EPA Research State Support Stories

April 2020 Update





U.S. EPA Research Supporting States

Addressing State Research Needs

The success of environmental protection and public health in the United States begins on the front lines at the state and local levels. U.S. EPA's Office of Research and Development (EPA ORD) is a vital scientific and technical resource to states and their communities, providing the technical support and training, science-based tools, and innovative approaches and methods they need to meet their highest priority environmental and related public health challenges, while also laying the groundwork for long-term health and prosperity.

Collaboration and teamwork with state environmental agencies make that all possible. EPA ORD has developed critical partnerships to ensure our work is relevant to real-world environmental challenges and that scientific findings and tools are delivered to decision makers in ways that make them immediately accessible and useful. EPA ORD has partnered with the Environmental Council of the States (ECOS, the national association of state environmental agency leaders) and its research arm, the Environmental Research Institute of the States (ERIS), to ensure that our research is useful and practical for states to help address on the ground environmental challenges.

Our state partners provide significant insights into the environmental problems they face and how EPA can best translate ORD science into well-informed decision tools for states and communities. Over the past several years, ERIS and EPA ORD have strengthened the alignment of EPA's scientific and technical capabilities with state research priorities and needs through a series of meetings and state surveys. As a result of this effort, EPA ORD better understands the science needs of state environmental agencies, and states better understand EPA ORD's research, tools and role within EPA. As recently as 2018, states identified their needs and grouped them into broad topics, such as water, emerging contaminants/toxics, waste/remediation and air/ozone. EPA ORD values the information the ERIS survey provides, as it will help us to continue to align our research program with state science needs.

This document compiles summaries of how EPA ORD's work during the past several years, in partnership with state agencies, counties, communities and universities, has supported states in their efforts to protect human health and the environment. These stories highlight a wide range of research, development, decision support tools and technical assistance efforts focusing on air and water pollution, chemicals, Superfund and other contaminated site remediation, infrastructure and homeland security – all of which are vitally important to helping states address the highest priority, on the ground environmental challenges.

We look forward to continuing to build our partnership with ECOS/ERIS to develop the science that meets states' immediate and long-term needs.

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AIR – SENSORS

Partner: South Coast Air Quality Management District's (SCAQMD) Air Quality Sensor Performance Evaluation Center (AQ-SPEC)
Challenge: Understanding the utility and accuracy of low-cost air sensors to measure pollution
Resource: Deployment and testing of air sensors in 'real-world' conditions
Project Period: 2016-2018

"The SCAQMD/AQ-SPEC collaboration with the US EPA on the Citizen Science Air Monitor (CSAM) evaluation project set the ground for the development of a sensor network across the South Coast Air Basin for the collection of $PM_{2.5}$, O_3, and NO_2 data with a high level of spatial and temporal resolution." – Andrea Polidori, SCAQMD Advanced Monitoring Technologies Manager

Air pollution impacts can vary depending on geography, weather and proximity to pollution sources. For example, the Los Angeles metropolitan area often faces unhealthy air quality levels due to the unique weather, geography and variety of air pollution sources. Some vulnerable communities in the area are disproportionately impacted because of their proximity to busy roadways, ports, railyards, refineries and other industrial facilities. This has raised public health and environmental justice concerns.

The recent emergence of smaller, portable, low-cost air quality sensors in the marketplace has provided new opportunities for the public to measure air quality. To assist local and state air quality managers, community groups, researchers and others, EPA ORD, in collaboration with EPA Region 9 (Pacific Southwest) and the South Coast Air Quality Management District's (SCAQMD) Air Quality Sensor Performance Evaluation Center (AQ- SPEC), deployed custom-built sensor devices (pods). Research collaborators are evaluating the performance of the pods under "real-world" conditions to measure fine particulate matter ($PM_{2.5}$), ozone (O_3) relative humidity, and temperature at nine locations throughout southern California. The measurements were taken from January 2017 to April 2017. The goal of this project was to characterize the performance of these newly developed Citizen Science Air Monitor (CSAM) pods and better understand their potential applications for community monitoring.

From October 2016 to April 2017, tests were conducted in the laboratory and field (Long Beach, Jurupa Valley, and Coachella Valley) to examine pod performance and operation in real-world conditions. EPA designed and developed the pods and provided guidance on the overall quality assurance and control of the project. AQ-SPEC designed, developed and conducted the field and laboratory testing evaluations of the pods, the field deployment, data collection, data quality assurance and control, and data analysis.

Results from the project will provide critical knowledge on pod performance in real-world conditions and sensor data quality, and will benefit the development, distribution and access to air quality monitoring technologies for communities. The project will also provide a better understanding of how ozone and $PM_{2.5}$ concentrations vary in southern California.

Read the final report titled *Spatial and Temporal Trends in Air Pollutants in the South Coast Basin Using Low Cost Sensors.*

Partner: Georgia Department of Natural Resources (DNR) Environmental Protection Division
Challenge: Understanding the precision and accuracy of low-cost air sensors to measure pollution
Resource: Deployment and testing of new air sensor technology and comparing to traditional sensors
Project Period: 2014-2015

"Georgia DNR staff were able to learn a lot about the strengths and weaknesses of the deployment of low-cost air sensors as a result of ORD's testing of them in the Atlanta area, and it would seem that further studies are warranted to improve our understanding" – Ken Buckley, Air Monitoring Unit Manager at Georgia Environmental Protection Division

Advances in air pollution sensor technology have enabled the development of small and low-cost systems to measure outdoor air pollution. The deployment of a large number of sensors across a small geographic area would have potential benefits to supplement traditional monitoring networks with additional geographic and temporal measurement resolution. However, it is necessary to understand if these new sensors will perform as needed and provide data of sufficient quality for decision making.

In response to this challenge and to better understand the capability of emerging air sensor technology, EPA ORD, in collaboration with EPA Region 4 (Southeast), deployed low cost, commercially-available air pollution sensors in two capacities: 1) at a regulatory air monitoring site, and 2) as a local sensor network over a ~2 km area in a suburban Atlanta area that is part of the Community Air Sensor Network (CAIRSENSE) project. The site is operated year-round as a multipollutant monitoring network site and includes an extensive suite of measurements including criteria pollutants and precursors, air toxics, and meteorology. As part of CAIRSENSE, a variety of particulate and gas sensors were deployed and tested from August 2014 to May 2015.

As a result, valuable knowledge was gained in the operation and performance of a wide variety of low-cost air quality sensors. Sensor technology was observed to provide varying degrees of agreement with collocated reference monitors. Environmental conditions, such as high relative humidity, were noted to sometimes impact some sensor technologies. The data value of establishing an array of sensors dispersed over an area was established as well as the type of communication and data management infrastructure needed to support automated sensor data collections. Because of this work, Georgia DNR and others have enhanced knowledge about low cost sensor performance and how such technologies might be used to meet their local air quality monitoring needs.

Read the final report titled *Community Air Sensor Network (CAIRSENSE) project: Evaluation of low-cost sensor performance in a suburban environment in the southeastern United States*.

Partners: Maryland Department of Environment (MDE), California, Colorado, Connecticut, Kentucky, New Hampshire and Oregon
Challenge: Identifying appropriate opportunities to use and communicate advanced monitoring tools, new data collection and analysis techniques to create improvements and gain efficiencies in environmental monitoring
Resources: Development, pilot testing, and evaluation of advanced monitoring technologies
Project Period: 2015-Present

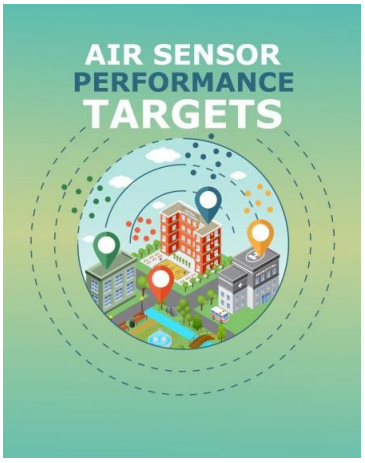
"Our partnership with EPA on advanced monitoring is extremely important. With new sensors entering the market every day, understanding if they work and how to communicate the data they generate is a critical need for state environmental agencies. In 2017, two major sensor studies are taking place in Baltimore, where hundreds of stationary and mobile sensors will be collecting data on multiple air pollutants and greenhouse gases. This partnership with EPA is both critical and timely." – MDE Secretary Ben Grumbles

Environmental monitoring is in the midst of a paradigm shift from data being collected, stored, distributed and communicated by the government to data being collected by anyone, anywhere and at any time. This shift is driven by recent technological advances, ubiquitous data communications and the reduced cost of monitoring technology.

New advanced monitoring technologies are already available that are smaller, more portable, and less expensive than traditional methods. However, the rapid evolution of monitoring technology also presents challenges to government agencies, the public and the regulated community because the performance (i.e., accuracy, precision and reliability) of new technologies is largely uncharacterized. Communities, citizens, industry and local, state, federal and tribal agencies are asking the same question: "How good is it?" EPA and the Maryland Department of Environment co-led a state-EPA effort to determine how to take advantage of these rapid changes in environmental monitoring technology. Additionally, through the EPA-funded Solutions for Energy, Air, Climate & Health (SEARCH) Center, about 80 air quality sensors were assembled and deployed in the Baltimore area and a prototype platform developed to manage the data with the aim of assessing variability in pollutant concentrations, source contributions and exposures across in the city.

The larger effort has now evolved into an EPA/state/tribal effort under "E-Enterprise" – a model for collaborative leadership among environmental co-regulators. In prior years, discussions with co-regulators concerning advanced monitoring spanned across media (i.e., water and air) and evolved more recently into media specific workgroups and projects. Current air research involves discussions on non-regulatory performance targets and evaluation protocols for supplemental and informational monitoring applications, analysis of methodologies used to communicate real-time air quality information, long term testing of devices, and application specific studies. EPA continues to partner and engage with local, state and tribal agencies on these efforts while continuing research on the use and performance of new monitoring technologies.

Partner: Environmental Council of the States (ECOS)
Challenge: Need for non-regulatory performance targets for sensors that measure fine particulate matter (PM2.5) and ozone in the U.S.
Resource: Deliberating Performance Targets for Air Quality Sensors Workshop and Webinar
Project Period: 2018-Present



"For this EPA ORD hosted workshop, state attendees were able to contribute the state agency perspective to a broad discussion regarding sensor quality, data quantity, and how smaller, lower-cost air monitoring sensors may be used by state agencies. They were also able to gain a sense of how different parties – national and international, private and public – are handling the addition of smaller, lower-cost sensors to the market."
– ECOS Senior Project Manager Kelly Poole

Over the past several years, miniaturized, lower-cost air monitoring sensors have entered the market and are now being used by researchers, industrial facilities, state and local government agencies, tribal nations, citizen scientists and the public for a variety of purposes. New applications include a variety of activities, including: real-time high-resolution mapping of air quality at a far greater density than regulatory monitors, real-time public communication of sensor data, fenceline monitoring to detect emissions events, community monitoring to assess hot spots, personal monitoring, and applications to collect data in remote places. Given the rapid adoption and technological advances of new air sensor technologies, there are numerous questions about how well they perform and how lower-cost technologies can be used for certain non-regulatory applications.

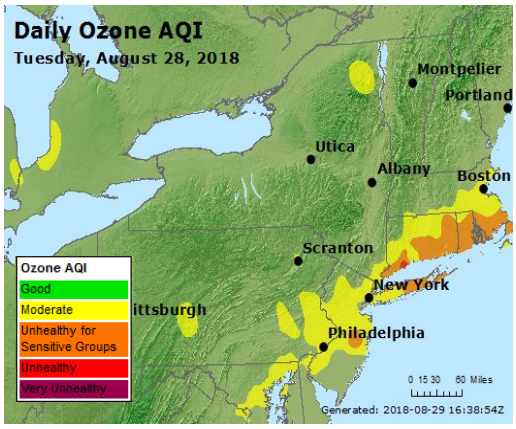
EPA, in coordination with ECOS, convened a workshop in June 2018 on *Deliberating Performance Targets for Air Quality Sensors*. The workshop solicited individual stakeholder views related to non-regulatory performance targets for sensors that measure fine particulate matter (PM2.5) and ozone in the U.S. Through on-site and webinar discussions, national and international participants addressed a range of technical issues involved in establishing performance targets for air sensor technologies. These issues included for example sensor performance for various measures like limits of detection and calibration, selecting appropriate performance targets, and adopting of one set of performance targets for all non-regulatory purposes, versus a tiered approach for different sensor applications. The workshop included discussion of lessons learned from other countries about choices or trade-offs they have made or debated in establishing performance targets for measurement technologies.

As a follow up, a group of technical experts worked with EPA to document and summarize the individual perspectives communicated at the workshop, within the context of relevant scientific literature. Workshop products, including presentations delivered to the workshop, a report summarizing peer reviewed literature, a brief research highlights article, and a more extensive peer-reviewed journal article discussing the workshop are all publicly available. Two more documents will be released as a result of this workshop in 2020.

These resources can be accessed at the Deliberating Performance Targets for Air Quality Sensors Workshops webpage.

AIR – OZONE AND PARTICULATE MATTER

Partners: Northeast States for Coordinated Air Use Management (NESCAUM),New Jersey Department of Environmental Protection (NJDEP), New York State Department of Environmental Conservation (NYSDEC), New York State Energy Research and Development Authority (NYSERDA) and the Connecticut Department of Energy & Environmental Protection (CTDEEP)
Challenge: Better understanding the causes of ground-level ozone formation and transport in the New York City Metropolitan area
Resource: The deployment of advanced air quality monitoring tools at eight sites as part of the Long Island Sound Tropospheric Ozone Study (LISTOS) in collaboration with scientists at NASA, NOAA, University of Maryland, SUNY-Albany, SUNY-Stony Brook, City College of New York and Yale University
Project Period: 2018-Present



"ORD's coordination with and support of LISTOS has helped New York better understand precursors of ground level ozone in the New York City area so that we will be able to better address it," – Dirk Felton, Research Scientist, Division of Air Resources, NYSDEC

Surface-level ozone is formed when nitrogen oxides and volatile organic compounds react with one another in the presence of sunlight. While air pollution levels have dropped over the years across the United States, the New York City (NYC) metropolitan area and surrounding region continue to persistently exceed both past and recently revised federal health-based air quality standards for ground-level ozone.

To better understand and address this challenge, EPA scientists collaborated in a multi-agency field study in spring and summer 2018 called the Long Island Sound Tropospheric Ozone Study (LISTOS). Data collected during LISTOS provided scientists and decision makers more detailed information on the sources of ground-level ozone photochemical formation and its transport downwind of NYC. Measurement assets supporting this field study included a combination of aircraft and ground-based measurements from numerous research organizations. The main part of the study ran from June-August 2018, but many ORD supported measurements are continuing in collaboration with the states to address their need to develop and carry out an Enhanced Monitoring Plan with the EPA. Information garnered from the study will inform efforts to better control and prevent ground-level ozone formation with the aim of eventually meeting the national standards.

For more information on the Long Island Sound Tropospheric Ozone Study, go to the Northeast States for Coordinated Air Use Management webpage.

Partners: Wisconsin Department of Natural Resources (DNR), Lake Michigan Air Directors Consortium (LADCO)
Challenge: Better understanding ozone formation and transport impacting the shorelines of Lake Michigan
Resource: Advanced air quality monitoring methods deployed at various sites across Lake Michigan's western shorelines, including on-board federal research vessel in collaboration with the National Oceanic and Atmospheric Administration (NOAA) and participation from research groups at NASA, the University of Iowa, the University of Northern Iowa, the University of Minnesota, the University of Wisconsin via the National Science Foundation, and the Electric Power Research Institute (EPRI)
Project Period: 2017-Present

"This study will improve the models that we use to inform science-based decision making."
– Wisconsin DNR, Environmental Management Division Assistant Deputy Secretary Pat Stevens

Ozone is formed when compounds such as nitrogen oxides (NOx) and volatile organic compounds (VOCs) react with sunlight. Despite dramatic reductions in these ozone precursor emissions, many areas bordering Lake Michigan continue to experience elevated ozone concentrations. This long-standing issue is one of the more challenging air quality issues in the eastern U.S.

A problem that is hindering states and stakeholders addressing this challenge is associated with the formation of ozone over Lake Michigan and the complex interaction of the meteorology and ozone chemistry, including the transport of ozone and ozone precursors in the region, which are not completely understood. Photochemical models are important tools for understanding such transport issues. However, these models historically have been unable to reproduce the lake breeze effect present around Lake Michigan, making it difficult for states, the LADCO and EPA to accurately predict and address ozone concentrations along the Lake Michigan lakeshore. LADCO is a regional planning organization that includes representation from Illinois, Indiana, Michigan, Minnesota, Ohio and Wisconsin

In the summer of 2017, EPA ORD, LADCO, academic and private institutions, and other state and federal agencies pooled their expertise and resources to commence a field study to collect information that will be used to better inform air quality models and improve the scientific understanding of ozone formation around Lake Michigan. EPA ORD, in conjunction with NOAA and NASA, outfitted a NOAA research vessel with EPA instruments to support over-the- water measurements. NASA and EPRI are providing airborne remote sensing measurement to complement EPA and state surface measurements to help understand pollutant transport over Lake Michigan. These measurements will be combined with satellite data to better understand ozone chemistry and transport over the area, and better inform efforts to reduce ozone formation along the shoreline.

All study data has been posted in a public archive, and the science team published a synthesis report in April 2019. Numerous modeling studies are begin conducted by external collaborators and by EPA, and EPA ORD is participating in Enhanced Ozone Monitoring activities with the Wisconsin Department of National Resources in 2020.

Partner: Utah Department of Environmental Quality (DEQ)
Challenge: Fine particle air pollution
Resource: Ground-based and remote sensing air measurements for the Utah Winter Fine Particulate Study in collaboration with the National Oceanic and Atmospheric Administration (NOAA) and other partners
Project Period: 2017-2018

"The in-kind funding EPA provided, including the sophisticated instrumentation, lab analysis and project management support, was invaluable in making [the 2017 Utah Winter Fine Particulate Study] a success. The nature of fine particle pollution during northern Utah's periodic winter inversions presents a complex scientific problem [which Utah] has been analyzing for many years, and the insight and technical expertise of EPA researchers will certainly help in our efforts to tackle this difficult problem. We are hopeful the measurements and analysis of the complex atmospheric chemical reactions this study captured will enhance our ability to create effective policy tools to improve Utah's air quality during these winter episodes."
– Utah DEQ Executive Director Alan Matheson

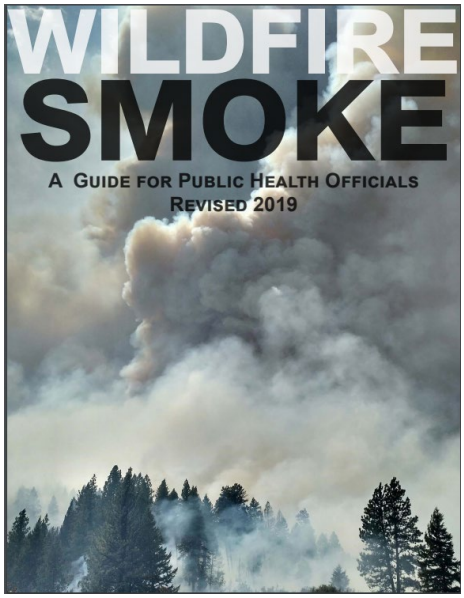
During the winter in Utah's northern valleys, cold air inversions trap pollution emitted from vehicles, industry and agriculture. This allows atmospheric chemicals to mix and leads to the formation of fine particulate matter ($PM_{2.5}$), which is an air pollutant that is harmful to health when it is concentrated at high levels.

In 2017, EPA ORD provided support to Utah in its Utah Winter Fine Particulate Study (UWFPS) – one of the most comprehensive efforts to date to determine the chemical processes in the atmosphere that lead to the formation of $PM_{2.5}$. During January and February, ORD scientists collected ground-based air measurements using new techniques they developed in the lab and remote sensing technology. The data were combined with measurements of the upper atmosphere taken by NOAA using aircraft to obtain a complete analysis of atmospheric chemistry in the valleys.

The science team collaborated on a report that was delivered to the State of Utah in spring 2018 on study findings. A follow-on study called AQUARIUS is planned which expands upon the UWFPS study to include additional western study areas impacted by similar NAAQS non-attainment issues. The data from the study will be used by Utah DEQ to develop effective strategies for their State Implementation Plan to reduce $PM_{2.5}$ levels during the winter months. The study will help to improve air quality for the more than two million residents who live in the area.

AIR – WILDFIRES AND PRESCRIBED BURNS

Partners: Arkansas Division of Environmental Quality (ADEQ) and the Arkansas Forestry Commission
Challenge: Ambient air quality and public health considerations from fires
Resource: EPA's Smoke Ready Toolbox for Wildfires
Project Period: 2018



"Through this forum Arkansas has advanced partnerships for natural resource management to further the protection of human health and the environment. EPA wildfire and air quality research has helped Arkansas spark collaboration and dialogue among those who benefit from, practice, and live on the periphery of prescribed burns." – Arkansas Department of Energy and Environment Cabinet Secretary Becky Keogh

Land managers utilize fire in a variety of contexts including forestry, conservation, and agriculture. While Arkansas is attaining and maintaining all national air quality standards, smoke from fires still contains air contaminants that affect air quality. Due largely to the growing urban/rural interface, the interaction between prescribed fire smoke and citizens has increased over time. Facilitating healthy air quality requires ongoing collaboration among land managers and air quality experts.

In March 2018, ADEQ and the Arkansas Forestry Commission jointly hosted a two-day Fire Policy Forum in Little Rock. The Fire Policy Forum was the first of its type in Arkansas and included attendees and speakers from across the country. The forum brought together a diversity of stakeholders, including land owners and managers from federal, state, local, and private sectors, for discussions regarding the intersection of careful and prudent use of "fire as a land management tool," air quality considerations, and solutions to the challenges of balancing these two necessities.

An EPA ORD expert participated in the forum to share EPA wildland fire research on the public health implications of wildfire smoke. The featured presentation informed the Forum's participants of the implications of the growing urban/rural interface and the nearby use of prescribed fire tool. EPA researchers collaborate with communities to facilitate the use of a variety of Agency developed resources to prepare and respond to fires, including the Community Health Vulnerability Index, Smoke Sense app, and *Wildfire Smoke: A Guide for Public Health Officials*. These resources are available on the Smoke-Ready Toolbox for Wildfires webpage.

The variety of presentations provided an opportunity for forum participants to discuss air quality as a factor to be considered when conducting activities that cause air contaminant emissions and how to incorporate best management practices and plans for use of fire as a management tool. It also fostered a vibrant dialogue surrounding the use of fire as a land management tool and its effect on air quality in the state of Arkansas.

For more information, please visit the ADEQ Fire Forum webpage.

Partners: Placer County Air Pollution Control District in Auburn, California
Challenge: Provide timely information to the public about air quality conditions and how to reduce exposure to smoke during wildfires
Resource: Smoke Sense App
Project Period: 2018

"Like the Wildfire Smoke: A Guide for Public Health Officials *publication, the* Smoke Sense App *is a valuable tool that resulted from state and federal collaborations. This innovative citizen science mobile application not only provides key information to the public, but also helps public health officials to learn directly from citizens about health impacts of wildfire smoke and actions people are taking to avoid smoke, all of critical importance in California."* – Dr. Mark Starr, Deputy Director for Environmental Health, California Department of Public Health

"With mobile devices being more and more for information, having the Smoke Sense App available from the District's webpage provided the public with another valuable resource on air quality conditions in the area along with steps one can take to reduce exposure." – Ann Hobbs, Associate Planner with the Placer County Air Pollution Control District

Over the past 30 years, an average of five million acres of wildlands have burned annually, with the average doubling in recent years. While fire is vital in maintaining ecosystems, there are tradeoffs with its use. Larger and more intense wildfires generate smoke that poses direct risks to human health. Exposure to smoke from fires can cause eye and throat irritation with more serious health problems for children, older adults, and those with existing heart and lung disease.

During the 2018 wildfire season, the Placer County Air Pollution Control District in Auburn, California, shared the Smoke Sense app with their residents as another resource to help them understand the impacts of wildfire smoke in their area and to learn ways to reduce smoke exposures to protect their health.

The Smoke Sense app is part of a study to better understand the health impacts of wildland fire smoke, which includes both controlled and uncontrolled burns; what people are willing to do to avoid smoke exposure; and how to develop health risk communication strategies to encourage people to protect their health during wildfires. EPA has collaborated with states, tribes, counties, public health organizations and others to promote the app as a way to increase awareness of the connection between wildland fire smoke and health.

The Placer County provided a link to the Smoke Sense app along with other public health materials on smoke and wildfires on their website, the California Smoke Blog and social media. Working closely with state, federal and local partners, EPA has created several tools, including the Smoke Sense app, that can be used to help communities prepare and respond to wildland fire smoke.

The Smoke Sense application and other resources on smoke and health are available on the Smoke-Ready Toolbox for Wildfires webpage.

Partner: Kansas Department of Health and Environment (KDHE)
Challenge: Understanding trade-offs associated with prairie rangeland burning
Resource: Multi-model framework and decision support tool in support of Kansas Flint Hills Smoke Management
Project Period: 2018-Present

"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." –KDHE Division of Environment John Mitchell (former director)

The Flint Hills ecoregion of eastern Kansas and northern Oklahoma is home to the largest (10,000 square miles) remaining contiguous natural grassland prairie in the U.S. Throughout the region, land managers frequently use controlled burns to sustain the natural prairie ecosystem from the encroachment of eastern Red Cedar and other woody species, and to enhance the quantity and quality of the grasses for cattle grazing. However, smoke from widespread prescribed spring burning has exceeded air quality limits and impacted urban areas such as Kansas City, Topeka and Wichita.

To assist rangeland managers and local and state officials in better understanding the economic, ecological and human health trade-offs of rangeland burning in Flint Hills, EPA Region 7 (Midwest) and ORD are collaborating with KDHE and Kansas State University to establish a user-friendly, multi-model framework for visualizing historical and hypothetical burning scenarios, including changes in the location, timing and frequency of rangeland burning practices. Part of this effort involves characterizing the emissions from the Flint Hills prescribed burning in both the spring and fall seasons. ORD is conducting aerial sampling with an instrumented, tethered aerostat as well as ground sampling to derive emission factors that characterize the amount and nature of the smoke. Tangible products of the research include computer-generated spatial and temporal maps of predicted changes in rangeland productivity and air quality. Stakeholders and decision makers can use these resources to identify best case scenarios for land management that strike a balance between the environmental, economic and human health objectives of rural and urban communities.

AIR - QUALITY

Partners: Arkansas Department of Environmental Quality (ADEQ), Arkansas Department of Health (ADH)
Challenge: Underground fire at abandoned dumping site sparks public health risks
Resource: Technical assistance and environmental monitoring
Project Period: 2018-2019

"*The ability to access EPA's Office of Research and Development (ORD) resources and expertise is critical for state response efforts. Arkansas appreciates continuing work with EPA to close the gaps on environmental challenges and to address community concerns.*"
– Arkansas Director of Energy and Environment Secretary Becky Keogh

In July 2018, residents of Bella Vista, Arkansas noticed a dull haze and the smell of smoke wafting through their community and seeping into nearby homes and businesses. The source of their concern turned out to be a smoldering underground fire at a former illegal dumping site. Two former owners of the property had turned it into a kind of unofficial (and unmonitored) dump, allowing nearby residents to dispose of brush, wood, and other organic material. Unfortunately, according to numerous news reports it is now clear that old car batteries, wiring, and old pool liners were also discarded. Subsequently buried - the whole mess was out of sight, out of mind. That was until smoke started rising from the ground.

Locally known as "the stump dump fire" the conflagration has continued to smolder for more than half a year, sparking health concerns and attracting the attention of ADEQ and ADH, as well as elected officials including the State's Congress Member and both Arkansas Senators. Together, they called on EPA for help.

To date, EPA has provided resources to the state for air monitoring, legal advice, and engineering tactics to assist the state in controlling the fire. Arkansas's congressional delegation along with the local and state officials acknowledge and appreciate this assistance as well as the technical assistance provided by the EPA Region 6 Office in Dallas, Texas," noted Arkansas Congress Member Steve Womack and Arkansas Senators Tom Cotton and John Boozman in a letter to the EPA Administrator asking for additional assistance.

