
EPA
RESEARCH

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Cleaner air, land, and water. Vibrant, healthy neighborhoods. These hallmarks have been the overarching impacts of more than 45 years of EPA research and engineering. For over four decades, EPA's innovative, cutting-edge work has made the nation a safer and more prosperous place for American families.

That work is most noticeable in times of national crisis – when drinking water is threatened or when oil and chemical releases endanger public health or vulnerable ecosystems – because EPA's premier environmental research organization ensures that emergency operations are ready to respond whenever and wherever they are needed. In times of crisis, EPA research delivers.

But EPA research doesn't only inform high-profile emergencies – it also provides the scientific foundation for life-saving environmental protections and directly helps states and communities across the nation make their neighborhoods healthy.

From neighborhoods struggling with contaminated sites to small towns looking for the latest science to improve their drinking water systems, EPA research is making a difference in communities across the country. And farmers looking to increase soil productivity along the Atlantic coast, along with residents in California concerned with a 100-year-old crumbling dam, turn to EPA research for scientific, technical solutions.

The stories in this document—such as how EPA's homeland security research helped New York City prepare for a potential biological attack; how Agency clean air experts are ushering in a new generation of small, inexpensive, and portable air monitoring technologies that communities can use; and how EPA researchers help state and regional partners address the challenges of contaminated lands—all illustrate how the advances of EPA science benefit communities of all scales and sizes.

This work cuts across every aspect of EPA's national effort to protect public health and meet the most pressing environmental challenges of the day all while working toward a healthier future for everyone.

PROTECTING AMERICAN FAMILIES AND WORKERS FROM HAZARDOUS CHEMICALS

In June 2016, Congress passed a bill to reform the Toxic Substances Control Act (TSCA), which helps EPA protect American families from the potential health effects of chemicals. This updated, bipartisan law is a major step in protecting Americans' health. To make sure TSCA is enforced effectively, EPA requires the best scientific data on chemical safety. That's where EPA research steps in.

Thousands of chemicals are currently in use, and hundreds more are introduced to the market every year. Workers can be exposed to these chemicals during production, and people can be exposed through the environment and products they use in their daily lives. Due to the time and resource-intensive nature of chemical safety testing, only a small fraction of chemicals has been evaluated for potential health effects. But EPA is developing groundbreaking approaches to quickly and cost effectively prioritize chemicals for in-depth testing.

Computational Toxicology

EPA is a leader in computational toxicology, which integrates advances in biology, biotechnology, chemistry, and computer science to find new and more efficient ways to test and screen chemicals. Using computational toxicology, EPA researchers are developing new techniques such as computer-based models and even robot-assisted high-throughput screening to make chemical evaluation and testing faster and less expensive by several orders of magnitude. Using this research, thousands of chemicals can be evaluated for potential risk at a small cost in a very short amount of time and without the use of animal testing. With this information, EPA can quickly and inexpensively prioritize potentially hazardous chemicals that need further testing.

Partnerships with Industry to Protect Consumers

The success of EPA's computational toxicology research has opened the door to partnerships with the consumer products industry. EPA recently partnered with L'Oréal to explore using EPA's computational toxicology data to predict the potential toxicity of chemicals that L'Oréal may use in cosmetics. When the collaboration launched in 2013, L'Oréal had already been investing in the development of animal-free toxicology tests and wanted to use CompTox to further these efforts. Since L'Oréal is based in France, another driver for the collaboration was the European Union's (EU) ban on using animal testing that occurred in March 2013.

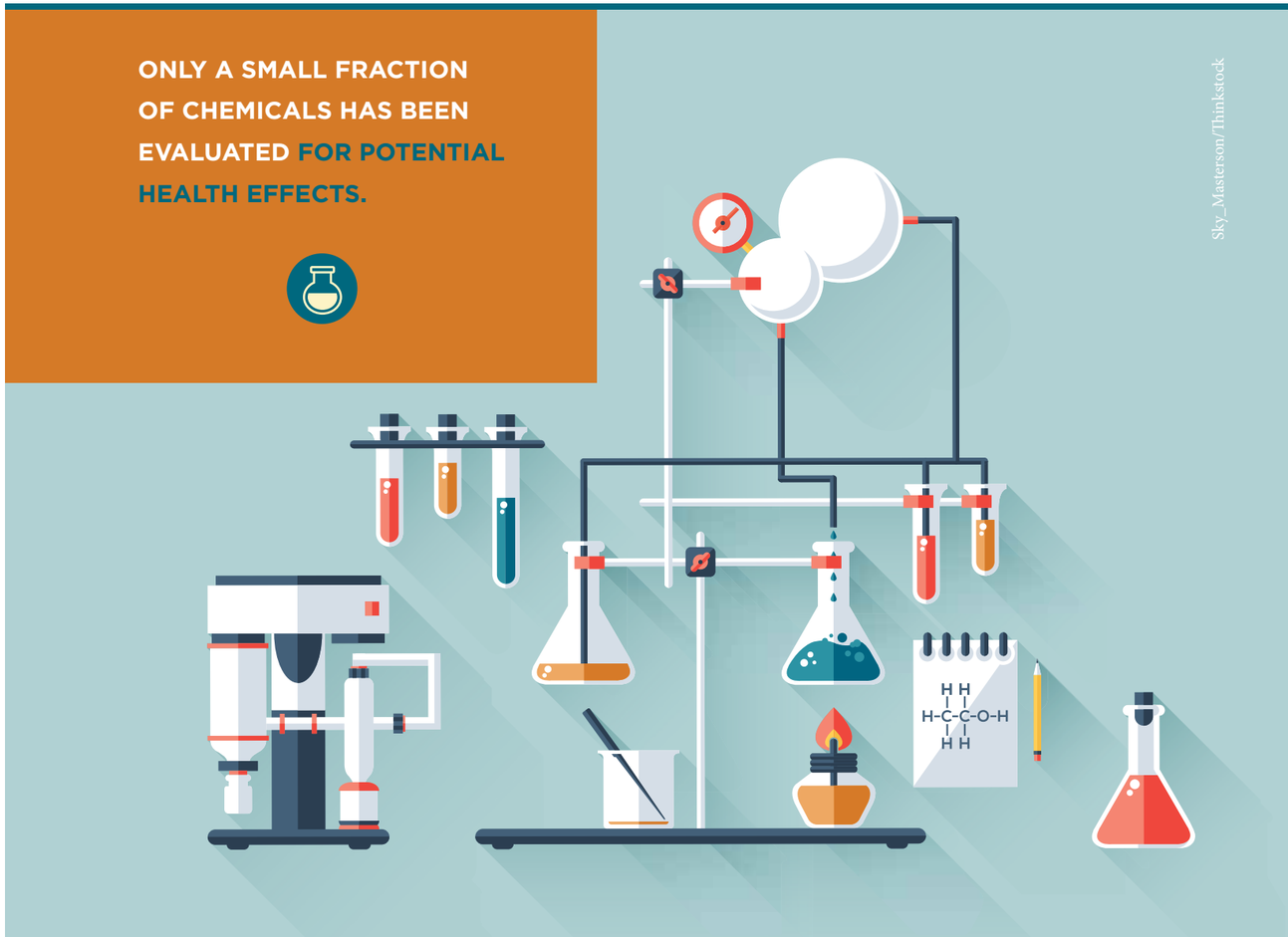
Through this collaboration, EPA improved its own database of animal toxicity studies and L'Oréal gained access to new approaches to chemical evaluation that are less expensive and less time consuming. The collaboration resulted in a computational model that can predict the dose at which toxic effects are observed in animals following repeated exposure.

