

# Statement of Qualifications

November, 2000

Frontier  
Geosciences



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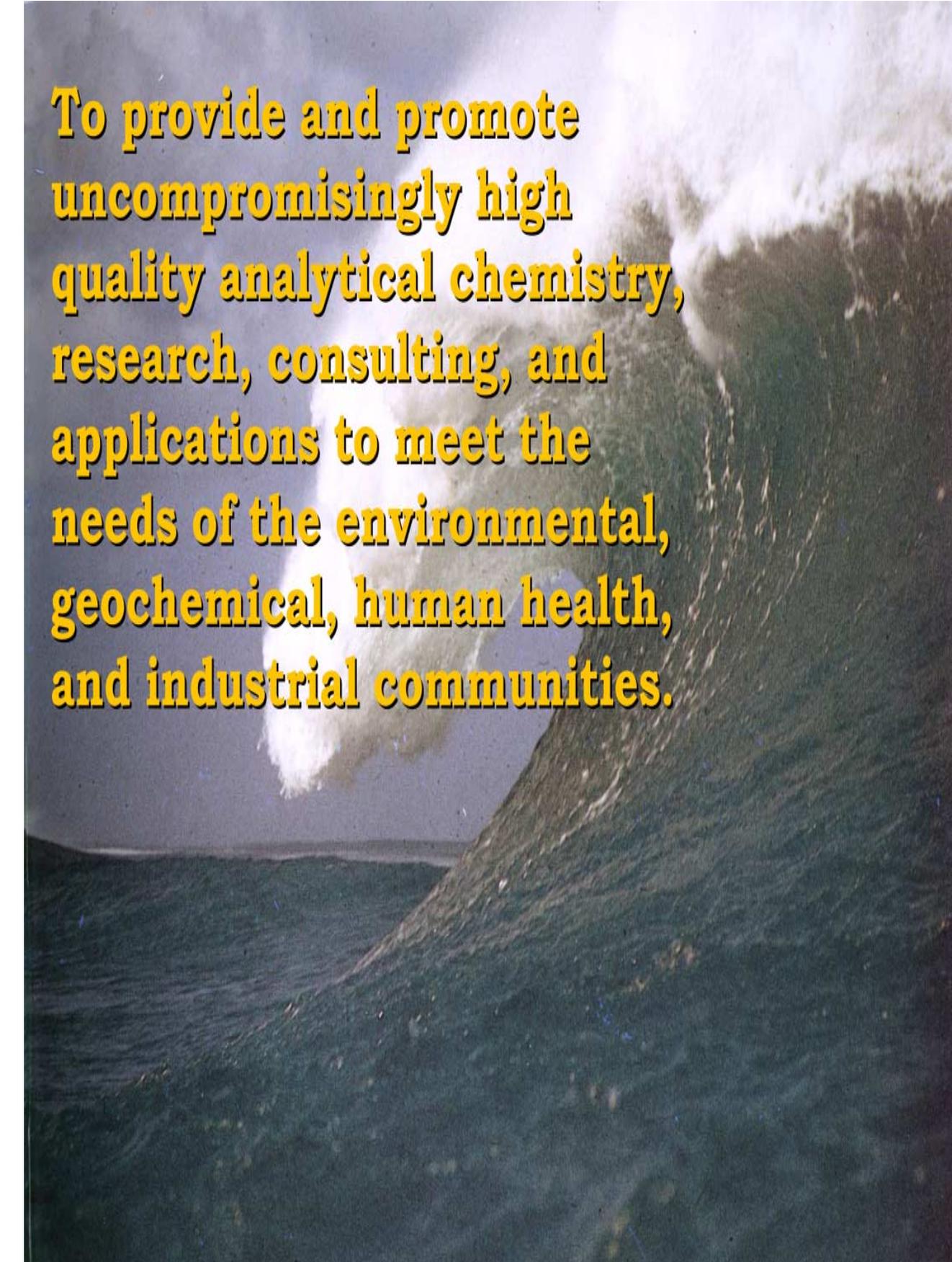
# CONTENTS

## Statement of Qualifications Contents

Company Profile .....	1
Capabilities .....	5
Bioavailability Studies .....	5
Field Sampling and Training .....	6
Flue Gas Emissions .....	6
Geochemistry .....	7
High Level Quality Assurance .....	7
Inter-Laboratory Intercomparisons .....	8
Low Level Cyanide Analysis by EPA Method 1677 .....	9
Organics Analysis .....	10
Project Design .....	11
Rapid Turn Around Time .....	11
Reaction Rate Studies .....	12
Speciation .....	12
Trace Metals Analysis .....	13
Waste Remediation Research .....	15
Customized Equipment Sales .....	15
Quality Assurance .....	16
Philosophy .....	16
QC Documentation with Frontier Data Packages .....	18
Quality Assurance Consulting .....	19
Personnel .....	21
Organizational Chart .....	21
How to Contact Us (company email addresses) .....	22
Shipping and Billing Address .....	24
Key Scientific Personnel .....	25
Nicolas S Bloom, Senior Research Scientist .....	25
Robert C. Brunette, Research Scientist .....	26
Anne Fowler, Project Manager .....	27
Michelle L. Gauthier, Laboratory Manager .....	28
Misty Kennard, Project Manager .....	29
Eric M. Prestbo, Senior Research Scientist .....	29
Eric von der Geest, Project Manager .....	30
Dirk Wallschläger, Research Scientist .....	31
Student Researchers .....	33

Facility Description .....	35
Facility.....	35
Major Analytical Equipment .....	37
Recent Project Descriptions .....	38
Rapid Response to an Environmental Hg Spill (Bloom) .....	38
Atmospheric Transformations of Mercury (Prestbo).....	39
Carson River Mercury Speciation Study (Bloom) .....	39
Diagenesis of Mercury in Marine Sediments (Bloom) .....	40
Long-Range Transport of Mercury Species (Prestbo) .....	40
Everglades Nutrient Removal Project (von der Geest) .....	41
Mercury at Chlor-Alkali Production Sites (Bloom) .....	41
Use of a Dilution Chamber to Study Combustion (Prestbo) .....	42
Mercury Speciation at Mining Sites (Bloom) .....	43
National Mercury Deposition Network (Brunette).....	43
Atmospheric Mercury Speciation Emissions(Prestbo) .....	44
New York Harbor Dredge Study (Gauthier) .....	45
Sacramento River Ambient Monitoring (Gauthier) .....	45
Selenium Speciation Methods Development (Wallschläger) .....	46
US EPA's 1600-Series Reference Laboratory (Bloom).....	46
Financial Information .....	47
Pricing Guidelines and General Business Information .....	47
Typical Price Ranges .....	49
Subcontracts .....	49
Insurance .....	50
Sample Basic Ordering Agreement (BOA) Form .....	51
Methods and Method Detection Limits .....	54
Methods .....	54
Method Detection Limits .....	54
Commonly Used Analytical Methods at Frontier .....	56
Recent MDLs for Fresh Water .....	57
Recent MDLs for Seawater .....	58
Recent MDLs for Sewage Effluent .....	59
Recent MDLs for Solids.....	60
Sample Handling .....	61
Sample Containers, Shipping and Receiving.....	61
Who to Contact .....	61
Preservation/Shipping .....	62
PLEASE READ THIS .....	62
Containers and Preservation .....	63

# CONTENTS



**To provide and promote  
uncompromisingly high  
quality analytical chemistry,  
research, consulting, and  
applications to meet the  
needs of the environmental,  
geochemical, human health,  
and industrial communities.**

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## Frontier Geosciences Inc.



Frontier Geosciences Inc. is a small, innovative environmental research, consulting, and analytical services company. Frontier specializes in leading-edge research on the sources, fate, and effects of toxic trace metals in the environment. With their strong biogeochemical background, Frontier consultants pride themselves on giving accurate interpretations of field results, designing experiments, and also designing novel, effective, trace metal remediation strategies. In fact, because of its science-based, unbiased approach, and universally respected integrity, industrial, academic, regulatory, and environmental advocacy groups have hired Frontier, at the same time, on the same controversial projects. Frontier's laboratory technicians and analysts are dedicated to producing accurate, precise, and scientifically cohesive data. Finally, all of Frontier's staff members maintain the highest standards for professionalism in customer service.

Although Frontier specializes in the entire range of trace metals biogeochemistry and speciation, it is in the field of mercury research where it has made its biggest mark. The techniques that co-founder, Nicolas S Bloom, helped develop are recognized as the method-of-choice, and are now used world wide for mercury detection, measurement, and speciation. Frontier's research scientists publish more than thirty journal articles, government reports, and



scientific presentations yearly, covering such diverse areas as atmospheric chemistry, analytical methods development, sediment/water exchange, and bio-monitoring. Approximately ten of these focus on the subject of mercury alone. In 1996, Nicolas Bloom was appointed to the EPA National Science Advisory Board as a reviewer for their Mercury Report to Congress, and has been retained as an advisory board member since. Frontier's research scientists authored, co-authored, or assisted with eight of the EPA's 1600 Method Series on ultra-clean analytical procedures. Two of those authored were on mercury and methyl mercury determination.

Frontier began extending its scientific focus beyond mercury research in 1994, developing and enlarging its capabilities for biogeochemical research, environmental monitoring, remediation analyses, compliance monitoring, and toxicity studies. The company has grown exponentially since then. Research groups at Frontier now include atmospheric sciences, wastewater treatment, methods development, aquatic geochemistry, and chemical oceanography and limnology. Most recently, Frontier has added a Quality Assurance (QA) consulting capability. This group is leading the way toward revising QA from rigid, bureaucratic policing, to methods based more on holistic, scientific coherence.

Frontier was founded in 1992 by Nicolas S Bloom (research scientist) and Sharon K. Goldblatt (administrator), and currently employs approximately fifty scientists, technicians, and administrative staff. It was the founders' goal to establish a sort of "artists' colony" for scientists—a place where intellectual creativity and cooperation could flourish. The founders also envisioned a place where they could develop sophisticated capabilities to enable the most efficient use of society's limited financial commitment to environmental improvement. With the help of a growing, dedicated staff, Frontier's founders worked hard to create a workplace that is inviting and stimulating. Locally produced art is exhibited throughout the facility to encourage and stimulate "outside-the-box" thinking. Frontier hosts seminars, workshops, and conferences featuring top-notch scientists from around the world, and invites the most promising graduate students for post-graduate appointments in the fields of oceanography, limnology, analytical chemistry, and environmental science.

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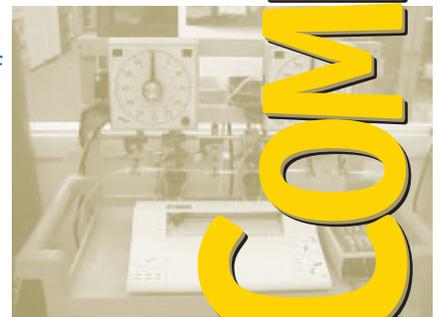
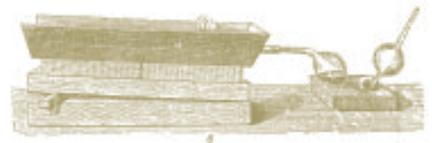
# COMPANY PROFILE



Frontier holds a unique niche in the business of environmental science research. While not an educational institution, principal investigators in Frontier's research and consulting group conduct academic-level scientific research, and mentor 2-3 college, graduate, and post-graduate students yearly. Although Frontier is not a volume-driven testing laboratory, analysts and technicians in the analytical laboratory conduct approximately \$3.5 million of specialty analytical services annually. As a for-profit S-corporation, Frontier competes with other research organizations and laboratories –most commonly not-for-profit agencies— for contracts. Frontier offers consulting services directly to clients, but very often other consultants hire Frontier researchers and project managers because their biogeochemical expertise and data interpretation abilities extend beyond the scope of most scientific consulting companies. Profits at Frontier are divided into three categories: business expenses, company-wide profit sharing, and reinvestment in the company. The reinvestment portion includes staff and equipment maintenance, and internal Frontier investment in research and development. Internally-funded research at Frontier results in approximately eight scientific journal publications, government reports, and conference presentations annually.

Frontier's business philosophy is progressive. It has been the recipient of awards from two Washington State governors for its hiring practices, and its human resources managers maintain an aggressive affirmative action program. The highest paid employees at Frontier are not permitted to make more than three times the pay of the lowest paid employees. Volunteer work is encouraged among the staff, and those who choose to do so are compensated at half their normal pay rate for up to 200 volunteer hours per year. On a corporate basis, Frontier provides pro bono or highly discounted analytical services and consulting to many small, non-profit, and environmental advocacy groups each year. Approximately five percent of Frontier's profits are contributed to philanthropic causes such as environmental improvement and conservation, medical research, programs to combat hunger and homelessness, and support of the arts in the local community.

Over the years, Frontier's founders have sold shares in the company to seven more of its employees, as a precursor to its ultimate plan of becoming a fully employee-owned company. This encourages long-term retention of the highest quality researchers and analysts, enhancing



# COMPANY PROFILE



# COMPANY PROFILE

both technical proficiency and the kind of scientific acumen that can only come from extensive experience.

In addition to laboratories, offices, and a clean room, our facilities include two Perkin-Elmer Elan 6000 ICP-MS's, a Zeeman graphite furnace atomic absorption spectrophotometer, as well as sophisticated custom-built analytical equipment for mercury, arsenic, selenium, and tin speciation—including a variety of ultra-sensitive detectors (atomic fluorescence, atomic absorption, UV-VIS, and electrochemical). We also have gas chromatographs, ultra-clean sampling equipment, a network of personal computers, water and air purification systems, support equipment and a full shop. We maintain a full inventory of Teflon and HDPE bottles and vials of various sizes for low-level metals research and sampling for clients, and a custom-built room for cleaning them according to rigorous procedures. In addition to our principal investigators, technical support personnel, and administrative staff, we also retain a carpenter, machinist, and glass fabricator for timely construction and development of constantly improving state-of-the-art equipment.



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**F**rontier consists of two main groups, Research & Consulting, and the Analytical Laboratory. Within each group are several subgroups, divided according to areas of research expertise (such as mercury, atmospheric, and trace metals). Following is a list and descriptions of Frontier's research, consulting, and analytical capabilities. For more detailed information, please call or email us. The email address of the relevant Frontier researcher is listed at the bottom of each capability description. If you are unsure, please email us at our general address: [Info@Frontier.WA.com](mailto:Info@Frontier.WA.com) and we will send you an information packet including the name and address of a suggested project manager.

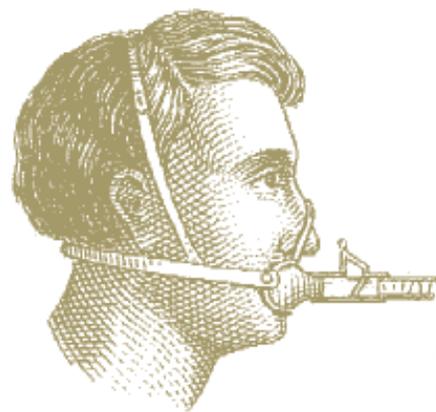


## Bioavailability Studies

**B**ecause of our extensive capabilities in aquatic and solid phase metals speciation, Frontier Geosciences has been involved in many sophisticated bioavailability, ecotoxicity, and food chain dynamics studies. We customarily team with partners, such as Trent University or Battelle MSL who have wet-lab exposure facilities, to set up toxicity or bioaccumulation studies with either ourselves or our partners in the lead. We have particular experience looking at the aquatic and terrestrial food chain dynamics (including individual zooplankton) of mercury and methyl mercury, through our collaboration on the Mercury in Temperate Lakes Project (MTL), MAPP, Carson River, Sudbury River, and Lavaca Bay studies. Please contact Nicolas Bloom ([NicolasB@Frontier.WA.com](mailto:NicolasB@Frontier.WA.com)) concerning the solid phase speciation of metals or food chain studies.



# CAPABILITIES



# CAPABILITIES

## Field Sampling and Training



Frontier developed and popularized ultra-clean sample handling protocols for environmental trace metal research and monitoring. These protocols are now used by researchers and clients around the world to lower their ultimate limits of detection. In some cases adoption of these protocols has eliminated sampling-related contamination, and precluded further monitoring under permits. In 1996 Frontier staff helped co-develop and write the new EPA ultra-clean sampling protocols, Method 1669. With our years of experience, Frontier can help clients perform this method with minimal difficulty and inconvenience. We can also implement air-free ultra-clean sediment pore water extraction in the field. Frontier has an extensive collection of ultra-low level sampling equipment, including Teflon-coated Go-Flo bottles, peristaltic and submersible pumping systems, pre-cleaned tubing, filtration units, and thousands of Teflon bottles. We can also pre-clean and modify or build low-level sampling and analytical equipment, and can provide field sampling crews and on-site analyses as needed. Frontier conducts seminars and on-site training, and has authored several articles on these subjects. Contact Michelle Gauthier for aquatic sampling ([MichelleG@Frontier.WA.com](mailto:MichelleG@Frontier.WA.com)), Bob Brunette for atmospheric sampling ([BobB@Frontier.WA.com](mailto:BobB@Frontier.WA.com)), and Nicolas Bloom for contaminated site and groundwater work ([NicolasB@Frontier.WA.com](mailto:NicolasB@Frontier.WA.com)). We'll also be happy to send you our packet entitled "Ultra-Clean Sample Handling."