That assistance has included significant technical and scientific support from EPA ORD, part of an ongoing partnership to match ORD expertise and resources with high priority needs in the states. ORD engineers have visited the burning stump dump site to assess conditions and gather information and contributed to an assessment of ongoing management approaches and mitigation options. ORD also provided comments on the ADEQ Draft Response Action Plan and has also been assisting ADEQ with responding to questions the State has received from the plan.

EPA researchers will continue to work closely with the State as officials to continue to monitor air quality and other conditions and provide expert advice as they decide on the best course for minimizing additional risks and move forward with plans to extinguish the fire and revitalize the site.

Partners: Participating pilot locations including the cities of Chicago, IL; Durham, NC; Hartford, CT; Houston, TX; Kansas City, KS; Oklahoma City, OK; Philadelphia, PA and Washington, DC
Challenge: Air quality monitoring for community awareness
Resource: Village Green Project
Project Period: 2015-2019

"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. We are thankful to be one of several cities across the country to have such an innovative tool." – Oklahoma DEQ Executive Director Scott Thompson *(referring to the Village Green Project in Oklahoma City)*

The Village Green Project (VGP) is a novel air and weather measurement station originally developed by EPA ORD scientists. The station is a compact, solar-powered system that incorporates air and weather instrumentation into a park bench. The project built upon the need to enhance transparency and showcases next-generation air measurement technology by providing quality-assured data to the public on a near real-time basis, updating to a public data website every minute.

The original prototype was field-tested outside a public library in Durham, NC. Following the successful prototype test, EPA created a pilot VGP expansion and engaged with state, local and tribal agencies in placing new park bench stations in various community environments. There are currently eight Village Green stations in the U.S. located in a variety of environments selected by the grant recipients, such as libraries, a public garden, and high foot-traffic tourist areas. In addition to Oklahoma City, OK and Durham, NC, participating cities include Hartford, CT, Kansas City, KS, Houston, TX, Washington, DC, Chicago, IL, and most recently Houston, TX. The state and local agencies have used the stations as an opportunity to host public outreach events, including ribbon-cutting ceremonies and informational sessions. Now that the project is complete, all of the benches, with the exception of the Durham bench, have been transitioned to the project partners for further operation.

Resources on how to construct, operate, and maintain a Village Green station are available at the Village Green Project webpage.

Partners: Utah Department of Environmental Quality (DEQ), Colorado Department of Public Health and Environment (CDPHE), West Virginia Department of Environmental Protection (WVDEP), oil and gas cooperators
Challenge: Support efficient development of U.S. energy resources while protecting human health
Resource: Next generation measurement methods
Project Period: 2016-Present

"EPA ORD has been a valuable partner in our efforts to advance needed energy development while improving air quality in the Uinta Basin." – Utah DEQ former Executive Director Alan Matheson

Oil and natural gas production has increased significantly within Utah's Uinta Basin, Colorado's Denver-Julesburg Basin, West Virginia's Marcellus Shale, and across the United States over the last decades. Approximately three-quarters of the production in the Uinta Basin is on Indian Country within the Uintah and Ouray Reservation. Oil and natural gas extraction and production activities co-emit volatile organic compounds, and greenhouse gases directly to the atmosphere. Industry, regulators and communities have shared interests in understanding and minimizing sources of harmful air emissions from oil and gas production activities.

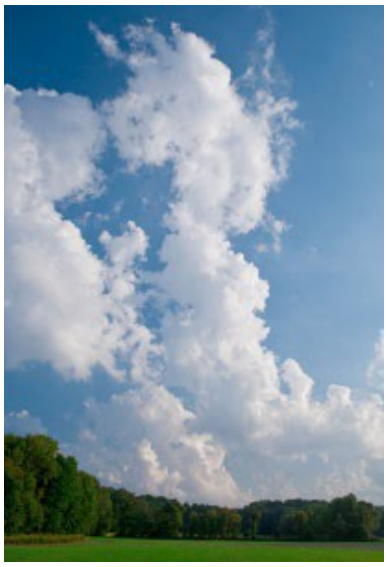
EPA ORD researchers in collaboration with Region 8 (Mountains and Plains) are working with Utah and Colorado state officials and oil and gas operators to conduct emissions research on pneumatic controllers used in upstream production. Pneumatic controllers provide process control and safety functions and emit natural gas to the atmosphere. Because of the very large number of these devices, they contribute significantly to air emissions, however some uncertainty remains regarding the real-world emissions from these devices. In 2016, research was conducted in cooperation with oil and gas operators in the Uinta Basin, Utah, on assessing emissions from pneumatic controllers using next generation measurement methods. In 2018, EPA ORD worked with CPDHE to conducted field surveys of pneumatic controller emissions in the Denver-Julesburg Basin. Currently, EPA ORD is performing cooperative research with Region 3 (Mid-Atlantic) and a Marcellus Shale oil and gas operator on emission measurements and inventory analysis of production in West Virginia, providing useful data to WVDEP for pneumatic controller and other emission sources.

The ongoing collaboration between EPA, the states of Utah, Colorado, West Virginia, and oil and gas operators will improve understanding of these devices and measurement methods, and ultimately support better development of U.S. energy assets in ways that also protect human health and the environment.

Additional resources:

- Assessment of Uinta Basin Oil and Natural Gas Well Pad Pneumatic Controller Emissions (published 2018)
- Advancing Understanding of Emissions from Oil and Natural Gas Production Operations to Support EPA's Air Quality Modeling of Ozone Non-Attainment Areas; Final Summary Report (published 2016)

Partners: Northeast States for Coordinated Air Use Management (NESCAUM), an association of eight Northeastern States including Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont
Challenge: Northeastern states' planning for energy and air emissions
Resource: Energy system database
Project Period: 2005-2016

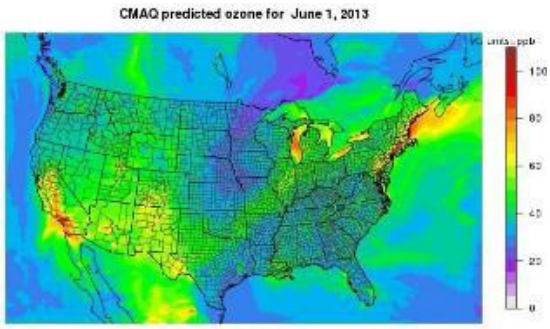


"EPA ORD, through its research programs, is well-positioned to support us in better understanding the numerous multi-state origins and inter-state transfer of air pollution and how it evolves as it travels to Rhode Island. No individual state in the Northeast is capable of studying this complicated issue alone." – RI Department of Environmental Management Director Janet Coit

The MARKet ALlocation (MARKAL) tool is used to model the nation's energy system and evaluate different energy technology options for reducing air quality emissions. The tool uses energy and water technology data to create future scenarios or options for optimizing water and energy consumption and management. City planners can run simulations on a variety of policy options to evaluate the most cost-effective and environmentally sustainable solutions for providing energy- and water-related services such as heating, cooling, and water and wastewater treatment.

EPA ORD collaborated with NESCAUM in the further development of a MARKAL model tailored specifically to the energy infrastructure of the Northeast. This NE-MARKAL model was based on ORD's U.S.-scale 9 region MARKAL/TIMES optimization model database used by decision makers for coordinated energy and air emissions planning. ORD provided expertise and support for the development of state-level model database(s) and implementation of the modeling framework and case studies. The NE-MARKAL framework can be used by decision makers to examine energy policy options and their resultant impacts on energy services in the region.

Partners: Maryland Department of the Environment (MDE), Georgia Environmental Protection Division, New Jersey Department of Environmental Protection, New York State Department of Environmental Conservation, North Carolina Department of Environmental Quality, San Joaquim Valley Unified Pollution Control District, South Coast Air Quality Management District, Utah Department of Environmental Conservation, and Virginia Department of Environmental Quality
Challenge: Need for effective strategies to reduce harmful air pollutants
Resource: EPA's Community Multiscale Air Quality (CMAQ) Modeling System
Project Period: 2005-Present



"Maryland has made dramatic progress over the past 10 years in reducing ozone and fine particle pollution. We have invested heavily into research and modeling and this investment has been one of the reasons we have been successful. The CMAQ photochemical model has been the key tool we have used to design and refine control strategies. It has helped us find least cost solutions to reduce ozone and fine particle pollution." – MDE Secretary Ben Grumbles

For more than 15 years, EPA and states have been using EPA's Community Multiscale Air Quality (CMAQ) Modeling System, a powerful computational tool for air quality management. CMAQ simultaneously models multiple air pollutants, including ozone, particulate matter and a variety of air toxics to help air quality managers determine the best air quality management scenarios for their states and communities.

State agencies that control air pollution use CMAQ to develop and assess implementation actions needed to attain National Ambient Air Quality Standards (NAAQS) mandated by the Clean Air Act. States use the tool to identify sources of air quality problems and to assist in the design of effective strategies to reduce harmful air pollutants. Using data about land use, meteorology and emissions, CMAQ provides detailed information about the concentrations of air pollutants in a given area for any specified emissions or air quality scenario. With information generated by CMAQ, states are able to examine the estimated impacts of different air quality policies.

The National Weather Service also uses the model to produce air quality forecasts twice daily, and the Centers for Disease Control and Prevention uses CMAQ data in two community-focused tools that allow users to access county-specific air quality information on pollutants, such as ozone and particulate matter.

The CMAQ modeling system is publicly available, undergoes rigorous scientific peer-review and is used worldwide (in over 125 countries) for air quality assessments and research. The system brings together three kinds of models including: meteorological models to represent atmospheric and weather activities; emission models to represent man-made and naturally-occurring contributions to the atmosphere; and an air chemistry-transport model to predict the atmospheric fate of air pollutants under varying conditions. The newest version of the model (CMAQ 5.3.1) was released in December 2019.

CHEMICALS – PFAS

Partner: Alaska Department of Environmental Conservation (ADEC)
Challenge: Contaminated site due to PFAS issues at Joint Base Elmendorf-Richardson
Resource: Technical support for site contamination in collaboration with the U.S. Air Force
Project Period: 2016-Present

"EPA's collaboration with the ADEC and the Air Force on PFAS sampling and analytical methods is key to ensuring valid, defensible data are collected on these emerging contaminants that are being found in soil, groundwater and drinking water in Alaska and elsewhere across the country. Extremely low concentrations, in the parts per trillion levels, in drinking water may pose unacceptable health risks, thus, rigorous sampling and analytical methods are critical in ensuring people have clean drinking water." – Former ADEC Commissioner Larry Hartig

With increased concern about the risk of per- and poly-fluorinated alkyl substances (PFAS) in drinking water, it is important to identify the source(s) of the contamination and manage/remediate the risk. To date, PFAS contamination has been observed at landfills, primary and secondary PFAS-related manufacturing sites, wastewater treatment plants, and emergency response and training sites where aqueous film forming foams (AFFF) were used for firefighting. The U.S. Department of Defense has identified hundreds of sites with potential AFFF contamination.

EPA ORD, in coordination with Region 10 (Pacific Northwest) and Region 5, is providing technical support for PFAS site characterization at Joint Base Elmendorf Richardson (JBER) in Anchorage. ORD previously provided a review of an Air Force work plan to collect groundwater and soil samples at JBER for PFAS analysis. ORD scientists observed the collection of groundwater samples by an Air Force contractor, visited locations where samples have been collected, and collected wastewater and creek samples. Region 5 scientists analyzed splits of some samples to evaluate the American Society for Testing and Materials (ASTM) analytical PFAS methods (ASTM 7968-14 and ASTM 7979-15, a preliminary version of SW-846 Method 8327). This sampling effort provided an opportunity to apply the ASTM methods to additional environmental matrices. In addition to the common PFAS analytes, samples were analyzed for PFAS precursors and transformation products. The analytical methods produced accurate and precise data for most analytes. Many groundwater locations contained PFOA and PFOS as well as other PFAS. The resulting data from EPA can be used to decide further site characterization priorities.

More information can be found on the Elmendorf Air Force Base and Fort Richardson Superfund site profiles.

Partner: New Hampshire Department of Environmental Services (NHDES)
Challenge: Understanding what perfluorochemicals (PFAS) are being emitted from industrial sources
Resource: Application of non-targeted high-resolution mass spectrometric methods to environmental characterization; air/stack sampling methods development and testing
Project Period: 2017-Present

"EPA ORD's application of non-targeted high-resolution mass spectrometric methods to detect current PFAS emissions in air, water and soils has been a tremendous assist to NH as we assess emissions from current operations and treatment technologies to stop air emissions." – NHDES Assistant Commissioner Clark Freise

Following the emergence of concerns about long-chain per- and polyfluoroalkyl substances (PFAS), the state of New Hampshire has conducted extensive work characterizing "legacy" PFAS, primarily using contract laboratories.

However, there are ongoing technical challenges in this work, including: limitations in current analytical methods to comprehensively assess PFAS environmental contamination and related fate and transport expertise, handling more complex sample matrices, and the unknown nature of compounds. Regional, state, and contract laboratories are able to evaluate a relatively narrow slice of legacy PFAS, leaving environmental degradants and new generation PFAS invisible.

There are known industrial sources of PFAS along the Merrimack River. To evaluate the environmental and public health impact, NHDES requested EPA ORD's assistance to help them assess emissions and contamination comprehensively. Of particular interest is conducting novel analyses to reveal the possible presence of newer fluoropolymer materials. This has led to a strong collaborative effort with EPA Region 1 (New England) and NH collecting valuable samples and ORD applying novel methods of sampling (air) and analysis (non-targeted high-resolution mass spectrometry). Samples of water and soil had previously been collected to help understand the entirety of contamination that may have resulted from the operation of the plant. The collaborative effort has allowed an opportunity to engage in research to test new monitoring methods and instruments with the end goal of a comprehensive assessment of environmental contamination of per- and polyfluorinated materials.

As a result, eight data reports have been provided since April 2018 identifying PFAS in samples collected from various media within facilities and the surrounding environment. Analysis is ongoing, as well as employing non-targeted analysis techniques to identify novel PFAS. This work will help NHDES better understand the extent of contamination and determine the needs for and proper design of air pollution control equipment to control PFAS emissions.

Partner: New Jersey Department of Environmental Protection (DEP)
Challenge: Determining the scope of PFAS contamination
Resource: Water, soil and sediment analyses
Project Period: 2015-Present

"EPA ORD's studies have provided critical information needed to develop PFAS human health risk assessments. In particular, we appreciate your foresight in initiating studies of PFNA several years before it was widely recognized as a potential concern. Also, we especially thank you for your ongoing willingness to share your knowledge of PFCs (perfluorinated compounds) in general, to answer all of our questions about your studies, and to continue working with us on identifying PFAS sources." – New Jersey DEP Research and Environmental Health, Division of Science, Gloria B. Post, PhD, DABT

A concern of New Jersey DEP is the ongoing presence of poly- and perfluoroalkyl substances (PFAS) in the drinking water resources of southwestern New Jersey. New Jersey DEP reached out to EPA ORD when they were faced with relatively high contaminant levels of a specific PFAS (perfluorononanoic acid, PFNA). New Jersey DEP continues to study the potential routes PFAS might be following in finding its way into these water resources.
The chief questions are where the contamination is originating and whether it is getting into the water through direct discharge or through the air. Previous analysis of water samples suggests that by looking at the ratios of different PFAS, it might be possible to identify a source signature that could help determine the contaminant's origin. The goals of this study are to confirm that PFAS contamination is occurring, establish specific PFAS source signatures, and evaluate the potential for impacts due to air deposition.

New Jersey DEP has requested that ORD continue to work with them to analyze water, sediment and soil samples for PFAS and their byproducts. In addition, ORD will collaborate with New Jersey DEP to evaluate the data and summarize the study's findings in a joint publication.

ORD has provided four data reports to NJ DEP since February 2019 identifying and quantifying PFAS in samples collected from various environmental media within the sampling area, including soils, vegetation, surface waters and groundwater wells. ORD analysis of results has shown promising methods for identifying source signatures and evaluate the effects of air deposition.

Partners: NC Department of Environmental Quality (DEQ), Cape Fear Public Utility Authority, Town of Pittsboro, Fayetteville, NC State Highway and Public Works Commission
Challenge: Mapping PFAS levels across an entire river basin
Resource: Methods development and laboratory analyses
Project Period: 2015-Present

"We are extremely grateful for EPA ORD's work as we analyze these chemical compounds. EPA's analyses will be crucial to our efforts in protecting public health and the environment as we learn more about these emerging substances." – NC DEQ Assistant Secretary Sheila Holman

Because of concerns about long-chain per- and polyfluoroalkyl substances (PFAS), which persist in the environment, their use began being phased out in 2006. In 2007, EPA ORD began a first-ever effort in the U.S. to map PFAS levels in an entire watershed, focusing on North Carolina's Cape Fear River Basin. This mapping effort demonstrated that there were multiple sources of many different PFAS throughout the basin, suggesting that since the basin is a major drinking water resource, it could potentially be responsible for human exposures to PFAS throughout the entire region. As part of this effort, EPA ORD also developed research-based methods to measure PFAS in drinking water and detect novel PFAS using high resolution mass spectrometry non-targeted analysis approaches.

EPA ORD's PFAS research in the Cape Fear Basin has continued to evolve. Having largely addressed PFAS waste water discharge to the Cape Fear River, attention has turned toward air emissions, fate, transport, deposition, and resulting land and surface water contamination down wind of the Chemours plant. EPA ORD is working with Region 4 and NC DEQ to test and deploy air sampling methods including the application of non-targeted analysis to comprehensively characterize air emissions. NC DEQ is also sampling and making available rain water for testing. This work is being done cooperatively with Chemours to evaluate air emissions control technology that they are considering. These efforts are expected to provide solutions for reducing exposures to these potentially hazardous chemicals.

Access EPA publications related to PFAS research in North Carolina.

CHEMICALS - ASBESTOS

Partner: Montana Department of Environmental Quality (DEQ)
Challenge: Asbestos exposure following forest fires
Resource: Computer modeling in collaboration with the U.S. Forest Service
Project Period: 2012-2016

"The modeling results were used to scope and plan for the potential socio-political and management challenges resulting from a wildfire occurring in or threatening a portion of the Libby Asbestos Superfund Site. These results will also be used to assist the Montana DEQ in evaluating proposed remedies, and [they] are important in informing local and Montana Department of Natural Resources and Conservation firefighters in developing response actions to protect firefighters and the citizens of Libby and the surrounding area." – Montana DEQ, Remediation Division Lisa Dewitt

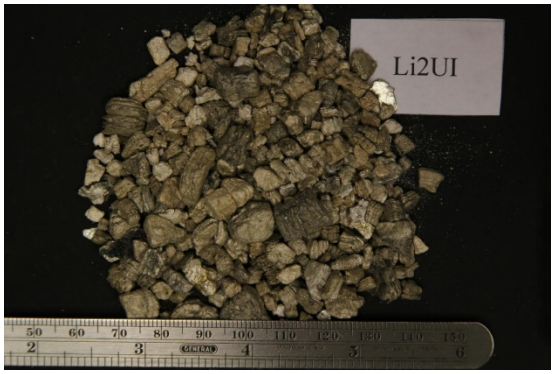
As noted above, Libby amphibole asbestos (LAA) has been found to co-occur with the vermiculite ore that was mined in Libby, Montana starting in the 1920s. Due to the presence of asbestos, additional concerns have been raised about the potential for forest fires near the Libby Asbestos site to spread asbestos fibers, exposing firefighters and those living adjacent to the Libby site.

To address this potential health hazard, EPA ORD, in collaboration with Region 8 (Mountains and Plains), provided technical support to Montana DEQ in assessing the health risks associated with potential forest fires near the Libby Asbestos site in Montana. Specifically, ORD conducted experiments to understand the potential asbestos emissions, and Region 8 used these data in a model to assess whether these emissions would result in potential exposures. To obtain emissions data, ORD first burned forest floor material from a portion of the Libby Asbestos site, simulating a forest fire. During these simulated burns, particulate matter and gaseous emissions were measured and samples of the ash were analyzed to determine whether these samples contained asbestos. These data suggested that only a small fraction of the asbestos in the forest floor material was released into the gas phase.

EPA Region 8 then used these data, along with direct measurements of asbestos in the forest floor at the Libby site, and estimated combustion and meteorological conditions in a model to estimate potential asbestos exposures under various scenarios. Because of these modeling efforts, EPA was then able to provide Montana DEQ with the range of potential exposures for these scenarios. In addition, EPA is now able to model forest fires when they do occur to more accurately estimate exposures and health risks to firefighters and to the surrounding communities.

Read the synthesis report titled *Emissions of Amphibole Asbestos from the Simulated Open Burning of Duff from Libby, Montana.*

Partner: Montana Department of Environmental Quality (DEQ)
Challenge: Addressing human health risks of exposure to Libby amphibole asbestos
Resource: Integrated Risk Information System (IRIS) assessment
Project Period: 2009-2019



"EPA ORD establishing the toxicity of the Libby amphibole asbestos (LAA) was key to completing the multipathway risk analysis that was necessary for the remedial action to move forward and provide confidence for the public that a decade of EPA removal actions was protective." – Montana DEQ, Remediation Division Lisa Dewitt

Libby amphibole asbestos (LAA) has been found to co-occur with the vermiculite ore that was mined in Libby, Montana starting in the 1920s. When the mining and milling operations were active, residents of the Libby region were exposed to high air concentrations of LAA. Local clinics began to observe incidences of respiratory disease in the Libby area that were much higher than the national average for these asbestos-related diseases. After mining and milling operations ceased, exposures still occurred from soils and vermiculite home insulation contaminated with LAA; from roads, driveways and recreational areas where mine tailings containing LAA had been used; and from former vermiculite processing facilities located in Libby. In 2002, the Libby mining and milling operations site (Libby Asbestos) was placed on the Superfund National Priorities List.

The community had great concerns about the risks posed by the asbestos contamination in the town, with a significant portion of residents concerned that the particular kind of asbestos in Libby was more toxic than other forms of asbestos. In 2009, EPA announced that a public health emergency existed at the Libby asbestos site – this was the first time EPA had made a determination under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) that conditions at a site constituted a public health emergency.

EPA ORD, in collaboration with Region 8 (Mountains and Plains), developed an Integrated Risk Information System (IRIS) assessment of the asbestos mixture found in Libby (referred to as Libby amphibole asbestos). Based on epidemiological analyses of workers exposed to LAA, the assessment concluded that inhalation exposure to LAA could lead to thickening of the membranes that envelop the lungs, which could decrease lung function. The assessment was able to identify a level of exposure that, over a lifetime, would be unlikely to cause such effects on the lung membranes. This was the first quantitative toxicity estimate of adverse non- cancer health effects for any type of asbestos. The assessment also established that the asbestos found in Libby produced cancer, and importantly for the community, was able to show it was similar in potency to other forms of asbestos.

With the IRIS assessment of LAA, along with site-specific exposure data, decisions could be made to protect human health and to address community concerns about the toxicity of the specific form of asbestos found in their area. EPA's Libby Superfund Site Human Health Risk Assessment, using the IRIS assessment, showed that the cleanup actions EPA has taken since 1999 have reduced LAA exposures and risks at the Libby Asbestos site. The asbestos ambient air concentrations there today are about 100,000 times lower than when mine and processing facilities were in operation, making today's air quality in Libby similar to other Montana cities. In April of 2019, EPA and the Montana Department of Environmental Quality were able to remove part of the site from the NPL, due in part to having the IRIS assessment values.

CHEMICALS – ASSESSMENTS

Partner: Alaska Department of Environmental Conservation (ADEC)
Challenge: Toxicity information for sulfolane to inform cleanup levels
Resource: Peer review of the available reference doses (RfDs) and technical support
Project Period: 2010-2014

"EPA's technical experts played a vital part in assisting the state of Alaska in understanding the risks of sulfolane in groundwater and the potential impacts to public health. EPA provided critical information on sulfolane mobility, toxicity and human health exposures that greatly assisted ADEC in making decisions on protecting residents. ADEC appreciates EPA for all their timely support and help by providing information on the best available science which was significant in Alaska's response actions for sulfolane." – ADEC Division of Spill Prevention and Response Director Kristin Ryan

Sulfolane is an industrial solvent used in gasoline production and petroleum refining. The discovery in late 2009 of sulfolane in drinking water wells near the Flint Hills North Pole Refinery (about 15 miles east of Fairbanks, AK), led to an extensive investigation of contaminated groundwater. The groundwater plume is approximately 2 miles wide, 3.5 miles long and over 300 feet deep, rendering it one of the largest in the state, with many private properties impacted. The National Toxicology Program (NTP) began new animal studies on sulfolane in 2014.

EPA's Region 10 (Pacific Northwest) requested that ORD develop a Provisional Peer-Reviewed Toxicity Value (PPRTV) assessment for sulfolane. The information in PPRTV assessments can be used in combination with exposure information to characterize the public health risks of a given substance at a particular hazardous waste site. Importantly, these risk characterizations can form the basis for risk-based decision making, regulatory activities, and other risk management decisions designed to characterize and protect public health. EPA ORD finalized the PPRTV assessment in 2012.

At ADEC's request in 2014, EPA ORD scientists participated in an independent, expert peer review workshop to discuss the available oral toxicity values/reference doses for sulfolane (including the PPRTV) and reach conclusions based on the available science. EPA ORD scientists provided essential technical support in the peer review workshop with respect to the scientific development process of the Sulfolane PPRTV assessment. This technical support assisted ADEC in their consideration of cleanup levels for contaminated groundwater.

Ultimately, ADEC decided to wait to set a cleanup level for sulfolane until more data become available from the new NTP studies, in order to best protect people from exposure. EPA ORD's input provided ADEC with important information that will be needed for making a final determination.

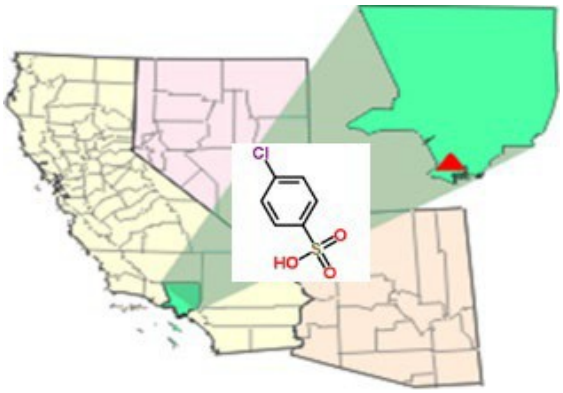
Partners: California Environmental Protection Agency's (CalEPA) Department of Toxic Substances Control (DTSC) and Office of Environmental Health Hazard Assessment (OEHHA)
Challenge: Evaluating chemicals for health effects
Resource: New technologies, models, tools, data and other chemical information
Project Period: 2015-Present

"California benefits significantly from our partnership with EPA ORD. We use ToxCast data to provide valuable insight into how chemicals may cause toxicity, and we use their lifecycle analytic and exposure modeling and monitoring for various state efforts including our work on safer consumer products. EPA ORD resources are helping us to make more informed decisions about the potential health effects of chemicals."
– CalEPA Matthew Rodriquez (former Secretary)

CalEPA's DTSC and OEHHA are collaborating with EPA ORD on the following projects: 1) using ORD's new technologies and computational modeling approaches to evaluate the potential health effects of chemicals; 2) improving and using ORD science for evaluating the risk of chemical exposure to threatened and endangered species; and 3) a collaboration which includes EPA's Region 9 (Pacific Southwest) and Office of Chemical Safety and Pollution Prevention to advance sustainable chemistry practices and activities.

ORD researchers have provided CalEPA staff training on the use and interpretation of the high-throughput chemical testing data contained in the ToxCast Dashboard; planned and participated in a workshop to discuss an endangered species case study in the Sacramento River Basin; and shared database architecture to help the state develop chemical information databases. This collaboration is helping California use scientific advances to make more informed decisions about the potential health effects of chemicals, as well as determine safer and more sustainable uses of chemicals found in products that consumers buy and use.