EPA is also working with Unilever to develop new, more efficient approaches for chemical safety assessment using computational toxicology data. Unilever is providing their expertise in consumer products to estimate exposures for each chemical. Even though personal care products like those produced by L'Oréal and Unilever aren't regulated by TSCA, many of the chemicals used in these products are. Additionally, research from collaborations such as these will result in better ways to evaluate the potential health effects of new ingredients and chemicals so that EPA has the tools and information to protect the health of everyone in the nation.

Screening Chemicals for Neurotoxicity

The human brain is the most complex organ in our bodies. So understandably, traditional methods that explore how chemicals affect the brain are complex as well, often being both costly and time-consuming. Reliance on these methods is one reason the pace of testing has not

ONLY A SMALL FRACTION OF CHEMICALS HAS BEEN EVALUATED FOR POTENTIAL HEALTH EFFECTS.



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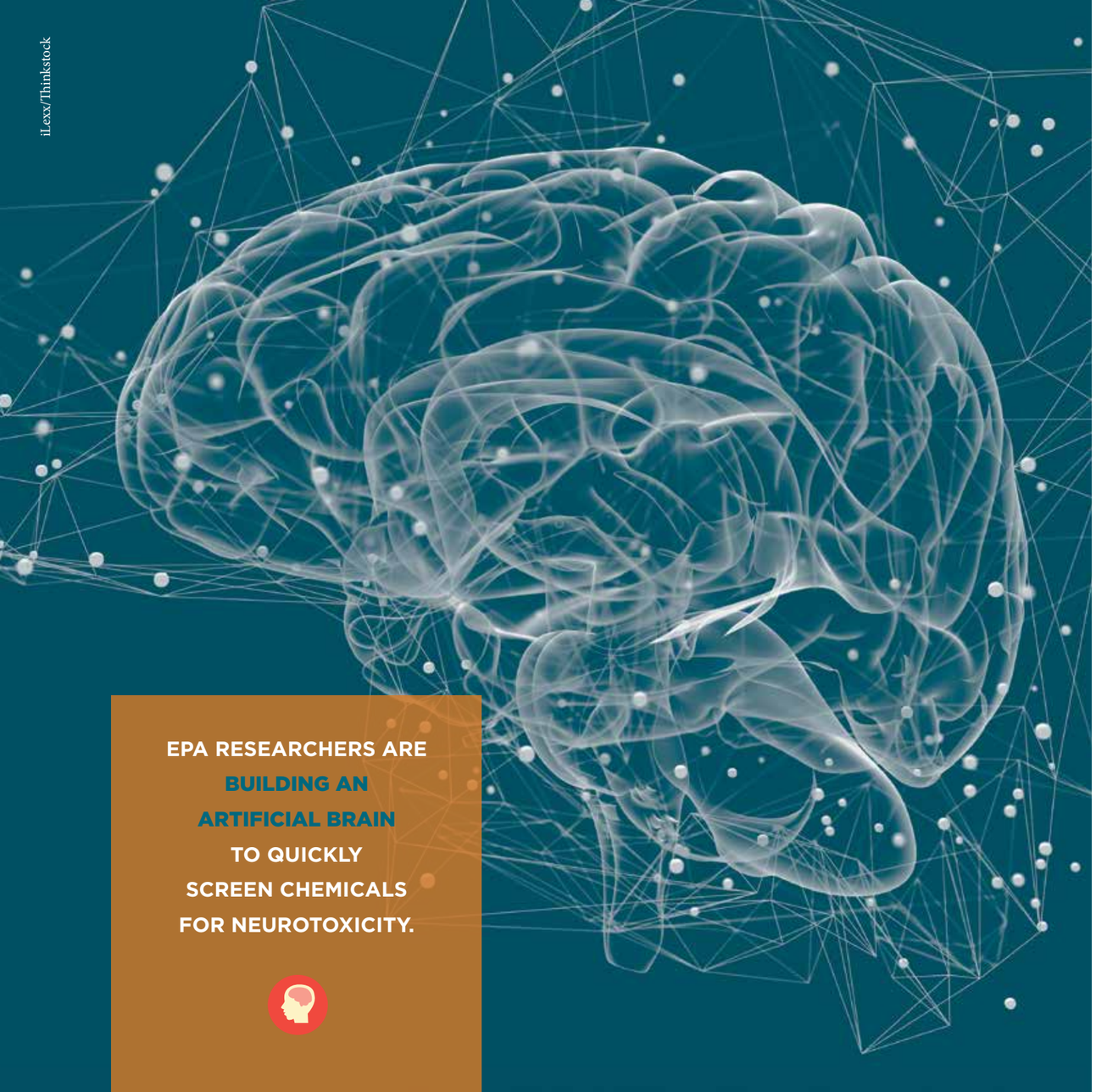

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EPA RESEARCHERS ARE **BUILDING AN ARTIFICIAL BRAIN** TO QUICKLY SCREEN CHEMICALS FOR NEUROTOXICITY.

(Protecting American Families and Workers from Hazardous Chemicals continued)

kept up with the development of commercial chemicals, leaving significant data gaps.

That's why EPA researchers are building a "brain-on-a-chip" to quickly screen chemicals for neurotoxicity. This method uses high-tech computer modeling, cellular models, and vast collections of data to simulate how the brain works. The brain-on-a-chip replicates biological interactions so that researchers can simulate how a chemical might affect the brain - without having to use actual tissues or organs.

The impact of this research is a new wave of neurotoxicology testing that is faster, more efficient, and far less costly, which will help EPA protect human health.

Easily Accessible Chemical Information

EPA researchers have also released the Interactive Chemical Safety for Sustainability Chemistry Dashboard - or the iCSS Chemistry Dashboard. It is an easy-to-search database containing information on over 700,000 chemicals. The data are downloadable with the click of a button on a smartphone or tablet. The iCSS Chemistry Dashboard provides chemical researchers easy access to existing data, while also allowing them to provide feedback. You can access the iCSS Dashboard here: **https://actor.epa.gov/dashboard/**

These advances in chemical safety testing strengthen the scientific foundation of TSCA and also help industry create safer products for consumers. This all helps EPA protect the health of everyone in the U.S. from hazardous chemicals.

Robust Chemical Evaluations to Protect Health

EPA's Integrated Risk Information System (IRIS) helps EPA, states, local agencies, and tribal nations make smart, informed, and thoroughly-researched decisions to protect people's health – decisions that protect against cancer and other diseases. IRIS develops comprehensive, rigorously peer-reviewed scientific assessments that directly inform EPA decisions to protect human health under an array of environmental laws, including the recently amended Toxic Substances Control Act.

Recently, EPA scientists in the IRIS program finalized toxicological assessments for ammonia, trimethylbenzenes, benzo(a) pyrene, and ethylene oxide. Ammonia, which can cause respiratory health effects, is used as a fertilizer, antimicrobial, and all-purpose cleaner, but also occurs naturally in air, soil, and water. Trimethylbenzenes are produced during petroleum refining and may be inhaled during exposure to vehicle emissions. Benzo(a)pyrene is in coal tar and cigarette smoke, and is produced during residential wood burning. And ethylene oxide is a colorless, flammable gas that is used in the production of a number of chemicals and is also used as a sterilizer or fumigant of medical equipment, spices, cosmetics, and other items.

"It's very important that we provide small water systems with timely, easy to use, and accessible tools and training to assist in operating these critical public water systems, and the webinars and one-on-one meetings are perfectly suited to meet this need."

