



Activation Laboratories Ltd.



www.actlabs.com

General Information

Sample Packaging & Shipping Instructions

For convenience and to improve turnaround time, a sample submittal sheet (Request for Analysis) can be filled out online or downloaded and e-mailed. Make sure to include carrier or shipment method and the waybill number so that we can track delayed shipments. Instructions for report and invoice distribution should also be included with each shipment. Filling out a Request for Analysis form will provide all of the information required. *Please visit www.actlabs.com for a Request for Analysis form.*

Please ensure all samples are identified clearly with sample numbers. This can be accomplished with waterproof ink on the sample bags or with sample tags in the sample bags. Turnaround time will be improved by neatly packaging samples in order in shipping containers and providing an accurate sample list, with a hard copy with the shipment and an electronic copy sent by e-mail. Sample submissions poorly labelled or packaged, or having incomplete or no submission sheets may not be processed until adequate written instructions are received from the client and may incur additional sorting charges.

If using pop top vials or glass bottles, ensure that they are taped shut and protected from breakage. Sealed plastic bags are best for shipping pulps. Complimentary shipping labels are available upon request. Heavy duty plastic sample bags, cloth sample bags, soil envelopes and sample books are available at cost.

For most efficient delivery, we recommend the use of couriers, or transport companies for heavier shipments. If shipping to our lab in Ancaster, Ontario using Bus Parcel Express, the bus station of destination Hamilton.

Samples should be shipped to: (for main Ancaster, Canada lab)

Activation Laboratories Ltd.
41 Bittern Street
Ancaster, Ontario
Canada L9G 4V5

Tel: 1-888-ACTLABS (1-888-228-5227)

or 1 (905) 648-9611

Fax: 1 (905) 648-9613

E-mail: samplerception@actlabs.com

Waybill Instructions:

**Samples for Analysis, No Commercial Value
Value for Customs: US\$5.00**

Canadian Customs Tariff (Harmonized Code) 2617.90.00.00

Customs Broker: Thompson Ahern & Co Ltd.

Indicate DDP = Delivered Duty Paid for customs

All soils and/or vegetation samples from outside Canada being sent to Canada for analysis should be sent to our main sample prep lab in Ancaster, Ontario.

Quality Assurance/Quality Control (QA/QC)

Activation Laboratories Ltd. has achieved the ultimate accreditation to international standards, with either ISO 17025 for specific registered tests or certification to ISO 9001:2008. ISO 17025 evaluates the quality system and specific analytical methodologies through proficiency testing and routine audits of the laboratory. In addition, we have achieved accreditation to CAN-P-1579, specific to mineral analysis laboratories. We are one of the few commercial laboratories which have achieved this distinction. Activation Laboratories Ltd. can also advise on methods you can use to ensure security of samples during transport to the laboratory. We have a rigorous chain of custody protocol in place to ensure security of your samples once we receive them. Analytical uncertainty is available on request.

Turnaround Time

Please enquire regarding turnaround time. Normal turnaround depends on the analytical package, sample volume as well as time of year. Excessively wet samples may slow turnaround time, as will undocumented and unorganized shipments. RUSH Analysis: If you require analyses by a certain date, please ensure that this is clearly noted on the Request for Analysis form. We will make every effort to meet your requirements, however, rush conditions will require payment of a surcharge (i.e., 3 days – 200%, 1 week – 100%, 2 weeks – 50%).

Return of Data

In an effort to reduce our impact on the environment, all reports and invoices are transmitted electronically in a PDF format and/or as an excel file at the e-mail address that you specified in your Request for Analysis form, sent together with your samples. If required, hard copies of reports and/or invoices are available upon request.

Weblims

We have implemented an online **Laboratory Information Management System (LIMS)**. Clients can track samples from sample reception and logging through to preparation, analysis and reporting. Please contact customerservice@actlabs.com to establish a WEBLIMS account for your project.

Turnkey Services

Actlabs offers services ranging from environmental consultation and sample collection to sample analysis. Sampling supplies, including appropriate sample containers and preservatives, as well as Chain of Custody forms are available. To obtain meaningful results, it is imperative that sample collection and preparation be done properly. We can also advise on sampling protocol for your field program if required.

Quality Statement

"Quality is meeting our customers' requirements at all times and striving to exceed whenever possible."

Quality Assurance and Quality Control (QA/QC) is an integral aspect of our analyses and is a key component to Actlabs' vision, strategy and mission. Actlabs' Quality System monitors all steps and phases of our operations. Our Quality System outlines comprehensive details concerning our facilities, personnel qualifications and processes used. Additionally, we are routinely audited by four regulatory agencies that focus on continual improvement. As a result, we continue to raise the bar with respect to quality of our services in order to exceed both their expectations and that of our customers.

Actlabs' Quality System is accredited to international quality standards through the International Organization for Standardization/ International Electrotechnical Commission (ISO/IEC) 17025 (ISO/IEC 17025 includes ISO 9001 and ISO 9002 specifications) with CAN-P-1578 (Forensics), CAN-P-1579 (Mineral Analysis) and CAN-P-1585 (Environmental) for specific registered tests by the SCC. The accreditation program includes ongoing audits which verify the QA system and all applicable registered test methods. We are also accredited by Health Canada.

Terms and Conditions

Fees and Payment

- a) All prices in this pricelist are in US dollars and are applicable for samples received in Canada from clients with billing addresses outside of Canada.
- b) These prices apply to most environmental materials for routine analyses. A surcharge may apply for abnormal matrices or non routine analytical requirements. The client will be advised of any such conditions prior to performing the analytical work.
- c) A minimum charge of \$100.00 will be effective on all orders. A fee of \$75.00 will be charged if a Chain of Custody form is required.
- d) Payment should accompany the order unless credit has been established. Terms are net 30 days.
- e) Prices and packages are subject to change without notice.
- f) Customers are responsible for paying bank charges and should not be deducted from the total amount of the invoice.
- g) Please select OUR under Details of Charges when paying by direct bank deposit (EFT).
- h) Clients can pay invoices by cheque, bank draft, Visa, Mastercard, AMEX or direct bank deposit (EFT). To pay by credit card, a signature is required - either in the original paperwork or sent by fax or e-mail. We also require the security code found on the card. If paying by Western Union please add a surcharge of 10% to your payment.
- i) Any customs or shipping charges incurred while shipping samples to Actlabs is the responsibility of the customer, unless specified otherwise.

For direct bank deposit, pay to the account of
Activation Laboratories Ltd. at:
Royal Bank of Canada
59 Wilson Street West
Ancaster, Ontario CANADA
L9G 1N1
Tel: (905) 648-4411
Transit #00102 Institution #003
Swift: Royccat2
Account #400 389 3

Liability

- a) Any analysis, testing, inspection or investigation in connection with any work performed by Activation Laboratories Ltd. shall be conducted in accordance with recognized professional analytical standards. Neither Activation Laboratories Ltd., nor its subcontractors, consultants, agents, officers or employees shall be held responsible for any loss or damage resulting directly or indirectly from any default, negligence, error or omission. While every effort will be taken to store the unused portion of your samples, Activation Laboratories Ltd. cannot bear any responsibility for loss or damage, regardless of the cause.
- b) The liability, if any, of Activation Laboratories Ltd. shall be limited to the cost of performing the analyses.
- c) Governing law shall be in the Province of Ontario, Canada.

Services

- a) We reserve the right to subcontract work to affiliated laboratories.
- b) It is the responsibility of the client to determine the suitability of any services provided by Activation Laboratories Ltd.

Confidentiality

- a) All data derived on client's samples is confidential only to the client and cannot be disclosed to other parties unless approved in writing by the client. In the event of demands by regulatory bodies data may be released to them if subpoenaed.