Partner: California Environmental Protection Agency (CalEPA)
Challenge: Setting a risk-based cleanup level for para-Chlorobenzene Sulfonic Acid (p-CBSA)
Resource: Provisional Peer-Reviewed Toxicity Value (PPRTV) for p-CBSA
Project Period: 2016



"When a chemical that had not been well-studied threatened an important drinking water aquifer in the L.A. Basin, scientists from ORD were important partners. They worked collaboratively with our state scientists to develop a risk assessment using the best available science."
– CalEPA Matthew Rodriquez (former Secretary)

The potential toxic effects of para-Chlorobenzene Sulfonic Acid (p-CBSA), a by-product of the production of the pesticide dichlorodiphenyltrichloroethane (DDT), present health concerns, particularly for drinking water contamination because the chemical is highly water soluble and mobile in aqueous environments. It has been identified in potential drinking water sources beneath and near sites in California, such as the former Montrose Chemical Corporation where DDT was manufactured from the 1950s to the early 1980s.

Because of high interest in evaluating the potential human health effects of p-CBSA, CalEPA and EPA ORD, in collaboration with Region 9 (Pacific Southwest), worked together in assembling existing study data leading to the development of a Provisional Peer-Reviewed Toxicity Value (PPRTV) assessment for p-CBSA. Importantly, the information in PPRTV assessments can be used in combination with exposure metrics to characterize the public health risks of a given substance at a particular Superfund site. These risk characterizations can form the basis for risk-based decision making, regulatory activities and other risk management decisions designed to characterize and protect human health.

EPA ORD's PPRTV assessment identified information sufficient for derivation of a provisional reference value that informs risk associated with oral p-CBSA exposures. The impact of this work will be realized in the facilitation of risk-based decision making and activities on sites contaminated with p-CBSA.

Partner: California Environmental Protection Agency's (CalEPA) Department of Toxic Substances Control (DTSC)
Challenge: To inform the identification of "Priority Products," California DTSC must understand the potential for exposures to chemicals contained in specific consumer products
Resource: Application of high-throughput human exposure models for thousands of chemical-product combinations
Project Period: 2017-2019

"The Safer Consumer Product regulations don't use quantitative risk assessment to prioritize product-chemical combinations as Priority Products. Instead, the regulatory criteria are exposure potential and hazard potential using a narrative standard. So, determining exposure is critical for our decision making. The Stochastic Human Exposure and Dose Simulation High Throughput (SHEDS-HT) model and product intake fraction modeling are valuable tools to help us assess exposure. CA DTSC can use SHEDS-HT to support the selection of Priority Product categories and accelerate our screening of chemicals in our work plan including flame retardants, antimicrobials, per- and polyfluoroalkyl substances (PFAS), and fragrances." – CalEPA DTSC Director Meredith Williams

California DTSC's Safer Consumer Products program uses a multi-step process to reduce toxic chemicals in the products that consumers buy and use. It identifies specific products that contain potentially harmful chemicals and asks manufacturers if the chemical is chemical necessary and if there a safer alternative. DTSC identifies "Candidate Chemicals" which may pose a health hazard, and then identifies "Priority Products" in which they may occur. DTSC would like to consider potential human exposures associated with Candidate Chemicals when deciding which products are a priority. However, since measured exposure data are rarely available for all potential chemicals and products, exposure model predictions are needed.

EPA ORD's High-Throughput Stochastic Human Exposure and Dose Simulation Model (SHEDS-HT) is a population-based model of human exposure to chemicals in consumer products that can be used to meet this need. Inputs to SHEDS-HT include product compositions (i.e., chemical concentrations in various product types), human behavior patterns (e.g., frequency and amount of product use), chemical properties, and population characteristics. ORD has also developed a database of product chemical ingredient data called the Chemicals and Products Database (CPDat) by collecting and summarizing data on thousands of products from publicly- available data sources such as Material Safety Data Sheets and manufacturer ingredient lists. Using CPDat, ORD scientists performed SHEDS-HT simulations of the predicted exposures associated with thousands of chemical- consumer product combinations, including chemicals currently included on the DTSC Candidate Chemical List.

DTSC plans on using the SHEDS-HT results to support selection of Priority Product categories and further prioritization or evaluation of products and chemicals. These activities will directly support California's Safer Consumer Products program stated goal of identifying and prioritizing chemicals in consumer products with the potential to cause adverse impacts on public health and environment.

For more information, visit the SHEDS-HT homepage.

Partners: Louisiana Department of Environmental Quality (LDEQ) and LaPlace, LA
Challenge: Potential cancer risks from emissions of chloroprene
Resource: IRIS assessment and air quality monitoring
Project Period: 2016-Present

"I want to thank EPA's Office of Research and Development for their assistance in gathering and interpreting air quality data from around the Denka Performance Elastomer facility in LaPlace, LA. The information ORD provided helped the LDEQ design and implement actions to reduce chloroprene emissions from the plant. The multi-step Denka remedy is in the first stages of its implementation and has already produced significant reductions in chloroprene emissions. When agencies work together, everyone benefits." – LDEQ Secretary Dr. Chuck Carr Brown

EPA ORD scientists assisted Region 6 (South Central U.S.) and the state of Louisiana with their evaluation of potential cancer risks from emissions of chloroprene from the Denka Performance Elastomer facility in LaPlace. Based on the risk evaluation and an engineering analyses, the company reached an agreement with Louisiana to install control equipment to significantly reduce chloroprene emissions. The facility had been identified in the EPA's National Air Toxics Assessment (December 2015) as the highest cancer risk facility in the U.S., leading to ambient air monitoring in the vicinity of the facility.

The air monitoring demonstrated high levels of chloroprene in the ambient air in the surrounding neighborhood and at schools near the facility. ORD scientists and staff from the LDEQ, EPA's Region 6 and Office of Air and Radiation met with the community at a public meeting in LaPlace. EPA researchers characterized the potential health risks associated with chloroprene.

In March 2020, EPA deployed a network of six SPod air monitors around the Denka facility. These new monitors should provide a better understanding of the frequency and magnitude of chloroprene emission spikes and may identify possible actions to further reduce chloroprene in the community. SPod monitoring results will be posted when they become available. EPA researchers continue to assist Region 6 and the state of Louisiana to achieve action to reduce public health risks from the chloroprene emissions.

Additional information on EPA's work in LaPlace, Louisiana.

Partners: Maine Department of Health and Human Services (DHHS) and Penobscot Indian Nation
Challenge: Unique contaminant exposure scenarios for tribal risk assessment
Resource: EPA report of analyses of sediment and water quality in collaboration with the Centers for Disease Control and Prevention (CDC)/Agency for Toxic Substances and Disease Registry (ATSDR)
Project Period: 2011-2015

"The report validated our concern that Penobscot Nation tribal members may be at risk simply by carrying out cultural and traditional activities that our tribe has practiced since time immemorial." – Penobscot Indian Nation, Director of Natural Resources John Banks

The Penobscot Indian Nation of Penobscot Island, Maine, was faced with high mercury levels in fish, triggering state fish advisories for many years. A team of EPA ORD scientists worked with the tribe to assess the environmental and human health risks in the Penobscot River watershed, which provides many of the cultural and natural resources for the tribe. After four years of study, the team released a 125-page report that chronicles the first tribal risk assessment by EPA, as well as the first study to examine the mutagenicity of environmental samples from a tribal nation in the United States. Staff from Maine DHHS, which oversees fish consumption advisories, served as peer reviewers for the assessment.

Unique to this risk assessment was the incorporation of Penobscot culture and traditions into exposure assumptions. Hunting, fishing, trapping, gathering, basket-making, pottery and use of moccasins and birch-bark canoes were among the considerations for exposure. For example, assessment scenarios included consideration of cultural uses of fish, plants (fiddlehead ferns and medicinal plants), snapping turtles and wood ducks in exposure estimates. Findings led researchers to conclude that consumption rates of most animal species, except duck, carried a public health concern for mercury exposure. Consequently, the CDC issued a recommendation to limit consumption of Penobscot River fish and turtles, but not ducks or plant life. The study also found that the Penobscot River water, its sediments and drinking water from an underground aquifer showed no evidence of mutagenicity from the classes of organic compounds known to be cancer-causing or mutagenic.

Partner: Minnesota Pollution Control Agency (MPCA)
Challenge: Evaluating risk of aquatic contaminants with minimal toxicity data
Resource: Extrapolation of species sensitivity and bioaccumulation to estimate potential impacts for contaminants of concern
Project Period: 2015-Present

"EPA's variety of tools have been critical in developing aquatic toxicity profiles (ATPs) for contaminants detected across Minnesota. The MPCA uses EPA's estimation tools and databases to quickly obtain relevant information about contaminants that have only recently been detected in an aquatic environment. Prior to the development of these tools, information about contaminants has been limited or time-consuming to find. The profiles combine contaminant information such as fate in the environment, aquatic life toxicity, and endocrine activity to screen contaminants detected in Minnesota. The MPCA uses this information to communicate potential effects of the contaminants found in Minnesota and to identify pollution prevention opportunities for contaminants of highest concern." – MPCA John Linc Stine (former Commissioner)

EPA ORD scientists support ongoing efforts in Minnesota to characterize potential effects for a wide variety of contaminants for which there exists limited information. MPCA uses a suite of EPA tools – Estimation Programs Interface (EPI) Suite, ECOTOX, Web-ICE – to prioritize chemicals based on toxicity effects and hazard characterization. Using these tools, MPCA develops toxicity profiles to screen contaminants that have been detected in the state, and then uses those profiles to prioritize chemicals for further monitoring or pollution prevention opportunities. The profiles are also used as a communication tool that the public or agency decision makers can access to get an overview of the potential hazards associated with individual contaminants detected in Minnesota. Specific recommendations are made to ensure the appropriate considerations are factored into future monitoring efforts (e.g., some contaminants have greater seasonal or geographical inputs, and some contaminants are more likely to partition to sediment or biota, and those matrices are important to sample in addition to water). By assessing the characteristics of the contaminants, future monitoring can be more strategic and less costly, yielding the most relevant data for those contaminants of highest concern.

As an example, during the development of an aquatic toxicity profile for triclocarban (an antibacterial agent common in personal care products like soaps and lotions), MPCA used EPISUITE to demonstrate a high potential for bioaccumulation and environmental persistence. They then used ECOTOX to obtain available toxicity information, which was used as input into Web-ICE to determine that the compound had high acute toxicity to a diversity of taxa. The toxicity profile resulted in the designation of triclocarban as a high priority contaminant for monitoring in systems with effluent input, with focus on sediment monitoring due to the potential to accumulate, persist and cause toxicity in sediment. The use of ORD tools allows MPCA to prioritize chemicals for monitoring to ensure resources address the contaminants of greatest environmental concern.

Partner: Oklahoma Department of Environmental Quality (DEQ)
Challenge: Fish kills and unknown contamination
Resource: Chemical composition analysis
Project Period: 2011-2013

"The ORD National Exposure Research Laboratory in Las Vegas was a valuable asset during Oklahoma DEQ's investigation into the Red River fish kills. This facility's expertise and analytical technologies assisted with researching potential causative agents related to these fish kills. In addition, I strongly support the mission of ORD to conduct valuable research that leads to improvements in the continued protection of public health and the environment." – Oklahoma DEQ Executive Director Scott Thompson

Between 2011 and 2013 there were several incidents of concern in the Red River watershed and Red Creek. There were four fish kills with unknown contaminants present in the water, and stray gas bubbling between fish kill events. Oklahoma DEQ requested EPA ORD assistance in identifying the unknown contaminants, and the source of the indeterminate stray gas.

EPA ORD scientists, in collaboration with Region 6 (South Central U.S.) set out to use state-of-the-art analytical tools to identify the contaminants, and to oversee an isotopic analysis of the gases sampled by a private company. Through these techniques, ORD was able to make conditional chemical assignments of the contaminants and help determine that the stray gases were from a biogenic (natural) source. This assistance provided information to Oklahoma DEQ to assist in understanding and managing these incidents.

Read the synthesis report titled *Four Fish kills Spanning 2011-2013 in the Red River Watershed Beaver Creek to Lake Texoma, OK.*

Partner: Utah Department of Environmental Quality (DEQ) Division of Water Quality (DWQ)
Challenge: Filling gaps in toxicity protocols and profiles for brine shrimp and brine flies of the Great Salt Lake
Resource: Technical support for the development and implementation of acute and chronic toxicity testing for Great Salt Lake brine shrimp and brine flies in order to site specific ambient water quality criteria
Project Period: 2013-Present

"ORD's active participation with this project has brought a depth of expertise that Utah and Region 8 were simply unable to provide. The value of their technically sound and practical advice can't be overstated." – Utah DEQ/DWQ Environmental Toxicologist Chris Bittner

Utah's Great Salt Lake (Lake) is the largest salt water lake in the western hemisphere and the 8th largest terminal lake (no outlet) in the world. The Great Salt Lake supports 7.5 million birds and is designated as a habitat of hemispheric importance by the Western Hemisphere Shorebird Reserve Network. The Lake contributes $1.1 billion annually to Utah's economy from mineral extraction industries and brine shrimp fishing. The Lake is the ultimate receiving water for the wastewater of approximately 78% of Utah's population. Utah's population continues to increase putting additional stress on the Lake's resources and services. The Great Salt Lake is both an economic and ecologic treasure, yet currently only has one water quality criterion (selenium).

National criteria are inappropriate for the Lake because of elevated and variable salt concentrations that support an unusual ecosystem. Salt concentrations lake-wide range from freshwater to 27% which is about 8- times saltier than seawater. The ideal salinities for a healthy brine shrimp population range between 10 and 20% but less is known about brine flies. Little or no toxicity data are available for brine shrimp and brine flies, the two-keystone species supporting the waterfowl and shorebirds.

EPA ORD, in collaboration with EPA Region 8 (Mountains and Plains), is assisting Utah DEQ/DWQ in the development and implementation of novel toxicity tests for brine shrimp and brine flies. The results of these tests will be used to support future numeric water quality criteria to protect the resource. Future work is also anticipated to include development of Lake-specific Whole Effluent Toxicity Tests. EPA remains committed to supporting Utah DEQ/DWQ and others' efforts to ensure that the water quality of Great Salt Lake continues to provide important recreational, ecological and economic benefits for current and future generations.

Access Utah Department of Environmental Quality's *Proposed Approach for Developing Aquatic Life Numeric Criteria for Priority Pollutants* (published 2014).

Partners: Public health agencies of Arizona, Colorado, New Mexico and Utah; New Mexico Environment Department; New Mexico Environmental Public Health Tracking Program; New Mexico Department of Health Private Well Program
Challenge: Persistent environmental health disparities that are common to the four states such as heavy metal mixtures and well water concerns
Resource: Center for Native American Environmental Health Equity Research
Project Period: 2016-Present

"The Center's research results informed the work on exposure assessments to metals from private drinking water conducted among communities in the Four Corners' states regions; we look forward to continuing this beneficial exchange of technical expertise." – New Mexico State Epidemiologist Dr. Mike Landen

Many Native American communities are impacted by mine wastes and heavy metal contamination from abandoned mines. There is also community concern about how these contaminants impact human health and cultural practices. To help address these challenges, the EPA and NIH have jointly funded the Center for Native American Environmental Health Equity Research.

The Center investigated various metal of concern (uranium, arsenic, manganese, mercury) and community- relevant metal mixtures in blood and urine samples obtained from community members. They also conducted mechanistic experimental studies to explore immunologic effects. The results of this research were presented at the *Four Corners States Biomonitoring Consortium* (4CSBC), organized by the state public health agencies of Arizona, Colorado, New Mexico and Utah. At the 2016 Annual 4CSBC Face-to-Face Meeting (September 28-30, 2016, Santa Fe, NM), the Center's Director presented and contributed to the discussion of biosample collection protocols (blood, urine). She applied the lessons learned in her center's previous Navajo Birth Cohort Study (funded by National Institute of Environmental Health Sciences) and subsequent analysis of biomonitoring for metals exposure conducted as part of the current center.

The Consortium developed three studies to investigate exposure and shared regional geophysical, cultural, economic, industrial, agricultural and political environment. For example, the consortium utilized the Center's findings as a starting point for a new study entitled, "The private well drinking water and metals contamination study." A study undertaken by the New Mexico Biomonitoring Program included environmental sampling and assessment of water quality from domestic wells. They conducted laboratory analysis of well-water samples for arsenic, cadmium, manganese, mercury, selenium, and uranium. Testing of water from domestic wells helped to identify potential sources of excessive exposures to those metals. Through this project, participants and communities learned about their water quality, and possible actions to control exposures. Ongoing efforts include investigating potential exposures to metals in drinking water across the state, investigating potential exposure to phthalates and other chemicals from the use of plastics and some consumer products, and chemicals used in some pesticides. At the local level, this collaborative project identified potential communities to include for monitoring, strengthened participant recruitment, and built collaborations with local governmental agencies and community coalitions in the recruitment and samples collection processes. The major impact of these efforts included developing states' capacity to conduct environmental exposure assessments through biomonitoring studies and investigating regional exposure concerns.

CHEMICALS – MERCURY

Partner: California Regional Water Control Board
Challenge: Reducing mercury methylation in the Nacimiento Reservoir
Resource: Technical investigation
Project Period: 2016-2017

"Understanding mercury methylation and cycling of mercury in the aquatic environment is particularly important to states and communities that oversee health advisories for fish consumption. The Lake Nacimiento study could help to enhance our understanding of mercury methylation and controls in reservoirs." – CalEPA Environmental Engineer Carrie Austin

Although operations ended in 1970, the legacy of previous mercury mining and processing activities at the Buena Vista, California mining district still pose environmental and related public health concerns. Mercury from the Buena Vista Superfund Site that enters the local watershed drains into the Nacimiento Reservoir. Researchers have identified active zones of methylation—when mercury is converted into a form that easily enters the food chain—in the reservoir's water columns and sediments.

Several remediation options are currently under consideration to protect the public from mercury exposure and its detrimental impact on the nervous system. Researchers from EPA ORD worked closely with their colleagues in Region 9 (Pacific Southwest) to identify the best ones. Together, they worked to determine how much methyl mercury in the water column comes from methylation taking place in reservoir sediment, and to identify the effect that higher dissolved oxygen levels in the water column can have on the methylation process. Results showed that methylmercury production was primarily taking place within the water column, and that reservoir sediment was not a significant contributor due to much lower methylation rates; additionally, increased levels of dissolved oxygen would reduce overall water column methylation.

The information will help site managers focus on remediation activities that alter water column chemistry, increase levels of dissolved oxygen, and utilize reservoir management strategies, thereby reducing seasonal fluctuations of methyl mercury production.

Partner: Minnesota Pollution Control Agency (MPCA)
Challenge: Addressing Beneficial Use Impairments through tracking and remediation of bioaccumulating contaminants
Resource: Modeling bioaccumulation of PCBs and mercury in fish
Project Period: 2017-Present

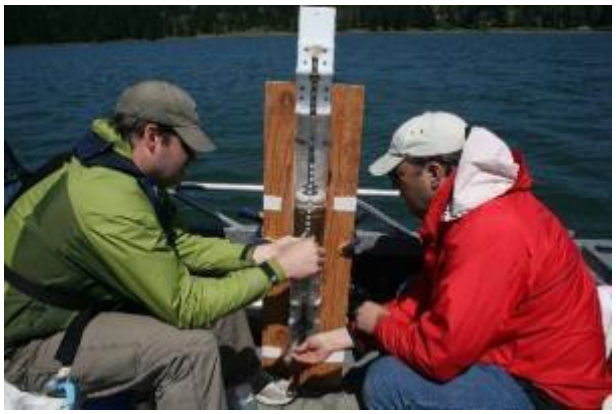
"EPA ORD's Great Lake Toxicology and Ecology Division has been instrumental in providing data, analytical expertise and guidance to support MPCA's efforts to remove Beneficial Use Impairments (BUI's) in the St. Louis River Area of Concern (AOC) in Duluth, MN and Superior, WI. This AOC is the largest and most complex of the 43 legacy pollution sites surrounding the Great Lakes in the U.S. and Canada. EPA's work on aquatic macrophyte models, bioaccumulative compounds in fish tissue, benthic invertebrate communities and spatial data sets has accelerated the implementation of our plan to complete all project work in the AOC by 2020 so that BUI's can be removed by the target date of 2025." – MPCA John Linc Stine (former Commissioner)

The St. Louis River is listed as a Great Lakes Area of Concern (AOC) under the Great Lakes Water Quality Agreement of 1987. This AOC has several Beneficial Use Impairments including loss of fish and wildlife habitat, excess loadings of sediment and nutrients, degradation of aquatic invertebrate communities (benthos), and restrictions on fish and wildlife consumption. MPCA conveyed a need to identify improvements and advance progress toward removing use impairments and eventual AOC delisting.

One of the critical impairments identified for this AOC is restriction of fish and wildlife consumption. Both Minnesota and Wisconsin have posted fish consumption advisories for the St. Louis River because fish have elevated mercury and polychlorinated biphenyl (PCBs) concentrations. Bioaccumulation of dioxins and furans in the Thomson and Scanlon reservoirs are also a concern for fish, wildlife and human health. MPCA identified the need to develop approaches to establish remediation targets for these and other bioaccumulating contaminants, and monitoring designs to track progress after sediment remediation has occurred.

EPA ORD researchers worked with state agency staff to develop a geospatial, habitat-based model of fish bioaccumulation of PCBs to help determine the extent of PCB contamination in the AOC. The model is being used to screen for contamination "hot spots," determine remediation targets for contamination, and develop monitoring plans for future assessments. ORD researchers also led a multi-federal/state agency team to apply cutting-edge chemical tracers to identify the source and pathways of mercury contamination in the AOC. The tracers are being applied to determine the role of legacy mercury contamination in the AOC, and aid in establishing a mercury-specific remedial target. Finally, an approach to determine the effectiveness of remediation that was developed in other Great Lakes AOCs was brought to the Thomson and Scanlon reservoirs to aid state agencies in implementing and tracking the success of remediation of dioxins and furans in the reservoir sediments that will begin in 2020.

Partner: Oregon Department of Environmental Quality (DEQ)
Challenge: Determine the influence of water level fluctuations on the seasonal production of methyl mercury in the Cottage Grove Reservoir
Resources: Technical Investigation to help reduce methyl mercury levels
Project Period: 2010-2018



"I think this is valuable information for understanding potential methyl mercury loading contributions and methylation mechanisms related to water level fluctuations in Cottage Grove Reservoir. Looking ahead, this study suggests some potential considerations related to reservoir flow management that could help mitigate mercury methylation potential." – Oregon DEQ, Water Quality Monitoring Manager Aaron Borisenko

The Cottage Grove Reservoir located south of the Historic Black Butte Superfund Site has received historical and ongoing loading of mercury and transport of contaminated mercury sediments resulting in strict fish consumption advisories. Cottage Grove Reservoir operates as a flood control reservoir, and lower water levels during the fall and winter expose 60-80 percent of the reservoir sediments.

EPA ORD researchers designed an investigation at Cottage Grove to determine whether the seasonal exposure of reservoir sediments was contributing to the elevated level of methyl mercury within the reservoir water column. Results from the investigation identified that the seasonal lowering of the water level corresponded with increased production of methyl mercury in sediments that were exposed to the atmosphere. Currently, discussions for altering reservoir management strategies to control seasonal production of methyl mercury are underway. By lowering the loading of mercury to the reservoir, Oregon DEQ hopes to benefit communities that catch and eat fish.

Additional information can be found in the fact sheet titled *EPA Cleans Up Furnace Creek Area at Black Butte.*

Partner: Rhode Island Department of Environmental Management (RI DEM)
Challenge: Determining freshwater fishing sites for safe catch consumption and predicting accumulation of mercury (Hg) at untested sites
Resource: Sampling and analysis of mercury from fish tissues sampled across Rhode Island
Project Period: 2005-Present

"EPA ORD has been instrumental in providing technical expertise and analysis of total mercury concentrations in fish from freshwater sites in Rhode Island for over a decade. The data generated are reducing a major data gap and have been used by RI DEM to identify impaired waters under Section 303(d) of the federal Clean Water Act. The data are also reviewed by the RI Department of Health which provides advice to the public about fish consumption and mercury."
– RI DEM Office of Water Resources Deputy Chief Sue Kiernan

Mercury (Hg) is a highly toxic contaminant of concern because of its propensity to accumulate in aquatic organisms and to bio-magnify as it moves upward in aquatic food webs to fish. In New England, many lakes, ponds and reservoirs are acidic, unenriched and have conditions conducive to bacterial methylation of Hg. This methylation facilitates movement of mercury into aquatic food webs.

Due to concerns about mercury levels in freshwater fish in Rhode Island, scientists from EPA ORD have been working with scientists in the RI DEM Office of Water and Division of Fish and Wildlife to sample fish and to determine their total Hg concentrations. This 15-year collaboration has resulted in the sampling and analysis of fish communities from more than 50 freshwater sites from locations across the state, including two sites on Narragansett Indian Lands. At more than 75% of sites, mercury concentrations were found to exceed the EPA tissue-based criteria for human consumption in higher trophic level fish, such as Largemouth Bass, Black Crappie and Chain Pickerel. As they are received, the results of fish Hg concentrations are shared with the RI Department of Health, which provides guidance on fish consumption to the public.

This cooperative research effort has also enabled EPA ORD scientists to measure stable isotopes of nitrogen and carbon on fish collected. These measurements are being used in corollary research to develop models for estimating trophic positions of different organisms in the food web. These models are useful for examining movement of energy and contaminants (including Hg) in aquatic systems.

Overall, this EPA ORD and RI DEM collaboration has helped determine which freshwater sites fishers can target for safe harvests and has provided data to develop models for predicting movement and accumulation of Hg in untested sites.

COMMUNITY RESOURCES

Partner: California Energy Commission
Challenge: Population and land use projections to the year 2100 consistent with emissions storylines
Resource: Integrated Climate and Land Use Scenarios (ICLUS) version 2
Project Period: 2012-2019

"It is extraordinarily beneficial to climate planning in California to be able to rely on tools like ICLUS v2 to provide a federally-vetted baseline for coordinated climate assessment research." – California Natural Resources Agency, former Special Assistant for Climate Change JR De la Rosa

EPA ORD researchers developed national population, land use and impervious surface projections that the state of California used in its Third Climate Change Assessment. For the fourth assessment, the state used EPA's updated climate model, the Integrated Climate and Land Use Scenarios version 2 (ICLUS v2), as a basis for land use scenarios in California, with minor modifications as necessary. These scenarios were used across multi-disciplinary and multi- sectoral research that informs the Fourth Assessment.

ICLUS v2 uses the latest census, land use and land cover datasets to model population growth, residential housing changes, and commercial and industrial development nationally to the year 2100. Projections use information on fertility, mortality and international immigration rates that are consistent with global storylines (e.g., Shared Socioeconomic Pathways) used in climate change impacts, vulnerability and adaptation assessments. In addition, ICLUS v2 projections use information on domestic migration, including how future climate may make certain places more desirable. Combined with the addition of commercial and industrial land uses, the updated projections from ICLUS v2 helped the state of California better assess potential future impacts from climate change and prepare adaptation and mitigation responses.

Partners: California State University (CSU) System
Challenge: Framework and decision support tools to advance priority projects in local government work plans
Resource: Supporting campus-community partnerships through the EPIC Framework and EPA tools
Project Period: 2015-Present




"This model shows us how to work together with the university to create a meaningful partnership to take on projects the city needs done. EPA has been an integral part of making this happen. It gave credibility to the project, to our city manager…. we're very thankful for their participation in bringing this together." – City of Chico Council Member and former Mayor Ann Schwab

Environmental and public health impacts affect people most significantly at the community level. Local governments and communities often lack capacity and need assistance managing pollution, natural resources, energy, water and waste. Creative approaches are needed to supply expertise and assistance to communities. An Educational Partnership for Innovation in Communities (EPIC) program is a partnership framework where a university (campus) provides direct support to a city, tribe or other local government entity to implement priorities and projects that align with local goals for protecting the environment while advancing public health, environmental and economic outcomes. The EPIC framework systematically matches real-world interests and needs with university capacity at a scale that can have lasting and sustainable impacts for all involved. EPA ORD and Region 9 (Pacific Southwest) staff have been working together to convene and educate potential campus- city partners about the framework; and leverage the EPIC network to more effectively share EPA resources and science-based decision tools and strategies that can be used to advance local projects.