Ohio EPA Director Craig Butler

John1179/Thinkstock

ENSURING SAFE DRINKING WATER

Across the country, 97 percent of the 152,000 public drinking water systems are considered small systems, meaning they serve 10,000 or fewer people. These small systems provide approximately 20% of Americans with their drinking water. While many of these small systems consistently provide safe and reliable drinking water to the people they serve, they face enormous challenges in their ability to maintain, replace, and improve their technologies due to multiple factors, including high staff turnover and fewer resources than larger systems. EPA scientists and engineers are conducting research to help protect small systems, and EPA is taking extra steps to make sure that state and local personnel, as well as small systems professionals, have the information, technical assistance, and training they need to keep their drinking water safe.

EPA hosts a free monthly webinar series, Challenges and Treatment Solutions for Small Drinking Water Systems, that provides state agencies, local governments, and small systems professionals with the latest scientific advancements and current guidance to deliver high quality drinking water. The webinar series has provided information and training to over 9,000 state and local agency personnel, system operators, and others from all 50 states, as well as U.S. tribal nations and territories and other countries. The webinars have the dual benefit of providing EPA with invaluable information from the states on the problems that they are currently encountering in their day-to-day interactions with small systems. With this information, EPA researchers can then modify their research to solve real-world problems that small systems are experiencing.

Helping Alaskans Manage Drinking Water Contaminants Released from Landfills

In collaboration with five Alaska tribal communities, EPA researchers and EPA Region 10 completed a study characterizing the fate of contaminants released from landfills in rural Alaska and their potential impact on local drinking water sources. This study gave the tribal communities of Allakaket, Eek, Ekwok, White Mountain, Fort Yukon, and other communities throughout the State of Alaska information that can be used to improve the management of their landfills and protect the drinking water of Alaskans.

97% OF THE 152,000 PUBLIC DRINKING WATER SYSTEMS SERVE 10,000 OR FEWER PEOPLE.

For more information on EPA's small drinking water research, please visit: www.epa.gov/water-research/small-drinking-water-systems-research-0

CLEANING UP THE NATION'S MOST CONTAMINATED SITES

Every state and inhabited territory in the United States has at least one Superfund site - but some states have dozens. These sites are some of the country's most contaminated land and include radiation waste dumps, toxic chemical release sites, and oil spill locations. EPA's Superfund program cleans up these sites and also responds to environmental emergencies, oil spills, and natural disasters. EPA's researchers are vital to the Superfund program, providing the scientific support and assistance needed to safely clean up the sites and make a visible and lasting difference in communities.

Each year, EPA researchers respond to hundreds of requests for scientific support at contaminated sites. The support the researchers provide helps ensure cost-effective, health protective solutions to waste contamination problems in communities across the country. Here are just two examples of this work:

Cleaning Up Caddo Lake in Texas

EPA researchers helped EPA Region 6 in monitoring site remediation at the Longhorn Army Ammunition Plant Superfund Site in rural eastern Texas. The former plant, occupying roughly 8,400 acres adjacent to Caddo Lake, was established during World War II to manufacture TNT. During the war, the plant produced almost 400 million pounds of TNT. Unfortunately, TNT, its breakdown products, and other materials manufactured at the site are among site environmental concerns. Since 1990, when it was added as a Superfund site, more than 7,000 acres have been cleaned to applicable standards and transferred to the U.S. Fish and Wildlife Service for the establishment of Caddo Lake National Wildlife Refuge.

Analysis of a Crumbling Dam in Jackson, CA

The Eastwood Multiple Arch Dam in Jackson, CA is holding back over 165,000 tons of tailings from the Argonaut Mine, which closed in 1942. The 100-year old dam is cracked and crumbling, and local officials are concerned that its instability could result in extensive damage to the town in the event of failure.

EPA researchers helped EPA Region 9 quantify the probabilities of damage and likely costs if the dam failed. The results of the analysis indicated there could be extensive damage to and strain on property, infrastructure, the local economy, and emergency services in the event of dam failure. In a wet season scenario, it was estimated the damages and losses could be as high as $100 million.

EPA gave the analysis results to the community of Jackson and shared concerns about the stability of the dam and the need for further investigation. The final modeling results were also presented to top officials at California's Environmental Protection Agency, Office of Emergency Services, Department of Transportation, California's Department of Toxic Substances Control, the Department of Water Resources, and other agencies. With EPA's access to researchers with modeling expertise, EPA was able to provide potentially life-saving consultation to key federal, state, and local agencies.

PREPARING FOR POTENTIAL ATTACKS

After a wide-area attack with a biological agent, like anthrax, rapid response is essential. Safe and effective clean-up methods based on sound science are crucial. That's why EPA researchers are looking for ways to speed up and simplify the decontamination process to rapidly and effectively respond to environmental catastrophes.

Low-tech Decontamination Methods

EPA researchers are creating low-tech decontamination solutions for a wide-area anthrax incident. These methods rely on products often available in drugstores and could be used by homeowners and business owners.

The researchers studied the effectiveness of a method creating hydrogen peroxide vapor using a standard humidifier. Pilot-scale tests show that off-the-shelf humidifiers using 3% or 8% aqueous hydrogen peroxide vapor solutions for one week are effective for decontaminating most materials contaminated with an anthrax surrogate (meaning it acts like anthrax in the study, but doesn't present the same level of danger). Some materials are more difficult than others to decontaminate with this method, such as wood and concrete.

EPA researchers are currently transitioning the laboratory work to full-scale experiments in a test house to determine the most promising solutions for home and business owners.