Sample Preservation Instructions

Parameter	Minimum Volume (mL)	Sample (g)	Container Type		Preservation *	Maximum ** Holding Time
			Liquid	Soil / Sediment		
Alkalinity	100		* Polyethylene		Refrigerate	ASAP 14 day max.
Ammonia	100	25	Glass or PET	Glass	4°C, H ₂ SO ₄ , < pH 2	10 days
Anions	50		* Polyethylene	Glass or PET	Refrigerate	28 days
BOD	500		* Polyethylene or Glass		Refrigerate	ASAP (2 days)
BTEX	40 mL x 2	50	^ Glass (amber) No headspace	^ Glass (amber) No headspace	4°C, H ₂ SO ₄ , < pH 2, No headspace	14 days, store at 4°C
Carbon, total organic (TOC)	50	100	* Polyethylene or ^ Glass (amber) No headspace	Glass	4°C, H ₂ SO ₄ or HCl < pH 2	28 days
Chlorine, total residual	50		* Polyethylene		Analyze immediately	---
Chromium VI	100		* Polyethylene		4°C	24 hours
C.O.D.	50	50	* Polyethylene	Glass	4°C, H ₂ SO ₄ , < pH 2	28 days
Total Coliform, E. Coli, Fecal Coliform, Heterotrophic Plate Count	125		* Polyethylene (Sterile)		Na ₂ SO ₄ Precharged	ASAP
Colour	50		* Polyethylene		4°C	48 hours
Conductivity	50	100	* Polyethylene	Glass	4°C	28 days
Cyanide	50	100	* Polyethylene	Glass	NaOH > pH 12	14 days
Dissolved Metals	30		* Polyethylene		Filter (0.45 microns) ** HNO ₃ pH < 2	28 days
DOC	50	100	Glass	Glass	4°C, H ₂ SO ₄ , < pH 2	14 days
Geosmin & Methyl Isoborneal	40 mL x 2	50	^ Glass (amber)		4°C	7 days, store at 4°C
Hardness	50		* Polyethylene		4°C, HNO ₃ < pH 2	28 days
Hydrogen Sulphide	100		Glass or * Polyethylene		0.5 mL Zn Acetate followed by NaCO ₃ to pH 10	7 days
Total Metals (ICP-MS / ICP-OES)	100	50	* Polyethylene	Ziploc or Soil Envelope	** HNO ₃ to pH < 2	30 days
Mercury	100	25	Glass (amber)	*** Ziploc or Soil Envelope	1 mL 1:1 HCl	28 days
Nitrite & Nitrate	50	100	Glass or PET	Glass	4°C	48 hours
Nitrogen (organic, kjeldahl)	20	100	* Polyethylene	Glass	4°C, H ₂ SO ₄ , < pH 2	28 days
Oil and Grease	1,000	250	^ Glass (amber)	Glass	4°C, H ₂ SO ₄ , < pH 2	28 days
Organic Volatiles	40 mL x 2		Glass (fill to overflowing)		4°C, H ₂ SO ₄ , < pH 2	7 days, store at 4°C
PAH / PNA	40 mL x 2	50	^ Glass (amber)	^ Glass (amber) No headspace	4°C, store in dark	14 days, analyzed within days of extraction
PCB	40 mL x 2		^ Glass (amber)		4°C	14 days, analyzed within 30 days of extraction
Pesticides / Herbicides	40 mL x 2		^ Glass (amber)		4°C	14 days, analyzed within 30 days of extraction
pH	50	100	* Polyethylene	Plastic bag	None	ASAP (within 72 hours of receipt)
Phenols (by GC)	40 mL x 2		^ Glass (amber)		4°C	7 days
Total Phenol (by 4AAP)	40 mL x 2		^ Glass (amber)		4°C, H ₂ SO ₄ , < pH 2	10 days
Propylene & Ethylene Glycol, Ethanol	40 mL x 2	50	^ Glass (amber)		4°C	7 days, analyzed within 40 days of extraction
Reactive Silica	40		* Polyethylene		4°C, H ₂ SO ₄ , < pH 2	28 days
Residue (solids)	100		* Polyethylene		4°C	7 days
Semi-volatiles	1,000		^ Glass (amber)		4°C	7 days
Sulfide	250		* Polyethylene		2N Zn acetate	7 days
Surfactants	500		* Polyethylene		4°C	48 hours
TPH or TEH	40 mL x 2		^ Glass (amber)	^ Glass (amber) No headspace	4°C, H ₂ SO ₄ , < pH 2	14 days, analyzed within 30 days of extraction
Total Solids	500		* Polyethylene		4°C	7 days
Total Dissolved Solids	500		* Polyethylene		4°C	7 days
Total Suspended Solids	500		* Polyethylene		4°C	7 days
Turbidity	50		* Polyethylene		4°C	48 hours

Notes:

* We recommend Nalgene brand screw-cap containers

** 0.6% HNO₃ (6 mL concentrated Ultrex HNO₃/litre. The amount will be varied depending on acid strength and volume of sample collected e.g., preservative 20% HNO₃-80% H₂O, for volume of 100 mL add 1 mL of preservative)

*** For Hg on soil or sediment, we recommend drying below 40°C

^ Teflon-lined cap

* If no temperatures are listed, then room temperatures apply

** Holding times for soils are indefinite

Additional information on sample containers is available by contacting Actlabs.

Sample Logging, Preparation, Submission, Storage & Return

Sample Logging

Code Random	Randomization of samples	\$1.40/sample
CP2	Sample list not provided for orders over 25 samples	\$0.40/sample
CP3	Sorting chaotic shipments	\$0.65/sample

Sample Preparation

Sample preparation is performed, where applicable, in accordance to current regulation protocols and guidelines.

Soils, Stream and Lake Bottom Sediments, and Heavy Minerals

Code ES1	Drying (60°C) and sieving (-177 µm) save all portions	\$4.00
Code ES1 DIS	Drying (60°C) and sieving (-177 µm), discard oversize	\$3.50
Code ES1-230	Drying (60°C) and sieving (-63 µm), save oversize	\$5.35
Code ES1-230 DIS	Drying (60°C) and sieving (-63 µm), discard oversize	\$5.25
Code ES2	Lake bottom sediment preparation crush & sieve (-177 µm)	\$8.50
Code ES3	Alternate size fractions and bracket sieving, add	\$2.75
Code ES5	Wet or damp samples submitted in plastic bags, add	\$2.10
Code ES6	Separating -2 micron (µm) material	\$26.75
Code ES7mi	Methylene iodide heavy mineral separation specific gravity can be customized (100 grams)	\$69.75
Code ES7w	Sodiumpolytungstate heavy mineral separation specific gravity can be customized (100 grams)	\$69.75
Code ES8	Sieve analysis (4 sieve sizes) coarser than 53 µm	\$37.50
Code ES9	Particle size analysis (laser)	\$96.50



Biogeochemical Samples

Code EB1	Drying and blending humus	\$5.50
Code EB2	Drying and macerating vegetation	\$6.50
Code EB3	Dry ashing	\$9.75
Code EB4	Washing vegetation	\$4.75
Code EB5	Samples submitted in plastic bags, add	\$2.25

Sample Submission, Storage and Return

When submitting samples, please indicate on the Request for Analysis form if you require sample storage, disposal or if you require samples to be returned after analysis. For returns, please include all necessary shipping information e.g., courier, account number, etc. Return of samples is done at cost + 15%. The reject portion of samples prepared by Actlabs will be retained for a period of not more than 60 days from the date of final report. Pulps and rejects stored at the customer's request will be subject to a storage charge (see sample submittal sheet for charges) billed quarterly. Irradiated material will be discarded after 30 days unless prior arrangements are made. Return of radioactive material requires a Nuclear Safety Commission licence. Cost per shipment of radioactive materials is \$200.00 plus shipping costs. Disposal of soil, sediment or vegetation samples, which have entered Canada under a CFIA permit, will incur a disposal cost for larger sample volumes.

All soil, sediment and vegetation coming from outside Canada require incineration prior to disposal under CFIA regulations. All pulps and rejects will be returned to the client at cost + 15%. Disposal costs are additional. Pulps and rejects will incur a storage fee after the free period listed.

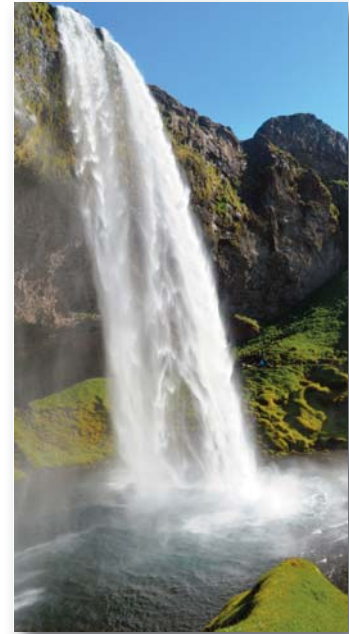
RTRN	Return of all reject portions and/or pulps	At cost + 15%
INCIN	Incineration of soil, sediment and vegetation samples from outside Canada (for samples up to 0.5 kg; samples over 0.5 kg will have higher incineration costs)	\$0.50
H&R	Handling and retrieval of stored sample material	\$57.75/hour
DISP	Disposal of environmental sample	\$2.00
STORE 1	Monthly storage of reject after 60 days	\$0.30
STORE 2	Monthly storage of pulps after 90 days	\$0.15
STORE 3	Monthly storage of sieve rejects after 3 months	\$0.20

