GEOLOGICAL SURVEY OF CANADA

OPEN FILE 5695

# Regional Stream Sediment and Water Geochemical Data, Nahoni Range area, west-central Yukon (parts of NTS 116F, G and K)

P.W.B. Friske, M.W. McCurdy, S.J.A. Day, R.J. McNeil, A.G. Grenier

2008

Natural Resources Canada Ressources naturelles Canada

Canada

Yukon Energy, Mines and Resources

**GEOLOGICAL SURVEY OF CANADA**
**OPEN FILE 5695**

Yukon Geological Survey Open File 2008-2

# Regional Stream Sediment and Water Geochemical Data, Nahoni Range area, west-central Yukon (parts of NTS 116F, G and K)

P.W.B. Friske, M.W. McCurdy, S.J.A. Day, R.J. McNeil, A.G. Grenier

**2008**



Available from:

**GSC Bookstore**
Sales and Distribution
107 - 601 Booth Street, Ottawa, ON K1A 0E8
Web: GSC Bookstore
Telephone: (613) 995-4342
Toll-free (Canada and U.S.A.): 1-888-252-4301
Fax: (613) 943-0646
E-mail: gscbookstore@nrcan.gc.ca

**Geoscience Information & Sales**
c/o Whitehorse Mining Recorder
Box 2703 (K102)
Whitehorse, Yukon, Canada
Y1A 2C6
Telephone: (867) 667-5200
Fax: (867) 667-5150
E-mail: geosales@gov.yk.ca

Recommended citation:
Friske, P.W.B., McCurdy, M.W., Day, S.J.A., McNeil, R.J., Grenier, A.G.
2008: Regional Stream Sediment and Water Geochemical Data, Nahoni Range area, west-central Yukon (parts of NTS 116F, G and K) Geological Survey of Canada, Open File 5695 / Yukon Geological Survey Open File 2008-2
1 CD-ROM

Open files are products that have not gone through the GSC formal publication process.

**Cover illustration**
Unnamed sandstone spires in the Mount Whitney area, *courtesy of Steve Day (GSC)*

# Regional Stream Sediment and Water Geochemical Data, Nahoni Range Area, West-Central Yukon (Parts of NTS 116F, G and K)

## Introduction

A regional geochemical survey, covering roughly 5,000 $km^2$, was undertaken in the Nahoni Range area of west-central Yukon during July 2006 (Fig. 1). This National Geochemical Reconnaissance (NGR) stream sediment and water survey was carried out under a Joint Research Agreement between the Yukon Government (Oil & Gas and Mineral Resources Division of the Department of Energy, Mines and Resources) and the Federal Government (Natural Resources Canada), acting through the Earth Science Sector's *Environment and Health Program*.

The Geological Survey of Canada (GSC) provided assistance in the form of geoscientific expertise and project management experience in the conduct of regional geochemical field surveys. Yukon Department of Energy, Mines and Resources provided funding for the project.

Regional geochemical surveys support the principles of the Earth Science Sector's Environment and Health Program by providing additional geochemical data to the national survey database. Analytical results and field observations contribute to building a national geochemical database for resource assessment, mineral exploration, geological mapping, and environmental studies. Sample collection, preparation procedures and analytical methods are strictly specified and carefully monitored to ensure consistent and reliable results regardless of the area, the year of collection or the analytical laboratory undertaking the analyses (Friske and Hornbrook, 1991).

Regional geochemical surveys have been carried out since 1976 in the Yukon under the NGR program. A total of 32 current open files (Fig. 1) have been published or are in publication, covering approximately 424,500 $km^2$ at an average density of 1 sample or site per 13 $km^2$.

This publication presents field observations and analytical and statistical data for 64 variables in stream sediments, and up to 55 variables in waters from 355 sites.


