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## USGS Activities Related to Environmental Health Science

### Pesticides Found in Amphibians from Remote Areas in California

U.S. Geological Survey (USGS) scientists have documented the occurrence of current-use pesticides, including several fungicides, in the Pacific Chorus frog (*Pseudacris regilla*) and its habitat in remote, high-elevation locations in California. Amphibian and environmental samples were taken from Giant Sequoia National Monument, Yosemite National Park, and Lassen Volcanic National Park. Limited information is available about the exposure of frogs to pesticides, especially in remote areas.



A Pacific Chorus frog in meadow located in Yosemite National Park, California. Photo credit: Devin Edmonds, USGS.

Fungicides, many not previously detected in amphibians, were found in adult male frogs from all sites. Data generated from this study indicate that amphibians residing in remote locations are exposed to, and capable of taking up, current-use pesticides. These remote areas are downwind of California's agricultural Central Valley and the scientists hypothesize that the pesticides

moved to the remote areas via precipitation and dust. This information improves future efforts to understand how these pesticides are transported in the environment, including to remote mountain lakes,

and how they affect the frogs, especially in areas where populations are declining.

This study was funded by the USGS Amphibian Research and Monitoring Initiative, Toxic Substances Hydrology Program, and Wildlife: Terrestrial and Endangered Resources Program.

### Pesticides Present in a California Estuary

Scientists from the USGS, the University of California, Davis and the California State Water Resources Control Board found fungicides and other current-use pesticides in water, sediment, and tissue of resident aquatic organisms from the Santa Maria estuary. The Santa Maria estuary is an agriculturally dominated estuary along California's Central Coast. Many of California's coastal estuaries are impacted by severe water-quality degradation, and many of these estuaries, including the Santa Maria estuary, provide critical nursery and foraging habitat for numerous marine and estuarine fish and other aquatic animals, including the threatened tidewater goby (*Eucyclogobius newberryi*).



Cattle graze next to the Santa Maria River estuary near Guadalupe, California. Photo Credit: Jason Cooper, USGS.

During 2009 and 2010, the scientists collected water, sediment, and tissue of resident aquatic organisms including starry flounder (*Platichthys stellatus*), staghorn sculpin (*Leptocottus armatus*), and sand crabs (*Emerita analoga*). Pesticide levels in water increased during the summer as pesticide application in the adjacent agricultural watershed increased. Pesticides in bed sediments decreased with increasing distance from source areas. Fungicides and several other current-use pesticides, including pyrethroid insecticides, were detected frequently in fish and sand crabs.

This is the first study to document the occurrence of many of these pesticides, including fungicides, in tissue from coastal estuaries. Limited information is available on the accumulation and effects of pesticides on aquatic organisms. Data generated from this study will help State and local agencies design best management practices to reduce pesticide loads to estuaries. The study also provides baseline data that will allow resource managers to track changes in the ecosystem as pesticide inputs and contamination change over time.

The California State Water Resources Control Board, USGS Cooperative Water Program, and USGS Toxic Substances Hydrology Program provided the funding for this work.

### Factors Affecting Public-Supply-Well Vulnerability to Contamination

USGS scientists studying public-supply-well vulnerability to contamination found that the following factors are important for understanding the quality of water pumped from individual public-supply wells, regardless of environmental setting:

1. The sources of recharge that contribute water to a well, and the contaminants associated with the recharge—a measure of contaminant input;
2. The chemical conditions encountered by water drawn into a well—a measure of contaminant mobility and persistence; and
3. The groundwater-age mixture of different waters that blend (or mix) in a well—a measure of intrinsic susceptibility.

Two findings of this study are

- Human activities that alter groundwater recharge or modify groundwater flow can lead to changes in chemical conditions within an aquifer that can mobilize naturally occurring contaminants such as arsenic and uranium to public-supply wells.
- The quality of water from public-supply wells producing water with a wide range of groundwater ages (recharge dates) can continue to degrade for decades after improved management practices have reduced contaminant sources.



Large pumps like the one in the photo are common at public-water utilities that use groundwater from wells. About 35 percent of the population in the United States receives its drinking water from public-supply wells. Photo credit: USGS.

Knowledge of how human activities influence the contaminants that go into solution and are persistent in groundwater can help water managers anticipate future water-quality conditions and prepare for appropriate water treatment.

Funding for this study was provided by the USGS National Water-Quality Assessment (NAWQA) Program.

### Harmful Algal Blooms in Illinois Lakes

USGS scientists identified potentially harmful levels of cyanobacteria in 10 lakes they sampled in Illinois during the drought of 2012. Toxins produced by the cyanobacteria were measured at harmful concentrations in four lakes. Cyanobacteria, also called blue-green algae, are capable of generating toxins (cyanotoxins), such as microcystin, that are potent enough to poison animals and humans.



An algae bloom on Lake Le-Auqana, Illinois. Photo Credit: Paul Terrio, USGS.

Working collaboratively with the Illinois Environmental Protection Agency (IEPA), the scientists conducted the study in response to multiple reports and observations of algal blooms in Illinois lakes. IEPA field screening for cyanotoxins earlier in 2012 and in previous years rarely detected concentrations of concern. However, an extended drought in 2012 and accompanying high temperatures might have

provided conditions that facilitated the growth of cyanobacteria and increases in the associated cyanotoxin production.

The scientists sampled 10 lakes in Illinois from August through October 2012 to determine the concentrations and spatial distribution of cyanobacteria and associated cyanotoxins throughout the State. Analysis of the samples indicated that both total cyanobacterial cell counts and concentrations of microcystin were frequently at levels likely to result in adverse human-health effects, according to World Health Organization guidance values. Samples collected in October, after precipitation events and lower temperatures, indicated that both microcystin concentrations and total cyanobacterial cell counts had decreased approximately one order of magnitude since late August or early September.

The results of this study will help State and local agencies manage water resources to protect human, animal, and ecological health. The USGS Cooperative Water Program and the IEPA provided the funding for this study.

