

# British Columbia Regional Geochemical Survey Program: New Analytical Data and Sample Archive Upgrades

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## Introduction

Government-funded reconnaissance-scale regional geochemical surveys have been conducted in British Columbia since 1976. Up to this point, more than 62 700 drainage sediment and water samples have been collected and sample sites cover approximately 77% of BC at an average density of one sample for every 12 km<sup>2</sup> (Figure 1). Compiled results from these surveys have provided a comprehensive multi-element geochemical database that delineates regional geochemical patterns and provides baseline information that is being used to guide and support mineral exploration activities (Lett et al., 2008).

Efforts to maximize the utility of the regional geochemical database are ongoing and include both new sampling and enhancements to available analytical information. In 2010, Geoscience BC supported the following database upgrade projects to

- reanalyze moss-mat sediment samples originally collected in 1988 and 1989 from creeks located on Vancouver Island; the samples were analyzed for 51 elements by aqua-regia digestion followed by inductively coupled plasma–mass spectrometry (ICP-MS) and Pt and Pd by fire assay;

- reanalyze drainage sediment samples from several surveys originally conducted in northern BC from 1977 to 1995 for 53 elements by aqua-regia ICP-MS; and catalogue and transfer sample pulps retained from surveys conducted in BC into a single materials archival facility maintained by Natural Resources Canada (NRCan).

## Regional Geochemical Survey Program History

Extensive orientation studies (Ballantyne and Bottriel, 1975; Sutherland-Brown, 1975; Friske, 1991; Cook, 1997) have established operational standards for survey design,

**Keywords:** *Vancouver Island, mineral exploration, geochemistry, regional geochemical survey, RGS, multi-element, reanalysis, stream sediment*

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media collection, sample processing and analytical work conducted in BC. These guidelines and protocols have maintained program quality and assisted in the long-term development of a consistent and functional database (Ballantyne, 1991; Friske and Hornbrooke, 1991). Under the guidance of the National Geochemical Reconnaissance (NGR) Program, the BC Regional Geochemical Survey (RGS) Program, administered by the BC Geological Survey emerged from the joint federal-provincial Uranium Reconnaissance Program (URP) and the Accelerated Mineral Development Program. These programs supported the sampling of 14 034 stream- and lake-based sites from 1976 to 1978 (Carter, 1978; Carter et al., 1979). From 1979 to 2004, more than 35 surveys were completed by the BC Geological Survey. In some cases, the work was jointly managed with the Geological Survey of Canada (GSC). These programs added results for 39 212 samples to the database. Since 2005, surveys supported by Geoscience BC have produced an additional 9671 new samples.

In BC, fine-grained stream sediment is the conventional sample media for most RGS projects conducted in mountainous regions. This is due to its widespread availability and ease of collection and analysis. Moss-mat sediment has been collected in areas such as Vancouver Island, where conventional stream sediment is scarce. Living mosses found in the stream channel below the high water level have been found to filter suspended sediment from the streamwater. Lake sediments are collected in areas of low relief, such as the Interior Plateau, where streams are either nonexistent or have very low energy.

Over time, modifications and upgrades have been adopted to improve the utility of the database. These have included the completion of surveys in areas not previously sampled, infill sampling to increase existing sample density, targeted multimedia surveys and the reanalysis, using up-to-date analytical techniques, of sample pulps saved from older surveys. In addition, the data have become more readily accessible to a wider segment of the exploration industry through the development of websites such as MapPlace (BC Geological Survey, 2010) and the compilation and public availability of RGS data in digital formats (Matysek, 1987; Lett, 2005).