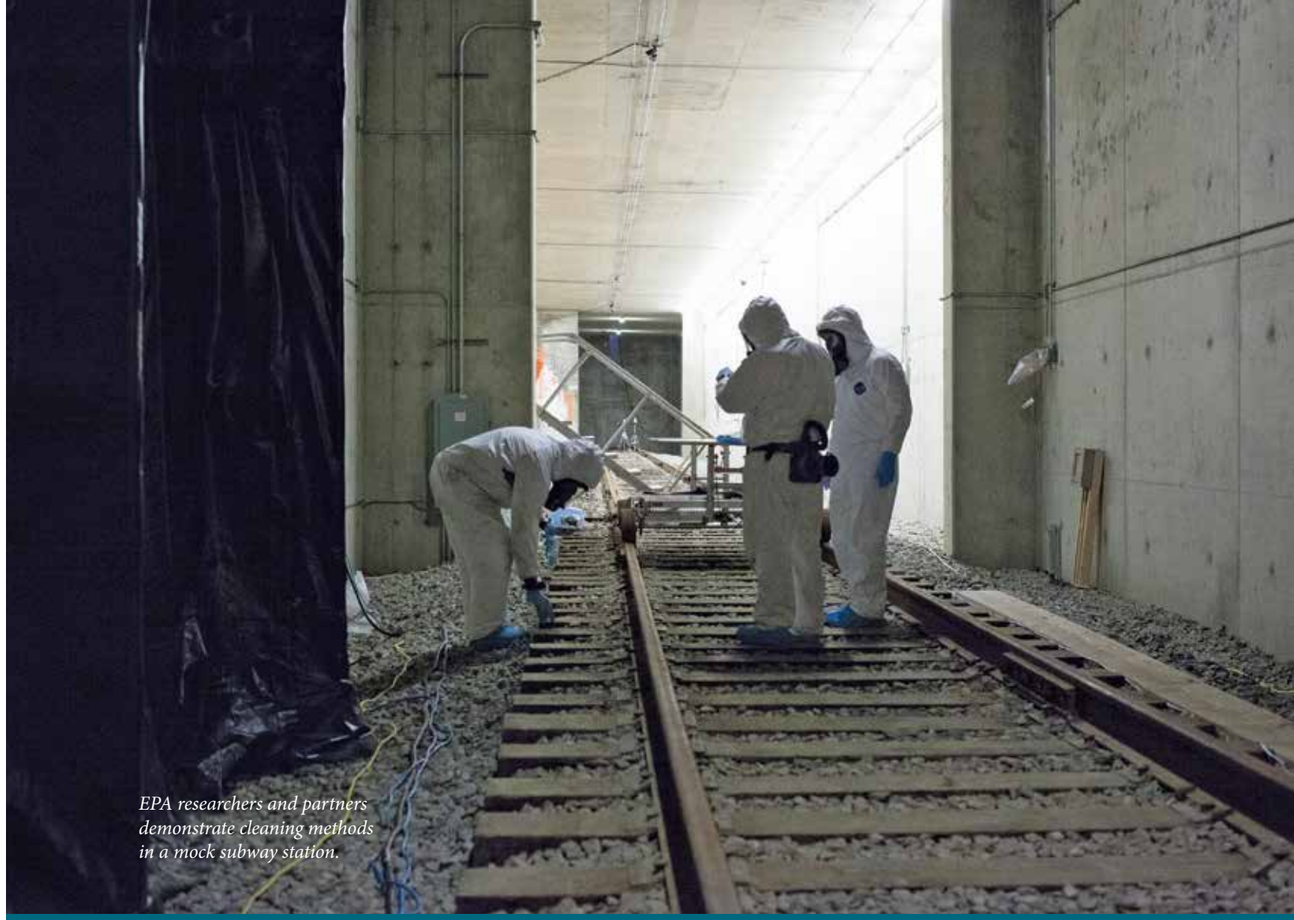
Decontaminating the Subway

In large cities, underground transportation systems are a part of everyday life. In the event of a biological incident, a rapid return to service of these critical infrastructure systems is necessary. Even a slight disruption in service can severely impact people's lives, businesses, and result in large economic losses. To help communities and individuals return to normal after a biological event, the Department of Homeland Security and EPA are collaborating to improve the recovery capabilities for a subway system.

Researchers started in the lab by evaluating the efficacy of various decontaminants, such as methyl bromide fumigation, chlorine dioxide fumigation, and bleach dispersed as a fog. They also tested different sampling methods and took an inventory of commercially-available equipment that could be used for rapid decontamination.

During the second phase of the project, EPA and its partners demonstrated several cleaning methods using a mock subway station and tunnel. This allowed researchers to transition the methods used in the lab to the field. Some aspects of the demonstration included using a robotic cleaner for surface sampling, which allowed researchers to cover a larger area than traditional sampling methods like swabbing. They also used a technique called aggressive air sampling, which tests numerous building interiors with fewer personnel. Traditional sampling is expensive, requires personal protective equipment, and is very time intensive, so these innovative techniques can shorten cleanup time by reducing the traditional sampling burden.

The research and evaluation will ultimately result in national guidance that will streamline the process and help the response community, other federal agencies, and



EPA researchers and partners demonstrate cleaning methods in a mock subway station.

"We work very closely with EPA to develop capabilities that can be used in the event of an incident involving Bacillus anthracis, the organism that causes anthrax, or another hazardous biological agent. It's important that we work in partnership so that we help the nation to prepare for a biological incident."

Don Bansleben, Program manager, Department of Homeland Security, Science and Technology Directorate

EPA RESEARCHERS HELPED BUILD THE WATER SECURITY TEST BED: THE NATION'S FIRST FULL-SCALE, ABOVE-GROUND DRINKING WATER DISTRIBUTION SYSTEM.

international governments rapidly respond and recover underground transit systems from a biological incident.

Helping New York City Plan for a Biological Incident

Responding to and cleaning up after a wide-area biological incident is difficult anywhere. But in a city as unique and complex as New York City, it's incredibly challenging. That's why researchers from EPA and the Sandia National Lab (with support from the CDC Public Health Emergency Preparedness grant) provided research and scientific expertise to assist the New York City Department of Health and Mental Hygiene develop an "Environmental Response and Remediation Plan for Biological Incidents."

This plan specifically addressed the release of anthrax spores in NYC and will make sure the city is prepared to protect the city's 8.4 million residents in the event of a biological incident. In addition to improving NYC's preparedness, the plan also provides a response and remediation framework for other metropolitan areas across the country.

Water Security Test Bed in Idaho

Our nation's drinking water distribution systems can be vulnerable to contamination-causing events such as industrial accidents, natural disasters, or terrorist attacks. EPA researchers work with water utilities to protect these distribution systems and clean up systems that do become contaminated. Whether purposeful or accidental, contamination of these systems can threaten people's health and result in large economic impacts. To better protect—and if necessary, decontaminate—our nation's drinking water, EPA researchers have partnered with Department of Energy's Idaho National Laboratory to build the Water Security Test Bed: the nation's first full-scale, above-ground drinking water distribution system.

The test bed is a replica of a portion of a drinking water pipe system and is 445 feet of above-ground, cement-lined pipes plus fire hydrants. Since most of the nation's water systems are not brand new, the test bed uses 30-year old weathered pipes that were exhumed from the ground nearby. The test bed is above ground, which allows researchers to easily tailor the system to address a wide variety of applied science questions.

Over the next several years, EPA and partner researchers will conduct experiments using various biological, chemical, and radioactive simulants that replicate highly-toxic materials. Approaches to contamination detection, infrastructure decontamination, and water treatment developed at lab and pilot scale will be demonstrated at this full-sized system. Results from this work will be easily transitioned for use by utilities because the tests have been conducted in a real distribution system.

"This is the first plan of its kind. Over 50 EPA subject matter experts from seven different EPA offices and three EPA Regions contributed to developing the Plan. The first version of the Plan was completed in July 2015 and since then the EPA has continued to offer subject matter expertise and guidance to operationalize the Plan."

Marisa Raphael, Deputy Commissioner of Emergency Preparedness and Response, New York City Department of Health and Mental Hygiene.

PROTECTING THE AIR WE BREATHE

EPA conducts research that provides the critical science to develop and implement Clean Air Act regulations that protect the quality of the air we breathe. This research also puts new tools and information in the hands of citizens, communities, and air quality managers to reduce air pollution. Take a look at just a tiny fraction of the work EPA researchers have done recently to help protect the air and the health of our nation.

Connecting Air Pollution and Heart Health

In 2016, EPA took a giant leap forward in our understanding of the relationship between air pollution and heart disease with the publication of results from the Multi-Ethnic Study of Atherosclerosis Air Pollution Study (MESA Air). MESA Air provides the strongest evidence yet that air pollution directly contributes to the development of heart disease, which is the number one killer of Americans and people in developed countries throughout the world.

The results of the study, gathered over a period of 10 years, define the relationship between air pollutants and the progression of heart disease over time. This relationship will help estimate the long-term health impacts and economic burden of air pollution within our population.

Using the results of MESA Air, doctors and nurses can take air pollution into consideration when treating patients, and air quality managers and state and local officials can take the effects of long-term exposure to air pollution into consideration when making decisions about public health.

MESA Air was funded by EPA and was part of a larger atherosclerosis study by the National Heart, Lung, and Blood Institute. The study was conducted by the University of Washington.