In July 2015, EPA sponsored a workshop in California that convened 76 participants including federal and local government, university and industry representatives to educate them on the EPIC Framework and EPA tools for protecting the environment while promoting local heath and economic goals. This event included a panel with San Diego State University's EPIC Program, The Sage Project, and National City – their first local partner.

From this workshop, six new California EPIC programs formed between California State Universities and local governments. These include Fresno, Chico and Sonoma State, and Cal State's Monterey Bay, San Marcos, East Bay and Fullerton. Through these partnerships, 1601 students completed 35 city priority projects gaining real-world learning experiences applying 103,500 student hours to local challenges. Currently, EPA staff are working with the CSU Chancellor's office, which sponsored an EPIC workshop at the 2019 California Higher Education Collaborative (CHEC) on October 1, to catalyze and leverage EPIC programs throughout the CSU system.

Partners: Research Triangle Cleantech Cluster, US2020, Citizen Schools, Durham Public Schools Science Alliance, WakeEd Partnership, NC Science Mathematics and Technology Education Center, NC Science Festival, East Durham Children's Initiative, NC State University Kenan Fellows Program for Teacher Leadership, Triangle Women in STEM, RTP Foundation, Duke Energy Initiative

Challenge: Preparing the future environmental health workforce by providing STEM (science, technology, engineering and math) education, especially in K-12 schools with low-income populations
Resource: EPA's Community Engagement & STEM Education Program (CE-STEM) in RTP
Project Period: 2003-Present

"EPA's Community Engagement and STEM Education Program in RTP has not only has been a source of ideas for our own outreach program improvement but also serves as a model STEM outreach organization in the region, because of its impactful work in schools, museums, and on-site for students of all ages through speed mentoring, job shadowing, and hands-on STEM activities."
– The Research Triangle Foundation, STEM in the Park Outreach Program Manager Sarah Council Windsor

CE-STEM communicates EPA science to K-12 and university students, to educators, and to the public. CE-STEM outreach at schools, community events, and at EPA-RTP increases the public's knowledge of how protecting the environment protects human health. Most CE-STEM programming serves students at low-income schools, i.e., 50%+ free/reduced lunch, to help close the opportunity gap and build capacity for a more diverse workforce. CE-STEM also provides training and guidance to EPA regional offices and laboratories as well as to U.S. embassies. CE-STEM was initiated in 2003 and currently reaches 25,000+ people at 350+ events, mostly in central NC, through the participation of 200+ EPA-RTP employees.

CE-STEM engages the public in protecting human health and the environment by:

- Establishing relationships with educators and local, regional, state, national, and international stakeholders;
- Translating EPA science into hands-on activities and lessons for employees to use in the community;
- Recruiting and training EPA employees to educate K-12 students, college/university students, and the public at school, community events, and at EPA-RTP; and
- Building capacity for an educated, informed, diverse, and inclusive pipeline of future EPA employees and environmental decision makers.

CE-STEM was awarded two US2020 STEM Mentoring Awards in 2017 – one for Excellence in Volunteer Experience, and a second for Volunteer Mobilization. The Excellence in Volunteer Experience Award recognizes STEM programs that provide high-quality, well-supported STEM activities for their volunteers, while the Volunteer Mobilization Award honors organizations that effectively engage their workforce to support youth-serving organizations. In 2019, the Research Triangle Cleantech Cluster recognized CE-STEM with the Diversity Initiative of the Year at their Cleantech Innovation Awards.

HABITAT

Partner: Hawaii Department of Land and Natural Resources (DLNR)
Challenge: Restore and enhance the health and resiliency of West Maui coral reefs
Resource: Corals and Climate Adaptation Planning (CCAP) Adaptation Design Tool
Project Period: 2017-Present

"Participating in the development of the CCAP Adaptive Design Tool has given the West Maui watershed planning team an opportunity to engage in in-depth conversations with experts from around the world about how climate change is likely to impact coral reef health and the connecting watersheds. Once the tool is finished, we anticipate incorporating the framework into our decision making to arrive at the most resilient set of watershed management strategies that are relevant into an uncertain future." – Hawaii DLNR, Watershed Coordinator Tova Callender

The West Maui Ridge to Reef (R2R) initiative, founded by Hawaii's DLNR, addresses adverse impacts to coral reefs in West Maui. It takes a comprehensive, watershed-based approach to reducing land-based sources of pollution as a critical step toward restoring and building the resiliency of coral reef ecosystems. However, climate change is complicating that effort. Increasing temperatures and ocean acidification directly impact the health of coral reefs. In addition, changing precipitation patterns are altering the frequency and load of nutrient pollution reaching coastal waters through runoff. Managers need tools that inflaplacecorporate climate change information and scenarios.

EPA ORD has been working with the R2R Initiative on 'climate-smart' management planning through the CCAP project. The CCAP project is a cooperative effort of the Climate Change Working Group of the Interagency U.S. Coral Reef Task Force, co-chaired by EPA and the National Oceanic and Atmospheric Administration (NOAA). The overall goal is to support the creation of effective, place-based adaptation actions using recent adaptation planning principles and frameworks, tailored specifically for coral reefs. To achieve this, the CCAP and R2R teams collaborated through workshops, webinars and expert consultations to develop, beta-test and refine the CCAP Adaptation Design Tool. The tool guides users through two activities to: 1) systematically analyze a series of 'design considerations' for adjusting existing management actions to be more 'climate-smart'; and 2) brainstorm and tailor additional adaptation actions based on general strategies compiled from the literature.

The Adaptation Design Tool is available on the Reef Resilience Network webpage.

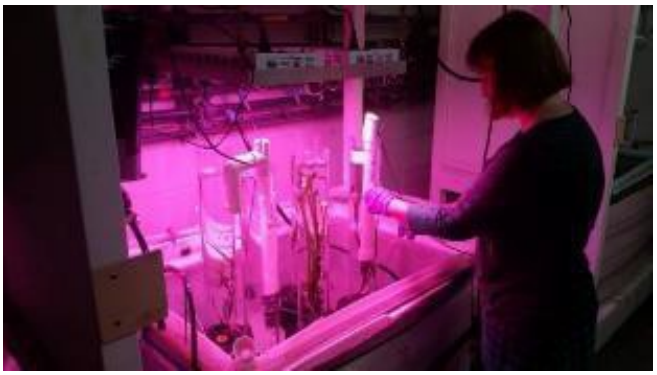
Partners: Florida Department of Environmental Protection (DEP), South Florida Water Management District (SFWMD)
Challenge: Saltwater encroachment damaging freshwater vegetation communities in the floodplain
Resource: Time series salinity model as a tool for development and evaluation of restoration alternatives
Project Period: 2017-2019

"The salinity tool will allow the ecological sub-team of the Loxahatchee River Watershed Restoration Project to evaluate the various potential project features in order to determine what grouping of features such as storage reservoirs, storm water treatment facilities, and restored wetlands performs the best for the restoration of flows to the federally designated Northwest Fork of the Loxahatchee River. The tool allows us to take the differing flow scenarios from the watershed and predict how those flows will change the salinity regimes in the river and therefore affect the location, health and survival of key indicator species such as juvenile fish, submerged aquatic vegetation and oysters." – SFWMD Applied Science Bureau, Coastal Ecosystems Section Science Supervisor Patti Gorman

Loxahatchee River contains a diverse array of aquatic and riparian ecosystems, with the upper reach being home to one of the last remnants of bald cypress (*Taxodium distichum*) floodplain swamp in southeast Florida. In 1985, a 16.6-km stretch of the river became Florida's first federally-designated National Wild and Scenic River. The unique ecosystem of the Loxahatchee River, with its quiet beauty, has captured the attention and imagination of residents and visitors, as well as agency and community leaders for many years. However, anthropogenic alterations of the Loxahatchee River watershed, particularly the permanent opening of the Jupiter Inlet and construction of drainage canals, have resulted in significant encroachment of a saltwater- tolerant, mangrove-dominated community into the freshwater floodplain currently dominated by bald cypress. Restoration of the ecosystem has become a priority for federal, state and local agencies and the general public.

Essential to the restoration of the Loxahatchee River ecosystem are technically sound modeling tools for the development and screening of restoration alternatives. EPA ORD scientists developed a salinity modeling tool implemented in a user-friendly Excel© platform. Salinity can be simulated with a given time series of freshwater inflow associated with varying restoration alternatives developed during the planning process. Spatial features of the tool also allow for estimation of salinities at any designated locations along the entire reach of the river. The simulated salinity data are further used to quantify the ecological benefits with respect to habit lifts of freshwater floodplain vegetation, fish larvae, oysters and seagrasses in response to these varying restoration alternatives. Stakeholders from the SFWMD and Florida DEP are using this tool in the development of restoration alternatives, while EPA ORD scientists continue to provide technical support for model development and application.

Partner: Oregon Department of Fish and Wildlife (DFW)
Challenge: Acidification in estuaries harming clam and crab fisheries
Resource: Ocean acidification research
Project Period: 2017-Present



"The expertise of the scientists at the Newport US EPA lab has been valuable as we evaluate how to improve monitoring of ocean acidification-related parameters and the value of seagrasses in buffering the effects of ocean acidification. Oregon's shellfish aquaculture industry – and likely our wild marine species – are at risk from current ocean conditions, which are projected to become more corrosive over the next several decades." – Oregon DFW, Marine Resources Program Manager Caren Braby

Increasing acidification of offshore ocean waters has harmed the oyster aquaculture industry in Oregon and threatens the state's recreational and commercial fisheries for bay clams and Dungeness crabs. Governors of California, Oregon and Washington have joined with stakeholders through the Pacific Coast Collaborative to develop coordinated solutions to address the adverse effects of ocean acidification. In Oregon, the Oregon Coast Ocean Acidification and Hypoxia Workgroup formed to advance recommendations from the Collaborative. This workgroup, led by the Oregon DFW, includes representatives from Oregon Department of Environmental Quality, Oregon Department of Agriculture, EPA ORD, Lower Columbia River Estuary Partnership, Tillamook Estuaries Partnership, several tribes and watershed councils, the oyster aquaculture industry and universities.

In addition to participating in the interagency workgroup, ORD scientists are conducting research on the contribution of excess nutrients to acidification of estuarine waters, methods to distinguish human from natural sources of nutrients in estuaries, and the use of seagrass meadows as a method to reduce the effects of acidification to shellfish. The research is being conducted at ORD's Pacific Coastal Ecology Laboratory in Newport and in Tillamook Bay – site of Oregon's largest inshore shellfisheries. The results of this research will provide state agencies with tools to reduce the causes and effects of acidification in Pacific Northwest estuaries, thereby enhancing the environment and economies that depend on the shellfisheries.

Partner: Washington State Department of Ecology
Challenge: Understanding causes of change in nearshore ecosystems in Puget Sound
Resource: Projecting species vulnerability to changes in sea level, water temperature and coastal acidification with the Coastal Biodiversity Risk Analysis Tool (CBRAT)
Project Period: 2016-2018

"The work EPA is doing through CBRAT will provide essential knowledge on how climate change may impact the benthic community and inform how we clean up contaminated sediment sites and restore habitat to improve the health of Puget Sound." – Washington State Department of Ecology, Toxic Cleanup Program's Chance Asher

Since the 1980's, the Washington Department of Ecology has monitored seafloor condition as an indicator of the health of Puget Sound nearshore ecosystems. Sediment chemistry, toxicity, and benthic invertebrate community structure are monitored annually to determine whether sediment-bound chemical contaminants, water quality or other stressors have affected the composition of seafloor communities. Findings indicate declining quality of Puget Sound seafloor ecosystem condition; however, in many locations changes do not appear to correspond with sediment contaminant concentrations. Consequently, the Washington State Department of Ecology is investigating which non- contaminant stressors may be causing this decline, including increased carbon and nutrient loading, alteration of biogeochemical processes, and climate change.

The Washington State Department of Ecology requested information from EPA ORD scientists using the Coastal Biodiversity Risk Analysis Tool (CBRAT) to determine whether climate-related stressors may be contributing to observed declines, and to predict which stressors may be drivers in the future. CBRAT is a web-based tool that projects the risk that invertebrates and fish face due to changes in sea level, water temperature and nearshore ocean acidification based on the species' distribution, abundance, life history, and environmental tolerances. Washington State and EPA are using environmental and life history traits available in CBRAT to assess which Puget Sound seafloor invertebrates are most vulnerable to changing nearshore conditions. Those results will inform the state about whether climate variables may have contributed to recent changes in seafloor communities and to help forecast the composition of those communities under future near-shore climate scenarios.

More information on the Coastal Biodiversity Risk Analysis Tool.

Partner: Washington State Department of Natural Resources (DNR)
Challenge: Selecting sites for restoration of native seagrass beds and managing invasive species
Resource: Habitat suitability models for native and invasive seagrasses in collaboration with the U.S. Army Corps of Engineers
Project Period: 2016-2018

"The eelgrass biomass production model, developed by EPA ORD's Newport lab, is a critical module in the eelgrass site selection model. A multi-faceted team of state, federal and private sector scientists integrated an existing Puget Sound coupled physical and biogeochemical model with the eelgrass biomass production model to identify sites where the biomass of transplanted eelgrass would increase over time. Knowledge of these parameters vastly improve eelgrass restoration site selection and transplant success." – Washington State DNR, Aquatic Biologist Dr. Jeffrey Gaeckle

Seagrass meadows are valued by coastal communities and tribes as nursery habitats for fisheries species (such as Dungeness crabs, bay clams, Chinook and Coho salmon) and habitat for multitudes of forage species that support fisheries and wildlife in the Pacific bays and estuaries. Washington has a goal to increase the area of native seagrass beds in the Puget Sound by 20 percent by the year 2020. This requires knowledge of where restoration and habitat conservation efforts will be most successful. Washington State DNR, working with Pacific Northwest National Laboratory as part of the Puget Sound Partnership, has been using EPA ORD research on seagrass physiology to help identify locations where native seagrass (*Zostera marina*) are likely to thrive. These sites were then prioritized for further assessment and the potential for seagrass restoration. Sites with favorable environmental conditions based on model output are more likely to be successfully restored with eelgrass.

In Washington, Japanese eelgrass has been identified by the shellfish aquaculture industry as a noxious weed that disrupts the growth and harvest of Manila clams. ORD has also been conducting research on the ecology of Japanese eelgrass and developed a habitat suitability model to determine where this invasive species has the potential to become established. Knowing where the invasive seagrass is likely to colonize can assist aquaculture biologists in developing efficient surveillance and eradication plans.

Additional resources:

- Eelgrass (Zostera marina L.) Restoration in Puget Sound: Development of a Site Suitability Assessment Process (published 2019)
- Development and validation of a habitat suitability model for the non-indigenous seagrass Zostera japonica in North America (published 2016)

Partners: Washington State Department of Ecology, Nooksack Indian Tribe, Lummi Nation
Challenge: Anticipating stream temperature stress on cold water fishes (salmon) in the Northwest
Resource: Long-term outlook models for rising stream temperatures to determine potential impacts of elevated temperatures and to examine potential mitigation strategies, in collaboration with the University of Washington, the U.S. Forest Service, NOAA Fisheries and U.S. Geological Survey
Project Period: 2012-2016

"Increased temperature and habitat degradation are a major threat to the many types of fish that live in this watershed. Through the process of research and data collection, we learned we must do everything we can to keep water quality conditions stable over the next few decades. We never would have had the ability to look into the future without the help of ORD." – Washington State Department of Ecology, Water Quality Engineer Steven Hood

Stream temperatures in the Pacific Northwest are projected to increase under future long-term weather scenarios due in part to increases in air temperature and in part to changes in water levels and water flow caused by altered rain and snowmelt patterns. Combined, these changes in stream temperature and hydrology could have substantial negative effects on cold-water fish species such as salmon**.** To better understand the potential impact of long-term weather changes on the potential to achieve water quality and salmon recovery goals, EPA ORD, in collaboration with Region 10 (Pacific Northwest) and the Office of Water, launched a collaborative research project in the South Fork Nooksack River with the Washington State Department of Ecology.

The research plan incorporates the total maximum daily load (TMDL) for temperature, which was developed by the Washington State Department of Ecology for the South Fork Nooksack River, as a pilot for integrating future weather scenarios into a watershed-specific plan to improve water quality for cold-water fish species. An overarching goal is to ensure that relevant findings and methodologies related to future stream temperature scenarios inform the South Fork Nooksack River Temperature TMDL Implementation Plan under development by EPA Region 10 and the state of Washington.

Read the final report titled *EPA Region 10 Climate Change and TMDL Pilot – South Fork Nooksack River, Washington*.

Partners: Maryland Department of Natural Resources (MDDNR), West Virginia Division of Natural Resources (WVDNR), California Department of Fish and Wildlife (CADFW), California Department of Water Resources (CADWR), California State Water Reclamation Control Board (CASWRCB)
Challenge: Accurate methods to detect hard-to-find endangered species
Resource: Environmental DNA (eDNA) for inventory and monitoring of imperiled species in collaboration with the U.S. Fish and Wildlife Service (USFWS) Pennsylvania Field Office, and the University of Kentucky Department of Forestry
Project Period: 2017-Present

"The development and validation of the eDNA methodology will profoundly change how aquatic populations are monitored and significantly improve the ability to conserve and recover rare aquatic species." - Janet Clayton, Wildlife Diversity Biologist, WVDNR

Conservation and management of endangered species requires being able to locate populations and determine their distribution in the environment. However, classical monitoring approaches may overlook or underestimate species presence. Because living organisms constantly shed DNA into the environment, environmental DNA (eDNA) may offer an efficient and non-invasive solution for detecting sensitive species at low abundances and can be readily obtained from environmental samples (e.g., water, soil) instead of thru capture of whole organisms. Because each organism's DNA contains a unique genetic code, eDNA can be used for precise taxonomic identification. The non-invasive nature of eDNA surveillance reduces stress, harm, and spread of disease to the species of interest.

To provide support to various state agencies and in collaboration with EPA Region 3 (Mid-Atlantic), EPA Region 9 (Pacific Southwest), the U.S. Fish and Wildlife Service (USFWS) Pennsylvania Field Office, and the University of Kentucky Department of Forestry, ORD scientist developed eDNA tools and assessed the capability of eDNA to determine distribution and relative abundance of species of concern. This included the federally-listed dwarf wedgemussel (*Alasmidonta heterodon*) within the Chesapeake and Potomac drainage basins in Maryland. Ongoing research is targeting multiple salamander species in KY streams, several imperiled freshwater mussels (Northern riffleshell, Snuffbox, Brook and Green floaters) in WV, PA, and MD; and listed species in the Sacramento river (Delta smelt) and Vernal pools (Fairy shrimp) in the Central Valley, CA.

These studies demonstrate how eDNA can be an effective tool for determining species occupancy at low abundances or limited biomass. For example, dwarf wedgemussel eDNA was detected in water samples from all Maryland streams known to support the species including streams with relatively low abundanc*es.* Innovative techniques like eDNA surveillance can be incorporated into the species conservation management tool box as an efficient and cost-effective means for state agencies to inventory and monitor imperiled species occupancy, to guide more localized traditional monitoring efforts, and to inform habitat suitability studies for species reintroduction programs.

HOMELAND SECURITY

Partner: City of San Francisco
Challenge: Testing the decontamination of a Bay Area Rapid Transit railcar contaminated with a non-pathogenic Bacillus anthracis surrogate
Resources: Technical assistance and field support in collaboration with the U.S Department of Homeland Security and U.S. Department of Energy labs
Project Period: 2015

"The Underground Restoration Project has been instrumental in assisting the San Francisco Bay Area Rapid Transit (BART) District prepare for a biological incident. BART does not have subject matter experts on staff, who can plan, prepare, develop and/or respond to a bio incident. Underground Transport Restoration Guidance prepares the agency for an unthinkable incident to a 'do-able' response. The tabletop exercise and guidance documents help us support and coordinate the regional management and response to an incident, allowing our service to be restored in a safe and timely manner. Without having the opportunity to participate in the project, if there was an actual event, the San Francisco region would be responding blindly, without plans in place, which would negatively impact lives, property and the environment." –BART Police Department Security Programs Manager Lt. Kevin Franklin

Release of biothreat agents, such as *Bacillus anthracis (Ba)* spores, by terrorists into an underground subway system could have devastating impacts on human health and the functioning of cities such as New York, Chicago, Washington, DC, and San Francisco. This critical transportation infrastructure could be down for weeks or months during the cleanup; in addition, the spores are likely to travel to street level, further increasing risk of exposure and the economy.

As part of the Department of Homeland Security's (DHS) Underground Transport Restoration (UTR) project, EPA ORD, Sandia National Laboratories (Sandia) and Lawrence Livermore National Laboratory (LLNL), in conjunction with DHS, conducted a scientific study in July 2015 to evaluate methyl bromide as a fumigant for decontaminating subway railcars contaminated with *Ba* using non-pathogenic *Ba* Sterne strain spores. The study was conducted to gain large-scale information on the use of methyl bromide for the decontamination of *Ba* spores, and to develop site-specific plans and guidance that could be modified and used during a real-world incident. The fumigant, methyl bromide, was selected because it has shown to be effective in the inactivation of *Ba* spores during laboratory testing, is not corrosive, and can be captured on activated carbon.

At the conclusion of the 36-hour fumigation period, the railcar was aerated and samples were collected and sent for analysis. Results showed that none of the 40 fiberglass or 40 aluminum test samples contained viable spores after fumigation while a few samples of the nylon carpet, rubber flooring sample, Mylar® and vinyl seating showed low but positive residual spore levels. As a result of these findings, EPA recommends fumigating railcars with methyl bromide for a 48-hour period to achieve complete decontamination.

Read the final report titled *Decontamination of Subway Railcar and Related Materials Contaminated with Bacillus anthracis Spores via the Fogging of Peracetic Acid and Aqueous Hydrogen Peroxide*.

Partners: New York City (NYC) Department of Health and Mental Hygiene (DOHMH) and NYC Transit
Challenge: The ability to effectively identify and map contaminated areas following a large biological incident within a highly urbanized area in the U.S.
Resource: Technical assistance to evaluate the compatibility of current surface sampling options and analytical methods for *Bacillus anthracis* in an urban environment
Project Period: 2017-2019

"The instant that a biological threat agent incident has been detected, incident commanders will depend on and expect accurate and reliable incident characterization to support informed public health decision making. EPA's groundbreaking efforts in this regard will prove critical to New York City's ability to determine the scale and scope of biological incidents rapidly and efficiently." – NYC DOHMH Bioterrorism Surveillance Coordinator Joel Ackelsberg, MD, MPH

EPA researchers have worked collaboratively with NYC DOHMH and NYC Transit to answer key gaps in capabilities to conduct effective sampling operations following a large biological incident within a highly urbanized area. EPA researchers, in collaboration with these partners, evaluated the compatibility of current surface sampling options, when applied to urbanized outdoor or underground (subway) surfaces, with current analytical methods for *Bacillus anthracis*. EPA researchers and NYC DOHMHC have also worked collaboratively to determine the potential utility of "Native Air Sampling" approaches, and their compatibility with analysis methods.

Because of this federal-local partnership, NYC personnel actively participate in project update teleconference meetings and provide critical input into the project's directions. In this way, NYC has access to research outcomes as they develop, and NYC has ensured that the project meets the city's emergency response needs. Ultimately, the project has resulted in an enhanced ability to conduct sampling and analysis operations for a large urban area following a *Bacillus anthracis* contamination incident.

Partners: North Carolina Department of Agriculture and Consumer Services (NCDA&CS)
Challenge: Disposal of contaminated animal carcasses following an agricultural emergency
Resource: A prototype transportable gasifier technology for on-farm disposal of animal carcasses
Project Period: 2014-2016

"EPA has served as the coordination point for both the research and the response efforts related to mass disposal. Actual event response and field testing identify real problems that cannot be properly identified or solved when designing or modeling in an office. Environment, material handling, human factors, size and volumes of actual events must be experienced not perceived. EPA understands these challenges and continues to assist states and industry in attempting to solve the problems and bring workable technologies. Continued research and development efforts of this type are critical to assisting industry in their efforts to protect the food chain." – NCDA&CS Jim Howard (retired)

Agricultural emergencies, such as foreign animal disease outbreaks, could result in the need to dispose of many contaminated animal carcasses. The environmental impacts of carcass disposal are site-specific. Some technologies (e.g., burial) are not viable in areas with a high-water table, such as North Carolina. Multiple disposal options are necessary. Gasification has the potential to be a technology for on-farm use, which reduces risk associated with transporting the carcasses to an off-site location (e.g., landfill, incinerator). It also has the potential to generate energy at agricultural sites during non-emergency times, and burns more cleanly thus requiring less pollution control equipment than conventional incineration.

As part of an interagency effort involving several federal agencies and the state of North Carolina, EPA built a prototype transportable gasifier intended to process 25 tons per day of carcasses (scalable to 200 tons per day) for on-farm disposal of animal carcasses. A demonstration was conducted to determine the feasibility of gasification for carcass disposal and to identify technical challenges and improvements to simplify and improve the gasifier as a mobile response tool. Past testing of the prototype demonstrated partial success, in that the transportability and rapid deployment requirements were met; however, the throughput of animal carcasses was approximately one-third of the intended capacity.

Significant modifications were made to various gasifier components, including the burner system, feed system, control system, power distribution and ash handling system, in order to increase its operating capacity to the rated design throughput. In September 2015, a series of tests were performed to evaluate the effectiveness of the design modifications at increasing the system's throughput, as well as to demonstrate the unit's ability to operate around the clock for an extended period of time. While the ash removal system and the system to move material across the bed failed during the tests, the new burner, feed, control and power distribution systems all functioned in an acceptable manner. The test and evaluation showed that improved alloys would be needed in some of the parts to achieve the desired results. EPA ORD's support has helped the NCDA&CS focus on which areas of the system require repair and additional modifications to achieve overall design goals.

Read the final report titled *Progress Report: Transportable Gasifier for On-Farm Disposal of Animal Mortalities (published 2016)*.

Partners: Washington Metropolitan Area Transit Authority (DC), Fort A.P. Hill Fire Department (VA), Lawrence Livermore National Laboratory (CA), Massachusetts Institute of Technology Lincoln Laboratories, Sandia National Laboratories (CA, NM), Virginia Commonwealth Department of Environmental Quality, Laboratory Response Network Laboratories (FL, MI, MN, NY, OH, VA), U.S. Department of Defense, U.S. Coast Guard
Challenge: Cleanup of a Bacillus anthracis contaminated subway
Resources: Full scale demonstration of technologies
Project Period: 2016-2018

"The work being done with the Underground Transportation Restoration Operational Technology Demonstration project has been critically important to helping Washington Metropolitan Area Transit Authority and other mass transit properties face the daunting preparedness challenges associated with an accidental or intentional release of a biological agent in the underground transportation environment. The project has helped inform our leadership in determining operational strategies that will lead to a more rapid return to service following such an event." – Homeland Security Investigations and Intelligence Bureau Metro Transit Police Department, CBRN Coordinator Brandon W. Graham

Following the 2001 Bacillus anthracis attacks, cleanup of the Hart Senate Office Building and Brentwood postal facility cost in excess of $1 billion, and it resulted in the Brentwood postal facility being closed for over two years. Since that time, EPA ORD has done a great deal of work to improve the nation's ability to cleanup buildings contaminated with Bacillus anthracis or other biological agents. In recognition of the complexities that would be involved, and the number of cities that have underground rail systems, EPA along with the Department of Homeland Security (DHS), the Department of Defense and several national laboratories turned their attention to the cleanup of subway systems that could be contaminated with Bacillus anthracis.

The Underground Transportation Restoration (UTR) Operational Technology Demonstration (OTD) was conducted during September 2016 at Fort A.P. Hill's Asymmetric Warfare Training Center to evaluate decontamination technologies that could be used in the event of an Bacillus anthracis incident in a subway system. The project used a non-pathogenic surrogate that behaves much like Bacillus anthracis spores in terms of how it is transported in the air, settles and how it can be killed. The project consisted of two rounds of background sampling, agent release, decontamination, sampling, waste removal and decontamination, and post-decontamination sampling. The technologies that were evaluated included a fogger that produced a fog from diluted bleach and a skid mounted sprayer that sprayed a liquid pH adjusted bleach solution. Both technologies were selected because they are off-the-shelf and could easily be purchased in an emergency.