Inorganics - Water / Wastewater Analysis

Inorganic Analysis

	ICP-MS	ICP-OES		ICP-MS	ICP-OES
Ag	0.2	5	Mo	0.1	5
Al	2	0.1 mg/L	Na	5	0.1 mg/L
As	0.03	30	Nb	0.005	
B	3 **		Nd	0.001	
Ba	0.1	20	Ni	0.3	5
Be	0.1	2	P		0.02 mg/L
Bi	0.3	20	Pb	0.01	10
Ca	700	0.1 mg/L	Pr	0.001	
Cd	0.01	2	Rb	0.005	
Ce	0.001	30	S		1 mg/L
Co	0.005	2	Sb	0.01	10
Cr	0.5	20	Sc	1	
Cs	0.001		Se	0.2	20
Cu	0.2	2	Si	200	0.1 mg/L
Dy	0.001		Sm	0.001	
Er	0.001		Sn	0.1	10
Eu	0.001		Sr	0.04	10
Fe	10	0.01 mg/L	Ta	0.001	
Ga	0.01		Tb	0.001	
Gd	0.001		Te	0.1	10
Ge	0.01		Th	0.001	
Hf	0.001		Ti	0.1	10
Hg	0.2 (0.006+)		Tl	0.001	10
Ho	0.001		Tm	0.001	
In	0.001		U	0.001	0.05 mg/L
K	30	0.1 mg/L	V	0.1	10
La	0.001		W	0.02	10
Li	1	0.05 mg/L	Y	0.003	10
Lu	0.001		Yb	0.001	
Mg	2	0.1 mg/L	Zn	0.5	5
Mn	0.1	0.01 mg/L	Zr	0.01	

All detection limits are in µg/L except where noted.



Sample Preservations Instructions on page 4.

** Optional element
+ Hg - cold vapour - FIMS

Code E6 ICP-MS is applicable only to natural waters with low total dissolved solid content (<0.05%). Any individual cations greater than the dynamic range of the ICP-MS will be reported as (>) unless the Overrange option is chosen. Samples submitted under all Code 6 packages will be analyzed on the supernatant portion of waters as received, acidified to pH <2 without filtration or digestion. Samples submitted as natural waters, but with elevated total dissolved solids (TDS >0.05%) will be charged as E6 MB. Analysis of waste waters and other solutions are available, but at varying costs. Please inquire. For hydro samples being analyzed by ICP-MS or by Ion Chromatography, please include field TDS/conductivity measurements, if available.

Code E6 - Water Analysis

Code E6 ICP-MS - Natural Waters with low TDS (<0.05%)	\$51.75
Code E6 Overrange - Overrange elements in Code E6 MB reanalyzed by ICP-OES or ICP-MS if required	add \$20.50
Code E6 Hg - Hg(+) option on separate sample by FIMS	add \$25.75
Code E6 Boron - Boron add-on by ICP-MS	add \$7.50
Code E6 Filter - Sample filtered with 0.45µ filter	add \$16.00
† Code E6 MB - Marine Water, Brines or other aqueous solutions with TDS > 0.05%	\$84.50
Code E6 ENVIR - Where Chain-of Custody for legal defense is required	\$75.00
Code E6 ICP-OES - Water analysis by ICP-OES for 36 elements	\$31.25
† Code E6 ICP-OES MB - Hydrogeochemistry ICP-OES for Marine Brines	\$47.00

† Detection limits for samples with high dissolved solids such as marine waters or brines, may be elevated by a factor of 10-1000.

Ion Chromatography

Code E6B - Anions (by Ion Chromatography)

Analyte	Detection Limit (mg/L)
Fluoride (F)	0.01
Chloride (Cl)	0.03
Bromide (Br)	0.03
Nitrite (NO ₂)	0.01
Nitrate (NO ₃)	0.01
Phosphate (PO ₄)	0.02
Sulphate (SO ₄)	0.03

First analyte \$26.75
Each additional \$18.50
All analytes \$67.50

NOTE: Contact laboratory for specific Detection Limit capabilities. Drinking Water samples cannot be analyzed.

Organic Water/Wastewater Analysis

Code E6W Organics (Waters)

Analysis	Method Instrumentation	Price
Phenols / Total Phenols (4AAP)	SKALAR Autoanalyzer (4AAP)	\$66.25
Atrazine	GC-MS	\$36.75
Bisphenol (A) and BHT (Butylated Hydroxytoluene)	GC-MS	\$73.50
BTEX (Benzene / Toluene / Ethyl Benzene / Xylenes)	GC-MS	\$50.50
FAME (Fatty Acids)	GC-MS	\$147.00
Glycols (Polyethylene and Polypropylene)	GC-MS	\$47.25
Geosmin and Methyl-Isoborneol (MIB)	GC-MS	\$126.00
Phthalates and Adipate	GC-MS	\$99.75
Polychlorinated Biphenyls (PCB - Total Arochlors)	GC-MS	\$68.25
Polychlorinated Biphenyls (PCB - Cogener Specific)	GC-MS	\$126.00
Polybromated Biphenyls and Polybromated Diphenyl Ethers (PPB and PBDE)	GC-MS	\$204.75
Polycyclic Aromatic Hydrocarbons (PAH/PNA - 16 compounds)	GC-MS	\$187.00
Sulfur (Elemental)	GC-MS	1-5 samples \$78.75 6+ samples \$63.00
Total Petroleum Hydrocarbons (VOH - C5-C10)	GC-FID	\$47.25
Total Petroleum Hydrocarbons (TPH - Gasoline and Diesel Fuel Range - C10-C44)	GC-FID	\$73.50
Trihalomethanes (THM)	GC-MS	\$50.50
Volatile Organic Contaminants (VOC)	GC-MS	\$126.00

NOTE: Contact laboratory for a list of specific compounds and their Detection Limit capabilities.

Drinking Water samples cannot be analyzed. TPH not compliant to CCME guidelines.

Miscellaneous Analyses

Code E6C

Acidity	\$22.50	Oil and Grease (Mineral)	\$43.00
Alkalinity (CaCO ₃) [includes carbonate (CO ₃) & bicarbonate (HCO ₃)]	\$22.50	Oil and Grease (Vegetable)	\$43.00
Biological Oxygen Demand (BOD)	\$36.50	Perchlorate (EPA 331.0)	\$247.50
Chemical Oxygen Demand (COD)	\$36.50	pH	\$7.50
Colour	\$18.50	Reactive Silica	\$24.75
Conductivity	\$7.50	Salinity	\$22.50
Cyanide (Total CN)	\$36.50	Total Dissolved Solids (TDS) (ISE)	\$22.50
Cyanide (Free CN)	\$36.50	Total Dissolved Solids (TDS) (Grav)	\$45.00
Cyanide (Weak Acid Dissociable - WAD CN)	\$36.50	Total Kjeldahl Nitrogen (TKN)	\$36.50
Dissolved Oxygen (DO)	\$30.25	Total Organic Carbon (TOC)	\$36.50
Hardness (must also do Code E6 ICP-OES)	\$11.75	Total Petroleum Hydrocarbon (TPH-GRO/DRO) - C6-C10/C10-C28 for Gasoline/Diesel Range	\$131.25
Microbiology (E.coli, Total Coliforms, Fecal Coliforms, Heterotrophic Plate Count)	\$43.00	Total Phosphorus	\$18.50
NH ₃ + NH ₄ (must provide pH or also do Code E6C pH)	\$36.50	Total Suspended Solids (TSS)	\$24.75
Oil and Grease (Total)	\$61.25	Turbidity	\$11.75

For Radionuclides, see page 11

Metal Speciation in Water

Our research activities over the last few years have allowed us to link the capillary electrophoresis and HPLC techniques to conventional ICP-MS or High Resolution ICP-MS. Using as little as 5 µg/L of solution, we can conveniently speciate a number of metals for their inorganic or organic metal species. This allows determination of a number of metal species sequentially. Actlabs can consult on the best ways to preserve samples for speciation analysis. **Note - Minimum of 10 samples. All prices are by request.**

Pore Water Extraction (from sediment core)
As speciation (As ³⁺ , As ⁵⁺ , MMA, DMA)
Sn speciation (Tripropylpentyl; Tributylpentyl; Dibutylpentyl; Monobutyl,tripentyl; Monophenyl,tripentyl; Diphenyl,tripentyl; Triphenyl,tripentyl)
Fe Speciation (Fe ³⁺ , Fe ²⁺)
Se Speciation (Se ⁶⁺ , Se ⁴⁺ , Se-Methionine, Se-Cystine)
Cr Speciation (Cr ³⁺ , Cr ⁶⁺)

AQUA REGIA “PARTIAL” DIGESTION - This leach uses a combination of concentrated hydrochloric and nitric acids to leach sulphides, some oxides and some silicates. Mineral phases which are hardly (if at all) attacked include barite, zircon, monazite, sphene, chromite, gahnite, garnet, ilmenite, rutile and cassiterite. The balance of silicates and oxides are only slightly to moderately attacked, depending on the degree of alteration. Generally, but not always, most base metals and gold are usually dissolved if the sample is ground finely enough.