## Flue Gas Emissions



Frontier Geosciences is highly experienced in the field of mercury emissions research; especially research on emissions from industrial and combustion gas streams. We have developed a rapid and economical means of Hg speciation and total Hg measurement in combustion flue gas (using solid sorbent traps instead of cumbersome impingers). The application of this method, combined with recent advances in fossil fuel analysis, has allowed successful routine mass-balancing of combustion sources. Frontier has developed the capability to determine the fate of Hg in emission plumes using a Static Plume Dilution Chamber (SPDC). Data from SPDC experiments are being used to improve national atmospheric models

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of mercury deposition from combustion sources. By teaming with outside sampling crews, Frontier Geosciences can provide full US EPA Method 5 trace metal capability. For more information contact Bob Brunette ([BobB@Frontier.WA.com](mailto:BobB@Frontier.WA.com)), or Eric Prestbo ([EricP@Frontier.WA.com](mailto:EricP@Frontier.WA.com)).

## Geochemistry

 The research and consulting staff at Frontier Geosciences is highly experienced with geochemical and aquatic processes. Our expertise is therefore particularly valuable for studies on the fate and effects of environmental trace metals. Frontier has quantified trace metal mass balances in systems ranging in size from global, to regional, to individual industrial plants. Mass balance studies for trace metals require much higher levels of accuracy and precision than ordinary testing laboratories can provide. In addition, an understanding of the underlying processes affecting the distribution of constituents is necessary to assure that all important fluxes and pools are considered, while not wasting resources by quantifying unnecessary parameters. Please contact Nicolas Bloom ([NicolasB@Frontier.wa.com](mailto:NicolasB@Frontier.wa.com)), or Dirk Wallschläger ([DirkW@Frontier.wa.com](mailto:DirkW@Frontier.wa.com)).

## High-Level Quality Assurance

 Frontier Geosciences is an accredited Washington State laboratory, and is certified/accredited in other states as well. We have extensive experience performing analytical chemistry services, field sampling, and bench top research to the exacting QA specification of the US EPA Superfund and CLP programs. Frontier has worked with the EPA to develop and codify techniques for ultra-clean sampling (US EPA Method 1669) and ultra-low level mercury analysis (US EPA Method 1631). We have also codified our technique for methyl mercury in water as EPA Method 1630. In addition, Frontier has significantly contributed to the development of EPA Methods 1632 (As by HG-CT-AAS), 1637 (trace elements by GF-AAS with preconcentration), 1638 (trace elements by ICP-MS), 1639 (trace



**CAPABILITIES**



elements by GF-AAS), and 1640 (trace elements by ICP-MS with preconcentration). Frontier has been selected as the EPA referee laboratory for the validation studies for all of the above EPA 1600-series methods.

With the advent of the newer, more stringent guidelines for metal concentrations in receiving waters, Frontier is one of very few laboratories capable of meeting both required detection limits and EPA QC guidelines. Consequently, our advice on projects requiring high level QA, and ultra-low detection limits has saved clients hundreds of thousands of dollars. Frontier's quality assurance program is audited an average of three times per year by various clients, and consistently receives excellent ratings. All of our audit reports are available to clients upon request.

The techniques we developed for low level mercury and methyl mercury determination, including extensive QC documentation, are generally sought after for EPA-mandated projects, such as the Carson River (NV), Onondaga Lake (NY), and Lavaca Bay (TX) remedial investigations. Although the quantity of documentation we provide varies according to specific project needs, all data gathered by Frontier adheres to the highest standards of quality assurance and scientific integrity. If you have questions about Quality Assurance at Frontier, our Quality Assurance Plan is available on our website ([www.frontiergeosciences.com](http://www.frontiergeosciences.com)) or contact Beverly van Buuren ([BeverlyvB@Frontier.WA.com](mailto:BeverlyvB@Frontier.WA.com)), Quality Assurance Program Director.

## Inter-Laboratory Intercomparisons

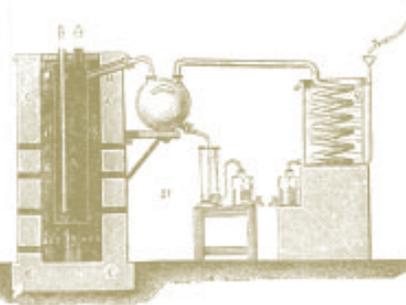
**B**ecause of our excellent reputation for ultra-clean sample handling and trace metal speciation, Frontier often serves as a benchmark of comparison for other laboratories. Major exercises have included the EPRI-sponsored International Mercury Speciation Intercomparison Exercise (Bloom, et al, *Wat. Air Soil Pollut.* 1995), and a biannual round-robin laboratory intercomparison program for low level mercury and methyl mercury (MIP). Frontier has also participated in the official certification of International Atomic Energy Agency (IAEA), National Research Council of Canada (NRCC), and National Institute of Standards and Technology (NIST) reference ma-

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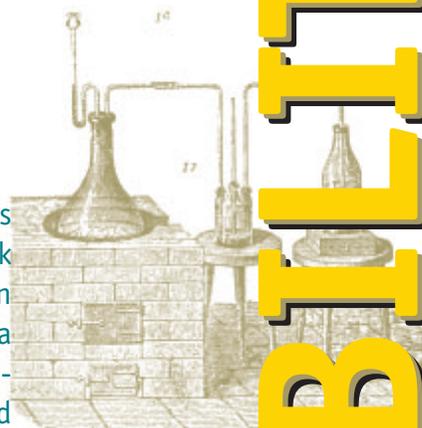
materials for mercury, methyl mercury, and other trace elements, including IAEA-085 (human hair), IAEA-086 (human hair), IAEA-356 (marine sediment), and NIST-8044 (mussel tissue). Our participation in the Mace Head, Ireland, international atmospheric mercury intercomparison and Steamboat Springs (NV) soil Hg flux intercomparison confirmed our reputation for accurate and precise atmospheric mercury measurements (Ebinghaus, et al, *Atmos. Environ.* 1999). Frontier Geosciences served under contract to the US EPA as one of the  $\beta$ -testing labs for Method 1632 (low level arsenic by HG-CT-AAS). We have also provided external laboratory comparison for numerous other laboratories and projects, setting up or participating in approximately six interlaboratory intercomparisons and/or standards checks per year. Please contact Beverly van Buuren ([BeverlyvB@Frontier.WA.com](mailto:BeverlyvB@Frontier.WA.com)), Quality Assurance Program Director for more information.



## Low Level Cyanide Analysis by EPA Method 1677

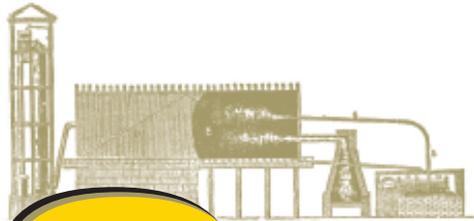
 Frontier Geosciences has enhanced its analytical capabilities by adopting the newly validated Method OIA-1677 for weak acid dissociable (WAD) cyanide. The Alpkem CN-3000 flow injection analyzer also allows the determination of total cyanide, following a photolytic breakdown of refractory iron cyanide complexes. No distillation steps are required, meaning that smaller samples are needed, and most potential positive artifacts are eliminated. The total cyanide methodology is currently under review for validation by the US EPA. The use of Method 1677 offers the following advantages over more traditional distillation/colorimetric methods, such as EPA 334.1-3.

- Routine detection limits in the range of 0.5–2  $\mu\text{g/L}$  for both total CN and WAD CN. Compare this to most labs using EPA 334.1, where detection limits in the range of 10-50  $\mu\text{g/L}$  are common.
- Positive interferences to the traditional cyanide amenable to chlorination (CAC) procedure caused by thiocyanate are eliminated. Thiocyanate is a common compound wher-



# CAPABILITIES

# CAPABILITIES



ever both reduced sulfur and cyanide is present (for example, in petroleum refineries or cyanide treatment facilities utilizing polysulfides to convert cyanide to thiocyanate), which is non-toxic, and should not be allowed to contribute to measured cyanide concentrations.

- Artifact cyanide formation caused by distillation of organic matter in the presence of nitrates, nitrites, or the breakdown of natural oximes is eliminated, because Method 1677 uses no distillation to free the cyanide. Instead, Method 1677 uses more gentle ligand exchange and photolysis steps to free bound cyanides.
- Large sample throughput is possible by using a distillation-free flow injection system. This means that on large projects generating many samples, prices may be reduced.

Please contact Nicolas Bloom ([NicolasB@Frontier.WA.com](mailto:NicolasB@Frontier.WA.com)) concerning projects requiring accurate low level cyanide analysis. We will be happy to discuss cyanide analysis alone, or in context with trace metals cycling, wastewater treatment optimization, or environmental impact studies.

## Organics Analysis

**B**ecause Frontier does not conduct organics analyses, we have entered into a strategic alliance with Axyx Analytical Services Ltd. (Sydney, BC), one of the world's premier trace organics laboratories. Through Axyx, our clients can make use of a wide range of ultra-low level (sub parts-per-trillion) organic capabilities, including PCBs (including congener-specific analysis), dioxins, furans, pesticides, chlorinated phenolics, organo-tin compounds, PAHs, and pharmacological residues. The primary analytical techniques are high resolution GC-MS methods, although Axyx is also certified to perform many of the more common standard EPA procedures. Please contact Laurie Phillips at Axyx directly ([Analytical@Axyx.com](mailto:Analytical@Axyx.com)) for projects involving only organics, or any Frontier project manager for projects involving both organics and trace metals. Volatiles and semi-volatiles can also be subcontracted to a nearby lab.



# Project Design

 Clients generally find that our participation in projects from the very beginning ultimately results in substantial savings over the course of a project. These savings may involve eliminating excessive sampling, substituting better and more economical analytical methods (including rapid field screening for mercury), reducing the amount of work that needs to be repeated, and a better correlation between project goals and appropriate sampling/analytical methodologies. Frontier has considerable experience managing and co-managing a range of large and small projects. Please contact Nicolas Bloom ([NicolasB@Frontier.WA.com](mailto:NicolasB@Frontier.WA.com)), or Eric Prestbo ([EricP@Frontier.WA.com](mailto:EricP@Frontier.WA.com)).

# Rapid Turn-Around-Time

 Frontier Geosciences has earned an excellent reputation for rapid turn-around time (TAT). Our standard TAT is four weeks, though generally clients can expect a preliminary report within 2-3 weeks of sample receipt. However, in special circumstances where immediate results are essential—as in process control and field experiments—we can, depending upon species and sample matrix, return results within 6-24 hours. Although there is an additional fee for this service, it is more than recovered in savings of down-time in the field, and/or on wasted experiments. If near real-time results are needed, Frontier can often set up a laboratory on-site to allow turn-around in as little as two hours from the time of collection, or we can design an experiment-specific on-line monitor. In addition, Frontier staff offer unique expertise on rapid field analysis of mercury in soil (20 minutes), and water (2 minutes). These techniques have proven to be accurate and cost-effective at several Hg-contaminated sites.



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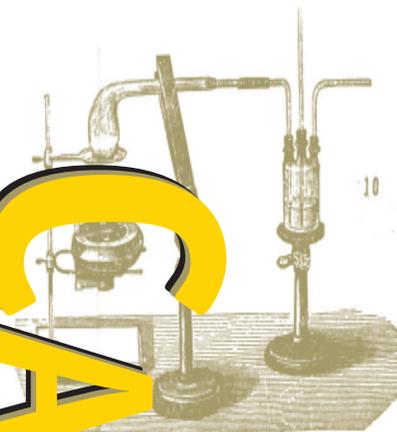


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## Reaction Rate Studies



Frontier Geosciences is one of very few laboratories in the United States undertaking the difficult task of quantifying the atmospheric reaction rates of mercury and its species (e.g.,  $\text{Hg}^0 + \text{Cl}_2$ ;  $\text{Hg}^0 + \text{O}_3$ ;  $\text{Hg}^0 + \text{H}_2\text{O}_2$ ). The techniques and equipment used in this research can be applied to other reaction rates studies, both gaseous and aqueous. Of particular interest is combustion flue gas and cooling stack plumes where Frontier developed the Static Plume Dilution Chamber (SPDC) to simulate Hg plume chemistry under a wide array of environmental conditions at the plant site. Our ability to specifically quantify the reaction products, rather than simply monitoring the change in reactant concentrations, significantly improves confidence in the measured rates. Please contact Eric Prestbo ([EricP@Frontier.WA.com](mailto:EricP@Frontier.WA.com)).



## Speciation



The term “speciation” in analytical chemistry refers to the separation and quantification of the different oxidation states or chemical forms of a particular element. Previously, the determination of total element concentrations was considered to be sufficient for clinical and environmental considerations. Although the total concentration of an element is still useful to know, and sometimes essential, the determination of species is a necessary task for fully understanding the biogeochemical and toxicological behavior of metals. Frontier has been leading the way in this field by providing the scientific and environmental communities with state-of-the-art speciation methods, and many published research papers in peer-reviewed journals.

Frontier was an early pioneer in the development of aqueous, solid, and gas phase speciation techniques for mercury, and has since developed speciation methods for all relevant mercury species in ambient environmental samples. For other elements, we have developed methods that utilize ion chromatographic separations of the species of interest followed by atomic absorption, atomic fluorescence, or inductively coupled plasma mass spectrometric



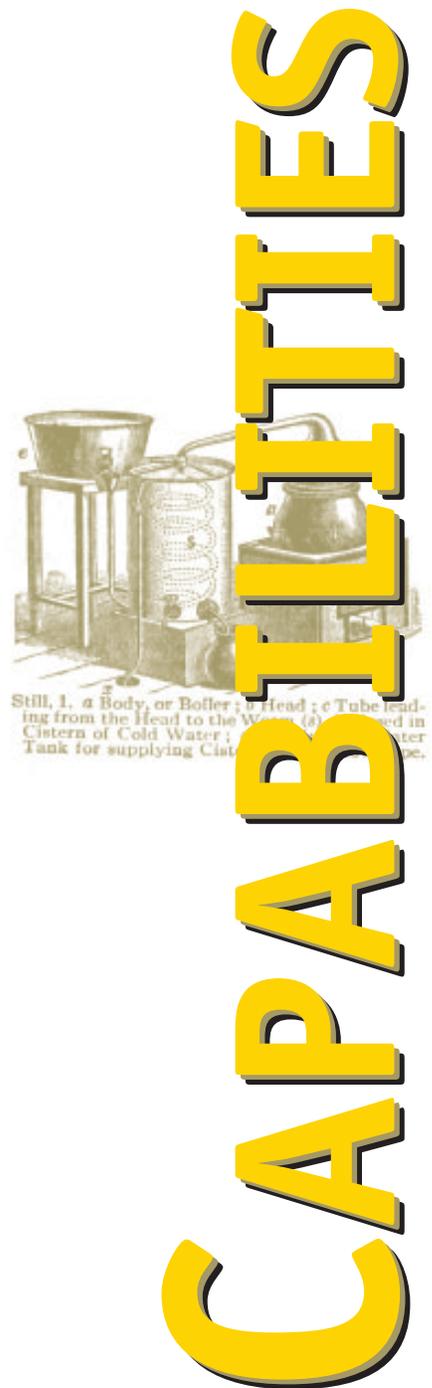
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detection. For selenium speciation in various matrices, ion chromatography is used for the determination of Se(IV), Se(VI) and selenocyanate utilizing post-column hydride generation before atomic fluorescence detection. For samples with ultra-trace concentrations, the same chromatographic separation can be used to produce detection limits in the low ng/L range by direct coupling to an ICP-MS. For speciation of arsenic, we developed a hydride generation-cold trapping-gas chromatography-atomic absorption technique to determine As(III), As(V), dimethylarsenic, monomethylarsenic, and total inorganic arsenic. We have also developed an ion chromatography-hydride generation-atomic fluorescence procedure for speciation arsenic. To our suite of speciation methods, we have recently added chromium speciation using ion chromatography followed by ICP-MS detection. This highly sensitive technique is used to determine Cr(III) and Cr(VI) with detection limits in the ng/L range. In addition, we have methods for the speciation of Sb, Te, Fe and I species in the environment.

