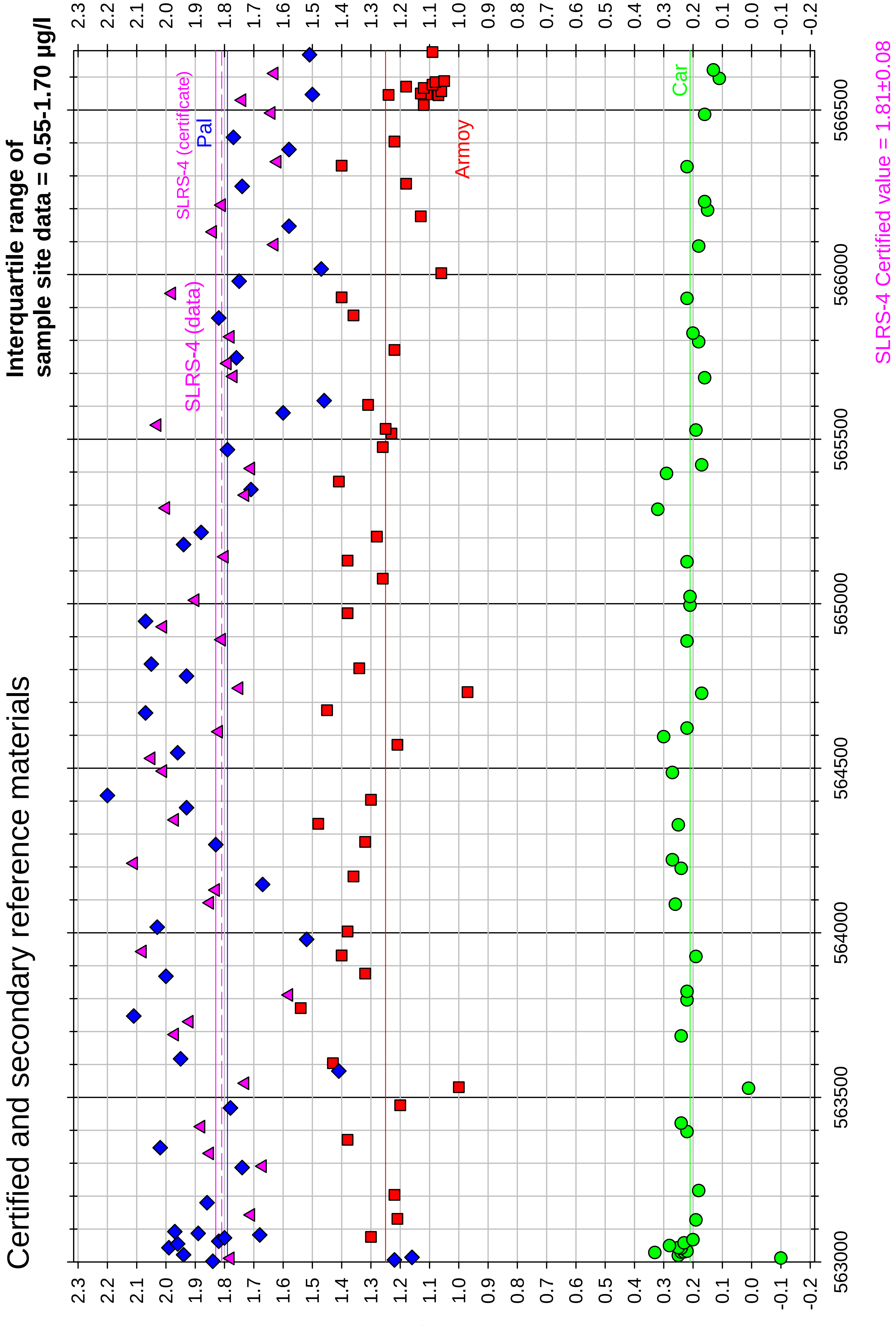
SLRS-4 Certified value = 0.33±0.02

Certified and secondary reference materials

Interquartile range of sample site data = <0.01 µg/l

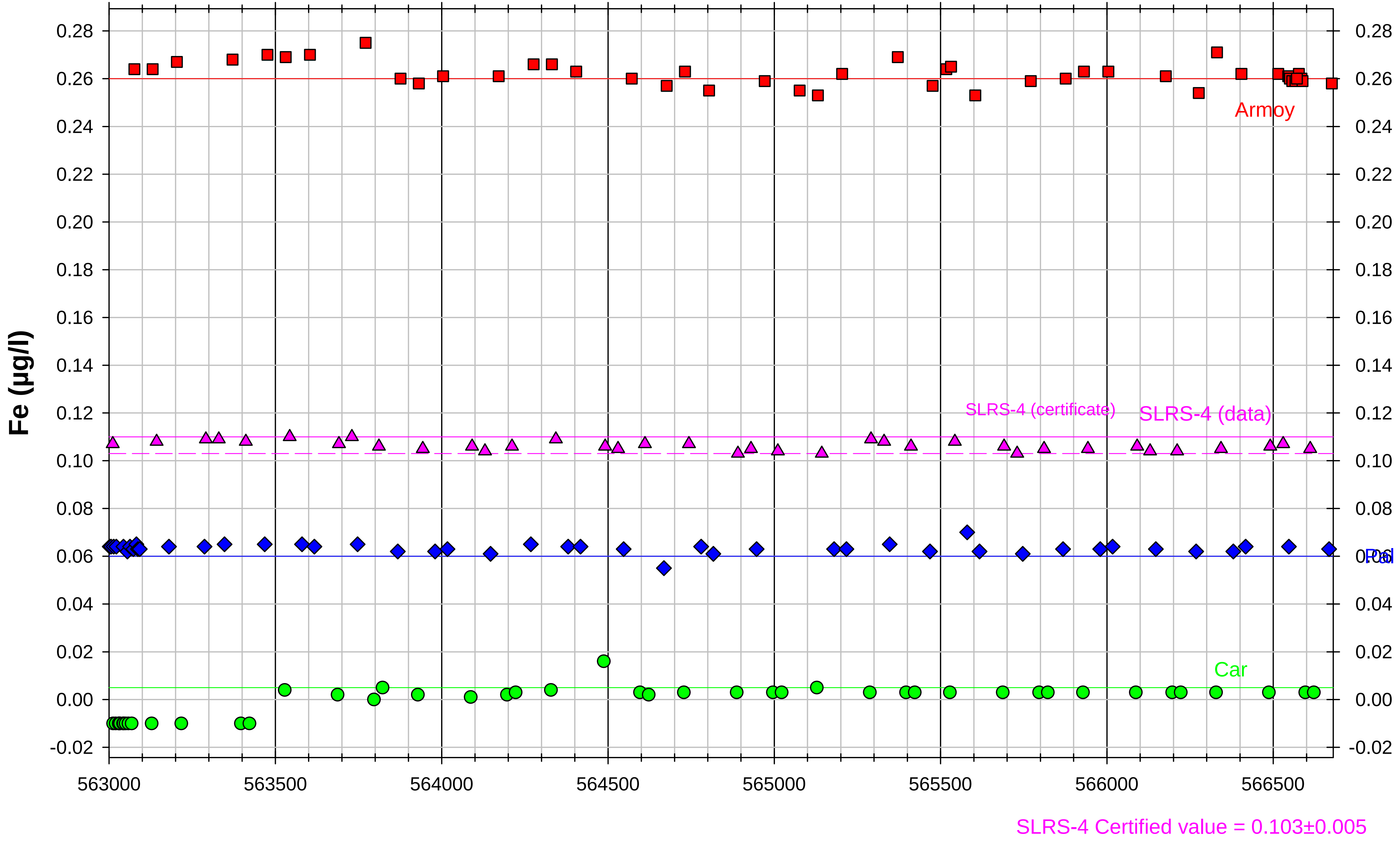


SLRS-4 Certified value = no value


Certified and secondary reference materials

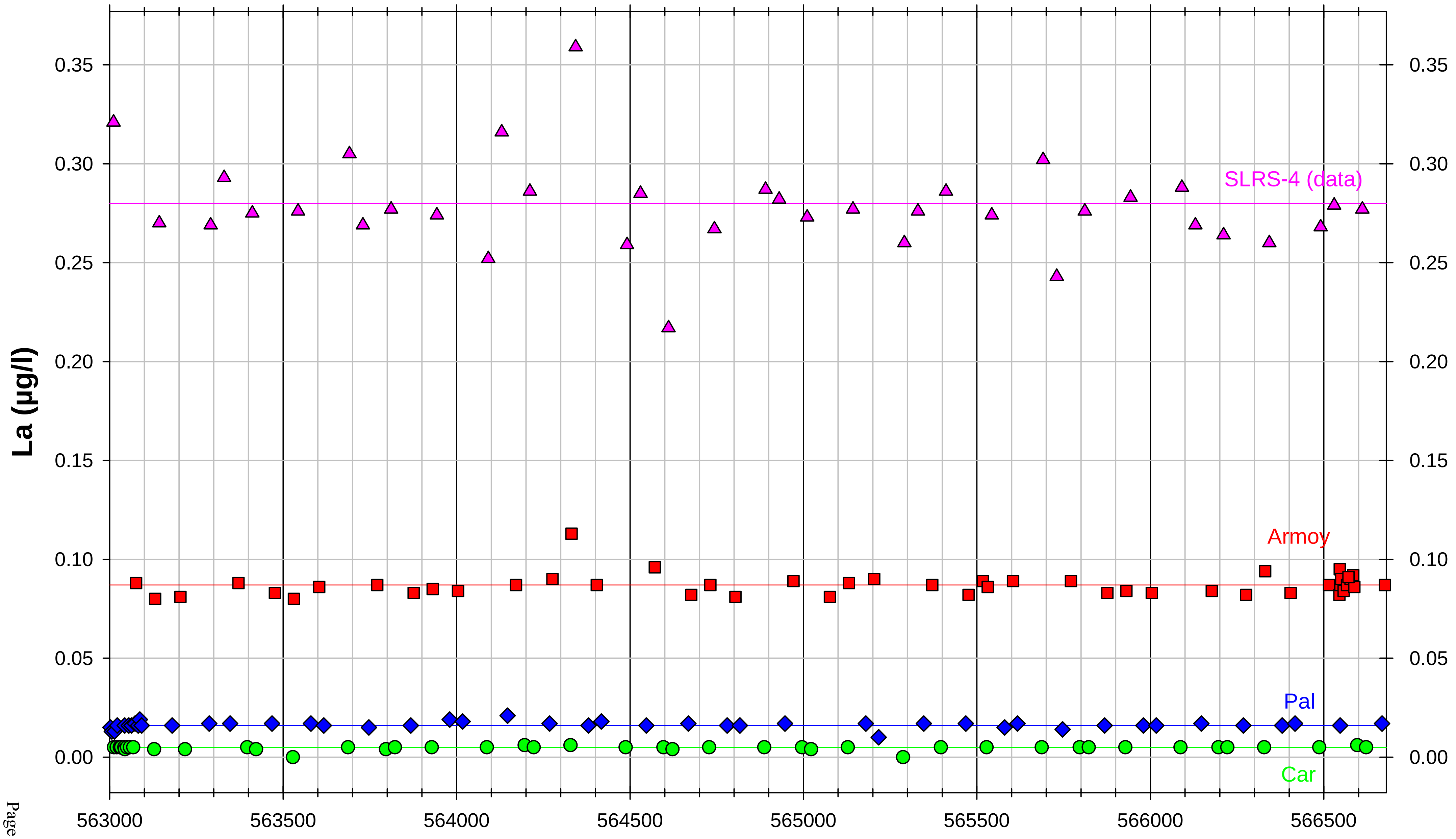
Certified and secondary reference materials

Interquartile range of sample site data = 0.054-0.378 mg/l

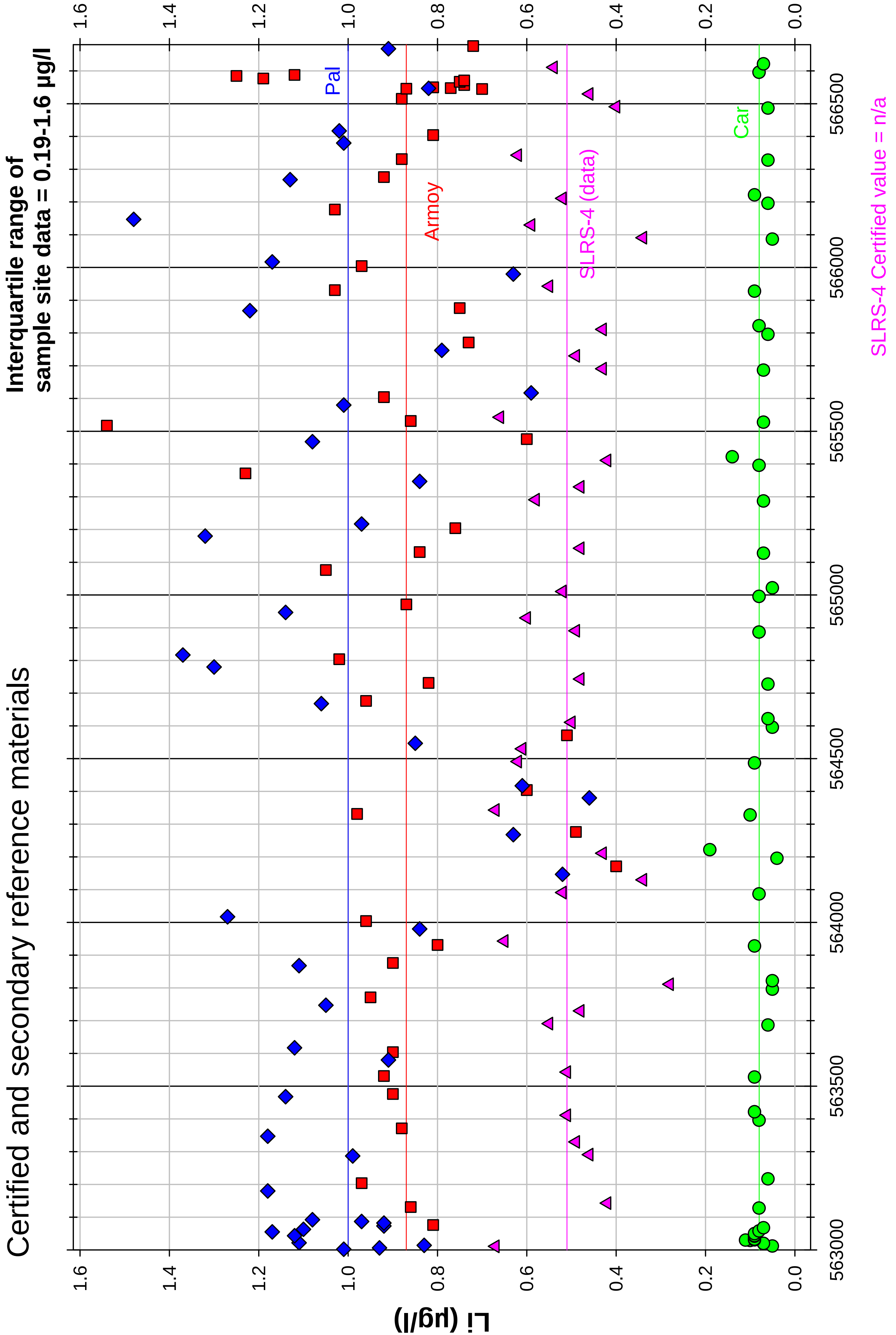


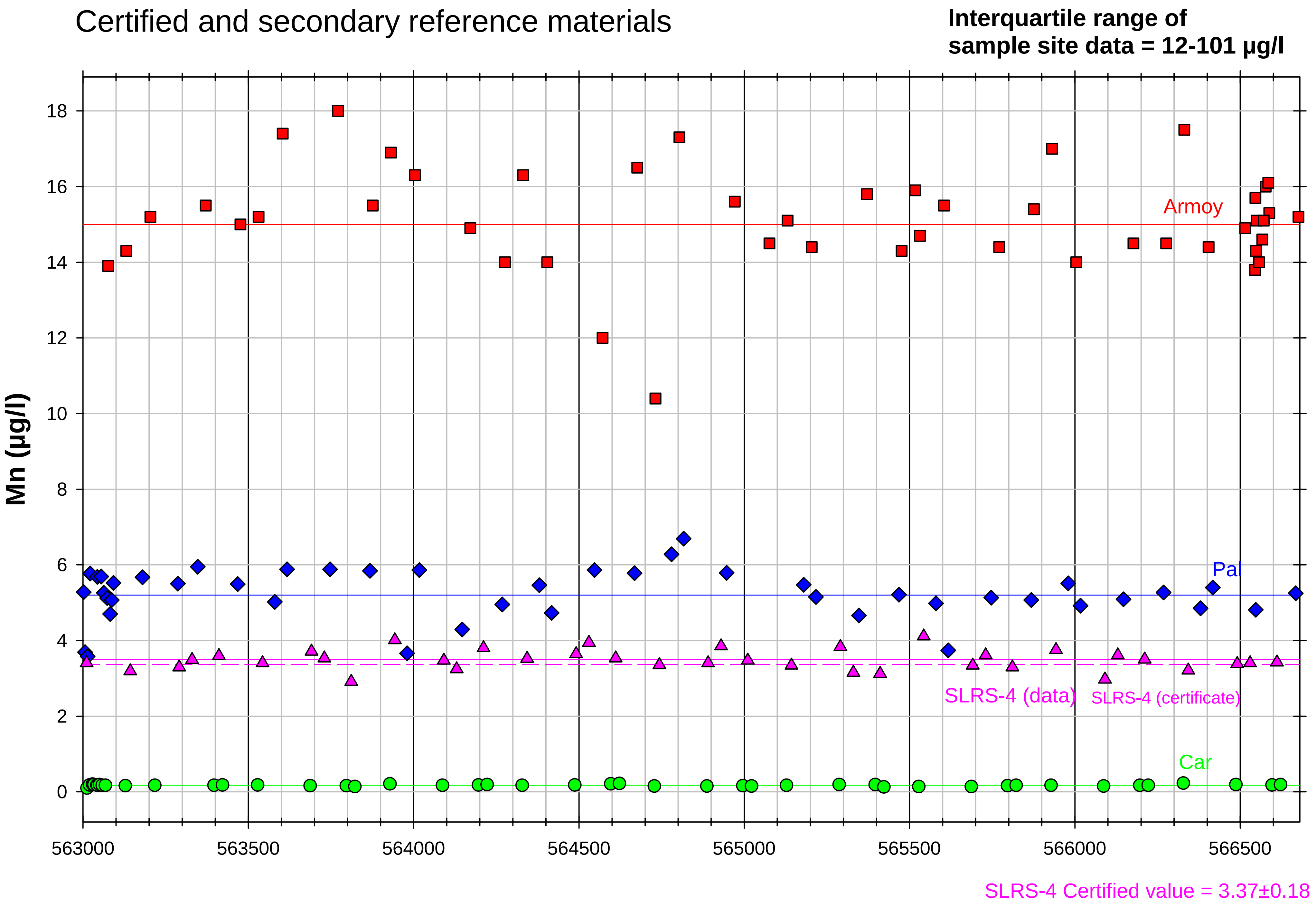
Certified and secondary reference materials

Interquartile range of sample site data = 0.009-0.063 µg/l



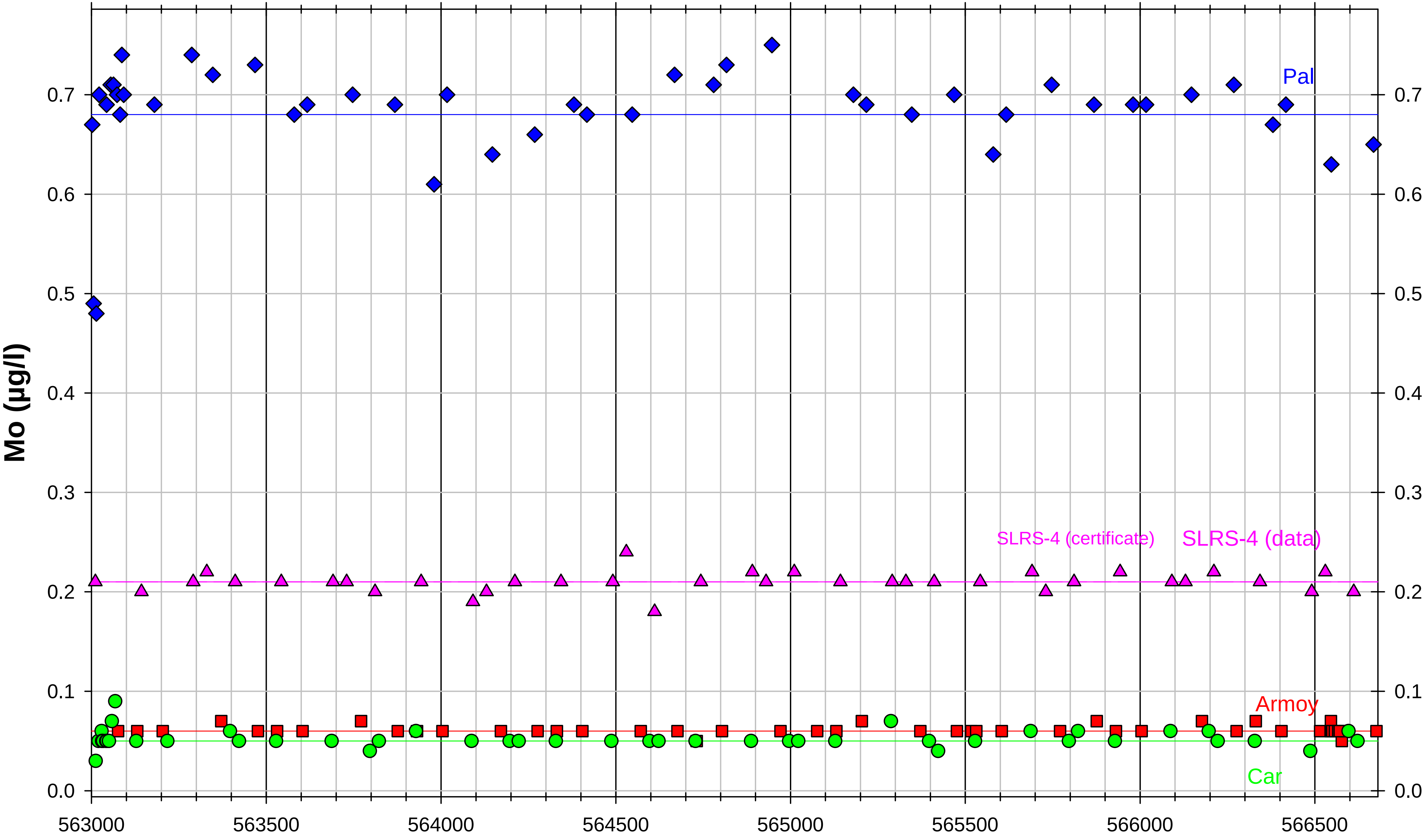
SLRS-4 Certified value = n/a


Certified and secondary reference materials
Interquartile range of
sample site data = 0.19-1.6 µg/l
Li (µg/l)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
563000
563500
564000
564500
565000
565500
566000
566500
Pal
Armoy
SLRS-4 (data)
Car
SLRS-4 Certified value = n/a

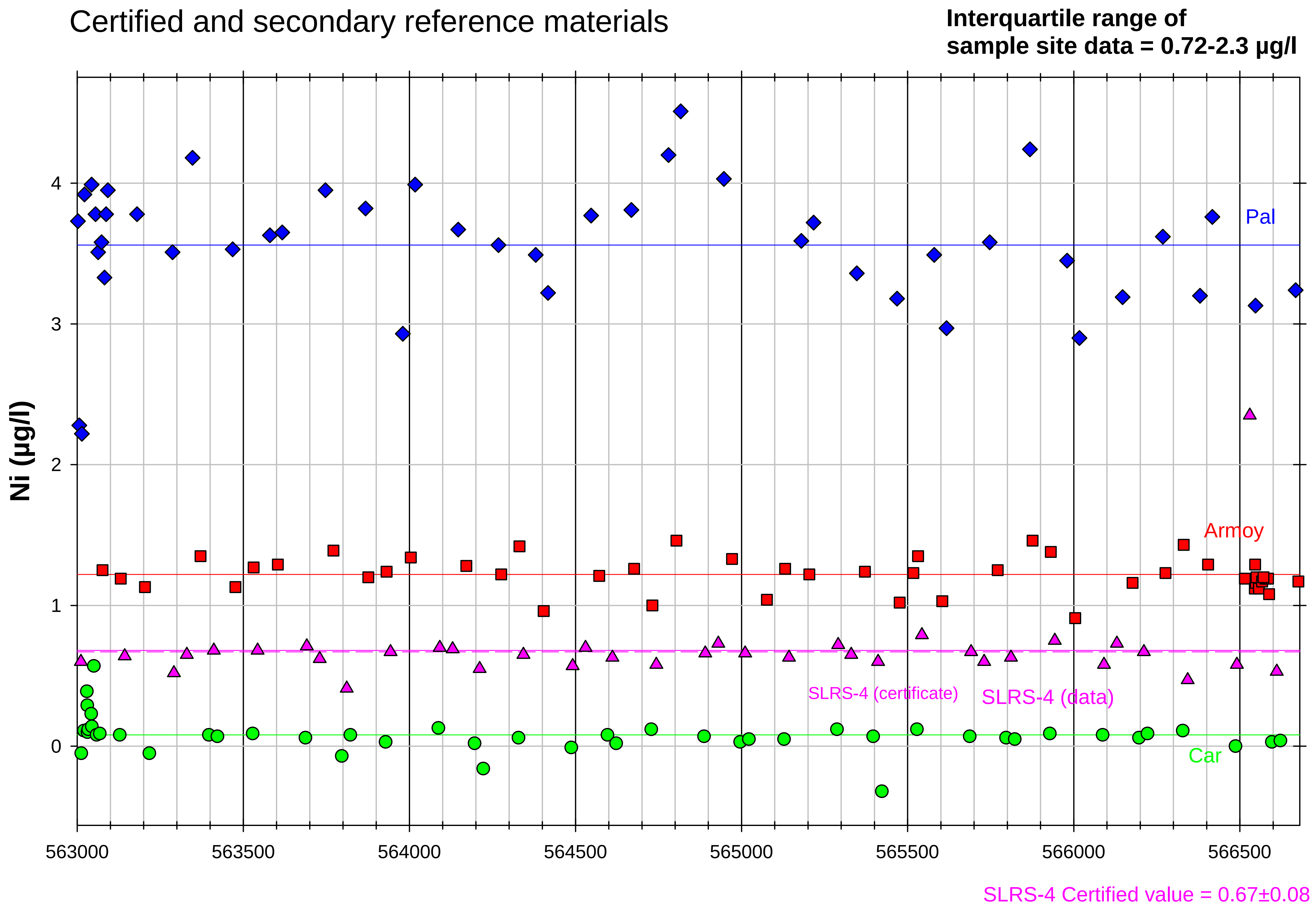

Certified and secondary reference materials
Interquartile range of sample site data = 12-101 µg/l
Mn (µg/l)
18
16
14
12
10
8
6
4
2
0
563000
563500
564000
564500
565000
565500
566000
566500
Armoy
Pal
SLRS-4 (data)
SLRS-4 (certificate)
Car
SLRS-4 Certified value = 3.37±0.18

