USGS
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Toxic Substances Hydrology Program

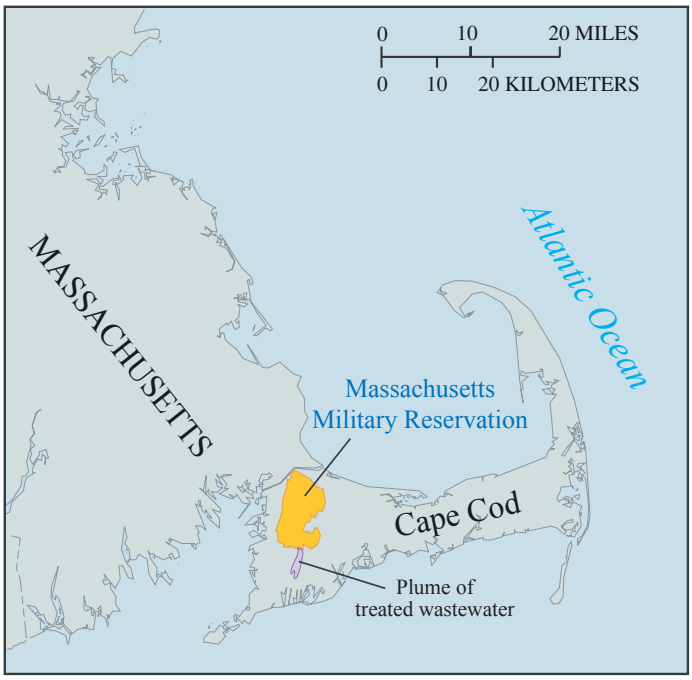
Cape Cod Toxic Substances Hydrology Research Site

Physical, Chemical, and Biological Processes that Control the Fate of Contaminants in Ground Water

Research on Contamination Issues of National and Global Concern

Ground-water contamination has many causes. Activities such as fuel and industrial-chemical use, hard-rock mining, fertilizer application, and land disposal of solid waste and wastewater can introduce organic and inorganic contaminants into the subsurface. Once there, the contaminants are carried by flowing ground water and can eventually reach water supplies, streams, lakes, and the ocean. Many physical, chemical, and biological processes alter and disperse contaminants in the subsurface. Understanding these processes is essential for predicting the fate of contaminants that are of global concern and determining how best to manage and remediate the contamination.

The U.S. Geological Survey (USGS) Toxic Substances Hydrology (Toxics) Program conducts research to develop and improve our understanding of the processes that control the fate and effects of major types of contaminants. A three-part approach is employed that combines in-depth, long-term field studies at representative sites with laboratory experiments and computer modeling to identify and quantify specific processes. Hydrologists, chemists, microbiologists, computer modelers, and geophysicists collaborate at the field sites to address these complex multidisciplinary contamination problems. Knowledge built up over many years at these representative field sites is then applied to aquifers around the world.



Location map showing MMR and plume of treated wastewater

Southeast view of wastewater-disposal beds and Ashumet Pond

The Cape Cod Field Research Site

The Cape Cod field research site is near the wastewater-treatment facility at the Massachusetts Military Reservation (MMR). A treated-wastewater plume originates from the facility's infiltration beds, which were used from about 1936 to 1995. The plume extends more than 6 kilometers from the disposal site in the sand and gravel aquifer and contains a complex mixture of phosphate, nitrate, metal ions, detergents, organic chemicals, and microbes. The plume and adjacent parts of the aquifer serve as an ideal field laboratory in which to investigate how contaminants are transported in ground water.

Since 1983, USGS scientists and their university colleagues from more than a dozen institutions in several nations have examined many aspects of the treated-wastewater plume. More than 1,500 wells have been drilled and

Nonbiodegradable detergents in wastewater plume cause foaming on water from monitoring well

thousands of water samples have been collected and analyzed to characterize the plume and to investigate processes such as the movement of bacteria and viruses in the plume and the dispersion that is caused by the geologic structure of the aquifer. An important aspect of research at the Cape Cod site is the use of controlled ground-water tracer experiments. More than 100 experiments have been conducted in which water containing chemical and biological tracers is injected into the plume and the tracers are tracked as they move and are altered in the subsurface. Several well arrays have been constructed for the experiments; one is a large-scale array with more than 12,000 sampling points. The U.S. Environmental Protection Agency, the National Science Foundation, the U.S. Departments of Agriculture, Defense, and Energy, and the Nuclear Regulatory Commission are among the agencies that have cofunded this research. The diversity of funding sources reflects the wide-ranging significance of the scientific results.

Contributions from Field Research at the Cape Cod Site

Scientific knowledge gained from research at the USGS Cape Cod site is used widely by resource managers, regulators, educators, and other scientists. This knowledge has been disseminated in more than 120 scientific articles, 140 federal reports, and 45 Masters and Ph.D. dissertations from 15 universities (http://toxics.usgs.gov/bib). Scientists working at the site have been featured participants at national meetings on topics such as the subsurface fate and transport of microbes, the fate of arsenic in ground water, and the discharge of contaminant plumes to lakes. The National Research Council recently used information from Cape Cod and other Toxics Program research sites to evaluate the potential for more reliance on natural processes to clean up ground water. Results from the Cape Cod site are featured in several textbooks, thus helping to educate the next generation of environmental professionals. Groups ranging from the National Academy of Sciences to the Upper Cape Cod Technical High School have visited the site to learn about the ongoing ground-water studies.

Array with more than 12,000 sampling points used for ground-water tracer experiments

The Cleanup of the Massachusetts Military Reservation

The ground-water cleanup at the Massachusetts Military Reservation is one of the most complex and expensive environmental restoration projects conducted by the U.S. military. More than $1 billion will probably be spent before the effort is completed. Results and methods from the USGS research on the treated-wastewater plume and surrounding aquifer have been applied to the investigation of other plumes on the MMR. USGS scientists from the Toxics group have worked directly with the military and its consultants to model ground-water flow, locate contaminant plumes discharging to ponds and the ocean, and develop more cost-efficient ground-water-sampling methods. Information about environmental programs at the MMR can be accessed online at <http://groundwaterprogram.army.mil>, <http://www.mmr.org>, and <http://www.mass.gov/guard/E&RC>.

USGS scientists sample ground water in the wastewater-disposal beds

For additional information contact:

Denis LeBlanc, Hydrologist
U.S. Geological Survey
Massachusetts-Rhode Island Water Science Center
10 Bearfoot Road
Northborough, MA 01532
<http://toxics.usgs.gov>
<http://ma.water.usgs.gov/capecodtoxics>