A report was published in 2018 that thoroughly analyzed each step of the cleanup process (gathering of samples, cleanup methods, waste management) as well as cost associated with each. The results of this study concluded that there was no significant difference between the two cleanup methods. Utilizing approaches that reduce cost, such as composite sampling which decreases the need for labor and supplies, data management, sample shipment, and laboratory analysis, could make cleanup more manageable. The study noted that waste management is an integral piece of the cleanup process and should be determined both during pre-incident and response planning due to its impact on cost and logistics. This information was provided to DHS which has developed site-specific plans for San Francisco and New York as well as guidance that could be used in other cities.

Read the final report titled *Underground Transport Restoration (UTR) Operational Technology Demonstration (OTD).*

Partners: New York City FD, HAZMAT, PD (NY), Chicago FD (IL), Los Angeles FD (CA), Vermont DEP, Cherokee Co FD (NC), NJ DEP, Cincinnati FD (OH), Alexandria Fire (DC), Ohio EPA, Columbus City Council (OH)
Challenge: Remediation after a wide area radiological contamination
Resources: Full scale demonstration of technologies in collaboration with the U.S. Department of Homeland Security (DHS) and National Laboratories (DOE)
Project Period: 2015

"It's a great advantage to us to have the federal authorities look at these products, be able to test them, with input obviously from the local response organizations that are going to respond, to see what the best product on the market is." – Charlotte-Mecklenburg Emergency Management Coordinator Michael Tobin

EPA ORD, in collaboration with DHS and DOE National Laboratories, conducted the Wide-Area Urban Radiological Contaminant, Mitigation and Cleanup Technology Demonstration in Columbus, OH in June 2015. This demonstration provided first responders with options for response to a wide area radiological incident, such as a dirty bomb explosion or a nuclear accident, by showing the responders the operation feasibility of the tools in real time.

Five radiological decontamination technologies (including strippable coatings, gels and chemical foam) were demonstrated on an urban building. Decontamination technologies were applied to remove contaminants from the building's surfaces by physical and chemical methods. In addition, vehicle wash technologies as well as several approaches to contain wash water and radioactive particles were demonstrated. "Radiological contaminant mitigation" technologies are measures taken to reduce adverse impacts of radiological contamination on people and the environment, and to facilitate restoration of first responder services and critical infrastructure. Radiological contaminant mitigation technologies are designed for containing and removing radiological contamination on the surface in the first hours or days following a radiological event. Such technologies include "radiological particle containment," which is designed to prevent the spread of particles that might result from vehicle or foot traffic. Radiological particle containment technologies are applicable for early phase response to contain the radionuclides and to reduce radiation dose to responders and the public.

Radiological contaminant mitigation also includes "gross decontamination," which is performed with the goal of reducing contamination levels. This reduction may not meet final cleanup levels but may be useful to mitigate some public hazard or to contain contamination.

While no live radiological agents were employed in this demonstration, critical operational insight was gained by the response community. This event continues the applied radiological cleanup research conducted by EPA ORD at bench and pilot scales over the last several years. In attendance were senior officials from Ohio EPA, Columbus, OH City Council, first responders from the U.S. and Canada, as well as representatives from New York City, the Navajo Nation, the United Kingdom, the Federal Emergency Management Agency, Battelle Memorial Institute and others. Watch the Toolbox of Technology video to learn more.

Read the final report titled *Demonstration of Wide Area Radiological Decontamination and Mitigation Technologies for Building Structures and Vehicles.*

Partners: Colorado, District of Columbia, Mississippi, Oklahoma, Tennessee, Vermont and Wisconsin state environmental and/or public health agencies
Challenge: Enabling state and local communities to rapidly respond to ricin contamination
Resource: Technical assistance to aid field and laboratory approaches for sampling and analysis, operationally applying decontamination methods, and strategically handling wastes
Project Period: 2013-2019

"Working with the EPA in response to this Ricin incident proved to be invaluable. They provided remediation expertise and testing resources that saved our agency significant staff time. Thanks to their support, the property was appropriately decontaminated, eliminating any potential for future concern. Further, their knowledge and availability helped to ensure that we could quickly respond to the needs of the community."
– Boulder County Public Health, Water Quality and Hazardous Waste Coordinator Erin Dodge

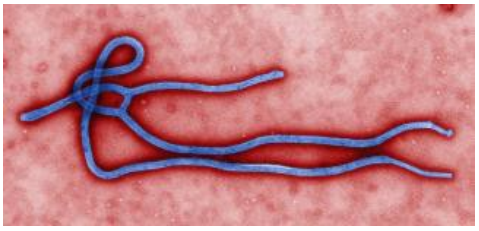
Ricin is a deadly biological toxin that is easily produced from castor beans, making it one of the most worrisome biological threat agents. Multiple ricin incidents occurred following episodes in the popular television show "Breaking Bad" that featured its production. EPA ORD researchers and subject matter experts from the CBRNE Consequence Management Advisory Division in EPA's Office of Land and Emergency Management/Office of Emergency Management were called upon by EPA Regions 1, 3, 4, 5, 6 and 8 to support various state and local communities during independent ricin incidents spanning several years (2013 to 2019). EPA researchers developed innovative applied solutions to the challenges encountered during the first ricin responses leading to significantly shortened response times and decreased costs and resources required for the subsequent ricin incidents. The developed tools provide the federal government with important new capabilities for helping states and local communities respond to ricin incidents.

As one recent example, EPA ORD researchers rapidly supported EPA Region 8's (Mountains and Plains) response to a ricin incident at a condominium in Boulder, Colorado. The applied solutions directly informed the sampling plan, sample analysis, decontaminant selection, decontamination of responders and their equipment, and handling of the ricin waste. Because the laboratory used ORD's recently developed sample processing (sample cleanup and concentration) method, some post- decontamination samples indicated that ricin was still present in the condominium; these method removed analytics interferences and, thereby, increased the capability to detect ricin in environmental samples. This information enabled state decision makers to determine that further decontamination of the unit was required to protect public health. Without this research, the condominium could have been declared clean and safe for re-occupancy when in fact ricin would have remained.

These efforts enabled the states and local communities to rapidly respond to ricin contamination incidents and effectively clean up the affected areas. EPA researchers helped close scientific gaps, transition scientific solutions, and enabled the states and local communities to be ready to rapidly respond to the next ricin or other biotoxin incident.

Read the journal article produced from this project titled *Sample Processing Approach for Detection of Ricin in Surface Samples* (published 2017).

Partners: Maryland Department of Health and Mental Hygiene (DHMH), New York State Department of Environmental Conservation (NYSDEC)
Challenge: How best to decontaminate materials and manage waste and wastewater contaminated with the Ebola virus
Resources: Technical assistance
Project Period: 2014-2016



"During the 2001 and 2006 anthrax incidents in New York City and the 2014 Ebola crises, New York state reached out to EPA ORD and Region 2 staff for their experience and acumen to collaborate on creating a 'complete waste solution.' This involved designing training sessions, developing a computerized decision support tool (I-WASTE), a NYC Environmental Response and Remediation Plan for Biological Incidents, and conducting and publishing research on the ability of commercial autoclaves to treat thermally resistant anthrax spores and the triple packaging used for transport of highly infectious agents. EPA ORD and Region 2 staff have been responsive to all of our state's requests for assistance. Collaborative efforts by EPA and the NYSDEC have contributed significantly in the management of biohazardous waste that has been both timely and crucial to protecting public health and the environment in New York State and nationally." – NYSDEC Division of Materials Management Research Scientist Alan Woodard, PhD

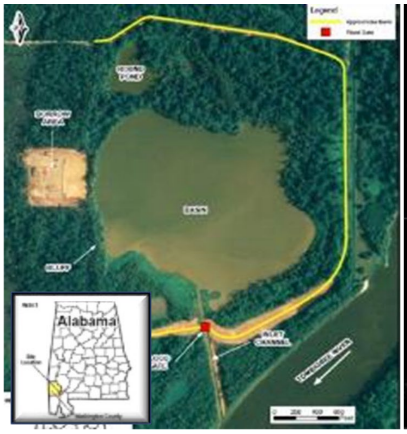
In 2014, there was an outbreak of Ebola cases in the United States. EPA ORD researchers were called upon to provide technical support to states in responding to the emergency. EPA ORD scientists provided technical support related to decontamination products and best ways to use them. They also delivered expert recommendations for best decontamination methods for personal protective equipment, a critically important issue for health care workers and others who came into contact with Ebola patients. EPA ORD provided instruction on how waste contaminated with the Ebola virus should be managed and the fate of the virus in wastewater. In addition, EPA ORD participated in a workshop with the Maryland DHMH and contributed to the National Security Council's development of the *Multi-Agency Interim Guidance on Management of Wastes containing Category A Infectious Agents*, such as Ebola. With EPA ORD technical support and assistance, Maryland and New York were in a better position to address the challenges associated with managing waste from the Ebola crisis.

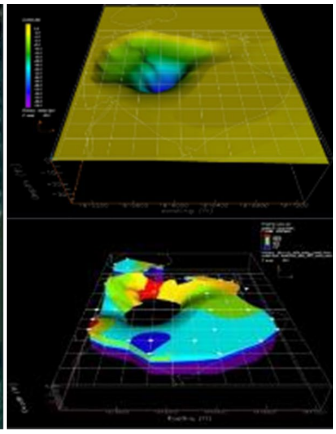
In November 2019 the Maryland Department of Health's Environmental Health Bureau released the report from the 2017 Workshop on "*Managing Highly Pathogenic Medical Waste: Finding a Way Forward*" in which ORD participated. The report, which highlights some of the challenges and opportunities for Maryland in addressing Category A infectious waste, will be particularly relevant for those interested in preparing for the possibility of highly pathogenic emerging infectious diseases in the hospital or community setting.

The report can be accessed on the Maryland Department of Health's Special Medical Waste page.

SUPERFUND AND CONTAMINATED SITE REMEDIATION

Partners: Alabama Department of Environmental Management (ADEM); McIntosh (Washington County), AL
Challenge: Cleanup of a complex site containing hazardous chemicals in various environmental media (soil, sediment, groundwater, surface water) and buried wastes
Resource: High resolution site characterization and analyses of site-specific contaminants of the Olin project, in collaboration with the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Services (FWS), the U.S. Geological Survey (USGS), and the U.S. Army Corps of Engineers (USACE)
Project Period: 2007-Present





"EPA ORD's efforts on the Olin project were essential to understanding the science of the contaminants of concern and the potential effects on target species. This information allowed the project team to make informed decisions on the most impactful approach forward. As the state project manager during those efforts, ORD's involvement was beneficial." – ADEM Section Chief Sonja B. Favors

The Olin Corporation McIntosh plant is an active chemical production facility that has been producing chlor-alkali chemicals since 1952. The site was listed on the National Priority List of Superfund sites in 1984. Site operations have resulted in contamination of soil, sediment, groundwater and surface water. EPA researchers, in collaboration with Region 4 (Southeast), the state of Alabama (ADEM) and industry conducted a risk assessment to determine the current and future effects of the site's contaminants on human health and the environment, identify exposure pathways, and calculate total site risk.

EPA researchers, working with subject matter experts from NOAA, FWS, USGS, and USACE, provided innovative measures for high resolution site characterization and analyses of site-specific contaminants (insecticides and other emerging contaminants) in different media. Presently, researchers are supporting identifying, tracking, and controlling sources of contamination to the site, and establishing a baseline for conducting post-cleanup effectiveness assessments. EPA researchers also continue to provide technical support for evaluating and assessing sampling methodologies, treatment technologies, and other options for the cleanup of the site.
Researchers are basing technical support on current research, development and evaluation of physical, chemical, and biological processes with the goal to reduce risk to public health and environment.

More information can be found on the Olin Chemical Superfund Site profile.

Partner: Arizona Department of Environmental Quality (ADEQ)
Challenge: Jet fuel contamination of soils and aquifer at the former Williams Air Force Base Superfund Site
Resource: Technology transfer and technical support for remediation of jet fuel, in collaboration with the U.S. Air Force (USAF)
Project Period: 1998-2016

"The ADEQ appreciates the support EPA ORD has provided at the former Williams Air Force Base Site (ST012 former fuel depot jet fuel release site). ORD personnel provided a comfort level to ADEQ to the extent that ADEQ could confidently champion innovative technology use at this site." – ADEQ Environmental Associate Engineer Wayne Miller

The former Williams Air Force Base in Mesa, Arizona, was commissioned as a flight training school in 1941, and pilot training was its primary mission throughout the history of the base. Fuel storage and distribution operations were conducted at the site (known as ST012), and releases from these systems contaminated the underlying soil and groundwater. The fuel reached depths of approximately 240 feet below ground surface, before the groundwater started rising, smearing the fuel within the aquifer. The base was closed in 1993, and the majority of the property has been converted to the Phoenix-Mesa Gateway Airport and college campuses, among other uses.

Around 1998, EPA Region 9 (Pacific Southwest) and ADEQ requested technical support from EPA ORD to discuss steam enhanced extraction (SEE) with the USAF as a potential remedy for the ST012 fuel spill. With continued technical support from ORD, a pilot study steam injection was implemented in 2008, which recovered an estimated 10,000 gallons of jet fuel. Based on the success of this pilot, a larger scale SEE remediation was initiated in 2014, and operations continued until early 2016. Three different vertical zones of the aquifer were treated, ranging from 140 to 240 feet below ground surface. The total volume of the treatment area was 410,000 cubic yards. More than 300 million pounds of steam were injected, and more than 2.6 million pounds (388,000 gallons) of petroleum hydrocarbons were recovered. The recovered jet fuel was burned in a thermal accelerator or recycled.

EPA ORD technical support for this project included assistance in choosing steam injection as the remedial technology, review of all technical documents (including the design and the remedial action work plan), monitoring the implementation of the technology, and oversite of the implementation of enhanced bioremediation as a polishing step. This technical support has been instrumental in EPA Region 9, the USAF and ADEQ moving forward in cleaning up the impacted areas of Williams Air Force Base.

More information can be found on the Williams Air Force Base Superfund Site profile.

Partners: Delaware Department of Natural Resources and Environmental Control (DNREC); Kent County Economic Development; City of Dover Planning, Inspections, and Community Development
Challenge: Informing decision makers on potential impacts on health, food access, and economic development from brownfield revitalization in the City of Dover
Resource: Rapid Health Impact Assessment (HIA) in partnership with EPA Region 3 and the Office of Brownfields and Land Revitalization (OBLR)
Project Period: 2017-2018

"The rapid HIA for the Chesapeake Utilities site provided the opportunity to envision a more positive future for this former brownfield. The process challenged all of the partners to think not only about bringing this property back into a productive state, but also about the many benefits healthy food production and access will bring to the community. We all appreciate the leadership and expertise EPA provided for this project." - David Edgell, Principal Planner, Office of State Planning Coordination, State of Delaware

"The city has been working on housing and crime issues, but without adequate access to healthy foods, these households would still struggle; the rapid HIA provided a setting which made cross-disciplinary discussions possible."- Dave Hugg, Director, Planning, Inspections and Community Development, City of Dover

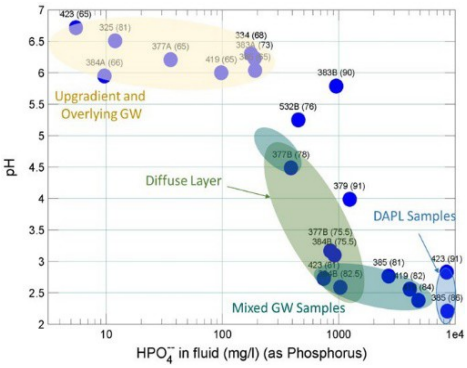
The City of Dover, Delaware and Kent County sought to redevelop a vacant and formerly contaminated property, or brownfield, to spur revitalization in the downtown Dover area. Given a desire to increase food access in and around Dover, local and state officials sought assistance with examining a cleaned brownfield site for economic development through food production; of particular interest was an integrated fish and plant farming option known as aquaponics. An EPA Region 3 (Mid-Atlantic) land revitalization project developed an Aquaponics Business Plan User Guide to assist communities facing the challenge of identifying and implementing reuse alternatives for brownfields.

A Health Impact Assessment (HIA) is a systematic process that uses various data sources, analytical methods, and input from stakeholders to determine the potential effects of a proposed policy or project on the health of a population and provides recommendations on managing those effects. EPA ORD hosted a training workshop on the HIA process for EPA Region 3 and interested parties from Delaware State University, the City of Dover, Kent County, and Delaware State governments, including the Department of Health and Social Services and DNREC. Building on the successes of the Aquaponics User Guide and HIA workshop, EPA staff (from ORD, OBLR, and Region 3) agreed to work with local and state officials and community partners to conduct an HIA in July 2017.

EPA ORD has piloted a rapid HIA – an abbreviated form of HIA – for partners to select among brownfield revitalization projects to improve food security in Dover. ORD staff guided the HIA process and utilized a mixed methods approach to evaluate the health impacts, including qualitative and quantitative data, geographic information system (GIS) and epidemiologic methods, and literature review. An HIA report has been developed that documents the HIA analyses, findings and recommendations for the City of Dover to consider public health when making decisions related to the revitalization project. This report also outlines opportunities for further development and future assessments.

Read the final report titled *Former Chesapeake Supply Brownfield Revitalization: Rapid Health Impact Assessment*.

Partner: Idaho Department of Environmental Quality (IDEQ)
Challenge: Groundwater geochemistry study at the Simplot Operable Unit, Eastern Michaud Flats Superfund Site
Resource: Technology transfer and technical support for understanding groundwater geochemical processes at a phosphoric acid plant
Project Period: 2013-2016



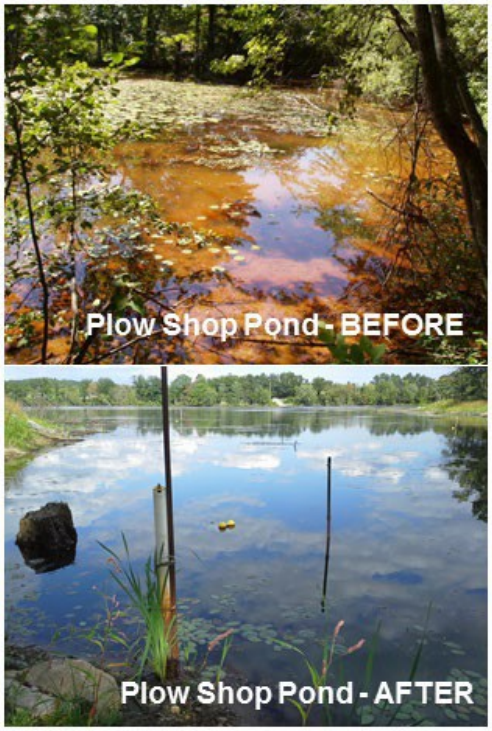
"The subsurface investigation at the Don Plant was an important step in better understanding the nature and sources of low pH dense aqueous phase liquids (DAPL) present in the Phosphoric Acid Plant (PAP) area. The results of this investigation, along with evaluation of monthly monitoring results from selected wells in the PAP, helped identify that more than one type of low pH DAPL was pooling on top of the clay in late 2015 and 2016 – one DAPL was high in phosphorus and the other was high in sulfate, suggesting separate process sources." – IDEQ Pocatello Region Mining Project Manager Margaretha English

The Don Plant fertilizer manufacturing facility is part of the Eastern Michaud Flats Superfund Site. It is a phosphoric acid/liquid plant located near Pocatello, Idaho. Process liquids released from the plant site, which are relatively dense and low-pH aqueous solutions, have migrated vertically through the groundwater column to the top of the American Falls Lake Bed clay layer. The dense aqueous phase liquid forms pools and migrates along the top of the clay layer towards the Lower Portneuf River. In order to control contaminant migration, groundwater extraction wells are pumped to recover the dense aqueous fluids. However, mineral solids precipitate as a result of pumping within the groundwater extraction wells. The mineral precipitation is sufficient to hamper the effectiveness of the pumps, in some cases even spark failure. The concern was to understand the geochemistry within the aquifer that was causing these wells to foul and to develop solutions to keep these extraction wells operating to reduce contaminant mass from moving towards the Lower Portneuf River. Additional data were needed to identify the cause of mineral precipitation and develop a plan to address the pump fouling issue when the groundwater extraction system is operating.

EPA Region 10 (Pacific Northwest) and the IDEQ first requested EPA ORD technical assistance in 2015 to support the development of a work plan designed to better understand the pump fouling problem. Technology transfer efforts by ORD scientists and the IDEQ/Region 10 team resulted in a plan to sample, analyze and identify mineral precipitates and develop a geochemical model that could predict mineral precipitation in the extraction wells.
ORD scientists continued to provide technical assistance as the study data were obtained, and they reviewed the technical aspects of the data analysis and modeling. Recommendations were provided to possibly reduce or prevent mineral fouling in the extraction wells. To date the extraction wells have helped mitigate downgradient migration of dense fluids.

More information can be found on the Eastern Michaud Flats Superfund Site profile.

Partners: Massachusetts Department of Environmental Protection (MassDEP), Massachusetts Development Finance Agency (MassDevelopment)
Challenge: Defining the extent and nature of contaminant impact to groundwater and a recreational lake from a landfill at the Former Fort Devens; providing technical analysis of viable alternatives to stop contaminant impacts to off-site public and private properties
Resource: Applying novel methods for detailed assessment of groundwater and contaminant movement in a complex setting, in collaboration with the U.S. Army
Project Period: 2014-Present



"EPA ORD's involvement has been essential to the ongoing development of a groundwater model that can be used to support a remedy modification. Because of the technical complexity and importance of this project, it is doubtful that the results from the model could be accepted by the state without EPA ORD's participation." –MassDEP Devens Project Manager David Chaffin

The Former Fort Devens made use of an onsite landfill for solid waste generated during several decades of operations. The landfill was not equipped with a system to prevent release of landfill leachate into the underlying aquifer. The resulting contaminated groundwater has since moved beyond the base property, impacting an adjacent recreational lake (Plow Shop Pond) and the aquifer underlying the Town of Ayer, MA.

EPA ORD, in collaboration with EPA Region 1 (New England) and the U.S. Army, implemented a monitoring program during 2005-2008 to clearly define the location and nature of impact to Plow Shop Pond.
This established that contaminated groundwater entering the lake was caused by leachate migration from the eastern edge of the landfill, causing contamination of lake sediment and water.

The multi-year effort included installation of supplemental monitoring locations and collection of detailed chemistry data to define the source of arsenic contamination observed in the lake. Confirmation that the landfill was the source of contamination led to construction of a remedy in 2013 to remove existing and prevent future contamination of the lake. Subsequent work (2014-2019) evaluated improvements in lake water and sediments in response to the 2013 remedy. Continued work will evaluate the success of the interim groundwater remedy installed at the northern edge of the landfill and allow stakeholders to select a permanent solution to address contamination impacting groundwater under the Town of Ayer, MA.

More information can be found on the Fort Devens Superfund Site profile.

Partner: Massachusetts Department of Environmental Protection (MassDEP)
Challenge: Chemical contamination of soils and aquifer at the General Chemical Corporation facility
Resource: Technology transfer and technical support for remediation of chlorinated solvents and petroleum hydrocarbons
Project Period: 2012-2017

"MassDEP greatly appreciates the expert advice we have received from EPA ORD on the General Chemical TSDF assessment and cleanup plans. MassDEP has been assisted with technical support from ORD for this site since 2012. At each point, ORD has provided valuable input, particularly with respect to the merits of thermal and chemical oxidation remedies. It has been a great service to the state program to receive the views of national experts on these complex investigative and remedial issues." – MassDEP Bureau of Waste Site Cleanup Steve Johnson

From 1960 to 2012, General Chemical Corporation (GCC) operated a permitted Treatment, Storage and Disposal Facility (TSDF) with waste management operations that included the storage and repackaging of bulk virgin solvents for resale, and the storage and consolidation of hazardous and nonhazardous wastes. The facility is the location of multiple historical releases. Contaminants include both petroleum hydrocarbons and chlorinated solvents, which impact the soils and groundwater at the facility. The contamination extends off site to former residential properties, under a wetland, and contaminants discharge to a drainage ditch that flow into a brook. A public elementary school abuts the site to the west/northwest.

In 2012, MassDEP requested technical support from EPA ORD to review the Remedy Implementation Plan prepared for the site by GCC's consultants. ORD scientists and engineers recommended that additional site characterization be carried out to better define the extent of the contamination, and then that the potential remedial actions be re-evaluated. MassDEP required the recommended additional site characterization, and ORD reviewed and commented on the subsequent Data Gap Action Plan Report (2013) and Remedial Action Plan (2016). The re-evaluation of remedial actions based on the additional characterization information led to a change in the recommended remedy for the site.

ORD's technical support helped lead to thermal remediation being chosen as an appropriate main remedial technology for the site due to the large contaminant mass that is present. Suitable remediation will lessen the various threats posed by the contaminants to the environment and human health.

Partner: Minnesota Department of Natural Resources (DNR)
Challenge: Determine the impact of wetland remediation and restoration on health
Resource: Health Impact Assessment (HIA) of a restoration site in the St. Louis River
Project Period: 2016-Present

"Through the HIA, EPA's team brought in a wide variety of methods and metrics capable of assessing these, and other, objectives as they relate to important health pathways. The HIA team involved members of the community through an extensive public input process, which was important as the Project areas are in close proximity to residential neighborhoods. EPA's assessments resulted in recommendations that were integrated into the Project design. We feel that the HIA process and products were a valuable addition to this Project's development."
—Minnesota DNR Habitat Coordinator Melissa Sjolund

Under the U.S.-Canada Great Lakes Water Quality Agreement, Areas of Concern (AOCs) are coastal communities that have lost beneficial uses of their aquatic resources owing to the presence of legacy pollution, especially contaminated sediments. The St. Louis River AOC along the Minnesota and Wisconsin border includes numerous remediation sites. In one phase of the cleanup, Minnesota DNR plans to address a large wetland remediation and restoration project at Kingsbury Bay and Grassy Point. The project will include excavating 350,000 cubic yards of sediment as well as restoring two stream channels, numerous coastal wetlands, and extensive shoreline habitat, including removing non-native species. The 200-acre site is considered important to the City of Duluth, Minnesota as a critical element to the revitalization of the community. The location provides a unique opportunity to enhance recreation and tourism, as well as improve quality of life in the adjacent neighborhoods.

At the request of stakeholders, EPA ORD conducted a Health Impact Assessment (HIA) for the project to consider the public health implications of both the environmental changes and the subsequent park amenities. Those amenities include trails, boardwalks, fishing piers, birding platforms, a new swimming beach, and improved boat access. Pathways through which the proposed projects could potentially impact health were identified based on input from stakeholders, community members, and scientific researchers, and using a mix of scientific methods. The health benefits from the project are likely to include reduced risk of chronic disease, reduced stress, increased social cohesion, and improved well-being.

Recommendations to improve the health- related outcomes include conserving existing high-quality wetlands and focusing efforts on areas with highly degraded conditions, the creation of sediment and vegetation management plans, increased communication about safety, the protection and enhancement of culturally important resources, and encouraged dialogue with neighborhood residents and user groups about changes to the existing parks. Recommendations from the HIA were incorporated into project design and implementation for the remediation and restoration work led by Minnesota DNR, which began in 2019. Also, recommendations from the HIA are being used in the upland vegetation design for Grassy Point.

More information on the Kingsbury Bay-Grassy Point Habitat Restoration project can be found on the Minnesota Department of Natural Resources' website.

Partner: Montana Department of Environmental Quality (DEQ)
Challenge: Remediation activities for Barker Hughesville Superfund Site
Resource: Technical Investigation in collaboration with the U.S. Forest Service (USFS) and EPA Region 8
Project Period: 2009-2016

"DEQ collaboration with EPA Region 8 and ORD at these two Superfund sites had enabled us to coordinate between the sites and to consider the effectiveness of pilot tests at locations across the sites." - Keith Large, Montana DEQ State Project Officer

EPA ORD provided technical assistance to Region 8 in their effort to evaluate ongoing and future remediation activities for the Barker-Hughesville and the Carpenter Snow Creek Superfund Sites located within the Helena-Lewis and Clark National Forest in Cascade and Judith Basin Counties, Montana.