Certified and secondary reference materials

Interquartile range of sample site data = 0.06-0.57 µg/l

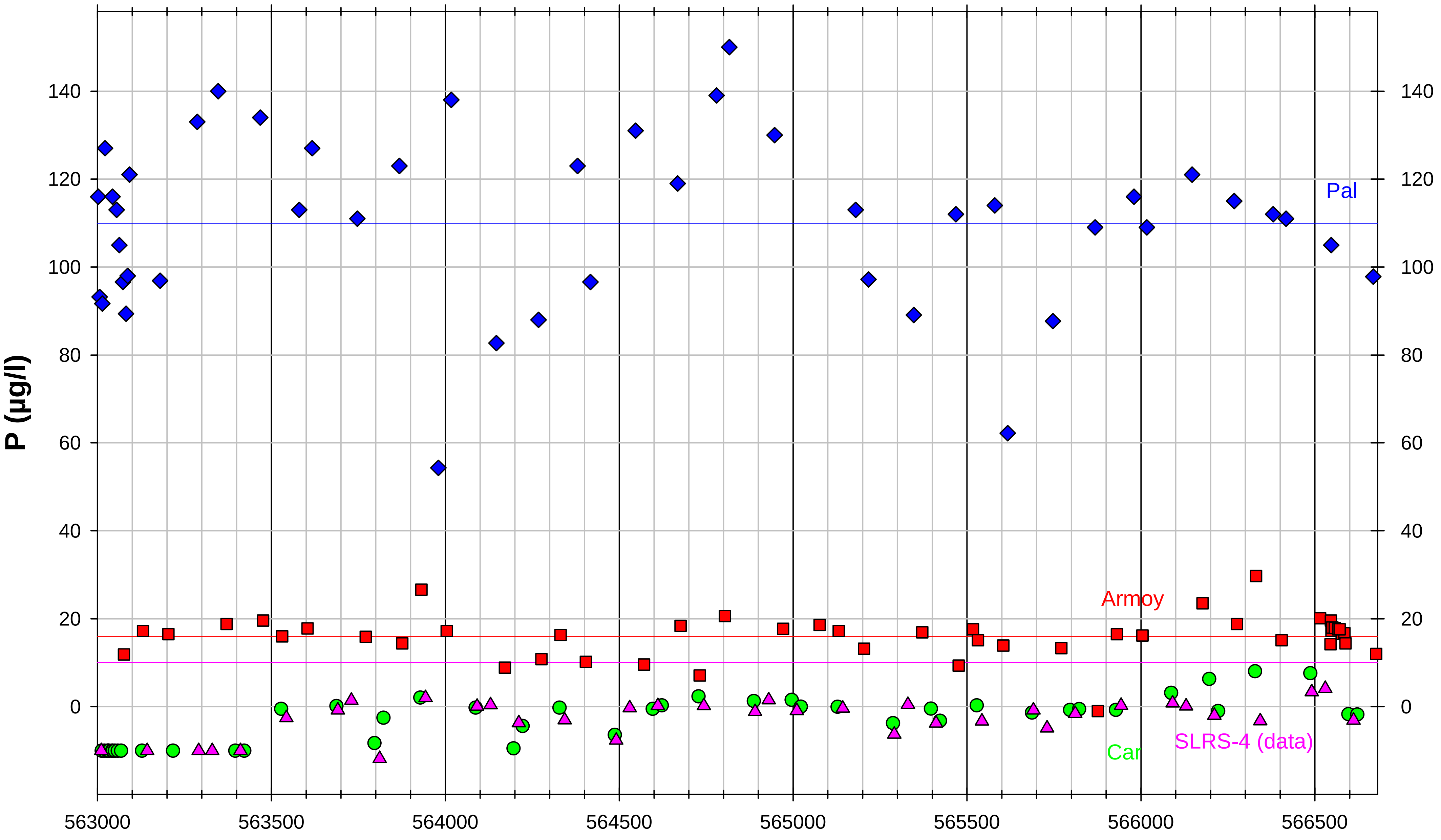


SLRS-4 Certified value = 0.21±0.02

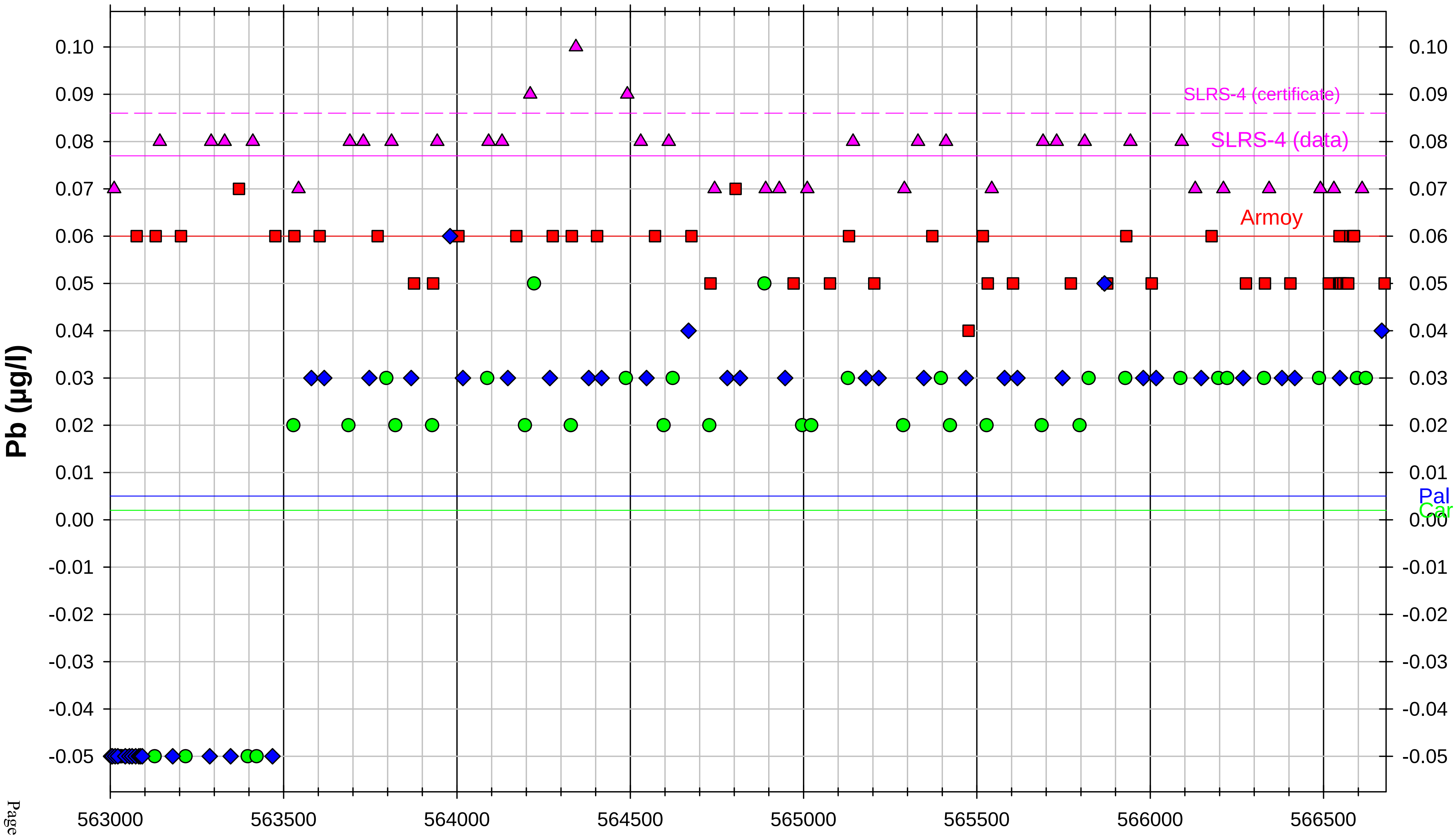

Certified and secondary reference materials
Interquartile range of
sample site data = 0.72-2.3 µg/l
Ni (µg/l)
Pal
Armoy
SLRS-4 (certificate)
SLRS-4 (data)
Car
SLRS-4 Certified value = 0.67±0.08
0
1
2
3
4
563000
563500
564000
564500
565000
565500
566000
566500

Certified and secondary reference materials

Interquartile range of sample site data = 23-226 µg/l



SLRS-4 Certified value = n/a



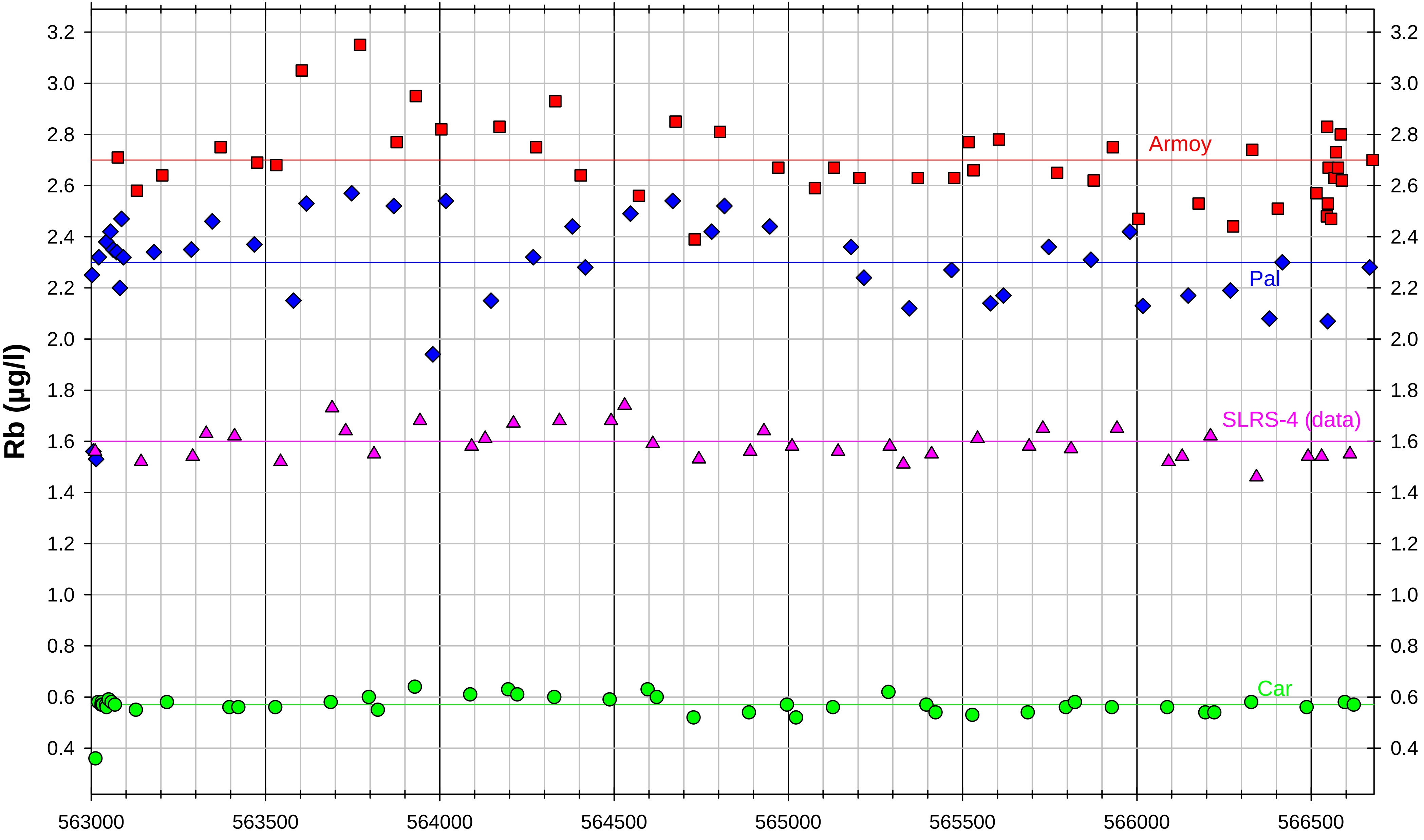
Certified and secondary reference materials

Interquartile range of sample site data = <0.05-0.12 µg/l

SLRS-4 Certified value = 0.086±0.007

Certified and secondary reference materials

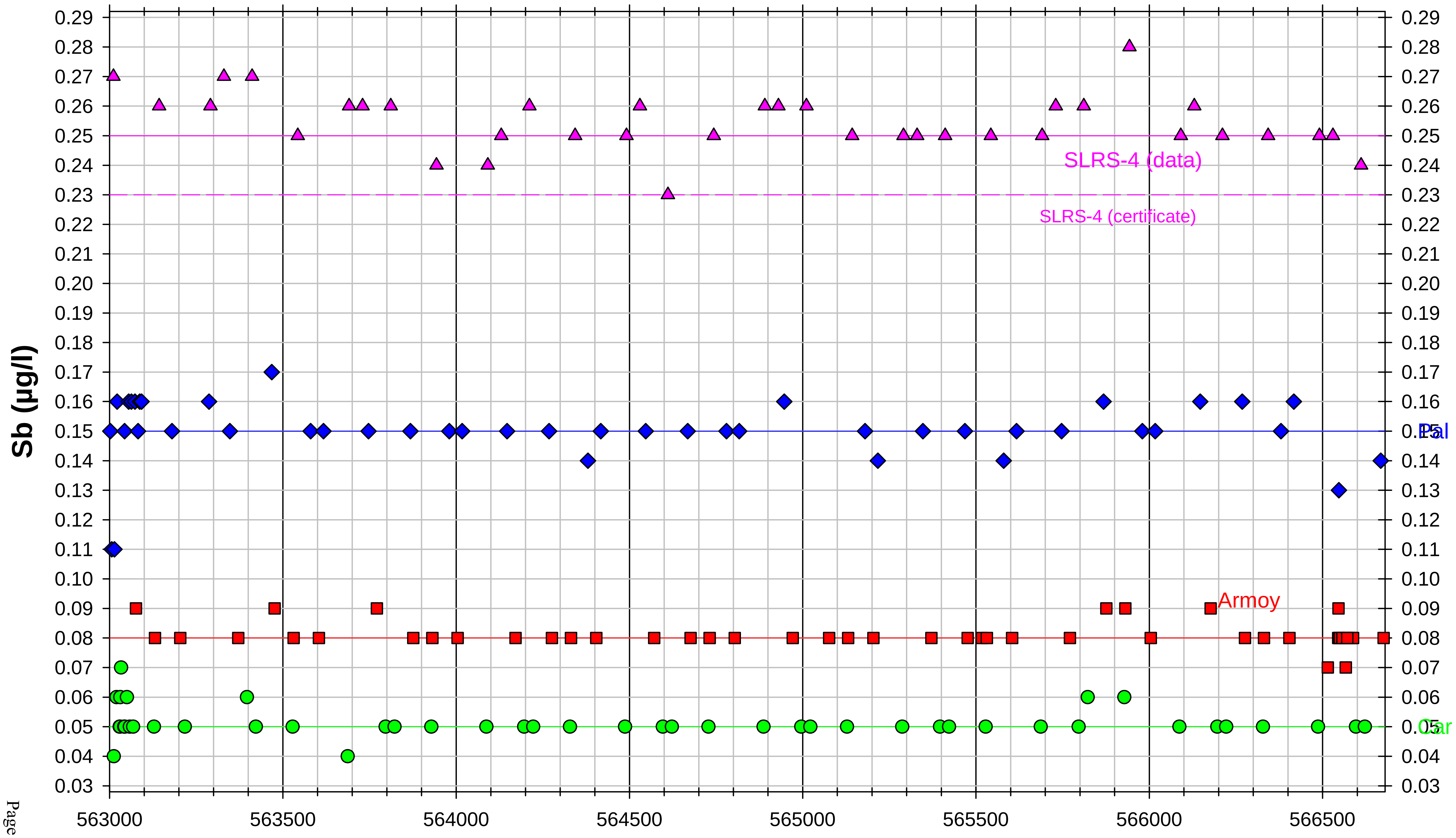
Interquartile range of sample site data = 1.13-4.79 µg/l



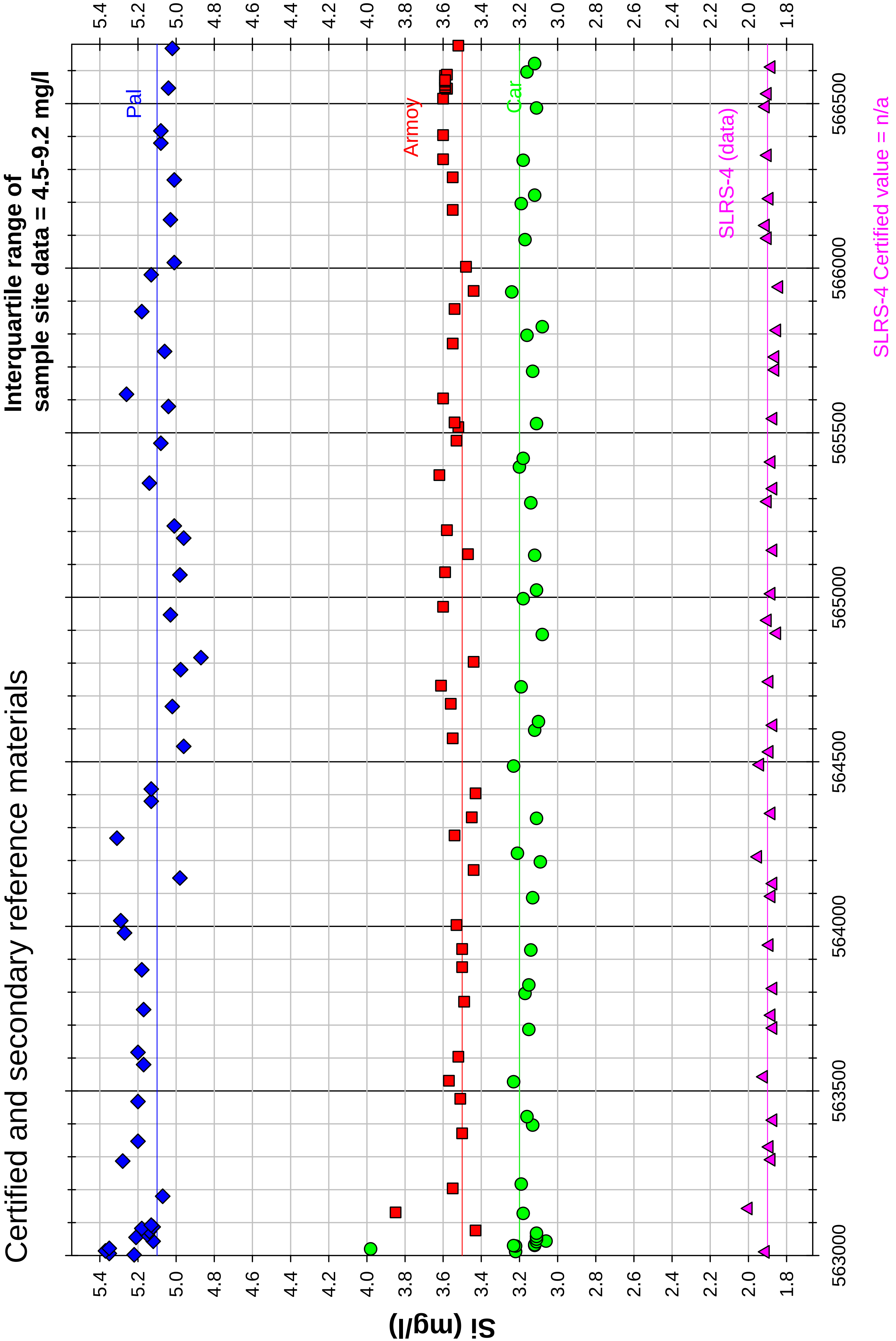
SLRS-4 Certified value = n/a

Certified and secondary reference materials

Interquartile range of sample site data = 0.04-0.14 µg/l

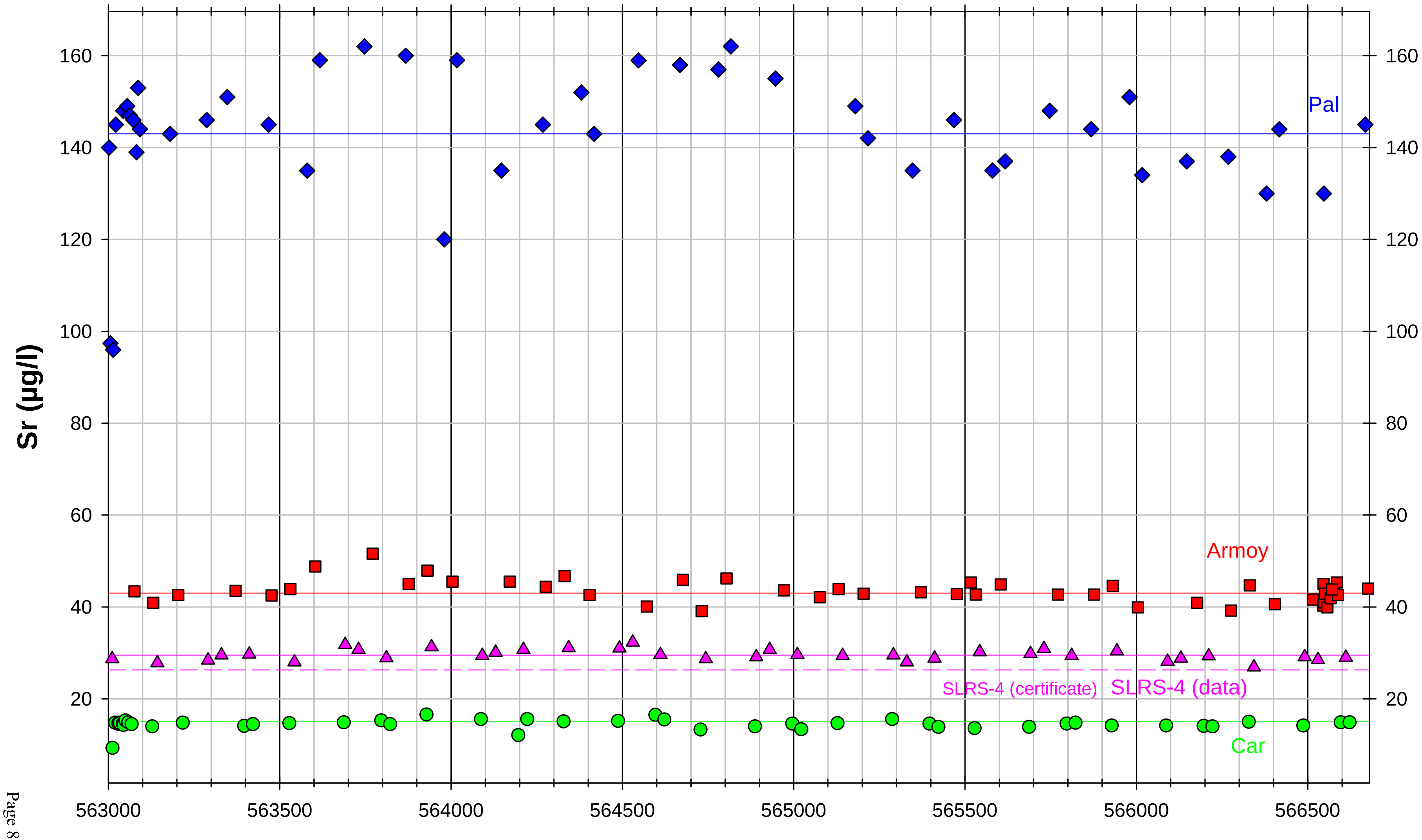


SLRS-4 Certified value = 0.23±0.04


Certified and secondary reference materials
Interquartile range of sample site data = 4.5-9.2 mg/l
Si (mg/l)
5.4
5.2
5.0
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
563000
563500
564000
564500
565000
565500
566000
566500
Pal
Armoy
Car
SLRS-4 (data)
SLRS-4 Certified value = n/a