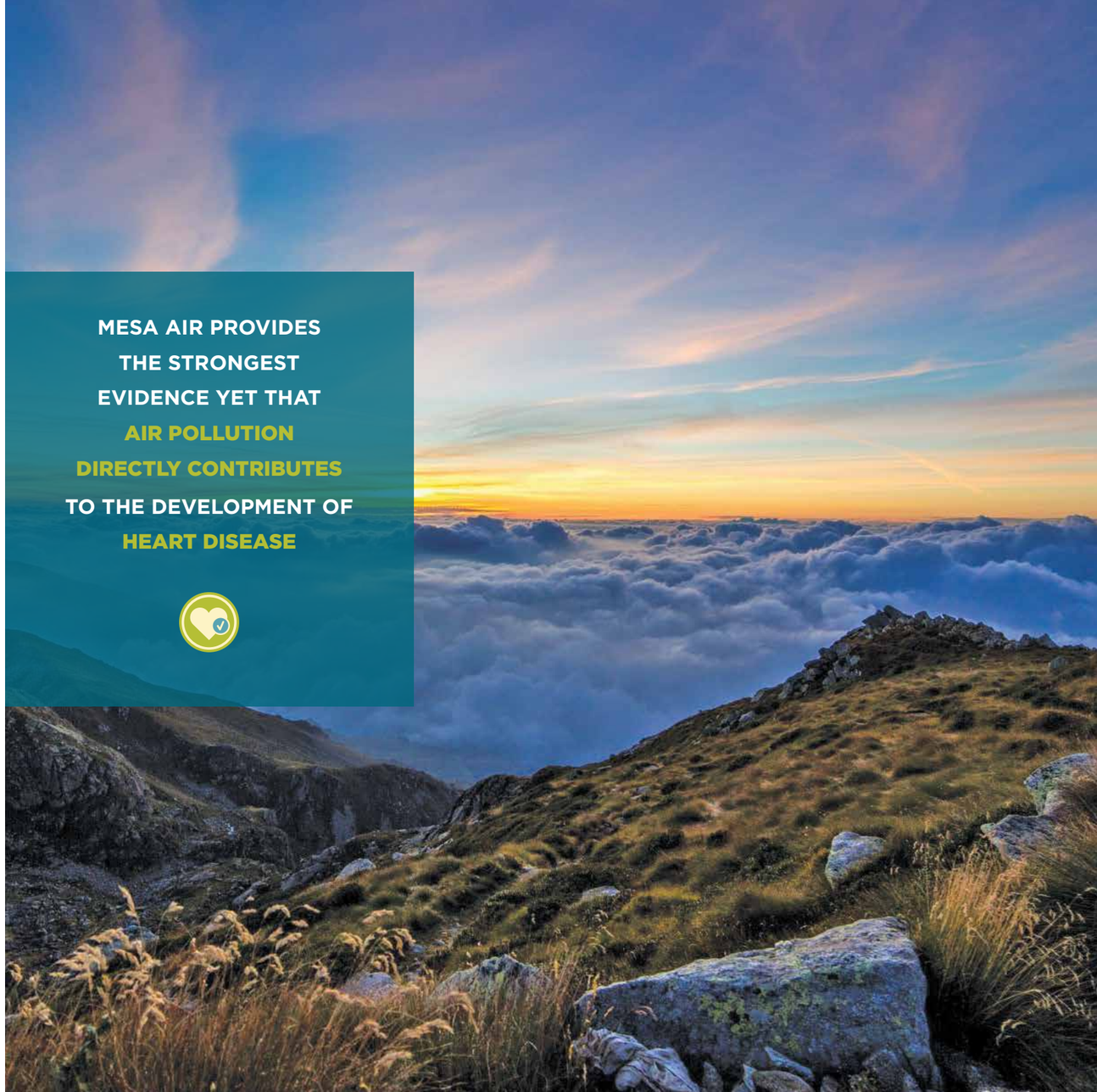
Giving People the Tools They Need to Monitor Their Air

There is a growing interest from the public to learn more about what's going on in their community: What's in the air I breathe? What does it mean for my health and the health of my family? How can I learn more about these things and even be involved in the process? Is there a way for me to measure, learn, and share information about my local air quality?

EPA is helping people answer these questions with the Air Sensors Toolbox, which helps people learn about local air quality where they live, work, and play. Anyone interested in understanding their air can use the Toolbox to learn how to use low-cost, portable air sensors and how to understand the data and results they collect from these sensors. All of this information, and more, is available at **https://www.epa.gov/air-sensor-toolbox.**

Helping Communities Understand Their Air Quality

EPA is exploring new ways to measure local air pollution while also helping communities understand the air around them. Through the Village Green project, EPA established air monitoring systems that also function as public park benches in cities across the country. The Village Green benches were designed and developed by EPA scientists, operate on solar and wind power, and are



"The Village Green station is a helpful tool in educating the public, and particularly children, about the importance of air quality in our everyday lives."

Oklahoma Department of
Environmental Quality
Executive Director Scott Thompson

made of recycled materials. The benches use sophisticated air quality measurement equipment to provide real-time data on two common air pollutants (fine particle pollution and ozone) and weather conditions such as wind speed, temperature, and humidity. The data is streamed live on the web with minute-by-minute updates that can be accessed at **www.epa.gov/air-research/village-green-project.** Communities can use this information to make important decisions that impact their health and their air quality.

Approximately 7 million people have had direct access to the benches, and the Village Green project has expanded to eight U.S. locations: Durham, NC (South Regional Library), Washington, DC (Smithsonian's National Zoo), Philadelphia, PA (Independence National Historical Park), Oklahoma City, (Myriad Botanical Gardens), Kansas City (South Branch Public Library), Hartford, CT (Connecticut Science Museum), Chicago, IL (Jane Addams Elementary School), and Houston, TX (The Health Museum). Interest from additional communities has resulted in sharing the Village Green blueprints, electrical circuitry specifications, and computer code approximately 100 times.

Integrated Science Assessments to Support the Clean Air Act

EPA uses science to make decisions that protect the air we breathe. But how does that actually work? The Clean Air Act requires EPA to set National Ambient Air Quality Standards for six common air pollutants found all over the U.S. that are known to harm human health and the environment. To provide the scientific foundation for these standards, EPA scientists produce Integrated Science Assessments (ISAs) that accurately and concisely evaluate a large number of peer reviewed publications that reflect the latest and most advanced scientific knowledge. All ISAs go through a very rigorous, independent peer review and a public comment period.

Recently, EPA finalized the ISA for Nitrogen Oxides (NOx) primary health criteria and held an external peer review meeting to discuss the assessment for Sulfur Oxides (SOx) primary health criteria. EPA also released for peer review a draft assessment of the ecological effects of sulfur and nitrogen oxides (e.g., acid rain) and held a public workshop to consider new science related to particulate matter (PM), which are early steps in the required review of these important pollutants.

Students at the Village Green bench in Durham, North Carolina.

APPROXIMATELY 7 MILLION PEOPLE HAVE HAD DIRECT ACCESS TO THE VILLAGE GREEN BENCHES, AND THE PROJECT HAS EXPANDED TO EIGHT U.S. LOCATIONS

SUPPORTING SMALL BUSINESSES

Environmental technology is one of the next economic frontiers. EPA has supported this sector for over 30 years through Small Business Innovation Research (SBIR) contracts, which help science- and technology-based small businesses develop and commercialize innovative environmental technologies. Here are just a few of the businesses that EPA has helped get started.