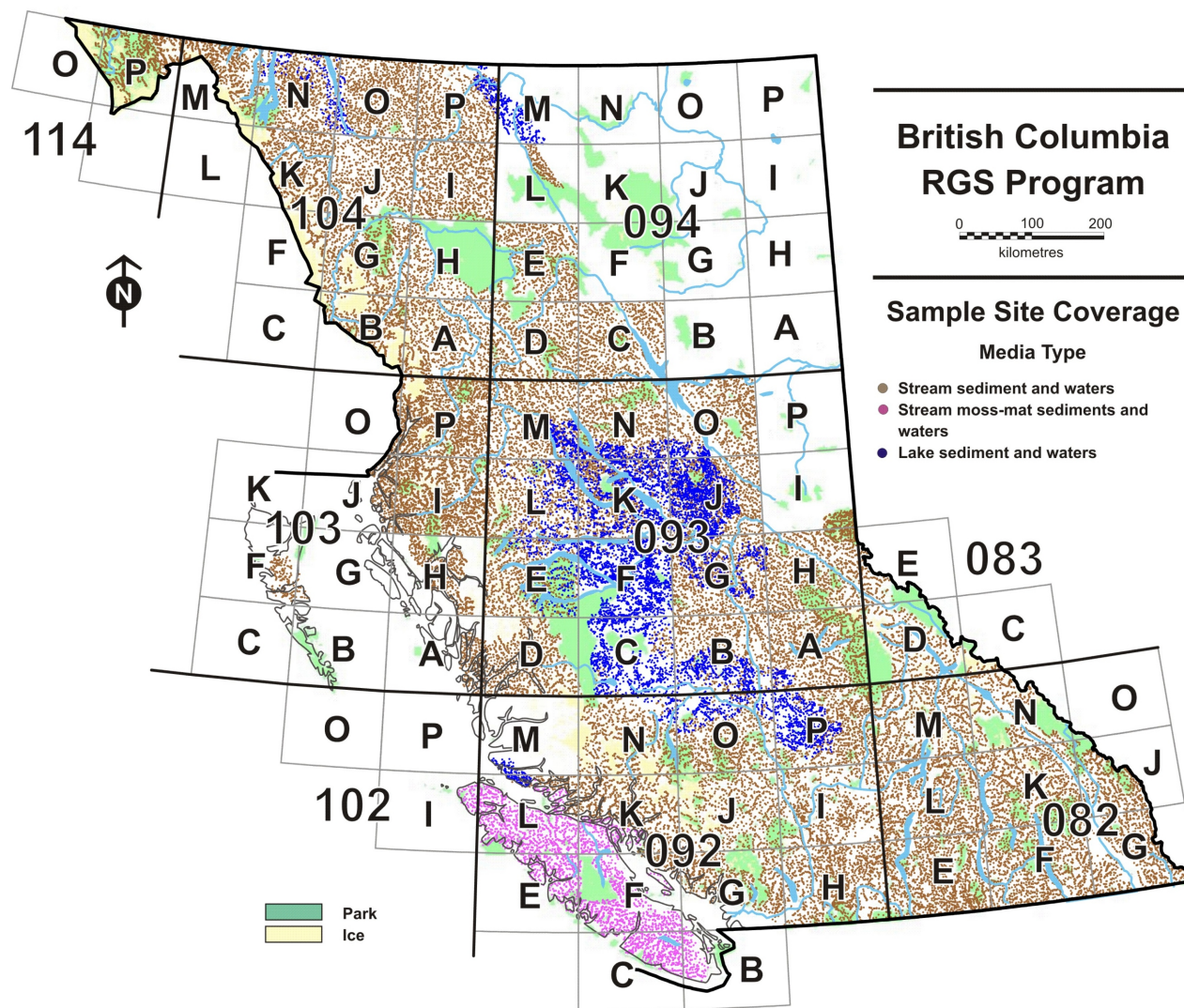


Figure 1. Location of Regional Geochemical Survey drainage sediment and water sample sites, British Columbia.

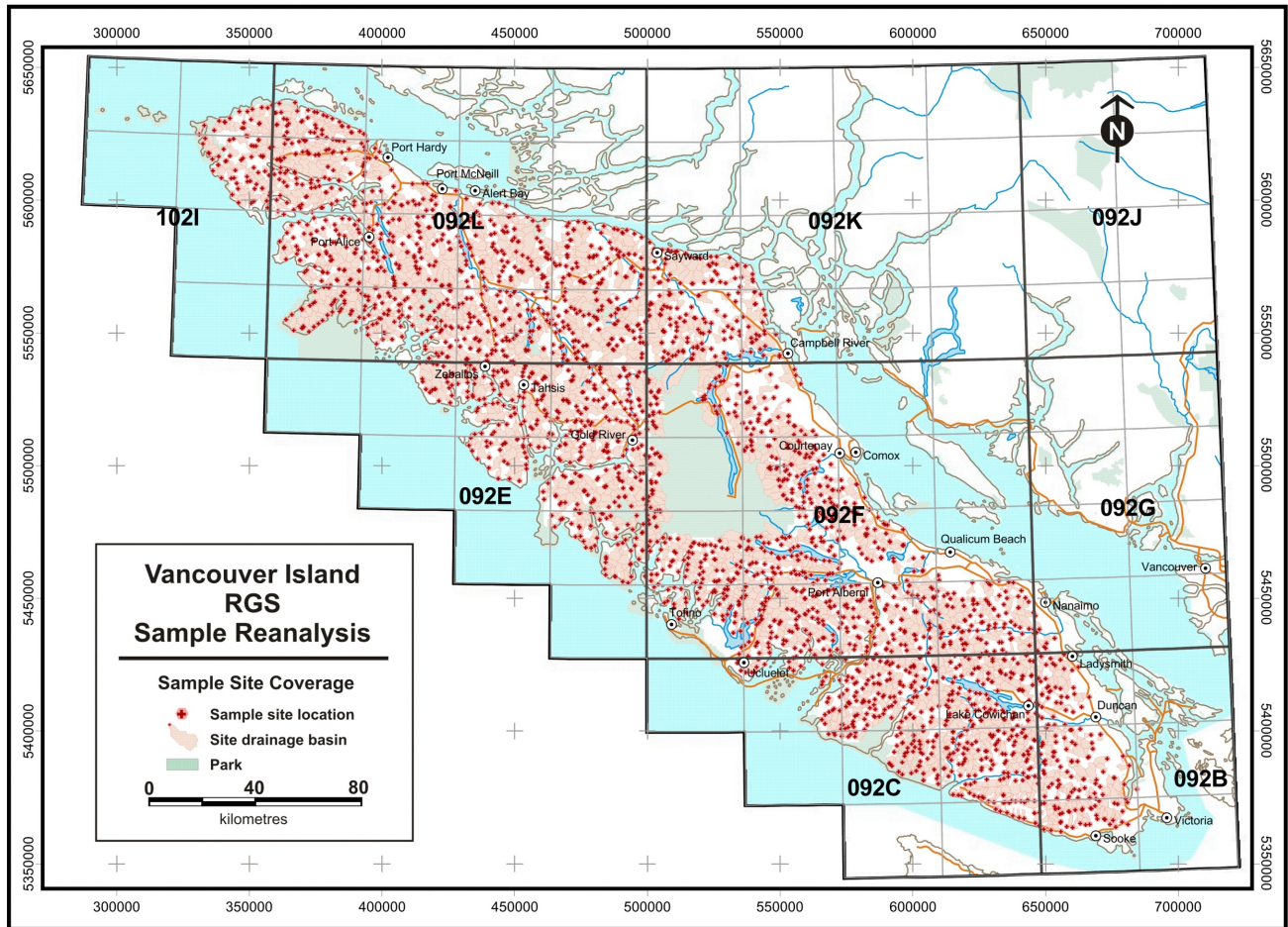
Analytical determinations reported for each survey have undergone various changes and enhancements. Initial surveys only reported a very limited number of metals in sediments including Zn, Cu, Pb, Ni, Co, Ag, Mn, Fe and Mo, determined by aqua-regia digestion atomic absorption spectrometry (AAS), W by a colorimetric method and U by neutron activation. Water samples were analyzed for U, F and pH. Recognizing the value of geochemical data for mineral exploration, new determinations were quickly added to the package, including Hg, Sn, As, Sb, Ba, Cd, V and loss on ignition. Results for Au were introduced for surveys conducted after the mid-1980s. More recently, analytical techniques such as instrumental neutron activation analysis (INAA) and ICP-MS have become the standard analytical package for the RGS program. The methods are cost effective and provide significantly lower detection levels for a wide range of base, precious, pathfinder and rare earth elements.

By design, samples have been routinely retained for all surveys completed in BC. The availability of these samples has provided the opportunity to generate enhanced analytical information for samples collected during older surveys. In the 1990s, more than 24 000 of these samples were reanalyzed by INAA (Jackaman et al., 1991), and more recently, more than 30 000 samples have been reanalyzed by ICP-MS as part of BC Geological Survey projects (Lett and Jackaman, 2004; Lett and Bluemel, 2006) and several Geoscience BC-funded initiatives (Jackaman, 2008a, b, 2009, 2010).

### Geoscience BC 2010 Projects

#### Vancouver Island Sample Reanalysis Project

Regional geochemical surveys were originally conducted on Vancouver Island and the adjacent mainland in 1988 and 1989 (Matysek et al., 1988; Lett, 2008). The Vancouver Is-



**Figure 2.** Regional Geochemical Survey sample locations and associated drainage basins in the Vancouver Island study area, southwestern British Columbia.

land portion of these surveys included the collection of 3138 moss-mat sediment samples and covered an area of 31 000 km<sup>2</sup> (Figure 2). When released, the sediment analytical package included Zn, Cu, Pb, Ni, Co, Ag, Mn, Fe, Mo, U, W, Sn, Hg, As, Sb, Cd, V, Bi and Cr by aqua-regia AAS and Au by fire assay. This relatively limited database combined with the region’s active mining and exploration history suggested that an enhanced analytical database would assist in the targeting of massive sulphide, porphyry, quartz vein and skarn deposits as well as ultramafic bodies that may host PGE sulphides (Larocque and Canil, 2007; Nixon and Orr, 2007).

To generate the new analytical information, a total of 3369 moss-mat sediment and quality-control samples have been reanalyzed for 51 elements by aqua-regia digestion (0.5 g) ICP-MS/inductively coupled plasma–emission spectroscopy (ICP-ES) analysis, and Pt and Pd by a lead fire assay (30 g) with ICP-MS finish. In co-operation with the BC Geological Survey, the original samples were recovered from the storage facility in Victoria. A total of 32 g of material was systematically removed from each storage vial,

placed in labelled sample bags and delivered to ALS Canada Ltd. (North Vancouver, BC). Fortunately, the archive included original analytical duplicate and control reference samples that were used to monitor and assess the accuracy and precision of the new analytical results. Additional control reference material applicable to this study was also added to the sample sequence prior to analysis. Table 1 provides a listing of metal determinations by aqua-regia AAS and Table 2 provides a complete listing of the new analytes and ranges.

Analytical results will be compiled and merged with original survey information and provided as digital data files. The data publication will include survey descriptions and details regarding methods, analytical and field data listings, summary statistics, sample location maps and maps for individual metals. The publication will be released as PDF files and raw digital data files used in the production process. The data packages are scheduled for release in spring 2011.

## Northern BC Sample Reanalysis Project

The Northern BC Reanalysis Project is a continuation of a series of large-scale reanalysis initiatives that have been sponsored by Geoscience BC since 2007 (Figure 3). Recognized as a cost-effective means of updating older RGS information, these programs have significantly improved

the BC geochemical database by providing a wide range of new analytical information at improved detection levels.

Regional geochemical surveys targeted for this project were originally conducted from 1979 to 1997 and include parts of NTS map areas 094C, D, E, L, M and 104B, G, I, O, P (Table 3). In co-operation with the BC Geological Survey and the GSC, samples were retrieved from storage facilities in Victoria and Ottawa. A total of 8572 drainage-sediment and quality-control samples have been delivered to Acme Analytical Laboratories Ltd. (Vancouver, BC) and are being analyzed by an ultratrace aqua-regia digestion (0.5 g) ICP-MS package for 53 elements. Table 4 provides a complete listing of the analytes and ranges.

Analytical results will be compiled and merged with original survey information and provided as digital data files. The data packages are scheduled for release in spring 2011.

## Regional Geochemical Survey Sample Archive Project

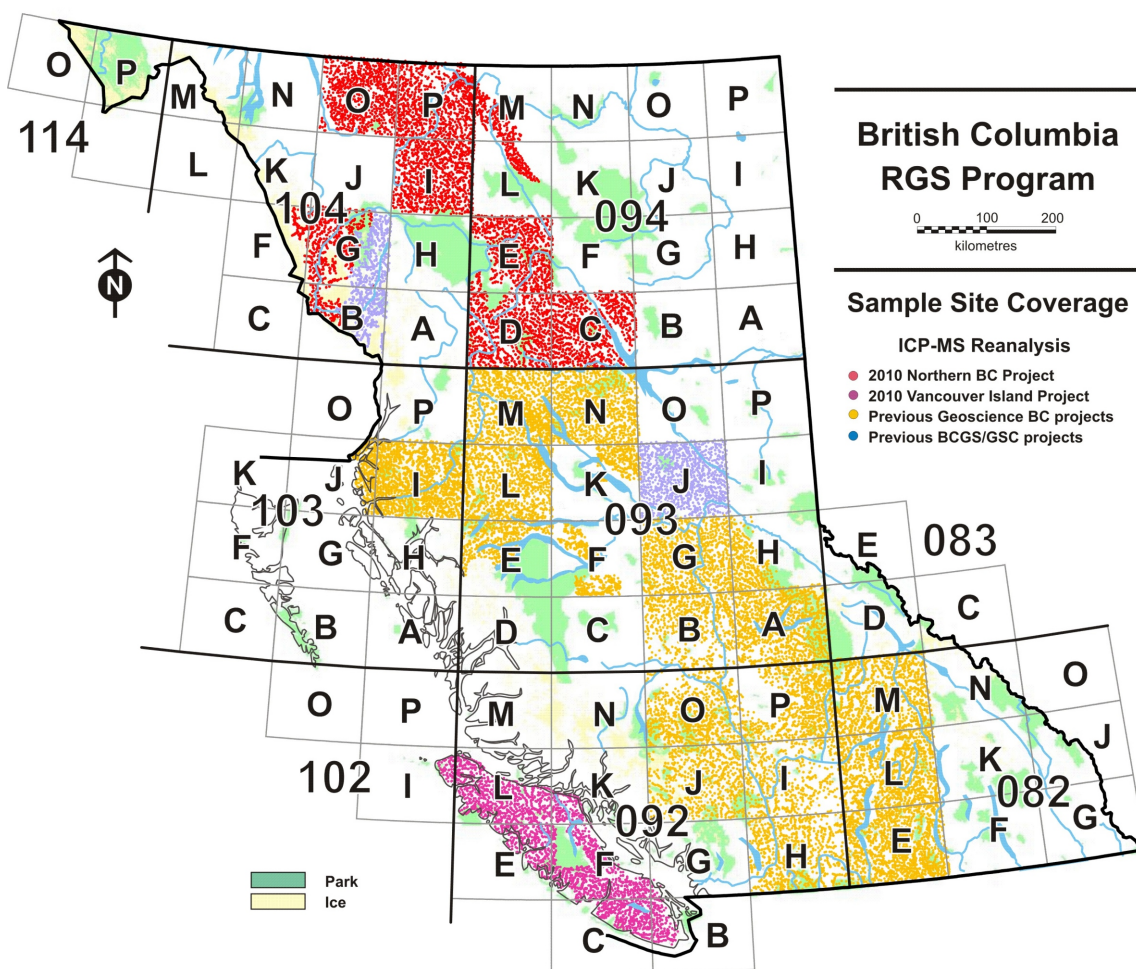
By design, drainage sediment material collected during previous RGS programs conducted in BC have been saved and stored at facilities in Ottawa and Victoria. Currently, more than 32 000 pulps are stored in Ottawa and 22 000 located in Victoria. There are also another 9000 samples retained from recent Geoscience BC-supported surveys. Based on the cost to acquire these samples, the value of this collection is estimated at more than \$10 million. In addition, access to the material has supported numerous reanalysis initiatives that are recognized as an extremely cost-effective means of improving older RGS information. Archival sample reanalysis programs are highly regarded

**Table 1.** List of elements and associated detection levels from published aqua-regia AAS analysis, Vancouver Island Project areas.

Element	Detection Levels	Units
Aluminum	0.01–25	%
Antimony	0.02–10 000	ppm
Arsenic	0.1–10 000	ppm
Barium	0.5–10 000	ppm
Bismuth	0.02–10 000	ppm
Boron	10–10 000	ppm
Cadmium	0.01–1000	ppm
Calcium	0.01–25	%
Chromium	0.5–10 000	ppm
Cobalt	0.1–10 000	ppm
Copper	0.01–10 000	ppm
Gallium	0.2–10 000	ppm
Gold	0.2–10 000	ppb
Iron	0.01–50	%
Lanthanum	0.5–10 000	ppm
Lead	0.01–10 000	ppm
Magnesium	0.01–25	%
Manganese	1–50 000	ppm
Mercury	5–10 000	ppb
Molybdenum	0.01–10 000	ppm
Nickel	0.1–10 000	ppm
Phosphorus	0.001–10	%
Potassium	0.01–10	%
Scandium	0.1–10 000	ppm
Selenium	0.1–1000	ppm
Silver	2–10 000	ppb
Sodium	0.001–10	%
Strontium	0.2–10 000	ppm
Sulphur	0.02–10 000	%
Tellurium	0.02–500	ppm
Thallium	0.02–10 000	ppm
Thorium	0.1–10 000	ppm
Titanium	0.001–10	%
Tungsten	0.05–10 000	ppm
Uranium	0.05–10 000	ppm
Vanadium	1–10 000	ppm
Zinc	0.1–10 000	ppm
Beryllium	0.05–1000	ppm
Cerium	0.02–500	ppm
Cesium	0.05–500	ppm
Germanium	0.05–500	ppm
Hafnium	0.02–500	ppm
Indium	0.005–500	ppm
Lithium	0.1–10 000	ppm
Niobium	0.1–10 000	ppm
Rubidium	0.1–10 000	ppm
Rhenium	0.001–50	ppb
Tin	0.2–500	ppm
Tantalum	0.01–500	ppm
Yttrium	0.05–500	ppm
Zirconium	0.5–500	ppm
Platinum	0.1–1000	ppb
Palladium	0.5–1000	ppb

**Table 2.** List of elements and associated detection levels from ICP-MS analysis using an aqua-regia digestion and Pt and Pd for fire assay, Vancouver Island Project areas.

Element	Detection Levels	Units
Antimony	0.2	ppm
Arsenic	0.5	ppm
Bismuth	0.2	ppm
Cadmium	0.2	ppm
Chromium	5	ppm
Cobalt	2	ppm
Copper	2	ppm
Iron	0.02	%
Lead	2	ppm
Manganese	5	ppm
Mercury	10	ppb
Molybdenum	1	ppm
Nickel	2	ppm
Silver	0.2	ppm
Tin	1	ppm
Tungsten	1	ppm
Uranium	0.5	ppm
Vanadium	5	ppm
Zinc	2	ppm
Gold	2	ppb



**Figure 3.** Locations of Geoscience BC– and BC Geological Survey–sponsored ICP-MS reanalysis work (abbreviations: BCGS, British Columbia Geological Survey; GSC, Geological Survey of Canada; ICP-MS, inductively coupled plasma–mass spectrometry; RGS, Regional Geochemical Survey).

by industry and other groups that use this important exploration resource.

samples located in Ottawa will be reinstated into the archive.

Over time, the collection has become fractured and existing storage containers have weakened or have been improperly stored, which has placed the overall security of the samples at risk. In an effort to revitalize the storage situation, a co-operative effort between the GSC, the BC Geological Survey and Geoscience BC has been initiated. The goal of the project is to repack the samples to current storage standards (Figure 4) and amalgamate with the collection in Ottawa as part of the Earth Material Collection. To date, approximately 20 000 samples that were stored in Victoria have been repackaged and delivered to the archive facility in Ottawa. During the next year, the remaining samples in Victoria will be transferred and

**Table 3.** List of Regional Geological Survey map areas and associated number of samples (including quality-control samples) included in the 2010 Northern BC Reanalysis Project.

Map	Survey Year	Survey Type	Survey Name	Samples
094C	1998	stream	Mesilinka River	1188
094D	1997	stream	McConnell Creek	1150
094E	1997	stream	Toodoggone River	1071
104B	1987	stream	Iskut River	235
104F	1987	stream	Sumdum	168
104G	1987	stream	Telegraph Creek	719
104I	1996	stream	Cry Lake	1362
104O	1979	stream	Jennings River	999
104P	1979	stream	McDame	944
104P/094M	1996	lake	North Kechika Trough	531
094L	1995	stream	Gataga Mountain	205
Total				8572

## Summary

Ongoing efforts by government-funded agencies such as the GSC, the BC Geological Survey and Geoscience BC to append to, update and maintain the RGS database has helped produce one of the most comprehensive collections of field information and multi-element geochemical data in Canada. The collection remains an important instrument

**Table 4.** List of elements and associated detection levels from ICP-MS analysis using aqua-regia digestion, Northern BC Reanalysis Project areas.

Element	Detection Levels	Units
Silver	2–100	ppb
Aluminum	0.01–10	%
Arsenic	0.1–10 000	ppm
Gold	0.2–100	ppb
Boron	20–2000	ppm
Barium	0.5–10 000	ppm
Beryllium	0.1–1000	ppm
Bismuth	0.02–2000	ppm
Calcium	0.01–40	%
Cadmium	0.01–2000	ppm
Cerium	0.1–2000	ppm
Cobalt	0.1–2000	ppm
Chromium	0.5–10 000	ppm
Cesium	0.02–2000	ppm
Copper	0.01–10 000	ppm
Iron	0.01–40	%
Gallium	0.1–100	ppm
Germanium	0.1–100	ppb
Hafnium	0.02–1000	ppm
Mercury	5–100	ppb
Indium	0.02–1000	ppm
Potassium	0.01–10	%
Lanthanum	0.5–10 000	ppm
Lithium	0.1–2000	ppm
Magnesium	0.01–30	%
Manganese	1–10 000	ppm
Molybdenum	0.01–2000	ppm
Sodium	0.001–5	%
Niobium	0.02–2000	ppm
Nickel	0.1–10 000	ppm
Phosphorus	0.001–5	%
Lead	0.01–10 000	ppm
Palladium	10–200	ppb
Platinum	2–100	ppb
Rubidium	0.1–2000	ppm
Rhenium	1–1000	ppb
Sulphur	0.02–5	%
Antimony	0.02–2000	ppm
Scandium	0.1–100	ppm
Selenium	0.1–100	ppm
Tin	0.1–100	ppm
Strontium	0.5–10 000	ppm
Tantalum	0.05–2000	ppm
Tellurium	0.02–1000	ppm
Thorium	0.1–2000	ppm
Titanium	0.001–5	%
Thallium	0.02–1000	ppm
Uranium	0.05–2000	ppm
Vanadium	2–10 000	ppm
Tungsten	0.05–100	ppm
Yttrium	0.01–2000	ppm
Zinc	0.1–10 000	ppm
Zirconium	0.1–2000	ppm



**Figure 4.** Packaging and storage of Regional Geochemical Survey sediment vials at the archive facility in Ottawa, Ontario.

for focusing and directing mineral exploration activities in the province and has been credited with locating many prospective areas and the discovery of new sources of metals. Its value is sustained by the fact that data have been acquired and maintained according to strict operational standards and is publicly available free of charge in usable digital and hard-copy formats. With continued development and maintenance, the utility of the information will remain relevant to exploration purposes and will help provide economic benefits in the future.

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