



## Environmental Sciences Laboratory

### Grand Junction, Colorado

The U.S. Department of Energy (DOE) office in Grand Junction, Colorado, created the Environmental Sciences Laboratory (ESL) in 1991, prior to establishing the Department's Office of Legacy Management in Grand Junction. At that time, a large, fully equipped analytical chemical laboratory was operating on the DOE office site. Operations at the laboratory were similar to those at commercial analytical laboratories. DOE recognized the benefits of having a research laboratory to support its contaminated sites remediation projects. As a result, DOE converted a standing facility into the ESL and soon after established a small ESL scientists' functional group.

Geochemists, ecologists, and other scientists use the ESL to perform applied research, laboratory-scale demonstrations of soil and groundwater remediation and treatment technologies, and pilot-scale tests to supplement numerical modeling efforts. These efforts were typically funded by outside sources like DOE remediation projects, the DOE Office of Environmental Management, and the U.S. Environmental Protection Agency. DOE later provided direct funding to the ESL to continue studies related to remediation technologies and long-term performance of disposal cells.

Specialized analytical services performed in the laboratory continue to support research projects, site characterization, and routine environmental monitoring activities. Over the years, the ESL has been equipped with more analytical instruments that have expanded its capabilities beyond chemical analysis.

### Environmental Sciences Laboratory Services

- Soil and aquifer physical properties analysis, including soil classification and saturated and unsaturated hydraulic properties.
- Plant ecophysiology (response of an organism's

physiology to environmental conditions).

- Groundwater contaminant transport modeling support.
  - Batch and column tests.
  - Contaminant speciation.
  - Secondary source identification and release rates.
  - Contaminant sequestration.
- Groundwater remediation technology, such as permeable reactive barriers.
- On-site support via mobile laboratory.
- Petrographic analysis.

### Laboratory Analytical Instruments

- Ion chromatograph.
- High-performance liquid chromatograph.
- Inductively coupled plasma-mass spectrometer.
- Total inorganic and organic carbon analyzer.
- Kinetic phosphorescence analyzer.

### Ion Chromatography

#### Dionex Aquion

Ion chromatography operates by separating ions in an ion exchange column based on their affinity for mobile or stationary phases. Eluent, an ion extraction liquid, carries the sample with its resident ions to the column and pushes the ions in the sample through the column. Ion species are then separated and detected at different times using conductivity or UV detection. The Dionex Aquion ion chromatograph (IC), when properly equipped, can analyze the following ions: fluoride, acetate, chloride, nitrite, bromide, nitrate, phosphate, sulfate, iodide, sodium, potassium, magnesium, and calcium.

Other analytical columns can be used to analyze ions, such as organics. The IC is used to analyze samples due to its relatively short analysis time, low detection limits, high selectivity in samples with a complex matrix, and species analysis (e.g.,  $\text{NO}_2^-$ ,  $\text{NO}_3^-$ ).



*Dionex Aquion.*

## High-Performance Liquid Chromatography

### Dionex UltiMate 3000

High-performance liquid chromatography (HPLC) is used analytically to separate, identify, and quantitatively and qualitatively quantify compounds within a mixture. It uses a pump to create high pressure to carry a solvent through a column. The high pressure allows columns to be packed with smaller particles than in regular columns, creating more surface area for interactions between the stationary phase and the mobile phase. This allows for better separation between the components in a mixture. Smaller compounds pass through the column more quickly than larger compounds, allowing them to be detected at different times. After the solvent passes through the column, it goes through a detector either ultraviolet (UV), fluorescence, or both. The detector is set at a desired wavelength depending on the compound or compounds needed to be analyzed. Samples analyzed are water samples. HPLC is used because it has a UV and fluorescence detector, which allows for the detection of non-ionic species, and in some cases, it is much more sensitive than conductivity detection.