Frontier continues to invest in internal research to optimize and validate methods for solid phase trace metals speciation by selective leaching, combined with species-specific analysis. We interact regularly with research scientists at the major centers of speciation research around the world, including Duquesne University, Stanford University, the University of Pau (France) and Trent University (Canada), exchanging ideas and methods as they become available. Our world-class staff, and our equipment capabilities, together with a commitment to internal research co-funding, means that Frontier can usually meet any client-specific trace metal speciation request. Please contact Nicolas Bloom ([NicolasB@Frontier.WA.com](mailto:NicolasB@Frontier.WA.com)), Dirk Wallschläger ([DirkW@Frontier.WA.com](mailto:DirkW@Frontier.WA.com)) or Hakan Gürleyük ([HakanG@Frontier.WA.com](mailto:HakanG@Frontier.WA.com)) for more details.

## Trace Metals Analysis

**M**ost trace metals analyses performed by Frontier Geosciences are determined by inductively coupled plasma-mass spectrometry (ICP-MS), using the state-of-the-art Perkin-Elmer Elan 6000. Extremely low detection limits (especially for the higher mass elements) in even traditionally difficult matrices are achievable in our



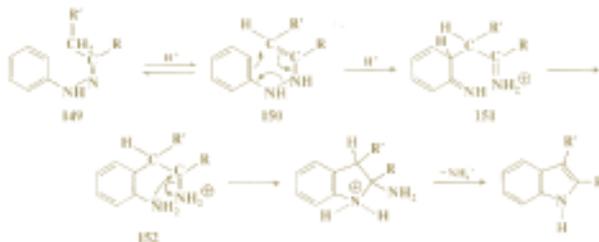


ultra-clean sample preparation environment. While the ICP-MS technique is superb for many matrices, there are some element/matrix combinations that have poor detection limits due to elemental or molecular interferences. The analytical laboratory staff at Frontier is experienced in choosing the most appropriate methods to analyze any element/matrix combination. For example, Frontier can utilize Zeeman Corrected Graphite Furnace Atomic Absorption (ZGFAAS), with the L'vov platform, and element-specific matrix modification for the greatest overall accuracy and precision.

For the analysis of arsenic, antimony and selenium at either ultra-trace levels or in complex matrices, Frontier developed a state-of-the-art analytical technique utilizing hydride generation and atomic fluorescence spectrometry (HG-AFS). Using HG-AFS, we are able to accurately measure total arsenic and selenium in nearly all matrices down to single-digit parts-per-trillion levels. Speciation information is determined using modifications of this technique, including cryogenic trapping/GC, and ion chromatographic separation.

For the analysis of Ag, Cd, Cu, Pb and Ni in seawater or other matrices with strongly interfering elements, Frontier developed co-precipitation with Co-APDC extraction, prior to analysis. This technique enables the quantitative extraction of metals from the interfering matrix. In addition, the extraction serves to preconcentrate the metals, thus improving the detection limits. Total recoverable Cr, Cr(III), and Be can also be selectively extracted from complex matrices and preconcentrated using co-precipitation with iron hydroxide. The advantages are similar to co-APDC extraction. Extracts are typically run on the Perkin-Elmer Elan 6000 ICP-MS with excellent detection limits in the parts-per-trillion range.

Mercury analysis employs lab-built cold vapor atomic fluorescence spectrometers (CVAFS), which give unparalleled sensitivity (EPA Method 1631). The use of these detectors, in combination with gold amalgamation or aqueous phase ethylation, plus (Method 1630, draft) gas chromatographic separation allows determination of Hg speciation at the parts-per-quadrillion level. Please contact Michelle Gauthier ([MichelleG@Frontier.WA.com](mailto:MichelleG@Frontier.WA.com)), Analytical Laboratory Manager.

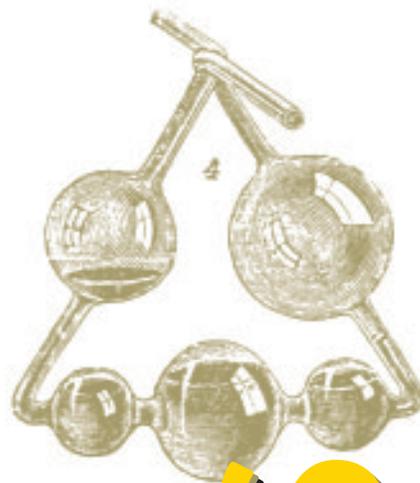


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# CAPABILITIES

# Waste Remediation Research

Frontier does not engage directly in the design and construction of waste remediation technologies, however, our experience in the biogeochemical behavior of trace metals provides insight into appropriate and efficient technologies. We possess considerable benchtop experience with a variety of means of Hg and trace metal removal from aqueous and gaseous waste streams, often demonstrating efficiencies of 90–99.99% in a single pass. In addition, we team with other research groups to provide advice and expertise in developing proprietary techniques. Often, understanding trace metal speciation, both physical and chemical, is the key to maximizing removal efficiencies. Frontier’s research staff also have the experience and geochemical background necessary to provide custom-designed *in-situ* waste immobilization strategies. Please request our packet entitled, “Removal of Trace Metals from Waste Waters,” and contact Nicolas Bloom ([NicolasB@Frontier.WA.com](mailto:NicolasB@Frontier.WA.com)).



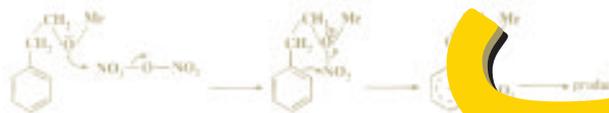
# Customized Equipment Sales

Frontier will manufacture and/or clean custom sampling and analytical equipment including, but not limited to:

- |   |  |
|---|--|
| sampling pumps                                | tubing and tubing weights  |
| ultra-clean filtration systems                | precipitation collectors   |
| ultra-clean Teflon bottles                    | various Hg species   |
| methyl Hg distillation systems                | diffusion tubes<br>(for the generation of<br>gaseous Hg species) |
| isothermal GC systems                         | gold-coated silica   |
| Carbotrap columns                             | QA samples   |
| gold sampling traps                           |  |
| species and matrix-specific mercury standards |  |



For optimal efficiency, we retain a variety of expert glass/quartz blowers and precision machinists. Please contact contact Bob Brunette ([BobB@Frontier.WA.com](mailto:BobB@Frontier.WA.com)) with your specific needs for an estimate of the costs and time required.



# CAPABILITIES

# QUALITY ASSURANCE



Beverly H. van Buuren,  
Quality Assurance Program Director

## Philosophy

 Frontier has a strong and vital commitment to its Quality Assurance Program, viewing quality assurance as a program *and* a philosophy. We begin quality control at the bench level, and continuously work to improve our processes at the management level. Statistical analyses of control parameters are monitored on a daily basis. Our management style is to solicit process improvements and problem-solving from our laboratory technicians and analysts, then use management for implementation.

The US EPA recognizes our commitment to quality assurance. Frontier was awarded the role of Referee Laboratory for EPA validation studies including EPA methods 1631, 1632, 1637, 1638, 1639, and 1640. Our Senior Research Scientist, Nicolas S Bloom, is consistently asked to serve as a resource for the US EPA on methods development. Mr. Bloom was also invited to present a paper on innovative QA approaches at the EPA's 20<sup>th</sup> Annual Conference on Analysis of Pollutants in the Environment, and serves on a National Science Advisory Board.

Frontier participates in several inter-laboratory intercomparison studies each year. These studies allow us to look at a wide range of matrices for all of our methods. Frontier is a regular participant in studies prepared by the National Oceanic and Atmospheric Administration, the National Research Council of Canada, the Institute for National Measurement Standards (Canada), the National Water Research Institute (Canada), the US Geological Survey, and Analytical Products Group, Inc. We also participate in unique intercomparisons; including a study between Frontier, the National Institute of Stan-

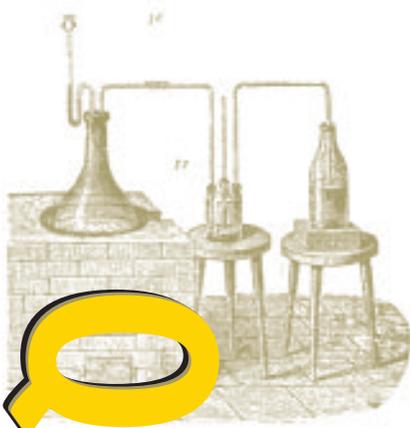
dards & Technology (NIST), and the International Atomic Energy Administration, which ultimately lead to the certification of NIST-2976. Performance evaluation studies are also a regular part of our quality assurance program.

Beverly van Buuren, Quality Assurance Program Director, manages and develops the quality assurance program and works as a QA Consultant. Ms. van Buuren approaches QA with a creative style, utilizing research-driven goals rather than the typical, dogmatic QA methods. As a QA consultant, she works with consulting firms, researchers, and other laboratories requiring assistance in any aspect of QA oversight. Please refer to the QA Consulting Services section of this document for more details.

Frontier is dedicated to producing data that not only meets or exceeds QA requirements, but more importantly, is scientifically coherent (i.e., tells a plausible story based upon state-of-the-art biogeochemical understanding). Various aspects of our program include the following:

- **Training:** Frontier's program is based on a mentorship model, with senior analysts, in cooperation with the QA Program Director, supervising and recording all steps in the process.
- **Standard Operating Procedures:** SOPs are constantly evaluated and updated. The QA office provides staff with the most recent documentation and ensures that all previous copies are archived.
- **Method Detection Limit Studies:** Frontier performs MDL studies following 40 CFR 136 at least annually. Matrix-specific MDL studies may be performed at client request or as part of research development.
- **Method Blank Correction:** All Frontier results are reported as corrected for the mean of the method blanks analyzed with the samples, unless previously specified in the contract.
- **Outliers:** Frontier holds the position that a single, non-compliant result on a QC sample does not automatically invalidate a data set. If the other QC data in the same data set are of acceptable quality, and a re-run of the out-of-control sample is also of acceptable quality, then the entire data set is considered to be in control and acceptable.





# QUALITY ASSURANCE

- **State Certifications:** Frontier is accredited in a number of states including California, Florida, Louisiana, New York, Washington, Wisconsin and New Jersey.

Frontier provides data packages in one of two QA formats. “Standard Level” is approximately between EPA Levels 2 and 3. “High Level” is approximately equivalent to EPA Level 4. In addition, Frontier provides custom QA/QC packages to meet specific needs. The two different levels do not represent differences in analytical quality, rather, they represent the degree of documentation, and therefore the ability to defend the data in legal proceedings. Quality control samples are run at a different frequency under the two QA levels. The quality of data produced under the two QA reporting schemes, as measured by quantitative indicators such as precision, accuracy, and detection limits, are equivalent.

## Quality Control Documentation Provided with Frontier Data Packages

Document	Standard Level	High Level
Chain-of-Custody Form	provided	provided
Analytical Bench Sheets	archived	provided
Sample Prep Logbook	archived	at client request
Raw Data	archived	provided
Corrected results	provided	provided (unless specified)
QC Data	summary or complete	complete
Case Narrative	abbreviated	complete
Instrument Logs	not provided	at client request
Reagent Prep Logs	not provided	at client request
Control Chart Data	not provided	at client request
Phone/Fax Records	not provided	at client request
Data Interpretation	at client request	at client request

# Quality Assurance Consulting



Frontier Geosciences' Quality Assurance (QA) Services provides comprehensive QA consulting for everything from individual laboratories and consulting firms, to large-scale, long-term projects. Our reputation as a leader in ultra-trace metals research brings the guarantee that your QA program will foster scientific creativity and satisfy rigorous quality control requirements.

Individual laboratories and consulting firms may need assistance in:

- Evaluating sub-contract laboratories
- Writing NELAP-compliant (ISO 25) QA Plans
- Writing EPA-compliant QA Project Plans
- Developing a sound QA program
- Developing training programs
- Producing data with solid legal standing and third-party validation

Large-scale projects commonly face two difficult questions.

- "How do we establish confidence that data produced by multiple researchers is comparable?"
- "How do we assure that data is valid for future use and interpretation?"

Frontier offers the following services for projects:

- QA project development
- Interlaboratory studies
- Performance test studies
- On-site audits (by an International Certified Quality Auditor)
- Development of a QA Project Plan
- Method and standard operating procedure review (both scientific and QA)
- Data validation
- QA meetings

Frontier has considerable experience in helping individual laboratories and large-scale projects set up QA programs. Some of our clients have been:

- Warner Lambert, Inc. (Puerto Rico)
- Moss Landing Marine Laboratory (California)



ASSURANCE  
QUALITY

# QUALITY ASSURANCE

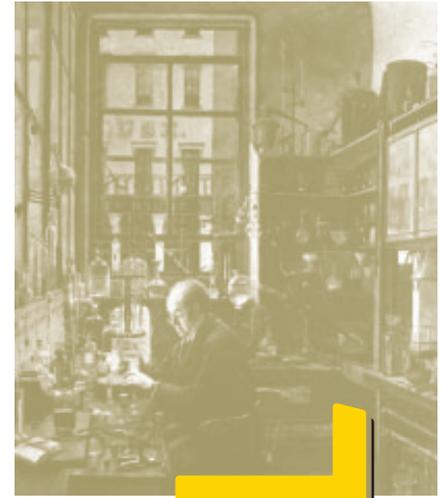
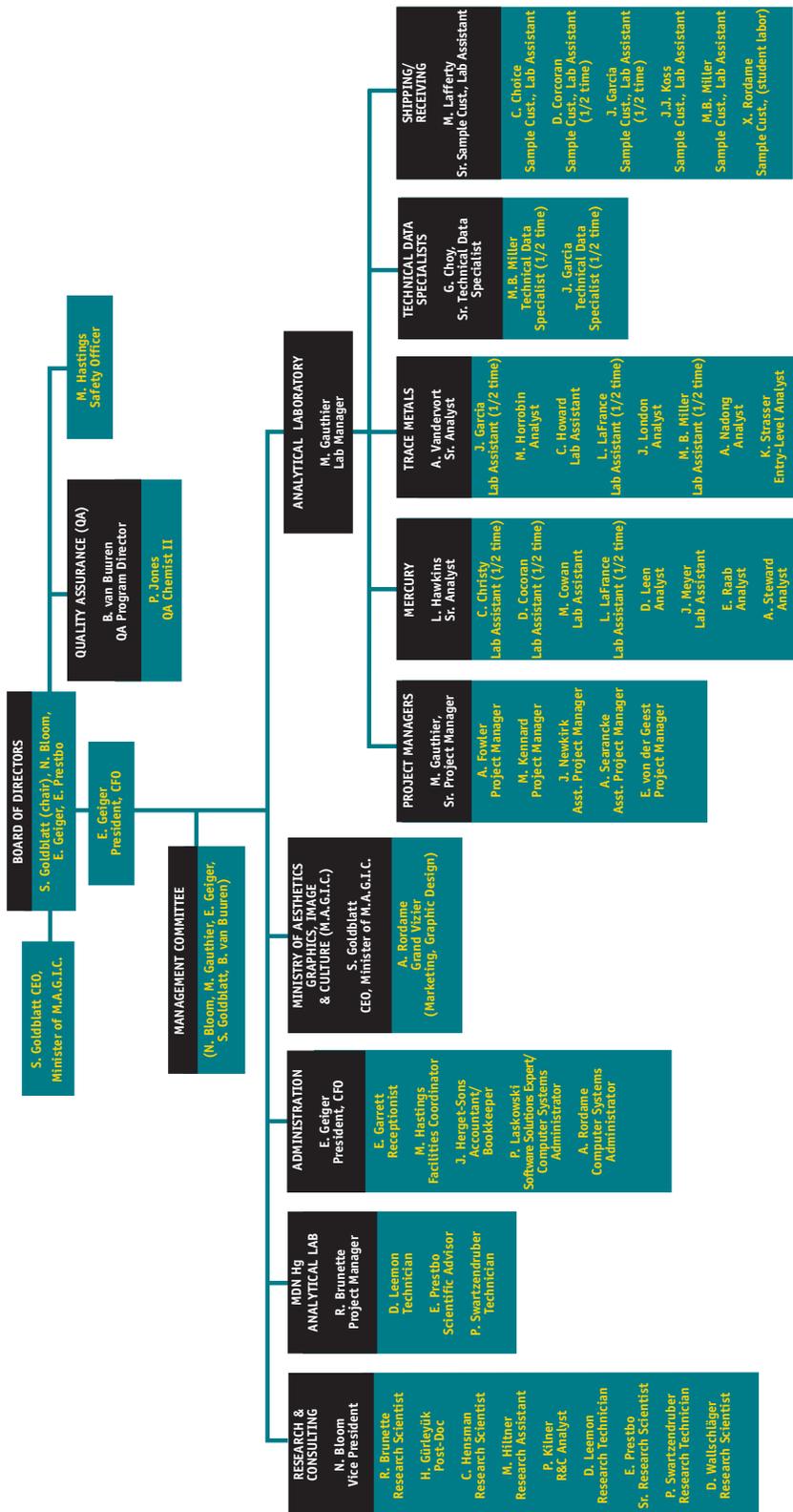
- The Central Research Institute of Electric Power Industry (Tokyo, Japan)
- The Great Lakes Mass Balance Study (Great Lakes area)
- The CALFED Mercury Project (California)

For more information please contact **Beverly H. van Buuren**, Quality Assurance Program Director. A full plan will be developed, customized to your particular projects' needs.