Ecovative

Before Ecovative became a leading biomaterials company, they were just two recent college graduates with a big idea—to use mushrooms to grow an environmentally-friendly and sustainable replacement for Styrofoam. Early in their business, they were awarded one of EPA's SBIR contracts that helped get them started. Their innovative process of using mycelium, the vegetative growth stage of fungi, to create custom-molded protective packaging is proving that the development of sustainable products can spark economic growth. The company recently opened a full-scale 20,000 square foot manufacturing plant and has been featured in outlets like The New Yorker, Architecture & Design, and TimesUnion.

GreenTechnologies

GreenTechnologies, a small business that manufactures environmentally friendly fertilizers, was awarded an EPA SBIR contract to develop a groundbreaking phosphorus removal technology that not only removes phosphorus from impaired water bodies, but also recycles those recovered nutrients to produce environmentally friendly slow-release fertilizer. Now the company's products are sold nationwide.

PittMoss

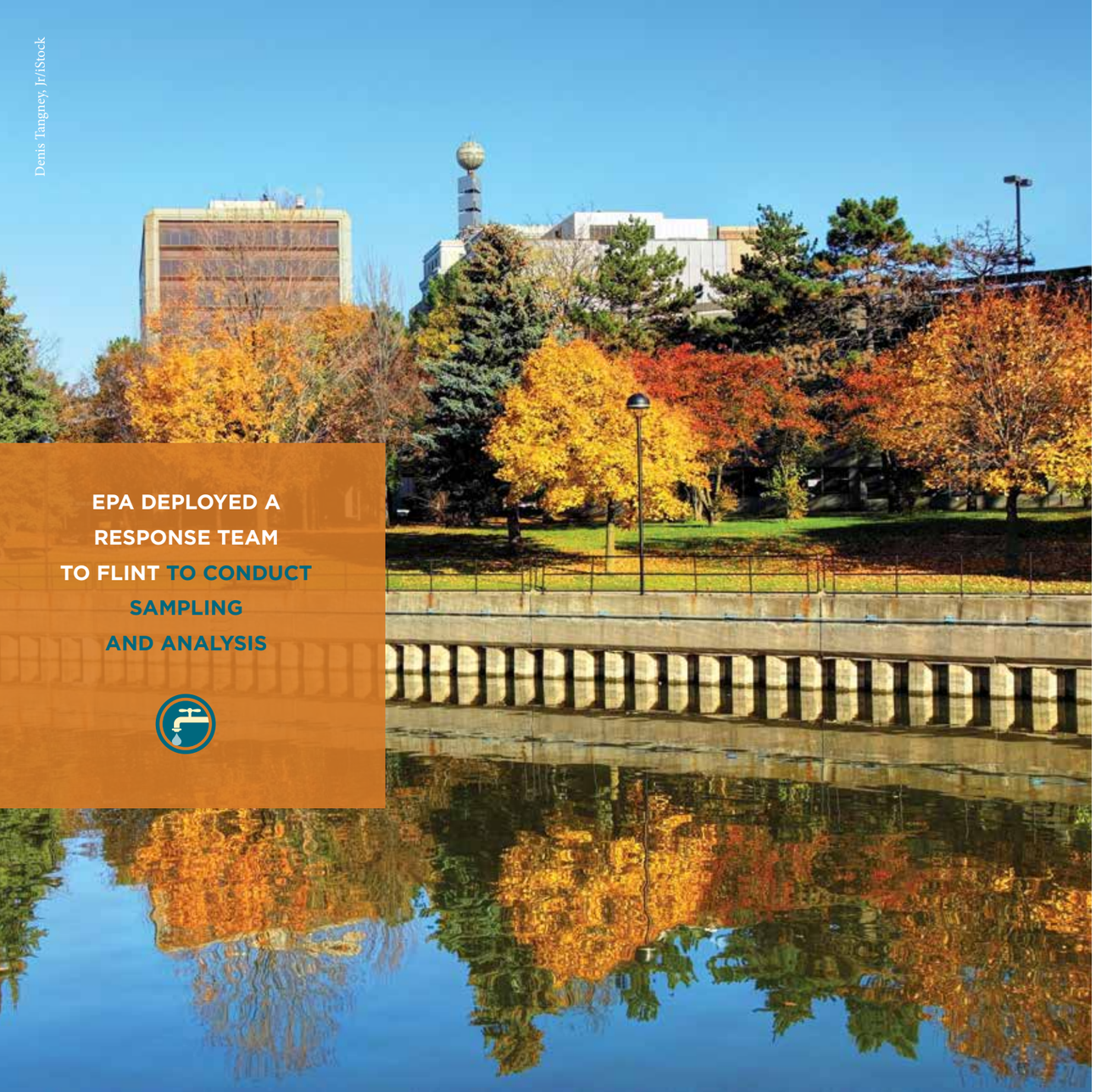
PittMoss, a small business based in Pittsburgh, developed an environmentally-friendly alternative to peat moss. PittMoss received an EPA SBIR contract that funded the critical growth trials that provided the scientific evidence and the foundation for the product's patents. PittMoss is now available to commercial greenhouses and nurseries from Michigan to Maine to North Carolina and is also sold to the public online. PittMoss founder Mont Handley even secured 600k in additional funding for the technology on ABC's tv show Shark Tank.

Okeanos Technologies

Okeanos Technologies, a recipient of one of EPA's SBIR awards, is developing and testing a new energy-efficient seawater desalination technology that could provide "clean, cheap and plentiful water for everyone, anywhere." The technology will cut costs to a point where desalination can take place off-grid, allowing it to be used where it's needed most. The technology has been featured in Popular Science, Fast Company, and in 2014 was selected as a Silicon Valley TiE50 Top Startup Award Winner in the clean energy sector.

Lucid

The Oakland-based company Lucid developed the "BuildingOS" platform that helps people monitor their building's energy and water consumption by providing real-time access to data from all of their meters. This technology gives people the information they need to take actions to save money on utility costs by conserving energy and water. So far, it's been extremely successful and the business has received support from EPA's SBIR Program to continue to develop the technology. Lucid's platform has over 500 customers, 11,000 buildings, and one billion square feet under management. Recently, BuildingOS earned Top Product of the Year Award from Energy Manager Today.



Denis Tangney, Jr/iStock

EPA DEPLOYED A RESPONSE TEAM TO FLINT TO CONDUCT SAMPLING AND ANALYSIS

RESPONDING TO ENVIRONMENTAL EMERGENCIES

In the event of an environmental or public health emergency, EPA researchers provide the science and technology needed to rapidly and effectively respond so that states, cities, and local communities are protected.

Drinking Water Contamination in Corpus Christi, Texas

EPA researchers recently responded to a request for assistance after an asphalt emulsifying agent, Indulin AA-86, contaminated the drinking water supply in Corpus Christi, Texas. Researchers helped identify suitable decontamination approaches to purge the drinking water systems of the contaminant. EPA researchers also helped understand the toxicity and possible risks associated with drinking contaminated water and helped establish a health-based action level for the contaminant. By supporting the immediate need of the state of Texas and the city of Corpus Christi, EPA's research gave the city the information it needed to protect the health of the city's 300,000 residents and lift the drinking water restriction.

Flint, Michigan

In January 2016, the President signed an emergency declaration ordering federal assistance to support state and local response efforts in Flint, Michigan. As part of an interagency effort, EPA deployed a response team to Flint to conduct sampling and analysis that helped state and local leaders identify the scope of contamination and design and execute a plan for mitigation.