Available from:

**GSC Bookstore**
Sales and Distribution
107 - 601 Booth Street, Ottawa, ON K1A 0E8
Web: GSC Bookstore
Telephone: (613) 995-4342
Toll-free (Canada and U.S.A.): 1-888-252-4301
Fax: (613) 943-0646
E-mail: gscbookstore@nrcan.gc.ca

**Geoscience Information & Sales**
c/o Whitehorse Mining Recorder
Box 2703 (K102)
Whitehorse, Yukon, Canada
Y1A 2C6
Telephone: (867) 667-5200
Fax: (867) 667-5150
E-mail: geosales@gov.yk.ca

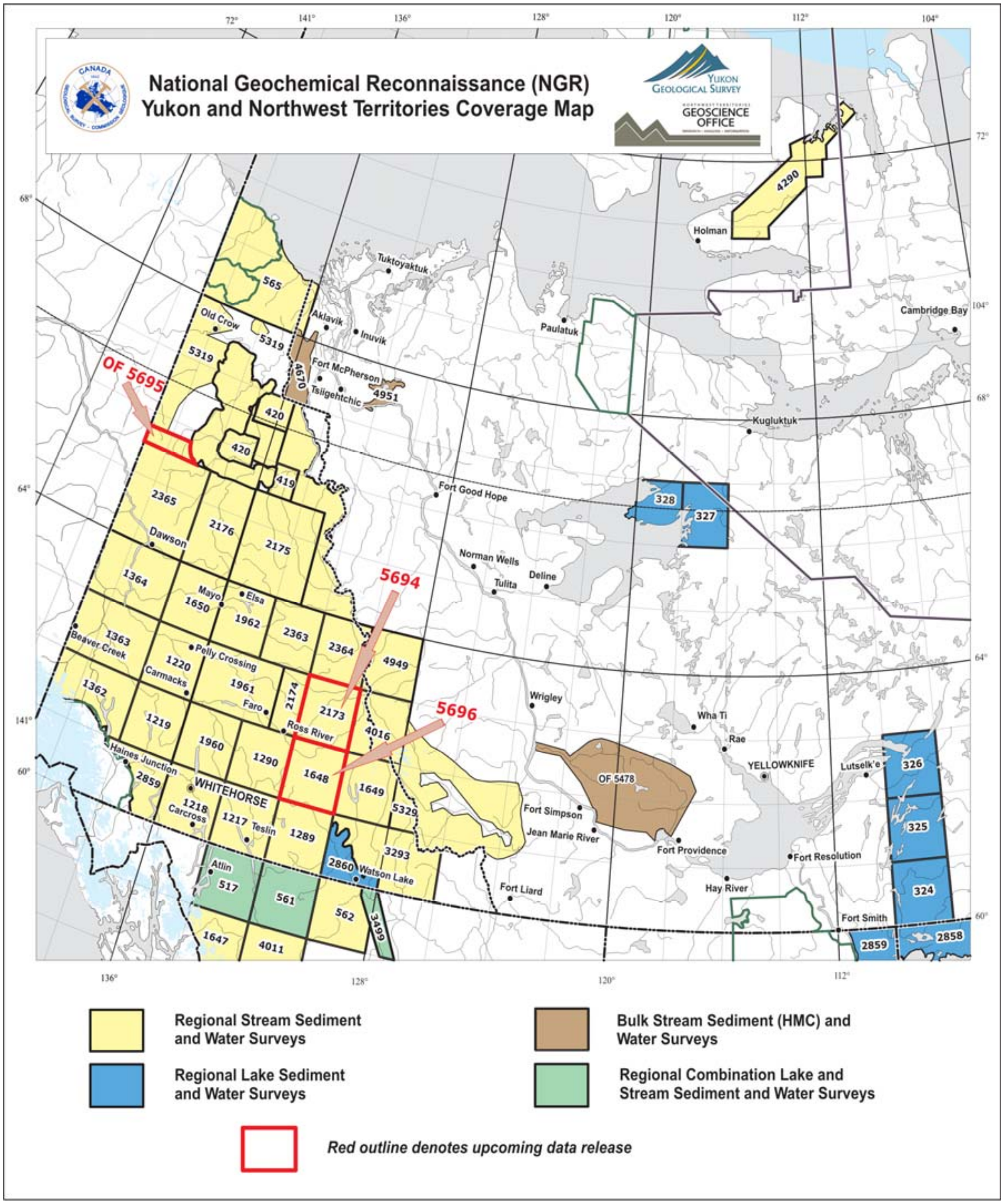


**Figure 1:** NGR coverage in Yukon and surrounding areas

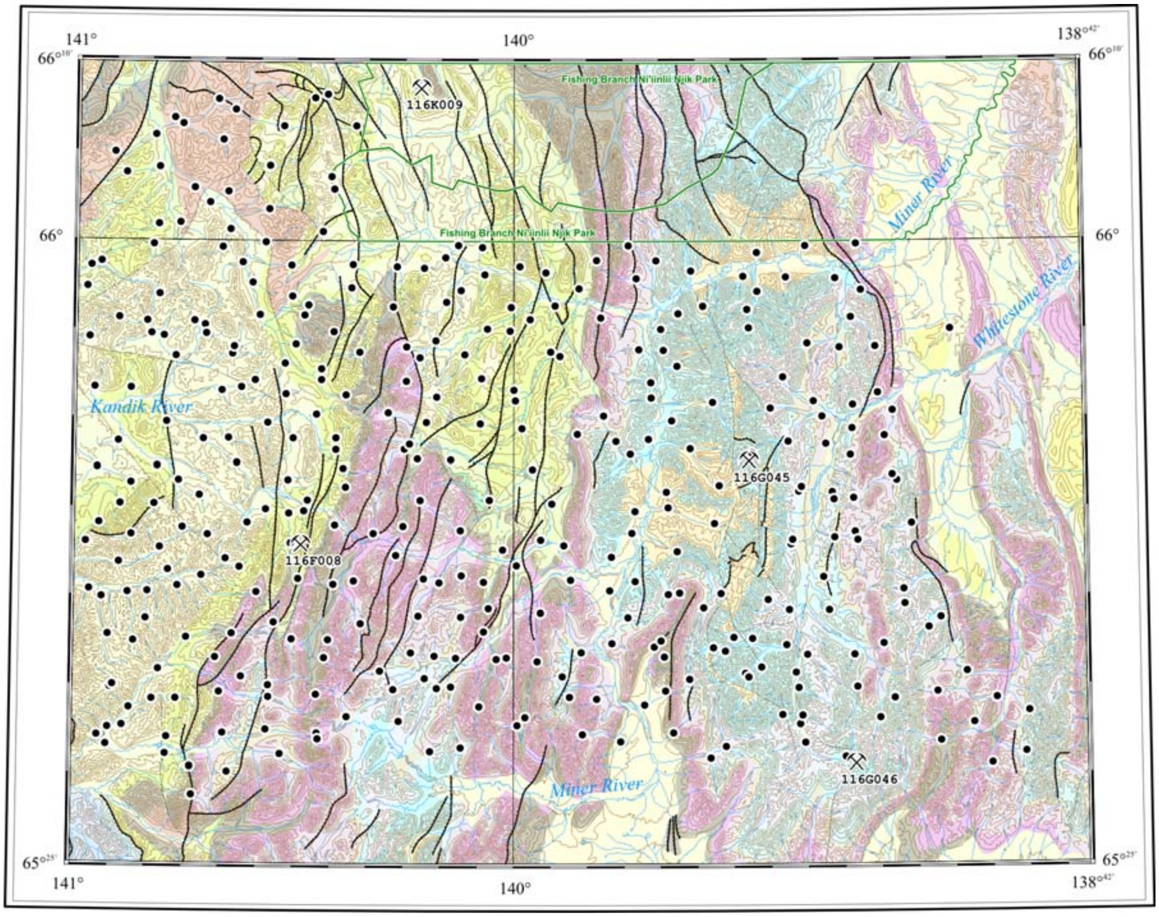