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# Organizational Chart



# PERSONNEL



# HOW TO CONTACT US:

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# PERSONNEL

Scientific Staff	Duties	Email Address
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<b>Robert C. Brunette,</b> Research Scientist, MDN Project Manager, Consultant	project management (R & C group)	BobB@Frontier.WA.com
<b>Julie Calhoun,</b> Special Projects PI	specific projects research	JulieC@Frontier.WA.com
<b>Citron Choice,</b> Sample Custodian, Lab Assistant	sample receipt, tracking, control, equipment processing, shipping & receiving	CitronC@Frontier.WA.com
<b>Gabriel G. Choy,</b> Technical Data Services Manager	data transfer, control charting, data entry	GabeC@Frontier.WA.com
<b>Caroline Christy,</b> 1/2-time Lab Assistant, 1/2-time Sample Custodian	sample prep, routine tasks, sample receipt, equipment processing, shipping & receiving	CarolineC@Frontier.WA.com
<b>Daniel Corcoran,</b> 1/2-time Lab Assistant, 1/2-time Sample Custodian	sample prep, routine tasks, sample receipt, equipment processing, shipping & receiving	DanielC@Frontier.WA.com
<b>Melinda Cowan,</b> Lab Assistant	sample prep, routine tasks	MelindaC@Frontier.WA.com
<b>Anne Fowler,</b> Project Manager	project management (Analytical Lab)	AnneF@Frontier.WA.com
<b>Jeni Garcia,</b> 1/2-time Lab Assistant, 1/2-time Technical Data Specialist	sample prep, routine tasks, data transfer, control charting, data entry	JeniG@Frontier.WA.com
<b>Michelle L. Gauthier,</b> Analytical Lab Manager	lab management, project management (Analytical Lab)	MichelleG@Frontier.WA.com
<b>Hakan Gürleyük,</b> Post-Doctoral Researcher	methods development, Cr speciation (R & C Group)	HakanG@Frontier.WA.com
<b>Matthew ("Bruno") Hastings,</b> Safety Officer, Facilities Coordinator	lab health and safety, facilities maintenance	BrunoH@Frontier.WA.com
<b>Lucas Hawkins,</b> Senior Analyst, Hg Lab Supervisor	sample prep, analysis	LucasH@Frontier.WA.com
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<b>Crystal Howard,</b> Entry-Level Analyst	sample prep, analysis	CrystalH@Frontier.WA.com
<b>Jim Johnston,</b> 1/2-time Lab Assistant, 1/2-time Sample Custodian	sample prep, routine tasks, sample receipt, equipment processing, shipping & receiving	JimJ@Frontier.WA.com
<b>Misty D. Kennard</b> Project Manager	project management	MistyK@Frontier.WA.com

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<b>Malaiika Lafferty,</b> Senior Sample Custodian, Lab Assistant	sample receipt, tracking, control, equipment processing, shipping & receiving	MalaiikaL@Frontier.WA.com
<b>Laura LaFrance,</b> Lab Assistant	sample prep, routine tasks	LauraL@Frontier.WA.com
<b>Paul Laskowski,</b> Computer Systems Administrator, Software Systems Expert	network maintenance, scientific software programing	PaulL@Frontier.WA.com
<b>Dan Leemon</b> MDN Technical Assistant	assist with MDN projects	DanL@Frontier.WA.com
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<b>Eric M. Prestbo,</b> Senior Research Scientist	research (R & C Group)	EricP@Frontier.WA.com
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<b>Kara Strasser</b> Analyst	sample prep, analysis (Analytical Lab)	KaraS@Frontier.WA.com
<b>Phillip Swartzendruber</b> R & C Research Technician	field trip preparation, experiment set-up, specialty analysis, troubleshooting	PhilS@Frontier.WA.com
<b>Amber Steward,</b> Analyst	sample prep, analysis	AmberS@Frontier.WA.com
<b>Amara M. Vandervort,</b> Senior Analyst	sample prep, analysis	AmaraV@Frontier.WA.com
<b>Eric J. von der Geest,</b> Project Manager	project management (Analytical Lab)	EricV@Frontier.WA.com
<b>Dirk Wallschläger,</b> Research Scientist	research (R & C Group)	DirkW@Frontier.WA.com





# PERSONNEL

Administrative Staff	Duties	Email Address
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<b>Ed G. Geiger,</b> President, CFO	finance, administration, marketing	EddieG@Frontier.WA.com
<b>Sharon K. Goldblatt,</b> CEO, MAGIC	policy, PR	SharonG@Frontier.WA.com
<b>Jeanne Herget-Sons</b> Accountant	accounting, bookkeeping	JeanneH@Frontier.WA.com
<b>Paulette Jones,</b> Quality Assurance Chemist II	assist Beverly van Buuren	PauletteJ@Frontier.WA.com
<b>Alfred Rordame iv,</b> Vice-Minister of MAGIC Computer Systems Administrator	graphic design, web design/maintenance network maintenance	AlfredR@Frontier.WA.com
<b>Beverly van Buuren,</b> Quality Assurance Program Director Human Resources Director	quality assurance program management, consulting, HR administration	BevvB@Frontier.WA.com



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## Key Scientific Personnel



**Nicolas S Bloom**  
**Senior Research Scientist**  
**(Research and Consulting Group)**



Nicolas Bloom has an M.S. degree in chemical oceanography, and has been involved in research on the biogeochemistry of trace metals in the environment for more than 20 years. He has 92 publications on the geochemistry of trace metals in the environment, and has made a similar number of presentations at major conferences world-wide. Mr. Bloom is an associate member of the US EPA National Science Advisory Board, where he participated in the review of the EPA's Mercury Report to Congress. Since 1995 he has helped the US EPA write and review its new 1600 series of ultra-trace analytical methods.

As a graduate student at the University of Washington, Mr. Bloom investigated the sorption behavior of ultratrace concentrations of cations and anions on ferric hydroxide suspensions. This research resulted in a new understanding of the role played by cation/anion interaction in the adsorption of specific trace metals from aqueous solution. The results of these laboratory studies were then applied to industrial waste water treatment systems to reduce metals discharges.

PERSONNEL

# PERSONNEL



As a marine chemist at Battelle Northwest Marine Research Laboratory (1980-1984), he developed sampling and analytical techniques to quantify a wide range of trace metals in sea water at ambient concentrations in the open ocean. Using these techniques, Mr. Bloom investigated the biogeochemical cycles of As, Hg, Ag, Pb, Cd, and Cu in Puget Sound and other anthropogenically impacted waters.

Mr. Bloom returned to graduate school in 1984, where he participated in developing analytical techniques to allow the detection of Hg at the sub-picogram level by atomic fluorescence spectrometry, and to directly speciate organomercurial compounds by cryogenic GC. These methods have since been applied to investigate the cycling of Hg and its various compounds in lacustrine systems. Mr. Bloom has been able to show that methyl mercury is an ubiquitous and critical component of the biogeochemical cycle of Hg in virtually all environments, including air and precipitation, surface waters, sediments, and biota.

In 1991, Mr. Bloom, together with Sharon K. Goldblatt, co-founded Frontier Geosciences Inc. At Frontier, Mr. Bloom has continued his research into ultra-low level metals speciation, developing or refining methods for Hg speciation in sediments, air, and fossil fuels, as well as mentoring the development of ICP/MS and IC/AFS methods for most other trace metals; and for Se, As, and Cr speciation. After serving as Laboratory Manager for 8 years, Mr. Bloom leads the Research & Consulting group at Frontier.



**Robert C. Brunette**  
**Research Scientist (R & C Group)**

**R**obert (Bob) Brunette earned his B.S. degree in environmental chemistry from Western Washington University in 1992. Since joining Frontier as an analytical chemist, Mr. Brunette has advanced rapidly and is now a project manager in our Research & Consulting group. One of Mr. Brunette's most important projects is the National Atmospheric Deposition Program—Mercury Deposition Network (MDN). The MDN is the largest national mercury deposition monitoring network in North America. It con-

sists of nearly 40 sites across the United States and Canada, with plans to increase to more than 100 in the near future, and to continue for at least another five to ten years. Mr. Brunette serves as MDN Site Liaison, Hg Analytical Lab (HAL) contact for the 28 agencies currently sponsoring the MDN, and Vice Chair of the Data Management and Analysis Subcommittee for the NADP. He also directs and problem-solves MDN field operations with approximately 40 field operators. As the MDN project manager, Mr. Brunette is proficient at all aspects of this project, including network site determination and set-up, troubleshooting, training, fieldwork, analysis and report writing.

Mr. Brunette also manages a variety of other aquatic and atmospheric trace metal projects, including ambient air point source Hg monitoring, industrial Hg emission control evaluations, and the US EPA's national information collection request (ICR) for coal Hg concentrations. He has done extensive field work, and participated in research on the development of flue gas mercury speciation techniques, simulated plume dilution studies for Hg, ambient air Hg measurements, wet deposition studies for total mercury, methyl mercury, and other trace metals; and dry deposition Hg studies. He has participated in the development and application of field sampling techniques for the measurement of Hg in flue gas, and helped to develop a water column sampler. Mr. Brunette is the author, or co-author, of a half-dozen published papers in scientific journals, conference proceedings and conference presentations.



**Anne Fowler**  
**Project Manager (Analytical Group)**



While attending Modesto Junior College in Modesto California, Anne Fowler worked in several laboratories on a variety of analytical projects including hazardous waste characterization and test determination, PCB extractions, toxicity characteristic leaching procedures and

soluble threshold leaching concentration extractions for metals, flashpoint analyses, conductivity analyses, and cyanide and sulfide



# PERSONNEL

analyses. For the past six years, Anne's work has focused on environmental science research. As a project manager, she has overseen everything from reviewing chains-of-custody, to contract bidding.

Ms. Fowler recently joined Frontier Geosciences Inc. as a Project Manager in the Analytical Laboratory. She is responsible for client relations, data and quality control review, problem solving, and report writing.



## **Michelle L. Gauthier** **Lab Manager (Analytical Group)**

**M**ichelle Gauthier obtained a B.S. degree in chemistry and physics from Western Oregon University in 1992. She joined Frontier Geosciences in 1995 as an analytical chemist in the trace metals group, and has rapidly advanced to her current position as Analytical Laboratory Manager. Ms. Gauthier continues to serve as Project Manager and backup

analyst for the Trace Metals group, and is adept at most aspects of laboratory work. She is proficient in sample processing, including receipt and custody, ultra-clean sample handling techniques, and various sample preparation methods for different, geochemically complex matrices. Ms. Gauthier is well-versed in sample analysis on the graphite furnace, arsenic and selenium analysis by hydride generation, and ICP-MS. She has considerable experience with methods development, data calculation and evaluation, report writing, and consulting with clients.

Among the major projects Ms. Gauthier currently manages are the New York Harbor Study with the New York Department of Environmental Conservation (NYDEC) and the New Jersey United States Geological Survey (NJ USGS). Ms. Gauthier also manages a project for CH<sub>2</sub>M-HILL studying 16 trace metals in seawater and effluent samples at five different waste water treatment plants in Puerto Rico.





**Misty Kennard  
Project Manager  
(Analytical Group)**



Currently, at Frontier Geosciences Inc., Ms. Kennard manages all performance evaluation and intercomparison studies required by various states and national laboratories for certification and accreditation for various trace metals and Hg. She recently developed a quality assurance

project plan (QAPP) for the City of Coeur d' Alene Metals Translator Study. The goal of the project is to identify through total and dissolved trace metals analysis the translator value for several metals within the mixing zone of the Spokane River and the waste water treatment plant (WWTP) treated effluent. Additionally, Ms. Kennard is the Project Manager for trace metals and low level mercury analysis for the City of Spokane (WWTP) and the City of Wichita, among several other waste treatment facilities, to maintain their regulatory compliance for the discharge of treated effluent. Ms. Kennard also manages several projects where estuarine waters within the San Francisco Bay region are analyzed for trace metals concentrations to help identify point source pollution within the surrounding area. Additionally, she manages the trace metals analysis of the effects non-point source pollution within stormwater run-off may have on the ecosystem within the local tributaries of the Sacramento River.



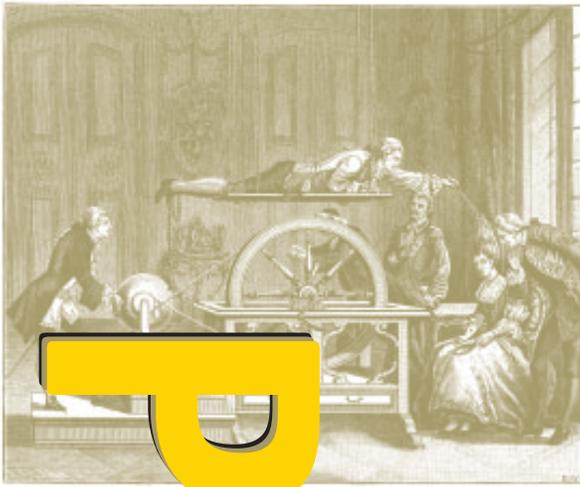
**Eric M. Prestbo  
Senior Research Scientist  
(R & C Group)**



Eric Prestbo obtained his Ph.D. in atmospheric chemistry from the University of Washington in 1992, studying the cycling of peroxy acetyl nitrate (PAN) in the atmosphere. Since coming to Frontier, Dr. Prestbo has achieved recognition among his peers as a leader in the field of atmospheric trace metal spe-



**PERSONNEL**



# P ERS OM NEL



ciation research and method development. For example, with support from a number of scientists and funding sources, ongoing research and method development by Dr. Prestbo has led to the quantification of gaseous Hg(II) at a number of sites such as Mace Head (Ireland), Tenerife (Canary Islands), Eagle Harbor (Michigan) and the Florida Everglades (Airplane).

Current research by Dr. Prestbo, in our Research and Consulting Group, focuses on the development of an automated atmospheric Hg speciation capability using cold vapor atomic fluorescence spectroscopy (CVAFS—Tekran 2537) and KCl-coated annular denuders (Tekran 1130p).

Using a custom-designed laboratory system, Dr. Prestbo can generate calibrated test atmospheres containing part-per-quadrillion  $HgCl_2$  for the evaluation of the Tekran 2537 and 1130p. Dr. Prestbo also leads the team of research scientists determining the reaction rates of  $Hg^0$  with various oxidants in order to provide collaborating scientists with more accurate input values for Hg modeling. Dr. Prestbo has developed a Static Plume Dilution Chamber (SPDC) to help characterize the important, but poorly understood chemistry of Hg in combustion plumes. He continues to be engaged in the US Department of Energy (DOE), Electric Power Research Institute (EPRI), and Energy and Environment Research Center (EERC) programs to develop an accurate and reliable Hg speciation method for coal flue gas. Working with collaborating scientists on US DOE and EPRI programs designed to evaluate new control technologies, Dr. Prestbo has been instrumental in the application of a very simple, inexpensive and fast turn-around technique for total and speciated Hg in flue gas.



## Eric J. von der Geest Project Manager (Analytical Group)



As its first lab technician, Eric J. von der Geest helped get Frontier started, while at the same time earning his degree with a double major in math and chemistry. He graduated from the University of Washington in 1993. He progressed rapidly in skill and respon-

sibility, and is now a Project Manager for Frontier's Analytical Laboratory. He is proficient at field sampling using ultra-clean techniques, sample handling, sample custody, processing, analysis, set-up and maintenance of analyzers and related analytical equipment, data evaluation and calculation, and report writing. Mr. von der Geest has been developing and practicing these skills for more than ten years, working in close partnership with Nicolas S Bloom, Senior Research Scientist. He has worked frequently on EPA CLP-style projects with their specific QA requirements. Currently, he is managing a number of important aquatic mercury research projects, including all work pertaining to industrial and municipal discharges.

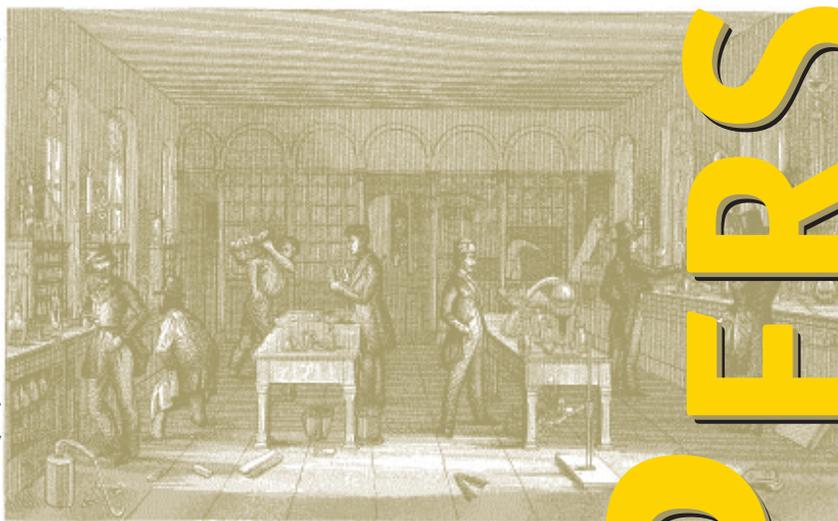
Mr. von der Geest has trained a succession of laboratory technical personnel and graduate students working on Master's and doctoral dissertation research projects, in all relevant laboratory and technical methodologies. He is the co-author of four published journal articles, and presented the results of one study at the 1994 World Mercury Conference at Whistler (B.C., Canada).