### New Fungal Disease Afflicting Snakes

A new fungus is infecting several species of snakes according to USGS scientists and their collaborators. USGS veterinarians are receiving snakes with rough, thickened skin that sloughs and appears like an abnormal molt. The snakes also have facial swelling, cloudy eyes, skin ulcers, scabs, and nodules. Although similar signs have been sporadically reported previously, the condition, called Snake Fungal Disease (SFD), has been reported more frequently since 2006. Laboratory testing at the USGS and elsewhere have most consistently isolated the fungus *Ophidiomyces* (formerly *Chrysosporium*) *ophiodiicola* from the snakes, but additional fungi are often isolated from the same samples, making it difficult to conclude that *O. ophiodiicola* is the definitive cause of SFD.

It is suspected that SFD is more widespread in the eastern United States than previously reported. The USGS has diagnosed SFD in snakes from 10 states (Florida, Illinois, Massachusetts, Minnesota, New Jersey, New York, Ohio, South Carolina, Tennessee, and Wisconsin). Rattlesnake species (*Crotalus horridus*, *Sistrurus catenatus*, *Sistrurus miliarius*) are the most common species diagnosed with SFD, but USGS veterinarians also have diagnosed this condition in northern water snakes (*Nerodia sipedon*), eastern racers (*Coluber constrictor*), eastern rat snakes (*Pantherophis obsoletus*), milk snakes (*Lampropeltis triangulum*), and copperheads (*Agkistrodon contortrix*). While some snakes have died from SFD, the impacts on snake populations are difficult to assess due to the secretive and solitary nature of snakes. However, clinical signs consistent with SFD were associated with about a 50-percent decline of an imperiled population of timber rattlesnakes in New Hampshire from 2006 to 2007.



Eastern racer (*Coluber constrictor*) with signs of Snake Fungal Disease, including opaque eye (spectacle) and rough, dark, crusty scales on the chin and side of neck (arrows). Photo credit: David E. Green, USGS.

The USGS is working with other agencies, organizations, researchers, and key stakeholders to investigate this emerging disease and to learn more about the impacts that SFD is having on snake populations in the eastern and midwestern United States.

Funding for the USGS's work on SFD is provided by the USGS Contaminant Biology Program.

### USGS Responds to Sea Star Mortality Event

Millions of sea stars on the west coast, from Alaska to southern California, have been dying from unknown causes. The USGS is collaborating with scientists from many organizations to:

- Learn more about this mortality event,
- Coordinate a potential response to the die offs,
- Conduct sea star necropsies (an autopsy on animals), and
- Uncover a potential cause.

The event, which began in June 2013, is affecting various sea star species in wild and captive populations. The two species affected



Whitish areas on this diseased sunflower sea star (*Pycnopodia helianthoides*) are lesions that result in the detachment of arms from the central disc. Photo credit: Dr. Lesanna Lahner, Seattle Aquarium.

most are the purple sea star or ochre starfish (*Pisaster ochraceus*) and the sunflower sea star (*Pycnopodia helianthoides*).

To date, no underlying cause(s) of these mass die offs has been identified. In previous outbreaks, bacterial and viral agents, as well as environmental toxins and contaminants, were suggested as underlying causes, but they were not confirmed. The 2013 outbreak appears more severe than previous outbreaks, killing up to 95 percent of some populations and affecting a much larger geographic area along the west coast. Scientists are:

- Compiling mortality reports from the public,
- Monitoring designated sites along the Pacific coast,
- Collecting specimens for diagnostic necropsy, and
- Conducting diagnostic testing and genetic sequencing to determine if infectious and/or toxic agents are involved.

The USGS and a network of partners across the country document wildlife mortality events in order to provide timely and accurate information on locations, species, and causes of death. This information is used by natural resource managers, scientists, public-health officials, and other decisionmakers to help design disease prevention and mitigation strategies and to identify interconnections between human, domestic animal, and wildlife disease.

The USGS Fisheries: Aquatic and Endangered Resources, the Contaminant Biology, and the Wildlife: Terrestrial and Endangered Resources Programs provide funding for wildlife mortality event monitoring and investigations.

### No Well Contamination Found from Fayetteville Shale Exploration

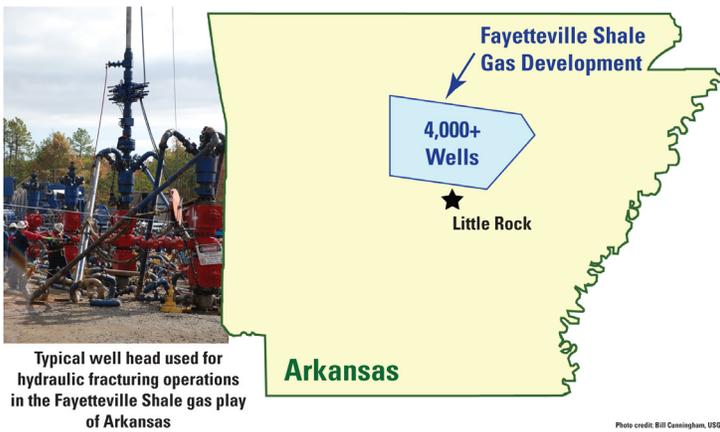
The results of a USGS study on the water quality of the shallow aquifer system used for drinking water above the Fayetteville Shale gas play in Arkansas indicate that the chemistry of the groundwater is not affected by gas development but is the consequence of natural processes. The Fayetteville Shale is a gas reservoir that underlies much of north-central Arkansas; gas production in the reservoir involves unconventional recovery techniques such as horizontal drilling and hydraulic fracturing.

In 2011, in order to test whether or not the gas production was impacting groundwater quality, USGS scientists collected groundwater samples from 127 shallow domestic wells in Faulkner and Van Buren Counties, both of which have natural gas production. After analyzing the samples, the scientists found that chloride, major ions, and trace metals all had lower concentrations in the 2011 groundwater samples than in samples from pre-gas-development collected in

The purple sea star (*Pisaster ochraceus*) is considered a top predator in the rocky intertidal zone and has long been referred to as a keystone species because its diet includes mussels, barnacles, snails, limpets, and mollusks. If this sea star is removed from the intertidal ecosystem through disease or some other mechanism, the mussel population has the potential to dramatically increase, which could significantly alter rocky intertidal community structure.