Barker Hughesville
Barker Hughesville is a 6,000-acre site, where commercial mining operations were carried out between 1879 to 1940s. These operations left several hundred thousand cubic yards of mine waste distributed among 46 known abandoned mines and along nearby creeks. Both private and U.S. National Forest Service (USNF) land is impacted. The site also contains 17 adits that discharge mine water that contaminates nearby surface water bodies.

Carpenter Snow Creek
Carpenter Snow Creek site is a 9,000-acre site, where commercial mining operations were also carried out between 1879 to 1940s.

Together, the operations left over 1.2 million cubic yards of mine waste distributed among 90 known abandoned mines and nearby creeks impacting both private and National Forest Service administered lands. The site also contains 22 discharging adits of various water quality.

Due to the widespread nature of contaminated soil, sediment, streamside deposits, surface water and groundwater with arsenic, copper, zinc, cadmium. manganese, thallium and lead, both sites were listed on the National Priority List of Superfund sites in 2001. While EPA has the lead on the Remedial Investigation and Feasibility Study at the Barker Hughesville site, Montana DEQ is developing the Remedial Investigation and Feasibility (RI/FS) for the Carpenter Snow Creek site. ORD has collaborated with Region 8, DEQ and the USFS in the evaluation of mine water treatment performed using sulfate-reducing bacteria to remove sulfate and metals in water collected at the adit of Big Seven Mine and Haystack Mine located in the Carpenter Creek site. Mine water was collected by DEQ's contractor and shipped to ORD's laboratory facilities in Cincinnati, Ohio for bench- scale testing. ORD has also helped Mt Emmons Mining Company, EPA Region 8, USFS and DEQ with evaluating the effectiveness of sulfate-reducing bacteria in treating water at the Danny T mine in Barker Hughesville where Mt Emmons Mining Company is under and EPA order to conduct these laboratory tests. Additionally, ORD has collaborated in providing technical comments on the feasibility studies of the remediation of several abandoned mines and the overall remediation approach at both sites.

More information can be found on the Barker Hughesville Superfund Site profile.

Partner: Nevada Division of Environmental Protection (DEP)
Challenge: Groundwater characterization and remediation at the Anaconda Mine Site (Lyon County)
Resource: Technical assistance and review of groundwater background conditions and groundwater characterization to assess the amount and type of groundwater contamination
Project Period: 2004-2016

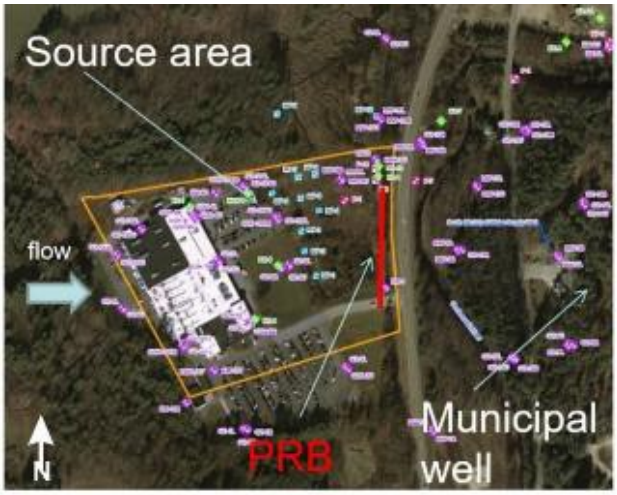
"ORD's technical assistance has been essential in characterizing the complex hydrogeological conditions and extent of groundwater contamination at the Anaconda Mine Site, setting the stage for evaluation of remedial options." – Nevada DEP Administrator Greg Lovato

The Anaconda Mine Site has uranium and previous copper ore mining. Hydrology at the Anaconda Mine Site is complex and subject to significant uncertainty, particularly with respect to the effects of local hydrology on long-term contaminant migration. Since naturally occurring sources of uranium and sulfate exist in the area, establishing background concentrations of uranium and sulfate in groundwater is also critical to understanding the extent and magnitude of groundwater contamination.

EPA ORD has provided technical assistance on and reviews of estimated background concentrations of site constituents, groundwater characterization, and groundwater/geochemical modeling efforts, as well as technical analyses that will be used to evaluate possible remediation options. Nevada DEP Abandoned Mine Land Program, in conjunction with EPA Region 9 (Pacific Northwest), is using the analyses provided by ORD to help design both better remediation strategies and better monitoring systems for the abandoned mine complex.

More information can be found on the Anaconda Copper Mine Superfund Site profile.

Partner: New Hampshire Department of Environmental Services (NHDES)
Challenge: Suitable groundwater remediation technologies at the South Municipal Supply Well Superfund Site
Resource: Technology transfer and technical support for permeable reactive barrier & thermal remediation
Project Period: 2009-Present



"EPA ORD personnel have provided invaluable technical support to the South Municipal Well government team."
– NHDES Waste Management Division Kenneth Richards

The South Municipal Water Supply Well Superfund Site located in Peterborough, New Hampshire, includes the New Hampshire Ball Bearings (NHBB) property, adjacent wetlands, commercial/residential properties, and the South Municipal Water Supply Well. Installed in 1952, the South Well provided water to Peterborough for nearly 30 years. In 1982, concentrations of volatile organic compounds were detected in the South Well at levels above 100 parts per billion and use of the well discontinued. Initial groundwater and soil cleanup actions at the site included in-situ vacuum extraction and groundwater pump-and-treat using air stripping and carbon adsorption. In 2010, revised groundwater remedies were initiated to include a combination of two treatment technologies: 1) thermal remediation within targeted source areas, and 2) in-situ groundwater treatment using a zero-valent iron permeable reactive barrier (PRB).

NHDES and EPA Region 1 (New England) first requested EPA ORD technical assistance in 2009 for information on innovative remediation technologies, including thermal, enhanced bioremediation, and PRB applications. Technology transfer efforts by ORD personnel resulted in recommendations on bench-scale studies, site characterization and monitoring requirements, and implementation of the thermal and PRB remedies. In 2014, the PRB was installed along the alignment of the former Boston & Maine Railroad (B&M) line to intercept and treat groundwater contaminants emanating from the eastern NHBB property line. Thermal remediation using Electrical Resistance Heating technology was completed in 2016. Approximately 5,000 pounds of tetrachloroethylene (PCE) were removed from the subsurface. ORD personnel continued to provide technical assistance to the NHDES and EPA Region 1 teams by helping to determine the effectiveness of the thermal and PRB remedies, and in determining the location of other source areas that require treatment.

Recent groundwater data collected from the site show that the PRB is failing to meet specified treatment criteria. Current technical transfer efforts being provided include: assistance in interpreting site data; recommendations on study designs for characterizing groundwater and solid-phase properties; and analytical support to help diagnose the cause of the unanticipated inadequate treatment performance.

More additional can be found on the South Municipal Supply Well Superfund Site profile.

Partner: New Hampshire Department of Environmental Services (NHDES)
Challenge: Suitable technologies to remediate waste oils and chlorinated solvents at the Beede Waste Oil Superfund Site
Resource: Technology transfer of Steam Enhanced Extraction and technical support for thermal remediation of waste oils
Project Period: 2007-Present

"U.S. EPA ORD personnel have provided invaluable technical support to the Beede Waste Oil Government team." – Ken Richards, New Hampshire Department of Environmental Services

The Beede Waste Oil Superfund Site is located in Plaistow, New Hampshire, within a predominantly residential area. Prior commercial operations at the site, which began in 1926, included storage and distribution of fuel oil and recycling of used oil. Spills, leaks from storage tanks, and discharges to lagoons on the site created subsurface plumes of light nonaqueous phase liquids (LNAPL) that contained a wide variety of petroleum hydrocarbons, polychlorinated biphenyls (PCBs), and chlorinated solvents. The Record of Decision (ROD) chose soil vapor extraction to remediate the smear zone of LNAPL, with a contingency for thermal enhancements if it was determined during the design stage that this was needed in order to meet the site soil cleanup goals. The ROD also included a groundwater extraction system to extract the downgradient dissolved phase plume.

In 2007, NHDES and EPA Region 1 (New England) requested EPA ORD technical assistance to aid in determining if a thermal enhancement to the groundwater extraction system would be required to meet soil cleanup goals, and if so, which of the thermal technologies would be most applicable to this site. In addition, ORD personnel provided technical support on delineation of the area to be treated using thermal remediation.

In 2010, ORD completed a bench scale treatability study that demonstrated that steam injection remediation of the soils was capable of reducing contaminant concentrations to meet the cleanup criteria. Subsequently, Steam Enhanced Extraction (SEE) was chosen as the remediation technique for the two LNAPL-contaminated areas that were delineated by the site characterization activities. From 2015 to 2016, SEE was used to successfully meet the soil cleanup criteria in the Phase 1 area, with the injection of 28.7 million pounds of steam and the recovery of more than 150,000 pounds of contaminants. In late 2018, steam injection was initiated in the Phase 2 treatment area, and this remediation was completed in the Fall of 2019 with the attainment of the soil cleanup goals. Approximately 66.3 million pounds of steam were injected in the Phase 2 area, and 177,300 pounds of contaminants were recovered.

More information can be found on the Beede Waste Oil Superfund Site profile.

Partners: New Mexico Environment Department (NMED), New Mexico Tech, University of Iowa, and Ohio State University
Challenge: Environmental sampling and assessment of local waterways and sediments following Gold King Mine Spill
Resource: Center for Native American Environmental Health Equity Research
Project Period: 2015-Present

"ORD's support of the Center for Native American Environmental Health Equity Research has helped NMED reach out to and coordinate with Navajo Nation communities that were affected by the Gold King Mine spill," – Dennis McQuillan, Chief Scientist, NMED

In 2015, about 3 million gallons of contaminated waste water from the Gold King Mine spilled into the Animas River impacting several tribes and states. Following the spill, a team of researchers from the University of New Mexico Center for Native Environmental Health Equity Research and New Mexico Tech, in collaboration with the New Mexico Environment Department (NMED), performed a sampling trip collecting water and sediment samples from Silverton, CO to Farmington, NM. The results obtained from this work were presented at the Environmental Conditions of the Animas and San Juan Watersheds conference (Farmington, NM; May 17-18, 2016) which was co-organized by their collaborator from NMED and other staff from the New Mexico Water Resources Institute and institutions from the state of New Mexico.

As a result of this work, the Center, in collaboration with NMED, the University of Iowa, and The Ohio State University, initiated an investigation of the mineral phases and metal release by microbiological activity from sediments collected along the Animas River after the spill which impacted the Navajo Nation. Additionally, NMED has utilized the information generated by the Center to propose a long-term monitoring program that has been partially funded by EPA.

- Post Gold King Mine Spill Investigation of Metal Stability in Water and Sediments of the Animas River Watershed (published 2016)
- Gold King Mine Water Spill Long-Term Monitoring Plan (published 2017)

The EPA ORD-supported Center for Native American Environmental Health Equity Research, jointly funded by EPA and NIH, was established to address pervasive environmental health disparities. The Center's primary focus is biomedical and environmental research and Native-focused community engagement. The research team aims to expand their understanding of mixed-metal toxicity and enhance confidence in the characteristics of the metal exposures and the populations that influence the generalizability of the results.

Partner: South Carolina Department of Health and Environmental Control (SC DHEC)
Challenge: Developing and piloting effective strategies to target and treat subsurface chlorinated solvent contamination in zones containing numerous subsurface impediments
Resource: Pilot study including design, construction and deployment of in-situ chemical oxidation (ISCO) technology in collaboration with the U.S. Marine Corps and the U.S. Navy
Project Period: 2012-2017


"Contaminated groundwater poses significant challenges to states. Development of new and innovative ways to treat it in situ is extraordinarily beneficial. We appreciate the availability of ORD expertise to partner with our state experts on this project, and we look forward to future opportunities to engage in collaborative problem-solving work." - SC DHEC Director of Environmental Affairs Myra C. Reece

EPA ORD is collaborating with multiple agencies to produce a pilot-scale demonstration of in-situ chemical oxidation (ISCO) technology at the U.S. Marine Corp Recruit Depot in Parris Island, SC.

Spills and leaks of perchloroethylene (PCE), a colorless liquid widely used in the dry cleaning of fabrics, leaked into sanitary sewers resulting in groundwater contamination that is threatening nearby wetlands. The site is underlain by numerous utilities (high pressure water main, high voltage power line, communication line, sanitary and storm sewers, overhead steam lines) and involves high pedestrian and automobile traffic. Rigorous site characterization was used to develop an accurate site conceptual model using an array of aquifer cores and micro-wells to sample groundwater. Relative to conventional groundwater monitoring, more than 60% of the aquifer requiring ISCO was eliminated due to the development of an accurate conceptual site model.

ORD designed, built and deployed a portable, multi-arm, low cost and efficient oxidant injection system. The injection strategy optimized oxidant delivery and distribution in high priority targeted zones. Rigorous monitoring of PCE and the sodium permanganate oxidant helped to focus subsequent injections and to assure hydraulic control of the oxidant. ISCO has been selected by the partnering team for remediation at the site, and recommendations have been provided for design and deployment of full-scale remediation.

Read the final report titled *Pilot-Scale Demonstration of In-Situ Chemical Oxidation Involving Chlorinated Volatile Organic Compounds - Design and Deployment Guidelines (Parris Island, SC, U.S. Marine Corp Recruit Depot, Site 45 Pilot Study)* (published 2017).

Partner: Washington State Department of Ecology
Challenge: Upper Columbia River contaminated site
Resource: Technical support for remedial investigation/feasibility study
Project Period: 2018-Present

"Washington is addressing surface soil legacy smelter-emission impacts across a range of communities and settings spanning the state. The assessment of state-of-the-art, minimally disruptive exposure reduction surface treatment technologies for rural-residential and rural tribal-use settings common to the upper Columbia River Valley is a fundamental step toward identifying long- term cleanup measures. ORD's participation is highly valued to ensure honest assessment, input and multi-disciplinary scientific oversight." – Washington State Department of Ecology, Toxics Cleanup Program, Upper Columbia River Site Project Coordinator John Roland

EPA ORD, in coordination with Region 10 (Pacific Northwest), is providing technical support for the Upper Columbia River (UCR) Valley Superfund Site's remedial investigation/feasibility study. EPA ORD is a member of the UCR Soil Amendment Technologies Evaluation Study technical team established through the interaction of the Coleville Confederated Tribes, Washington State Department of Ecology, Teck Resources Limited, Ramboll Environ and EPA Region 10. EPA ORD is engaged as a third-party to provide an unbiased, scientific assessment of, and expertise on, soil amendment alternatives for soil lead and associated metals in the UCR area. Amendment alternatives being evaluated include phosphate, magnesium oxides, ECOBOND®, compost, biochar and other widely accepted treatment options for lead in soil.

At this point, EPA has provided input on potential alternative treatments for the site and provided input on testing that could be done to predict treatment suitability/effectiveness at the site. EPA ORD also participates in site meetings and teleconferences with the region, state and potentially responsible party to discuss the site soils and alternative soil remediation approaches.

For more information, go to the Upper Columbia River Remedial Investigation and Feasibility Study webpage.

Partner: Idaho Department of Fish and Game (IDFG), Washington State Department of Ecology
Challenge: Development of a passive remediation alternative at the Bunker Hill Superfund Site (Lane Marsh)
Resource: Technical Investigation
Project Period: 2015-Present

"Abundant natural resources and clean functioning ecosystems are highly valued by local and regional residents and a huge part of why we choose to live here. The IDFG is committed to restoring healthy and productive ecosystems in the lower basin. We are happy to have been able to support and partner with EPA ORD in the effort to find new, innovative, and cost-effective approaches to the wildland contamination problems we face there." – IDFG Regional Wildlife Habitat Biologist David Leptich

"The Washington State Department of Ecology appreciates ORD's involvement in the Bunker Hill Superfund Site. The tools being developed by ORD will not only ensure that lakes and marshes receive appropriate cleanups and reduce contaminant transport into Washington, but also may assist us in determining the best remedial strategies at our own cleanup sites." – Washington State Department of Ecology, Toxics Cleanup Program Hydrogeologist Sandra Treccani

The Lower Coeur d'Alene River Basin in northern Idaho and eastern Washington is an active habitat for migratory birds (including the Canadian Tundra Swan) and part of the Bunker Hill Superfund Site, a former lead refining and smelting facility. Historical and ongoing transport of contaminated sediment to floodplains, marshes and side lakes from the Bunker Hill site has resulted in annual acute lead toxicity of migratory birds that utilize the surrounding wetlands for feeding during migration. The concentration of lead in some sediments is so elevated that acute effects of lead toxicity are seen within as little as a two-week period. The loss of bird life has also resulted in reduced use of the river basin for recreational activities. The historical release of contaminated materials has led to the contamination of more than 18,000 acres of prime water fowl habitat. The size and scope of the sediment contamination prohibits the use and application of traditional remediation practices at this site, including sediment removal. A passive treatment option that reduces the potential for biological uptake of lead is required. EPA ORD is collaborating with state partners to develop a passive soil amendment option that would reduce bioaccessible lead concentrations in wildlife.

EPA ORD in collaboration with Region 10 (Pacific Northwest) have conducted an initial site investigation to evaluate geochemical cycles, contaminant distribution and chemical speciation of lead throughout Lane Marsh. This information was used to develop laboratory conditions for bench scale studies evaluating the performance of sediment amendments to reduce lead bioavailability. Research is ongoing as scientists begin selecting specific materials for field trials.

ORD's partners will use the results of the bench scale testing and field trials to determine the best options for passive remediation efforts. In addition, the potential for remedy selection based upon existing geochemical properties and contaminant speciation will be employed at other locations within the Lower Coeur d'Alene Basin. Successful identification and deployment of affordable and effective passive sediment remediation technologies will ultimately result in a reduction of bioavailable lead improving the ecosystem by protecting migratory birds and subsequently revitalizing recreational activities in the Lower Basin.

More information can be found on the Bunker Hill Superfund Site profile.

Partners: Florida Department of Environmental Protection, Georgia Environmental Protection Division, Kentucky Department of Environmental Protection, North Carolina Department of Environmental Quality, South Carolina Department of Health and Environmental Control and Tennessee Department of Environment and Conservation
Challenge: Characterizing urban background levels for contaminated site cleanup levels
Resource: Sampling protocol
Project Period: 2015-2016

"Having a data set like the one gathered during the urban background study is invaluable. It is very helpful to now have a comprehensive data set that we can use to make scientific determinations regarding appropriate urban background concentrations for many constituents."– Tennessee Department of Environment and Conservation Environmental Consultant Merrie Embry, in the Memphis Environmental Field Office, who also noted that the benefit of working with EPA ORD and the other Southeastern states has helped to ensure consistency in their sampling approach and data evaluation.

In 2015, EPA scientists partnered with several Region 4 (Southeast) states to figure out how urban background contaminants differ from industrial waste at urban sites. Initial efforts were focused on creating a process for both soil sample collection and analysis that could be consistently applied across southeastern cities.

Soil samples collected from Louisville, KY; Lexington, KY; Memphis, TN; Raleigh, NC; and Winston-Salem, NC, were analyzed in EPA laboratories and added to a growing urban background database for metals and PAHs. The data and sampling process can be used by EPA, state agencies and local authorities to assess hazardous waste and brownfield sites and make decisions around cleanup. The database will provide a general range of urban background contaminant levels to be expected from sites in Region 4 cities. It can also serve as a screening tool for comparison of potential sites. The utility of the tool is improved as coverage of data for comparison over broader areas increases and more urban background data are added.

The success of the project has allowed sampling efforts to expand to additional cities in Tennessee, Georgia and Florida. Recently, EPA and the state of Tennessee have used the study protocol to conduct an urban background sampling effort in Chattanooga, TN. Additional regions, states and universities, including Georgia State University in Atlanta, have expressed interest in the results and established sampling process. Professors and students at the University of Florida in Gainesville have already used the sampling process in two urban areas in central Florida.

More information on the Regional Urban Background Study.

Access the presentation materials from the EPA Tools & Resources webinar on the Urban Background Study.

Partner: Interstate Technology and Regulatory Council (ITRC)
Challenge: Need for specialized risk assessment training
Resource: Training module, *Decision Making at Contaminated Sites: Issues and Options in Human Health Risk Assessment*
Project Period: 2015-2017

"The experience and knowledge of EPA scientists were essential to the success of this important training used by state risk assessors and others to address complex challenges at contaminated sites."
– California Department of Toxic Substances Control Senior Toxicologist Claudio Sorrentino

"The ITRC risk training is more robust as a result of our partnership with EPA experts on this effort." – South Dakota Department of Environment and Natural Resources Engineering Specialist John McVey

EPA ORD partnered with ITRC, a program of the Environmental Research Institute of the States, to develop specialized training for state risk assessors responsible for the cleanup of chemicals released into the environment. Based on feedback from EPA's Risk Assessment and Training Experience (RATE) program, ORD scientists reached out to ITRC and proposed that ITRC create training modules on the harmonization of risk assessment approaches across state regulators. EPA experts provided materials developed for its RATE program for the ITRC effort. These materials provide up-to-date and comprehensive training for human health risk assessment, ranging from beginner to expert classes.

The ITRC team of approximately 75 representatives from various environmental sectors completed a comprehensive web-based training module entitled, *Decision Making at Contaminated Sites: Issues and Options in Human Health Risk Assessment*. ORD scientists provided expert technical support as needed along the development processes and extensive peer reviews before release of the final product. To date, more than 2,700 people have taken the online course and the associated guidance document is available to download.

Currently, all interested risk assessors in the U.S. and around the globe have free access to the ITRC training materials.

WASTE AND MATERIALS MANAGEMENT

Partner: California Environmental Protection Agency (CalEPA) Office of Environmental Health Hazard Assessment (OEHHA)
Challenge: Addressing safety concerns of tire crumb rubber used in synthetic turf fields and playgrounds
Resource: Research for improved exposure assessment in collaboration with the Centers for Disease Control and Prevention (CDC) and the U.S. Consumer Products Safety Commission (CPSC)
Project Period: 2016-Present

"The U.S. EPA study complements and strengthens what we are doing in California. Consultations with the U.S. EPA scientists benefit our project team and help to improve the quality of the California synthetic turf study."
– CalEPA OEHHA Senior Toxicologist Dr. Patty Wong

The U.S. Environmental Protection Agency's (EPA) Office of Research and Development (ORD) is collaborating with the CDC's National Center for Environmental Health and Agency for Toxic Substances and Disease Registry (ATSDR) and the CPSC to study key environmental and human health questions. To address the concerns that have been raised about the potential health risks from playing on synthetic turf fields containing tire crumb rubber, a Federal Research Action Plan was launched in 2016 to investigate potential human health implications. The Federal Research Action Plan has four parts: a literature review and data gaps analysis, outreach with key stakeholders, tire crumb rubber characterization research, and human exposure characterization research. This research will provide a better understanding of the chemicals found in tire crumb rubber and the potential exposures that field users may experience by using these fields.

EPA and CDC/ATSDR are reporting research findings in two parts. Part 1 communicates the research objectives, methods, results and findings for the tire crumb rubber characterization research (i.e., what is in the material). This report is now available. Part 2, to be released later, will include data to characterize potential human exposures to the chemicals found in the tire crumb rubber material while using synthetic turf fields. Part 2 will be released along with results from a biomonitoring study being conducted by CDC/ATSDR to investigate potential exposure to constituents in tire crumb rubber infill. CPSC is conducting separate research on playgrounds. These research activities and the resulting findings do not provide an assessment of the risks associated with playing on or contact with the recycled tire crumb rubber used for synthetic turf fields. Instead, these research results should inform future risk assessments.

Researchers at CalEPA OEHHA are also conducting research aimed at reducing data gaps for tire crumb rubber constituents and human exposures. The federal research team regularly consults with OEHHA scientists to discuss how the two studies can be mutually informative. The federal and state researchers will identify and implement methods and approaches that will, where feasible, produce comparable data. This could effectively expand the overall U.S. research sample size and will provide additional insight into potential exposure variability. There are also important differences between the federal and OEHHA studies that will provide complementary data for improved exposure assessment.

Partner: Georgia Department of Natural Resources (DNR) Environmental Protection Division (EPD)
Challenge: Sustainable materials management
Resource: Developing a model and web application to implement EPA's state-based sustainable materials management prioritization framework
Project Period: 2014-2015

"Georgia recognizes the need to adopt a life-cycle holistic perspective in managing materials. This project has given us the opportunity to input Georgia economic data to determine environmental impacts to the state for a wide number of sectors. We expect the model to allow us to consider a wide array of environmental and economic impacts when considering strategies intended to reduce waste and improve the health and environment within the state." – Georgia DNR EPD, Solid Waste Program Manager William Cook

Through the Resource Conservation and Recovery Act (RCRA), Congress gives EPA the authority and responsibility to assist states with properly managing solid and hazardous waste. The primary objectives of RCRA are to minimize the risks to human health and the environment arising from waste disposal activities and promote the conservation of valuable material and energy resources by minimizing waste.

EPA's Office of Resource Conservation and Recovery (ORCR) uses a sustainable materials management (SMM) framework to fulfill the Agency's responsibilities under RCRA. ORCR assists states in voluntarily adopting the SMM framework into their own efforts, promoting effective, efficient waste management while simultaneously promoting economic growth, resiliency and jobs. SMM engages business, all levels of government, non-profits and academia to enhance the economy and environment.

Georgia DNR/EPD expressed interest in testing EPA's SMM framework. A pilot study was initiated in 2014 involving Georgia DNR/EPD, the Georgia Department of Economic Development, the Georgia Recycling Coalition, as well as EPA's Region 4, ORCR and ORD. EPA ORD is developed an SMM model, based on the national USEEIO framework, that identifies opportunities to reduce material use and potential human health and environmental burdens associated with economic activity in Georgia. The EPA ORD SMM model merges the principles of life cycle thinking with traditional economic theory and leverages data collected by EPA and other federal agencies in a way that is easily adaptable for any state. The SMM model is being integrated into a customizable web application called the Sustainable Materials Management State Prioritization Tool using feedback gathered from Georgia stakeholders that ORCR will maintain. ORD is developing SMM models for other states based on lessons learned with this initial GA model. The State Tool will enable organizations like Georgia DNR/EPD to prioritize opportunities for SMM in their state and assemble appropriate stakeholders from within the state to develop potential policy alternatives that capitalize on these opportunities.

Access the presentation materials from the EPA Tools & Resources webinar on Sustainable Materials Management and this pilot study with Georgia DNR.

Partners: South Carolina Department of Health and Environmental Control (SC DHEC), South Carolina Department of Commerce (Commerce), and the City of Columbia
Challenge: Food waste reduction and landfill diversion
Resource: Food Waste Tracker Technology in collaboration with the U.S. Army (Fort Jackson)
Project Period: 2014-2017

"EPA ORD's proposal of the LeanPath demonstration came at an optimal time for Fort Jackson. In the installation's efforts to meet Net Zero Waste initiatives, we have explored ways to divert solid waste from the landfill via off-site composting and food donations. With the implementation of the Lean Path scales, we are able to collect data that supports these measures. Additionally, there is the opportunity to critically assess our dining operations and identify ways to improve operations and make fiscally-sound decisions. EPA ORD has been very engaging and more than helpful during the demonstration." – U.S. Army Garrison Fort Jackson DPW-Environmental Division, Senior Project Manager Tameria Warren

The U.S. Department of Agriculture estimates that one out of six people struggle with hunger in the United States, yet food waste is the single largest component being sent to landfills and accounted for 21 percent (35.2 million tons) of the nation's waste in 2013. South Carolina alone produced an estimated 607,000 tons of food waste in 2015.

In 2014, researchers with EPA ORD's Net Zero program initiated a partnership with SC DHEC, SC Commerce and the U.S. Army to better manage organic waste in the Columbia, SC region. ORD's Net Zero partnerships work with communities and military installations to develop and apply innovative approaches to reduce energy, landfill waste and water use. Collaborators in this South Carolina partnership included representatives who work on waste management issues from local businesses, municipal officials, non-governmental organizations and the Fort Jackson Army base. The partnership provided opportunities to share ideas and best practices through conferences and face-to-face meetings. EPA also conducted a feasibility study for the partnership that recommended strategies for optimizing recycling, repurposing and recovery of organic materials in the region.