**Dirk Wallschläger**  
**Research Scientist**  
**(R & C Group)**

**D**irk Wallschläger's doctoral research (Environmental and Analytical Chemistry, University of Bremen, Germany, 1996) focused on

the speciation and transport of mercury in wetlands. He applied his findings to the determination of mercury fluxes from floodplain soils via aqueous and atmospheric paths. He also developed methodologies for the determination of concentrations of  $Hg^0$  and  $(CH_3)_2Hg$  in soil air, and for measurements of mercury air/soil exchange. In addition, Dr. Wallschläger developed a new



# PERSONNEL



# P E R S O N N E L

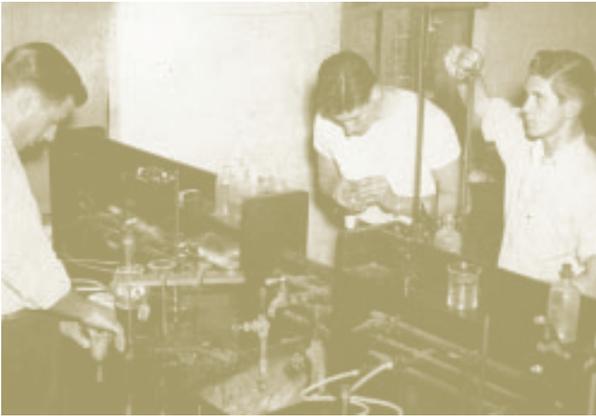
selective leaching procedure for the speciation of mercury in the solid phase, emphasizing the organic-bound fraction, which he then applied to study the influence of organic matter on mercury geochemistry.

During his post-doctoral work at Frontier Geosciences, Dr. Wallschläger developed and improved speciation techniques for arsenic, selenium, and mercury in all compartments of the environment. His current emphasis is on the development of “hyphenated methods,” in which chromatographic separation of individual species precedes their element-specific detection, such as IC-AFS or GC-AAS. He also studies the environmental air-surface exchange of mercury and its volatile species, and works on improving the required measurement techniques.

Since accepting a permanent position with Frontier’s Research and Consulting Group, Dr. Wallschläger’s research has focused on the development of reliable hyphenated methods for the speciation of selenium and arsenic in complex matrices, such as industrial waste waters. This research aims at providing industries affected by environmental concerns with accurate speciation information, on which they can base environmental risk assessment and the design of successful treatment/remediation strategies.



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## Student Researchers

 In the interest of encouraging a progressive, free, and open approach to the exchange of scientific information, Frontier offers a variety of programs. In addition to our complimentary lunch-time seminars, periodic training workshops, and frequent presentations, Frontier's researchers enjoy a mentor relationship with students from primary grades through post-doctoral levels. These student/mentor associations have resulted in significant contributions to a number of Masters and Ph.D. dissertations, as well as more than 10 publications and presentations. Individuals with whom we have worked include the following:

**Sebastian Backström, M.S.**, Chalmers Technical Institute (Göteborg, Sweden) 1990.

**Lee Barber, Ph.D.**, Duke University (Durham, North Carolina), 1999.

**Anthony Carpi, Ph.D.**, Cornell University (Ithaca, New York) 1994.

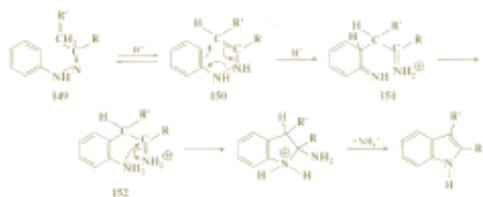
**Chris Canavan, M.S.** University of New Mexico (Las Cruces, New Mexico) 1998.

**Jennifer Covert**, Garfield High School (Seattle, Washington) high school student intern, 1997–2000.

**Andrew Hayes, Ph.D.**, McGill University, (Montreal, Canada) 1996.



# PERSONNEL



# PERSONNEL

**Michael Hegg**, Shoreline High School (Seattle, Washington) high school student intern, 1997. Washington and Lee University (Lexington, VA) undergraduate student summer intern, 1999.

**Crystal Howard**, University of Washington (Seattle, Washington) undergraduate work-study student, 1998–1999 (currently a full-time permanent employee).

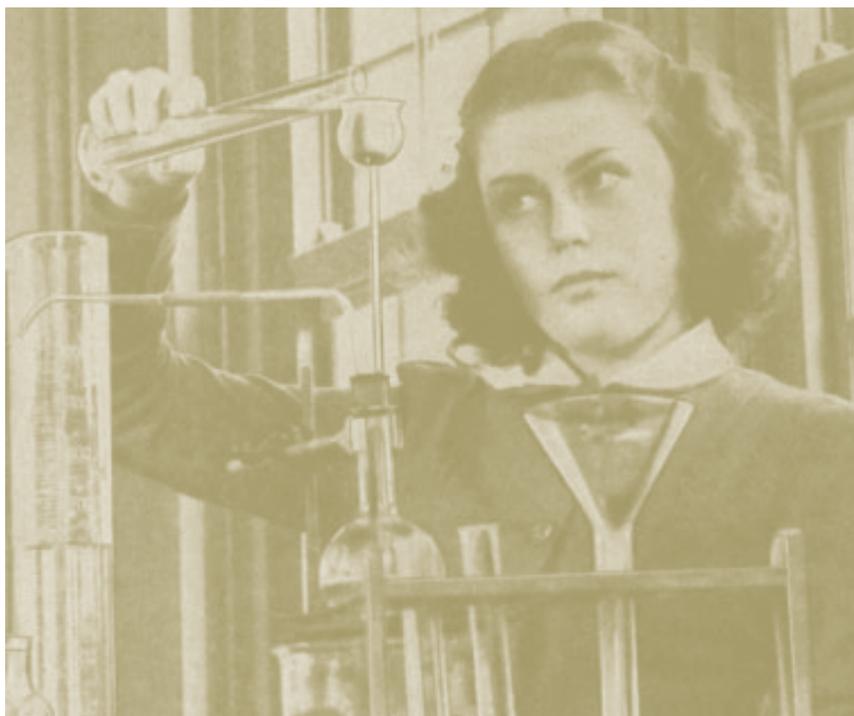
**Jodie Katon**, Boston University (Boston, Massachusetts) undergraduate student summer intern, 1999 & 2000.

**Marc Paladini**, Seattle Central Community College (Seattle, Washington) undergraduate student intern, 1996.

**Rebecca Timson's 3<sup>rd</sup>-5<sup>th</sup> graders**, Spruce Street School (Seattle, Washington) study of urban run-off, 1997–98.

**Efrosini Tsalkitzis, MS**, York University, Ontario, 1993–94.

**Wendy Walker**, Oregon State, doctoral candidate, 1999–present.



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## Facility



Frontier's 8,000 ft<sup>2</sup> research and analytical laboratory facilities are located in downtown Seattle, Washington. The location is close to Sea-Tac Airport, the University of Washington, and NOAA. The space contains a small clean room for sample prep, a 1,000 ft<sup>2</sup> state-of-the-art all-plastic Class-100 bottle washing and storage area, and six other Class-100 clean air stations. Frontier has two mercury analysis laboratories, four sample preparation rooms, a graphite furnace AA laboratory, ICP-MS laboratory, atmospheric reactions laboratory, and two research laboratories (currently one is devoted to metalloid speciation using IC-AFS, and the other to Hg research and special projects). In addition to the laboratory space, Frontier has a dedicated sample shipping and receiving room (with Class-100 clean air station), MDN staging room, long-term sample storage trailer, hazardous waste control facilities, work shop, conference room, walk-in fire-proof safe (where our server and computer back-up system is kept), and staff offices. Frontier's entire space is in a security-locked facility.

The laboratories are served by a custom-designed HVAC system with ESP pre-cleaners, providing an atmosphere that is clean and well isolated from outside dust and dirt. Each laboratory atmosphere is routinely monitored for gaseous Hg, and appropriate action is taken if it exceeds 25 ng/m<sup>3</sup> in any location, or 10 ng/m<sup>3</sup> in the clean rooms. Frontier uses continuously monitored acid neutralization discharge systems for liquid acid-waste disposal. Disposal of all other toxic materials is carried out under contract to a certified disposal company. The

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# FACILITY DESCRIPTION

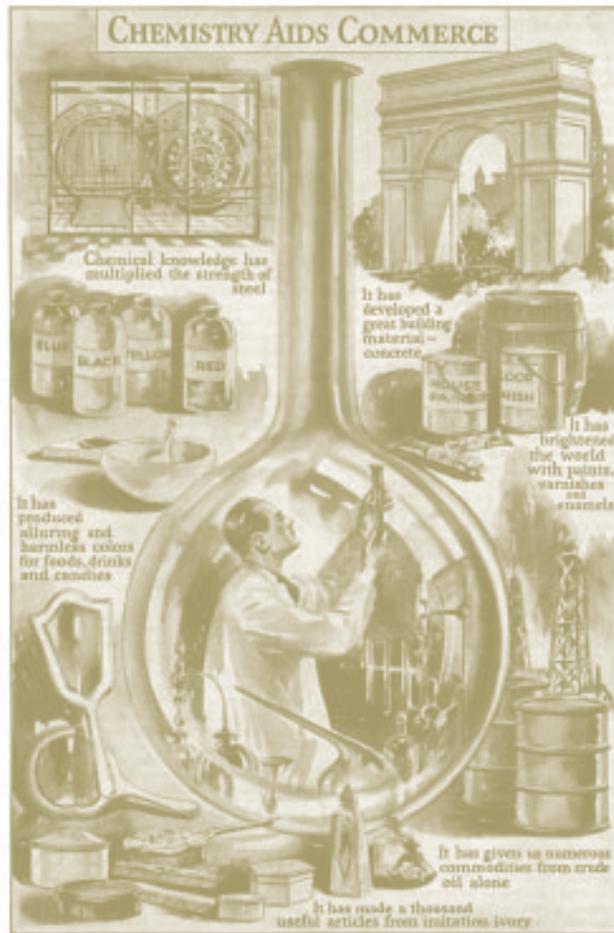




# FACILITY DESCRIPTION

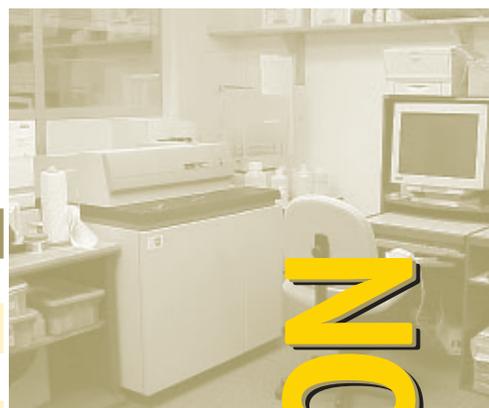
entire Frontier space has been inspected and passes all city and state code requirements for fire, emissions, and storage of low-level radioactive samples.

The offices are equipped with document production equipment, including laser printers, document and image processing software, high volume photographic-quality color printer, large capacity collating copier, and a binding machine. A LAN connects staff computers and printers for local access, and provides external email, faxes, and internet access. Frontier also maintains a web site at [www.FrontierGeosciences.com](http://www.FrontierGeosciences.com), and has a Fed-Ex Powership shipping computer and access to Fedex pick-up until 5:00 PM Pacific Coast time. Staff are also present on Saturdays to receive sample shipments.



# Major Analytical Equipment

Quantity	Instrumentation
7	Cold Vapor Atomic Fluorescence Hg Detector
3	Isothermal GC for Hg Speciation
1	Tekran 2537 Atmospheric Hg Monitor
1	Tekran 2600 Automated Aqueous Hg Analyzer
2	Perkin-Elmer ELAN-6000 ICP/MS
1	Perkin Elmer Zeeman 4110 GFAAS
1	Cryotrap-HG/AAS System (As speciation)
1	IC-HG/AFS System (Se speciation)
2	UV-VIS Spectrophotometer
1	PSA "Millennium" HG/AFS System (As, Se, Sb)
1	Dionex Ion Chromatograph
1	Low Level Ozone Analyzer/Calibrator
4	Specific Ion/Conductance/pH Meter
7	Class 100 Clean Air Hood
3	Milli-Q Reagent Water System
1	4' Hg-Free Nitrogen-Purge Glove Box
1	Large Volume Centrifuge (250 mL bottle)
1	Tungsten Carbide Ball Mill
6	Methyl Hg Distillation Units
5	Complete Sets of Fluegas Sampling Equipment
24	Teflon Bulk Deposition Collectors
2	Gold Sputter Coater
10	Digital Mass Flowmeter
2	Teflon-Coated Go-Flo Water Sampling Bottle
2	Ultra-Clean Peristaltic Field Sampling Pumps
1	Temperature Controlled Gas Reaction Mixing System
2	Static Plume Dilution Chamber (Teflon Coated)
1000's	Ultra-Clean Teflon Bottles (various sizes)
1	All Plastic Class-100 Bottle Washing Room
1	Alpkem CN3000 Low Level Cyanide Analyzer



FACILITY DESCRIPTION



# RECENT PROJECTS

## Rapid Response to an Environmental Mercury Spill

*Nicolas S Bloom, Team Leader*

*Michelle Gauthier, Project Manager*



In response to an elemental mercury spill in several towns located in the Peruvian Andes, Frontier Geosciences provided project design, consulting, field personnel, and laboratory analysis on ultra-fast TAT basis, allowing remediation decisions to be made rapidly and effectively. Among the services provided, Frontier set up a 3-person remote screening laboratory at the site for the determination of total mercury in thousands of soil samples over a three month period. Frontier also provided equipment and training for real-time monitoring of atmospheric Hg levels from ambient ( $0.002 \text{ mg/m}^3$ ) to levels of concern ( $> 20 \text{ mg/m}^3$ ). Atmospheric mercury was measured in hundreds of residences as part of the remediation process in the ambient air, and in soil flux chambers, to provide guidance in locating spilled mercury along the road. Field crews collected hundreds of water samples for ultra-low level Hg quantification (these were sent back to the full-QA clean lab in Seattle for overnight analysis), and provided training for mine-site consultants to continue sample collection after the departure of the Frontier crew. Frontier also provided expertise in document review, calibration of instrumentation at high altitude, and specialty analyses such as TCLP extractions, and diffusion of Hg into asphalt. This project had a value of approximately \$500K in the first three months, with lower-level on-going monitoring expected over the next several years.

## Atmospheric Transformation and Fate of Mercury from Combustion Point Sources

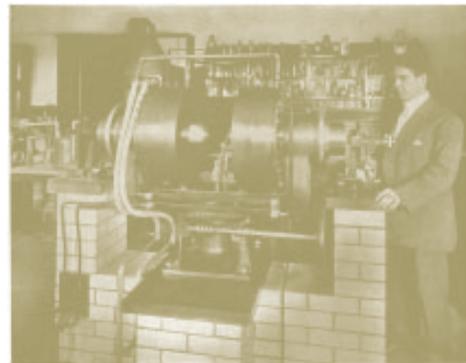
*Eric M. Prestbo, Senior Research Scientist*

 Current research funded by Florida's Department of Environmental Protection is focusing on the development of an automated atmospheric Hg speciation capability using cold vapor atomic fluorescence spectroscopy (CVAFS - Tekran 2537) and KCl-coated annular denuders (Tekran 1130p). Using a custom-designed laboratory system, calibrated test atmospheres containing part-per-quadrillion HgCl<sub>2</sub> are made in order to evaluate the Tekran 2537 and 1130p (FY97-98 funding of \$110 K). The atmospheric Hg speciation instrument will be used with a Static Plume Dilution Chamber (SPDC) Method developed by Frontier Geosciences. This project will characterize the important, but poorly understood chemistry of Hg in combustion plumes. The SPDC has been used to study two coal-combustion utility boilers and one municipal waste incineration facility. As predicted, we have shown that the speciation of Hg in the plume of a combustion source has changed from the speciation in the fluegas duct. Funding has come from Wisconsin DNR (\$180 K) and Maryland DNR (\$70 K) and another two studies are planned with funding from US DOE, EPRI, EPA-CATM and EPA-GLNPO (\$120 K).

## Carson River Mercury Speciation Study

*Nicolas S Bloom, Project Manager*

 Mercury speciation analyses of water, porewater, sediment, and a wide variety of organisms including fish, lizards, crayfish, zooplankton, and birds has provided the EPA with background information on the extent of mercury contamination caused by Civil War-era gold mining. Mercury and methyl mercury concentrations are measured in various body parts of birds including blood, brains, kidneys, livers, stomach contents, feathers, and eggs. These birds feed primarily on aquatic prey, and are being studied as bioindicators. Frontier also provides equipment and sampling advice. This study is funded by the EPA, at a total value to Frontier of over \$300K.



RECENT PROJECTS



## Diagenesis of Mercury in Marine Sediments

*Nicolas S Bloom, Research Scientist*



Frontier Geosciences provided field training, sampling plan design advice, and analytical services on a large biogeochemical reconnaissance study at a mercury-contaminated bay (Lavaca Bay, TX). Field work, consisting of 4000 analyses for mercury, methyl mercury, and ancillary parameters such as Fe, Mn, DOC, and TSS was completed in six weeks, with one week turn-around-time on results, to allow semi-real-time plan modifications. Before beginning work, various methods for the collection of mercury speciation in sediment porewater were extensively tested, and one (inert gas centrifugation and filtration) was modified and perfected for the task. As part of this study the methylation and release of mercury as a result of marine sediment dredging was also investigated. The project generated nine research papers (several published in *Environmental Science & Technology*), and numerous oral presentations. This study was conducted in 1996–1999, at a total value of over \$400K.

## Long-Range Transport of Mercury Species at the Western Boundary of North America

*Eric M. Prestbo, Senior Research Scientist*



Current research funded by the USEPA in collaboration with Dr. Dan Jaffe of the University of Washington is focused on the measurement of atmospheric mercury speciation at Cheeka Peak Observatory on the coast of Washington. The data derived from this study are important in two ways. First, these data will serve as the boundary input for continental atmospheric Hg transport models. Recent research has shown that cross-Pacific Ocean pollution events (CO, O<sub>3</sub> and aerosols) are observed on the West Coast of North America. East-Asia is estimated to have the highest regional anthropogenic Hg emissions rates on the globe. Thus, this study will also test the hypothesis that mercury will be significantly elevated above background concentrations during these cross-Pacific Ocean pollution events. The measurements will be made using cold vapor atomic fluorescence spectroscopy (CVAFS - Tekran 2537). Speciation will be possible with the Frontier tested KCl coated annular denuder



RECENT PROJECTS

technique (Tekran 1130p). A newly developed gaseous Hg(II) calibration method, developed at Frontier Geosciences, will be used in this field study. The project is planned for FY2001-2002 at approximately \$100 K.

### Everglades Nutrient Removal Project

*Eric von der Geest, Project Manager*



The Everglades Nutrient Removal (ENR) Project is an ongoing multi-year study to monitor and determine the atmospheric inputs of mercury, bioaccumulation of methyl mercury, and mercury mass balance in the vicinity of the Florida Everglades. Frontier Geosciences provides mercury speciation analyses (total mercury and methyl mercury) in various matrices (aqueous and solid) at ultra-trace levels of detection. Frontier's high quality assurance and low detection limits ensure accurate interpretations and effective policy decisions. This study has been conducted since 1995 and is funded by the Florida Department of Environmental Protection and South Florida Water Management District, at a total value to Frontier of over \$1,000K.

### Mercury at Chlor-Alkali Production Sites

*Nicolas S Bloom, Project Manager*



Many chlorine-caustic production facilities which use or used mercury cell technology are currently targeted for environmental characterization and cleanup. Frontier is, or has been involved in one manner or another with a number of these, and is currently providing critical scientific expertise to several sites in Canada and the U.S. Frontier staff team with full-service consulting companies, and the facility owners in the investigation, risk assessment, and remediation of the sites. Frontier provides expertise in sampling and analysis, ambient monitoring, innovative groundwater treatment technology development, and experience with similar sites. These projects have been ongoing since 1995, with a total value of more than \$700K.



# PROJECTS



# RECENT



## Use of a Dilution Chamber to Study Combustion Plume Emissions and Near-Term Transformations

*Eric M. Prestbo, Senior Research Scientist*



The overarching project goal was to make significant advances in the determination of the physical and chemical transformations of Hg in combustion plumes. This was accomplished by evaluating an improved static plume dilution chamber (SPDC) technique and fluegas Hg speciation method, Sorbent Ontario Hydro (SOH), in a controlled manner, at the pilot-scale level, using dynamic fluegas spiking of known mercury compounds. The new SPDC system used a Tekran 2537 automated Hg instrument to measure  $Hg^0$  continuously behind a KCl-denuder to capture gaseous Hg(II) and mini-filter for PHg collection. Real-time, continuous  $Hg^0$  values were generated. Both Hg(II) and particulate Hg required 20-minute sampling times, but serial samples provided a picture of changing Hg(II) and PHg with time. Thus it was possible to better observe Hg species transformations with respect to time, allowing for calculations of “effective” plume Hg reaction rates.

An improved delivery system for the introduction of simulated rainwater used an all-plastic diaphragm water pump and spray nozzle system that generated well-characterized droplet sizes of 50-100  $\mu m$ . The Hg speciation input to the SPDC was precisely characterized by EERC using the EPA validated Ontario Hydro fluegas speciation method. In addition, recent experiments have shown that a new method that samples fluegas using a series of sorbents, KCl-coated quartz and iodized carbon, agrees with the Ontario-Hydro method in side-by-side tests. The Sorbent Ontario Hydro (SOH) Method was improved by adding an in-stack, isokinetic particulate filter.

The SOH was evaluated against the OH Method using the EPA’s “Performance Based Measurement System.” The specific objective of the project was to do test runs in a controlled manner at the pilot-scale level using dynamic spiking of known mercury compounds (i.e.  $Hg^0$  and  $HgCl_2$ ) to quantify the performance of the SPDC to determine the following: 1) mass balance of total Hg using sum of species in SPDC, 2) the fraction of gaseous Hg(II) adsorbed onto either flyash or ambient particulate matter in a cooling plume, 3) the fraction of gaseous Hg(II) dry deposited to the SPDC walls, and what form it takes, particulate or dissolved, in a simulated rainwater washout, 4) the conversion of Hg(II) adsorbed to particles and SPDC walls to  $Hg^0$  in the presence of simulated sunlight, and 5) what fraction of

each Hg species is removed to the aqueous phase during a real-time simulated rainwater washout. A tangential result of this project will be a full intercomparison of the new Sorbent Ontario Hydro (SOH) Method with the EPA validated Ontario Hydro Method with dynamic standard additions of  $\text{HgCl}_2$  and  $\text{Hg}^0$ . A total of 16 SPDC runs were done with changing variables of  $\text{HgCl}_2$  spiking,  $\text{Hg}^0$  spiking, flyash input, light input,  $\text{O}_3$  input and rainwater input. The entire project was funded at about \$250 K.

## Mercury Speciation in Mining Sites

*Nicolas S Bloom, Project Manager*



Several abandoned mining sites throughout the Western United States are being investigated by various USGS personnel. These include Cinnabar Creek in Southeastern Alaska, and the Clear Lake, Cache Creek, and Homestake mining areas of California. Also included in these investigations are studies of natural mercury and trace-metals-rich hot springs around Clear Lake, and eventual discharges of mercury contaminated suspended matter to San Francisco Bay (CALFED). Species analyzed for these projects include total and methyl mercury in water, suspended matter, plants and soils, as well as the assessment of  $\text{Hg}^0$  and  $\text{HgS}$  in soils. Arsenic speciation has been studied at a more limited number of sites. These various projects have been ongoing since 1995, with an estimated total value of \$450K.

## National Atmospheric Deposition Program— Mercury Deposition Network

*Bob Brunette, Project Manager*



Frontier Geosciences is the Hg Analytical Lab (HAL) and Site Liaison center for the largest Hg deposition monitoring network in North America. The Mercury Deposition Network (MDN), coordinated through the National Atmospheric Deposition Program (NADP), was designed with the primary objective of quantifying the wet deposition of mercury in North America to determine long-term geographic and temporal distributions. The MDN began in 1995 with 17 sites, and, to date, has grown to nearly 50 sites across the US



RECENT PROJECTS

# RECENT PROJECTS

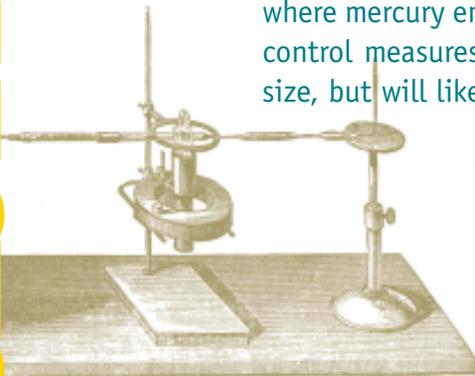
and Canada. Each MDN site collects weekly integrated wet deposition samples in special automated trace metal clean samplers. At a number of sites, methyl mercury is also determined in the rain sample. In addition, a separate trace metal sample train capability has been developed and will soon be deployed at a number of sites. MDN data will be particularly critical for evaluating the effectiveness of state and federally mandated controls on North American mercury emissions, to take effect as part of the Clean Air Act Amendment. In anticipation of lower Hg emissions limits, the MDN plans to increase the number of sites to over 100, and continue operations for at least 5–10 years. Data and a full description of the program is available for review on the web site (<http://nadp.sws.uiuc.edu/mdn/>). This ongoing, long-term project generates \$420K/year and is expected to double in size by 2002.

## Atmospheric Mercury Speciation Emissions from a Bauxite Refinery

*Eric M. Prestbo, Senior Research Scientist*



This project was designed to accomplish three goals. First, Frontier Geosciences developed the capability to measure Hg concentrations in real-time in the complex two-phase, high temperature exhaust gases found at a bauxite refinery. The detector used was a Lumex RA915+ Zeeman, long-path atomic absorption spectrometer. The front-end module used multiple mass flow meters and dry nitrogen to dilute and pre-treat the gases so that mercury could be accurately measured over 6 orders of magnitude. Second, the speciation in the fluegas was measured, and indicated that the emissions were dominated by the elemental form, suggesting that local impacts due to transport and deposition will be small. Third, the entire facility was mass-balanced for mercury so that an accurate emission estimate could be calculated, and so that those places where mercury emissions are greatest and could be reduced through control measures could be identified. This project was \$100 K in size, but will likely be expanded to other sites around the world.



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## New York Harbor Dredging Study

*Michelle Gauthier, Project Manager*



Thus far, Frontier has been helping the various agencies involved design or modify sampling and analytical plans to allow accurate ultra-low metals determination. When the major sampling campaigns begin, the work load will consist mostly of analysis for low level cadmium, mercury, and methyl mercury in fresh water, salt water, and effluent samples taken from the Hudson River/New York Harbor area. Tissues and sediments will also be analyzed. Data is collected and reported under rigorously scrutinized Level-4 QA/QC protocols. It is anticipated that this project will generate over \$300K per year for 3–5 years.

## Sacramento River Ambient Monitoring Program & Priority Pollutant Prevention Program

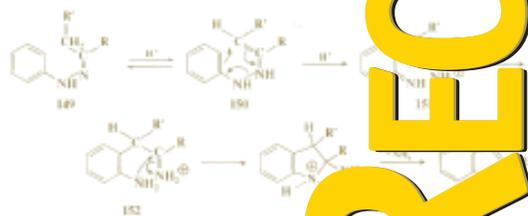
*Michelle Gauthier, Project Manager*



The Ambient Monitoring Program (AMP) looks at total and dissolved trace metals in river samples both above and below the Sacramento Municipal Waste Water Treatment Plant (WWTP), and the Priority Pollutant Prevention Program (P4) investigates the trace metals removal efficiency of the WWTP itself. This project began in 1993, with the demonstration that mercury could be routinely monitored at ambient water concentrations of < 1 ng/L. The key was found to be implementation of simplified clean sampling techniques, analytical lab pre-cleaned and tested sampling bottles, and sample filtration in the clean-lab rather than in the field. Based upon the dramatic improvement in data interpretability, Sacramento awarded Frontier a three year contract to look at ten other trace metals using a variety of ultra-clean techniques, including ICP-MS and HG-AFS. This project has been ongoing since 1993, with a total value of \$620K.



RECENT PROJECTS



# RECENT PROJECTS

## Selenium Speciation Methods Development

*Dirk Wallschläger, Research Scientist*

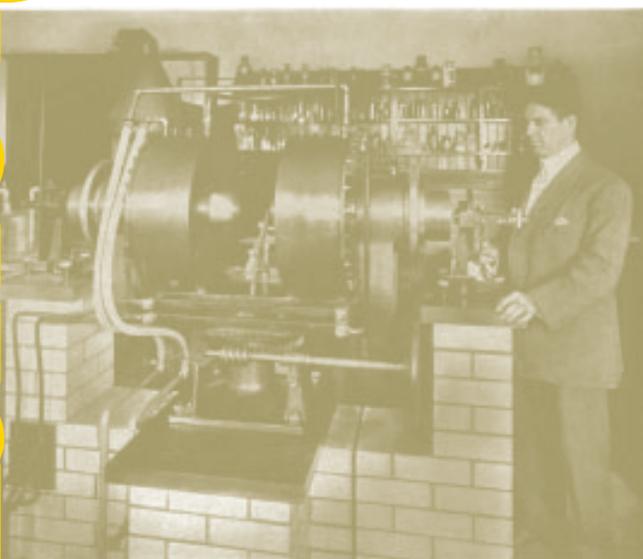
**D**evelopment of a more accurate ultra-trace selenium speciation methodology based upon ion chromatographic separation and hydride generation plus atomic fluorescence spectrometric detection. The initial goal is to allow exploration of speciation changes in industrial and mining wastewater treatment systems to allow optimization for the removal of selenium. The developed analytical technique will be applicable to As, Sb, and Te speciation as well. This project obtained start-up funding of \$80K in 1997, and has been an ongoing Frontier internal research project since then.

## US EPA's 1600-Series Reference Laboratory

*Nicolas S Bloom & Michelle Gauthier, Project Managers*

**F**rontier Geosciences wrote the draft Method 1631 (low level total mercury) and Method 1630 (low level methyl mercury), and provided advice on the remainder of the 1600 series trace metals and clean sampling methods (Method 1669). Frontier was chosen to be the reference lab for the US EPA validation study for Method 1631, providing sample collection, homogenization, spiking, and distribution to 12 participating validation labs around the world. Frontier worked closely with Dyncorp personnel, who put together the study design, validated the data, and created the final report.

This validation study has been characterized by several EPA contractors as, "the most efficiently run, cost effective, and successful study of its kind in history." Frontier is currently the reference lab for the remaining 1600 series trace metals validation studies. This project was conducted between 1993 and 1999 with a total value of \$125K.





Ed Geiger, President, CFO

## Pricing Guidelines and General Business Information

**B**ecause client-specific QA/QC, turn-around time (TAT), detection limits, and electronic data deliverable (EDD) requirements vary, it is impossible to obtain an exact cost quote without first discussing your project with a Frontier project manager or research scientist. Please check the “personnel” section for a list of project managers and research scientists, their areas of specialty, and how they can be reached. Or call, (206) 622-6960, fax, (206) 622-6870, or email us at [Info@Frontier.WA.com](mailto:Info@Frontier.WA.com). For non-scientific information on contracts, general business information, invoice questions, and collections, please contact the following:

Contracts, and general business information

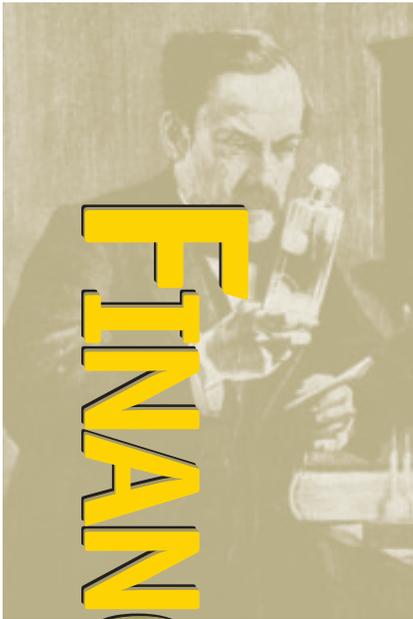
Ed Geiger, President, CFO  
[EddieG@Frontier.WA.com](mailto:EddieG@Frontier.WA.com)

Invoice questions, and collections

Jeanne Herget-Sons, Accountant  
[JeanneH@Frontier.WA.com](mailto:JeanneH@Frontier.WA.com)



# FINANCIAL INFORMATION



# FINANCIAL INFORMATION

Factors which may affect the price quote include the size or continuity of the project, past interactions with Frontier, special hazardous materials handling, season (our workload often varies according to the time of year), and potential for Frontier staff to publish papers with the data. Discounts may be available to non-profit agencies in certain circumstances. Clients might also consider establishing a Basic Ordering Agreement (BOA) with us. The benefits of a BOA include discounted prices (5-15%), minimized paper work, and a simplified working relationship. For a sample BOA, please see the end of this section.

For information on shipping, receiving, sample containers, etc., please see the section in this brochure called "Sample Shipping & Receiving." Following are the answers to other frequently-asked price-related questions:

- We accept Visa and MasterCard
- Payment for services is due 30 days from the date of invoice
- Out-of-pocket expenses incurred during consulting (i.e., airfare, hotels, etc.) will be charged at cost +15% handling fee

The following information will help you make a quick estimate of costs, **but please contact one of our staff with full project details to obtain a firm quote.** We offer many more analytical and consulting services than those listed on the next page. The approximate costs also listed on the next page assume standard QA, standard (28 day max) TAT, simple or no EDD, and a minimum of eight billable samples per analytical set. The analysis costs do not include the cost of the digestion/extraction, which is a separate, per sample (not necessarily per analyte) cost. Up to one half-hour of expert consultation is included for jobs between \$2,500 and \$10,000. An additional hour is included for projects larger than \$10,000. More hours are available at Frontier's consulting rates.



# Typical Price Ranges

Type of Service	Approximate Cost (US dollars)
solids digestions/extractions (per sample)	30–120
aqueous digestions (per sample)	20–55
aqueous extractions (per sample)	60–85
dry weight basis	12
ultra-clean filtrations or TSS	35
single metal analysis by ICP-MS or GFAAS	30
next 5 elements (2–6) by ICP-MS	17
each additional ICP-MS metal analysis per run	12
As or Se analysis by HG-AFS	60–80
Hg analysis by CVAFS	55
methyl Hg analysis by CVAFS	140
full As or Se speciation in water	200–350
full As, Se, Hg speciation (solids)	360–1,500
full Hg speciation in flue gas	450–600
gaseous and particulate Hg in air EPA IO-5	180–250
high level (litigation) QA/QC	+30%
complex EDD	2–5 per data point
24-72 hour TAT (if possible)	+100%
3-7 day TAT (if possible)	+75%
8-14 day TAT (if possible)	+50%
15-21 day TAT (if possible)	+30%
22–27 day TAT (if possible)	+20%
technical staff hourly	45-80/hour
scientific staff hourly	80-225/hour
consulting rates per hour	81–199

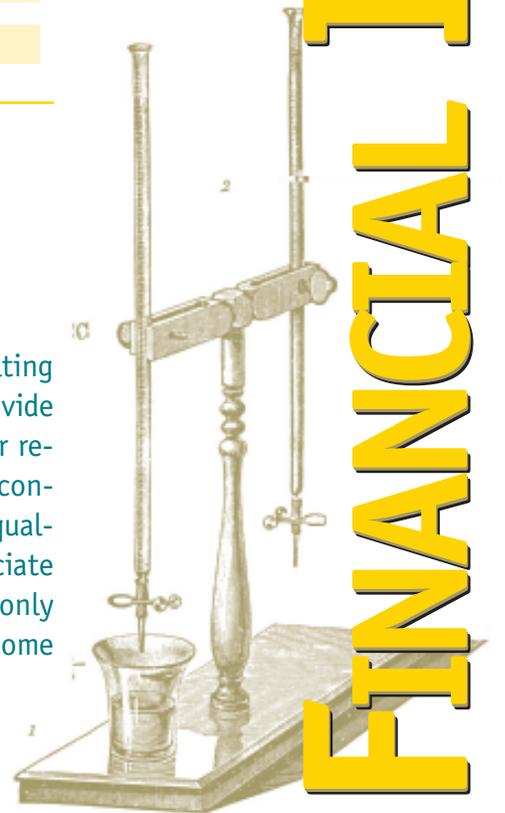


**FINANCIAL INFORMATION**

## Subcontracts

 Frontier maintains affiliations with a number of consulting agencies, laboratories, and universities in order to provide our clients with expertise outside our range of capabilities. For research projects, we often team with these organizations, or subcontract work to them. We offer this service in the belief that the quality of professionalism of the organizations we choose to associate with, combined with the convenience to our clients of having only one company to manage their project, ensures a better outcome and consequently encourages repeat business.

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 Info@Frontier.WA.com www.FrontierGeosciences.com



# Insurance



Our insurance includes \$2 million in general liability aggregate (1 million for each occurrence), \$1 million in accidental, auto, etc., \$1 million in commercial liability, and \$1 million in errors & omissions. Please see the sample insurance certificate below.

FINANCIAL INFORMATION

ACORD CERTIFICATE OF LIABILITY INSURANCE						DATE (MM/DD/YY) 03-01-99
<b>PRODUCER</b> INSURANCE WEST, INC. P.O. BOX 6099 BELLEVUE WA 98008			THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW.			
<b>COMPANIES AFFORDING COVERAGE</b>						
<b>FRONTIER GEOSCIENCE, INC.</b> 414 PONTIUS AVE NO. SEATTLE, WASH 98107			COMPANY A HARTFORD COMPANY B COLONY INS. CO. COMPANY C COMPANY D			
<b>COVERAGES</b> THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED, NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN. THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.						
CD STR	TYPE OF INSURANCE	POLICY NUMBER	POLICY EFFECTIVE DATE (MM/DD/YY)	POLICY EXPIRATION DATE (MM/DD/YY)	LIMITS	
A X	GENERAL LIABILITY <input checked="" type="checkbox"/> COMPREHENSIVE FORM <input type="checkbox"/> PREMISES/OCCUPATIONS <input type="checkbox"/> LABORERS AND EXPLOSION & COLLAPSE HAZARD <input type="checkbox"/> PRODUCTS/COMPLETED OPER <input type="checkbox"/> CONTRACTUAL <input type="checkbox"/> INDEPENDENT CONTRACTORS <input type="checkbox"/> SPECIAL FORM PROPERTY DAMAGE <input type="checkbox"/> PERSONAL INJURY	52 UUC JQ2073	09-18-98	09-18-99	BODILY INJURY OCC \$ BODILY INJURY AGG \$ PROPERTY DAMAGE OCC \$ PROPERTY DAMAGE AGG \$ BI & PD COMBINED OCC \$ 1,000,000 BI & PD COMBINED AGG \$ 2,000,000 PERSONAL INJURY AGG \$ 1,000,000 FIRE LEG 50,000 PREM MED 5,000	
A X	AUTOMOBILE LIABILITY <input type="checkbox"/> ANY AUTO <input type="checkbox"/> ALL OWNED AUTOS (Private Pass) <input type="checkbox"/> ALL OWNED AUTOS (Other Than Private Passenger) <input checked="" type="checkbox"/> HIRED AUTOS <input type="checkbox"/> NON-OWNED AUTOS <input type="checkbox"/> GARAGE LIABILITY	SAME	SAME	SAME	BODILY INJURY (Per Person) \$ BODILY INJURY (Per Accident) \$ 1,000,000 PROPERTY DAMAGE \$ BODILY INJURY & PROPERTY DAMAGE COMBINED \$	
A X	EXCESS LIABILITY <input checked="" type="checkbox"/> UMBRELLA FORM <input type="checkbox"/> OTHER THAN UMBRELLA FORM	52RHUXM4639	SAME	SAME	EACH OCCURRENCE \$ 2,000,000 AGGREGATE \$ 2,000,000	
	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY THE EMPLOYER'S POLICY/REGULATOR OFFICIALS ARE: <input type="checkbox"/> IBCL <input type="checkbox"/> SCL				THE EMPLOYER'S POLICY/REGULATOR OFFICIALS ARE: <input type="checkbox"/> IBCL <input type="checkbox"/> SCL \$L EACH ACCOUNT \$ \$L DISEASE - POLICY/LIMIT \$ \$L DISEASE - EA EMPLOYEE \$	
B	PROP E & O LIAB.	PE 10200668	04-17-98	04-17-99	1,000,000	
DESCRIPTION OF OPERATIONS/LOCATIONS/VEHICLES/SPECIAL ITEMS						
CERTIFICATE HOLDER IS ALSO AN ADDITIONAL INSURED						
CERTIFICATE HOLDER  SAMPLE COPY			CANCELLATION SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, THE ISSUING COMPANY WILL endeavor TO MAIL 30 DAYS WRITTEN NOTICE TO THE CERTIFICATE HOLDER NAMED TO THE LEFT. BUT FAILURE TO MAIL SUCH NOTICE SHALL IMPOSE NO OBLIGATION OR LIABILITY OF ANY KIND UPON THE COMPANY, ITS AGENTS OR REPRESENTATIVES.			
ACORD 25-N (1/98)			AUTHORIZED REPRESENTATIVE <i>Ray Thomas</i> © ACORD CORPORATION 1988			

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# Sample Form (BOA)

## Basic Ordering Agreement for Analytical and Consulting Services

\_\_\_\_\_ (Hereinafter called "Client") and FRONTIER GEOSCIENCES INC. (Hereinafter called "Lab") hereby agree as follows:

- I. During the term of this Agreement, the Lab agrees to sell to the Client, including its subsidiaries and offices, located in the United States, the analytical services and consulting services at an initial price discount of 5% from the then current published price list.
  - A. The discount will increase to 10% after sole-sourced cumulative invoices within any calendar year are between \$50,000 and \$100,000.
  - B. The discount will increase to 15% after sole-sourced cumulative invoices within any calendar year are over \$100,000.
- II. The term of this Agreement shall be from the signing date of this agreement \_\_\_\_\_ to calendar year end. Either party shall have the right to terminate this agreement at any time on sixty (60) days prior written notice to the other by fax or mail.

# FINANCIAL INFORMATION

- III. During the term of this Agreement, all sole-sourced (and only sole-sourced) purchases by the Client shall be subject to the provisions of this Agreement and Lab's standard terms and conditions at time of sale (see FRONTIER GEOSCIENCES SOQ).
- IV. Payment terms: Payable 30 days after services are rendered and invoice is mailed. Continued delinquencies will cause subject member facility to be withdrawn from this agreement until the account is returned to a current status.
- V. Minimum Order Value: None. 12-month order projection \_\_\_\_\_.
- VI. This Agreement is a General Contract which allows Frontier to start a new job with no more than a Work Order or Purchase Order describing the work needed.
- VII. Client agrees:
  - A. That Frontier Geosciences shall be a preferred but not (necessarily) exclusive service supplier of Client.
  - B. To make available the information contained in this Agreement to each of Client's member facilities, providing copies of this Agreement.
  - C. To provide a list of individual Client national account contact representatives, with mailing addresses and telephone numbers.
  - D. To periodically work with FRONTIER GEOSCIENCES to update the mailing list of Client's purchasing representatives for analytical and consulting services so that appropriate technical information pertaining to said services may be provided.

**Client:**

\_\_\_\_\_

By: \_\_\_\_\_

Signature: \_\_\_\_\_

Title: \_\_\_\_\_

Date: \_\_\_\_\_ / \_\_\_\_\_ / \_\_\_\_\_

Mailing Address: \_\_\_\_\_

\_\_\_\_\_

Telephone: \_\_\_\_\_

Fax: \_\_\_\_\_

Email: \_\_\_\_\_

**Lab:**

Frontier Geosciences Inc.

By: Ed Geiger

Signature: \_\_\_\_\_

Title: President

Date: \_\_\_\_\_ / \_\_\_\_\_ / \_\_\_\_\_

Mailing Address: 414 Pontius Ave. N., Suite B

Seattle, WA 98109-5461

Telephone: (206) 622-6960

Fax: (206) 622-6870

Email: EddieG@Frontier.WA.com

**SCHEDULE I**

This FRONTIER GEOSCIENCES INC. Basic Order Agreement shall apply to the following Client subsidiaries and Offices:

Subsidiary/Office

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Subsidiary/Office

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

(Please attach additional pages if necessary)

**FINANCIAL INFORMATION**



# Methods and Method Detection Limits

## Methods

Frontier Geosciences utilizes state-of-the-art analytical techniques. Some are in use by the scientific research community. Others are under development at our own research lab, but not yet available as standard, EPA-approved methods. Frontier has worked diligently with the EPA Engineering and Analysis Division of the Office of Science and Technology to convert this new generation of methods to EPA-approved status (e.g., US EPA's 1600 series). Listed below are brief descriptions of our most commonly used analytical methods, as well as the equivalent EPA method number or other reference. Please be aware that all of the methods we employ for client use are highly QC-validated, and may be officially approved for use even on EPA CLP and NPDES studies, on a case-by-case basis. In addition to the methods listed, Frontier can design custom analytical and extraction methods to meet the most exacting requirements for your specific matrix/analyte combination. Examples might include silicon, phosphorous, or iodine by ICP-MS, metallo-cyanide complexes by IC-Colorimetry, organo-tin compounds by derivatization, HG-CT-GC-AAS, or lead speciation in soils by selective extraction.

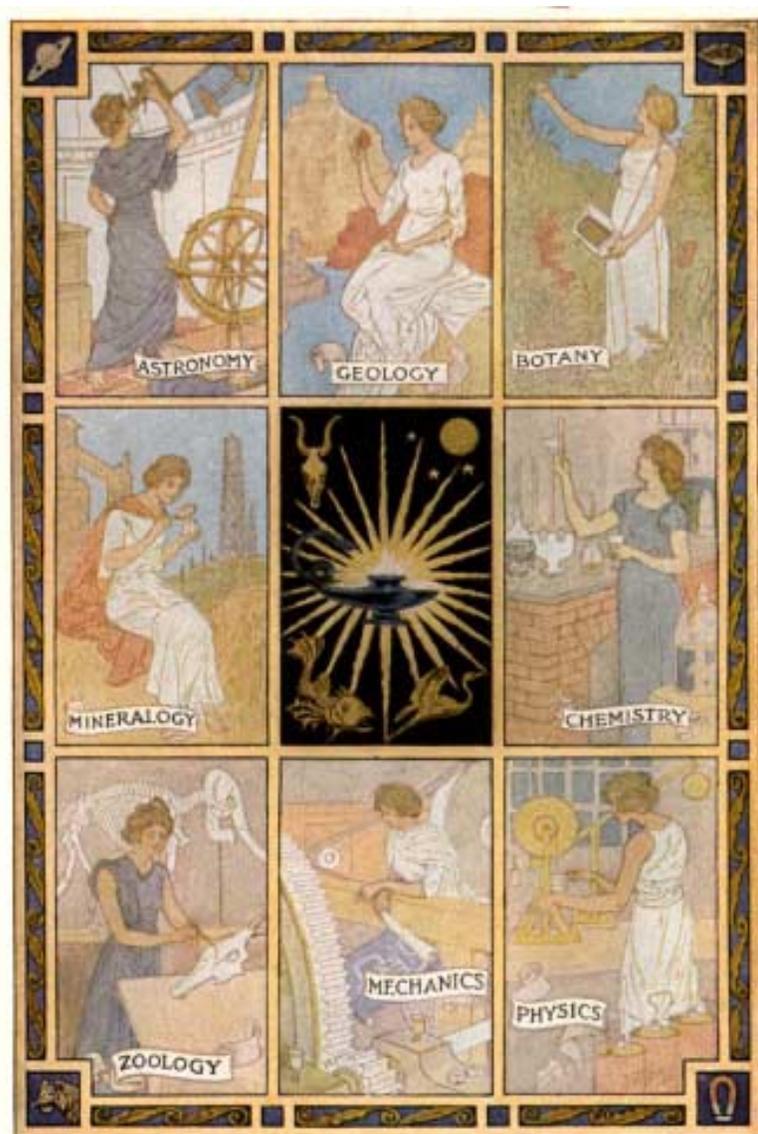
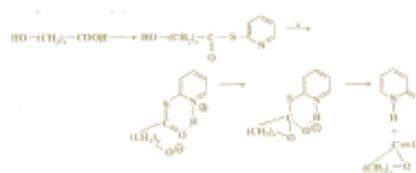
## Method Detection Limits

The method detection limit (MDL) tables in this section were compiled from recent 40 CFR 136 studies, where seven or more low level spikes in reagent water are processed exactly as samples, and the MDL is then determined as  $t \cdot SD$  of the seven or more replicates ( $t \approx 3$  for this number of replicates), and then rounded up to one significant figure. In cases where an official MDL study was not performed, the MDL is estimated as  $3 \cdot SD$  of three or more complete method blanks. Frontier

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TYPICAL MDLS

has MDLs for more matrices and elements than are shown here, going back several years, and can always perform an MDL study for your particular matrix/analyte combination. Also, please note that these MDLs are “typical,” and so may vary approximately  $\pm 100\%$  from data set to data set. In some cases, these MDLs can be improved upon by a factor of 2-10 by using special techniques (there may be a surcharge for such treatment). In 1999, we rigorously determined MDLs for all 69 elements that can be measured by ICP-MS. These MDLs were determined in both deionized water and brine, and are available upon request.



# TYPICAL MDLS



## Commonly Used Analytical Methods at Frontier

Analyte	Method Description	Reference
ultra-clean sampling	clean hands/dirty hands	Method 1669
trace metals	ICP-MS	Method 1638/200.8 modified
trace metals (single)	stabilized platform ZGFAAS	Method 1637 modified
metals in seawater	Co-APDC co-precipitation	Method 1640/1639 modified
As (very low level)	HG-CT-AAS	Method 1632 modified
As (low level)	HG-AFS	internal
As speciation	HG-CT-AAS	Method 1632 modified
As speciation	IC-HG-AFS	Wallschläger
total Hg	BrCl oxidation, CVAFS	Method 1631 modified
methyl mercury	ethylation, GC- CVAFS	Method 1630 modified
ionic, elemental Hg	purge and trap, CVAFS	Method 1631 modified
dimethyl mercury	purge and trap GC-CVAFS	Method 1630 modified
Se (low level)	HG-AFS	internal
Se speciation	selective redox; HG-AFS	Cutter, 1986
Se speciation	IC-HG-AFS	Wallschläger, 1999
Cr(VI)	colorimetric	Method 7196A modified
Fe(II)	colorimetric	Stookey, 1970
soil, coal digest for Hg	cold aqua regia	Method 7471 modified
soils Hg speciation	selective extraction	Bloom, et al., 1999-2000
total metals in soils	HF/HNO <sub>3</sub> bomb digest	NOAA
total metals in tissue	HNO <sub>3</sub> reflux digestion	internal
total metals in water	dilute HF/HNO <sub>3</sub>	Bloom & Gauthier, 1992
AVS-SEM (soil)	5% HCl leach	Allen, et al., 1991
indoor air Hg (industrial hygiene)	passive gold trap	Bloom, 1999
flue gas Hg speciation	Sorbent Ontario Hydro (SOH)	Prestbo, et al., 1989
ambient air total Hg	gold trap	EPA-I05
ambient air particulate Hg	quartz filter	EPA-I05
total cyanide	flow injection potentiometric	Method OIA-1678
WAD cyanide	flow injection potentiometric	Method OIA-1677

### acronyms:

HG-CT-AAS—cryogenic trapping hydride generation atomic absorption  
 IC-HG-AFS—ion chromatography hydride generation atomic fluorescence  
 CVAFS—cold vapor atomic fluorescence spectrometry  
 ZGFAAS—Zeeman graphite furnace atomic absorption spectrometry  
 ICP-MS—inductively coupled plasma mass spectrometry

TYPICAL METHODS

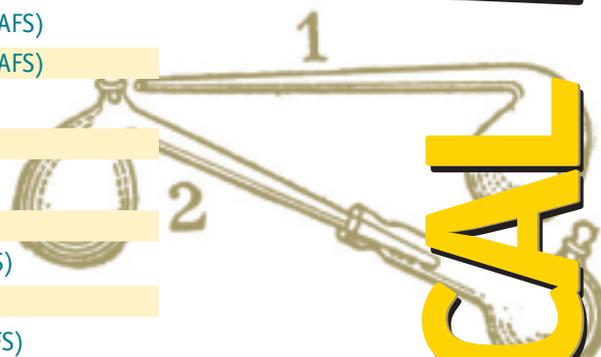


# Recent MDLs (40 CFR 136) for Fresh Water, $\mu\text{g/L}$ (ppb)

Element	ICP-MS	ZGFAAS	Other
Be	0.023	0.2	
Al	0.87	2	
V	0.06	na	
Cr	0.03	0.05	
Cr(VI)	na	na	0.3 (colorimetric)
Mn	0.01	0.3	
Fe	1.2	1	2.0 (colorimetric)
Fe(II)	na	na	1.5 (colorimetric)
Co	0.02	0.2	
Ni	0.015	0.99	
Cu	0.02	0.35	
Zn	0.05	0.13	
As	0.1	3	0.003 (HG-CT-AAS)
As(III)	na	na	0.003 (HG-CT-AAS)
CH <sub>3</sub> As	na	na	0.005 (HG-CT-AAS)
(CH <sub>3</sub> ) <sub>2</sub> As	na	na	0.005 (HG-CT-AAS)
Se	0.16	4	0.02 (HG-AFS)
Se(IV)	na	na	0.05 (IC-HG-AFS)
Se(VI)	na	na	0.05 (IC-HG-AFS)
SeCN <sup>-</sup>	na	na	0.05 (IC-HG-AFS)
Mo	0.01	2	
Ag	0.005	0.055	
Cd	0.004	0.1	
Sn	0.08	na	
Sb	0.002	2	0.02 (HG-AFS)
Ba	0.02	30	
Hg	0.01	na	0.0001 (CVAFS)
Hg(II)	na	na	0.0001 (CVAFS)
Hg <sup>0</sup>	na	na	0.00005 (CVAFS)
CH <sub>3</sub> Hg <sup>+</sup>	na	na	0.00002 (GC-CVAFS)
(CH <sub>3</sub> ) <sub>2</sub> Hg	na	na	0.00002 (GC-CVAFS)
Tl	0.002	3	
Pb	0.002	0.25	
U	0.002	na	



TYPICAL MDLS

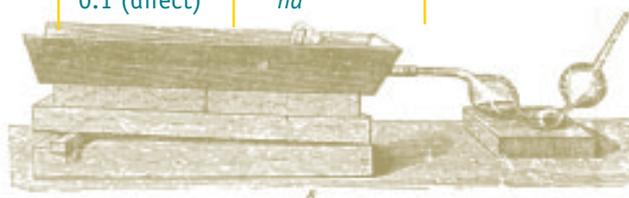




## Recent MDLs (40 CFR 136) for Sea Water, $\mu\text{g/L}$ (ppb)

TYPICAL MDLS

Element	Pre-Concentrated ICP-MS	Direct ZGFAAS	Other
Be	0.0002	0.2	
Cr	0.05	0.3	
Cr(VI)	na	na	0.3 (colorimetric)
Mn	na	0.5	
Fe	na	2	1.5 (colorimetric)
Fe(II)	na	na	1.5 (colorimetric)
Ni	0.018	na	
Cu	0.012	2	
Zn	na	0.3	
As	0.02	na	0.003 (HG-CT-AAS)
As(III)	na	na	0.003 (HG-CT-AAS)
CH <sub>3</sub> As	na	na	0.005 (HG-CT-AAS)
(CH <sub>3</sub> ) <sub>2</sub> As	na	na	0.005 (HG-CT-AAS)
Se	na	4	0.02 (HG-AFS)
Se(IV)	na	na	0.01 (HG-AFS)
Se(VI)	na	na	1 (IC-HG-AFS)
SeCN <sup>-</sup>	na	na	1 (IC-HG-AFS)
Ag	0.001	na	
Cd	0.002	0.5	
Sb	0.02	na	0.02 (HG-AFS)
Ba	0.3 (direct)	30	
Hg	na	na	0.0001 (CVAFS)
Hg(II)	na	na	0.0001 (CVAFS)
Hg <sup>0</sup>	na	na	0.00005 (CVAFS)
CH <sub>3</sub> Hg <sup>+</sup>	na	na	0.00002 (GC-CVAFS)
(CH <sub>3</sub> ) <sub>2</sub> Hg	na	na	0.00002 (GC-CVAFS)
Tl	0.1 (direct)	na	
Pb	0.002	na	
U	0.1 (direct)	na	



# Recent MDLs (40 CFR 136) for Sewage Effluent, $\mu\text{g/L}$ (ppb)

Element	ICP-MS	ZGFAAS	Other
Be	0.05	0.2	
Al	1.0	2	
Cr	0.07	0.1	
Cr(VI)	na	na	0.3 (colorimetric)
Mn	0.2	0.3	
Fe	6	0.8	1.5 (colorimetric)
Fe(II)	na	na	1.5 (colorimetric)
Ni	0.04	2	
Cu	0.06	0.5	
Zn	0.2	0.1	
As	0.4	3	0.003 (HG-CT-AAS)
As(III)	na	na	0.003 (HG-CT-AAS)
CH <sub>3</sub> As	na	na	0.005 (HG-CT-AAS)
(CH <sub>3</sub> ) <sub>2</sub> As	na	na	0.005 (HG-CT-AAS)
Se	0.3	4	0.05 (HG-AFS)
Se(IV)	na	na	0.02 (HG-AFS)
Se(VI)	na	na	0.2 (IC-HG-AFS)
SeCN <sup>-</sup>	na	na	0.2 (IC-HG-AFS)
Mo	0.02	2	
Ag	0.08	0.05	
Cd	0.03	0.1	
Sb	0.02	2	0.02 (HG-AFS)
Ba	0.02	30	
Hg	0.01	na	0.0006 (CVAFS)
Hg(II)	na	na	0.0001 (CVAFS)
Hg <sup>0</sup>	na	na	0.00005 (CVAFS)
CH <sub>3</sub> Hg <sup>+</sup>	na	na	0.00002 (GC-CVAFS)
(CH <sub>3</sub> ) <sub>2</sub> Hg	na	na	0.00002 (GC-CVAFS)
Tl	0.03	3	
Pb	0.03	0.4	
U	0.006	na	



# MDLS TYPICAL





# Recent MDLs (40 CFR 136) for Solids, $\mu\text{g/g}$ (ppm)

TYPICAL MDLS

*All Results by ICP-MS Unless Noted*

Element	Soils/Sediments	Tissues	Coal/Oil
Be	0.09	0.02	0.01
Al	10	0.2	10
V	0.3	0.1	0.1
Cr	0.5	0.1	0.05
Mn	0.8	0.02	0.04
Fe	10	0.6	10
Ni	0.05	0.01	0.07
Cu	0.3	0.01	0.02
Zn	0.3	0.04	0.02
As	0.5 or 0.1 (H)	0.05	0.07
As(III)	0.01 (H)	<i>experimental</i>	<i>na</i>
CH <sub>3</sub> As	0.02 (H)	<i>experimental</i>	<i>na</i>
(CH <sub>3</sub> ) <sub>2</sub> As	0.02 (H)	<i>experimental</i>	<i>na</i>
Se	0.05 (H)	0.06 or 0.01 (H)	0.02 [H]
Se(IV)	0.05 (H) or 0.5 (I)	<i>experimental</i>	<i>na</i>
Se(VI)	0.5 (I)	<i>experimental</i>	<i>na</i>
SeCN <sup>-</sup>	0.5 (I)	<i>experimental</i>	<i>na</i>
Mo	0.05	0.02	0.04
Ag	0.02	0.01	0.01
Cd	0.02	0.02	0.002
Sn	0.6	0.003	<i>nd</i>
Sb	0.02	0.005	0.006
Ba	0.4	0.01	0.6
Hg	0.0005 (C)	0.001 (C)	0.0002 (C)
Hg(II)	<i>experimental</i>	0.0024 (C)	0.0001 (C)
Hg <sup>0</sup>	<i>experimental</i>	<i>na</i>	0.0005 (C)
CH <sub>3</sub> Hg <sup>+</sup>	0.000005 (C)	0.0012 (C)*	0.00005 (C)
(CH <sub>3</sub> ) <sub>2</sub> Hg	0.000005 (C)	0.000005 (C)	<i>na</i>
Tl	0.03	0.01	0.004
Pb	0.04	0.01	0.03
U	0.01	0.008	0.001

\*0.000005  $\mu\text{g/g}$  is possible using distillation, but levels in tissues are too high to require this

(C) Cold vapor atomic fluorescence methods

(H) Hydride generation methods

(I) Ion chromatography/hydride generation methods

# Sample Containers, Shipping, and Receiving

## Who to Contact

 Frontier Geosciences supplies rigorously cleaned sample bottles at no additional cost, and sampling equipment at agreed-to prices. For low-level water samples, it is critical that sampling and filtering be done with Frontier-supplied or approved equipment. If it is more convenient, solid and tissue samples can usually be collected using “off the shelf” containers. *All shipments must be accompanied by a chain-of-custody form or letter identifying each sample in the shipment, and warning of any potential dangers or high levels of analytes.* Samples without such identification may be returned to the client, or may be delayed in processing. For samples requiring immediate processing (i.e., filtration, speciation), clients must notify the lab at least one day in advance of sample receipt, so that the special procedures can be scheduled. Failure to warn of such samples in advance could result in processing delays which might invalidate the speciation information to be gained, or could necessitate extra charges for employees’ over-time.

**To place an order for sample bottles or sampling equipment, contact our Senior Sample Custodian, Ms. Malaika Lafferty ([MalaikaL@Frontier.WA.com](mailto:MalaikaL@Frontier.WA.com)). Please call one of our project managers or research scientists for recommendations concerning speciation, unusual matrices, or unusual analytes.**



FIG. 36.—Specimen vials and rack for air samplers.



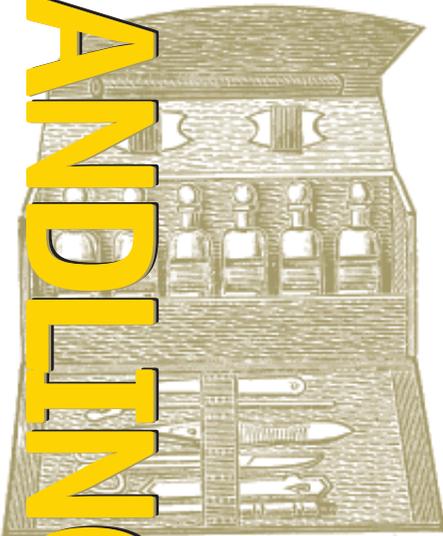
# SAMPLE HANDLING

## Preservation/Shipping

**B**ecause of rigorous DOT (Department of Transportation) rules for packaging and shipping acidic and basic solutions, and because of the risk of contamination by field crews, we recommend that samples not be field preserved unless absolutely necessary (for example, Cr(VI)). Ideally, water and sediment samples should be shipped in full bottles at 1–4°C via overnight courier so that they arrive at Frontier within 24–48 hours of collection. If this is not possible, bottles should be 70% filled, frozen, and shipped on dry ice. Tissue samples should be shipped frozen (preferably with dry ice). Aqueous samples that require filtration should, if possible, be field-filtered using Frontier-supplied clean equipment (EPA Method 1669). If this is impossible because of logistics, or because of the risk of field contamination, then oxic surface waters and effluents may be sent via overnight courier to be filtered at the lab. However, ground water, anoxic waters, sediment pore waters, and samples from an effluent/water mixing zone must be field filtered. Frontier can aid in sampling these media by sending a field crew, and/or providing training.

## PLEASE READ THIS.

**F**rontier does not accept human tissue (except hair), excreta (except municipal sewage), radioactive materials above our permit levels, or samples that may contain human pathogens (e.g., rabies, hanta virus, ebola virus, etc.). Frontier will only accept samples containing dangerous levels of toxic gas-producing compounds (e.g., cyanides, sulfides, sodium azide, chlorine bleach, etc.), mammal tissues, and explosive or unstable materials with prior written permission. *It is the responsibility of the client to divulge all known or suspected hazards, as well as high analyte concentrations—clearly, and in writing-- appended to the COC, and in the same container as the samples.* Failure to do so may lead to personnel injury or damages to the analytical laboratory which will be recovered by legal means. Prior arrangements must be made to return unused portions of EPA/RCRA-defined Hazardous Materials to the client, or to pay a surcharge for Frontier disposal of these materials.



# Containers and Preservation

Media	Analytes	Container	Laboratory Preservation	Unpreserved Hold Time
pristine water	most metals	UC P, T, G	1% HNO <sub>3</sub>	7 days
	total Hg	UC T	1% BrCl	7 days
	methyl mercury	UC T	0.4% HCl*	48 hours
	volatile Hg	UC G	immediate analysis	24 hours (ASAP)
	As speciation	UC P, G, T	immediate analysis	48 hours
	Se speciation	UC G	0.1% HCl	7 days
	Cr(EVI)	UC P	0.2% NaOH (field)	1 hour
waste water	most metals	UC P, G	1% HNO <sub>3</sub>	7 days
	total Hg	UC G	1% BrCl	7 days
	methyl mercury	UC G	0.4% HCl	48 hours
	volatile Hg	UC G	immediate analysis	24 hours (ASAP)
	As speciation	UC P, G	immediate analysis	48 hours
	Se speciation	UC G	0.1% HCl	7 days
	Cr(VI)	UC P	0.2% NaOH (field)	1 hour
tissues	all analytes	P, G, T	keep frozen	1 year-frozen
sediments	most metals	P, G, T	freeze	1 year
	methyl mercury	G, T	freeze	48 hours
	volatile Hg	G	immediate analysis	48 hours (ASAP)
	As speciation	G	freeze	7 days
	Se speciation	G	freeze	7 days
soils/ores	all analytes	P, G, T	none	indefinite
wood/paper	all analytes	P, G, T	none	indefinite
chemicals	all analytes	as per metal	none	indefinite

UC=Ultra-Clean  
P= Polyethylene  
T=Teflon  
G=Glass

\*except seawaters are 0.4% H<sub>2</sub>SO<sub>4</sub>



SAMPLE HANDLING