*Dionex UltiMate 3000.*

## Inductively Coupled Plasma-Mass Spectrometry

### Agilent 7850 ICP-MS

Inductively coupled plasma-mass spectrometry (ICP-MS) measures ions produced by a radio frequency inductively coupled plasma. Analyte species originating in a liquid are

nebulized and the resulting aerosol transported into the plasma torch by argon gas. The ions produced are entrained in the plasma gas, introduced by a vacuum interface, and separated based by a mass spectrometer on their mass-to-charge ratio. The ions transmitted through the mass spectrometer are quantified by an electron multiplier and processed by the instrument's data handling system. The ions transmitted through the mass spectrometer are quantified by an electron multiplier and processed by the instrument's data handling system. ICP-MS is used to quantify metal and some non-metal species at very low concentrations. ICP-MS can also detect different isotopes of the same element.

Solids and highly contaminated water samples are digested using one or more acids (nitric acid and/or hydrochloric acid) followed by hydrogen peroxide (if necessary) using a sample digestion vessel and cover. The digestate is reduced to low volume, cooled, adjusted to volume and, if necessary, filtered.

No digestion is required prior to analysis for dissolved elements in water samples; instead, samples are filtered and then preserved at the time of collection.

## Carbon Measurements of Aqueous and Solid Samples

### Shimadzu TOC-L

The Shimadzu TOC-L instrument analyzes non-purgeable organic carbon (NPOC) in aqueous samples, and total carbon and inorganic carbon determination in soil samples.



*Agilent 7850 ICP-MS.*



*Shimadzu TOC-L.*



The liquid analysis uses a combustion pathway with acidification and sparging as pretreatments to remove purgeable organic carbon. For the aqueous and solid samples, the combustion method of carbon analysis of aqueous and solid samples employs the oxidation of all carbon species to CO<sub>2</sub> in the presence of a platinum catalyst. CO<sub>2</sub> then passes through a series of scrubbers and a nondispersive infrared detector. The TOC-L is used because it has the capacity to efficiently oxidize hard-to-decompose organic compounds, including insoluble and macromolecular organic compounds. This is important because organic carbon can be an indication of bacteria, and organic compounds combine with other elements to produce molecules that can be harmful to the environment.

## Kinetic Phosphorescence Analyzer

### Chemchek KPA 11

The kinetic phosphorescence analyzer (KPA) operates by exciting a liquid sample with a laser beam. Phosphorescence involves the absorption of a photon, which electronically excites the molecule. Return to ground state occurs by relaxation incorporating a triplet electronic state. Relaxation lifetimes range from microseconds to hours. The laser is pulsed, and intensity measurements are taken at fixed intervals in time, called time gates, following the laser pulse. The intensity values from these intervals are summed over the number of pulses used in each measurement. The instrument software compares these values to the calibration curve and reports the concentration of the uranium present in micrograms per liter (µg/L). The Chemchek KPA 11 uses this method to measure the concentration of uranium in the +6 oxidation state.



*Chemchek KPA 11.*

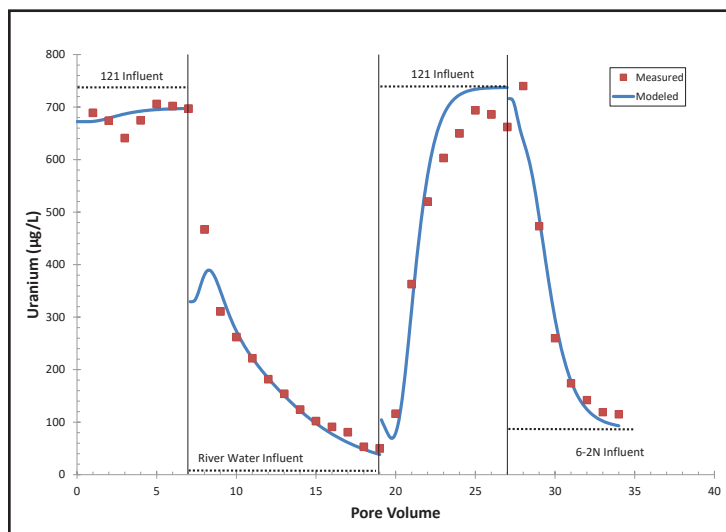
## Leachability, Release Rates, and Reactive Transport Parameters Using Column Tests