EPA researchers assisted Flint and other partners in monitoring for potentially harmful disinfection byproducts (DBPs), assessing chlorine residual levels, and developing a flushing optimization plan, in addition to other assistance efforts. EPA is also monitoring chlorine in the system to ensure that disinfectant levels in the distribution system are adequate to prevent bacterial growth while minimizing the formation of DBPs.

Lead levels in Flint's drinking water system continue to improve. EPA will continue to collaborate with state and local authorities to provide access to the best available data.

Ebola Response

In 2014, EPA researchers supported the states in preparing for the aftermath of treating Ebola patients in the United States. EPA researchers helped identify the best decontamination methods for Personal Protective Equipment used by healthcare workers and others who came into contact with Ebola patients. EPA also provided technical support for waste management and the fate of the virus in wastewater.

Toledo Harmful Algal Bloom Drinking Water Crisis

In August 2014, Ohio EPA and the City of Toledo requested the assistance of EPA researchers to analyze treated drinking water for the presence of cyanobacterial toxins. Researchers also helped identify the best approach for controlling cyanobacterial toxins in the drinking water plant and the distribution system.

The fast response by EPA's researchers provided the

Jesse Allen and Robert Simmon/NASA Earth Observatory, using USGS Landsat

"Ohio and EPA ORD [Office of Research and Development] continue to lead the Nation in working with public water systems to ensure safe drinking water and minimize the threat of harmful algal blooms and other emerging contaminants. Research that EPA ORD is doing is providing Ohio with immediate and practical information as we implement first in the Nation rules on HABs, and we are grateful and fortunate and thankful for the collaboration on these important issues."

Ohio EPA Director Craig Butler

rapid, crucial scientific assistance to inform the Do Not Drink order that the City of Toledo issued for approximately 500,000 people. The researchers also produced timely and accurate results that provided critical information for the Mayor of Toledo and the Governor of Ohio to help them make the decision to lift the Do Not Drink order after it was established the water was safe to drink.

Red River, Oklahoma Fish Kill

The Red River Fish Kill happened along a 70-mile stretch of the river in Oklahoma. EPA, including researchers from EPA's Office of Research and Development and EPA Region 6, helped the State of Oklahoma Department of Environmental Quality identify unknown contaminants that were present during four fish kills in the Red River watershed. These environmental samples were unique in that they were collected during the active phase of the fish kills along the Red River in 2011, 2012, and 2013. This effort helped identify which of those contaminants could be contributing to the fish kills so that future fish kills might be prevented.

Algal bloom in Lake Erie.

DETECTING NEW AND EMERGING CONTAMINANTS IN THE WATER

Per- and polyfluoroalkyl substances (PFASs) are a group of man-made compounds that can make products stain-resistant, waterproof, and nonstick. These chemicals do not break down easily in the environment and can build up in exposed organisms, like fish and wildlife, over time. After concerns were raised about the impact of long-chained PFASs on human health and the environment, manufacturers began voluntarily phasing out their use by substituting alternative and/or shorter-chained materials. However, there is little information on where these alternatives end up and whether or not they present harm to people's health and the environment. That's why EPA researchers are using new screening methods to gain additional information on these alternative chemicals.

Usually, when researchers test to see what is in the water, they identify what they are looking for and then they test for it. To do this, EPA scientists are developing and using methods to detect and quantify specific chemicals - this is called "targeted screening." But when researchers don't know what chemicals to look for, they use *non*-targeted screening methods that can identify thousands of chemicals that may be present in a sample. Using non-targeted screening methods, EPA researchers can take a water sample and identify unknown chemicals that may be present, rather than simply seeing if a particular chemical is present or not.

Acting as environmental detectives, EPA researchers identified alternatives to long-chain PFAS in surface water samples in North Carolina where previous efforts showed PFAS contamination. Researchers evaluated what chemicals were present using non-targeted screening methods such as time-of-flight mass spectrometry analysis. Time-of-flight mass spectrometry determines the mass of a charged molecule, which gives researchers enough information to predict the atoms that make up a chemical. Researchers compiled this data and then used a technique called molecular feature extraction to determine what chemicals were present in the samples. In this way, the researchers identified unknown chemicals that should be further investigated. Several of these chemicals were alternatives that had not been formerly observed in the environment.

Although more work is necessary to determine how widespread and how much of these newly-identified chemicals are in our environment, this methodology will help researchers continue to discover and identify emerging contaminants. Researchers can then evaluate how the contaminants might impact human health and the environment, which will help inform decisions to protect the people of our nation and the places where we live, work, and play.

PROTECTING PUBLIC HEALTH FROM WILDFIRES

On average, each year over 60,000 wildfires burn over 6 million acres of land in the United States. That's why EPA is using its expertise in air quality and health research to provide information that will help protect our health from wildfires.

Investigating Emissions

Particulate matter, which is produced anytime something is burned, has been linked to effects on the heart and lungs. Due to fire's chaotic nature, it is difficult to study how much and what types of particulate matter is produced. But EPA researchers are studying fire emissions in a controlled environment. They are using a technology originally developed to investigate tobacco's health effects to compare emissions produced from various types of trees and burn stages - from smoldering to flaming. Knowing these differences will provide better information to protect public health.

Wildfire Health Guide

EPA has worked with other expert organizations, including CDC and the U.S. Forest Service, to publish an updated wildfire smoke guide for public health officials. This updated guide is an easy-to-use source of information that outlines whose health is most affected by wildfire smoke, how to reduce exposure to smoke, what public health actions are recommended, and how to communicate air quality to the public. This guide is helping doctors, nurses, and others protect the health of people who are impacted by wildfires.

Helping Communities with Controlled Burns

Sometimes controlled burns are needed to manage land, and EPA researchers are helping communities make sure these burns don't harm people's health. In eastern Kansas and northern Oklahoma, land managers frequently use controlled burns to sustain the natural prairie ecosystem of the Flint Hills area, which is the largest (12,000 square miles) contiguous natural grassland prairie in the US. To help land managers and state officials understand the ecological and health impacts of these controlled burns, EPA is working with the Kansas Department of Health and Environment and Kansas State University to visualize historical and hypothetical burning scenarios. This will help Kansas and Oklahoma make decisions about controlled burns that provide benefits for the prairie ecosystem while ensuring clean and healthy air for people.

"Kansas Department of Health and Environment is excited and optimistic about the potential uses of this multi-model framework, including predicted spatial and temporal patterns of surface fuel loads, live biomass (forage), and soil moisture information that can be used to supplement our existing Flint Hills Smoke Management Plan modeling tool."

John Mitchell, Director, Division of Environment, Kansas Department of Health and Environment

HELPING FARMERS IN THE ATLANTIC COASTAL PLAIN

Centuries of agricultural practices in the southeastern U.S. have degraded the sandy soil of the Atlantic coastal plain. Poor soil fertility and water storage have contributed to economic challenges in the agricultural producing areas of the region. To improve soil quality, EPA researchers, working with scientists from the USDA's Agricultural Research Service, studied the use of biochar in regional soils.

Biochar, the carbon-rich solid derived by heating biomass, such as wood chips or manure, has the potential to improve the health and fertility of degraded soils. Researchers designed a biochar mixture of pine chip and poultry litter tailored specifically for the sandy soils found in the southeast. When this special biochar mixture was applied to the soil, researchers noticed significant impacts on soil characteristics such as pH, organic carbon content, and microbial composition.

As biochar research continues, farmers in the region are hopeful that this innovative technique will improve the health of the soil and increase crop yields.