Certified and secondary reference materials

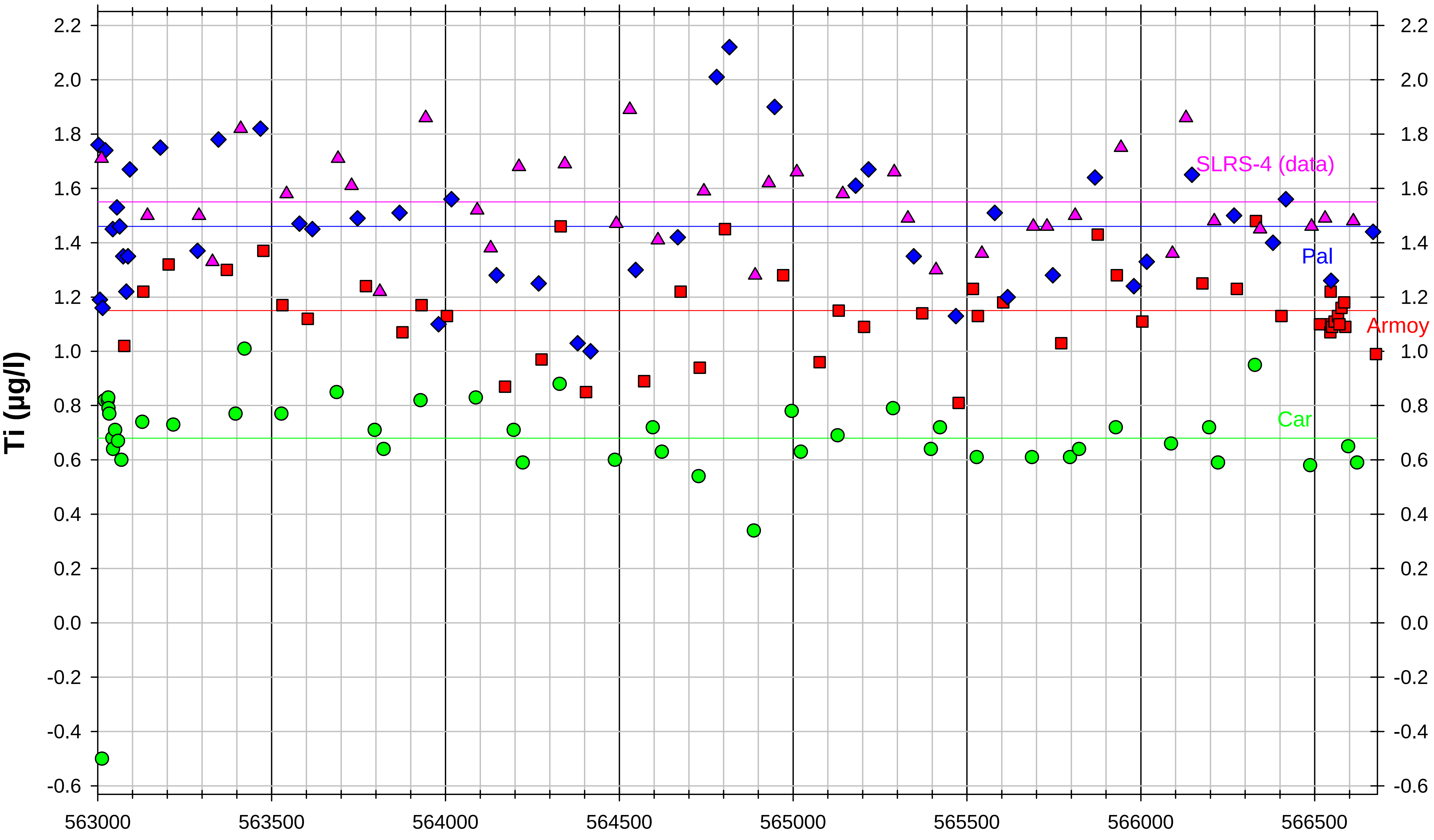
Interquartile range of sample site data = 29-161 µg/l



SLRS-4 Certified value = 26.3±3.2

Certified and secondary reference materials

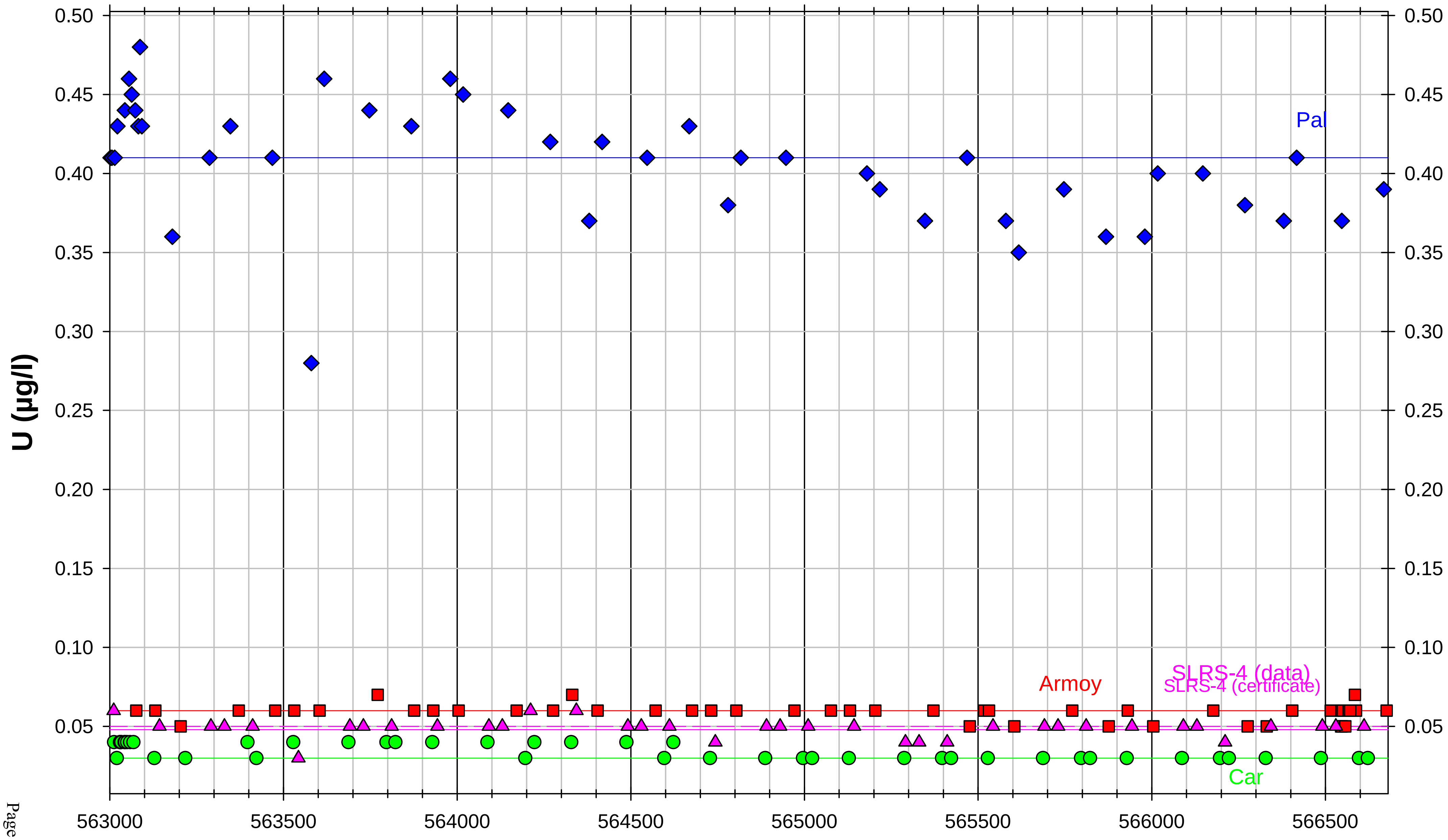
Interquartile range of sample site data = 1.7-3.4 µg/l



SLRS-4 Certified value = n/a

Certified and secondary reference materials

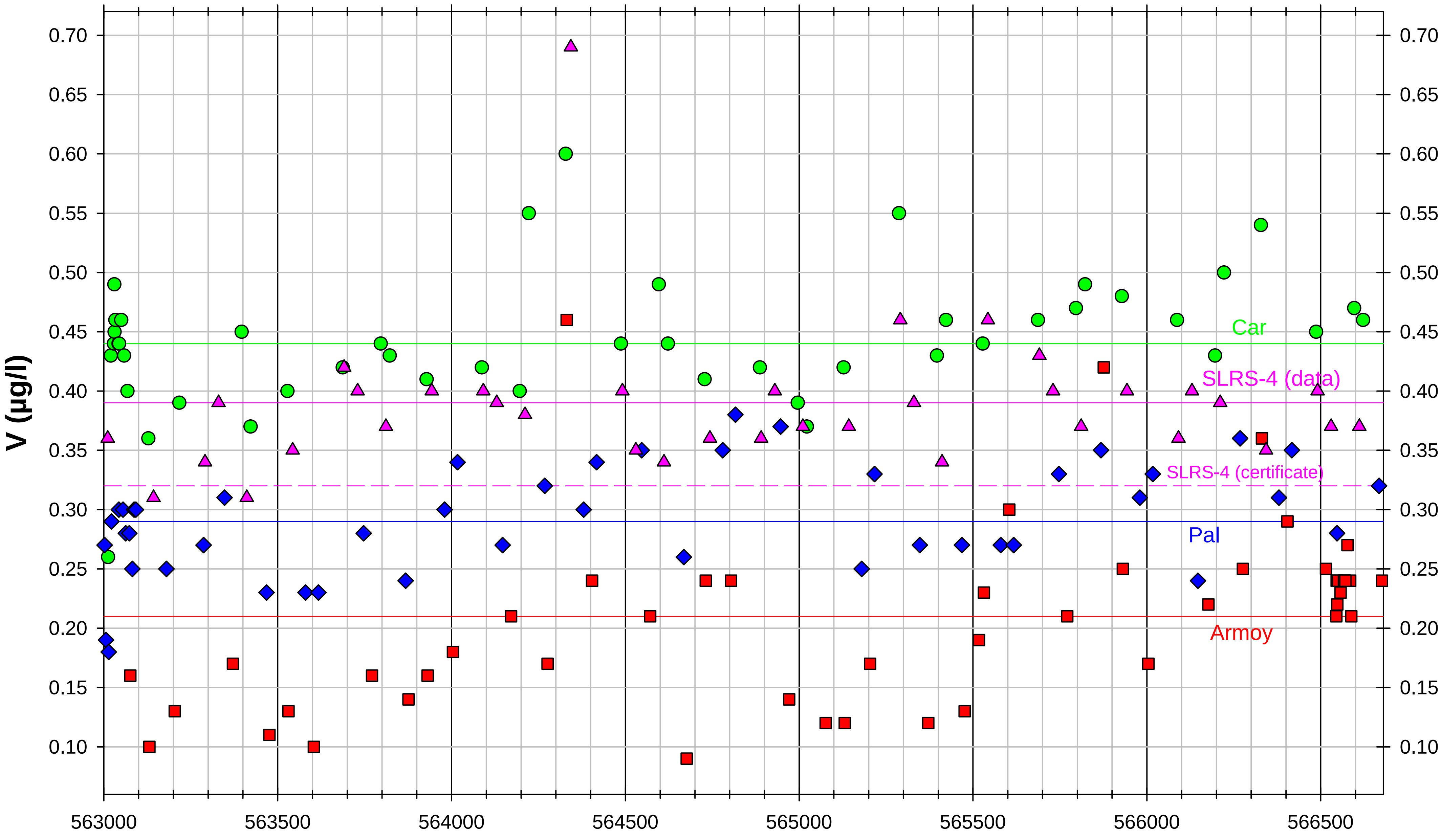
Interquartile range of sample site data = 0.06-0.38 µg/l



SLRS-4 Certified value = 0.050±0.003

Certified and secondary reference materials

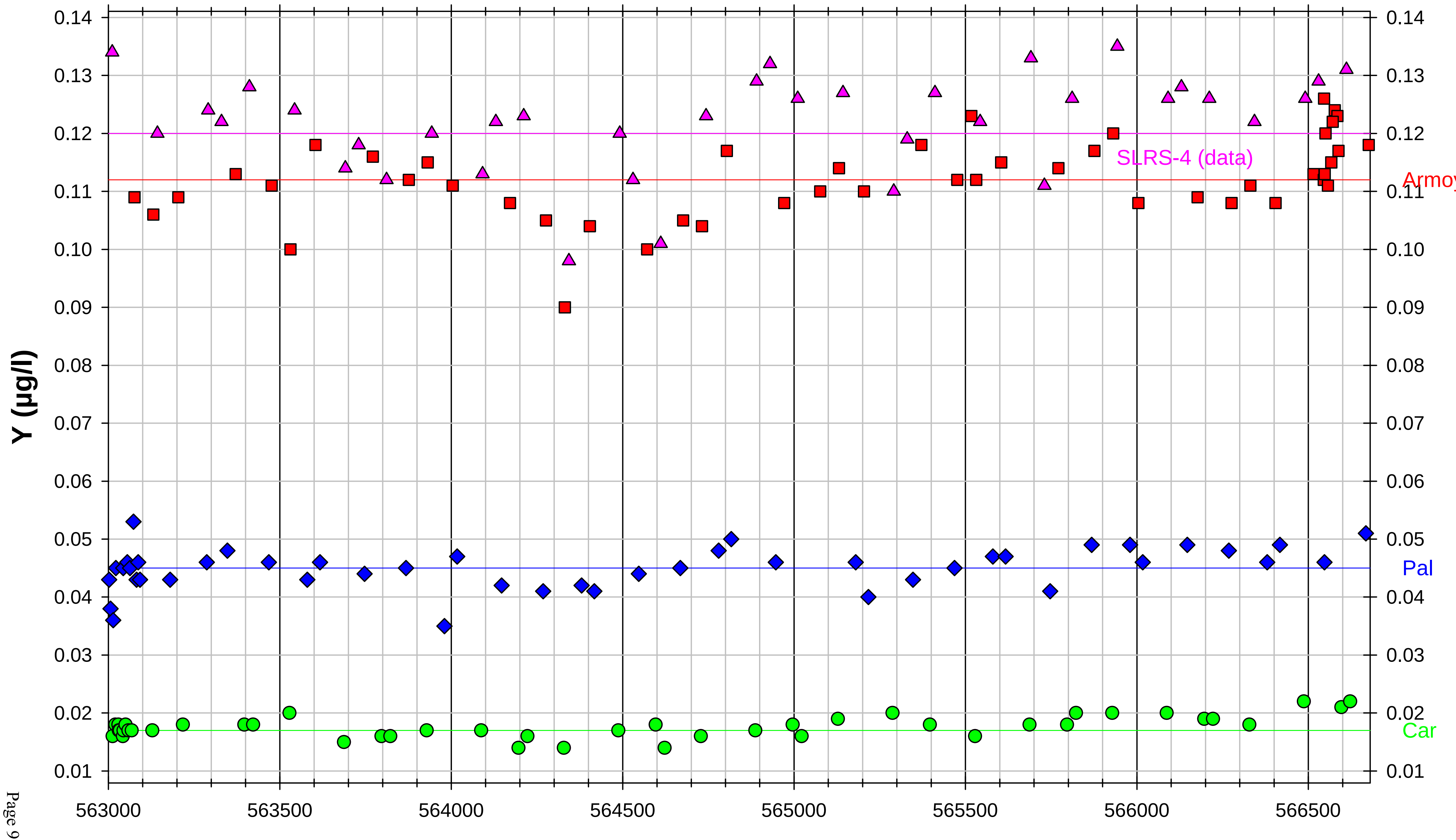
Interquartile range of sample site data = 0.52-2.25 µg/l



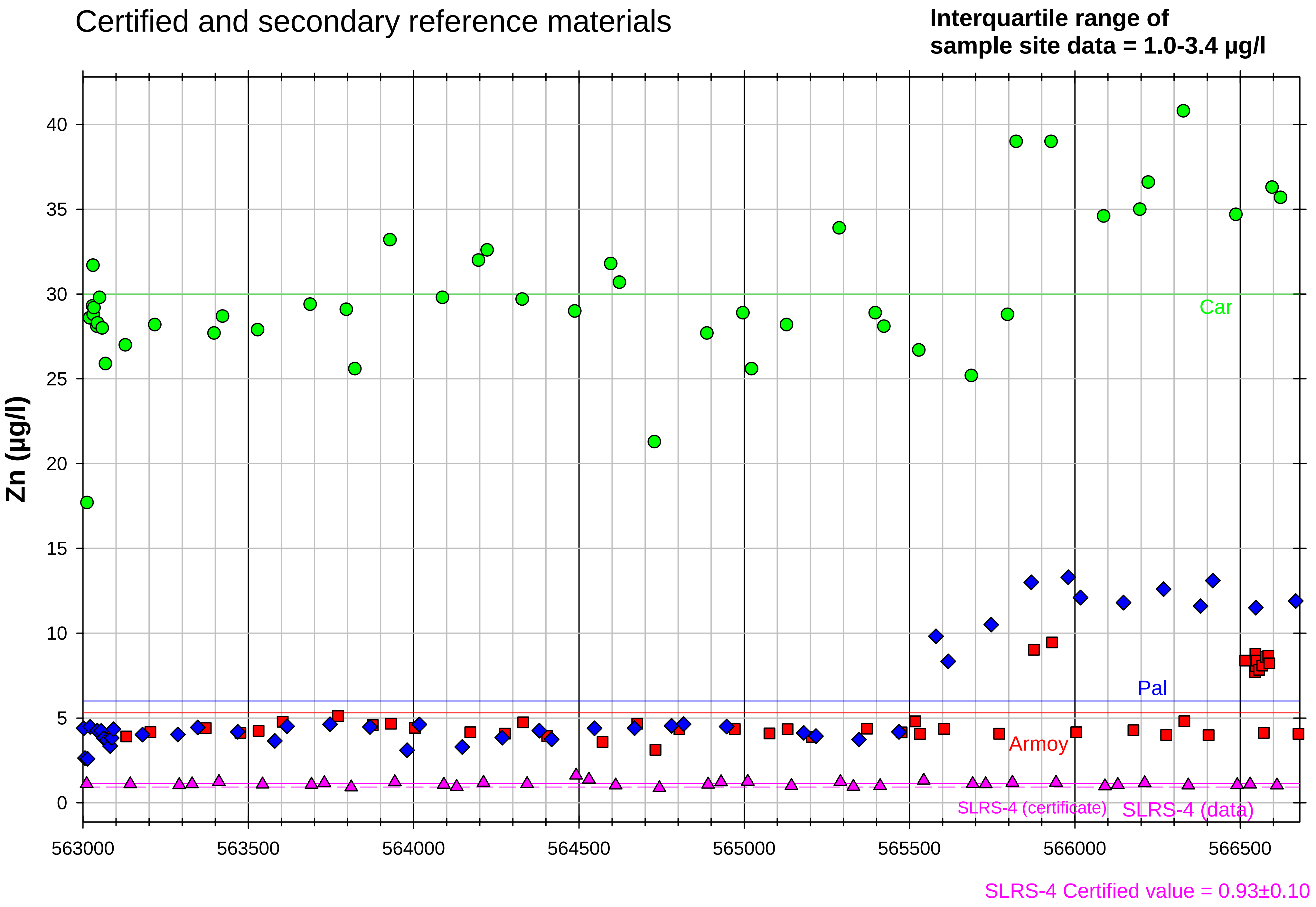
SLRS-4 Certified value = 0.32±0.03

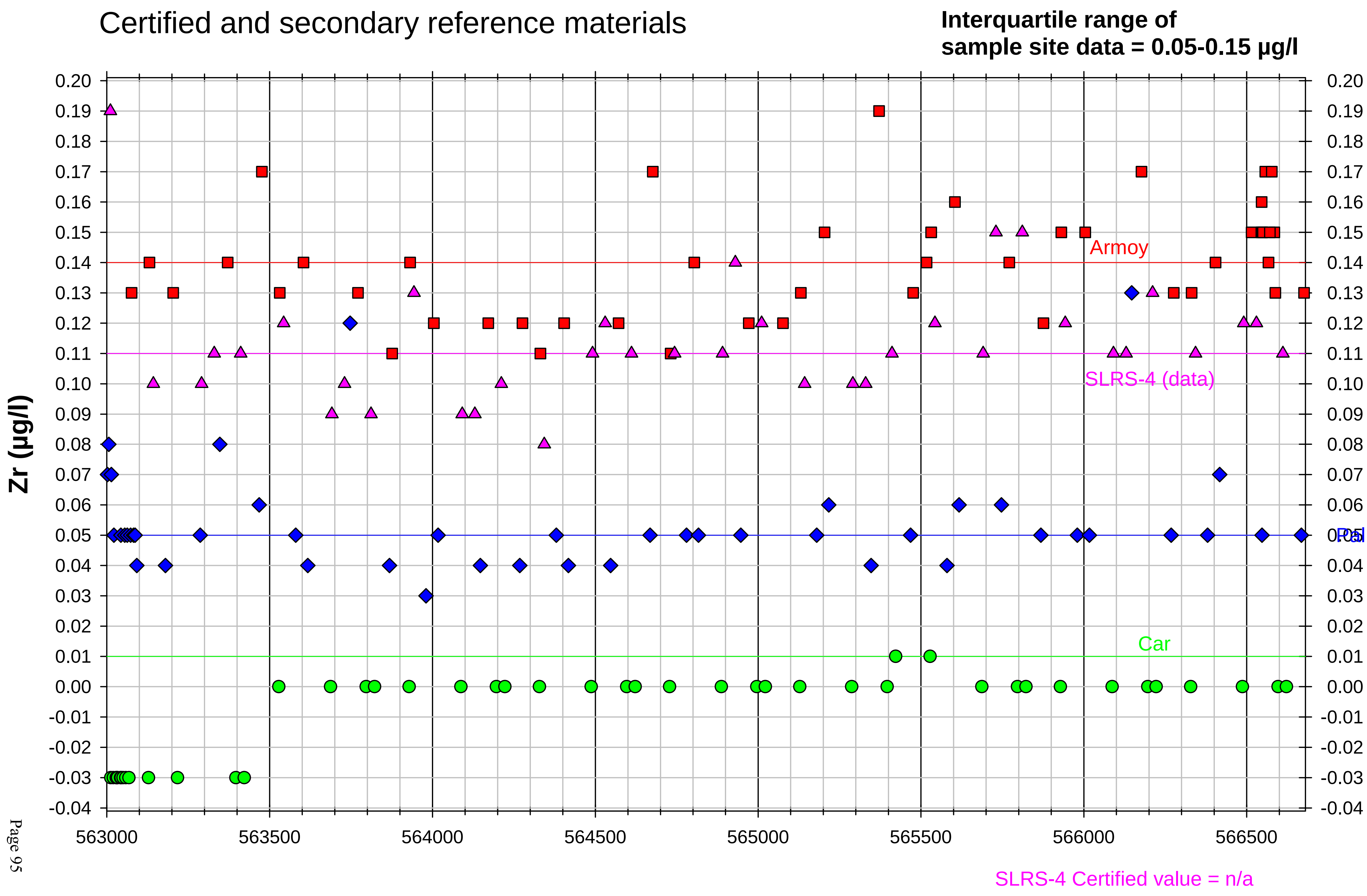
Certified and secondary reference materials

Interquartile range of sample site data = 0.045-0.14 µg/l



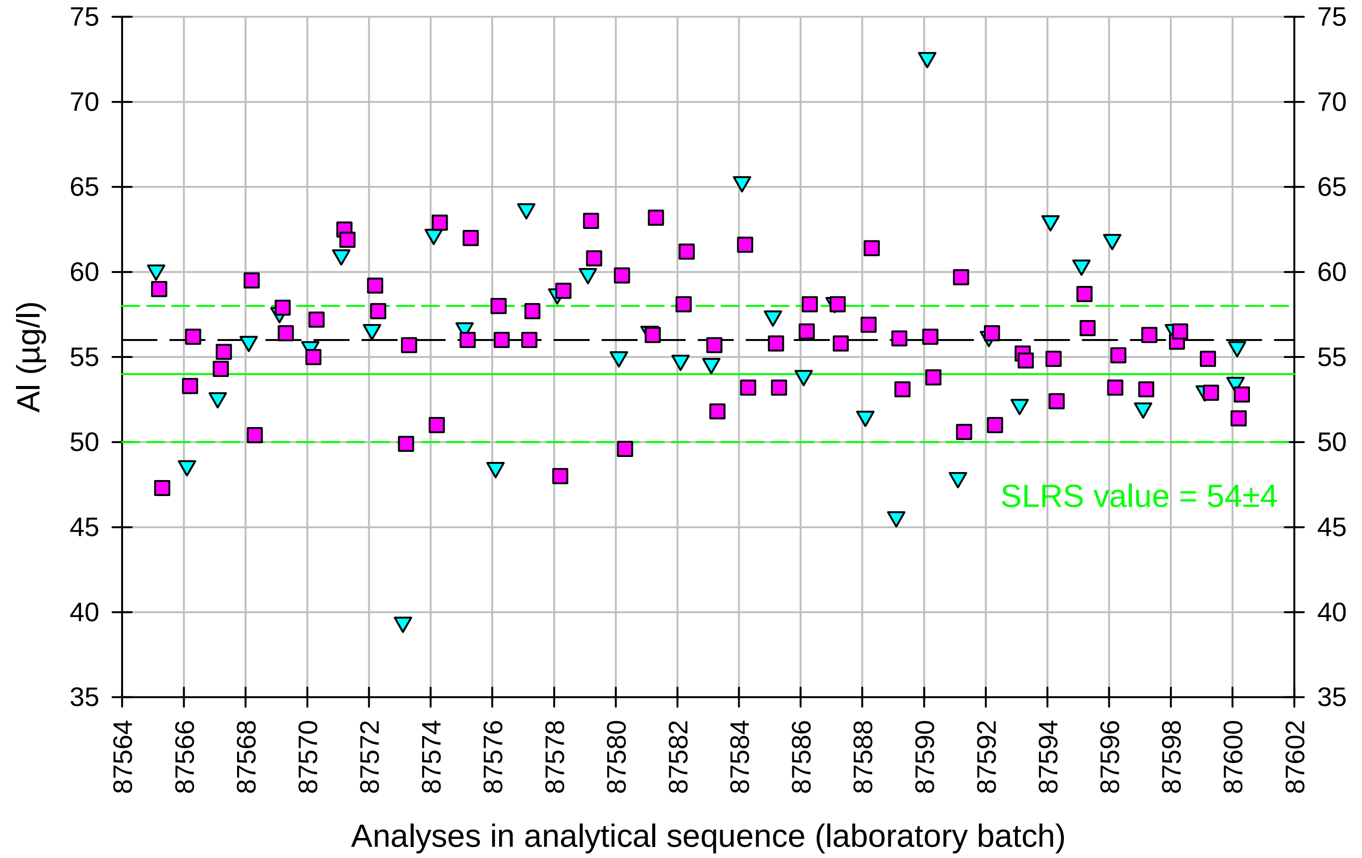
SLRS-4 Certified value = n/a

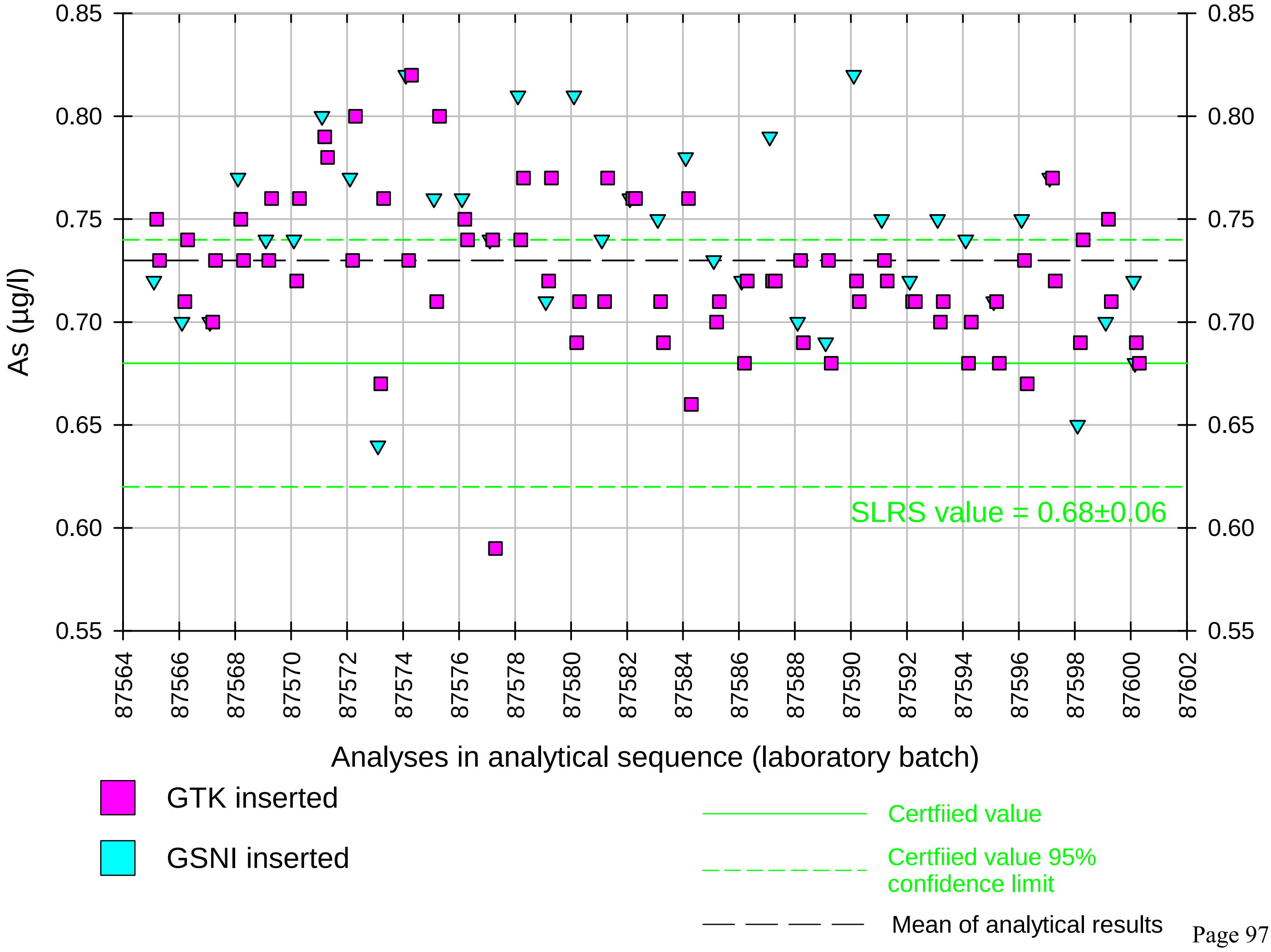

Certified and secondary reference materials
Interquartile range of
sample site data = 1.0-3.4 µg/l
Zn (µg/l)
0
5
10
15
20
25
30
35
40
563000
563500
564000
564500
565000
565500
566000
566500
Car
Pal
Armoy
SLRS-4 (certificate)
SLRS-4 (data)
SLRS-4 Certified value = 0.93±0.10

Certified and secondary reference materials
Interquartile range of
sample site data = 0.05-0.15 µg/l
Zr (µg/l)
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
563000
563500
564000
564500
565000
565500
566000
566500
Armoy
SLRS-4 (data)
Pal
Car
SLRS-4 Certified value = n/a

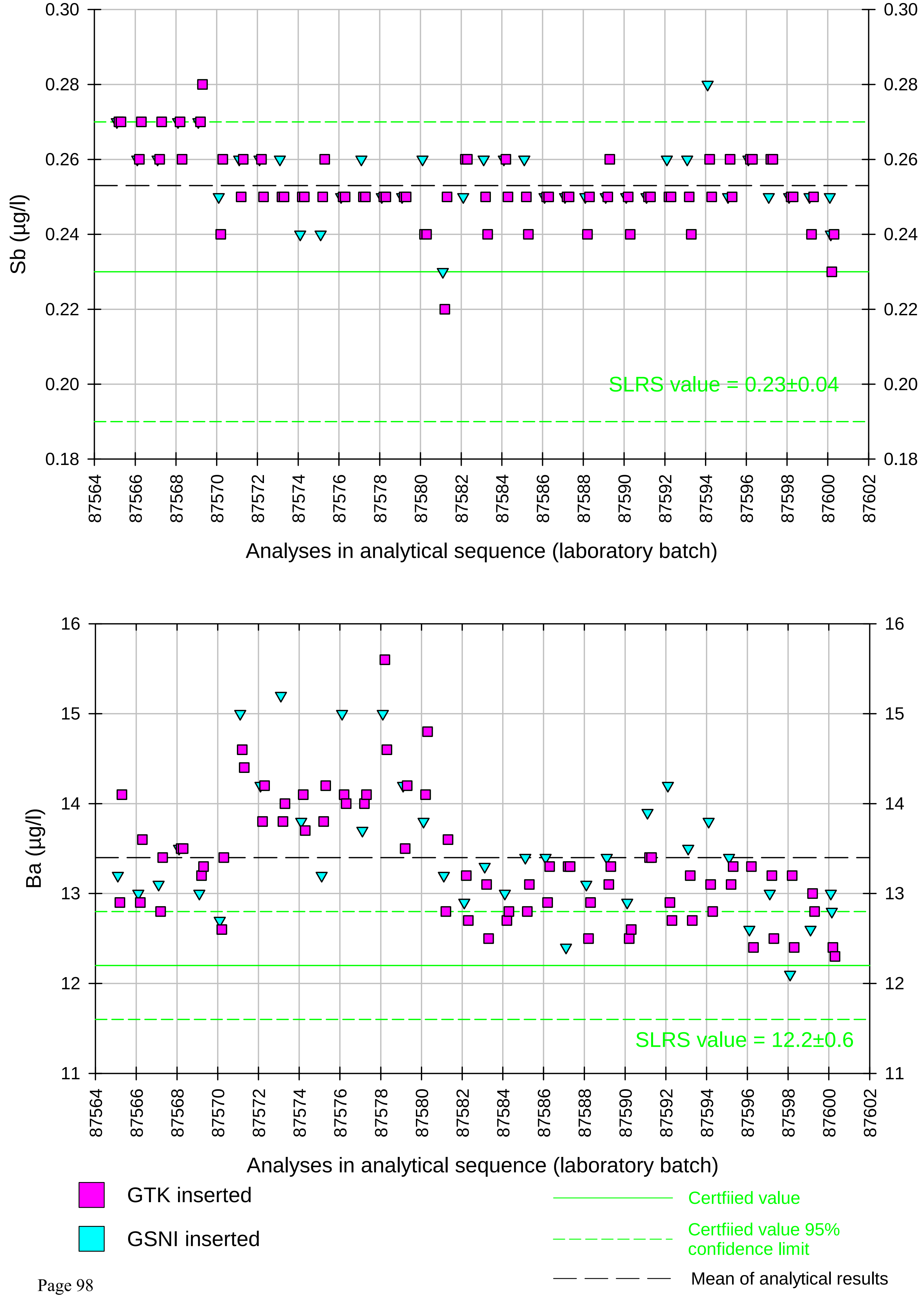
Appendix 4 – Reference Material SLRS-4 data plots

Comparison of GTK inserted SLRS-4 and GSNI inserted SLRS-4 CRM

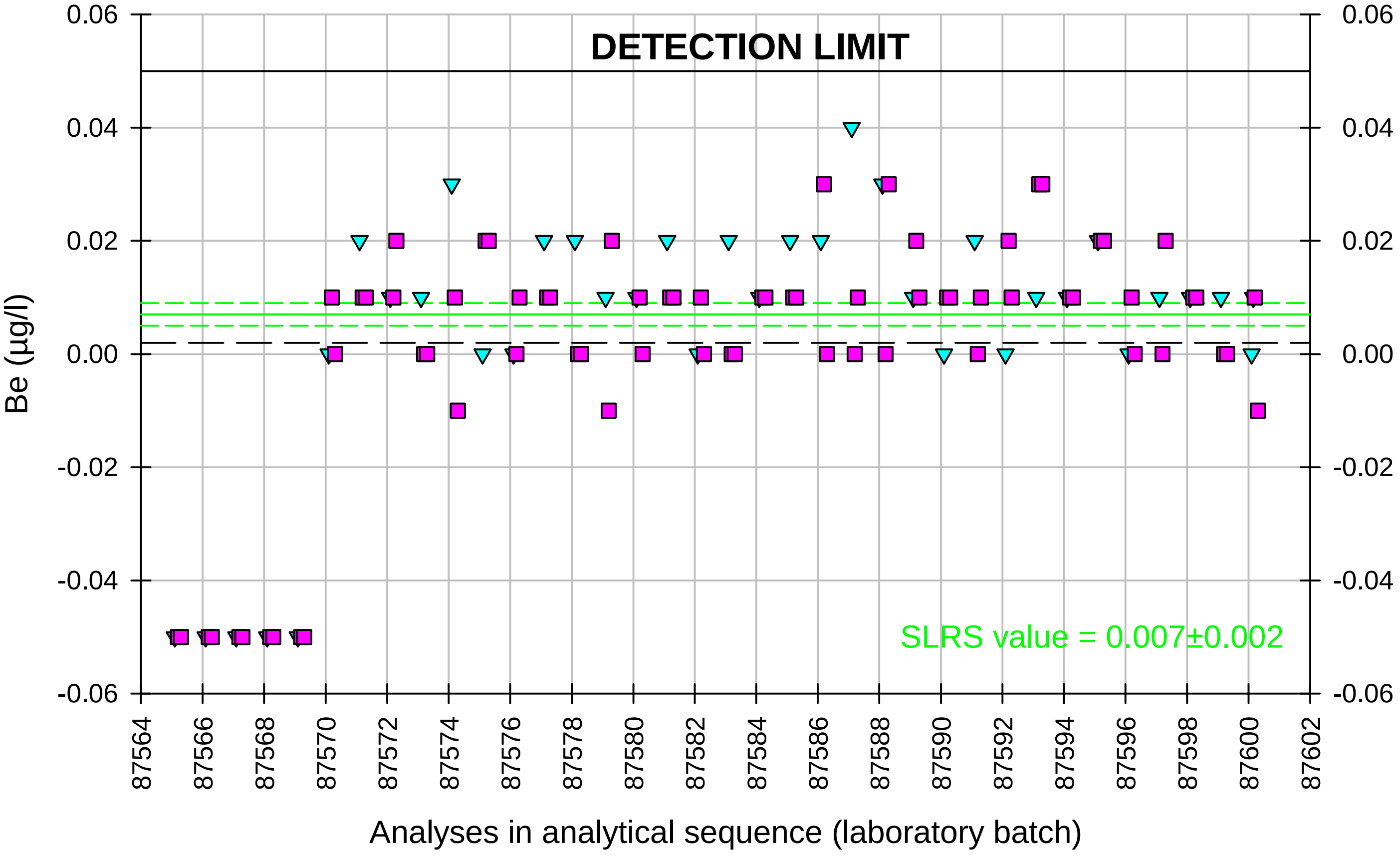


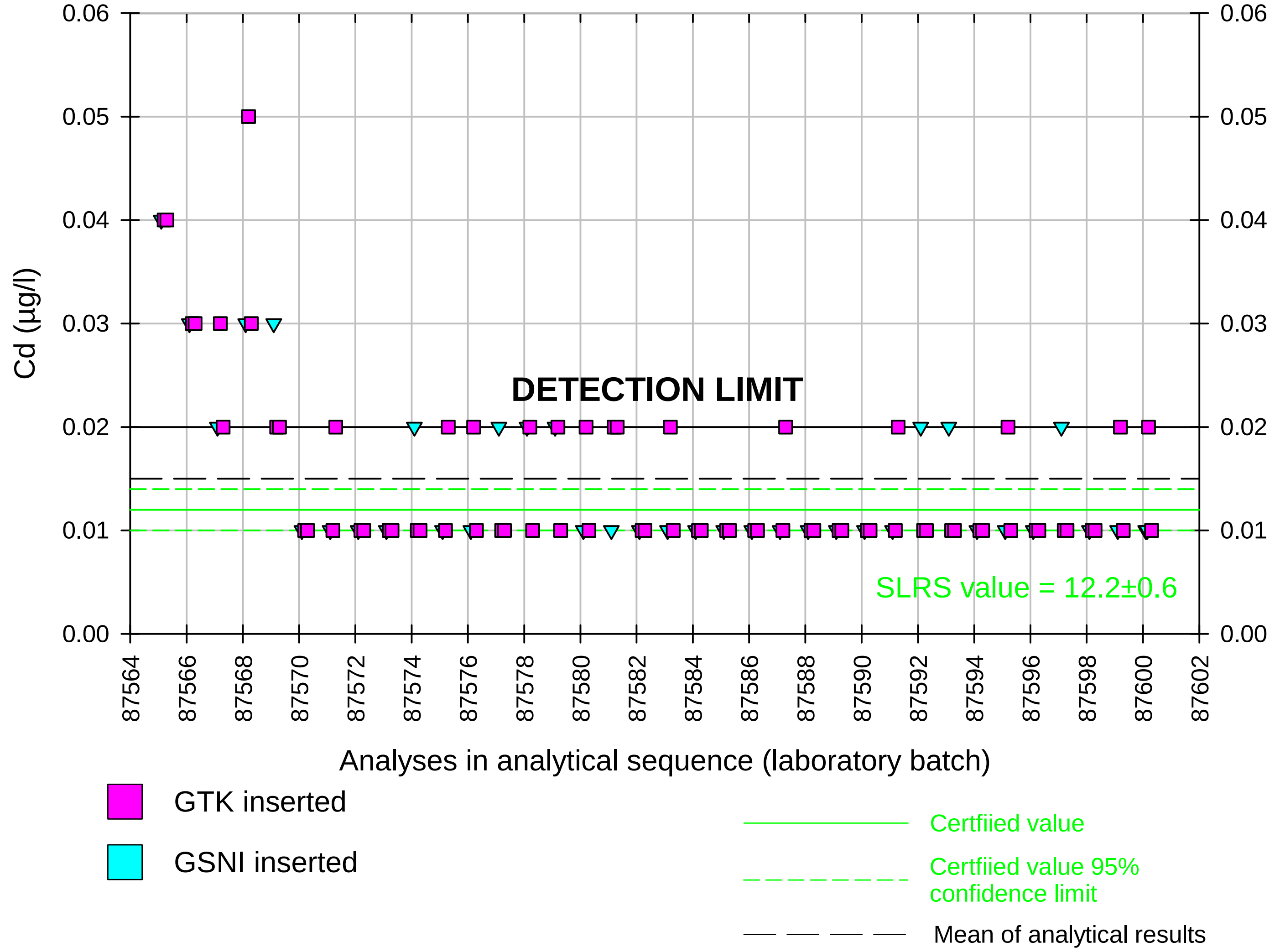


Comparison of GTK inserted SLRS-4 and GSNI inserted SLRS-4 CRM

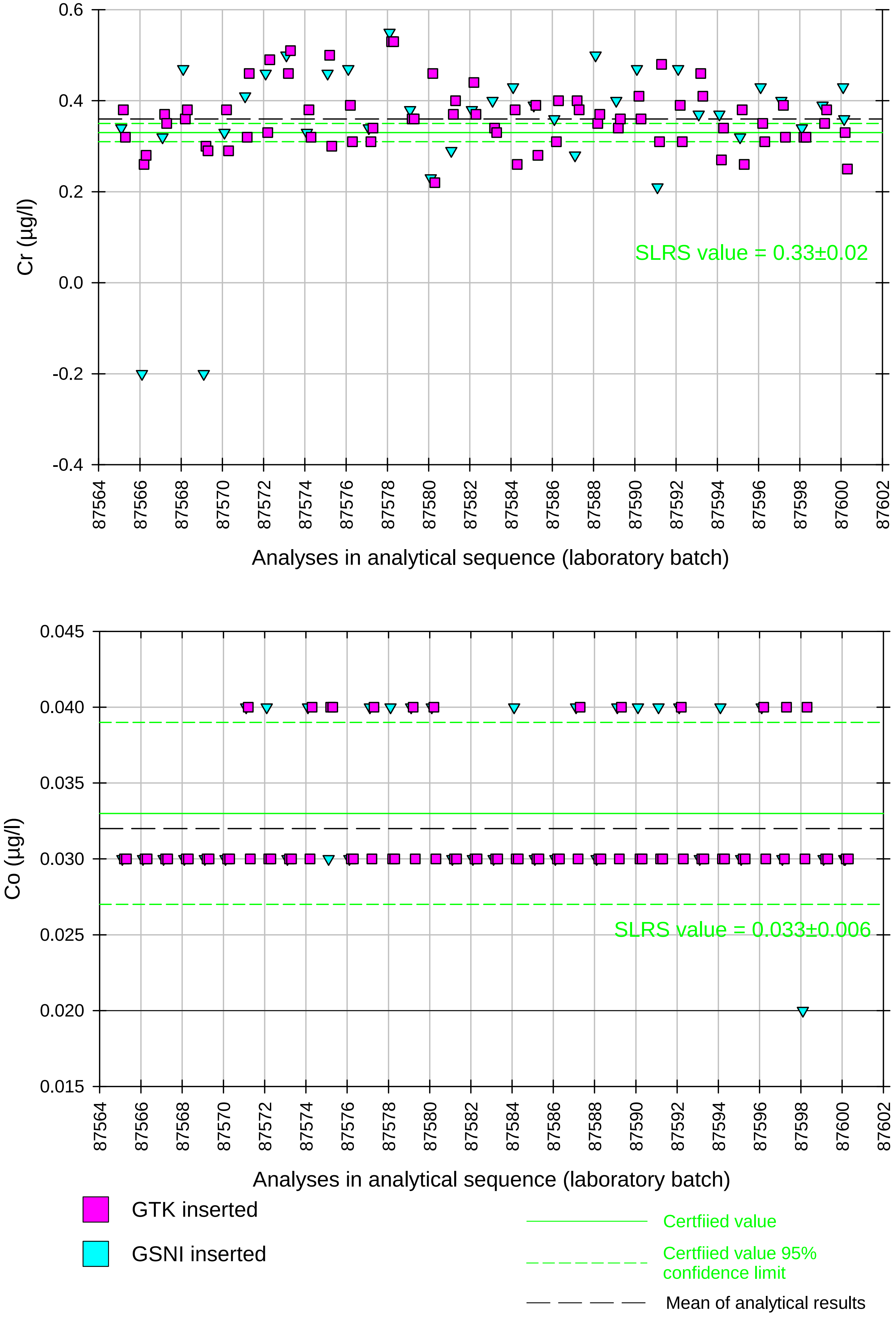


Comparison of GTK inserted SLRS-4 and GSNI inserted SLRS-4 CRM

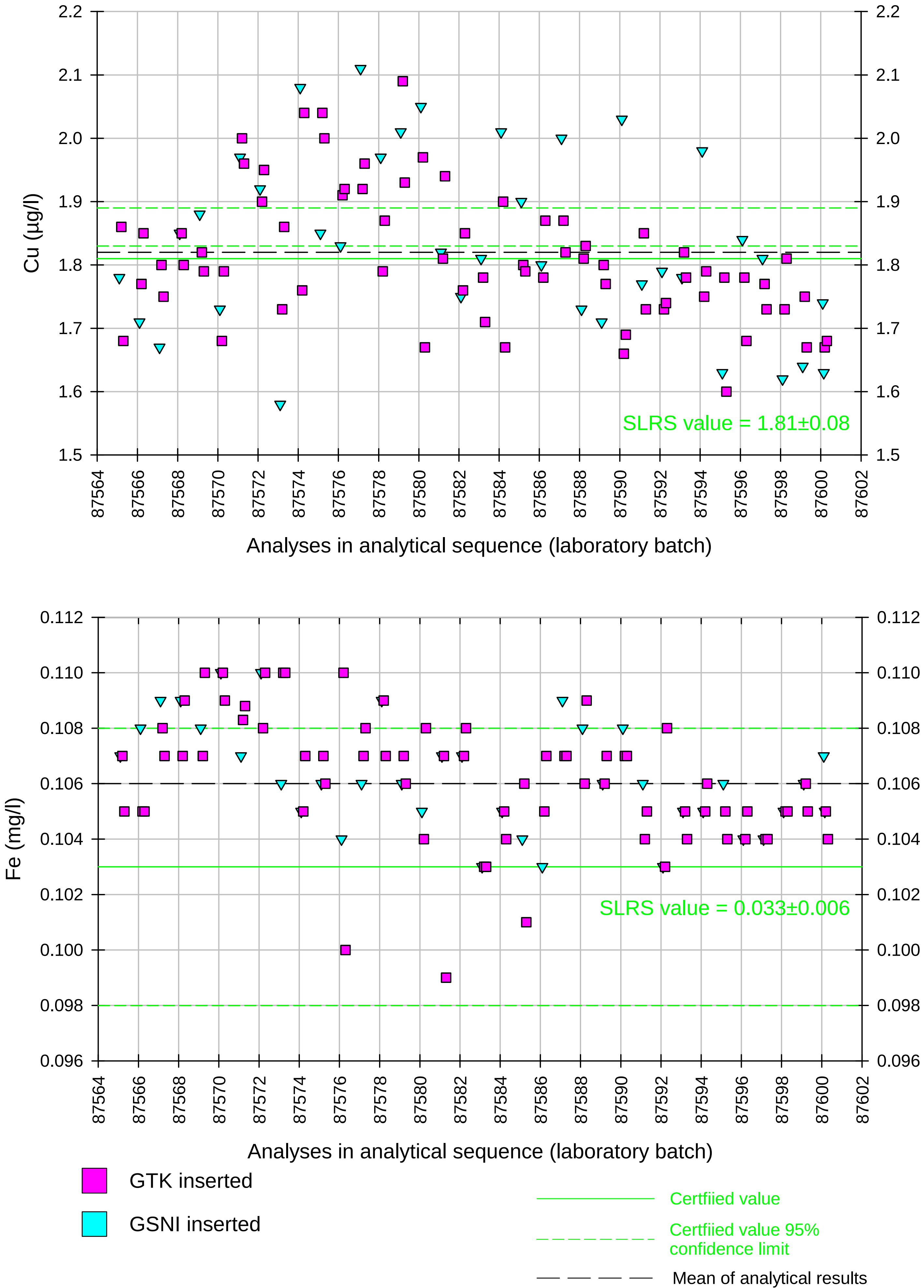




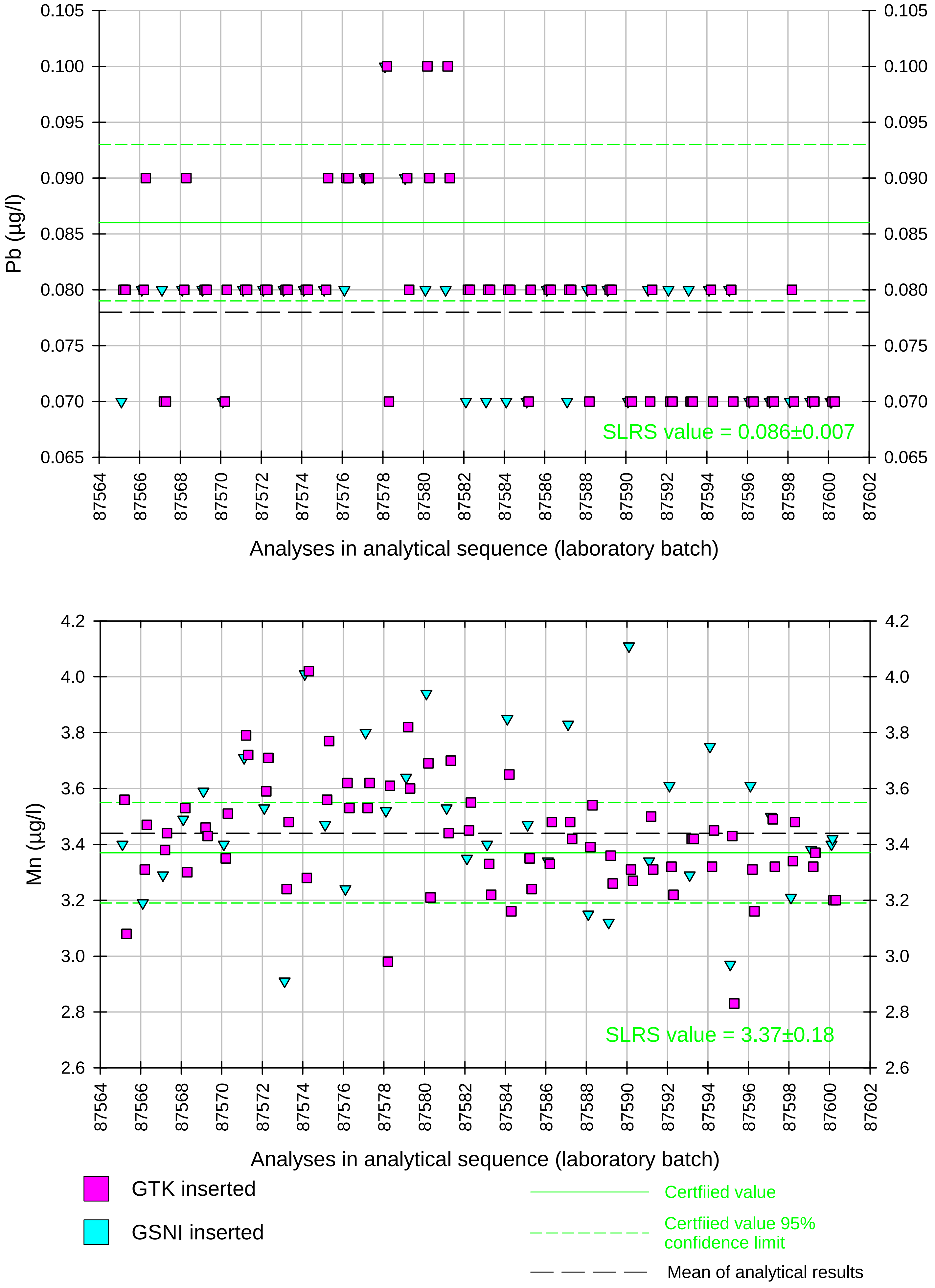
Comparison of GTK inserted SLRS-4 and GSNI inserted SLRS-4 CRM



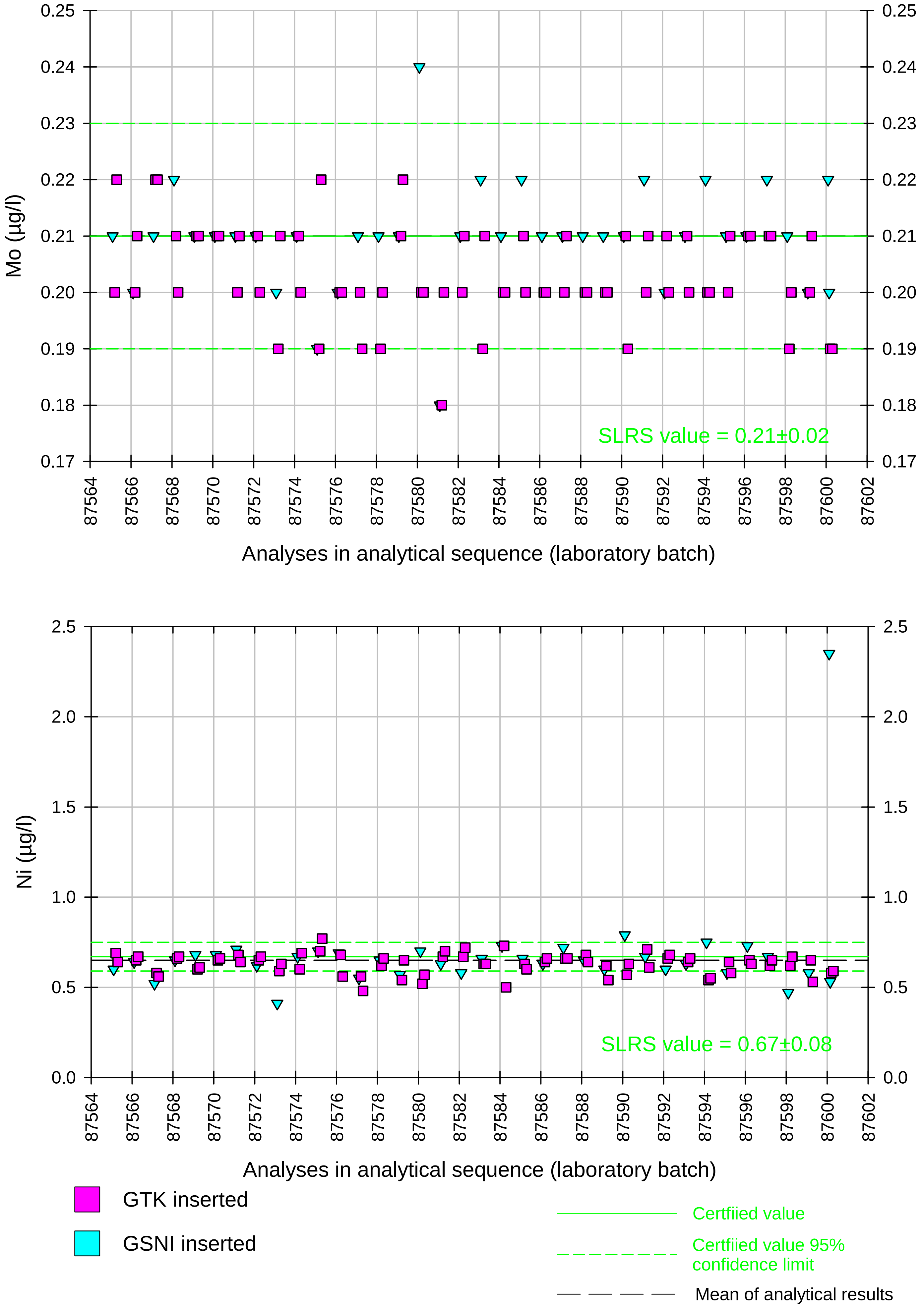
Comparison of GTK inserted SLRS-4 and GSNI inserted SLRS-4 CRM



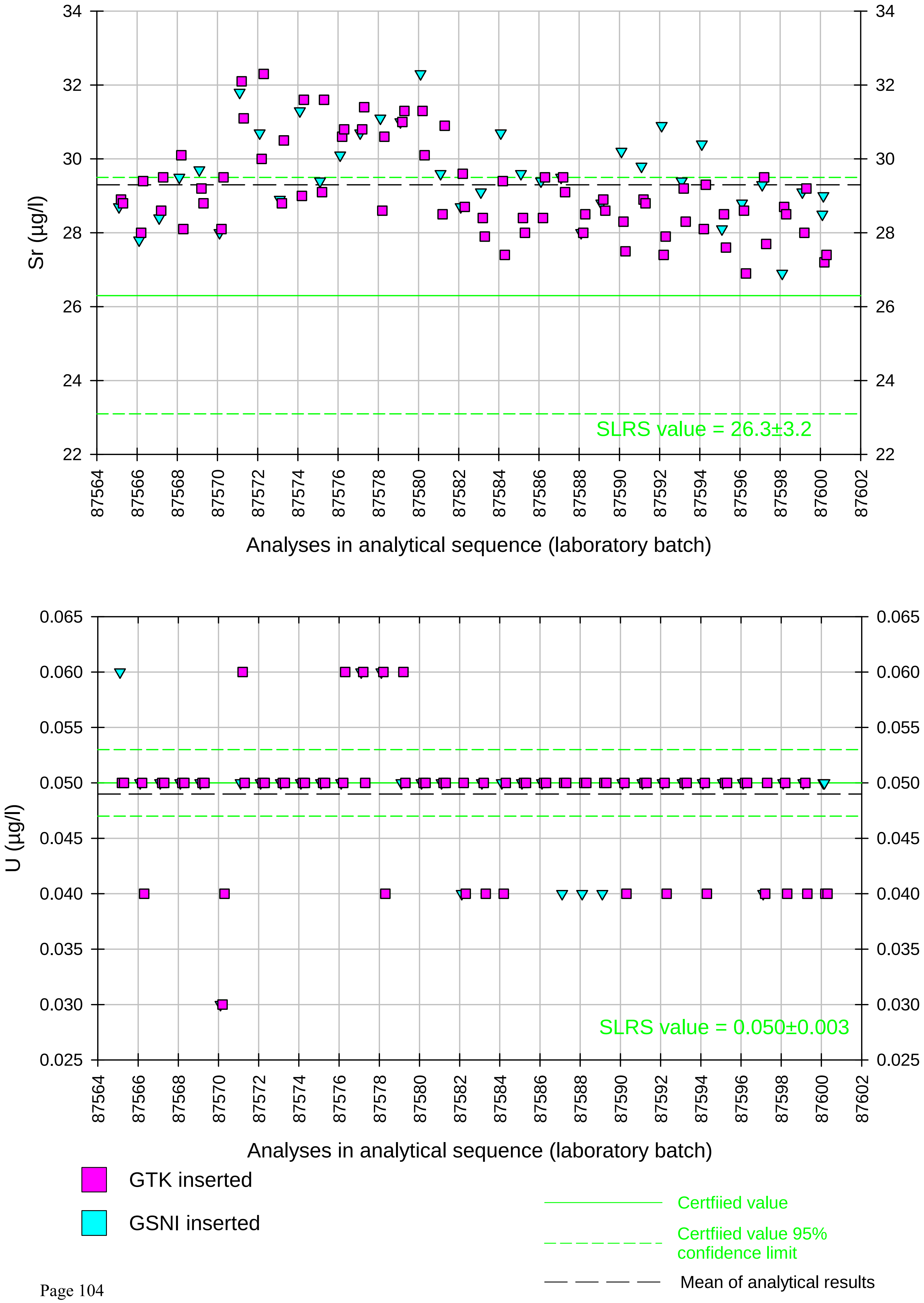
Comparison of GTK inserted SLRS-4 and GSNI inserted SLRS-4 CRM



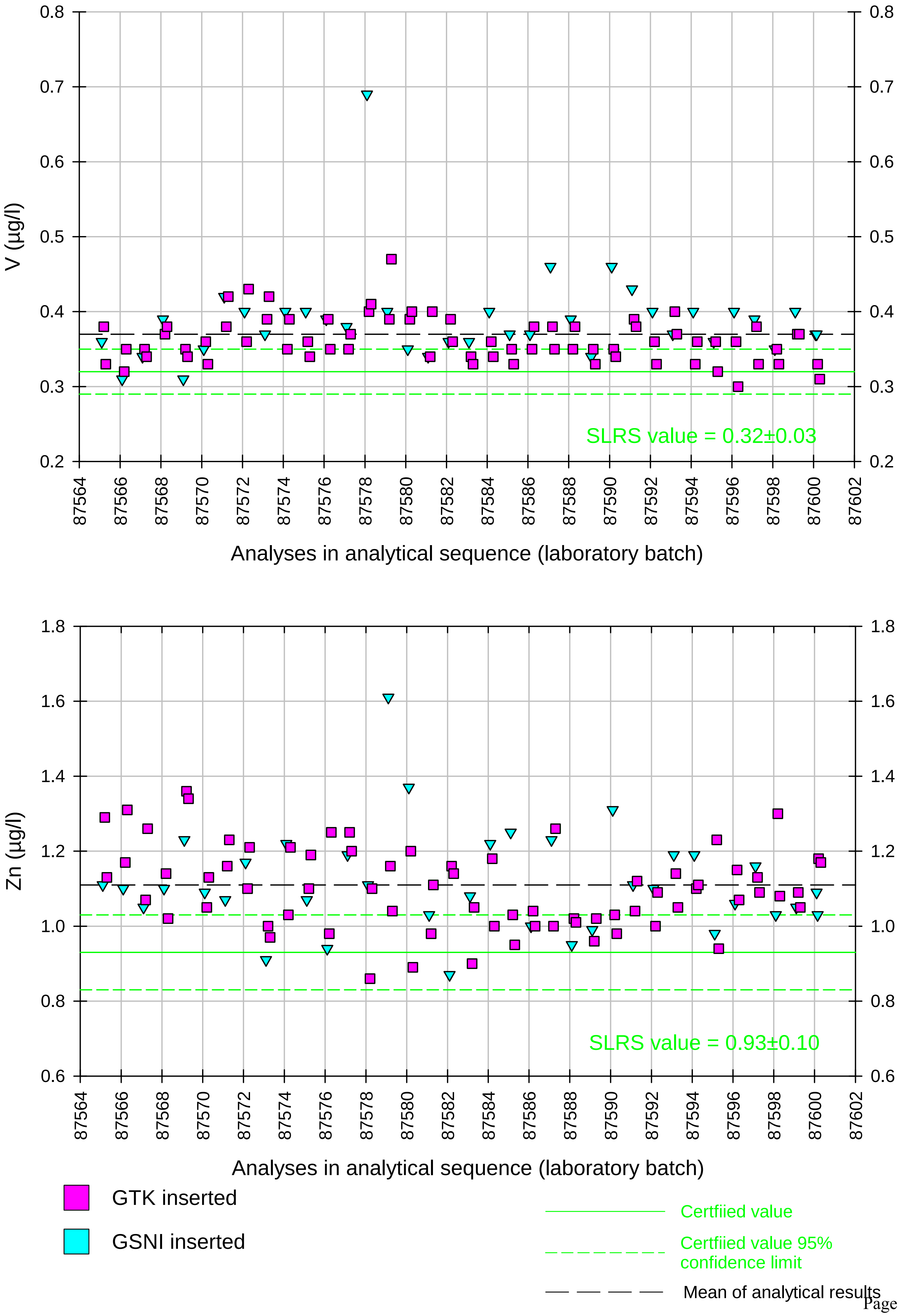
Comparison of GTK inserted SLRS-4 and GSNI inserted SLRS-4 CRM



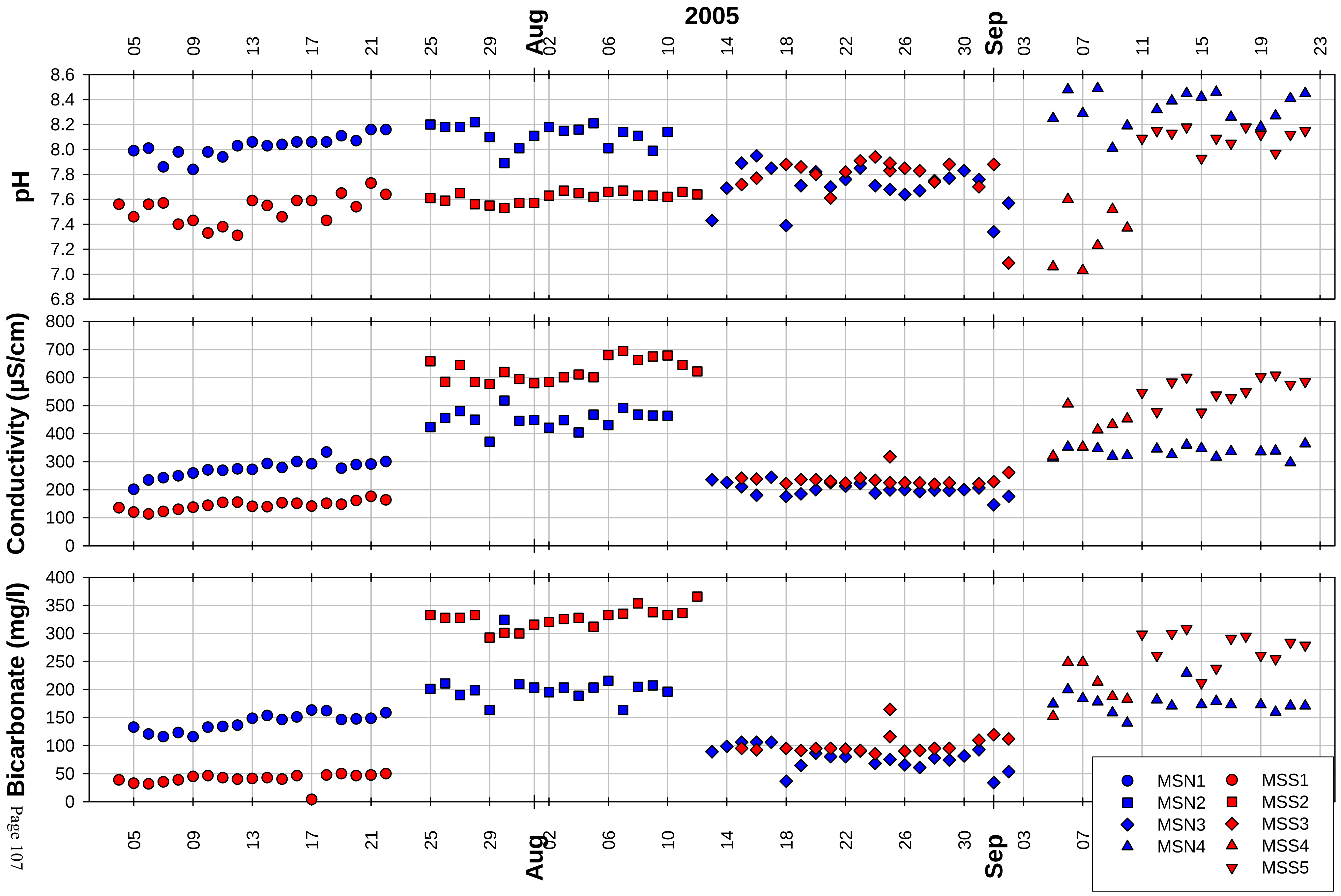
Comparison of GTK inserted SLRS-4 and GSNI inserted SLRS-4 CRM

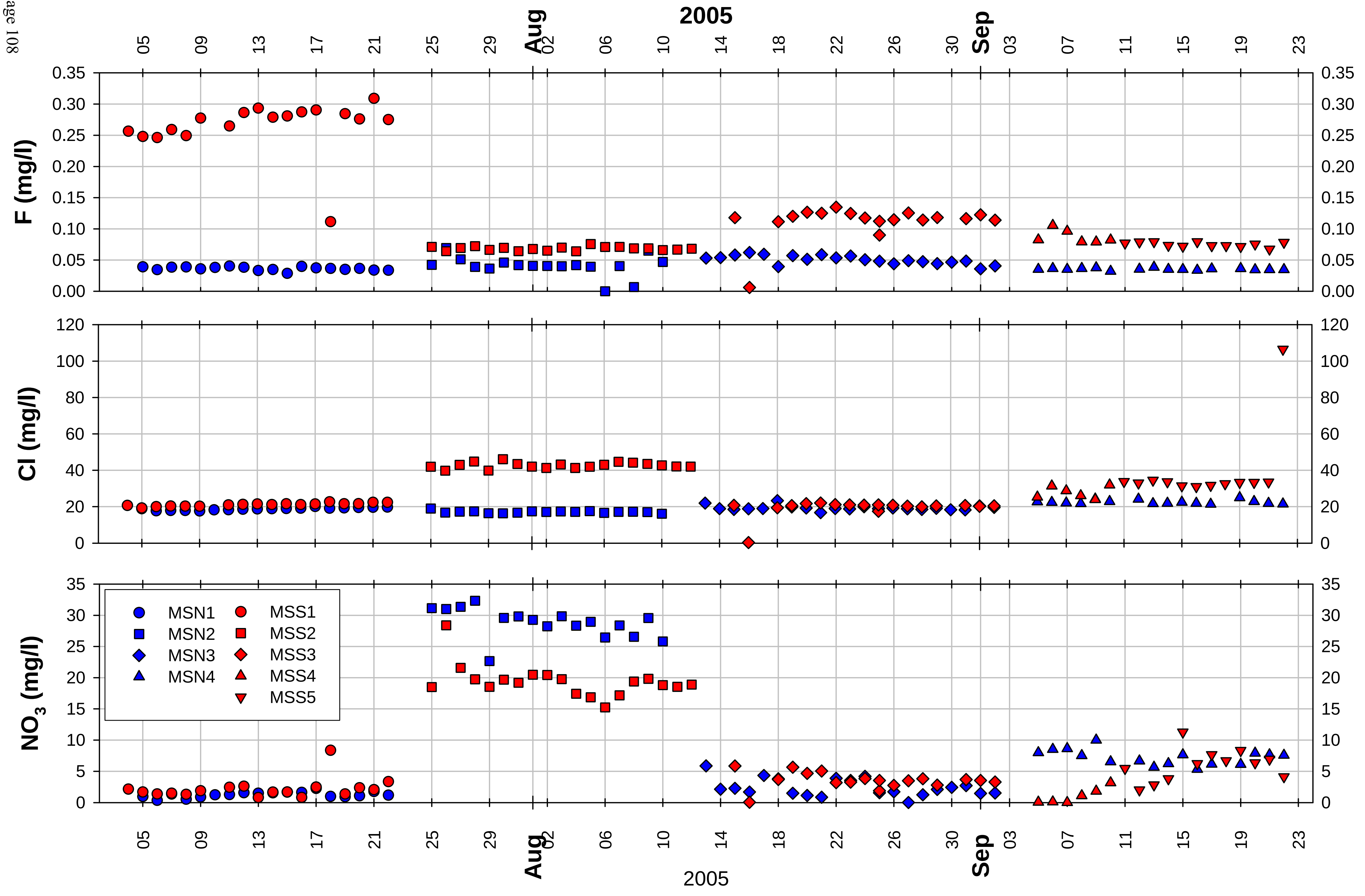


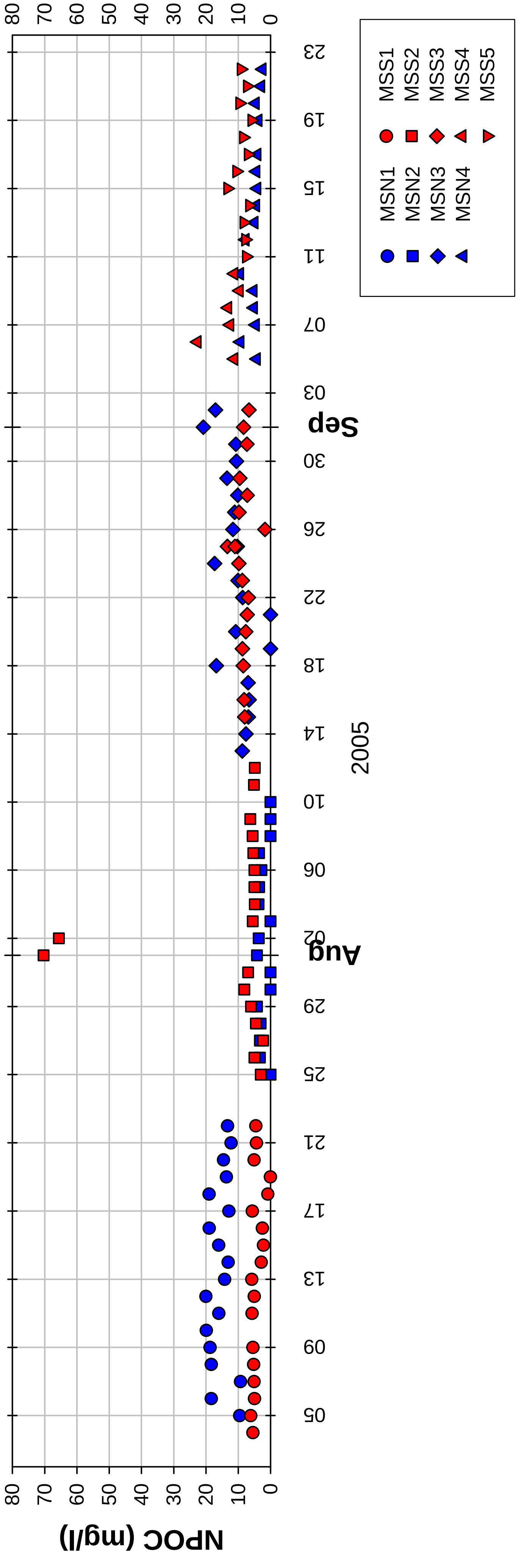
Comparison of GTK inserted SLRS-4 and GSNI inserted SLRS-4 CRM

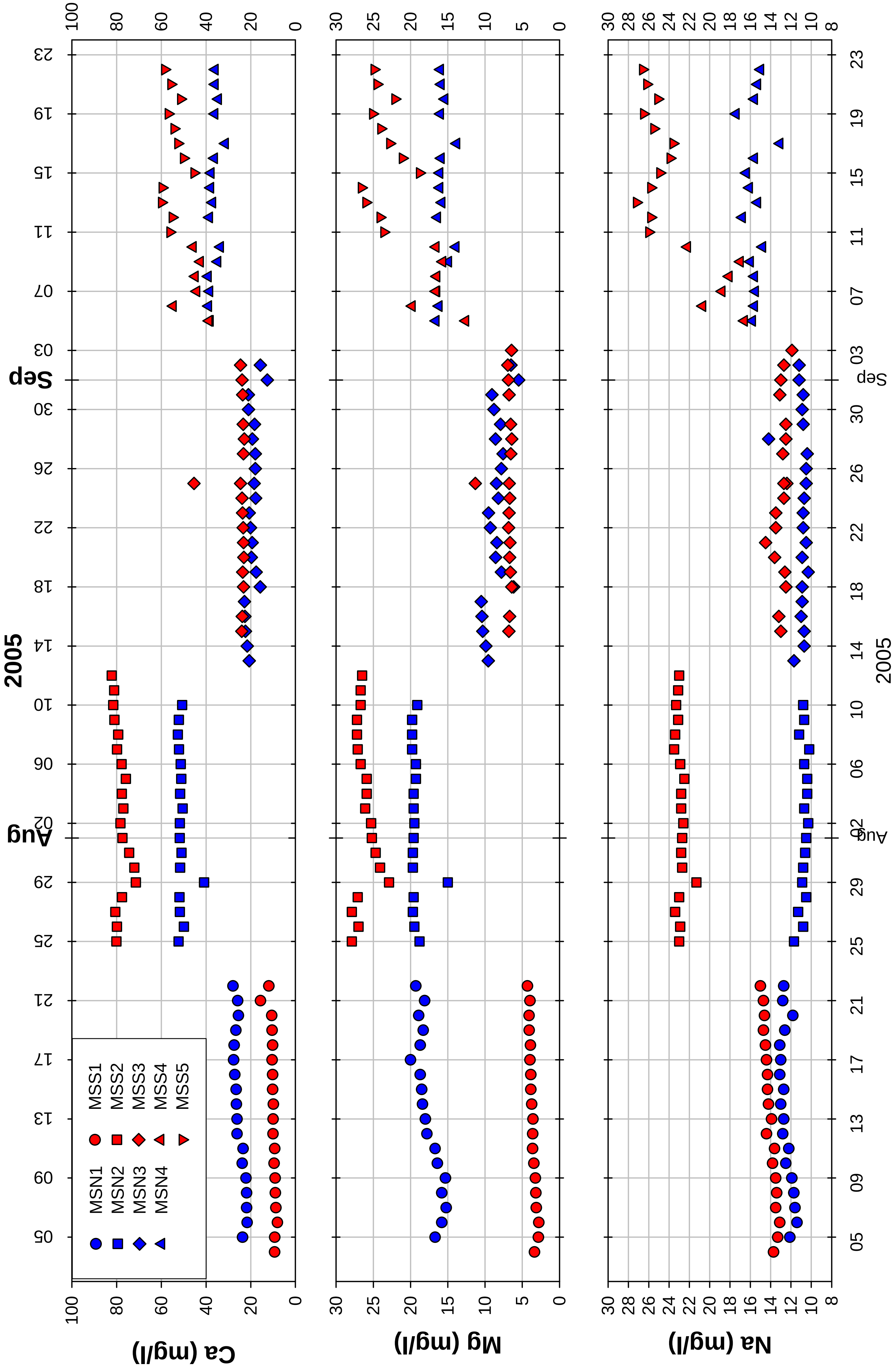


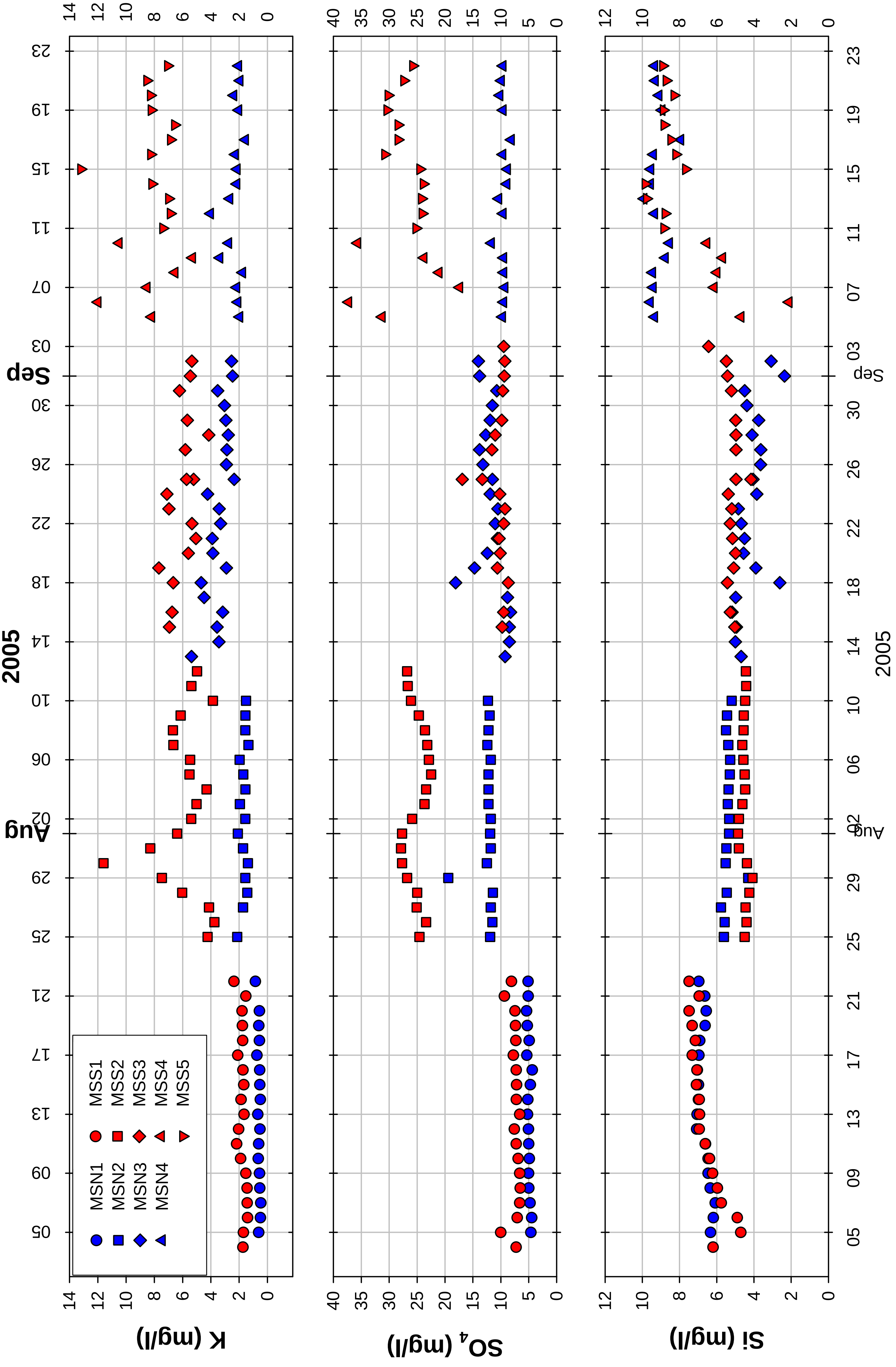
Appendix 5 – Monitor site data plots

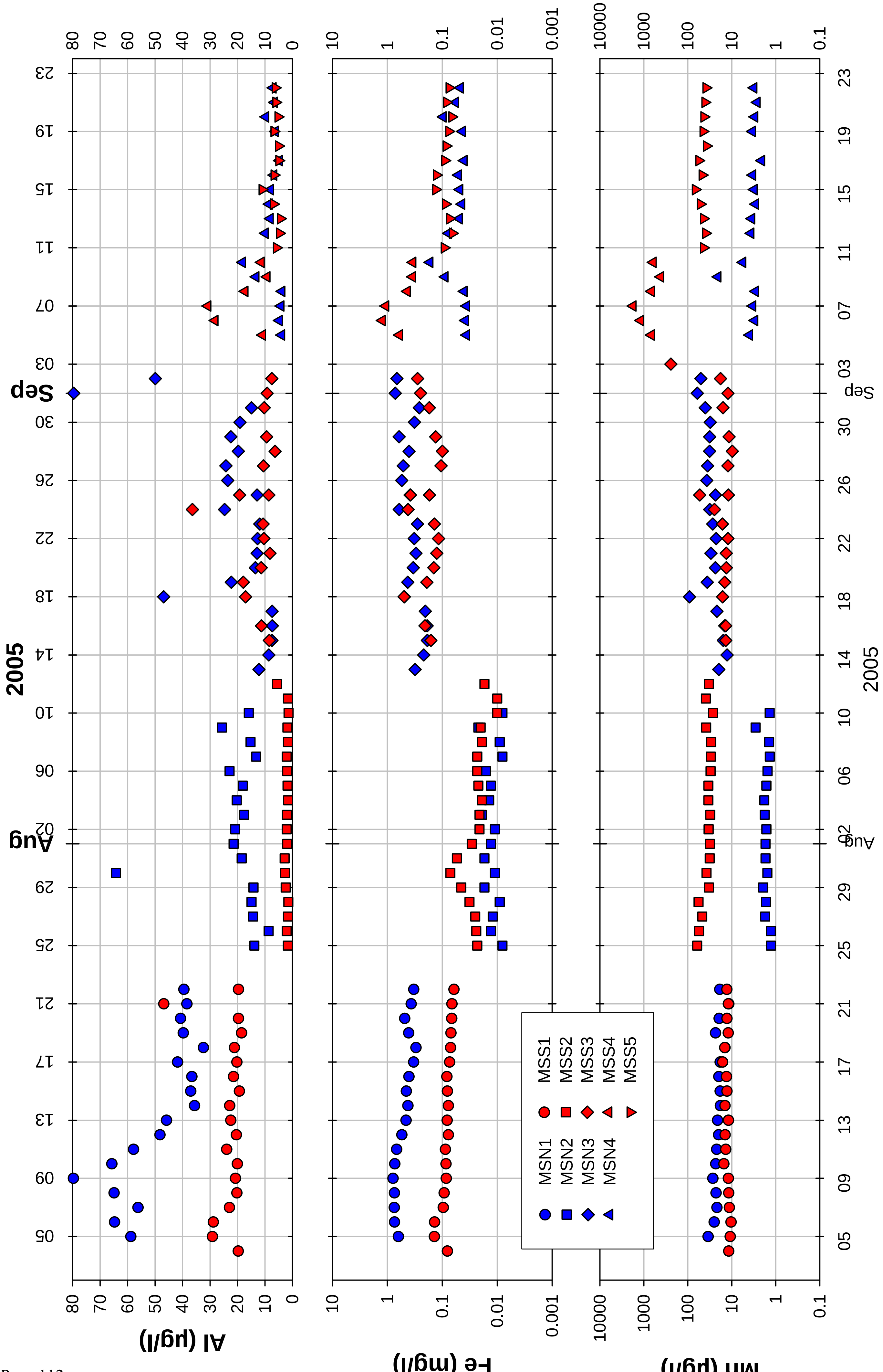

2005
Aug
Sep
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
pH
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
Conductivity (µS/cm)
800
700
600
500
400
300
200
100
0
Bicarbonate (mg/l)
400
350
300
250
200
150
100
50
0
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5

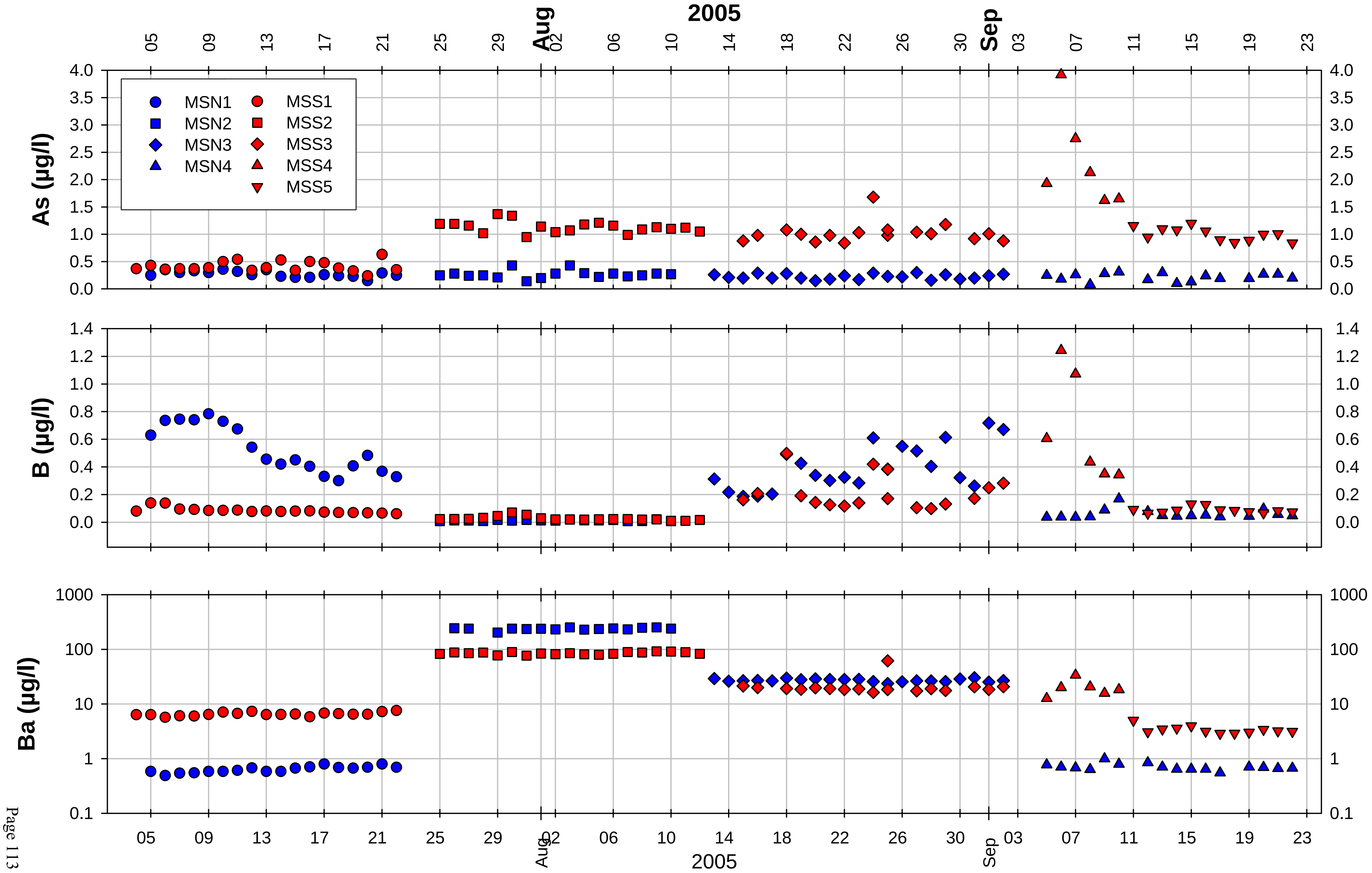

2005
Aug
Sep
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
F (mg/l)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Cl (mg/l)
0
20
40
60
80
100
120
NO_3 (mg/l)
0
5
10
15
20
25
30
35
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5

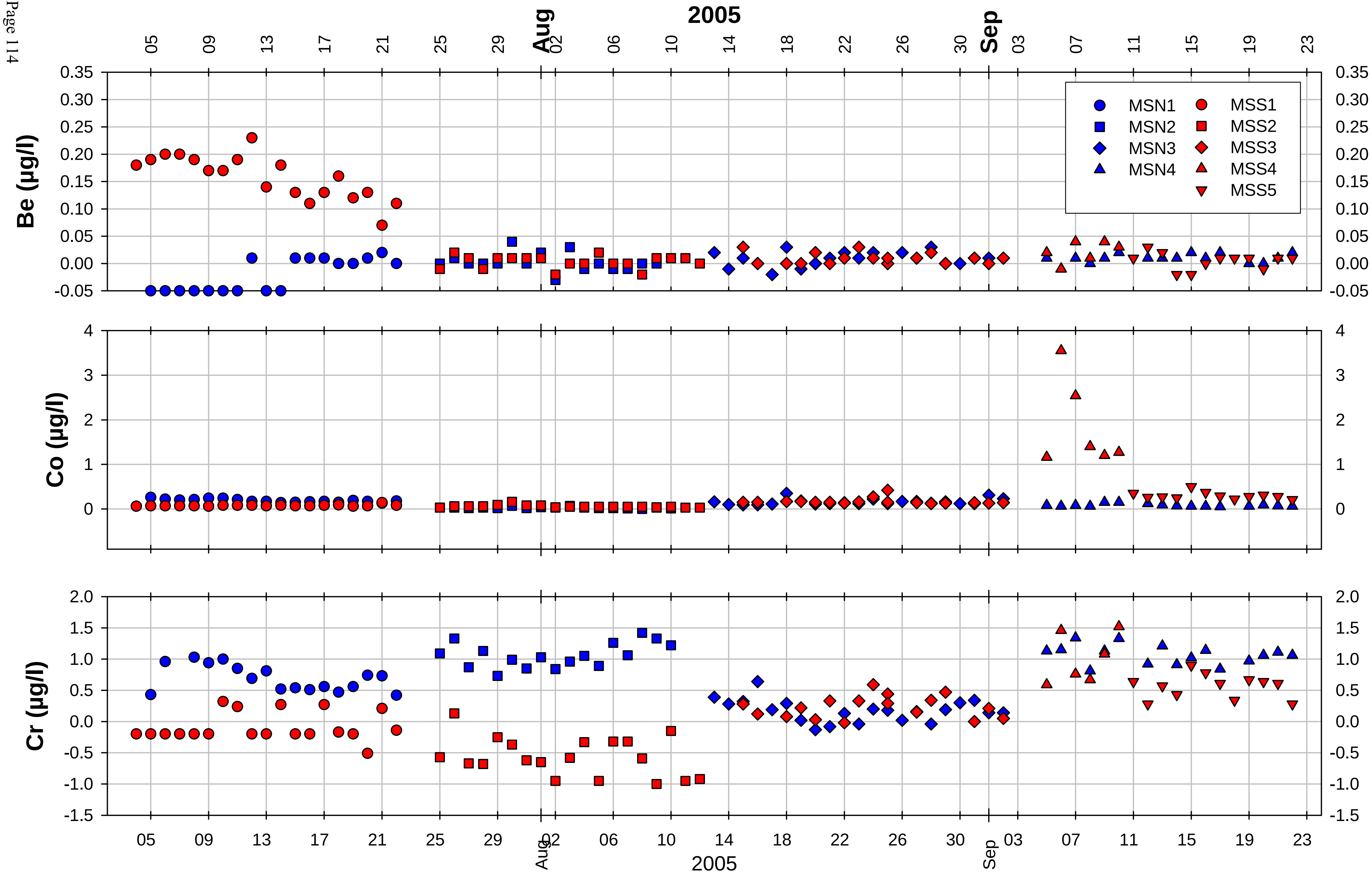

NPOC (mg/l)
0
10
20
30
40
50
60
70
80
05
09
13
17
21
25
29
Aug
02
06
10
14
18
22
26
30
Sep
03
07
11
15
19
23
2005
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5

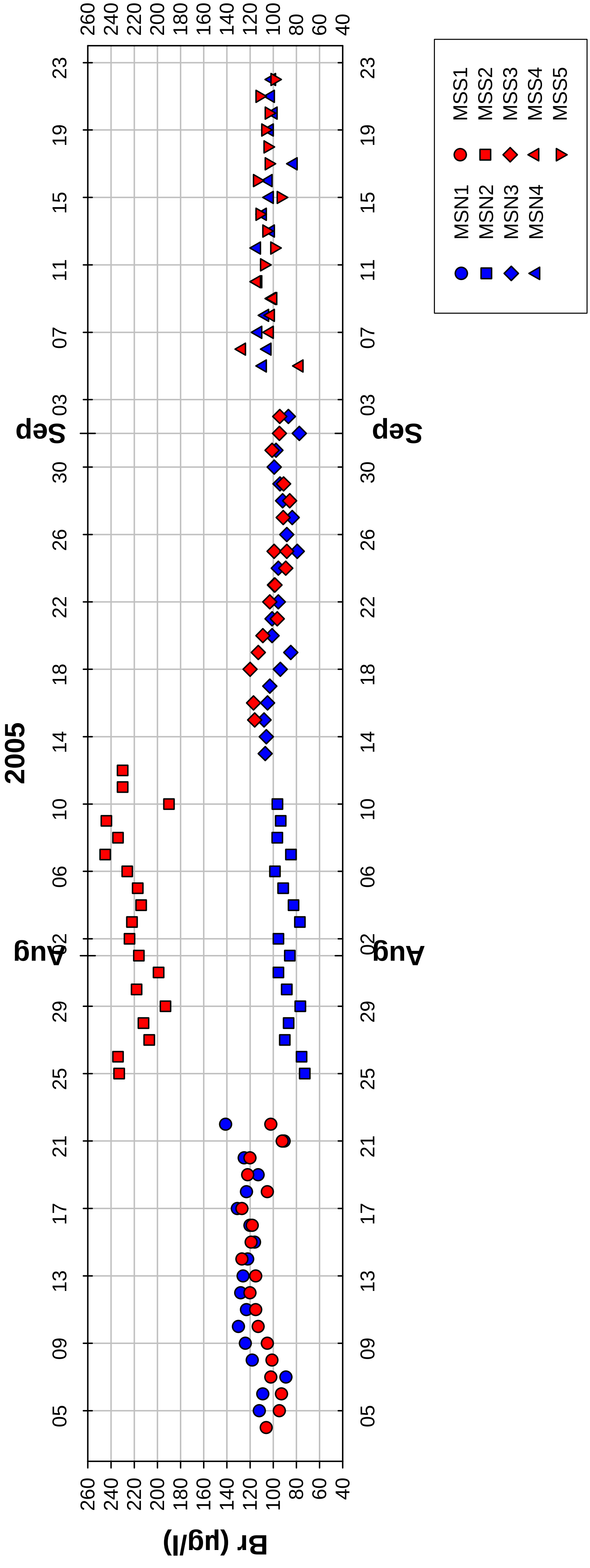

Ca (mg/l)
Mg (mg/l)
Na (mg/l)
2005
Aug
Sep
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
0
20
40
60
80
100
0
5
10
15
20
25
30
8
10
12
14
16
18
20
22
24
26
28
30
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5