Contaminant leachability and release rates under various conditions are a critical component for determining natural flushing rates and potential remedial options. The ESL can run up to six column tests at once, and the resulting water samples can be analyzed in house using the equipment

described. In addition to straight empirical data on sediment leachability and contaminant release rates, techniques developed under various AS&T projects can apply geochemical modeling to the column results. This modeling allows reactive transport parameters that can be included in LM site models to be determined. These models allow for a predictive evaluation of various remedial strategies, thereby providing a way to do cost/benefit analyses of the strategies before implementing any field testing.



*Column Experiment at the ESL.*



*Column Experiment Results With Geochemical Modeling.*

## Petrographic Analysis

This ESL technology is able to identify low-concentration uranium in thin sections, which involves irradiating a thin section covered with a thin mica sheet. The resulting radioactive decay of uranium etches the mica sheet to produce fission tracks. Using dual microscopes, the fission-tracked image can be compared to plain light thin section images show where uranium occur in relation to the particle





*Colorado Mesa University intern in the ESL microscope room.*



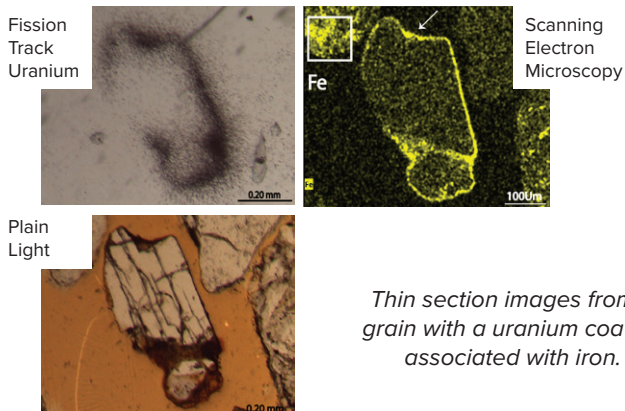
*Exterior of the mobile lab during groundwater tracer testing.*

## Mobile Laboratory

ESL scientists conduct in-field testing using LM's mobile laboratory. The mobile laboratory trailer includes power, cabinets, sink, and a fume hood, which allow LM scientists to perform environmental investigations and conduct real-time analysis during field investigations or drilling campaigns.

## Solids Processing Room

Solids from cores, sediments, and other areas are manipulated in the ESL soils processing room. Solid samples processing includes sieving, grinding, packing, drying, and digesting.



*Thin section images from a grain with a uranium coating associated with iron.*

grain (see image above). These images are used as a map for the thin section when conducting additional analyses on a scanning electron microscope (SEM, external laboratories). The results help determine the elements that are also associated with uranium coatings. Environmentally significant uranium concentrations are below SEM detection limits. Thus, uranium fission-track radiography is necessary to determine mineralogic associations.



*Interior of the mobile lab.*



*Solids processing room.*



## ESL Sample Analysis Support Capabilities

The ESL is equipped with sample support infrastructure and equipment to ensure sample analysis integrity and support a wide range of research efforts. The equipment includes, ample refrigerated sample storage, general chemistry analytical instruments, digestion blocks, and transport pumps.



*ESL sample support equipment.*



*ESL sample support equipment.*



*ESL sample support equipment.*



## CONTACT INFORMATION

**IN CASE OF AN EMERGENCY AT THE SITE,  
CONTACT 911**

**LM TOLL-FREE EMERGENCY HOTLINE:  
(877) 695-5322**

Site-specific documents related to the **Environmental Sciences Laboratory** on the LM website at [www.energy.gov/lm/environmental-sciences-laboratory-esl](http://www.energy.gov/lm/environmental-sciences-laboratory-esl).

For more information about LM activities at the **Environmental Sciences Laboratory** in Grand Junction, Colorado, contact:

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