**Figure 2:** Open File 5695 stream silt sediment and water locations

## Methods

### Sample Collection

*Stream Sediments*

At each site a pre-labelled Kraft paper bag (12.5 cm x 28 cm with side gusset) (Fig. 3) was two-thirds filled with silt or fine sand collected from the active stream channel. In practice, the silt sample was collected after water samples were. Commonly, the sampler collected handfuls of silt from various points in the active stream channel while moving gradually upstream. If the stream channel consisted of clay or coarse materials from which suitable sample was scarce or absent, a moss mat sample might be collected.


**Figure 3.** Example of pre-labelled flagging tape, Kraft paper bag, plastic bottle, Garmin GPSmap 76 and field card.

*Stream Waters*

Waters were sampled in mid-channel, from flowing water where possible, at every site. Samples were contained in 125-ml Nalgene high density polyethelene (HDPE) bottles (Fig. 3). Samples were collected after first rinsing bottles two or three times in flowing water before a final fill.

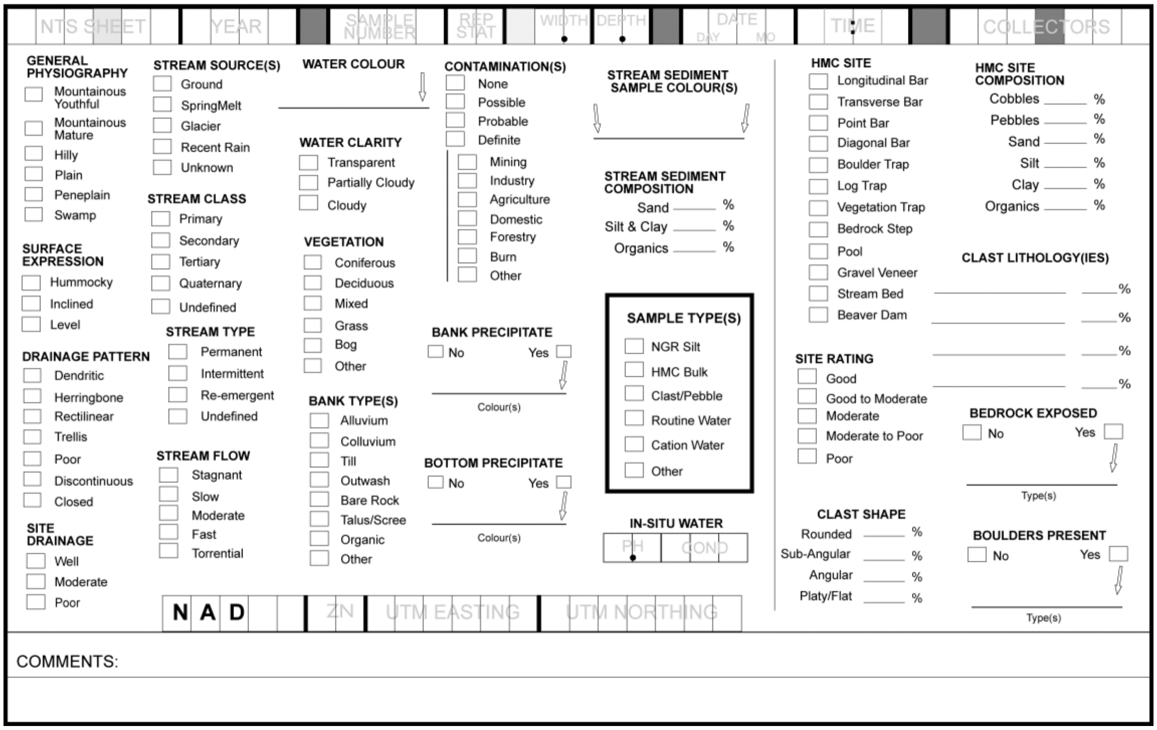


Figure 4: Example of form used to collect site specific field data.