STUDYING HYDRAULIC FRACTURING

People rely on clean and plentiful water to meet their basic needs, including drinking, bathing, and cooking. In the early 2000s, members of the public began to raise concerns about potential impacts on their drinking water from hydraulic fracturing at nearby oil and gas production wells. In response to those concerns, Congress urged the EPA to study the relationship between hydraulic fracturing and drinking water in the United States. The results of this detailed, six-year study provide states and others with the scientific foundation to better protect drinking water resources and, ultimately, public health.

EPA's study focused on the acquisition, injection, management, and disposal of water associated with hydraulic fracturing activities and the potential impacts of those activities on the quality and/or quantity of drinking water resources in the United States. The study resulted in over 26 original peer-reviewed technical publications and journal articles. The capstone product of the study is the state-of-the-science assessment report released in December 2016, *Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States*. The assessment report provided an integration and synthesis of EPA's study results with information from over 1,200 other publications. In this report, EPA concluded that hydraulic fracturing activities can impact drinking water resources under some circumstances and also identified factors that influence those impacts. Impacts can range in frequency and severity, depending on the combination of hydraulic fracturing water cycle activities and local or regional-scale factors. The report also identified data gaps and uncertainties that prevented EPA researchers from determining the national frequency of impacts or fully characterizing the severity of impacts.

EPA STUDIED HYDRAULIC FRACTURING ACTIVITIES AND ITS EFFECTS ON DRINKING WATER RESOURCES

The scientific information in the report can help inform decisions by federal, state, tribal, and local officials; industry; and communities. In the short-term, attention could be focused on the combination of activities and factors outlined in the report that have led to impacts on drinking water resources. In the longer-term, attention could be focused on reducing the data gaps and uncertainties identified in the report. Through these efforts, current and future drinking water resources can be better protected in areas where hydraulic fracturing is occurring or being considered. Publications from EPA's study, including the December 2016 assessment report, are all available online at **www.epa.gov/hfstudy.**

GREEN INFRASTRUCTURE

Stormwater runoff is one of the fastest growing sources of pollution. When rain hits rooftops, parking lots, and roads, water runs into storm drains that are directly connected to our waterways - often taking pollutants and sediment on those surfaces along with it. But if rain hits natural resources like wetlands, forests, and grasslands, the water can soak into the earth and be retained. Green infrastructure, like rain gardens, green roofs, and permeable pavement, mimics natural processes and helps to absorb and retain water, which can reduce stormwater volumes that directly discharge into our streams, lakes, and rivers. Green infrastructure also provides social and economic benefits by improving community aesthetics, property values, and recharging our groundwater aquifers.

Green Infrastructure in Fort Riley, Kansas

EPA is working with the U.S. Army, the Army Corps of Engineers, Kansas Unified School District 475, and others to install and evaluate a permeable parking lot at an elementary school in Fort Riley, Kansas. This permeable parking lot is made with porous material (unlike traditional pavement) so that stormwater can soak through into the soil. Researchers are gathering data from this project that will help improve permeable pavement technology. The project is also improving the community's environment, teaching students about water quality, and providing local governments with more information to help protect their waterways.

Green Infrastructure to Protect the Chesapeake Bay

Through a STAR grant, EPA supports the Chesapeake Bay Center for Green Infrastructure and Stormwater Management, which helps protect and restore the Chesapeake Bay. The Center brings together stakeholders and researchers from multiple disciplines to improve stormwater management in urban and suburban settings. It also helps the region reduce pollutant loads of nutrients, sediments, organics, and metals, and the Center helps minimize stormwater volume and energy use across a range of storm event magnitudes.

"An ounce of stormwater pollution prevention is worth a pound of cure, particularly when it adds multiple benefits through green infrastructure and natural treatment systems. The Center helps Chesapeake Bay states and stakeholders find solutions to some of our most challenging water quality problems through science-based innovation and collaboration."

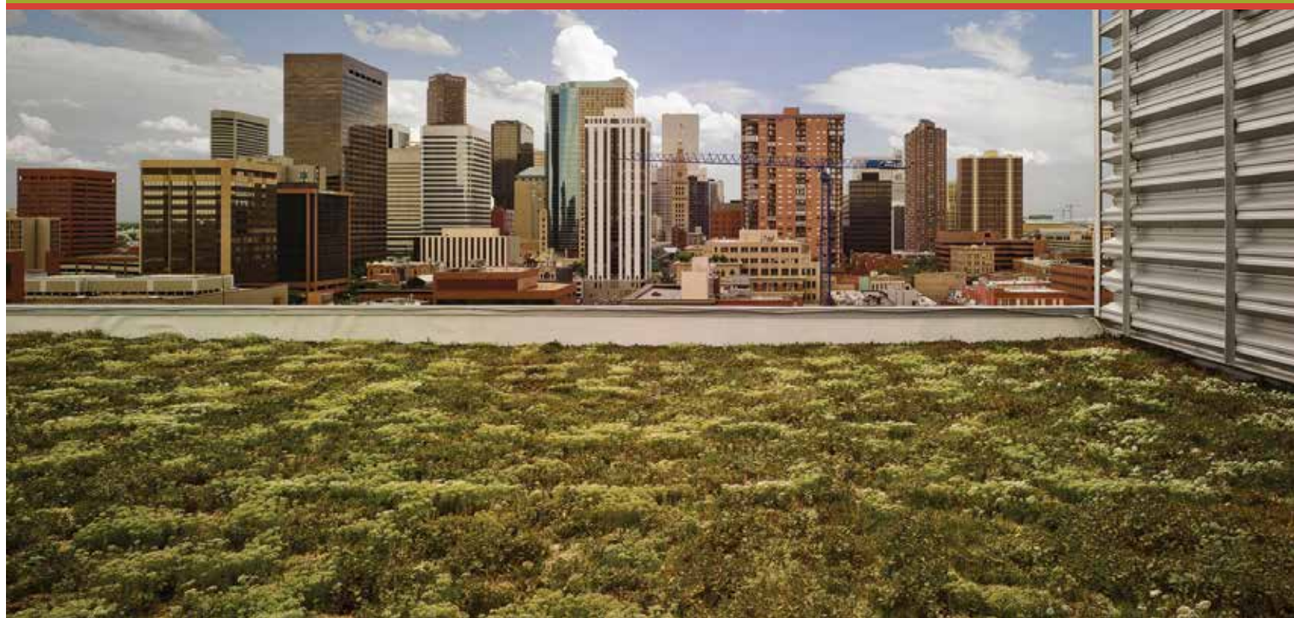
Maryland Department of the Environment
Secretary Ben Grumbles

Tools for Communities

Interested in green infrastructure for your community? Any community can use EPA's innovative tools to install and evaluate their own green infrastructure:

- GWiz is an interactive web application that connects communities to EPA green infrastructure tools and resources.
- WMOST is a user-friendly tool that helps planners manage water resources across a watershed in the most cost-effective manner.
- VELMA helps regional planners and land managers assess optimal green infrastructure options to improve water quality of streams, rivers, and estuaries.
- SWMM predicts the quantity and quality of runoff in urban areas. SWMM can also be used to model the potential effectiveness of green infrastructure implementation.
- The National Stormwater Calculator estimates the annual amount of stormwater and frequency of runoff from specific sites in the U.S. and can be used by anyone trying to reduce runoff from a property.

To learn more and access these tools, go to:
www.epa.gov/water-research/green-infrastructure-modeling-toolkit.



A green roof at EPA offices in Denver, CO.

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