Since the partnership was created, South Carolina has launched several educational and food waste diversion campaigns, including the "Don't Waste Food SC" state-wide campaign.

As a follow-on activity, in March 2017, EPA provided technical expertise, community outreach and funding to conduct a technology demonstration study using the *Lean Path 360* food waste prevention technology at the Fort Jackson Army base – one of the largest military training installations in the nation. LeanPath is an automated food waste tracking system that helps companies and organizations reduce food waste. The project has resulted in over 5 tons of food being donated to South Carolina food donation and composting programs.

WATER – SOURCE AND RECREATIONAL PROTECTION

Partner: Kansas Department of Health and Environment (KDHE)
Challenge: Efficient and defensible survey designs for stream monitoring
Resource: Probabilistic survey designs integrating national and state reporting requirements
Project Period: 2007-2018

"In my view, this collaboration with ORD is a very good example of the state-national partnership we have had with ORD. The Corvallis Lab provided the statistical expertise and analytical framework, and we provided our local knowledge and creativity and put our state level monitoring priorities on the table. The result is a survey design that is better for everyone involved." – KDHE Division of Environment John Mitchell (former director)

Kansas Department of Health and Environment (KDHE) is charged with reporting on the stream condition for all streams in the Kansas Surface Water Register (KSWR), which was developed in 1994.

It is a challenge for both state- and national-scale assessments to develop a survey design that ensures representativeness when only a limited number of locations are available for sampling. If the state and national monitoring efforts can be integrated, it not only supports inter-calibration but is efficient and cost-effective. EPA ORD uses a probabilistic sampling design that ensures representativeness and allows the use of statistical tools to determine condition values and the reliability of those estimates (uncertainty). This strategy has been incorporated into the NARS, which includes national-scale assessments of rivers and streams, lakes, coastal zones and wetlands. In working to refine the KSWR, KDHE was interested in whether it could be used in the National Aquatic Resource Surveys (NARS) National Rivers and Streams Assessment (NRSA).

In collaboration with EPA ORD, Kansas first conducted a study to determine if the KSWR included all the streams with flowing water required by NRSA. After determining that was the case, EPA ORD used the Kansas Register of streams as part of the NRSA 2018-19 survey design. By integrating state requirements for Kansas with NRSA requirements, Kansas reached a cost-effective solution for meeting their state assessment needs and simultaneously participating in the NRSA survey.

Partners: Maryland Department of Natural Resources; Blue Water Baltimore; City of Baltimore; Waterfront Partnership of Baltimore; National Aquarium
Challenge: Improve the water quality in Baltimore's Harbor and gather water quality data
Resource: Using sensors to provide real-time water quality data, in collaboration with the U.S. Geological Survey (USGS)
Project Period: 2017-2019

"The National Aquarium uses Village Blue as a tool to better understand what is entering Baltimore's Inner Harbor through Jones Falls. This data provides sound science on core water quality parameters necessary for the Aquarium's long-term harbor projects and for evaluating the harbor's health." – National Aquarium, Chesapeake Bay Program Manager Charmaine Dahlenburg

Maryland's Baltimore Harbor has suffered from poor water quality for several years. Some of this is caused by the city's aging sewage system leaking fecal bacteria into the harbor when it rains.

EPA ORD and Region 3 (Mid-Atlantic), in collaboration with USGS, initiated the Village Blue project to provide real-time water quality monitoring data to the public in Baltimore, MD to raise awareness about water quality in the harbor. Water sensors were installed to gather real-time water quality monitoring data that is then streamed to EPA's interactive Village Blue monitoring application, which does not require a download and is compatible with all operating systems. The application displays the data in a mobile-friendly, easy-to-understand format complimentary to work that a number of state and local organizations are already doing to make water quality data available to the public. As part of this project, EPA scientists are developing a how-to guide so that other communities can develop their own Village Blue stations.

The project has provided information about water quality in a publicly accessible website and allowed visualization of real-time water quality data. The project supports the Waterfront Partnership of Baltimore goal of making the Baltimore Harbor "swimmable and fishable" by 2020. This project has been completed in December of 2019 and is no longer providing data.

More information on the Village Blue project and available water sensor data.

Partner: New Hampshire Department of Environmental Services (NHDES)
Challenge: Stream assessment integration and efficiency
Resource: Probabilistic survey designs integrating national and state reporting requirements
Project Period: 2018

"The partnership between EPA ORD and NHDES on the national stream assessments has created synergies that allow both organizations to meet their respective goals. Using each organization's strengths – NH DES' familiarity with streams in the state and EPA's skill with survey sampling design – the result is far greater than either could achieve alone." – NHDES Water Pollution Division, Watershed Management Bureau Biomonitoring Program Andy Chapman

The NHDES Water Quality Assessment Program is responsible for reporting on the quality of the streams in New Hampshire under the Clean Water Act. It is impossible to sample every stream, so NHDES sought a means to subsample streams in such a way that was representative of all state streams. EPA researchers have developed a statistically robust protocol for doing just that. EPA ORD scientists have developed a probabilistic survey design that ensures that results from sampled locations are representative of the condition of all streams in the survey area. This strategy has been incorporated into the National Aquatic Resources Surveys (NARS), which includes national-scale assessments of rivers and streams, lakes, coastal zones and wetlands.

NHDES assembled a geographic data layer that identifies all streams within the state that must be assessed. They requested that EPA ORD integrate this stream data layer into the NARS National Rivers and Stream Assessment (NRSA). Using their stream network instead of the NRSA network enables the state to use the results of the state survey for the national dataset. Consequently, the state will conduct a state-level survey design for 2018-22 and integrate it with NRSA. This integration of the state and national survey designs is a cost- effective option for participating in NRSA while also meeting state assessment requirements.

In 2004, EPA partnered with states to provide national and regional level assessments for Clean Water Act reporting. EPA ORD has assisted 53 different states, tribes and territories since 2012 to develop sample survey designs and biological, chemical and physical habitat indicators. The survey designs provide statistical rigor for small sample sizes, which allow states to report on more of their waterbodies than previously possible.

Partners: Virginia Department of Environmental Quality (DEQ)
Challenge: Integration of state and national stream condition assessments
Resource: Probabilistic survey designs integrating national and state reporting requirements
Project Period: 2005-2015

"Virginia DEQ has found it very helpful to integrate our state stream condition assessment into the National Streams and Rivers Assessment. With technical assistance from ORD, we were able to apply robust statistical analysis to calculate a picture of stream health for the entire state from a small, manageable set of field samples." – Virginia DEQ Director David Paylor

Virginia DEQ is charged with reporting stream condition for the state, presenting a challenge to strategically conduct sampling protocols that will accurately represent stream water quality across the state's many streams without overwhelming state resources. EPA researchers have pioneered the design of just such survey techniques to assist water quality analysis across large areas. The EPA-developed strategy of probabilistic surveying has been incorporated into the National Aquatic Resources Surveys (NARS), which includes national-scale assessments of rivers and streams, lakes, coastal zones and wetlands.

Virginia DEQ took steps to integrate the state stream condition assessment requirements with the NARS National Rivers and Streams Assessment (NRSA). To achieve this, Virginia DEQ collaborated with EPA ORD to develop and interpret probabilistic survey designs specifically for their state stream condition assessments. The resulting survey design ensures representativeness of sampling locations, which then facilitates the use of statistical tools to determine condition values that incorporate acceptable levels of uncertainty. Virginia also adopted NRSA stream condition field and laboratory procedures to further integrate with the NRSA approach. Because of common measurements and survey design, Virginia is using the stream sites from their state program for the NRSA 2018-19 monitoring, thus promoting inter-calibration and efficiency.

Partners: Local and regional beach managers across states that border the Great Lakes, as well as other states
Challenge: Predicting water quality at beaches
Resource: Virtual Beach software
Project Period: 2007-Present

"This reliable, predictive water quality model is key to protecting health and promoting recreational enjoyment of our beaches. The model provides same-day public notifications of beach conditions at a lower cost than traditional monitoring.
Communities that use Virtual Beach can dedicate more of their resources to locating and correcting sources of contamination and improving local beaches. The (Wisconsin DNR's) partnership with EPA in the development of this practical scientific tool offers a great pay off." – Wisconsin DNR Cathy Stepp (former secretary)

To protect public health, beach managers need to continually assess the level of potentially harmful microbes (primarily bacteria) in the water. However, traditional culture-based testing methods take a full 24 hours to get results – preventing same-day, proactive beach closures and leaving many recreational swimmers open to sickness or infection, or potentially close a beach needlessly and incur economic losses. EPA's Virtual Beach tool offers a solution.

Virtual Beach (VB) is a Windows desktop-based software package designed by EPA researchers that provides rapid, real-time assessments of microbial water quality with model accuracy typically exceeding 80 percent. Beach managers use VB to develop site-specific statistical models for predicting fecal contamination based on readily-available data on such as wind direction/speed, antecedent rainfall, cloud cover, wave height, water turbidity and sunlight intensity. Once a model is developed for a site using historical data, environmental information can be collected at a site in the morning, and moments later the model can produce a prediction to guide decisions about closing the beach for the day or for issuing advisories.

VB is used to assist in advisory issuances in the Great Lakes states and to forecast water conditions in numerous locations in Illinois, Indiana, Maryland, Michigan, Minnesota, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, and Wisconsin. VB facilitates efforts to support the local economy while protecting the health of residents. An updated, web-based version of VB is on the horizon (2-3 years); it will provide cutting edge analytical tools, like ensemble modeling using a variety of machine-learning algorithms, as well as methods for handling non-detects and missing data, in order to improve the accuracy of water quality models, whether they be for recreational beach sites, shellfish harvesting areas, or public drinking water intake locations.

Partners: Depts. of Environmental Protection (KY, MA, ME, NJ, PA and WV); Depts. of Environmental Management (AL and RI); CT Dept. of Energy & Environmental Protection; DE Dept. of Natural Resources and Environmental Control; Depts. of Natural Resources (GA, MD and Red Lake Nation (tribal)); MA Dept. of Fish & Game; NH Dept. of Environmental Services; Depts. of Environmental Conservation (NY and VT); Depts. of Environmental Quality (NC and VA); SC Dept. of Health & Environmental Control; TN Dept. of Environment & Conservation; VA Dept. of Game and Inland Fisheries; Susquehanna River Basin Commission; TN Valley Authority
Challenge: Develop a baseline monitoring network to detect long-term trends
Resource: Technical support to states and tribes through workshops and stream monitoring network development, in collaboration with the U.S. Forest Service and the U.S. Geological Survey
Project Period: 2012-Present

"As an interstate agency, the Susquehanna River Basin Commission (SRBC) certainly recognizes the value of the regional partnership EPA has assembled to address the need for collecting the data necessary for detecting changes to water quality and aquatic life communities over time, especially as it relates to any regional trends that may result from climate change effects. The establishment of an effective regional network is a bigger task than any single agency can undertake given the resources involved, and EPA's staff provided the needed leadership to establish and guide the partnership, as well as the scientific expertise on the study methods for characterizing any future changing conditions." – SRBC Executive Director Andrew Dehoff

EPA ORD is working with regional offices, states, tribes, river basin commissions and other entities to establish Regional Monitoring Networks (RMNs) for freshwater wadeable streams. The objectives of the RMNs are to collect long-term biological, thermal, hydrologic, physical habitat and water chemistry data to document baseline conditions across sites and detect long-term changes. Consistent methods are being used to increase the comparability of data, minimize biases and variability, and ensure that the data meet data quality objectives. Continuous sensors are being employed when possible. RMN surveys build on existing state and tribal bioassessment efforts with annual sampling of a limited number of sites that can be pooled at a regional level.

Pooling data enables more robust regional analyses and improves the ability to detect trends over shorter time periods. The collaborations across states, tribes and other entities resulted in the development of RMNs, some of which have collected data since 2012. Recently, EPA Regions 1, 2, 3 and 5, in coordination with their states and tribes, began developing RMNs for lakes and wetlands with the same objectives as the stream RMNs.

RMN data can be used for many purposes, over short and long-term timeframes. These applications include informing water quality and biological criteria development and protection planning priorities, refining lists of biological, thermal and hydrologic indicators, and detecting trends in commonly-used water quality and biological indicators. The RMN data also are important for detecting climate change effects in the context of biomonitoring. There are a number of climate change projections that are relevant to aquatic life condition, including increasing temperatures and changing frequency and magnitude of extreme precipitation events and frequency of summer low flow events. Managers will be able to use the monitoring data to help inform adaptive management.

Read the final report and fact sheet on *Regional Monitoring Networks (RMNs) to Detect Changing Baselines in Freshwater Wadeable Streams.*

Partners: Ohio River Valley Water Sanitation Commission (ORSANCO), an interstate commission representing 8 states (Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia and West Virginia) and the federal government
Challenge: Providing information to water utilities that will inform operating decisions and minimize impacts on water users results from spills within U.S. waterways
Resource: River Spill model in collaboration with Corona Engineering and American Water
Project Period: 2016-Present

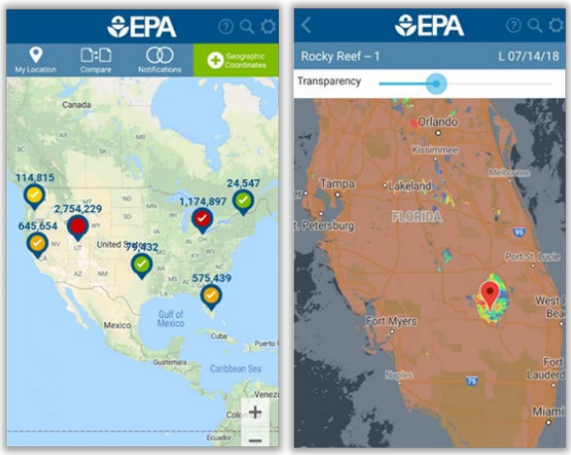
"The River Spill model has been used on several recent spills on the Ohio river and has predicted the actual times and concentrations very well. If accurate spill and river condition data is fed into the River Spill model, the model seems to accurately predict the resulting conditions downstream." – ORSANCO Technical Program Manager Sam Dinkins

There are 25,000 navigable miles of inland waterways within the contiguous U.S., which transport an estimated 630 million tons of commodities valued at $73 billion annually. There are also hundreds of drinking water intakes that supply drinking water to 66% of American water consumers. Spills within U.S. waterways can threaten safe drinking water supplies, fire protection, commerce, and critical navigation activities.

Given this challenge, EPA ORD researchers developed software that can run two-dimension models of spills in rivers. The software helps utilities decide if they should close their intake, add additional treatment, or access alternative water supplies, if available, while the worst of the spill plume passes. The River Spill model uses real time river data collected and distributed by the U.S. Geological Survey and the U.S. Army Corps of Engineers, and it can be run on a computer or handheld device. The model adds two-dimension definition and real-time updates to the U.S. Department of Defense's Technical Reachback Division's IC Water model.

The River Spill model is currently being tested by ORSANCO and American Water on spills that occur on the Ohio River and its tributary system. The initial results indicate good correlation between the model and actual spill conditions. Commercial entities such as Corona Engineering and American Water, which is the largest publicly held water company in the U.S., are partnering with EPA to test the River Spill model in West Virginia. The River Spill model is also being adapted to work on other river systems within the U.S. Current ongoing applications for the model include the Tom Bigbee Water Way and the Des Moines River. The model will allow any water utility utilizing source water from a river system to make the most informed operating decisions concerning spills within minutes of data input.

Partners: AR, AZ, CA, CO, FL, ID, IA, KS, KY, LA, MO, ND, NY, OH, OR, PA, RI, SC, SD, TN, UT, VT, WA, WI and WY state environmental or health departments
Challenge: Support the environmental management and public use of U.S. lakes and reservoirs by providing a capability of detecting and quantifying cyanobacteria harmful algal blooms using satellite data records
Resource: Provide satellite derived measures of cyanobacteria, software and training in collaboration with the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and U.S. Geological Survey (USGS)
Project Period: 2015-Present



"The images we've been receiving through the CyAN project have been tremendously helpful to the Utah Division of Water Quality (UDWQ), providing the foundation for a wide range of useful outputs. It allows UDWQ to better target field sampling and more efficiently use our limited resources to protect public health. Finally, images are easily shared with response agencies as a useful visual communication aid." – Utah Division of Water Quality Standards & Technical Services Section Manager Benjamin M. Holcomb

Cyanobacteria blooms are an environmental and human health problem across the U.S. They are capable of producing toxins, odors, and surface scum that threaten the health of humans and animals, the quality of drinking water supplies, and the ecosystems in which they develop. Scientists at EPA are part of a team of specialists using remote sensing data to improve cyanobacteria detection methods. Improving the detection process would help state environmental and health agencies better determine whether to post public advisories to protect aquatic and human health.

The Cyanobacteria Assessment Network (CyAN) Project is a multi-agency effort among EPA, NASA, NOAA, and USGS to develop an indicator system using historical and current satellite data to quantify the temporal frequency, spatial extent, and magnitude of blooms in U.S. lakes. CyAN is providing weekly cyanobacteria monitoring data to state environmental and health departments from the European Space Agency Sentinel-3 satellite, training opportunities, and software applications.

As part of the CyAN Project, EPA developed the CyAN app, an easy-to-use and customizable mobile application that provides access to algal bloom satellite data for over 2,000 of the largest lakes and reservoirs across the United States. EPA scientists developed the CyAN app to help local and state water quality managers make faster and better-informed management decisions related to cyanobacterial blooms. The app is free and available for download on Android devices™. During the CyAN app development, several states participated in beta testing, including Arizona, Arkansas, California, Colorado, Florida, Idaho, Iowa, Kansas, Kentucky, Louisiana, Missouri, New York, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, Washington, Wisconsin, and Wyoming.

WATER – DRINKING WATER

Partner: Illinois EPA, City of Galesburg
Challenge: High lead levels found in drinking water due to lead service lines
Resource: Lead service line identification project and technical support, in collaboration with Battelle
Project Period: 2014-Present

"The Illinois EPA was very pleased that Galesburg volunteered to participate in ORD's lead service line identification project. We are very hopeful that this project will go a long way in assisting water suppliers who are unsure of the material types of the plumbing connected to their distribution systems. Ultimately, the Illinois EPA hopes that this lead service line identification project, combined with other research being conducted by ORD, will provide low-cost alternatives to digging to determine service line material types."
– W. David McMillan, Manager, Division of Public Water Supplies, Bureau of Water, Illinois EPA

EPA ORD has been working with the City of Galesburg, Illinois EPA, and EPA Region 5 (Midwest) on lead service line (LSL) identification project in Galesburg. The LSL identification project, led by ORD and its contractor Battelle, was initiated as part of the Flint response to address the national issue of helping water distribution utilities and individuals locate LSLs. Galesburg has implemented phosphate-based corrosion control treatment to reduce lead levels in the distribution system and provided public education while actively replacing LSLs throughout the city.

During the week of July 31, 2017, Battelle collected sequential samples from 12 homes in Galesburg. On August 10, 2017, the project team received the first round of sampling results from the Region 5 lab. The results indicated elevated lead levels at some locations.

EPA developed notification language that was sent to the City via email on August 11 to inform them of the sampling results and to recommend use and/or installation of point-of-use filtration devices. The LSL identification project also includes a past sampling effort in Flint, MI and is ongoing.

Partners: Michigan Department of Environment, Great Lakes and Energy (EGLE), City of Flint
Challenge: High lead levels and other water quality challenges in the Flint water system
Resource: Technical support, computer modeling and sampling equipment
Project Period: 2016-Present

"The information that our EPA colleagues shared was critical to our understanding of water systems in Flint." – Genesee County Health Department, Public Health Division Director Suzanne Cupal, MPH

In April 2014, the City of Flint, Michigan, switched from purchasing finished drinking water from the City of Detroit to treating raw water from the Flint River. For several reasons, the finished drinking water was corrosive following this change. As a result, the water stripped the protective mineral layer from pipes in the drinking water system and caused lead to leach from the pipes, increasing the lead levels in the water. In October 2015, Flint switched back to purchasing finished water from Detroit, and EPA formed the Flint Drinking Water Technical Support Team to provide technical assistance to the City and State. In January 2016, EPA started a large-scale sampling effort in Flint for lead, water quality parameters, and chlorine residual throughout the distribution system.

EPA ORD scientists and engineers, in coordination with Region 5 and the Office of Water, provide technical support for the Flint drinking water response effort and the Flint Drinking Water Technical Support Team. The Technical Support Team provides technical assistance to the Michigan EGLE and the City of Flint to inform decisions about a source of drinking water and to optimize corrosion control for the Flint system. EPA researchers reviewed the treatment history, corrosion control and water quality for the Flint water system and made treatment recommendations. They also provided sampling equipment and advice in the field on sampling strategies and developed a disinfectant residual monitoring plan to ensure that residual is maintained throughout the distribution system. Pipe loop rigs were built that incorporated lead pipes removed from Flint homes for real-time monitoring of lead and corrosion control assessment. In addition, an improved distribution system hydraulic model was built so the city now has a better understanding of the quality of the water moving through the system.

ORD researchers continue to support the City of Flint and are currently working on lead service line detection methodologies for identifying existing lead pipes, lead particle analysis and assessment, corrosion control treatment optimization studies for water source change using the pipe rigs, lead source/release diagnostic studies, and pipe analyses for long-term treatment assessment and mechanisms of lead and other metals release.

Additional information on the Flint Drinking Water Technical Support Team's activities.

Partners: Ohio Environmental Protection Agency (EPA) and public water utilities along Lake Erie
Challenge: Managing algal toxins in drinking water treatment plants
Resource: Algal toxin and water quality studies at drinking water treatment plants using Lake Erie as their source
Project Period: 2013-2014

"Ohio and EPA ORD continue to lead the nation in working with public water systems to ensure safe drinking water and minimize the threat of harmful algal blooms (HABs) 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 Craig Butler (former Director)

Increasingly, drinking water treatment plants are challenged by changes in the quality of their source waters and their often-aging treatment and distribution system infrastructure. Individually or in combination, factors such as, climate change, agricultural runoff, and landscape development increase the probability that harmful algal blooms will occur, and that algal toxins will break through treatment barriers and end up in drinking water.

In cooperation with public water utilities along Lake Erie, EPA ORD conducted studies to improve our understanding of cyanobacterial toxin propagation through the drinking water treatment process, and to identify the best approaches for removing them. The recent sampling campaign provided a unique opportunity to characterize the impact of Lake Erie's cyanobacterial bloom and its associated toxins on drinking water treatment facilities at a high level of analytical detail. Researchers were able to provide utilities and regulators with treatment recommendations that will help them make better informed long-term decisions regarding the operation and modification of treatment processes to optimize removals.

Partner: Ohio Environmental Protection Agency (EPA) and the City of Toledo
Challenge: Harmful algal bloom preventing access to drinking water
Resource: Drinking water testing to help restore drinking water availability
Project Period: 2014

"When we were faced with an emergency in Toledo, August 2014, due to cyanobacterial toxins detected in their treated drinking water, EPA ORD staff was a great partner and exceeded our expectations in understanding science and helping optimize treatment and restore safe drinking water to our residents." – Ohio EPA Craig Butler (former Director)

On August 2, 2014, the Mayor of Toledo, Ohio, issued a "Do Not Drink" order for the 500,000 people of the City of Toledo and neighboring communities because the water utility detected microcystin, a cyanobacterial toxin, in the finished drinking water. The City's drinking water source, Lake Erie, was experiencing a large cyanobacterial bloom at the time, and microcystin was the primary toxin detected. Microcystin is resistant to high temperatures so a "boil water" advisory would not have been effective. The water ban set in motion a number of emergency actions, including Ohio Governor John Kasich declaring an emergency in the area, the mobilization of the Ohio National Guard to distribute bottled water, and the closure of hundreds of water dependent businesses in the Toledo metro area.

Working in conjunction with the City of Toledo, Ohio EPA officials immediately reached out to EPA ORD's Cincinnati-based research laboratory for technical assistance. This laboratory is known as a world leader in the evaluation and development of innovative drinking water testing, monitoring, and treatment technologies. Ohio EPA asked for assistance with laboratory analyses for the presence of cyanobacterial toxins in treated drinking water and identifying the optimal approach for controlling cyanobacterial toxins in the drinking water treatment plant and distribution system. EPA ORD assembled a team of scientists and engineers to work throughout the weekend. The ORD team led discussions regarding sample handling and procedures and facilitated an agreement between Ohio EPA and the City of Toledo as to how they would collect and handle samples. Samples were handled per the protocol, and chemical analyses were run by an agreed upon procedure between Ohio EPA, the City of Toledo and EPA. Following the initial set of samples, the City of Toledo collected additional water samples throughout their treatment plant to assess the effectiveness of various treatment processes in reducing the cyanotoxin concentrations. The ORD team assessed sample results as the analyses were completed and recommended treatment plant adjustments to further reduce cyanotoxin levels in the finished drinking water, and they communicated the issues to local and state officials in real time during the event.

ORD's efforts to produce timely and accurate results were critical for the Mayor of Toledo and the Governor of Ohio when making their decision to lift the "Do Not Drink" order two days later on August 4, restoring safe drinking water to some half a million people. Soon after the order was lifted, EPA's Office of Water consulted with the ORD team and Ohio EPA to identify the lessons learned from the Toledo incident, particularly with regard to the sample preservation and handling procedures for cyanotoxin samples, identifying areas where improved guidance could be provided to U.S. drinking water systems performing cyanotoxin monitoring to assure samples are appropriately preserved for transport and prepared for analysis.

Partners: Texas Commission on Environmental Quality (TCEQ), Texas Department of State Health Services (DSHS) and City of Corpus Christi
Challenge: Chemical contamination in Corpus Christi's water supply
Resources: Determine health risks and action level
Project Period: 2016

"The water situation in Corpus Christi in December 2016 was a good example of cooperation between Texas and EPA and the success we have when all work towards solving an environmental issue." – TCEQ Bryan W. Shaw (former Chairman)

In December 2016, EPA ORD scientists, in coordination with Region 6 (South Central U.S.), responded to a request for assistance in Texas after an asphalt emulsifying agent, Indulin AA-86, contaminated Corpus Christi's water supply. Toxicity information along with treatment options to remove this chemical from water was lacking. ORD researchers provided assistance early in the response concerning decontamination approaches that might be suitable for use in removing the contaminant from the system. In addition, EPA helped dissect and understand the toxicity of the chemical and possible risks associated with ingestion of contaminated water and the water-soluble salt from the product. Texas state agencies, TCEQ and the Texas DSHS, along with ORD researchers and their colleagues across EPA worked together to establish a health-based action level for the contaminant and supported an immediate need to protect public health.

Partners: Iowa Department of Natural Resources (DNR), Illinois, Indiana and Ohio
Challenge: Ammonia found in drinking water in agricultural areas
Resource: Cost-effective treatment technologies for small drinking water systems with EPA licensed NoMoniaTM technology to reduce ammonia in drinking water, in collaboration with AdEdge Technologies
Project Period: 2014-2017

"Given the array of challenges faced by small drinking water systems, ORD's development of an affordable and easy to use ammonia treatment technology is very helpful to Iowa and many other states. Technical and research support of small drinking water systems is very important to Iowa." – Bill Ehm (former Iowa DNR Environmental Services Division Director)

Across the United States, ammonia is found at high levels in many agricultural areas where groundwater is the primary drinking water source, and it can be a significant source of nitrate within the pipes of drinking water distribution systems. When nitrate exceeds regulated levels, it poses significant health risks to infants, causing symptoms that include shortness of breath and blue baby syndrome. Ammonia can also compromise the effectiveness of conventional water treatments for removing arsenic and othercontaminants.

EPA ORD researchers developed a new, affordable and easy-to-use drinking water treatment system –now known to the world as Patent No. US 8, 029,674 and marketed commercially by AdEdge Water Technologies under the trade name NoMoniaTM – for small drinking water systems. The innovative technology uses naturally occurring microorganisms to remove ammonia and other potential contaminants. It is a single treatment process that generates no hazardous waste.

Working with AdEdge, EPA researchers conducted pilot tests in several small, rural communities, including Gilbert, Iowa, which uses a drinking water source that contains ammonia, iron, manganese and arsenic. The EPA technology proved to be the low cost, sustainable solution they needed.