Samples digested by aqua regia analyzed by ICP-OES (AR-ICP) or by ICP-MS (AR-MS).

4-ACID “NEAR-TOTAL” DIGESTION - This acid attack is the most vigorous digestion used in geochemistry. It will employ hydrochloric, nitric, perchloric and hydrofluoric acids. Even with this digestion, certain minerals (barite, gahnite, chromite, cassiterite, etc.) may not go into solution. Other minerals including zircon, sphene and magnetite may not be totally dissolved. Most other silicates will be dissolved, however some elements will be erratically volatilized, including As, Sb, Cr, U and Au.

Samples digested with four acids are analyzed by ICP-OES (TD-ICP) or by ICP-MS (TD-MS).

Near-Total digestion **cannot** be used to obtain accurate determinations of REE, Ta, Nb, As, Sb, Sn, Hg, Cr, Au and U.

ICP-OES and ICP-MS analyses by 4-acid (hydrochloric, nitric, perchloric and hydrofluoric) digestion are “near total” digestions. INAA (Instrumental Neutron Activation Analysis) yields total metals.

NOTE: Results from acid digestions may be lab dependent or lab operator dependent. Actlabs has automated this aspect of digestion using a microprocessor designed hotbox to accurately reproduce digestion conditions every time.

Hg add-on by cold vapour FIMS

Code E1G (5 ppb) add \$9.75

Package	AR-ICP	AR-MS	INAA+TD-ICP	TD-MS
	ICP-OES	ICP-MS	INAA+ICP-OES	ICP-MS
	E1E3	EUT1	E1H	EUT4
Ag	0.2 - 100 ppm	0.002 - 100 ppm	0.3 - 10,000 ppm	0.05 - 100 ppm
Al	0.01 - 10 %	0.01 - 8 %	0.01 - 50 %	0.01 - 10 %
As	2 - 10,000 ppm	0.1 - 10,000 ppm	0.5 - 10,000 ppm	0.1 - 10,000 ppm
Au	-	0.5 - 10,000 ppb	2 - 30,000 ppb	-
B	10 - 10,000 ppm	1 - 5,000 ppm	-	20 - 6,000 ppm
Ba	10 - 10,000 ppm	0.5 - 6,000 ppm	50 - 500,000 ppm	1 - 5,000 ppm
Be	0.5 - 1,000 ppm	0.1 - 1,000 ppm	1 - 10,000 ppm	0.1 - 1,000 ppm
Bi	2 - 10,000 ppm	0.02 - 2,000 ppm	2 - 10,000 ppm	0.02 - 2,000 ppm
Br	-	-	0.5 - 5,000 ppm	-
Ca	0.01 - 10 %	0.01 - 50 %	0.01 - 70 %	0.01 - 50 %
Cd	0.5 - 2,000 ppm	0.01 - 2,000 ppm	0.3 - 2,000 ppm	0.1 - 1,000 ppm
Ce	-	0.01 - 10,000 ppm	3 - 10,000 ppm	0.1 - 10,000 ppm
Co	1 - 10,000 ppm	0.1 - 5,000 ppm	1 - 5,000 ppm	0.1 - 500 ppm
Cr	1 - 10,000 ppm	1 - 10,000 ppm	2 - 100,000 ppm	1 - 5,000 ppm
Cs	-	0.02 - 500 ppm	1 - 10,000 ppm	0.05 - 100 ppm
Cu	1 - 10,000 ppm	0.2 - 10,000 ppm	1 - 10,000 ppm	0.2 - 10,000 ppm
Dy	-	0.1 - 1,000 ppm	-	0.1 - 5000 ppm
Er	-	0.1 - 1,000 ppm	-	0.1 - 1,000 ppm
Eu	-	0.1 - 100 ppm	0.2 - 10,000 ppm	0.05 - 100 ppm
Fe	0.01 - 30 %	0.01 - 30 %	0.01 - 70 %	0.01 - 50 %
Ga	10 - 10,000 ppm	0.02 - 500 ppm	-	0.1 - 500 ppm
Gd	-	0.1 - 1,000 ppm	-	0.1 - 5,000 ppm
Ge	-	0.1 - 500 ppm	-	0.1 - 500 ppm
Hf	-	0.1 - 500 ppm	1 - 5,000 ppm	0.1 - 500 ppm
Hg	1 - 10,000 ppm	10 - 10,000 ppb	1 - 10,000 ppm	10 - 10,000 ppb
Ho	-	0.1 - 1,000 ppm	-	0.1 - 1,000 ppm
In	-	0.02 - 500 ppm	-	0.1 - 100 ppm
Ir	-	-	5 - 10,000 ppb	-
K	0.01 - 10 %	0.01 - 5 %	0.01 - 10 %	0.01 - 5 %
La	10 - 10,000 ppm	0.5 - 10,000 ppm	0.5 - 10,000 ppm	0.1 - 10,000 ppm
Li	-	0.1 - 10,000 ppm	1 - 10,000 ppm	0.5 - 400 ppm
Lu	-	0.1 - 100 ppm	0.05 - 10,000 ppm	0.1 - 100 ppm
Mg	0.01 - 25 %	0.01 - 10 %	0.01 - 50 %	0.01 - 50 %
Mn	5 - 100,000 ppm	1 - 10,000 ppm	1 - 100,000 ppm	1 - 10,000 ppm
Mo	1 - 10,000 ppm	0.01 - 10,000 ppm	1 - 10,000 ppm	0.05 - 10,000 ppm
Na	0.001 - 10 %	0.001 - 5 %	0.01 - 50 %	0.01 - 3 %
Nb	-	0.1 - 500 ppm	-	0.1 - 500 ppm
Nd	-	0.02 - 5,000 ppm	5 - 10,000 ppm	0.1 - 10,000 ppm
Ni	1 - 10,000 ppm	0.1 - 10,000 ppm	1 - 100,000 ppm	0.5 - 5,000 ppm
P	0.001 - 5 %	0.001 - 5 %	0.001 - 10 %	-
Pb	2 - 5,000 ppm	0.1 - 5,000 ppm	3 - 5,000 ppm	0.5 - 5,000 ppm
Pr	-	0.1 - 1,000 ppm	-	0.1 - 5,000 ppm
Rb	-	0.1 - 500 ppm	15 - 10,000 ppm	0.2 - 500 ppm
Re	-	0.001 - 100 ppm	-	0.001 - 100 ppm
S +	0.01 - 20 %	1 - 20 %	0.01 - 20 %	-
Sb	2 - 10,000 ppm	0.02 - 500 ppm	0.1 - 10,000 ppm	0.1 - 500 ppm
Sc	1 - 10,000 ppm	0.1 - 10,000 ppm	0.1 - 1,000 ppm	-
Se	-	0.1 - 10,000 ppm	3 - 10,000 ppm	0.1 - 1,000 ppm
Sm	-	0.1 - 100 ppm	0.1 - 10,000 ppm	0.1 - 100 ppm
Sn	-	0.05 - 200 ppm	0.02 - 20 %	1 - 200 ppm
Sr	1 - 10,000 ppm	0.5 - 5,000 ppm	1 - 10,000 ppm	0.2 - 10,000 ppm
Ta	-	0.05 - 50 ppm	0.5 - 10,000 ppm	0.1 - 1,000 ppm
Tb	-	0.1 - 100 ppm	0.5 - 10,000 ppm	0.1 - 100 ppm
Te	1 - 500 ppm	0.02 - 500 ppm	-	0.1 - 500 ppm
Th	20 - 10,000 ppm	0.1 - 200 ppm	0.2 - 10,000 ppm	0.1 - 500 ppm
Ti	0.01 - 10 %	0.001 - 10 %	0.01 - 10 %	-
Tl	2 - 10,000 ppm	0.02 - 500 ppm	-	0.05 - 500 ppm
Tm	-	0.1 - 1,000 ppm	-	0.1 - 1,000 ppm
U	10 - 10,000 ppm	0.1 - 10,000 ppm	0.5 - 10,000 ppm	0.1 - 10,000 ppm
V	1 - 10,000 ppm	1 - 1,000 ppm	2 - 10,000 ppm	1 - 10,000 ppm
W	10 - 200 ppm	0.1 - 200 ppm	1 - 10,000 ppm	0.1 - 200 ppm
Y	1 - 1,000 ppm	0.01 - 500 ppm	1 - 1,000 ppm	0.1 - 10,000 ppm
Yb	-	0.1 - 200 ppm	0.2 - 10,000 ppm	0.1 - 5,000 ppm
Zn	2 - 10,000 ppm	0.1 - 5,000 ppm	1 - 100,000 ppm	0.2 - 10,000 ppm
Zr	1 - 10,000 ppm	0.1 - 5,000 ppm	-	1 - 5,000 ppm
Price:	\$12.25	\$20.75	\$36.75	\$22.50

Extraction of each element by Aqua Regia or 4-Acid Digestion is dependent on mineralogy + Sulphide sulphur and soluble sulphates are extracted

When submitting pulp material it must be 95% -74 µm or additional pulverization charges will apply.

All elements are in ppm except where noted. Prices per sample.

	FUS-ICP	FUS-ICP + ICP-MS		OES+ INAA
	E4B	E4L	E4LR	E4EE
Al ₂ O ₃	0.01%	0.01%	0.01%	0.01%
CaO	0.01%	0.01%	0.01%	0.01%
Fe ₂ O ₃	0.01%	0.01%	0.01%	0.01%
K ₂ O	0.01%	0.01%	0.01%	0.01%
MgO	0.01%	0.01%	0.01%	0.01%
MnO	0.001%	0.001%	0.001%	0.01%
Na ₂ O	0.01%	0.01%	0.01%	0.01%
P ₂ O ₅	0.01%	0.01%	0.01%	0.01%
SiO ₂	0.01%	0.01%	0.01%	0.01%
TiO ₂	0.001%	0.001%	0.001%	0.005%
LOI	0.01%	0.01%	0.01%	0.01%
Ag	(0.3+)	0.5	0.5	0.5
As	(0.5++)	5 (0.5++)	5 (0.5++)	2
Au	(2 ppb++)	(2 ppb++)	(2 ppb++)	5 ppb
Ba	2	2	3	3
Be	1	1	1	1
Bi		0.4	0.1	2
Br	(0.5++)	(0.5++)	(0.5++)	1
Cd	(0.5+)	(0.5+)	(0.5+)	0.5
Co	(1++)	1	1	1
Cr	(5++)	20 (5++)	20 (5++)	1
Cs	(1++)	0.5	0.1	0.5
Cu	(1+)	10 (1+)	10 (1+)	1
Ga	-	1	1	(5 ±)
Ge	-	1	0.5	-
Hf	(1++)	0.2	0.1	0.5
In	-	0.2	0.1	-
Ir	(5 ppb++)	(5 ppb++)	(5 ppb++)	2
Mo	(5++)	2	2	5
Nb	-	1	0.2	(1 ±)
Ni	(1+)	20 (1+)	20 (1+)	1
Pb	(5+)	5	5	(5 ±)
Rb	(20++)	2	1	20 (2 ±)
S	(100+)	(100+)	(100+)	0.001%
Sb	(0.2++)	0.5 (0.2++)	0.2	0.2
Sc	1	1 (0.1++)	1 (0.1++)	0.1
Se	(3++)	(3++)	(3++)	3
Sn	-	1	1	(5 ±)
Sr	1	2	2	2
Ta	(0.5++)	0.1	0.01	1
Th	(0.2++)	0.1	0.05	0.5
Tl	-	0.1	0.05	-
U	(0.5++)	0.1	0.01	0.5
V	5	5	5	5
W	(1++)	1	0.5	3
Y	1	1	0.5	1
Zn	(1+)	30 (1+)	30 (1+)	2
Zr	2	2	1	4
La	(0.5++)	0.1	0.05	0.5
Ce	(3++)	0.1	0.05	3
Pr	-	0.05	0.01	-
Nd	(5++)	0.1	0.05	5
Sm	(0.1++)	0.1	0.01	0.1
Eu	(0.2++)	0.05	0.005	0.1
Gd	-	0.1	0.01	-
Tb	(0.5++)	0.1	0.01	0.5
Dy	-	0.1	0.01	-
Ho	-	0.1	0.01	-
Er	-	0.1	0.01	-
Tm	-	0.05	0.005	-
Yb	(0.2++)	0.1	0.01	0.1
Lu	(0.05++)	0.01	0.002	0.05
Price:	\$35.75	\$83.75	\$117.75	\$59.00

Code E4B

A lithium metaborate/tetraborate fusion ICP-OES package. 3 g of sample required.

Code E4L

A lithium metaborate/tetraborate fusion ICP-OES and a trace metal ICP-MS package. 5 g of sample required.

Code E4LR

The same as our Code E4L package but with enhanced detection limits. 5 g required.

Code E4EE

This package uses ICP-OES and INAA technologies to completely characterize samples. A minimum sample weight of 5 g is required.

Options:

(+) **Code E4B1:** Optional elements by multiacid digestion. Add 0.5 g. **Add \$10.50**

(++) **Code E4B-INAA:** Optional elements are available by INAA. Add 0.5 - 30 g. **Add \$18.75**

‡ **Code E4E-XRF:** Ga, Pb, Sn, Nb and Rb are examined by Pressed Pellet XRF. This package can be added to Code E4EE. Please add 6 g of sample. **Add \$22.50**

Lithium Metaborate/Tetraborate Fusion - In platinum crucibles, casting the molten sample into a glass disc. Truly a total technique with analysis by XRF.

INAA - Samples are encapsulated and irradiated at the nuclear reactor and measured instrumentally.

Pressed Pellet - Samples are compressed into a powdered disc with a wax binder and analyzed by XRF.

Carbon & Sulphur Analyses

E4F - C-Total (0.01%) by IR	\$17.50
E4F - C-Organic (0.02%) (non-carbonate carbon)	\$33.00
E4F - C-Organic (0.5%) by IR (calc)	\$54.00
E4F - C-Graphitic (0.05%) by IR	\$26.75
E4F - C,S (0.01%) by IR	\$21.50
E4F - S (0.01%) by IR	\$17.50
E4F - Sulphide	\$24.75
E4F - SO ₄ (0.3%) by IR	\$24.75
E4F - CO ₂ (0.01%) by IR	\$18.50

Code E5G - Carbon & Sulphur/Metallurgical Balance Package

Element	Detection Limit	Price: \$91.00/sample
C-Total	0.01%	
C-Graphitic	0.05%	
C-Organic	0.5%	
CO ₂	0.01%	
S	0.01%	
SO ₄	0.3%	

Miscellaneous Analyses

E4F - Cl (0.01%) by INAA	\$32.50
E4F - B (2 ppm) by PGNA	\$44.25
E4F - B (0.5 ppm) by PGNA	\$57.25
E4F - F (0.01%) by ISE	\$22.50
E4F - N (Total)	\$43.00
E4F - Hg by Cold Vapour FIMS	\$9.75
E4F - FeO (0.1%) by Titration	\$18.50
E4F - H ₂ O +/- (0.1%) IR or Gravimetric	\$24.75

Inorganics / Metals - Vegetation

	Humus INAA E2A	Vegetation INAA E2B	Ash Package INAA E2C	Base Metal Vegetation Aqua Regia-ICP E2C1	Ash Package Digestion ICP-MS E2D	Ash Package ICP-MS Au+Pt+Pd E2E	Vegetation Unashed ICP-MS E2G	Vegetation Unashed HR-ICP-MS E2F
Ag	2	0.3	2	0.2	0.2	0.2	3	1
Al					2	2	4 ppm	
As	1	0.01	0.5		1	3	10	5
Au	1 ppb	0.1 ppb	5 ppb			5 ppb	0.2	0.1
B					5	5	1 ppm	200
Ba	100	5	50		3	3	100	1 ppm
Be					0.005	0.08	30	0.1
Bi					0.05	0.05	2	1
Br	1	0.01	1					
Ca	0.5%	0.01%	0.2%		0.1%	0.1%	25 ppm	2 ppm
Cd					0.01	0.01	6	0.1
Ce	1	0.1	3		0.01	0.01	15	0.5
Co	1	0.1	1		0.01	0.01	4	0.5
Cr	1	0.3	1		1	10	100	10
Cs	0.5	0.05	0.5		0.001	0.001	0.2	0.1
Cu				1	0.2	0.2	50	20
Dy					0.001	0.001	0.5	0.05
Er					0.001	0.001	0.4	0.05
Eu	0.2	0.05	0.01		0.001	0.001	0.2	0.1
Fe	0.05%	0.005%	0.05%		0.01%	0.01%	3 ppm	0.5 ppm
Ga					0.1	0.1	4	0.5
Gd					0.01	0.01	0.4	1
Ge					0.1	0.1	3	10
Hf	0.5	0.05	0.5		0.01	0.01	0.4	2
Hg	0.5	0.05	1				2	5
Ho					0.001	0.001	0.2	0.01
In					1 ppb	1 ppb	0.2	0.1
Ir	5 ppb	0.1 ppb	2 ppb					
K		0.01%	0.05%		0.01%	0.01%	10 ppm	10 ppm
La	0.1	0.01	0.1		0.002	0.002	10	0.2
Li					0.5	0.5	10	5
Lu	0.1	0.001	0.05		0.001	0.001	0.5	0.2
Mg					0.01%	0.01%	2 ppm	0.5 ppm
Mn				1	0.1	0.1	100	10
Mo	0.5	0.05	2	1	0.1	0.1	10	1
Na	100	1	10		0.01%	0.01%	5 ppm	10 ppm
Nb					0.005	0.005	2	0.5
Nd	3	0.3	5		0.002	0.002	5	0.2
Ni	10	2	50	1	5	5	50	0.1 ppm
P							4 ppm	
Pb				1	0.1	0.1	50	10
Pd						3 ppb	0.2	2
Pr					0.002	0.002	1	0.5
Pt						2 ppb	0.2	2
Rb	20	1	5		0.01	0.01	10	10
Re					0.1 ppb	0.1 ppb	0.2	0.1
Rh								
Ru						10 ppb		
Sb	0.1	0.005	0.1		0.02	0.02	10	0.2
Sc	0.1	0.01	0.1		0.5	0.5		1
Se	2	0.1	2		1	10	10	0.2 ppm
Si					0.2%	0.2%		
Sm	0.1	0.001	0.1		0.001	0.001	1	0.1
Sn						1	50	40
Sr	100	10	300		0.1	0.1	40	20
Ta	0.5	0.05	0.5		0.001	0.001	0.2	0.1
Tb	0.2	0.1	0.5		0.001	0.001	0.2	0.02
Te					0.01	0.01	8	1
Th	0.5	0.1	0.1		0.001	0.001	2	5
Ti					1	1	150	20
Tl					0.001	0.001	1	0.5
Tm					0.001	0.001	0.1	0.05
U	0.1	0.01	0.1		0.001	0.001	1	1
V					1	10	10	10
W	1	0.05	1		0.5	0.5	25	5
Y					0.001	0.001	2	0.2
Yb	0.1	0.005	0.05		0.001	0.001	0.4	0.4
Zn	20	2	50	1	1	1	400	0.2 ppm
Zr					0.5	0.5	20	5
Price	\$21.50	\$25.50	\$23.50	\$11.75	\$29.25	\$36.50	\$37.50	\$68.75

Codes E2A, E2B, E2C, E2C1, E2D, E2E:
all elements are in ppm, except where noted.
Codes E2F, E2G:
all elements are in ppb, except where noted.

Code E2A - Hummus

Code E2B - Vegetation

Code E2C - Vegetation Ash INAA

Code E2C1 - Vegetation Ash ICP-OES
Prices for Code E2C1 for single element
is \$6.25 with each additional element
costing \$2.75.

Code E2D - Vegetation Ash ICP-MS

Code E2E - Vegetation Ash ICP-MS
Samples are ashed at low temperature
(480°C) and metals are determined on
the ash. Please note when samples are
ashed, there may be volatile loss of
certain elements (Au, As, Br, Hg, Cd,
etc). Results are reported on an ash
weight basis. Not all elements may be
total.

Code E2F - Vegetation HR-ICP-MS
Dry vegetation samples are dissolved in
acid and analyzed by High Resolution
ICP-MS.

Code E2G - Vegetation ICP-MS
Dry vegetation samples are dissolved in
acid and analyzed by ICP-MS.
***** RECOMMENDED*****



*Actlabs only ashes vegetation in
dedicated vegetation ashing furnaces
to avoid contamination.*

Organics - Soil

Code E6W Organics (Soils)

Analysis	Method Instrumentation	Price
Phenols / Total Phenols (4AAP)	SKALAR Autoanalyzer (4AAP)	\$66.25
Atrazine	GC-MS	\$36.75
Bisphenol (A) and BHT (Butylated Hydroxytoluene)	GC-MS	\$73.50
BTEX (Benzene / Toluene / Ethyl Benzene / Xylenes)	GC-MS	\$50.50
FAME (Fatty Acids)	GC-MS	\$147.00
Glycols (Polyethylene and Polypropylene)	GC-MS	\$47.25
Geosmin and Methyl-Isoborneol (MIB)	GC-MS	\$126.00
Phthalates and Adipate	GC-MS	\$99.75
Polychlorinated Biphenyls (PCB - Total Arochlors)	GC-MS	\$68.25
Polychlorinated Biphenyls (PCB - Cogener Specific)	GC-MS	\$126.00
Polybromated Biphenyls and Polybromated Diphenyl Ethers (PPB and PBDE)	GC-MS	\$204.75
Polycyclic Aromatic Hydrocarbons (PAH/PNA - 16 compounds)	GC-MS	\$198.00
Sulfur (Elemental)	GC-MS	1-5 samples \$78.75 6+ samples \$63.00
Total Petroleum Hydrocarbons (VOH - C5-C10)	GC-FID	\$47.25
Total Petroleum Hydrocarbons (TPH - Gasoline and Diesel Fuel Range - C10-C44)	GC-FID	\$92.00
Trihalomethanes (THM)	GC-MS	\$50.50
Volatile Organic Contaminants (VOC)	GC-MS	\$126.00

NOTE: Contact laboratory for a list of specific compounds and their Detection Limit capabilities.

TPH not compliant to CCME guidelines.

Radionuclides

Naturally-Occurring Radioactive Materials (NORM) consist of radioactive material that comes out of the earth's crust and mantle. Human activity results in increased radiological exposure. Industries, excluding uranium mining and all associated fuel cycle activities, are known to have NORM issues, include coal mining and combustion, oil and gas production, metal mining and smelting, mineral (rare earth, titanium and zirconium), fertilizer (phosphate), building and recycling.

Actlabs provides NORM radiological testing to determine whether materials meet the safe limits for handling, disposal and transportation. The following radionuclides are usually regulated under the NORM guidelines: **Uranium²³⁸ series, Thorium²³⁰, Radium²²⁶, Lead²¹⁰, Thorium²³², Radium²²⁸, Thorium²²⁸ and Potassium⁴⁰.**

Solids and waters are analyzed using a Gamma Spectroscopy method for the NORM radioactive elements.

Code E14 - Radiochemical Test Packages

The following radiochemical tests are offered for both geological (solid, water, vegetation, sediment, soil and rock) and environmental materials.

Nuclide	Method	Water - Detection Limit	Solid - Detection Limit	Price - Water	Price - Solid
Ra ²²⁶	Alpha Spectrometry	0.005 Bq/L	0.01 Bq/g	\$193.00	\$225.00
Gross α, Gross β	L/B Alpha, Beta Counting	α = 0.05 Bq/L; β = 0.15 Bq/L	α = 0.05 Bq/g; β = 0.15 Bq/g	\$128.75	\$128.75
Pb ²¹⁰	L/B Alpha, Beta Counting	0.01 Bq/L	0.1 Bq/g	\$214.25	\$246.50
Po ²¹⁰	Alpha Spectrometry	0.01 Bq/L	0.01 Bq/g	\$187.50	\$219.75
Th ²³⁰ and Th ²³²	Alpha Spectrometry	0.01 Bq/L	0.01 Bq/g	\$214.25	\$246.50
Ra ²²⁸	Beta Counting	0.01 Bq/L	0.04 Bq/g	\$214.25	\$246.50

Code E15 - Gamma Scan Method: Gamma Spectrometry

Nuclide	Detection Limit
Pb ²¹⁰	0.1 Bq/g
Ra ²²⁶	0.1 Bq/g
Pb ²¹²	0.05 Bq/g
Pb ²¹⁴	0.1 Bq/g
Tl ²⁰⁸	0.03 Bq/g
Bi ²¹²	0.05 Bq/g
Bi ²¹⁴	0.1 Bq/g
Ac ²²⁸	0.1 Bq/g
K ⁴⁰	1.0 Bq/g
Price	\$107.00

Many different radioactive elements can be determined by gamma scan in different types of materials.

Cs²³⁴ Cs¹³⁷ Pb²¹⁰
 Pb²¹⁴ K⁴⁰ Ra²²³
 Ra²²⁶ Ra²²⁸ Tl²⁰⁸
 Th²²⁷ Th²²⁸ Th²³⁰
 Th²³⁴ U²³⁵

U²³⁸ and Th²³² are analyzed by HR-ICP-MS.

Code E16A - Equivalent uranium (eU)

Method: Gamma Spectrometry

Nuclide	Detection Limit
K ⁴⁰	1.0 Bq/g
U ²³⁸	0.01 Bq/g
Th ²³²	0.01 Bq/g
Price	\$214.25

Code E16B - Uranium Isotopes

Nuclide	Method	Water - D.L.	Solid - D.L.	Price - Water	Price - Solid
Uranium Isotopes	Alpha Spectrometry	0.01 Bq/L	0.01 Bq/g	\$202.00	\$220.75
	HR-ICP-MS	0.01 Bq/L	0.01 Bq/g	\$69.75	\$69.75

Code E17 - Equilibrium Studies

The most abundant naturally occurring radioactive elements are potassium (K) uranium (U) and thorium (Th). K, eU and eTh are determined by gamma spectrometry from daughter products of the uranium and thorium series. The method assumes that the decay series are in radioactive equilibrium. The samples are sealed and stored for a minimum of 28 days before analysis. When total U, Th and K are determined, it is possible to determine if the samples are in equilibrium with their natural environment or if components have been leached out.

X-Ray Diffraction, Isotopic Analysis

X-Ray Diffraction

Most minerals are crystalline and therefore scatter X-rays in a regular, characteristic way dependant on their crystal structure. Each mineral produces a unique diffraction pattern and can be identified from that pattern like a fingerprint. Identification of minerals is made by comparing their diffraction patterns with a library of over 17,000 mineral patterns stored in the International Centre for Diffraction Data (ICDD). Detection limits depend on the sample. For geological material, it is estimated that the minerals present in less than 2% of the sample might not be detected. The samples for X-ray diffraction analysis are ground or milled to a fine powder and then hand pressed into the sample holder. Approximately 1cm³ of the material is sufficient for rock mineral analysis but smaller amounts can also be accommodated by using a low background holder.

Code E9	Price
Mineral Identification (semi-quantitative) - minerals are identified and their amounts determined using the Rietveld method	\$107.00
Mineral Identification (quantitative) - minerals are identified and their amounts determined using the Rietveld method Corundum is added to the sample as an internal standard in order to determine the amount of X-ray amorphous material	\$166.25
Mineral Identification (qualitative) - minerals are identified, however their amounts are not determined	\$80.25
Clay Speciation	\$214.25
Alpha Quartz	\$107.00
Mineral Identification (Rietveld) + Clay Speciation	\$321.25

* Quantity discounts may be applicable.

Isotopic Analysis

Code E10A

Parameter	Amt. Required	Precision	Price
Pb - Isotopic analysis by HR-ICP-MS (Pb >15ppm) (1-10 samples)	~ 1 g	0.4 - 0.5%	\$225.00
Pb - Isotopic analysis by HR-ICP-MS (Pb >15ppm) (>10 samples)	~ 1 g	0.4 - 0.5%	\$166.25
Pb - Isotopic analysis	~ 1 g	0.1 - 0.2%	On request
Nd - Isotopic Analysis	~ 1 g		On request
Sr - Isotopic Analysis	~ 1 g		On request
Sm-Nd - Isotopic Analysis	~ 1 g		On request
Rb-Sr - Isotopic Analysis	~ 1 g		On request
Hg - Isotopic Analysis	~ 1 g		On request
$\delta^{13}\text{C}$ - Graphite or Organic Material	1 mg C	0.2 ‰	\$179.25
$\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ - Carbonates	1 mg C	0.2 ‰	\$124.00
$\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ - Siderite, Magnesite, Dolomite	1 mg C	0.2 ‰	\$179.25
Nitrogen Isotopes - Organic Material			\$166.25
Deuterium Isotopic Analysis - Water	20 ml	3.0 ‰	\$198.25
Deuterium Isotopic Analysis - Minerals	1 mg	0.2 ‰	\$455.25
$\delta^{18}\text{O}$ - Water	20 mL	0.2 ‰	\$131.75
$\delta^{18}\text{O}$ - Silicates	15 mg	0.3 ‰	\$297.25
$\delta^{18}\text{O}$ - Sulphates	25 mg	0.3 ‰	\$168.50
$\delta^{18}\text{O}$ - Organics	10 mg N	0.2 ‰	\$173.50
$\delta^{34}\text{S}$ - Sulphate	10 mg	0.2 ‰	\$114.00
$\delta^{34}\text{S}$ - Sulphate in water			\$178.50
$\delta^{34}\text{S}$ - Sulphide	5 mg	0.2 ‰	\$114.00
$\delta^{34}\text{S}$ - Sulphide-bearing material which contains carbonate	100 mg	0.2 ‰	\$158.50
$\delta^{34}\text{S}$ - Silicate rocks which contain sulphur			\$158.50
^3H - Direct	20 mL	8.0 TU	\$171.50
^3H - Enriched	1L	0.8 TU	\$460.75
^3H - Accelerator Mass Spectrometry (AMS)	1L		\$749.75
C-14 - Accelerator Mass Spectrometry (AMS)	please inquire		\$642.50

EPA Method 6010C - Inductively Coupled Plasma-Atomic Emission Spectrometry

Price: \$64.25

Inductively coupled plasma-atomic emission spectrometry (ICP-OES) may be used to determine trace elements in solution. The method is applicable to all of the elements listed below. With the exception of groundwater samples, all aqueous and solid matrices require acid digestion prior to analysis. Groundwater samples that have been prefiltered and acidified will not need acid digestion.

Element	Element	Element	Element
Aluminum (Al)	Chromium (Cr)	Molybdenum (Mo)	Sodium (Na)
Antimony (Sb)	Cobalt (Co)	Nickel (Ni)	Strontium (Sr)
Arsenic (As)	Copper (Cu)	Phosphorus (P)	Thallium (Tl)
Barium (Ba)	Iron (Fe)	Potassium (K)	Tin (Sn)
Beryllium (Be)	Lead (Pb)	Selenium (Se)	Titanium (Ti)
Boron (B)	Lithium (Li)	Silica (SiO ₂)	Vanadium (V)
Cadmium (Cd)	Magnesium (Mg)	Silver (Ag)	Zinc (Zn)
Calcium (Ca)	Manganese (Mn)		

If filtering and acidifying required, add \$15.00.

EPA Method 6020A

Price: \$75.00

Inductively coupled plasma-mass spectrometry (ICP-MS) is applicable to the determination of sub- $\mu\text{g/L}$ concentrations of a large number of elements in water samples and in waste extracts or digests. When dissolved constituents are required, samples must be filtered and acid-preserved prior to analysis. No digestion is required prior to analysis for dissolved elements in water samples. Acid digestion prior to filtration and analysis is required for groundwater, aqueous samples, industrial wastes, soils, sludges, sediments, and other solid wastes for which total (acid-soluble) elements are required.

ICP-MS has been applied to the determination of over 60 elements in various matrices. Analytes for which EPA has demonstrated the acceptability of this method in a multilaboratory study on solid and aqueous wastes are listed below.

Element	Element	Element	Element
Aluminum (Al)	Calcium (Ca)	Magnesium (Mg)	Silver (Ag)
Antimony (Sb)	Chromium (Cr)	Manganese (Mn)	Sodium (Na)
Arsenic (As)	Cobalt (Co)	Nickel (Ni)	Thallium (Tl)
Barium (Ba)	Copper (Cu)	Potassium (K)	Vanadium (V)
Beryllium (Be)	Iron (Fe)	Selenium (Se)	Zinc (Zn)
Cadmium (Cd)	Lead (Pb)		

If filtering and acidifying required, add \$15.00.

EPA Method 200.8 - Determination of Trace Elements in Waters and Wastes by ICP-MS

Price: \$90.75

This method provides procedures for determination of dissolved elements in ground waters, surface waters and drinking water. It may also be used for determination of total recoverable element concentrations in these waters as well as wastewaters, sludges and soils samples.

Element	Element	Element	Element
Aluminum (Al)	Chromium (Cr)	Mercury (Hg)	Thallium (Tl)
Antimony (Sb)	Cobalt (Co)	Molybdenum (Mo)	Thorium (Th)
Arsenic (As)	Copper (Cu)	Nickel (Ni)	Uranium (U)
Barium (Ba)	Lead (Pb)	Selenium (Se)	Vanadium (V)
Beryllium (Be)	Manganese (Mn)	Silver (Ag)	Zinc (Zn)
Cadmium (Cd)			

If filtering and acidifying required, add \$15.00.

EPA Method 200.7

Price: \$64.25

Inductively coupled plasma-atomic emission spectrometry (ICP-OES) is used to determine metals and some nonmetals in solution. This method is a consolidation of existing methods for water, wastewater, and solid wastes.

Element	Element	Element	Element
Aluminum (Al)	Calcium (Ca)	Lead (Pb)	Nickel (Ni)
Antimony (Sb)	Cerium (Ce)	Lithium (Li)	Phosphorus (P)
Arsenic (As)	Chromium (Cr)	Magnesium (Mg)	Potassium (K)
Barium (Ba)	Cobalt (Co)	Manganese (Mn)	Selenium (Se)
Beryllium (Be)	Copper (Cu)	Mercury (Hg)	Silica (SiO ₂)
Boron (B)	Iron (Fe)	Molybdenum (Mo)	Silver (Ag)
Cadmium (Cd)			

If filtering and acidifying required, add \$15.00.

Static Testing

Code E11 – Acid-Base Accounting

Acid Base Accounting (ABA) is used to make static measurements of Acid Rock Drainage potential. Measurements of total sulphur or sulphide sulphur are used to estimate the amount of acid bearing material. Using this information the Neutralization Potential (NP), Acid Producing Potential (AP) and Net Neutralization Potential (Net NP) are reported.

The Sobek package is the original method described by Sobek for the US EPA. The Modified Sobek package is that by Lawrence and Wang. The Siderite correction package applies a method to limit the overestimation of Net NP in the Sobek method caused by the presence of siderite.

Actlabs offers the following ABA packages:

Parameter	11-Acid/Base Package	11-Acid/Base Enhanced Package	11-Acid/Base Supreme Package
AP	•	•	•
NP	•	•	•
Net NP	•	•	•
MPA	•	•	•
NP: MPA Ratio	•	•	•
Paste pH	•	•	•
Sulphur (total)	•	•	•
Acid Soluble Sulphate		•	•
Sulphide		•	•
Sulphate (total)			•
CO ₂			•
Sobek Package	\$80.25	\$107.00	\$150.25
Modified Sobek Package	\$134.00	\$160.75	\$203.75
Siderite Correction Package	\$134.00	\$160.75	\$203.75

Code E11 – Maximum Potential Acidity (MPA)

The amount of acid that could be generated by the sulphur contained within a sample. This is done assuming that all sulphur occurs as reactive pyrite.

Code E11 – Net Acid Generation (NAG)

A direct oxidation method used to estimate the acid forming potential of a sample. The sample is reacted with hydrogen peroxide to oxidize any sulphide minerals present. The sample must be acid generating and not acid neutralizing. This causes acid generation and acid neutralization to occur simultaneously, with the end result being a direct measurement of the net amount of acid a sample can generate. If the reacted sample has a pH of 4.5 or less it is likely to be acid generating. Titration of the mixture is used to determine the amount of acidity generated. False positive results may occur if a high organic content is present. This false positive can be identified by combination with a NAPP test. In order to analyze for metals in the leachate a full second leach must be performed. Therefore the procedure will be charged twice.

Price per sample: \$117.75

Price per sample with NAG and NAPP: \$235.75

Code E11 – Acid Neutralizing Capacity (ANC)

Acid buffering inherent to the sample caused by a reaction of produced acid with other minerals contained within the sample. The ANC is determined using the Modified Sobek Method. A known amount of hydrochloric acid is added to a sample and allowed to react. The sample is then back-titrated with sodium hydroxide to determine the amount of unreacted HCl. The amount of acid consumed by the reaction with the sample is calculated and expressed as kg H₂SO₄/t.

Price per sample: \$150.25

Code E11 – Net Acid Production Potential (NAPP)

Amount of acid potentially produced by a sample after allowing for inherent neutralizing capacity (ANC). The NAPP is calculated using the formula: NAPP = Maximum Potential Acidity – ANC.

Refer to ANC and ABA for pricing.

Kinetic Testing

Code E11 – Kinetic Net Acid Generation

This test provides an indication of the reactivity of sulphides contained within a sample. It is used to provide a qualitative assessment of the likely lag time before the onset of acid conditions in the field. The test is performed like the NAG test, however the pH and temperature are monitored. The reaction kinetics are then extrapolated to the field situation.

Price per sample: \$128.75

Code E11 – Sequential Net Acid Generation

Samples with high sulphide content may need to be reacted with hydrogen peroxide more than once in order to ensure complete oxidation of all sulphides has occurred. A sample is reacted several times and at the end of each stage the sample is filtered to separate the solids and NAG liquor. The NAG liquor is then assayed for pH and acidity, following the method for a standard NAG test. The solids are then recovered for repeat oxidation. The total NAG capacity of the sample is determined by adding the individual acid capacities from each stage.

Please inquire for price.

Code E11 – Acid Buffering Characterization Curves (ABCC)

ABCC is determined by acidifying a sample with dilute acid to approximately pH of 3 in a 16 to 24 hour time period. This method typically accounts for more readily available carbonates, such as calcite and dolomite, as this is a less aggressive treatment than the ANC method. When carbonates are present in sufficient quantity they will typically buffer a waste rock at near neutral pH. This is required to maintain low metal solubilities.

Please inquire for price.

Code E11 – Free Draining Kinetic Column Leach Procedure

These columns are used in addition to environmental geochemical investigations on mine rock and waste materials to determine drainage chemistry. The columns simulate field weathering conditions in order to provide data for sulphide reactivity, oxidation kinetics, metal solubility and leaching behavior of test materials. The procedure simulates a weekly wet-dry cycle and a monthly leaching cycle.

Please inquire for price.

Code E11 – Shake Flask Extraction (SFE)

Used to obtain leached elements of interest, such as As, Se and Hg, from a sample. Leached elements are analyzed using ICP-MS and measurements of pH and conductivity are reported.

Price per sample: \$64.25

Code E12 - Leachate Quality

Parameters	Leachate Extraction & Analysis
SWEP	•
TCLP	•
EPA (includes metals and Hg)	•
MWEP (leach only for metals)	•
Price	On request

Leachate Extraction Procedure - for organics
Please inquire

Code E13 - Humidity Cell (ASTM D5744 – 96)

This method accelerates the natural weathering rate of a sample causing diagnostic weathering products. The weekly parameters measured are pH, Eh, conductivity, sulphate-ion concentration, acidity and alkalinity. Selected metals are measured on a less regular basis (weeks 0, 1, 2, 4, 8, 12, 16 and 20). Weekly cycles are used with three days of dry air, followed by three days of water saturated air. Day 7 uses a leach with water. It is recommended that a test duration of 20 weeks be used.

Test
Humidity Cell set-up
Weekly Humidity Cell test
Metal Measurements (Cu, Zn) (cost per analysis)

Price on Request.



Periodic Table of the Elements

Atomic number
Element symbol
Atomic mass
Name

Substrate Type:
 Rock
 Vegetation
 Water

Standard States (25°C, 101 kPa)
 Solid
 Liquid
 Gas
 Artificially Prepared

Preferred Analytical Method
 ICP-MS
 ICP-OES
 INAA
 Fire Assay
 CV-FIMS
 Ion Chromatography
 ISE
 Infrared
 XRF

ICP-MS on vegetation is based on Ash

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H Hydrogen 1.008	2 He Helium 4.0026	3 Li Lithium 6.94	4 Be Beryllium 9.0122	5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180	11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43* Tc Technetium [98]	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29
55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanoids 57-71	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61* Pm Promethium [145]	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.05	71 Lu Lutetium 174.97	
87* Fr Francium [223]	88* Ra Radium [226]	89-103 Actinoids	89* Ac Actinium [227]	90* Th Thorium 232.04	91* Pa Protactinium 231.04	92* U Uranium 238.03	93* Np Neptunium [237]	94* Pu Plutonium [244]	95* Am Americium [243]	96* Cm Curium [247]	97* Bk Berkelium [247]	98* Cf Californium [251]	99* Es Einsteinium [252]	100* Fm Fermium [257]	101* Md Mendelevium [258]	102* No Nobelium [259]	103* Lr Lawrencium [262]
113* Nh Nihonium [284]	114* Fl Flerovium [289]	115* Mc Moscovium [288]	116* Lv Livermorium [293]	117* Ts Tennessine [292]	118* Og Oganesson [294]	119* Uue Ununennium [295]	120* Uub Unbinilium [296]	121* Uut Untrium [297]	122* Uuq Unquadium [298]	123* Uuq Unquadium [299]	124* Uuq Unquadium [300]	125* Uuq Unquadium [301]	126* Uuq Unquadium [302]	127* Uuq Unquadium [303]	128* Uuq Unquadium [304]	129* Uuq Unquadium [305]	130* Uuq Unquadium [306]

* identifies a radioactive element (unstable)
 The updated atomic masses (2016) are from the IUPAC website <http://www.iupac.org>