LANL is a complex site for environmental management. The site encompasses about 100 km2 (37 square miles) of terrain with 600 m (2,000 feet) of elevation change, and an average rainfall of less than 300-400 mm (12 to 16 inches) per year. The site is intersected by 14 major canyon systems. Ecosystems within the site range from riparian to high desert and boast over 2,000 archaeological sites, as well as endangered species habitats. The surface and subsurface water flow discharges primarily along the Rio Grande to the east of LANL. The Rio Grande traverses the Española basin from north to south; several major municipalities are using the river water downgradient from LANL for water supply (Santa Fe, Albuquerque, El Paso/ Ciudad Juarez).

The **regional aquifer** beneath LANL is a complex hydrogeological system. The regional aquifer extends throughout the Española basin, and is important source for municipal water supply for City of Santa Fe, Los Alamos, Española, LANL, and Native-American Pueblos. The wells providing groundwater supply from this aquifer for Los Alamos and LANL are located within the LANL site and in close vicinity to existing contamination sites. The regional aquifer is comprised of sediments and lavas with heterogeneous flow and transport properties. The general shape of the regional water table is predominantly controlled by the areas of regional recharge to the west (the flanks of Sierra de los Valles and the Pajarito fault zone) and discharge to the east (the Rio Grande and the White Rock Canyon Springs). At more local scales, the structure of groundwater flow is also influenced by (1) local infiltration zones (e.g., beneath wet canyons); (2) heterogeneity and anisotropy in the aquifer properties; and (3) discharge zones (municipal water-supply wells and springs). The aquifer is also characterized by well defined vertical stratification with in general provide sufficient protection of the deep groundwater resources.

The **vadose zone** above the top of the regional aquifer is about 180-300 m (600-1000) ft thick. The vadose zone is comprised of sediments and lavas with heterogeneous flow and transport properties. The variably saturated flow and transport through the thick vadose zone occurs through pores and fractures, and is predominantly vertical with lateral deviations along perching zones. The groundwater velocities in the vadose zone are high beneath wet canyons (up to 1 m/a) and low beneath the mesas (1 mm/a). Due to complexities in local hydrogeologic conditions, the hydraulic separation between the regional aquifer and the vadose zone is difficult to identify at some localities.

The complexity and size of LANL site make environmental management a continuing engineering and scientific challenge. Legacy contamination—both chemical and radioactive—exists at many locations. Some of the oldest worldwide radioactive Material Disposal Areas (MDA’s) are located on the site. LANL is mandated to follow timetables and requirements specified by Order of Consent from the New Mexico Environment Department (NMED) for investigation, monitoring, and remediation of hazardous constituents and contaminant sites. Currently, all the remediation activities are scheduled for completion in 2015. LANL is taking actions to prevent any potential contamination effects on human health and the environment.

The environmental work performed at the LANL site is managed by the [Environmental Programs (EP) Directorate](http://www.lanl.gov/environment/). A team of external and LANL (Computational Earth Sciences Groups, Earth & Environmental Sciences) researchers is tasked by the Environmental Programs (EP) Directorate to provide modeling and decision support to enable scientifically-defensible mitigation of the risks associated with various LANL sites. PI of this team is Velimir Vesselinov.

Since the 1950's, the LANL site has been subject of intensive studies for characterization of the site conditions, including regional geology and hydrogeology. Various types of research have been performed at the site related to the contaminant transport in the environment which include (1) laboratory experiments, (2) field tests, and (3) conceptual and numerical model analyses. The work have presented in a series of technical reports and peer-reviewed publications.

Currently, important aspects of the environmental management at the LANL site include:

* design of long-term monitoring network of groundwater flow and transport in the vadose zone and regional aquifer;
* investigation of the hexavalent chromium plume in the regional aquifer; and
* model-based analyses of the environmental impact caused by Material Disposal Areas (MDA’s): performance assessments (PA) and corrective measures evaluations (CME).

# Chromium plume in the regional aquifer

A chromium plume has been identified in the regional aquifer beneath the LANL site. Our team has been tasked with providing modeling decision support to the Environmental Programs (EP) Directorate to enable scientifically-defensible mitigation of the risks associated with chromium migration in the environment. Large amount of data and information are available related to chromium site (vadose zone pressures, aquifer water levels, contaminant concentrations, geologic observations, drilling logs, etc.); they are used to develop and refine conceptual and numerical models of the contaminant transport in the environment. The development of the numerical models and the performance of model analyses (model calibration, sensitivity analyses, parameter estimations, uncertainty quantification, source identification, data-worth analyses, monitoring-network design, etc.) is computationally intensive effort due to large model domains, large number of computational nodes, complex flow medium (porous and fracture flow), and long model execution times. Due to complexities in the model-parameter space, most of the model analyses require substantial number of model executions. To improve computational effectiveness, our team utilizes state-of-the-art parallel computational resources and novel theoretical and computational methods for model calibration, uncertainty analysis, risk assessment and decision support.

**LANL Strategic Importance**

**Goal 1: Radioactive Waste and Repositories**:

Novel theoretical and computational methods developed to perform model analyses at the LANL site for environmental management are applicable at any other radioactive-waste management site

**Goal 6: High Performance Computing Capability:**

Novel theoretical and computational methods developed to perform model analyses at the LANL site utilize existing high-performance capabilities at LANL (analyses are not feasible without parallelization)

Developed parallel methods and techniques provide computationally efficient model optimization, parameter estimation, sensitivity analysis, uncertainty quantification, risk assessment, data-worth analysis, monitoring and remedial design, and decision support.