In the subtidal zone, the sunflower sea star (*Pycnopodia helianthoides*) is a major predator of numerous species and a decline in its population will likely have far-reaching ecological impacts. Sea star larvae are an important component of plankton, the base of the ocean food web.

Sea star is the new name for starfish. Since starfish are not fish, scientists are now calling them sea stars. Sea stars are echinoderms.



Typical well head used for hydraulic fracturing operations in the Fayetteville Shale gas play of Arkansas

Photo credit: Bill Cunningham, USGS

In north-central Arkansas there are over 4,000 gas production wells. Photo credit: Bill Cunningham, USGS.

nearby areas from 1951 through 1983. In addition, no statistical difference existed between chloride concentrations from wells located less than 2 miles from a gas-production well and wells located 2 miles or more from a gas-production well. The closest domestic well to a production well was 75 meters (0.05 miles). The

scientists did not analyze for other potential contaminants from production activities. The scientists also showed that methane in the samples was from sources within the shallow aquifer and not from the shale gas play. Results from this study provide baseline information on the water quality of shallow groundwater in the study area. The information can be used to assess future potential changes to groundwater used for drinking water.

This study was conducted in cooperation with the Arkansas Natural Resources Commission, Arkansas Oil and Gas Commission, Duke University, Faulkner County, Shirley Community Development Corporation, and the University of Arkansas at Fayetteville, in coordination with the USGS Groundwater Resources Program and Cooperative Water Program.

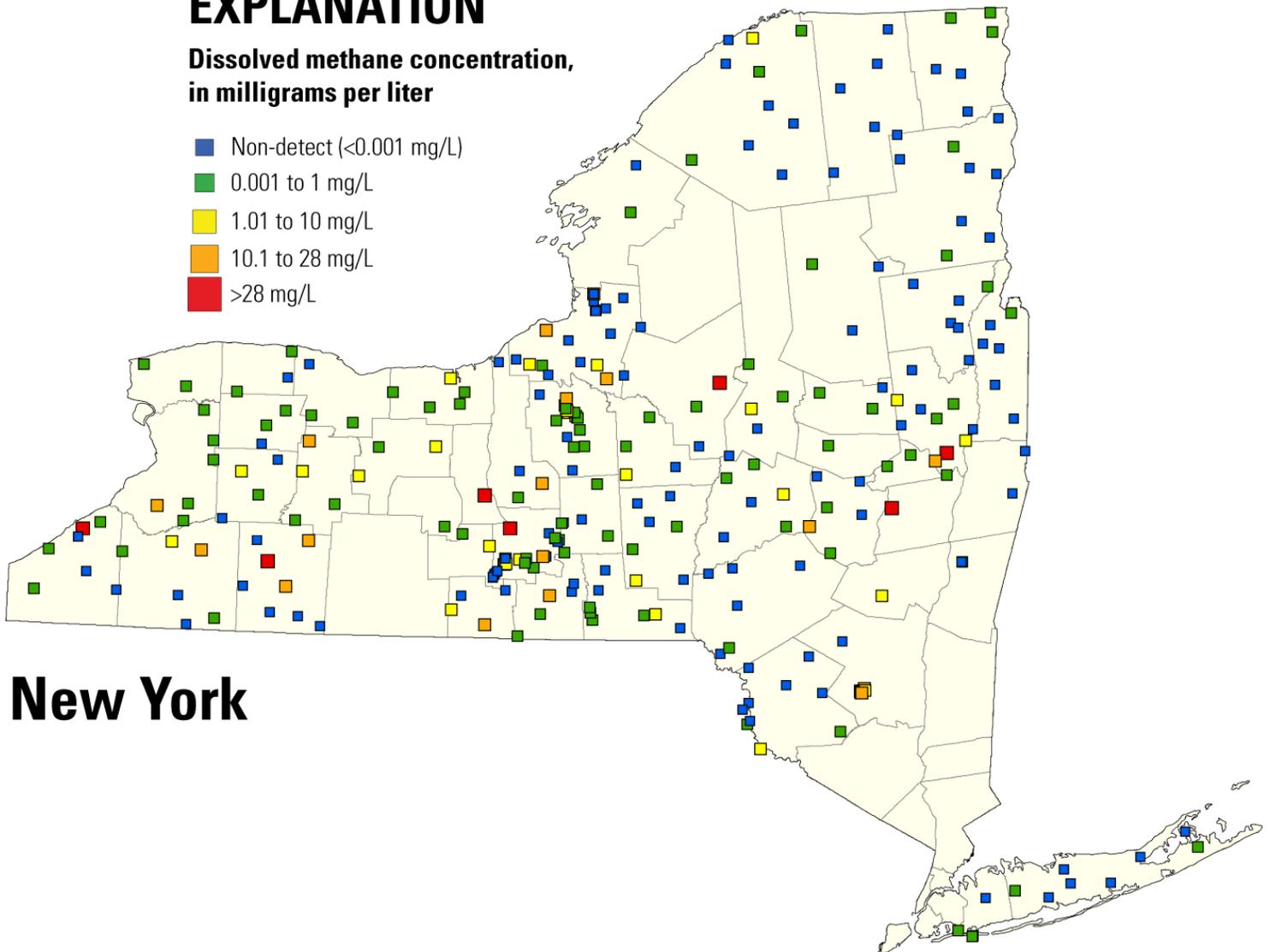
### Dissolved Methane Found in New York Groundwater Wells

Ninety-one percent of more than 200 groundwater wells tested by USGS scientists across New York State had levels of naturally-occurring dissolved methane below the threshold that would require monitoring. Nine percent of the wells tested had levels of dissolved methane high enough to warrant monitoring or other actions. Seven percent of the wells tested had methane levels above 10 milligrams

## EXPLANATION

Dissolved methane concentration, in milligrams per liter

- Non-detect (<0.001 mg/L)
- 0.001 to 1 mg/L
- 1.01 to 10 mg/L
- 10.1 to 28 mg/L
- >28 mg/L



## New York

Location of wells and dissolved methane concentrations in New York groundwater, 1999–2011. Modified from fig. 3, p. 4, USGS Open-File Report 2012-1162.

per liter, the level recommended by the Office of Surface Mining at which well owners should contact local health departments for information on monitoring or remediation. Two percent tested at levels above 28 milligrams per liter, a level that requires removal of any potential ignition source and venting the gas away from confined spaces to avoid possible explosive conditions.