NoMoniaTM was selected as the winner of the "Executive Board Technology Award" at the 2017 National Federal Laboratory Consortium. An announcement (April 2017) in Water Online notes that "The award highlights a successful technology transfer from a federal agency to a private sector company to commercialize, design, and market the aforementioned technology."

Read the final report titled *Innovative Biological Treatment Process for the Removal of Ammonia, Arsenic, Iron and Manganese from a Small Drinking Water System in Gilbert, Iowa (Phase 1: Pilot Evaluation)*.

Access the presentation materials from the EPA Tools & Resources webinar on Cost-Effective Treatment Technologies for Small Drinking Water Systems.

Partners: Colorado, Florida, Kentucky, Michigan, and Ohio state environmental or health departments
Challenge: Simulating and monitoring conditions in drinking water utilities
Resources: Technical assistance and field support
Project Period: 2014-2018

"Having access to my operational data in real-time keeps me on top of the system performance even when I am not at the plant. This tool helps me manage my staff and resources by providing greater flexibility and real-time information." – Milford, OH Water Department Supervisor Matt Newman

EPANET-RTX (real-time extension) and RTX:LINK are software tools that have helped states and their drinking water utilities by allowing continuous monitoring of their operations to improve water quality and respond to incidents. Together states and their utility partners use the tools to better understand and help improve drinking water system operations.

EPANET-RTX was developed to allow utilities to link their raw Supervisory Control and Data Acquisition (SCADA) data with their EPANET distribution system hydraulic model to evaluate conditions in the system in real time. The development of real-time analytics can provide utilities with the necessary tools to enhance system operations including emergency response and improved operations, e.g., better pressure management, leak detection and water quality. EPANET-RTX has been tested or demonstrated in several locations including Ohio, Colorado, Florida, Kentucky, and Michigan .

To make real-time monitoring available to small systems that lack powerful computing capability, RTX:LINK provides access to the SCADA data through mobile applications and desktop computers. RTX:LINK software provides simple and secure access to key water utility operational data streams, using web-based dashboards for trending and alerting. With RTX:LINK drinking water utilities have the ability to better understand water quality and operational conditions in their system at any point in time.

RTX:LINK software is easy to install on popular SCADA systems and has been tested in several locations. RTX:LINK was piloted in the Milford, Ohio, water system, where it has provided 24-hour access to current and historical tank levels, pump statuses and distribution system flows via mobile or desktop devices.

RTX:LINK was also tested in the city of Flint, Michigan, where it was used to provide the same benefits as those in Milford along with a continuous, real-time understanding of water age. Using this technology has helped these water systems better understand how to optimize operations, e.g., where and how to decrease water ages and identify low-pressure areas, and help predict available pressures for firefighting should disruptions occur in the distribution system.

Read the final report titled *Deployment of Real-Time Analytics and Modeling at the City of Flint, Michigan, Water System*.

Partners: Ohio Environmental Protection Agency (EPA), Association of State Drinking Water Administrators (ASDWA) and other state contributors
Challenge: Providing information, technical assistance, and training to small drinking water systems
Resource: Webinars, workshops and workgroup to address challenges and treatment solutions for small systems
Project Period: 2003-Present

"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 Craig Butler (former director)

EPA's ORD and Office of Water, in coordination with Ohio EPA and ASDWA, began hosting a monthly webinar series in 2015 targeted to state agencies on challenges and treatment solutions for small water systems. Because they tend to have fewer resources than larger systems, small systems can face enormous challenges in consistently providing safe and reliable drinking water. As of September 2019, the series has attracted over 50,000 participants from all 50 states, including 38 tribal nations, and several U.S. territories, and has provided over 32,000 continuing education credits. Presenters are typically from EPA and the states to help encourage communication between EPA and the states and between the states themselves. Access the schedule, registration, and recordings for the small water systems monthly webinars.

In addition to the webinar series, EPA's ORD and OW, in partnership with ASDWA, hosts a free annual workshop to provide in-depth information and training on various solutions and strategies for handling small drinking water system challenges. It is primarily designed for state personnel responsible for drinking water regulations compliance and treatment technologies permitting. The 2019 workshop attracted 422 attendees, including representatives from 53 state/territory agencies from 40 states and 3 territories, 40 water utilities, 9 federal agencies, and 3 tribal nations. In collaboration with Ohio EPA, the workshop provided over 1,700 continuing education contact hours. More information on the annual EPA Drinking Water Workshop.

Both the webinar series and the workshop allow EPA to communicate directly with the states to provide training and foster collaboration and dissemination of information. This, in turn, provides them with information and resources needed to communicate the latest scientific advancements and current guidance to their small systems. These forums also provide EPA invaluable information on the problems that states are currently encountering in their day-to-day interactions with their small systems. With this increased awareness, ORD experts can then modify their research to solve real-world problems that small systems are experiencing.

Formed during the 2011 workshop, ORD also leads an EPA/states small drinking water systems technical communications workgroup focused on targeted outreach efforts. In addition to EPA staff, the workgroup includes state regulatory agency and small water utility representatives from 13 states. The workgroup meets on a regular basis to decide on needed topics for the webinar series and to discuss the development of new tools.

WATER – NUTRIENTS

Partners: San Francisco Estuary Institute (SFEI)
Challenge: Reduced ecosystem resilience and stability of San Francisco Bay from nutrient pollution
Resource: Statistical evaluation of 40 years of monitoring data in the San Francisco Delta region
Project Period: 2015-Present

"EPA ORD provided critical expertise in developing a scientifically-defensible approach to estimating chlorophyll-a concentrations in San Francisco Bay that would be protective of designated uses. This work is forming a foundation of science that will be ultimately used to develop nutrient management strategies for San Francisco Bay, which is one of the most nutrient-enriched estuaries in the United States." – Southern California Coastal Water Research Project Authority, Biogeochemistry Department Head Martha Sutula, PhD

San Francisco Bay on the Pacific Coast of the U.S. is one of the most prominent—and closely monitored—estuaries in the western hemisphere. A robust database compiled over the past four decades has revealed that the Bay has consistently high nutrient concentrations yet has rarely experienced eutrophication. Recent changes in land use and weather, however, could lead to changes from the historic norm.

Local management agencies have prioritized the analysis of the monitoring data collected over the years from the Delta region surrounding San Francisco Bay, a complex mosaic of inflows that receive, process and export nutrients from the watershed to the lower Bay, as a preliminary approach to understanding large-scale properties of the Bay.

EPA researchers are helping to conduct the first comprehensive evaluation of the long-term monitoring dataset in the Delta. In collaboration with SFEI researchers, they have applied statistical models for trend analysis to better understand regional water quality dynamics. The Weighted Regressions on Time, Discharge and Season (WRTDS) model was used to provide the descriptive potential of long-term data by describing variation in flow- normalized concentrations, frequency of occurrence of extreme events, and nutrient response to historical changes. Results will provide scientific support for nutrient criteria development, Total Maximum Daily Load implementations, and routine condition assessments. Information provided by these models can also be used to generate and test hypotheses of how responses to anthropogenic nutrient interacts with other environmental changes to cause eutrophication.

Learn more about ORD's regional monitoring efforts in the San Francisco Bay Delta.

Partners: Florida Department of Environmental Protection (DEP), Escambia County
Challenge: Nitrogen pollution in urban environments
Resource: Isotopes as tracers to identify sources of nitrogen pollution
Project Period: 2017

"Our partnership with EPA ORD offers us a wonderful opportunity to gain a better understanding of nutrient loads and likely sources within the Bayou Chico and Pensacola Bay watersheds. Funding for environmental restoration is always limited. Having this understanding allows Escambia County and our partners to prioritize projects that have the greatest potential to have a positive impact on our ability to attain our surface water quality goals. We hope to use this research in the future as the basis for better resource management decisions." – Escambia County, Water Quality and Land Management Division Manager Brent Wipf

Bayou Chico is part of the Pensacola Bay System in northwest Florida and the subject of a basin management action plan by the Florida DEP to improve water quality through reductions in nitrogen loadings. Moreover, local governments are investing heavily to restore Bayou Chico and spur economic development in the surrounding area. Two creeks in the watershed provide an ideal urban setting to compare nitrogen loadings between contrasting land use and land coverages. Jackson Creek traverses residential and business developments and is listed as impaired for elevated fecal coliforms and nitrogen levels. Jones Creek originates in a reclaimed nature preserve/greenway and rarely exceeds water quality standards for fecal coliforms and nitrogen.

EPA ORD scientists in collaboration with Region 4 (Southeast) and partners collected water and sediment samples in the creeks and watershed to compare and contrast potential sources, fate and transport of nitrogen in the two creeks. Sampling locations were located along the creeks, the bayou, adjoining lakes and wells for groundwater sampling. Samples were collected on a quarterly basis for base flow measurements and more frequently around rainfall events. Samples were then analyzed for a suite of water quality chemical parameters including nitrite, nitrate and chemical tracers of wastewater discharge. Elemental isotope ($\delta^{15}N$ and $\delta^{15}O$) data was analyzed using mixing models in conjunction with water quality data to provide estimates of N loading and turnover in the two creeks and their contribution to the bayou. This project provided the technical basis for the County and Florida DEP to better understand nutrient loads and sources in the watershed and inform decision making for the basin wide management action plan.

Partner: Georgia Department of Natural Resources (DNR) Environmental Protection Division (EPD)
Challenge: Establishing a scientific framework to guide the development of numeric nutrient criteria for coastal waters
Resource: Technical support in collaboration with academic experts from Southeastern U.S.
Project Period: 2015

"Georgia EPD is currently working on a collaborative project with the University of Georgia and EPA to collect data necessary to develop a water quality model to aid in setting numeric nutrient criteria for estuaries. The model will examine the sensitivity of water quality to changes in land and water use. Specifically, it combines watershed and hydrodynamic models to a water quality model, and we're applying it to estuaries in McIntosh County, GA. The coupled modeling system will allow us to model nutrient dynamics and the biological responses of algae, including chlorophyll and dissolved oxygen estimates, and ultimately to predict changes in water quality associated with changes in land/water use and climate change. EPA has been instrumental in guiding the collection and interpretation of data for the linked models." – Georgia DNR EPD, Watershed Planning Manager Victoria Booth

Coastal waters are an important resource driving coastal recreation, tourism, fisheries and other economic activity. A number of states have recently taken significant steps to address nutrient pollution that threatens these uses. For example, nutrient criteria and a bay-wide Total Maximum Daily Load (TMDL) has been established for the Chesapeake Bay and its watershed, and the state of Florida adopted numeric nutrient criteria for nearly all of its estuaries and coastal waters. In both instances, widely recognized water quality issues such as seagrass loss, hypoxia and harmful algal blooms were among the useful endpoints for criteria development. The unique coasts of South Carolina and Georgia present a different challenge, however, as high tides, extensive salt marshes and naturally turbid waters create a unique but valuable ecosystem.

As part of EPA's long-standing approach of supporting states to develop water quality criteria and nutrient management approaches for their waters, EPA Region 4 (Southeast) convened the Georgia-South Carolina Estuary Team (GASCET) to adapt the previously applied approaches in Florida and Chesapeake Bay to create a unique framework appropriate for the ecology of the Georgia and South Carolina coast. EPA ORD provided expertise in eutrophication and nutrient criteria development.

The team, which included local academic experts and agency representatives from both states, evaluated available scientific information and produced a report in 2015 that identified three unique classifications for coastal systems in Georgia and South Carolina. These include estuaries associated with Piedmont riverine systems, blackwater systems with coastal plain headwaters, and coastal embayments with only local freshwater inputs. The team also identified candidate criteria development approaches and evaluated their potential applicability to coastal waters in the two states. The report is being used to inform early steps in criteria development in both states, including guidance on new data to collect in support of anticipated future requirements of the process.

Read the final report titled *An Approach to Develop Numeric Nutrient Criteria for Georgia and South Carolina Estuaries.*

Partner: Clermont and Brown County Soil & Water Conservation Districts, Clermont County Office of Environmental Quality, Clermont County Water Division, Ohio EPA, Ohio Department of Agriculture/National Resources Conservation Service
Challenge: Managing excessive nutrient runoff into East Fork Lake (Lake Harsha), which is causing harmful algal blooms
Resource: The East Fork Watershed Cooperative is a collaboration between local, state and federal entities including the U.S. Army Corp of Engineers (USACE) and the U.S. Geological Survey (USGS) responsible for assessing and managing water resources
Project Period: 2010-Present

"This partnership has made a huge difference in what we've been able to do at the local level. The research and expertise involved in the Cooperative has made things possible that we would never have been able to do on our own." – Clermont County Soil and Water District Administrator John McManus

Excessive nutrient runoff in East Fork Lake causes harmful algal blooms (HABs). These HABs in turn can produce cyanotoxins, which are harmful to human health, and can compromise drinking water safety. EPA ORD along with several federal, state and local agencies collaborated to form the East Fork Watershed Cooperative to address this issue.

This multiagency cooperative, led by EPA ORD staff, leverages resources to help demonstrate how to better protect water quality in the watershed. EPA provides technical support and guidance, runs watershed simulation models, provides expert review, assists USACE in monitoring water quality, participates in state-wide HAB modeling efforts with USGS, and supports the state of Ohio on nutrient Total Maximum Daily Load (TMDL) implementation in the East Fork.

The short-term goal of the cooperative Is to provide early warning and efficient treatment plans for the toxic algae problem in Lake Harsha. Their long-term goal is to eliminate the algae problem by reducing runoff from nonpoint sources.

More information on the East Fork Watershed Cooperative (EFWCoop) webpage.

Partners: Oregon Department of Environmental Quality (DEQ); Oregon Department of Agriculture
Challenge: Improve surface and groundwater nitrate contamination from agriculture
Resource: Collaborating with farmers to assess the effectiveness of fertilizer best management practices
Project Period: 2017-2020

"EPA ORD scientists have made significant contributions to the monitoring program in the southern Willamette Valley Groundwater Management Area. Their technical expertise has enhanced analyses of complex hydrological systems, as well as informed Oregon DEQ synthesis of multi-scale factors impacting nitrate concentrations in the southern Willamette Valley." – Oregon DEQ Joni Hammond (former acting director)

Groundwater nitrate contamination affects thousands of households in the Southern Willamette Valley Groundwater Management Area in Oregon. To reduce non-point source loading of nitrogen to groundwater and surface water, successful approaches are needed within affected communities to integrate science, outreach and management efforts. A partnership was formed that brings together commercial farmers, Oregon Department of Agriculture, soil and water conservation districts and EPA to assess the current state of groundwater in the Valley, and to evaluate best management practices (BMPs) in fertilizer management.

In this collaborative project, scientists measured nitrate leaching from 14 fields in the Valley. They shared the data with farmers and discussed BMPs for fertilizer application that would reduce the leaching. Scientists documented the effectiveness of these BMPs on their fields and now are seeing positive results for less nitrate leaching in some fields.

In addition, EPA ORD scientists have provided stable isotopic analyses to identify the causes of high temporal nutrient variability within local wells. These efforts have helped illuminate complex groundwater-surface water interactions and greatly improved Oregon DEQ's monitoring program for the groundwater management area. ORD efforts helped to reduce potential new inputs of nitrate into the groundwater system and understand the complex dynamics of groundwater in general.

Partners: Rhode Island Department of Environmental Management (RI DEM), Rhode Island Department of Health, City of Newport
Challenge: Establish target phosphorous and chlorophyll-*a* concentrations necessary to restore and protect the Newport Water Supply Reservoirs
Resource: Analysis of nutrients and other parameters in water
Project Period: 2014-2015

"EPA ORD's contributions to the effort – spanning from its inception to its end – were critical to its success. Of utmost significance was the ORD Atlantic Ecology Division's involvement in securing analytical chemistry support from ORD's Mid-Continent Ecology Division in Duluth, MN, and in performing certain instrumented analyses critical in enabling RI DEM to pursue a comprehensive monitoring program to evaluate relationships between nutrients, algae and cyanobacteria production, total organic carbon and disinfection by-product formation that serve as the foundation for setting TMDL targets for these critical water supply reservoirs." – RI DEM Office of Water Resources Deputy Chief Elizabeth Scott

In 2014, RI DEM identified all nine Newport Water Supply Reservoirs as impaired, citing low water clarity, low levels of dissolved oxygen, frequent algal and cyanobacteria blooms, and elevated levels of total phosphorus, total organic carbon and chlorophyll-*a*. RI DEM added each of the reservoirs to the List of Impaired Waters under the Clean Water Act, and initiated a Total Maximum Daily Load study to address their degraded water quality. The goal of the study was to establish target phosphorus and chlorophyll-*a* concentrations that will ensure algal growth and total organic carbon concentrations are reduced to a level that supports safe drinking water and protects aquatic life as required under the Clean Water Act.

To assist RI DEM, EPA ORD collected water quality monitoring data biweekly from early May through mid- October 2015, from the nine impaired reservoirs located in Newport, Middletown, Portsmouth, Little Compton and Tiverton – all towns in southeastern Rhode Island. RI DEM, in consultation with the Rhode Island Department of Health, will use the analytical chemistry data results to help establish the target total phosphorous and chlorophyll-*a* concentrations necessary to restore and protect the Newport Water Supply Reservoirs.

Partner: Washington State Department of Fish and Wildlife (DFW)
Challenge: Managing nutrients in riparian ecosystems for fish and wildlife benefits
Resource: Science synthesis of nutrient processes in riparian ecosystems
Project Period: 2018-2019

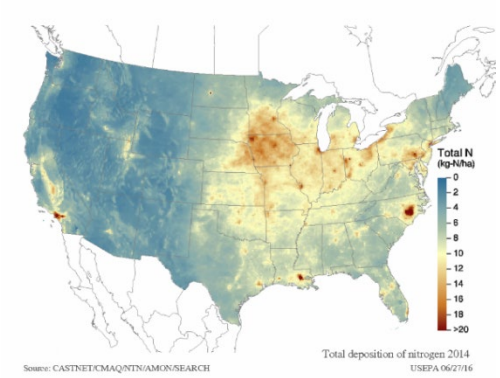
"EPA's willingness to co-author the nutrient chapter of the Washington DFW's riparian science synthesis document was critical to providing the best science to biologists, managers and policy makers throughout Washington. We viewed EPA as an essential partner that provided a very high level of expertise that Washington DFW simply did not have." – Washington State DFW, Chief Scientist Dr. Timothy Quinn

Riparian ecosystems and their streams are critically important locations for sustaining a healthy balance of nutrients–primarily carbon (C), nitrogen (N), and phosphorus (P) – across watersheds and far downstream. Vegetated riparian areas can be efficient natural filters by storing, removing and "fixing" potentially harmful excess nutrients that flow into aquatic ecosystems from uplands dominated by human activities, such as agriculture and urbanization.

To assist Washington State DFW, EPA ORD scientists provided state-of-the-science information on nutrients and riparian ecosystems as a chapter in an upcoming guidance manual designed for states, tribes and commercial interests responsible for managing riparian zones. The chapter provides a basic understanding of nutrient (C, N and P) cycling in riparian zones, including stream channels and Pacific Northwest groundwater. In highlighting the well-studied effects of various land uses, this chapter provides for state officials the key factors they need to consider for maintaining conditions needed for optimal nutrient transport, such as hydrologic connection, vegetation type, soil condition and salmon use of streams.

Access Washington State DFW guidance manuals for managing riparian zones.

Partners: Delaware Department of Agriculture, D.C. Department of Energy & Environment, Maryland Department of the Environment (MDE), Virginia Department of Environmental Quality, West Virginia Department of Environmental Protection
Challenge: Estimating the impact of atmospheric deposition on nutrient loading in Chesapeake Bay
Resource: Improved models for calculating historic and predicting future atmospheric deposition of nitrogen
Project Period: 2015-Present



"Science-based decision-making is at the core of the Chesapeake Bay Program Partnership and ORD's work to update the CMAQ airshed model provided the partnership with a better understanding of past progress and well as future opportunities for reducing atmospheric sources of pollution," – Lee Currey, Water and Science Administration Director, MDE

The Chesapeake Bay Watershed (CBW) includes parts of six states and the District of Columbia and is home to over 18 million people. It provides over $100 billion annually in economic benefits. However, the growth in industry, population, and agriculture in the CBW has degraded water quality, with much of the decline attributed to excessive nutrient loading.

Consequently, in 2010, a Total Maximum Daily Load (TMDL) was established to reduce nutrient loading to the CBW. Atmospheric deposition is among the largest pathways of nitrogen loading to the CBW and the individual and combined impacts of climate and emissions changes on nitrogen loading from NH_x and NO_x to the CBW had not been well assessed.

Working in collaboration with EPA Region 3's Chesapeake Bay Program (CBP), EPA ORD scientists tailored the Community Multiscale Air Quality (CMAQ) modeling system so that it could be used to estimate atmospheric nitrogen deposition for historical (2002-2012), near-term (2017, 2023, 2028), and future (2023, 2028, 2045- 2054) scenarios. The work was conducted to assist partner states and watershed managers.

The work revealed that average meteorological and atmospheric nitrogen deposition model estimates for the historical period matched the observations well and were comparable to retrospective simulations that use observational data assimilation. The future meteorological simulations estimated that the Chesapeake Bay watershed would be warmer, more humid and receive more precipitation by 2050. The future projections also displayed more variability in precipitation compared to historical and current scenarios. Future CMAQ simulations estimated a 21% reduction in atmospheric nitrogen deposition to the watershed, while the future simulation with historical emission rates indicated only a 4% increase in nitrogen deposition due to changes in meteorology (particularly the increase in precipitation). As a result, the nitrogen deposition estimates generated were used in the Phase 6 version of the Chesapeake Bay Model for the 2017 Mid Term Assessment and have been widely distributed among the federal, state, academic, and local Chesapeake Bay Program research partners as they consider options for reducing nutrient loading.

WATER – STORMWATER

Partners: Manomet, Audubon, Nature Conservancy, Southeastern Regional Planning and Economic Development District (Taunton, MA), nine townships in upper Taunton River Watershed in response to recommendations from the state of Massachusetts
Challenge: Evaluate robust management practices to improve water quality, sustain water supply, and reduce flooding under varying weather regimes and projected landscape development using conservation and restoration of natural infrastructure and natural processes
Resource: Case study application of EPA's Watershed Management Optimization Support Tool (WMOST)
Project Period: 2016-Present

"Manomet is partnering with EPA ORD to apply the WMOST model in the Taunton River Watershed in southeastern Massachusetts. The WMOST analysis will provide insight on the nutrient pollution ramifications of different degrees of protection of the green infrastructure network identified by Manomet and project partners. Without the support of EPA ORD, the application of WMOST to quantify the value of the green infrastructure network would not have been possible." – Manomet, Senior Program Leader Climate Services Eric Walberg

The Taunton River in Massachusetts is a designated Scenic River with significant natural resources, but it is located in a rapidly developing region with water supply issues and degrading water quality. The state of Massachusetts has recommended conservation objectives for the watershed that include creation of public forums on the economic value of purchasing (conservation) lands to control municipal budgets and the development of a land purchase priority system.

Based on this recommendation, EPA ORD is assisting the non-governmental organization (NGO) Manomet with an application of the Watershed Management Optimization Support tool (WMOST), to evaluate costs and benefits of natural and nature-based green infrastructure in protecting property and drinking water quality. EPA ORD will also help communities in the upper Taunton by demonstrating a new version of WMOST designed to support consideration of multiple objectives. This will provide stakeholders information to evaluate tradeoffs. In addition, this case study is providing information that will be used by the NGOs and regional planning commission for training workshops on green infrastructure in surrounding communities.

Partners: Maryland Department of the Environment (MDE), Montgomery County, City of Rockville
Challenge: Identifying the most cost-effective suite of stormwater best management practices (BMPs) to meet both local sediment total maximum daily loads (TMDLs) and downstream targets for Chesapeake Bay TMDL
Resource: Case study application of EPA's Watershed Management Optimization Support Tool (WMOST) version 3
Project Period: 2019

"One of Maryland's greatest challenges, and opportunities, is to ensure its Phase I MS4's meet permit and TMDL restoration requirements in ways that are affordable and sustainable. This study, in a small urban watershed, is a cooperative effort among state, county and city governments and EPA to develop a balanced implementation strategy. EPA ORD's modeling tools used in this study have unique features such as stormwater BMP runoff reduction estimates and cost optimization modules to help us achieve environmental results, while maximizing savings for ratepayers." – MDE Secretary Ben Grumbles

The Maryland Department of the Environment (MDE) has identified the Cabin John Creek watershed in Montgomery County, MD as impaired by sediments, nutrients, bacteria, chlorides, sulfates and impacts to biological communities. Cabin John Creek drains to the Potomac River, part of the Chesapeake Bay watershed. To help address these impairments, MDE is providing guidance to local communities about applying cost- effective best management practices (BMPs) to meet regulatory targets set by the total maximum daily loads (TMDLs) for sediments.

EPA ORD is applying version 3 of EPA's Watershed Management Optimization Support Tool (WMOST) to the Cabin John Creek watershed to determine the most cost-effective suite of stormwater BMPs (including green infrastructure) for controlling sediment loading. Watershed managers are using the results of WMOST calculations to identify solutions that will meet both local sediment targets and downstream loading targets for total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN) for the entire Chesapeake Bay watershed.

Read the final report titled *WMOST v3 Case Study: Cabin John Creek, Maryland*.

Partners: Missouri Department of Natural Resources (DNR); City of Kansas City
Challenge: Defensible models to reduce sewer overflows and improve regional water quality in a cost-effective manner
Resource: Storm Water Management Model
Project Period: 2016

"States are focusing on ways to address storm water and tools like the Storm Water Management Model are essential to a successful outcome. This model makes analyses of best management practice options readily available. In addition, the climate adjustment addition helps cities reach sustainable solutions." – Missouri DNR Sara Parker Pauley (former director)

States and municipalities heavily use EPA ORD's Storm Water Management Model (SWMM) to model stormwater flows and the performance of water infrastructure in urban areas. SWMM's Climate Adjustment Tool can also be used to consider potential future changes in temperature and precipitation that will influence the runoff volumes. SWMM is the engine for the basis of almost all future water infrastructure design. SWMM runoff and flow predictions are used for multi- billion-dollar decisions for foreign, federal, state and municipal governments. The city of Kansas City, Missouri, designed its $10 million, 100-acre Middle Blue River pilot on SWMM predictions, and the City intends to design any future green infrastructure controls using SWMM.

Read the final report titled *EPA's Summary Report of the Collaborative Green Infrastructure Pilot Project for the Middle Blue River in Kansas City, MO.*

Partner: Vermont Department of Environmental Conservation (DEC)
Challenge: Prioritization of developed areas for retrofit stormwater best management practices
Resource: High resolution impervious cover data for Vermont watersheds
Project Period: 2017

"The impervious cover data we received from EPA saved me one to two days of work in our efforts to bring increased awareness of the negative impacts on water quality of impervious surfaces which are directly connected to surface waters in developed areas. Increased awareness of problem areas helps us work with municipalities to mitigate impacts." – Vermont DEC Watershed Management Division, Hank (David) Ainley

EPA ORD has developed methods for high accuracy classification of high resolution (1-meter) imagery for impervious cover from the U.S. Department of Agriculture (USDA) National Agriculture Imagery Program (NAIP) imagery for impervious cover with the understanding that such data are needed by states and local communities for infrastructure and development planning. Vermont DEC was looking for mapping data to quickly prioritize developed areas for stormwater best management practices retrofits. ORD was able to provide copies of the in-house developed high-resolution impervious cover data, developed in-house, to Vermont DEC's Watershed Management Division.

Vermont DEC staff are now using these data in conjunction with mapped sewer drainages to quantify connected impervious cover in municipalities with wastewater treatment plants. Vermont DEC is also comparing the condition of streams in watersheds with differing levels of connectivity and using this information to inform decision on where to retrofit. Together Vermont and EPA are exploring ways in which ongoing ORD research on watershed-scale effects of nature-mimicking infrastructure development can complement the state's efforts.

Partners: Alliance for Chesapeake Bay, Chesapeake Bay Foundation, Dauphin County Conservation District, Lancaster County Clean Water Consortium, Lancaster County Conservancy, Lebanon County Conservation District, