Rocky Flats Cleanup Aided by Improved Understanding of Radioactive Transport

The cleanup of the Rocky Flats Environmental Technology Site (RFETS), completed in 2005 ahead of schedule and under budget, was aided by new understanding in the movement of radioactive compounds. The federal Superfund site, located about 16 miles from Denver, was contaminated with large amounts of plutonium, uranium, and other high-level hazardous waste.

The Rocky Flats Nuclear Weapons Plant was originally developed by the Atomic Energy Commission, which later became the Department of Energy. From 1952 to 1989, operated by Dow Chemical and then Rockwell International, the facility processed plutonium and other radioactive and hazardous materials to manufacture detonators and other components for nuclear weapons.

In 1989, the Federal Bureau of Investigation and the Environmental Protection Agency raided the facility based on alleged environmental and safety concerns, including violations of the Resource Conservation and Recovery Act and the Clean Water Act. Operations were immediately suspended and never resumed. The sudden closure meant large amounts of plutonium and other materials in various stages of processing and storage had to be dealt with, in addition to all the waste and poor environmental practices that were the basis for the raid. Original estimates were that cleanup would require $36 billion and take 65 years.

The site was renamed RFETS in 1995, following DOE's cessation of nuclear weapon production. The same year, Kaiser-Hill won the contract to manage the cleanup. In 2000, the company and DOE agreed on an accelerated closure plan to be completed by the end of 2006. In fact, Kaiser-Hill declared physical closure of the site in October 2005 at a cost of around $30 billion less than earlier estimates.

RFETS once contained more than 800 structures in a 385-acre industrial area, surrounded by a 6,000-acre buffer zone. Although a large portion of the cleanup involved demolishing the buildings and the packaging, off-site transport, and storage or disposal of "weapons-usable" material (some of which could be used for nuclear reactor fuel), environmental cleanup of the site also was a key component.

In an article published last September in *Physics Today*, Clark and others described the evolution in understanding of the transport of plutonium in the surface water and shallow groundwater at the site that occurred during the remediation process. Originally, scientists thought that the elevated concentrations of plutonium must be due to aqueous sorption-desorption processes, but geochemical models predicted little movement. Site monitoring showed that plutonium and americium had similar spatial distribution in surface soils, with about 90 percent of the total inventory occurring in the upper five inches but with wide variations in concentration. Upon further study, researchers discovered that "plutonium and americium form insoluble oxides and colloids that adhere to small organic and mineral particles in the soil," the article said. Wind and surface water were transporting contaminated particles over the site; wind patterns, surface topography, vegetation, and soil erodability significantly affected this distribution. Scientists switched to erosion and sediment-transport models and got much better results.

According to Clark and others, researchers used the process-oriented Water Erosion Prediction Project (WEPP) model developed by a consortium of federal agencies (see *Southwest Hydrology*, Jul/Aug 2006) to model hillside erosion and sediment deposition in streams. Output from WEPP was used as input to

HEC-6T, developed by the U.S. Army Corps of Engineers, to model stream channel sediment erosion and deposition. The coupled models were used to simulate the transport of contaminants during storm events, the amount of contaminated sediments in surface water, pathways of contaminant migration, and potential effects of various management scenarios on cleanup activities.

As a result of improved understanding of how the contaminants were moving across the site, Clark and others state that the parties involved were able to come to agreement on the terms of the cleanup, and erosion control technologies were the primary tool used.

See Clark, D.L., D.R. Janecky, and L.J. Lane, 2006. Science-based cleanup of Rocky Flats, Physics Today, 59(9), 34-40, www.physicstoday.org.

GRACE Monitoring Global Water Shifts

From temperatures.com

For the first time, scientists have demonstrated that precise measurements of Earth's changing gravity field can effectively monitor changes in the planet's climate and weather. This finding comes from more than a year's worth of data from the Gravity Recovery and Climate Experiment (GRACE), a two-spacecraft, joint partnership of NASA and the German Aerospace Center.

Results published in the journal *Science* show monthly changes in the distribution of water and ice masses could be estimated by measuring changes in Earth's gravity field. The GRACE data measured the weight of up to four inches of groundwater accumulations from heavy tropical rains, particularly in the Amazon basin and Southeast Asia. Smaller signals caused by changes in ocean circulation were also visible.

Launched in March 2002, GRACE tracks changes in Earth's gravity field. GRACE senses minute variations in gravitational pull from local changes in Earth's mass. To do this, GRACE measures, to one micron, changes in the separation of two identical spacecraft in the same orbit approximately 137 miles apart.

GRACE maps these variations from month to month, following changes imposed by the seasons, weather patterns, and short-term climate change. These maps are up to 100 times more accurate than existing ones, substantially improving the accuracy of many techniques used by oceanographers, hydrologists, glaciologists, geologists, and other scientists to study phenomena that influence climate.

"Measurements of surface water in large, inaccessible river basins have been difficult to acquire, while underground aquifers and deep ocean currents have been nearly impossible to measure," said Dr. Byron Tapley, GRACE principal investigator at the University of Texas Center for Space Research in Austin, Texas. "GRACE gives us a powerful new tool to track how water moves from one place to another, influencing climate and weather."

Dr. Michael Watkins, GRACE project scientist at NASA's Jet Propulsion Laboratory in Pasadena, California, said the results mark the birth of a new field of remote sensing.

"The GRACE gravity measurements will be combined with water models to sketch an exceptionally accurate picture of water distribution around the globe. Together with other NASA spacecraft, GRACE will help scientists better understand the global water cycle and its changes."

Visit www.tempsensor.net, the University of Colorado Real-Time GRACE Data Analysis Site (geoid.colorado.edu/grace/index.html) and NASA-JPL (grace.jpl.nasa.gov).

Testicles Shrinking in Las Vegas Bay

The U.S. Geological Survey, in cooperation with the U.S. Fish and Wildlife Service, recently released a four-page report, "Investigations of the Effects of Synthetic Chemicals on the Endocrine System of Common Carp in Lake Mead, Nevada and Arizona." The report summarizes a number of investigations over the last decade concerning the potential of endocrine disruption in fish in the lake. Water discharged into Lake Mead via Las Vegas Wash includes residential-irrigation runoff, stormwater runoff, subsurface flow, and tertiary treated sewage effluent, collectively carrying a cocktail of chemicals. The characteristics of fish from Las Vegas Bay were compared to other, more remote areas of Lake Mead. Major findings to date are:

- Studies conducted in 1995 and 1999-2000 showed that male carp from Las Vegas Bay have low levels of androgen and smaller testes compared to male fish from reference sites in Lake Mead.
- The same and other studies also showed the presence of higher levels of synthetic chemicals in water, sediment, and fish from Las Vegas Bay compared to reference sites.
- Commonly used products, such as triclosan (an antimicrobial drug) are being accumulated in fish from Las Vegas Bay.
- Some of the chemicals present in Las Vegas Bay have been shown by laboratory studies to cause endocrine disruption in male fish.

Since the 2000 study was completed, regional drought caused lake levels to drop to historic lows. New studies are planned to assess the potential affects of drought-induced alterations on lake hydrology. In addition, baseline information is being collected to monitor changes in contaminant distribution and the potential for endocrine disruption that may occur due to the redistribution of wastewater inflow, as municipal dischargers in the Las Vegas Valley have been considering plans to divert their wastewater from Las Vegas Wash to other locations.

USGS Fact Sheet 2006-3131 is available at pubs.usgs.gov/fs/2006/3131/.