



Certificate of Analysis

Certified Reference Material

SLRS-6

River Water Certified Reference Material for Trace Metals and other Constituents

The following tables show those constituents for which certified, reference and information values have been established for this river water certified reference material (CRM).

The expanded uncertainty (U_{CRM}) in the certified value is equal to $U = ku_c$ where u_c is the combined standard uncertainty calculated according to the JCGM Guide [1] and k is the coverage factor. A coverage factor of two (2) was applied for all elements. It is intended that U_{CRM} accounts for every aspect that reasonably contributes to the uncertainty of the measurement. The density of SLRS-6 is 0.9985 g/mL at 21 °C.

Table 1: Certified quantity values and expanded uncertainties for SLRS-6

Element	Mass fraction, µg/kg	Mass concentration, µg/L	International recognition of measurement capability (CMC)
aluminium (b,c,d)	33.9 ± 2.2	33.8 ± 2.2	TEW01
antimony (a,b)	0.3377 ± 0.0058	0.3372 ± 0.0058	TEW02
arsenic (b,c,e)	0.57 ± 0.08	0.57 ± 0.08	TEW03
barium (a,b,c,d)	14.30 ± 0.48	14.28 ± 0.48	TEW04
cadmium (a,b)	0.0063 ± 0.0014	0.0063 ± 0.0014	TEW06
calcium (c,d)	8770 ± 200	8760 ± 200	TEW32
chromium (a,b,d)	0.252 ± 0.012	0.252 ± 0.012	TEW07
copper (a,b,c,d)	24.0 ± 1.8	23.9 ± 1.8	TEW09
iron (a,b,c,d)	84.5 ± 3.6	84.3 ± 3.6	TEW10
lead (a,b)	0.170 ± 0.026	0.170 ± 0.026	TEW11
magnesium (c,d)	2137 ± 58	2133 ± 58	TEW34
manganese (b,c,d)	2.12 ± 0.10	2.12 ± 0.10	TEW12
molybdenum (a,b,d)	0.215 ± 0.018	0.215 ± 0.018	TEW13
nickel (a,b,d)	0.617 ± 0.022	0.616 ± 0.022	TEW14
potassium (c,d)	652 ± 54	651 ± 54	TEW33
sodium (c,d)	2770 ± 220	2760 ± 220	TEW35
strontium (a,b,c,d)	40.72 ± 0.32	40.66 ± 0.32	TEW15
uranium (a,b)	0.0699 ± 0.0034	0.0698 ± 0.0034	TEW16
vanadium (b,d)	0.352 ± 0.006	0.351 ± 0.006	TEW17
zinc (a,b,c,d)	1.76 ± 0.12	1.76 ± 0.12	TEW18

Table 2: Reference values and expanded uncertainty for SLRS-6

Element	Mass fraction, µg/kg	Mass concentration, µg/L	International recognition of measurement capability (CMC)
beryllium (b)	0.0066 ± 0.0022	0.0066 ± 0.0022	TEW05
cobalt (b)	0.053 ± 0.012	0.053 ± 0.012	TEW08

Table 3: Information values for SLRS-6

Compound	Mass fraction, µg/kg	Mass concentration, µg/L
inorganic arsenic (f)	0.36	0.36
monomethylarsenic (as As) (f)	0.07	0.07
dimethylarsenic (as As) (f)	0.07	0.07
trimethylarsenic (as As) (f)	0.021	0.021

Coding

The coding refers to the instrumental method of analyte determination.

- a Isotope dilution inductively-coupled plasma mass spectrometry (ID-ICP-MS)
- b Standard addition inductively-coupled plasma mass spectrometry (SA-ICP-MS)
- c Inductively-coupled plasma mass spectrometry (ICP-MS)
- d Standard addition inductively-coupled plasma atomic emission spectroscopy (SA-ICP-AES)
- e Hydride generation SA-ICP-MS
- f Hydride generation cryo-trapping ICP-MS

International recognition of measurement capability

The measurement capabilities supporting these results are registered at the Calibration and Measurement Capabilities (CMC) database of the Bureau international des poids et mesures (BIPM) indicating recognition of the measurement certificates by National Metrology Institutes (NMIs) participating in the Mutual Recognition Arrangement (MRA) with the corresponding identifiers. List of all registered measurement capabilities in water matrix could be found in the BIPM database at <https://www.bipm.org/kcdb/>

Certified values

Certified values are considered to be those for which the National Research Council Canada (NRC) has the highest confidence in accuracy and that all known and suspected sources of bias have been taken into account and are reflected in the stated expanded uncertainties. Certified values are the best estimate of the true value and uncertainty (Table 1).

Reference values

Reference values are non-certified values for which insufficient data are available to provide a comprehensive estimate of uncertainty to permit their full certification (Table 2).

Information values

Information values are those for which insufficient data are available to provide any estimate of uncertainty (Table 3)

Intended use

This certified reference material is primarily intended for use in the calibration of procedures and the development of methods used for the analysis of water for trace metals. A minimum sample volume of 10 mL is recommended.

Storage and sampling

It is recommended that the material be stored at nominal temperature of +4 °C under typical refrigerator conditions. Material shall not be frozen. The bottles should be opened only in a clean area with precautions taken against contamination during sampling.

Preparation of material

Untreated river water was collected at the City of Ottawa's Britannia Water Purification Plant. The water was peristaltically pumped through 0.45 µm porosity acrylic copolymer filters and immediately acidified with ultrapure nitric acid to pH 1.6 during transfer to polypropylene carboys. The water was later refiltered through 0.2 µm porosity acrylic copolymer filters into a polyethylene tank in a clean room at NRC. It was subsequently blended and bottled in precleaned polyethylene containers. The bottled water was gamma irradiated to a minimum dose of 25 kGy at the Canadian Irradiation Centre, Laval, Quebec, to inhibit any bacterial action.

Stability

The predecessor CRMs have been periodically analyzed for more than 10 years and found to be stable with respect to total trace metal concentration over this interval. Uncertainty components for long and short term stability were considered negligible and are thus not included in the uncertainty budget.

Homogeneity

The material was tested for homogeneity at NRC using ICP-MS. Results from sub-samples (10 mL) were evaluated using ANOVA and/or the DerSimonian-Laird random effects model and included in the calculation of the certified values [2].

Uncertainty

Included in the overall combined uncertainty estimate (u_c) are uncertainties in the batch characterization (u_{char}), uncertainties related to possible between-bottle variation (u_{hom}), and uncertainties related to inconsistency between the various measurement methods (u_{method}). The latter is estimated as the heterogeneity in the random effects model fitted to the results of individual methods, also known as the dark uncertainty [3,4]. Expressed as standard uncertainties, these components are listed in Table 4.

Table 4: Uncertainty components for SLRS-6

Element	U_c , $\mu\text{g/kg}$	U_{char} , $\mu\text{g/kg}$	U_{hom} , $\mu\text{g/kg}$	U_{method} , $\mu\text{g/kg}$
aluminium	1.1	1.0	0.0	0.5
antimony	0.0029	0.0026	0.0013	0.0000
arsenic	0.04	0.04	0.00	0.00
barium	0.24	0.21	0.11	0.00
cadmium	0.0007	0.0007	0.0001	0.0000
calcium	100	90	40	0
chromium	0.006	0.006	0.000	0.000
copper	0.9	0.9	0.2	0.0
iron	1.8	1.7	0.5	0.0
lead	0.013	0.013	0.000	0.000
magnesium	29	17	23	0
manganese	0.05	0.05	0.00	0.00
molybdenum	0.009	0.008	0.005	0.000
nickel	0.011	0.008	0.008	0.000
potassium	27	12	24	0
sodium	110	100	40	0
strontium	0.16	0.14	0.08	0.00
uranium	0.0017	0.0017	0.0000	0.0000
vanadium	0.003	0.003	0.000	0.000
zinc	0.06	0.05	0.03	0.00

Table 4 (continued): Uncertainty components for SLRS-6

Element	U_c , $\mu\text{g/kg}$	U_{char} , $\mu\text{g/kg}$	U_{hom} , $\mu\text{g/kg}$	U_{method} , $\mu\text{g/kg}$
beryllium	0.0011	0.0011	0.0003	0.0000
cobalt	0.006	0.006	0.000	0.000

Metrological traceability

Results presented in this certificate are traceable to the SI through gravimetrically prepared standards of established purity, CRMs and international measurement intercomparisons. As such, SLRS-6 serves as suitable reference material for laboratory quality assurance programs, as outlined in ISO/IEC 17025.

Quality Management System (ISO 17034, ISO/IEC 17025)

This material was produced in compliance with the NRC Metrology Quality Management System, which conforms to the requirements of ISO 17034 and ISO/IEC 17025. The Metrology Quality Management System supporting NRC Calibration and Measurement Capabilities, as listed in the *Bureau international des poids et mesures* (BIPM) Key Comparison Database (kcdb.bipm.org/), has been reviewed and approved under the authority of the Inter-American Metrology System (SIM) and found to be in compliance with the expectations of the *Comité international des poids et mesures* (CIPM) Mutual Recognition Arrangement. The SIM approval is available upon request.

Updates

Users should ensure that the certificate they have is current. Our website at www.nrc.gc.ca/crm will contain any new information.

References

1. Evaluation of measurement data: Guide to the expression of uncertainty in measurement JCGM100:2008.
2. R. DerSimonian, N. Laird (1986) Meta-analysis in clinical trials. *Controlled Clinical Trials* 7: 177-188
3. A. Possolo, B. Toman (2007) Assessment of measurement uncertainty via observation equations. *Metrologia*, 44:464-475.
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Cited by

A list of scientific publications citing SLRS-6 CRM can be found at doi.org/10.4224/crm.2015.slrs-6

Authorship

The following NRC staff members contributed to the production and certification of SLRS-6: Lu Yang, Kenny Nadeau, Patricia Grinberg, Christine Brophy, Indumathi Pihillagawa Gedara, Juris Meija, Zoltan Mester, Scott Willie, and Garnet McRae.

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SLRS-6

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This Certificate is only valid if the corresponding material was obtained directly from the NRC or an Authorized Reseller.

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