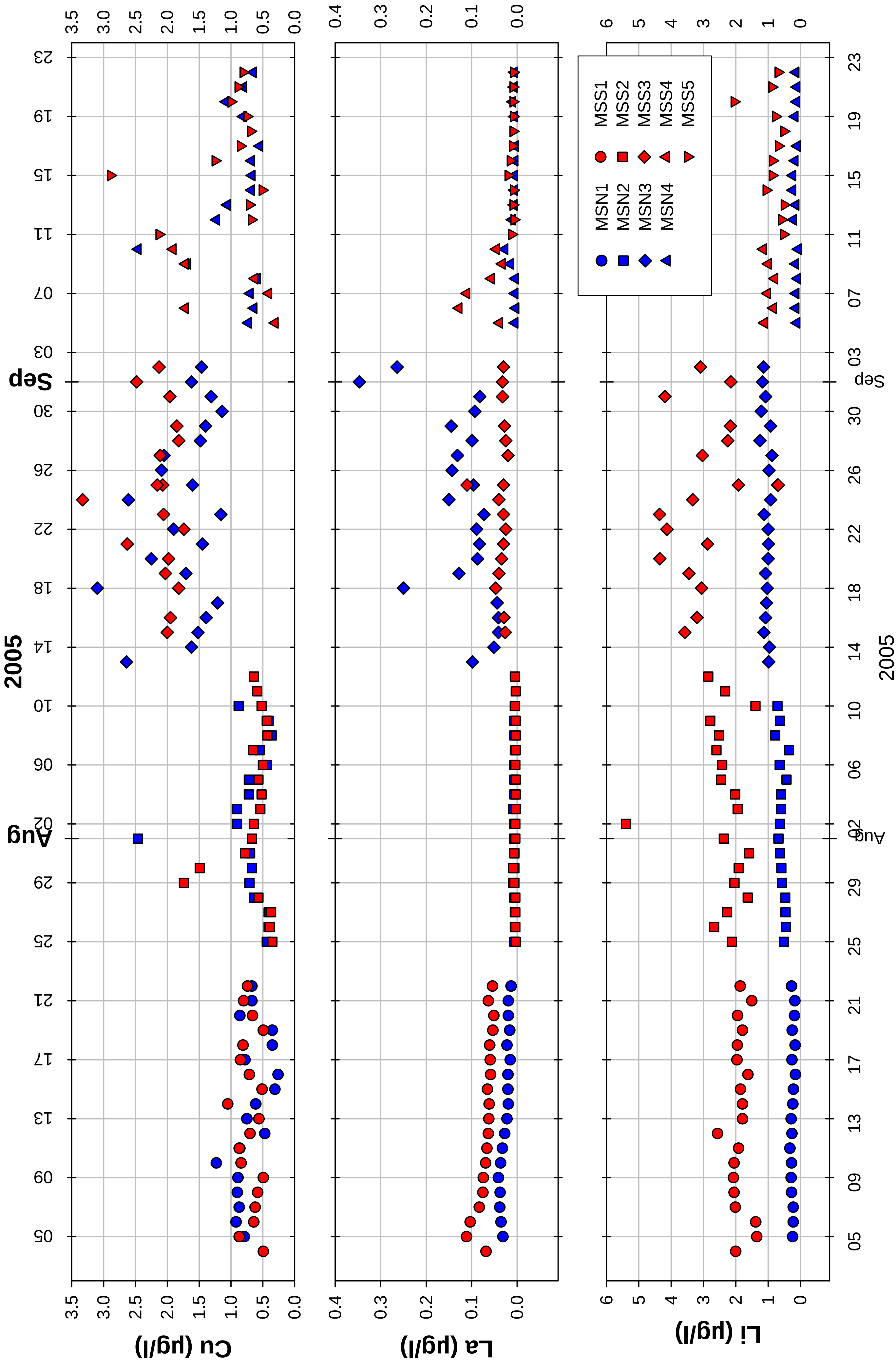

2005
Aug
Sep
K (mg/l)
SO_4 (mg/l)
Si (mg/l)
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40
0
2
4
6
8
10
12

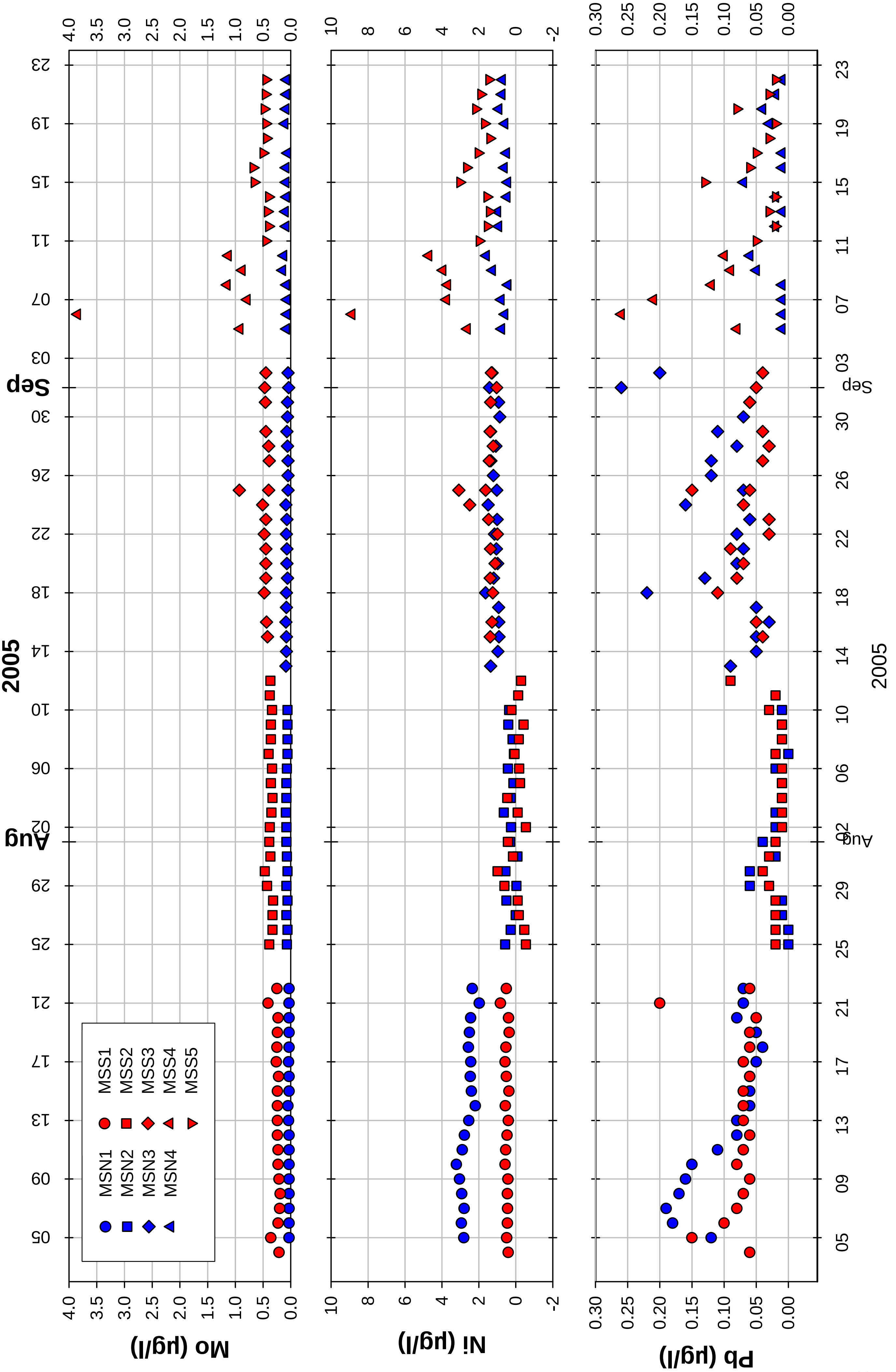

Al (µg/l)
Fe (mg/l)
Mn (µg/l)
2005
Aug
Sep
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
80
70
60
50
40
30
20
10
0
10
1
0.1
0.01
0.001
10000
1000
100
10
1
0.1
● MSN1
■ MSN2
◆ MSN3
▲ MSN4
● MSS1
■ MSS2
◆ MSS3
◀ MSS4
▶ MSS5

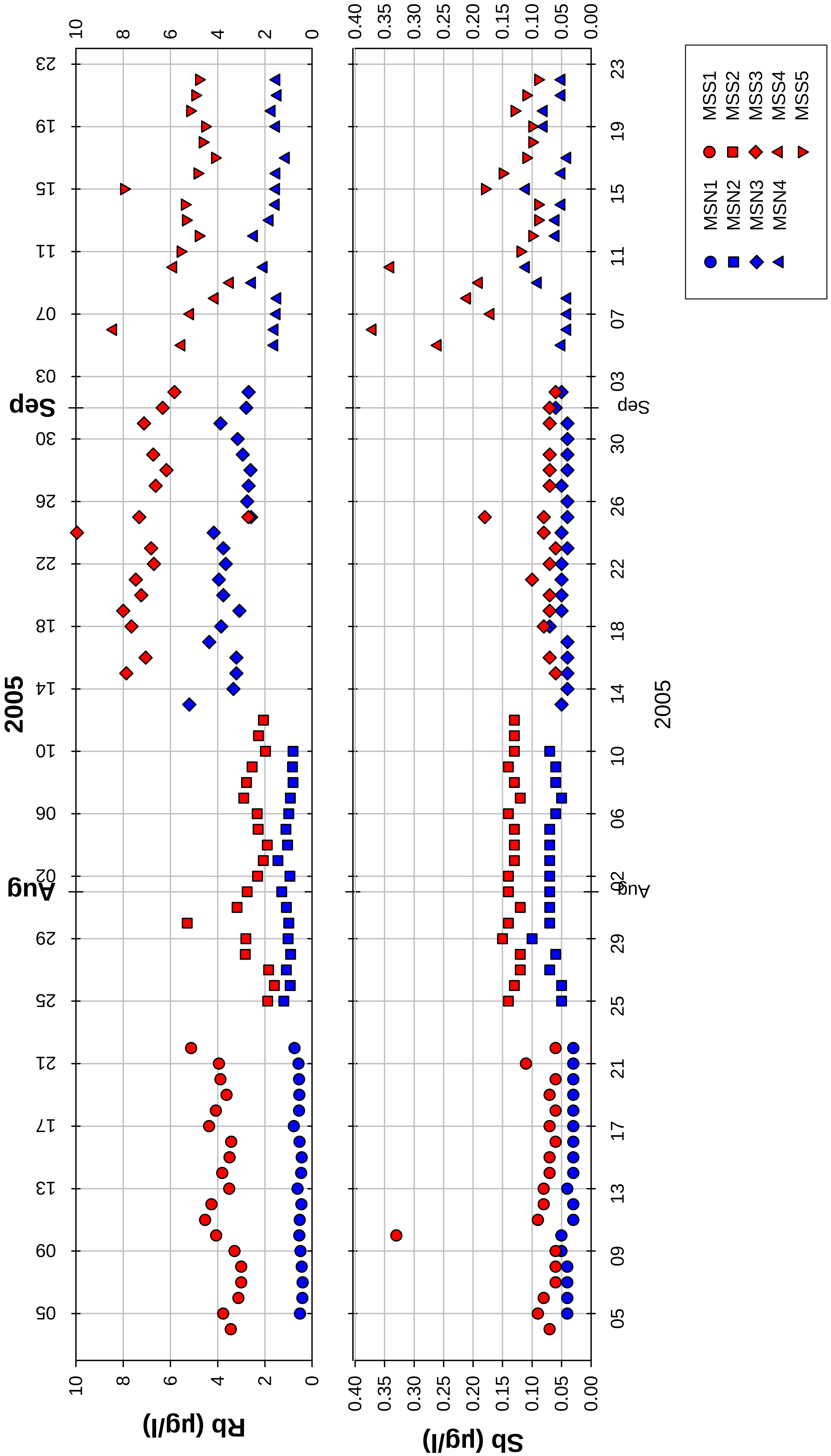

2005
Aug
Sep
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
As (µg/l)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5
B (µg/l)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Ba (µg/l)
0.1
1
10
100
1000
2005

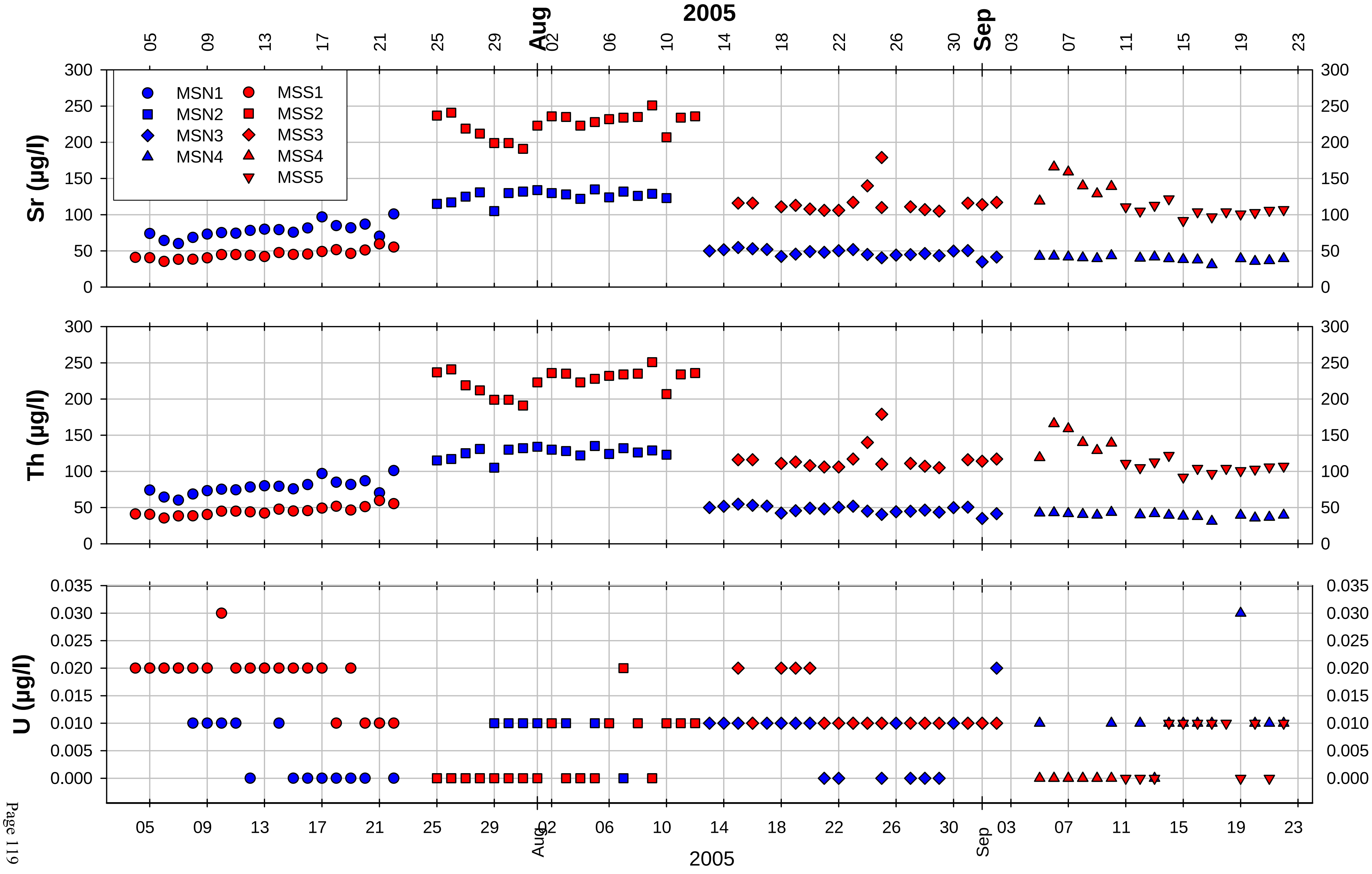

2005
Aug
Sep
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
Be (µg/l)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5
Co (µg/l)
4
3
2
1
0
Cr (µg/l)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5


Br (µg/l)
260
240
220
200
180
160
140
120
100
80
60
40
2005
Aug
Sep
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5


Cu (µg/l)
La (µg/l)
Li (µg/l)
2005
Aug
Sep
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0.0
0.1
0.2
0.3
0.4
0
1
2
3
4
5
6
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5


Mo (µg/l)
Ni (µg/l)
Pb (µg/l)
2005
Aug
Sep
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
-2
0
2
4
6
8
10
0.00
0.05
0.10
0.15
0.20
0.25
0.30


Rb (µg/l)
Sb (µg/l)
2005
Aug
Sep
05
09
13
17
21
25
29
02
06
10
14
18
22
26
30
03
07
11
15
19
23
0
2
4
6
8
10
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5


2005
Aug
Sep
Sr (µg/l)
Th (µg/l)
U (µg/l)
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5
0
50
100
150
200
250
300
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
05
09
13
17
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25
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02
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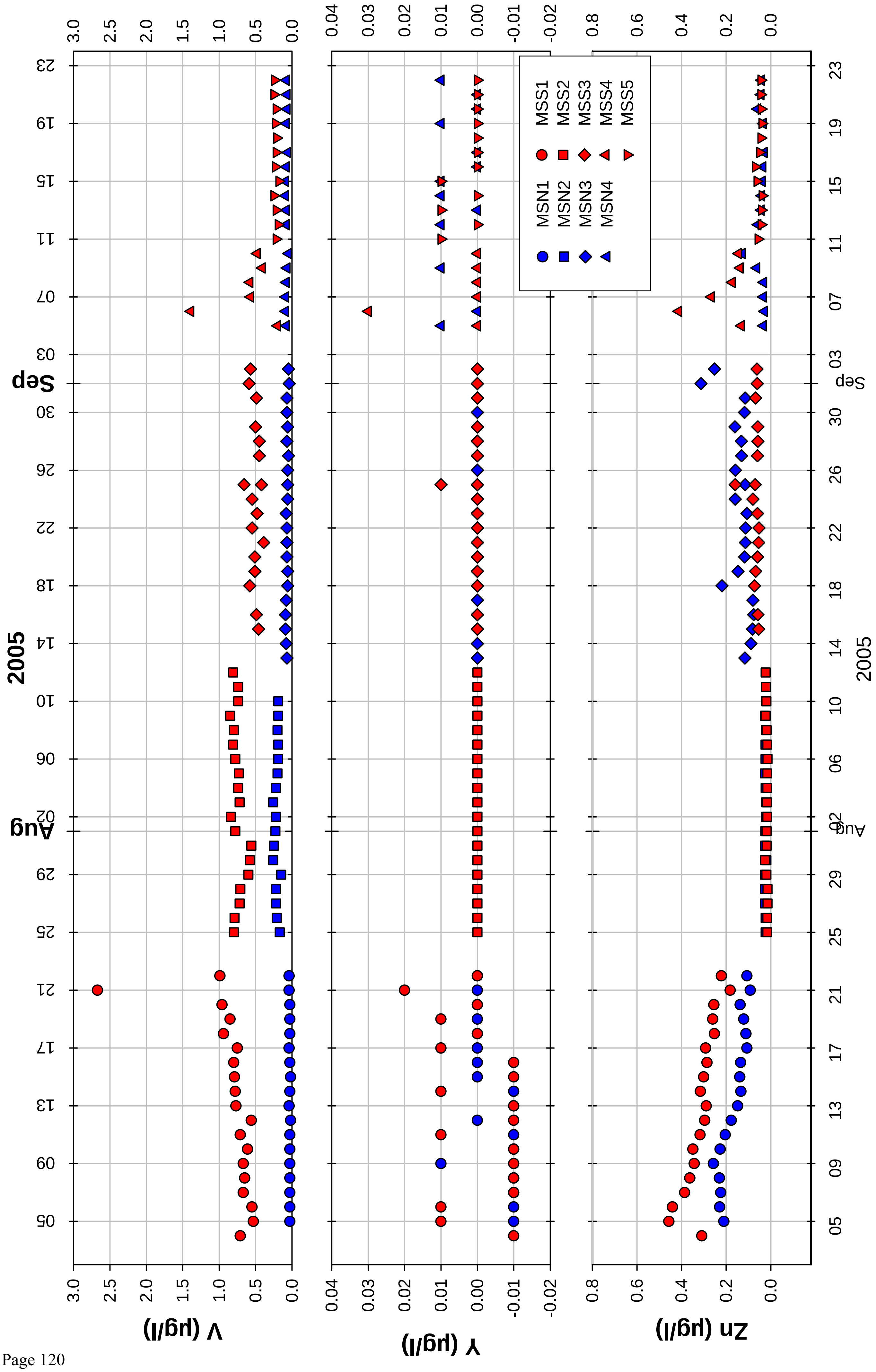
18
22
26
30
03
07
11
15
19
23


V (µg/l)
Y (µg/l)
Zn (µg/l)
2005
Aug
Sep
05
09
13
17
21
25
29
02
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10
14
18
22
26
30
03
07
11
15
19
23
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
0.8
0.6
0.4
0.2
0.0
MSN1
MSN2
MSN3
MSN4
MSS1
MSS2
MSS3
MSS4
MSS5

Appendix 6 – Charge balance errors in excess of ±10%

Appendix 6 – Charge balance errors in excess of ±10%

Sample	Chg Bal (%)	Error	ActionTaken	Sum Cat meq/l	Sum An meq/l	Ca meq/l	HCO3 meq/l	Mg meq/l	SO4 meq/l	Na meq/l	Cl meq/l	K meq/l	NO3 meq/l
563225	-53.4	Anions	Caution Cl NO3 for mapping	2.00	6.58	1.103	1.139	0.425	0.283	0.381	4.030	0.088	1.131
563223	-51.5	Anions	Caution NO3 for mapping	3.24	10.11	1.622	2.238	0.625	0.197	0.522	7.654	0.471	0.020
565339	-48.4	Bicarb	Caution HCO3 for mapping	0.73	2.10	0.248	1.798	0.225	0.063	0.254	0.236	0.004	0.002
566438	-48.0	Anions	Caution Cl and NO3 for mapping	2.90	8.25	1.457	2.218	0.930	0.287	0.424	5.257	0.087	0.487
566469	-45.2	Bicarb	Caution HCO3 for mapping	2.40	6.35	1.248	5.515	0.597	0.312	0.465	0.455	0.085	0.072
563395	-37.6	Bicarb	Caution HCO3 for mapping	5.12	11.27	2.071	9.672	1.802	0.433	1.066	0.947	0.179	0.222
563336	-34.0	Bicarb	Caution HCO3 for mapping	3.61	7.35	1.452	6.594	1.506	0.144	0.639	0.577	0.017	0.031
563686	-33.1	TDS	No action for low TDS	0.39	0.78	0.054	0.068	0.065	0.068	0.260	0.607	0.012	0.032
563140	-33.0	Bicarb	Caution HCO3 for mapping	1.61	3.20	0.524	2.578	0.503	0.063	0.479	0.556	0.107	0.003
564193	-32.8	Bicarb	Caution HCO3 for mapping	4.69	9.27	2.246	8.333	1.769	0.273	0.635	0.561	0.039	0.102
564548	-32.7	Bicarb	Caution HCO3 for mapping	4.18	8.23	1.841	7.514	1.753	0.165	0.513	0.472	0.070	0.081
564997	-32.5	Indeterminate	No action. Caution.	1.29	2.54	0.599	2.078	0.327	0.052	0.361	0.405	0.006	0.002
564910	-29.5	Bicarb	Caution HCO3 for mapping	0.77	1.41	0.241	1.019	0.193	0.049	0.325	0.347	0.012	0.000
563665	-28.8	TDS	No action for low TDS	0.34	0.62	0.031	0.038	0.045	0.064	0.261	0.442	0.006	0.078
564998	-27.6	Indeterminate	No action. Caution.	2.07	3.65	1.148	3.157	0.509	0.044	0.395	0.448	0.020	0.000
564229	-27.6	Bicarb	Caution HCO3 for mapping	6.37	11.21	4.027	10.191	1.514	0.239	0.770	0.754	0.057	0.028
563181	-26.3	Bicarb	Caution HCO3 for mapping	3.32	5.69	1.387	4.976	1.374	0.178	0.505	0.460	0.051	0.074
566150	-25.1	Bicarb	Caution HCO3 for mapping	2.94	4.92	1.287	4.476	1.226	0.133	0.411	0.290	0.019	0.017
564983	-24.9	Bicarb	Caution HCO3 for mapping	2.55	4.24	1.093	3.477	1.111	0.123	0.307	0.512	0.035	0.125
566641	-23.6	Bicarb	Caution HCO3 for mapping	4.56	7.37	1.717	5.955	1.094	0.118	1.061	1.300	0.688	0.000
565698	-23.2	Bicarb	Caution HCO3 for mapping	3.88	6.23	1.791	4.576	0.938	0.487	0.953	1.105	0.198	0.058
565204	-22.3	Bicarb	Caution HCO3 for mapping	3.55	5.59	1.951	4.296	0.718	0.452	0.705	0.657	0.178	0.180
566145	-22.0	Bicarb	Caution HCO3 for mapping	3.26	5.10	1.432	4.436	1.177	0.189	0.535	0.402	0.120	0.075
564752	-21.9	Bicarb	Caution HCO3 for mapping	4.45	6.95	1.976	6.115	1.786	0.229	0.631	0.549	0.060	0.058
563171	-21.6	Bicarb	Caution HCO3 for mapping	4.21	6.52	1.881	5.435	1.662	0.188	0.639	0.519	0.022	0.378
565292	-21.1	Bicarb	Caution HCO3 for mapping	3.51	5.39	1.672	3.877	0.750	0.456	0.792	0.728	0.297	0.334
563669	-21.1	TDS	No action for low TDS	0.37	0.56	0.040	0.076	0.048	0.067	0.268	0.399	0.009	0.018
564139	-21.0	Bicarb	Caution HCO3 for mapping	5.62	8.62	2.799	7.534	2.041	0.391	0.744	0.558	0.039	0.132
566010	-21.0	Indeterminate	No action. Caution.	1.74	2.66	0.958	1.179	0.372	0.177	0.345	1.293	0.064	0.013
565757	-20.8	Bicarb	Caution HCO3 for mapping	3.75	5.72	2.380	4.976	0.872	0.191	0.479	0.416	0.020	0.135
563004	-20.5	TDS	No action for low TDS	0.94	1.42	0.286	0.759	0.165	0.135	0.457	0.502	0.031	0.027