*Field Data*

At the time of collection, site-specific field observations were recorded on a standard NGR stream sediment and water form (Fig. 4). Sample site locations were recorded using a Garmin GPSMAP 76.

## Sample Preparation

*Stream Sediments (Silts)*

The Kraft paper bags containing the silt samples were initially air-dried in the field then placed into plastic bags, taped with electrical tape and shipped directly to a commercial lab, where they were air-dried to completion at temperatures below 40ºC and sieved through a minus 80-mesh (177 µm) screen. At the laboratory, control reference and blind duplicate samples were inserted into each block of twenty sediment samples.

*Waters*

Within 24 hours of collection, water samples were filtered through single-use Millipore Sterivex-HV 0.45 µm filter units attached to 50-ml sterile plastic syringes. After 50 ml of water was filtered into new 60-ml bottles, the remainder was used for the determination of pH and conductivity before being discarded. Using an Eppendorf pipette repeater with disposable plastic tips, 0.5 ml 8M $HNO_3$ was added to filtered water samples. Syringes were re-used after rinsing with distilled, de-ionized water, but replaced daily. At this point, control reference samples (filter, acid and travel blanks[*]) were inserted. Filtered and acidified waters were kept in a cool dark place until shipment to the lab. For the water samples, only control

[*] Filter (sample) blanks are 60-ml bottles filled with deionized water used in the field that has been filtered and acidified at the same time as routine samples; acid blanks are samples of the deionized water used in the field and acidified (but not filtered) at the same time as routine samples; travel blanks are bottles of deionized water pre-filled at the lab in advance of collection and stored with routine samples, and acidified with routine samples.

reference samples were inserted into the block of 20 water samples. There were no blind duplicate water samples.

## Analytical Procedures

### *Stream Sediments (Silts)*

*Instrumental Neutron Activation Analysis (INAA)*

Weighed and encapsulated samples, normally 30 g, were packaged for irradiation along with internal standards and international reference materials. Samples and standards were irradiated together with neutron flux monitors in a two-megawatt pool type reactor. After a seven-day decay period, samples were measured with a high-resolution germanium detector. Typical counting times were 500 seconds. Elements determined by INAA are listed in Table 1.

Data for Ag, Cd, Ir, Ni, Se, Sn, Te, Ti, Zn, and Zr are not published because of inadequate detection limits and/or precision.

*Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Other Analyses*

For the determination of 36 elements listed in Table 1, a one-gram sample was leached with 6 ml of a mixture of HCl, $HNO_3$, and distilled, deionized water (2:2:2 v/v) at 95° C for one hour. The sample solution was diluted to 20 ml and analysed by inductively coupled plasma emission spectroscopy on a Jarell-Ash instrument and inductively coupled plasma mass spectroscopy on a Perkin-Elmer Elan instrument.

Loss-on-ignition was determined using a one-gram sample. The sample, weighed into a Leco® crucible, was placed into a 100ºC muffle furnace and brought up to 500° C for one hour. The oven was cooled to 100ºC and crucibles transferred to a desiccator for cooling to room temperature. The crucibles were re-weighed, and the difference was reported as loss-on-ignition.

Tin in stream sediments was determined by heating a 200 mg sample with $NH_4I$: the sublimed $SnI_4$ was dissolved in acid and the tin determined by atomic absorption spectrometry after solvent extraction of the tin into methyl isobutyl ketone containing trioctylphosphine oxide (TOPO). Welsch and Chao (1976) describe the method.

Fluorine was determined using 0.25-gram sample splits weighed into Ni crucibles. One gram of sodium hydroxide was added and the mixture was fused at 600ºC in a muffle furnace. The fusion product was dissolved in 7 ml of de-ionized water and 5 ml of 30% sulphuric acid. The solutions were transferred to plastic beakers and 5 ml of 30% ammonium acetate added. The volume was made up to 90 ml with de-ionized water. The pH was tested and adjusted to 7.8 with either of sodium hydroxide or sulphuric acid. Fluorine content was determined using a fluorine selective ion electrode.