Methane is a colorless, odorless, and tasteless gas that can be flammable or even explosive. The first commercial gas well in the United States was dug in the early 1820s in Fredonia, south of Buffalo, New York. In New York, methane naturally discharges to the land surface in some locations, and also occurs locally in the groundwater; as a result, it may be present in drinking-water wells, in the water produced from those wells, and in the associated water-supply systems or plumbing.

The results of this study provide background information on the presence of dissolved methane in New York's groundwater, allowing public-health officials, resource managers, and residents to understand more about the quality of drinking water in their State. With ongoing unconventional gas development in Pennsylvania and surrounding States and possible unconventional gas development in New York, knowing the current quality of groundwater is important to establish baseline water-quality conditions for individual and public water-supply wells.

The USGS Cooperative Water Program and the New York State Department of Environmental Conservation provided the funding for this study.

### Explaining Transmission of Chronic Wasting Disease

USGS, University of Wisconsin, Wisconsin Department of Natural Resources, and Illinois Department of Natural Resources scientists have determined that transmission of chronic wasting disease (CWD) in yearling white-tailed deer (*Odocoileus virginianus*) is influenced concurrently by the prevalence of the disease in the deer population and, to a lesser extent, the density of infected deer. CWD is a fatal neurodegenerative disease caused by proteins called prions that infect North American deer and elk. Understanding the ecology and transmission of CWD in free-ranging wildlife is challenging, but essential for predicting and managing future wildlife disease impacts.

The team of scientists found that CWD transmission to yearling white-tailed deer increases substantially with disease prevalence in neighboring deer. They also found that the disease rapidly saturates (infects a maximum number of deer) as the number of deer living in one area (deer density) increases. They concluded that (1) continued increases in disease prevalence will increase the rate at which young deer become infected, (2) reducing the density of deer

"The research is important because it raises the awareness of the natural quality of people's drinking water" said William Kappel, lead author of the study. "Well owners should work with local health departments to understand the quality of their drinking water to know if methane and (or) other chemicals are present."



White-tailed deer (*Odocoileus virginianus*) with chronic wasting disease (CWD). Photo credit: Wisconsin Department of Natural Resources.

through non-selective culling may help to reduce infection rates, but only when deer densities are relatively low, and (3) management strategies that reduce prevalence of CWD in a population will likely be more effective in reducing CWD transmission and spread than non-selective reductions in deer abundance.

The same social and behavioral patterns driving CWD transmission are likely key to understanding the transmission of other infectious diseases in deer populations, including bovine tuberculosis and bovine viral diarrhea—diseases that also have significant implications for the health of livestock. While it is always fatal in deer, CWD is not currently known to affect livestock or humans. However, the long-term disease trends and future risks to deer and elk, other wild-life species, and livestock are not fully understood. Currently there are no methods for eradicating the disease or preventing its spread.

This study was funded and supported by the USGS Wildlife: Terrestrial and Endangered Resources Program and the Wisconsin Department of Natural Resources.

### Deadly Disease Could Strike Bighorn Sheep

Declining bighorn sheep populations may be vulnerable to one of the same fatal diseases that afflict deer, elk, and moose—chronic wasting disease (CWD). USGS and University of Wisconsin–Madison scientists studying bighorn sheep (*Ovis canadensis*) found that they are likely to be susceptible to this deadly neurological disease, as well as scrapie, a similar disease affecting domestic sheep, both of which are occurring in or near natural bighorn sheep habitat.

These fatal diseases are caused by proteins called prions and are known as transmissible spongiform encephalopathies.

The scientists developed and conducted laboratory tests that did not involve live animals. The tests showed evidence that bighorn sheep could be vulnerable to both CWD from white-tailed deer or elk, and to scrapie from domestic sheep. None of a small number of bighorn sheep sampled in the same study showed evidence of infection. The results do not mean that bighorns get, or will eventually get, prion diseases; however, wildlife species like bighorn sheep are increasingly exposed to CWD as the disease expands to new areas.

Because bighorn sheep habitats overlap with farms and ranches with scrapie-infected sheep and regions where CWD is common in deer, elk, and moose, wildlife managers can use these findings to help understand the potential risk of CWD infections in bighorn sheep. In addition, the tests the scientists developed could potentially be modified to test other species for susceptibility to CWD.

The USGS Wildlife: Terrestrial and Endangered Resources Program funded this study.



Bighorn sheep (*Ovis canadensis*) on Mt. Wilbur in Glacier National Park, Montana. Photo credit: Kim Keating, USGS.

"Bighorn sheep are economically and culturally important to the western U.S.," said Dr. Christopher Johnson, USGS scientist and senior author of the study. "Understanding future risks to the health of bighorn sheep is key to proper management of the species."

## New Hexavalent Chromium Assessment

The Illinois Environmental Protection Agency in cooperation with the USGS is conducting a statewide assessment of chromium in untreated source water and treated drinking water in Illinois. The impetus for the assessment is a recent U.S. Environmental Protection Agency review of the potential human-health effects of hexavalent chromium in drinking water.

Chromium can be present in the environment in two forms—trivalent chromium (Cr III) and hexavalent chromium (Cr VI). Water chemistry, principally oxygenation, can greatly enhance the transformation of Cr III to the much more toxic Cr VI. The presence of Cr VI in groundwater and surface waters generally is attributed to industrial sources, but also can be of natural origin.

Presently, only the concentration of total chromium is regulated in public drinking water supplies, at a Maximum Contaminant Level (MCL) of 100 micrograms per liter ( $\mu\text{g/L}$ ). The goals of the statewide assessment are to

1. assess potential public health concerns of Cr VI in drinking water, and
2. understand the implications of a drinking-water standard for Cr VI for managing the quality of public drinking-water.

The scientists are collecting untreated water samples at public drinking-water supply facilities from 119 wells and 32 surface-water intakes; additionally, they are collecting 64 treated surface-water samples. Sample sites were selected by a stratified-random method, using criteria such as well depth for groundwater sample sites and geology for surface-water sites.

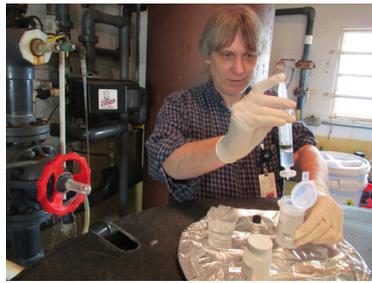
The USGS Cooperative Water Program and the Illinois Environmental Protection Agency provided funding for the assessment.

## Geophysical Technique Helps Map Uranium-Contaminated Groundwater

USGS scientists applied a geophysical technique to delineate groundwater movement in complex heterogeneous aquifers. Some aquifers have isolated zones (less permeable zones), such as pockets of silt, clay, or dead-end fractures; or pore spaces that have limited exchange with main groundwater flow patterns. These isolated zones can store contaminants for extended periods and prolong remediation.



USGS scientists monitor a saltwater tracer injection at a uranium-contaminated site in Colorado using a combination of geophysical and well sampling arrays. Photo credit: John Ong, USGS.



Illinois Environmental Protection Agency scientist collecting a water sample for analysis of hexavalent chromium at a public supply well. Photo credit: Patrick Mills, USGS.

The geophysical technique was implemented at a former uranium mill site located along the San Miguel River in southwestern Colorado, just northwest of the town of Naturita. The scientists have been investigating the reactive transport of hexavalent uranium (U VI) in groundwater at the site for over 10 years. Contamination of groundwater in heterogeneous unconsolidated sediments (complex interweaving and discontinuous layers) such as those found at Naturita can be difficult to remediate, in part because contaminants are stored in sediment with less-connected pore space and leach out over long periods of time, even when the better-connected pore space is actively pumped clean. The scientists injected a solution of saltwater into the shallow aquifer and monitored the resultant plume for a month using a combination of shallow wells and downhole electrode arrays. The results of the monitoring revealed strong heterogeneity in groundwater flow characteristics with discrete zones of potential long-term contaminant storage.

For the first time, scientists have the ability to evaluate an aquifer's small-scale variability related to the potential storage of contaminants—information that is being used to improve the models scientists use to predict reactive uranium transport in the subsurface and to develop improved remediation technologies for cleanup of contamination in highly heterogeneous aquifers.

The U.S. Department of Energy funded this study (agreement DE-SC0003681) and the USGS Toxic Substances Hydrology Program provided additional support.

## Rainbow Trout Aid Viral Disease Research

USGS and University of Washington scientists have developed novel approaches to measure the viral fitness of two strains of an RNA virus (infectious hematopoietic necrosis virus) in rainbow trout. Just like their hosts, viruses have differences in fitness that are important to their biology and ecology. For viruses, fitness is measured by their ability to produce more infectious viruses. Within a virus species, some strains may enhance their fitness by producing either milder or more severe disease, spreading more efficiently in populations, or jumping to new hosts or locations. Most research on viral fitness has been conducted in cell culture lines that are useful, but lack the complexity and immune responses of living hosts.



A USGS scientist studying the fitness of fish viruses adds a virus solution to aquariums containing juvenile rainbow trout. Photo by Gael Kurath, USGS.

Infectious Hematopoietic Necrosis Virus (IHNV) infects both trout and salmon, and infections in young fish (fry) are particularly severe. The virus can cause death by attacking the kidney and spleen in fish.

The new approach the scientists developed tracked the presence and quantity (fitness) of two fish virus strains as they competed within living fish. The results showed that viruses that caused more severe disease in the fish (higher virulence) also

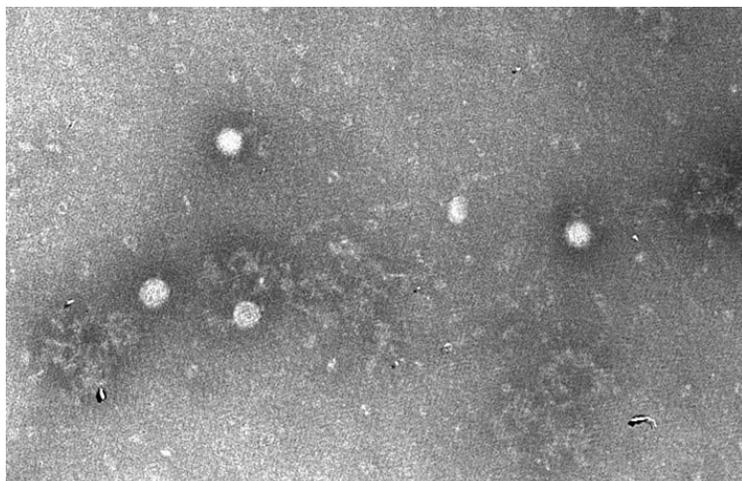
had higher fitness, which included increased replication and higher rates of shedding, suggesting more efficient transmission to other fish. Surprisingly, higher virulence did not correlate with an increased ability to infect a host that was already infected with the less fit strain

(superinfection). These new techniques provide a novel experimental system that advances our basic understanding of viral fitness in animals, with potential relevance to other animals including humans.

The USGS Fisheries: Aquatic and Endangered Resources Program, the National Science Foundation, and the U.S. Department of Agriculture's Ecology and Evolution of Infectious Diseases Program provided funding for these studies.

### Fish Virus Aids Medical Research

Scientists from the USGS and the University of California, Davis, found that the genetic makeup (genome) of the cutthroat trout virus (CTV) is very similar to the Hepatitis E virus, a finding which may aid medical research and help save human lives. CTV was first isolated in 1988 in California and later found to be widespread among several trout species in the Western United States. The virus cannot infect humans and shows no signs of disease in infected fish. Hepatitis E is a potentially deadly emerging human disease. Because the Hepatitis E virus has proven difficult to grow in cell cultures, USGS and Rega Institute for Medical Research, Belgium, scientists proposed that CTV might provide a surrogate that could be used to test potential drug therapies and vaccines against this type of virus.



Electron micrograph of the cutthroat trout virus. The small round virions are typical of members of the Hepatitis E virus family. The virions in the photo are much smaller than bacteria and are approximately 30 nanometers in diameter. Photo credit: Dr. Ronald Hedrick, University of California, Davis.

Typically acquired from contaminated water or infected swine, the Hepatitis E virus infects thousands of people annually, mainly in the developing world. Most infected people clear the virus from their systems without much damage. For reasons that are still unclear, the virus may cause full-blown hepatitis and liver failure during pregnancy. As a result, pregnant women comprise a disproportionate number of the 50,000 to 60,000 annual deaths due to Hepatitis E as well as suffering approximately 3,000 stillbirths. Medical researchers are looking for answers, but there are significant gaps in the understanding of the biology of Hepatitis E and in the search for antiviral drugs that can be used safely during pregnancy.

The scientists showed that CTV can indeed provide an infection model relevant to Hepatitis E. They reported the results of experiments that tested several antiviral compounds for their ability to inhibit the growth of CTV in fish cells. They also tested the effects of sex steroids on virus replication that provided clues into the basis of the increased mortality from Hepatitis E observed among pregnant

women. It is hoped that the results of these studies will help public-health professionals effectively deal with Hepatitis E infections and save human lives.

The USGS Fisheries: Aquatic and Endangered Resources, and Contaminant Biology Programs, and the Research Foundation - Flanders and European Union Framework Programme provided funding for this study.

### Urban Sediment in Wisconsin Can be Toxic

Sediment that gets washed away from urban areas can be toxic to aquatic life, according to a recent study by the USGS.

From 2009 through 2011, a team of scientists from the USGS and the Wisconsin State Laboratory of Hygiene measured concentrations of selected trace metals and polynuclear aromatic hydrocarbons (PAHs) in both the fine particles (silt size) and the coarser particles (sand size)



Sediment-laden stormwater flowing near a stormwater intake. Photo credit: William Selbig, USGS.

from four sources of sediment collected in Milwaukee and Madison, Wisconsin. The types of sediment the scientists sampled consisted of street dirt, solids that settle to the bottom of storm sewers (stormwater bed), solids suspended in stormwater, and bed sediment found in urban streams. They found that all of the sediment types showed some level of potential toxicity to aquatic life when observed concentrations were compared to published sediment quality guidelines. Stormwater bed sediment had the highest potential toxicity followed by suspended solids in stormwater, street dirt, and streambed sediments.

As was expected, the finer particles measured in this study generally had higher concentrations of contaminants. This is important because many treatment structures are designed to capture coarse sediment, but do not effectively capture the finer particles. On the other hand, PAH concentrations were higher in the sand size fraction in most cases. PAHs are an environmental health concern because several are probable human carcinogens and they are toxic to fish and other aquatic life. The concentrations of metals were found at high, but not toxic, levels.

These findings may help environmental managers make informed decisions on how best to mitigate pollution from urban stormwater. The USGS Cooperative Water Program and Wisconsin Department of Natural Resources provided funding for this study.

### Anticoagulant Rodenticides are Very Toxic to Raptors

A team of USGS and U.S. Department of Agriculture scientists conducted controlled exposure studies and risk assessments that found diphacinone, an anticoagulant rodenticide, to be considerably more toxic to raptors than to mallards (*Anas platyrhynchos*) and northern bobwhites (*Colinus virginianus*). For example, in acute oral toxicity studies with American kestrels (*Falco sparverius*) diphacinone was 20 to 30 times more potent (median lethal dose (LD50) = 96.8 mg/kg body weight) than reported in northern bobwhite (LD50 = 2,014 mg/kg) and mallards (LD50 = 3,158 mg/kg). In 7-day feeding studies, adverse toxic effects (including prolonged clotting time and anemia) were detected in Eastern screech-owls (*Megascops asio*) at ingested

doses as low as 0.16 milligram per kilogram body weight per day, and measurements of lethality suggest that owls are 5 times more sensitive than mallards. These are extremely important findings given that toxicity data from mallards and northern bobwhites are often used to evaluate the hazard associated with exposure of raptors, such as owls and hawks, to rodenticides.



Raptors, such as this Eastern screech-owl (*Megascops asio*) are very sensitive to the toxic effects of rodenticides. Photo credit: Rebecca S. Lazarus, USGS.

Diphacinone and other anticoagulant rodenticides are used to control rats, mice, and other rodent pests in urban, suburban, and agricultural areas, and in habitat restoration projects. Despite widespread use, there is growing concern by regulators and natural resource managers about their risk to children, pets, domestic animals, and non-target wildlife. Recently, the U.S. Environmental Protection Agency placed new restrictions on the use of some highly toxic second-generation anticoagulant rodenticides (SGARs), which might result in expanded use of the first-generation anticoagulant rodenticides (FGARs). Regrettably, even FGARs have been implicated in non-target wildlife mortality events.

To assess adverse effects on non-target wildlife, the USGS and the U.S. Fish and Wildlife Service conducted a multi-year field study of black-tailed prairie dog (*Cynomys ludovicianus*) colonies to examine the response to applications of bait containing the FGAR chlorophacinone. While concerns about bird poisonings from FGARs and SGARs have traditionally focused on secondary poisoning of raptors, the scientists discovered that ground foraging songbirds are directly poisoned by feeding on the chlorophacinone bait.

Natural resource managers can use the results of these studies to assess the costs and benefits of pest control and eradication activities using FGAR compounds, and the potential effect on non-target wildlife. These studies were funded by the USGS Contaminant Biology Program, the U.S. Fish and Wildlife Service, and the U.S. Department of Agriculture.

### Biochar Reduces Nitrous Oxide Emissions from Soil

Scientists from the USGS and the Norwegian Geotechnical Institute found that sorption is the process by which nitrous oxide strongly attaches to biochar. Nitrous oxide is a powerful greenhouse gas formed in soil when microorganisms oxidize ammonia ( $\text{NH}_3$ ) and is present when microorganisms reduce nitrates to nitrogen gas (denitrification). Biochar is charcoal made from waste plant and other biomass, such as agricultural waste material. Due to biochar's stability in soil, some scientists have proposed that it could provide a means of sequestering carbon in soil, while simultaneously improving the fertility and quality of soils. Though most studies showed an associated suppression of nitrous oxide emissions by biochar, the mechanism for the suppression was poorly understood until now.



Uncharred Pine Shavings



Charred Pine Shavings

Biomass material, such as the pine shavings in the upper photo, is converted to biochar (lower photo) through the application of intense heat in an oxygen free chamber (pyrolysis). Photo credit: Colleen E. Rostad, USGS.

The team of scientists compared the nitrous oxide sorption capacity of biochar to that of other sorbents that are potentially present in soils. They found that biochar binds nitrous oxide more strongly than the mineral and organic soil materials they tested. Sorption of nitrous oxide to the biochar itself could be a viable mechanism for suppression of nitrous oxide emissions from soil.

The USGS Toxic Substances Hydrology and Hydrologic Research and Development Programs funded this study.

### For Endangered Mussels in the Delaware River, It's All about Temperature

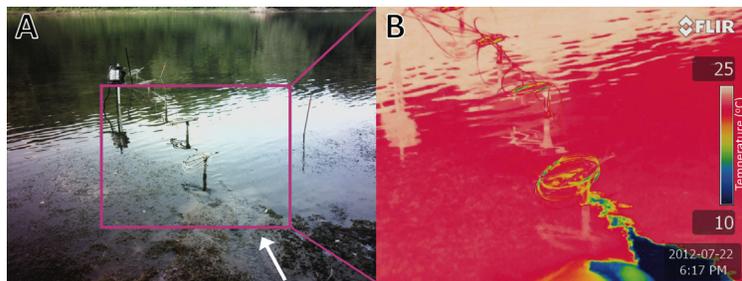
USGS scientists have recently developed and applied high-resolution fiber-optic temperature sensing methods to define the niche habitat preferred by the endangered dwarf wedgemussel (*Alasmidonta heterodon*) in the upper Delaware River (Pennsylvania and New York). The scientists identified numerous cold groundwater springs—both focused and diffuse—at several locations in the upper Delaware River where dwarf wedgemussels still can be found. The wedgemussel is known to be particularly sensitive to high water temperatures. During summer months



The endangered dwarf wedgemussel (*Alasmidonta heterodon*). A centimeter ruler is used for scale. Photo credit: Jeffrey Cole, USGS.

the mussels may actively seek out regions where cold groundwater is entering the river. At one mussel bed the scientists studied, infrared imagery and custom-made, fiber-optic temperature sensors revealed the complex interaction between the cold water discharging from a spring and the much warmer river water. A relatively stable plume of cold groundwater extended for several meters along the riverbed, keeping average streambed temperatures approximately 8 degrees Celsius colder than the main river water. Resource managers could potentially use the thermal signature of streambank seeps to identify unknown populations of wedgemussels. This information is useful to resource managers developing future river management strategies that may prioritize the protection of these discrete cold-water habitats for the mussels and other cold-water dependent species.

This work was funded by the U.S. Fish and Wildlife Service, with additional support from the USGS Toxic Substances Hydrology Program and Groundwater Resources Program.



Panel (A) shows the instrumented area where USGS scientists studied dwarf wedgemussel habitat; panel (B) is an infrared subset of (A), and shows how a groundwater spring along the river bank is much colder (blue tones) than the surrounding Delaware River water (reds and yellows), and quickly plunges below the surface to form a stable plume. Photo credit: USGS, Emily Voytek.

## Upcoming Meetings

### Iowa Groundwater and Public Health Symposium, Des Moines, Iowa, March 11, 2014

This symposium is being sponsored by the Iowa Groundwater Association and the University of Iowa Center for Health Effects of Environmental Contamination. The symposium will highlight recent research and surveillance projects on viruses, arsenic, and nitrate contamination combined with groundwater characterization. Potential health impacts of these drinking water contaminants will be discussed, and a look at possible future groundwater contaminant issues will be presented. USGS environmental health science will be presented at the symposium.

<http://www.igwa.org/>

### 5th International Congress on Arsenic in the Environment (As2014), Buenos Aires, Argentina, May 11-16, 2014

The theme of As2014 is "One century of the discovery of arsenicosis in America (1913-2014)." The symposium commemorates 100 years of the discovery of the effects of arsenic on human life in Latin America.

<http://www.as2014.com.ar/>

### Dust 2014; International Conference on Atmospheric Dust, Castellana Marina, Italy, June 1-6, 2014

The Italian Association for the Study of Clays (AISA) and the Institute of Methodologies for Environmental Analysis (IMAA) are sponsoring DUST 2014, the International Conference on Atmospheric Dust. The conference features several sessions on the health and environmental aspects of atmospheric dusts. USGS scientists have conducted studies on the transport of pathogens and toxic chemicals by airborne dusts.

<http://www.dust2014.org/>

### 144th Annual Meeting of the American Fisheries Society, Québec City, Canada, August 17-21, 2014

144th Annual Meeting of the American Fisheries Society will feature information on the managing and understanding of fisheries of all kinds. The meeting's theme is "From Fisheries Research to Management: Think and Act Locally and Globally." Scientists from the USGS frequently present at the conference environmental health science information on aquatic organisms and aquatic habitats that can help natural resources managers and decision makers do their jobs.

<http://afs2014.org/>

### EmCon 2014—Fourth International Conference on Emerging Contaminants in the Environment, Iowa City, Iowa, August 19-22, 2014

This conference provides a forum for scientists to present information on emerging contaminants (ECs) in the environment. The topical themes for the conference include: Sources and Exposure Pathways; Treatment Processes and Technologies; Waste, Wastewater Recycling, and Reuse; Sampling, Analytical, and Characterization Methods; Fate and Transport in Aquatic and Terrestrial Ecosystems; Aquatic and Terrestrial Effects; and Risk Assessment, Risk Management, Regulations, and Policy Frameworks. USGS scientists are helping organize the conference. Abstracts are due March 14, 2014.

<http://www.emcon2014.com/>

### 26th Annual ISEE Conference—From Local to Global: Advancing Science for Policy in Environmental Health, Seattle, Washington, August 24-28, 2014

The International Society for Environmental Epidemiology (ISEE) is conducting a joint conference on environmental health. The conference goal is to present recent achievements in the field of environmental epidemiology research and practice with a focus on emerging issues and innovative approaches to environmental epidemiology.

<http://depts.washington.edu/uwconf/isee2014/>

### 20th Annual Conference of The Wildlife Society, Pittsburgh, Pennsylvania, October 25-30, 2014

The Wildlife Society will be holding its annual conference in Pittsburgh, Pennsylvania, October 25-30, 2014. The conference will feature information on wildlife conservation challenges. USGS scientists frequently present environmental health science information at this conference.

<http://www.wildlife.org/conferences/>

**2014 GSA Annual Meeting and Exposition, Vancouver, Canada, October 19-22, 2014**

The Geological Society of America (GSA) annual meeting features a broad array of special technical sessions, field trips, short courses, and special lectures. USGS scientists frequently present a wide variety of information on USGS science at the meeting, including environmental health science.

<http://www.geosociety.org/meetings/2014/>

**SETAC North America 35th Annual Meeting, Vancouver, Canada, November 9-13, 2014**

The Society of Environmental Toxicology and Chemistry (SETAC) Annual Meeting's theme is Interconnecting Ecosystems. The meeting covers environmental health related topics such as aquatic toxicology and ecology, ecological risk assessment, environmental or analytical chemistry, and terrestrial or wildlife toxicology and ecology. In past meetings, USGS scientists have presented environmental health science in many of the meeting's sessions.

<http://vancouver.setac.org/>

**2014 APHA Annual Meeting and Exposition, New Orleans, Louisiana, November 15-19, 2014**

The American Public Health Association (APHA) annual meeting addresses current and emerging health science, policy, and practice issues with the goal to prevent disease and promote health. The theme of the meeting is Healthography: How where you live affects your health and well-being.

<http://www.apha.org/meetings/AnnualMeeting/>

**AGU 46th Annual Fall Meeting, San Francisco, California, December 15-19, 2014**

The American Geophysical Union's (AGU) annual fall meeting will cover a wide range of environmental health science topics. At past meetings, USGS scientists have presented information on a wide range of science topics including environmental health science.

<http://sites.agu.org/meetings-events/>

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## New Publications

### Coming Soon!

Alpers, C.N., Fleck, J.A., Marvin-DiPasquale, M., Stricker, C.A., Stephenson, M., and Taylor, H.E., Mercury cycling in agricultural and managed wetlands, Yolo Bypass, California—Spatial and seasonal variations in water quality: *Science of the Total Environment*, doi:10.1016/j.scitotenv.2013.10.096.

Andraski, B.J., Jackson, W.A., Welborn, T.L., Böhlke, J.K., Sevanti, R., and Stonestrom, D.A., Soil, plant, and terrain effects on natural perchlorate distribution in a desert landscape: *Journal of Environmental Quality*.

Zaugg, S.D., Phillips, P.J., and Smith, S.G., Analysis of pharmaceutical and other wastewater compounds in filtered and unfiltered water samples by gas chromatography/mass spectrometry: U.S. Geological Survey Open-File Report.

Marvin-DiPasquale, M., Windham-Myers, L., Agee, J.L., Kakouros, E., Kieu, L.H., Fleck, J., Alpers, C.N., and Stricker, C., Methylmercury production in sediment from agricultural and non-agricultural wetlands in the Yolo Bypass, California, USA: *Science of the Total Environment*, doi:10.1016/j.scitotenv.2013.09.098.

Alvarez, D.A., Maruya, K.A., Dodder, N.G., Lao, W., Furlong, E.T., and Smalling, K.L., Occurrence of contaminants of emerging concern along the California coast (2009-10) using passive sampling devices: *Marine Pollution Bulletin*, doi:10.1016/j.marpolbul.2013.04.022.

Battaglin, W.A., Meyer, M.T., Kuivila, K.M., and Dietze, J.E., Glyphosate and its degradation product AMPA occur frequently and widely in US soils, surface water, groundwater, and precipitation: *Journal of the American Water Resources Association*.

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Fuller, C.C., and Akstin, K.C., Laboratory studies of biostimulated uranium reduction by ISR aquifer sediments and suboxic remobilization of sequestered uranium, (Chapter 3), *in Assessing the Potential for Bioremediation of Uranium In Situ Recovery Sites: U.S. Nuclear Regulatory Commission NUREG-CR*.

Maruya, K.A., Dodder, N.G., Weisberg, S.B., Gregorio, D., Bishop, J.S., Klosterhaus, S., Alvarez, D.A., Furlong, E.T., Bricker, S., Kimbrough, K.L., and Lauenstein, G.G., The Mussel Watch California pilot study on contaminants of emerging concern (CECs)—Synthesis and next steps: *Marine Pollution Bulletin*, doi:10.1016/j.marpolbul.2013.04.023.

Windham-Myers, L., Marvin-DiPasquale, M., Stricker, C.A., Agee, J.L., Kieu, L.H., and Kakouros, E., 2013, Mercury cycling in agricultural and managed wetlands of California, USA—Experimental evidence of vegetation-driven changes in sediment biogeochemistry and methylmercury production: *Science of the Total Environment*, doi:10.1016/j.scitotenv.2013.05.028.

Windham-Myers, L., Marvin-DiPasquale, M., Kakouros, E., Agee, J.L., Kieu, L.H., Stricker, C.A., Fleck, J.A., and Ackerman, J.T., Mercury cycling in agricultural and managed wetlands of California, USA—Seasonal influences of vegetation on mercury methylation, storage, and transport: *Science of the Total Environment*, doi:10.1016/j.scitotenv.2013.05.027.

Delin, G.N., and Herkelrath, W.N., Effects of dual-pump crude oil recovery system, Bemidji, Minnesota, USA: *Ground Water Monitoring and Remediation*.

McLemore, V.T., Smith, K.S., and Russell, C.C., Environmental sampling and monitoring for the mine life cycle—Management technologies for metal mining influenced water series: *Society for Mining, Metallurgy, and Exploration, Inc.*

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### Published Recently!

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