Sample	Chg Bal (%)	Error	ActionTaken	Sum Cat meq/l	Sum An meq/l	Ca meq/l	HCO3 meq/l	Mg meq/l	SO4 meq/l	Na meq/l	Cl meq/l	K meq/l	NO3 meq/l
566471	-20.4	Bicarb	Caution with HCO3	4.75	7.19	2.345	5.475	1.317	0.829	0.840	0.793	0.249	0.095
566474	-20.2	Bicarb	Caution with HCO3	3.92	5.91	1.751	4.656	1.119	0.337	0.753	0.831	0.297	0.085
563219	-19.9	TDS	No action for low TDS	0.36	0.54	0.065	0.300	0.070	0.044	0.215	0.189	0.010	0.007
564197	-19.8	Bicarb	Caution with HCO3	4.27	6.38	2.116	5.715	1.481	0.205	0.552	0.407	0.122	0.057
566126	-19.8	Bicarb	Caution with HCO3	3.53	5.27	1.527	4.736	1.514	0.101	0.461	0.432	0.027	0.000
565637	-19.7	Bicarb	Caution with HCO3	4.14	6.18	1.717	5.176	1.350	0.294	0.731	0.695	0.345	0.012
564315	-19.3	Bicarb	Caution with HCO3	3.86	5.71	1.971	4.816	1.366	0.418	0.509	0.472	0.019	0.004
563625	-19.0	Bicarb	Caution with HCO3	1.71	2.51	0.783	1.998	0.431	0.080	0.395	0.434	0.101	0.000
563908	-17.9	Indeterminate	No action. Caution.	4.71	6.76	2.021	5.375	1.909	0.314	0.744	0.762	0.033	0.304
565837	-17.6	Bicarb	Caution with HCO3	5.73	8.18	3.159	6.714	1.448	0.454	0.866	0.888	0.256	0.118
564329	-17.6	Indeterminate	No action. Caution.	4.20	5.99	1.687	4.356	1.391	0.431	1.079	1.140	0.046	0.066
564098	-17.1	Bicarb	Caution with HCO3	3.45	4.87	1.841	3.757	0.864	0.427	0.587	0.631	0.152	0.052
566466	-16.7	Bicarb	Caution with HCO3	5.68	7.96	2.854	6.055	1.572	0.785	0.948	0.996	0.302	0.123
566420	-16.2	Bicarb	Caution with HCO3	5.20	7.22	2.844	6.175	1.391	0.256	0.692	0.663	0.276	0.125
564144	-16.2	Bicarb	Caution with HCO3	5.49	7.61	2.610	6.355	1.983	0.308	0.835	0.875	0.061	0.072
564334	-16.2	Bicarb	Caution with HCO3	4.70	6.51	2.575	5.315	1.621	0.260	0.470	0.462	0.035	0.477
566382	-16.1	Bicarb	Caution with HCO3	6.13	8.48	3.179	6.594	1.605	0.132	1.114	1.336	0.230	0.423
565399	-16.1	Indeterminate	No action. Caution.	1.48	2.05	0.519	1.818	0.692	0.027	0.269	0.206	0.003	0.000
563007	-16.0	TDS	No action for low TDS	0.53	0.74	0.105	0.260	0.109	0.104	0.315	0.369	0.004	0.003
564019	-16.0	Bicarb	Caution with HCO3	5.22	7.21	2.535	4.296	1.506	0.916	0.961	1.655	0.218	0.343
564192	-15.7	Bicarb	Caution with HCO3	5.47	7.50	2.475	6.395	2.107	0.358	0.809	0.690	0.075	0.058
566009	-15.4	Indeterminate	No action. Caution.	2.23	3.04	1.023	1.539	0.623	0.207	0.439	1.206	0.141	0.084
564198	-15.3	Bicarb	Caution with HCO3	5.42	7.38	2.710	6.075	1.975	0.654	0.666	0.585	0.065	0.064
564299	-15.2	Anions	Caution with HCO3	11.46	15.58	0.868	9.352	0.540	5.288	9.875	0.938	0.182	0.000
565897	-15.1	Bicarb	Caution with HCO3	4.98	6.75	2.804	5.435	1.103	0.421	0.961	0.803	0.112	0.092
566357	-14.4	Bicarb	Caution with HCO3	6.33	8.46	2.819	7.254	2.189	0.333	1.161	0.878	0.163	0.000
565950	-14.4	Indeterminate	No action. Caution.	2.36	3.15	1.103	2.638	0.913	0.092	0.323	0.374	0.017	0.045
565650	-14.3	Anions	Caution with HCO3	0.95	1.27	0.328	0.859	0.263	0.100	0.338	0.313	0.026	0.000
566391	-14.0	Bicarb	Caution with HCO3	6.54	8.67	3.244	7.154	1.753	0.458	1.418	1.060	0.127	0.000
565867	-13.8	Indeterminate	No action. Caution.	4.63	6.11	2.380	5.315	1.457	0.143	0.683	0.650	0.111	0.001
566421	-13.2	Anions	Caution with HCO3	6.19	8.07	3.149	6.215	2.082	0.556	0.827	1.182	0.137	0.120
566619	-13.0	Anions	Caution with HCO3	6.31	8.19	2.919	4.576	2.049	0.537	1.157	3.006	0.181	0.067
564280	-12.3	Anions	Caution with HCO3	9.11	11.66	5.040	7.953	2.576	0.777	1.370	1.642	0.124	1.286

Sample	Chg Bal (%)	Error	ActionTaken	Sum Cat meq/l	Sum An meq/l	Ca meq/l	HCO3 meq/l	Mg meq/l	SO4 meq/l	Na meq/l	Cl meq/l	K meq/l	NO3 meq/l
566074	-11.9	Indeterminate	No action. Caution.	7.76	9.85	3.882	8.713	2.872	0.385	0.927	0.727	0.076	0.027
563080	-11.8	Anions	Caution with HCO3	4.20	5.33	1.642	3.297	0.704	0.279	1.262	1.067	0.593	0.682
563214	-11.7	TDS	No action for low TDS	0.61	0.77	0.220	0.440	0.128	0.098	0.246	0.209	0.018	0.028
563637	-11.2	Indeterminate	No action. Caution.	4.82	6.03	2.016	4.196	1.094	0.119	0.944	0.995	0.765	0.719
566054	-11.2	Indeterminate	No action. Caution.	5.89	7.37	2.924	5.156	1.358	0.768	1.314	1.078	0.297	0.370
564050	-10.6	Indeterminate	No action. Caution.	6.69	8.27	2.939	4.696	1.539	1.006	1.457	1.729	0.752	0.842
564042	-10.5	Indeterminate	No action. Caution.	4.70	5.80	2.525	3.577	1.308	0.369	0.787	1.038	0.075	0.819
564690	-10.5	Indeterminate	No action. Caution.	3.66	4.52	1.252	3.277	1.094	0.356	0.831	0.885	0.483	0.003
564201	-10.4	Indeterminate	No action. Caution.	6.87	8.46	2.640	5.895	1.580	0.400	2.279	1.652	0.371	0.513
566350	-10.2	Bicarb	Caution with HCO3	9.72	11.93	4.980	7.294	2.732	3.352	1.849	1.256	0.163	0.030
565601	-10.1	Indeterminate	No action. Caution.	3.93	4.81	1.771	3.237	0.987	0.489	0.944	1.000	0.223	0.085
564706	-10.0	TDS	No action for low TDS	5.57	6.82	2.570	5.675	1.736	0.329	1.118	0.743	0.148	0.069
564783	10.0	Sulphate	Caution with SO4	4.95	4.05	2.121	3.157	1.991	0.264	0.761	0.546	0.078	0.080
566110	10.0	Sulphate	Caution with SO4	1.89	1.54	0.709	1.259	0.864	0.040	0.307	0.243	0.008	0.000
564796	10.2	Sulphate	Caution with SO4	4.96	4.04	2.310	2.598	1.292	0.483	1.048	0.890	0.310	0.072
565398	10.2	TDS	No action for low TDS	0.58	0.47	0.101	0.120	0.198	0.060	0.280	0.293	0.002	0.000
565173	10.4	TDS	No action for low TDS	0.46	0.37	0.071	0.000	0.086	0.063	0.298	0.307	0.002	0.000
564786	10.5	Sulphate	Caution with SO4	4.90	3.97	1.941	2.698	1.654	0.518	1.188	0.649	0.117	0.105
565329	10.5	Sulphate	Caution with SO4	1.57	1.27	0.609	0.999	0.604	0.051	0.346	0.219	0.008	0.000
564096	10.5	Sulphate	Caution with SO4	5.02	4.07	2.605	2.618	1.481	0.616	0.809	0.780	0.126	0.054
564959	10.6	TDS	No action for low TDS	0.91	0.73	0.304	0.280	0.214	0.053	0.375	0.398	0.015	0.003
565538	10.6	Sulphate	Caution with SO4	1.25	1.01	0.467	0.679	0.448	0.054	0.326	0.265	0.006	0.010
565589	10.7	Sulphate	No action for low TDS	1.10	0.89	0.397	0.540	0.415	0.087	0.284	0.262	0.003	0.000
565102	10.7	Sulphate	Caution with SO4	1.48	1.19	0.534	0.939	0.657	0.043	0.286	0.211	0.003	0.000
565573	10.8	Sulphate	No action for low TDS	1.15	0.93	0.422	0.619	0.430	0.051	0.297	0.257	0.005	0.003
564946	10.8	TDS	No action for low TDS	0.65	0.52	0.181	0.160	0.156	0.041	0.304	0.321	0.007	0.000
565385	10.8	TDS	No action for low TDS	0.72	0.58	0.166	0.260	0.286	0.047	0.262	0.269	0.002	0.001
564961	10.8	TDS	No action for low TDS	0.89	0.71	0.275	0.180	0.179	0.045	0.422	0.483	0.010	0.004
564937	10.9	Sulphate		4.34	3.49	1.981	2.918	1.786	0.084	0.505	0.458	0.070	0.031
564985	11.0	TDS	No action for low TDS	0.68	0.55	0.186	0.140	0.165	0.042	0.325	0.366	0.006	0.000
565929	11.2	Sulphate		1.35	1.08	0.519	0.759	0.541	0.055	0.274	0.260	0.012	0.001
566463	11.2	Sulphate		6.21	4.96	2.949	4.556	2.140	0.400	1.044	0.000	0.078	0.000

Sample	Chg Bal (%)	Error	ActionTaken	Sum Cat meq/l	Sum An meq/l	Ca meq/l	HCO3 meq/l	Mg meq/l	SO4 meq/l	Na meq/l	Cl meq/l	K meq/l	NO3 meq/l
565140	11.2	Sulphate	No action for low TDS	1.11	0.88	0.472	0.599	0.305	0.032	0.328	0.252	0.003	0.000
565113	11.3	Sulphate		1.33	1.06	0.447	0.619	0.523	0.063	0.360	0.381	0.005	0.000
565121	11.3	TDS	No action for low TDS	0.44	0.35	0.066	0.000	0.086	0.053	0.283	0.298	0.006	0.000
565368	11.4	Sulphate		1.45	1.15	0.574	0.759	0.488	0.092	0.383	0.298	0.002	0.000
565384	11.6	Sulphate		1.26	1.00	0.408	0.679	0.513	0.045	0.337	0.278	0.007	0.000
564969	11.7	Sulphate		1.36	1.08	0.629	0.779	0.411	0.049	0.318	0.246	0.005	0.002
565124	11.8	Sulphate		1.46	1.15	0.524	0.859	0.560	0.074	0.362	0.216	0.010	0.000
565358	11.9	Sulphate		1.67	1.31	0.604	0.979	0.732	0.069	0.325	0.265	0.005	0.000
565507	11.9	Sulphate	No action for low TDS	1.13	0.89	0.397	0.440	0.383	0.121	0.343	0.326	0.004	0.000
565144	12.0	TDS	No action for low TDS	0.66	0.52	0.164	0.080	0.160	0.053	0.325	0.344	0.007	0.038
564971	12.1	TDS	No action for low TDS	0.47	0.37	0.061	0.000	0.101	0.058	0.308	0.312	0.001	0.000
565141	12.1	TDS	No action for low TDS	0.41	0.32	0.062	0.000	0.080	0.045	0.268	0.279	0.004	0.000
564788	12.1	Sulphate		4.69	3.68	2.690	2.698	1.448	0.327	0.430	0.515	0.126	0.141
563513	12.2	Sulphate		9.85	7.71	4.192	5.216	3.234	0.521	1.436	1.972	0.987	0.000
565362	12.2	Sulphate		1.59	1.24	0.554	0.899	0.651	0.044	0.382	0.300	0.002	0.000
564926	12.2	TDS	No action for low TDS	0.93	0.72	0.339	0.320	0.243	0.045	0.333	0.360	0.012	0.000
565369	12.3	TDS	No action for low TDS	0.75	0.59	0.220	0.300	0.300	0.061	0.229	0.225	0.001	0.000
565179	12.3	TDS	No action for low TDS	0.87	0.68	0.273	0.240	0.230	0.082	0.348	0.355	0.015	0.000
563190	12.4	Sulphate	No action for low TDS	1.19	0.92	0.356	0.560	0.497	0.072	0.320	0.291	0.013	0.002
564704	12.5	Sulphate		3.21	2.50	1.732	1.639	0.713	0.176	0.639	0.565	0.128	0.121
565147	12.6	TDS	No action for low TDS	0.64	0.50	0.140	0.000	0.132	0.150	0.364	0.344	0.004	0.002
565156	12.6	TDS	No action for low TDS	0.99	0.77	0.316	0.480	0.397	0.040	0.271	0.246	0.003	0.000
564724	12.7	Sulphate		4.46	3.46	1.906	2.678	1.761	0.158	0.700	0.561	0.091	0.058
564902	12.8	Sulphate	No action for low TDS	1.17	0.90	0.433	0.440	0.351	0.081	0.367	0.380	0.018	0.003
565501	12.8	Sulphate	No action for low TDS	1.11	0.86	0.391	0.520	0.421	0.059	0.286	0.277	0.008	0.000
565178	12.9	Sulphate		1.47	1.14	0.629	0.839	0.469	0.046	0.368	0.249	0.006	0.001
564909	12.9	TDS	No action for low TDS	0.96	0.74	0.335	0.320	0.260	0.053	0.347	0.367	0.018	0.000
565148	12.9	TDS	No action for low TDS	0.41	0.32	0.063	0.000	0.078	0.054	0.268	0.264	0.004	0.001
565381	13.0	TDS	No action for low TDS	0.91	0.70	0.292	0.400	0.338	0.050	0.278	0.247	0.003	0.004
565312	13.1	Sulphate	No action for low TDS	1.15	0.89	0.446	0.619	0.445	0.045	0.260	0.222	0.002	0.000
564966	13.1	TDS	No action for low TDS	0.48	0.37	0.062	0.000	0.104	0.060	0.318	0.311	0.001	0.000
565302	13.3	TDS	No action for low TDS	0.65	0.50	0.202	0.280	0.239	0.035	0.210	0.184	0.001	0.000
565578	13.4	TDS	No action for low TDS	0.87	0.67	0.341	0.260	0.198	0.067	0.328	0.341	0.007	0.000

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565139	13.7	TDS	No action for low TDS	0.55	0.42	0.151	0.300	0.146	0.046	0.248	0.070	0.004	0.000
565542	13.9	TDS	No action for low TDS	0.92	0.70	0.302	0.400	0.347	0.066	0.271	0.232	0.003	0.000
565167	14.0	TDS	No action for low TDS	0.91	0.69	0.225	0.320	0.398	0.085	0.282	0.283	0.006	0.000
565340	14.4	TDS	No action for low TDS	0.96	0.72	0.259	0.420	0.435	0.048	0.265	0.251	0.000	0.000
565389	14.5	Sulphate		1.43	1.07	0.504	0.819	0.540	0.028	0.380	0.218	0.004	0.000
565195	14.5	Sulphate		1.38	1.03	0.459	0.480	0.472	0.100	0.423	0.448	0.023	0.000
565163	14.6	TDS	No action for low TDS	0.74	0.55	0.243	0.120	0.169	0.085	0.323	0.349	0.009	0.000
564819	14.7	Chloride		3.21	2.39	1.662	2.198	0.750	0.190	0.526	0.000	0.271	0.000
563667	14.8	TDS	No action for low TDS	0.61	0.45	0.122	0.088	0.099	0.118	0.383	0.247	0.007	0.001
565375	14.8	Sulphate		1.49	1.11	0.485	0.739	0.623	0.055	0.379	0.314	0.006	0.000
565355	14.8	TDS	No action for low TDS	0.98	0.72	0.311	0.460	0.421	0.046	0.242	0.218	0.001	0.000
565321	14.8	TDS	No action for low TDS	0.55	0.41	0.155	0.140	0.184	0.052	0.213	0.219	0.003	0.000
565164	14.9	TDS	No action for low TDS	0.63	0.47	0.146	0.000	0.125	0.117	0.354	0.350	0.005	0.000
564948	15.0	TDS	No action for low TDS	0.67	0.50	0.207	0.140	0.162	0.037	0.294	0.318	0.007	0.001
565529	15.2	TDS	No action for low TDS	0.70	0.52	0.200	0.140	0.169	0.055	0.330	0.323	0.005	0.000
565189	15.3	Sulphate	No action for low TDS	1.11	0.82	0.373	0.520	0.461	0.044	0.272	0.251	0.003	0.000
565518	15.4	TDS	No action for low TDS	0.71	0.52	0.208	0.260	0.259	0.051	0.241	0.210	0.002	0.000
565387	15.4	Sulphate	No action for low TDS	1.23	0.90	0.400	0.599	0.508	0.042	0.323	0.263	0.004	0.000
563591	15.5	Bicarb		8.68	6.34	5.539	4.736	1.243	0.229	0.905	1.377	0.990	0.000
565116	15.6	TDS	No action for low TDS	0.81	0.59	0.268	0.360	0.287	0.031	0.251	0.200	0.003	0.000
566158	15.7	Indeterminate		3.97	2.90	1.687	2.378	1.613	0.168	0.605	0.351	0.069	0.000
565122	15.7	TDS	No action for low TDS	0.91	0.66	0.384	0.400	0.284	0.044	0.232	0.218	0.008	0.001
564957	15.7	TDS	No action for low TDS	0.73	0.53	0.193	0.140	0.192	0.042	0.329	0.346	0.012	0.000
565365	15.7	TDS	No action for low TDS	0.83	0.60	0.267	0.380	0.328	0.035	0.230	0.188	0.003	0.000
565320	15.7	TDS	No action for low TDS	0.68	0.50	0.219	0.220	0.236	0.064	0.225	0.213	0.004	0.001
565103	15.7	TDS	No action for low TDS	0.76	0.55	0.203	0.120	0.181	0.059	0.361	0.373	0.015	0.000
565154	15.8	TDS	No action for low TDS	0.50	0.36	0.153	0.040	0.092	0.054	0.245	0.267	0.006	0.000
565198	15.9	Sulphate	Caution SO4 for mapping	1.58	1.15	0.479	0.719	0.692	0.076	0.396	0.350	0.011	0.000
565199	16.0	TDS	No action for low TDS	0.96	0.70	0.323	0.460	0.364	0.029	0.270	0.207	0.003	0.000
564967	16.0	TDS	No action for low TDS	0.62	0.45	0.167	0.080	0.142	0.039	0.304	0.329	0.007	0.000
565504	16.0	TDS	No action for low TDS	0.75	0.54	0.236	0.300	0.258	0.034	0.250	0.207	0.003	0.000
565125	16.8	TDS	No action for low TDS	0.48	0.34	0.090	0.000	0.081	0.049	0.306	0.291	0.002	0.001
565112	16.9	TDS	No action for low TDS	0.75	0.53	0.223	0.300	0.284	0.026	0.242	0.208	0.002	0.000

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565118	17.2	TDS	No action for low TDS	0.89	0.63	0.287	0.380	0.299	0.031	0.302	0.219	0.003	0.000
565351	17.2	Sulphate	No action for low TDS	1.13	0.80	0.306	0.440	0.503	0.055	0.321	0.306	0.003	0.000
565522	17.5	TDS	No action for low TDS	0.98	0.69	0.336	0.460	0.397	0.024	0.247	0.206	0.002	0.000
565335	17.5	Sulphate	No action for low TDS	1.09	0.77	0.371	0.500	0.449	0.056	0.265	0.208	0.004	0.002
565519	17.7	TDS	No action for low TDS	0.69	0.48	0.199	0.160	0.211	0.071	0.274	0.248	0.002	0.000
565600	18.1	Bicarb	Caution HCO3 for mapping	1.27	0.88	0.539	0.360	0.314	0.122	0.402	0.401	0.017	0.000
564873	18.1	Chloride	Caution Cl for mapping	2.49	1.72	1.188	1.519	0.551	0.197	0.574	0.008	0.173	0.001
565134	18.2	TDS	No action for low TDS	0.53	0.37	0.146	0.120	0.147	0.041	0.232	0.205	0.004	0.000
563419	18.2	TDS	No action for low TDS	0.51	0.35	0.158	0.206	0.175	0.024	0.175	0.122	0.001	0.001
565372	18.4	TDS	No action for low TDS	0.71	0.49	0.207	0.240	0.266	0.050	0.230	0.195	0.005	0.003
565392	18.4	TDS	No action for low TDS	0.36	0.25	0.075	0.060	0.102	0.035	0.177	0.151	0.003	0.000
565342	19.0	TDS	No action for low TDS	0.96	0.65	0.307	0.260	0.328	0.075	0.323	0.311	0.004	0.008
565524	19.0	TDS	No action for low TDS	0.39	0.26	0.061	0.000	0.095	0.054	0.229	0.209	0.001	0.000
565107	19.0	Sulphate	Caution SO4 for mapping	1.25	0.85	0.419	0.639	0.518	0.059	0.305	0.150	0.005	0.000
565170	19.1	TDS	No action for low TDS	0.74	0.50	0.242	0.040	0.140	0.108	0.349	0.354	0.007	0.000
565513	19.3	TDS	No action for low TDS	0.81	0.55	0.270	0.240	0.268	0.067	0.268	0.240	0.003	0.000
565152	19.3	TDS	No action for low TDS	0.99	0.67	0.311	0.360	0.353	0.045	0.324	0.266	0.003	0.000
565506	19.9	TDS	No action for low TDS	0.60	0.40	0.137	0.040	0.132	0.046	0.320	0.314	0.009	0.000
566461	20.7	Sulphate	Caution SO4 for mapping	6.41	4.21	2.695	2.997	1.621	0.091	1.253	1.126	0.844	0.000
565313	21.6	TDS	No action for low TDS	0.67	0.43	0.175	0.160	0.221	0.040	0.268	0.230	0.003	0.000
565532	22.0	TDS	No action for low TDS	0.72	0.46	0.220	0.220	0.251	0.047	0.242	0.190	0.005	0.002
565160	22.5	TDS	No action for low TDS	0.83	0.52	0.277	0.360	0.308	0.031	0.241	0.133	0.003	0.000
565175	22.5	TDS	No action for low TDS	0.83	0.52	0.270	0.280	0.276	0.023	0.280	0.221	0.003	0.000
565391	22.7	TDS	No action for low TDS	0.97	0.61	0.335	0.260	0.308	0.075	0.325	0.277	0.003	0.000
565597	22.8	TDS	No action for low TDS	0.63	0.40	0.161	0.132	0.217	0.048	0.249	0.216	0.003	0.000
565864	23.2	Indeterminate	No action. Caution.	6.38	3.98	3.987	2.618	1.407	0.475	0.744	0.745	0.242	0.138
565547	23.3	TDS	No action for low TDS	0.72	0.45	0.195	0.220	0.291	0.029	0.233	0.200	0.002	0.001
565196	23.5	TDS	No action for low TDS	0.57	0.35	0.141	0.000	0.136	0.063	0.293	0.289	0.002	0.002
565336	23.8	Sulphate	Caution SO4 for mapping	1.03	0.63	0.343	0.380	0.425	0.046	0.253	0.204	0.005	0.002
565157	23.8	Bicarb	Caution HCO3 for mapping	1.25	0.77	0.319	0.001	0.398	0.182	0.505	0.585	0.026	0.000
566472	24.9	Sulphate	Caution SO4 for mapping	5.51	3.31	2.764	2.298	1.703	0.208	0.757	0.806	0.284	0.000
565566	25.0	TDS	No action for low TDS	0.46	0.28	0.103	0.082	0.153	0.033	0.207	0.163	0.002	0.000
565574	25.3	TDS	No action for low TDS	0.50	0.30	0.124	0.084	0.170	0.033	0.206	0.182	0.002	0.000

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565361	25.9	TDS	No action for low TDS	0.85	0.50	0.293	0.280	0.314	0.035	0.240	0.185	0.002	0.000
565153	26.0	Sulphate	Caution SO4 for mapping	3.11	1.82	1.173	1.539	1.547	0.108	0.381	0.176	0.005	0.000
565191	26.6	TDS	No action for low TDS	1.01	0.59	0.303	0.300	0.321	0.090	0.378	0.195	0.010	0.003
563424	27.0	Bicarb	Caution HCO3 for mapping	1.52	0.88	0.519	0.070	0.326	0.161	0.626	0.606	0.053	0.040
565111	27.0	TDS	No action for low TDS	0.59	0.34	0.128	0.000	0.150	0.071	0.309	0.267	0.002	0.000
565176	27.4	TDS	No action for low TDS	0.52	0.30	0.117	0.000	0.132	0.052	0.270	0.243	0.002	0.001
565168	28.6	TDS	No action for low TDS	0.59	0.33	0.154	0.000	0.146	0.062	0.286	0.263	0.002	0.001
565138	30.2	TDS	No action for low TDS	0.68	0.36	0.166	0.000	0.170	0.075	0.340	0.288	0.002	0.000
565171	33.3	TDS	No action for low TDS	0.61	0.30	0.149	0.000	0.172	0.049	0.283	0.255	0.003	0.000
563242	35.2	Bicarb	Caution HCO3 for mapping	3.89	1.86	2.345	1.199	0.504	0.171	0.561	0.472	0.481	0.020
565325	40.7	TDS	No action for low TDS	0.93	0.39	0.266	0.001	0.293	0.075	0.361	0.314	0.005	0.000
565304	41.7	TDS	No action for low TDS	0.66	0.27	0.178	0.001	0.258	0.055	0.214	0.213	0.005	0.000
565318	57.0	Bicarb	Caution HCO3 for mapping	1.35	0.37	0.544	0.001	0.439	0.069	0.365	0.297	0.006	0.004
565101	64.0	TDS	No action for low TDS	0.55	0.12	0.131	0.020	0.163	0.045	0.257	0.056	0.002	0.000