### Water Analyses

The pH of stream waters was determined using an WTW MultiLine® P3 pH/LF-SET with automatic temperature compensation, a range of –2.00 to +16.0 pH, resolution of 0.01 pH and an accuracy of ±0.01 pH. Meters were calibrated using commercial buffer solutions with pH values of 4.0, 7.0 and 10.0.

Conductivity of stream waters was determined using an WTW MultiLine® P3 pH/LF-SET with automatic temperature compensation and a range of 500 µS/cm, a resolution of 1 µS/cm and a full-scale accuracy of ±1%. Meters were calibrated using commercial conductivity standards.

*Trace and Major Elements*

Acidified and filtered stream water samples were analyzed for trace metal and major elements. A complete list of elements and stated detection limits are given in Table 1.

Trace metal analysis was performed using a VG PQII ICP-MS with a Meinhard concentric glass nebulizer, Type K (solution uptake rate 1 ml $min^{-1}$), a quartz Scott-type double-pass chilled spray chamber (2ºC) and a 27 MHz standard quartz torch. The argon flow-rates are: Cool 12.5 l $min^{-1}$, Auxiliary 0.85 l $min^{-1}$, and Nebulizer 0.9 l $min^{-1}$. The RF power is 1350 watts. Isotopes measured and corrections for spectral interferences are detailed in Hall et al. (1995) and Hall et al. (1996). Data for hafnium and zirconium are not published because these elements are not sufficiently stabilized in waters by the addition of nitric acid. Data for indium, selenium, silver, tantalum and thulium are not published because of inadequate detection limits and/or precision.

Major element analysis was performed using a Perkin-Elmer 3000DV Inductively Coupled Plasma – Emission Spectrometer (ICP-ES) with a cross-flow nebulizer (solution uptake rate 1 ml $min^{-1}$), a Ryton Scott-type double-pass spray chamber and a custom demountable quartz ICP-ES torch. The argon flow-rates are: Plasma 15.0 l $min^{-1}$, Auxiliary 0.5 l $min^{-1}$, and Nebulizer 0.7 l $min^{-1}$. The RF power is 1350 watts. All elements were analyzed in axial mode except for sodium and potassium. These elements were run in radial mode. Inter-element correction factors were applied as required to correct for various spectral interferences. Data for scandium are not published because of inadequate detection limits and/or precision.

**Table 1** Summary of Analytical Data and Methods

| Element | Analytical Method | Units of Measurement | Detection Limit |
|---|---|---|---|
| ***Silt*** | | | |
| **Ag** | ICP-MS | ppb | 2 |
| **Al** | ICP-MS | % | 0.01 |
| **As** | ICP-MS | ppm | 0.1 |
| **As** | INAA | ppm | 0.5 |
| **Au** | INAA | ppb | 2 |
| **Ba** | ICP-MS | ppm | 0.5 |
| **Ba** | INAA | ppm | 50 |
| **Bi** | ICP-MS | ppm | 0.02 |
| **Br** | INAA | ppm | 0.5 |
| **Ca** | ICP-MS | % | 0.01 |
| **Cd** | ICP-MS | ppm | 0.01 |
| **Ce** | INAA | ppm | 5 |
| **Co** | ICP-MS | ppm | 0.1 |
| **Co** | INAA | ppm | 5 |
| **Cr** | ICP-MS | ppm | 0.5 |
| **Cr** | INAA | ppm | 20 |
| **Cs** | INAA | ppm | 0.5 |
| **Cu** | ICP-MS | ppm | 0.01 |
| **Eu** | INAA | ppm | 1 |
| **F** | Fusion | ppm | 10 |
| **Fe** | ICP-MS | % | 0.01 |
| **Fe** | INAA | % | 0.2 |

| | | | |
|---|---|---|---|
| **Ga** | ICP-MS | ppm | 0.2 |
| **Hf** | INAA | ppm | 1 |
| **Hg** | ICP-MS | ppb | 5 |
| **K** | ICP-MS | % | 0.01 |
| **La** | ICP-MS | ppm | 0.5 |
| **La** | INAA | ppm | 2 |
| **LOI** | Grav | % | 0.1 |
| **Lu** | INAA | ppm | 0.2 |
| **Mg** | ICP-MS | % | 0.01 |
| **Mn** | ICP-MS | ppm | 1 |
| **Mo** | ICP-MS | ppm | 0.01 |
| **Mo** | INAA | ppm | 1 |
| **Na** | ICP-MS | % | 0.001 |
| **Na** | INAA | % | 0.02 |
| **Ni** | ICP-MS | ppm | 0.1 |
| **P** | ICP-MS | % | 0.001 |
| **Pb** | ICP-MS | ppm | 0.01 |
| **Rb** | INAA | ppm | 5 |
| **S** | ICP-MS | % | 0.01 |
| **Sb** | ICP-MS | ppm | 0.02 |
| **Sb** | INAA | ppm | 0.1 |
| **Sc** | ICP-MS | ppm | 0.1 |
| **Sc** | INAA | ppm | 0.2 |
| **Se** | ICP-MS | ppm | 0.1 |
| **Sm** | INAA | ppm | 0.1 |
| **Sn** | Fusion | ppm | 1 |
| **Sr** | ICP-MS | ppm | 0.5 |
| **Ta** | INAA | ppm | 0.5 |
| **Tb** | INAA | ppm | 0.5 |
| **Te** | ICP-MS | ppm | 0.02 |
| **Th** | ICP-MS | ppm | 0.1 |
| **Th** | INAA | ppm | 0.2 |
| **Ti** | ICP-MS | % | 0.001 |
| **Tl** | ICP-MS | ppm | 0.02 |
| **U** | ICP-MS | ppm | 0.1 |
| **U** | INAA | ppm | 0.2 |
| **V** | ICP-MS | ppm | 2 |
| **W** | ICP-MS | ppm | 0.1 |
| **W** | INAA | ppm | 1 |
| **Wt** | INAA | grams | 0.01 |
| **Yb** | INAA | ppm | 2 |
| **Zn** | ICP-MS | ppm | 0.1 |
| | | | |
| ***Water*** | | | |
| **Al** | ICP-MS | ppb | 2 |
| **As** | ICP-MS | ppb | 0.1 |
| **B** | ICP-MS | ppb | 0.5 |

| | | | |
|---|---|---|---|
| **Ba** | ICP-MS | ppb | 0.2 |
| **Be** | ICP-MS | ppb | 0.005 |
| **Ca** | ICP-ES | ppm | 0.02 |
| **Cd** | ICP-MS | ppb | 0.02 |
| **Ce** | ICP-MS | ppb | 0.01 |
| **Co** | ICP-MS | ppb | 0.05 |
| **Conductivity** | | µS/cm | 1 |
| **Cr** | ICP-MS | ppb | 0.1 |
| **Cs** | ICP-MS | ppb | 0.01 |
| **Cu** | ICP-MS | ppb | 0.1 |
| **Dy** | ICP-MS | ppb | 0.005 |
| **Er** | ICP-MS | ppb | 0.005 |
| **Eu** | ICP-MS | ppb | 0.005 |
| **Fe** | ICP-ES | ppm | 0.005 |
| **Ga** | ICP-MS | ppb | 0.01 |
| **Gd** | ICP-MS | ppb | 0.005 |
| **Ge** | ICP-MS | ppb | 0.02 |
| **Ho** | ICP-MS | ppb | 0.005 |
| **K** | ICP-ES | ppm | 0.05 |
| **La** | ICP-MS | ppb | 0.01 |
| **Li** | ICP-MS | ppb | 0.02 |
| **Lu** | ICP-MS | ppb | 0.005 |
| **Mg** | ICP-ES | ppm | 0.005 |
| **Mn** | ICP-MS | ppb | 0.1 |
| **Mo** | ICP-MS | ppb | 0.05 |
| **Na** | ICP-ES | ppm | 0.05 |
| **Nb** | ICP-MS | ppb | 0.01 |
| **Nd** | ICP-MS | ppb | 0.005 |
| **Ni** | ICP-MS | ppb | 0.2 |
| **P** | ICP-ES | ppm | 0.05 |
| **Pb** | ICP-MS | ppb | 0.01 |
| **pH** | | | |
| **Pr** | ICP-MS | ppb | 0.005 |
| **Rb** | ICP-MS | ppb | 0.05 |
| **Re** | ICP-MS | ppb | 0.005 |
| **S** | ICP-ES | ppm | 0.05 |
| **Sb** | ICP-MS | ppb | 0.01 |
| **Si** | ICP-ES | ppm | 0.02 |
| **Sm** | ICP-MS | ppb | 0.005 |
| **Sn** | ICP-MS | ppb | 0.01 |
| **Sr** | ICP-MS | ppb | 0.5 |
| **Tb** | ICP-MS | ppb | 0.005 |
| **Te** | ICP-MS | ppb | 0.02 |
| **Ti** | ICP-MS | ppb | 0.5 |
| **Tl** | ICP-MS | ppb | 0.005 |
| **U** | ICP-MS | ppb | 0.005 |
| **V** | ICP-MS | ppb | 0.1 |

| | | | |
|---|---|---|---|
| **W** | ICP-MS | ppb | 0.02 |
| **Y** | ICP-MS | ppb | 0.01 |
| **Yb** | ICP-MS | ppb | 0.005 |
| **Zn** | ICP-MS | ppb | 0.5 |
| **Zr** | ICP-MS | ppb | 0.05 |


## Acknowledgements

Contracts were let to the following companies for helicopter charter, sample preparation and sample analysis:

Helicopter: TransNorth Helicopters (Doug Hladun – pilot)
Whitehorse, Yukon

Stream silt sediment preparation: Acme Analytical Laboratories
Vancouver, British Columbia

ICP-MS silt sediment analysis (Table 2):
Acme Analytical Laboratories
Vancouver, British Columbia

INA silt sediment analysis (Table 1):
Becquerel Laboratories Inc.
Mississauga, Ontario

Water analysis (Table 3):
GSC Analytical Method Development Laboratory
Ottawa, Ontario

John Buckle of the GSC reviewed this open file and provided many useful comments and suggestions.

## References


Deklerk, R. and Traynor, S. (compilers)
2008 Yukon MINFILE 2007 - A database of mineral occurrences. Online at: www.geology.gov.yk.ca/databases_gis.html

Friske, P.W.B. and Hornbrook, E.H.W.
1991 Canada's National Geochemical Reconnaissance programme; Transactions of the Institution of Mining and Metallurgy, London, Section B; Volume 100, p. 47-56

Gordey, S.P. and Makepeace, A.J. (comp.)
1999 Yukon bedrock geology in Yukon digital geology; Geological Survey of Canada Open File D3826 and Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, Open File 1999-1(D)

Hall, G.E.M., Vaive, J.E., and McConnell, J.W.
1995 Development and application of a sensitive and rapid analytical method to determine the rare-earth elements in surface waters; Chemical Geology, Vol. 120, Nos. 1-2, pp. 91-109.

Hall, G.E.M., Vaive, J.E., and Pelchat, J.C.
1996 Performance of inductively coupled plasma – mass spectrometric methods used in the determination of trace elements in surface waters in hydrogeochemical surveys; Journal of Analytical Atomic Spectrometry, Vol. 11, pp. 779-786.

Welsch, E.P. and Chao, T.T.
1976 Determination of trace amounts of tin in geological materials by atomic absorption spectrometry; Anal. Chim. Acta., Vol. 82, pp. 337-342.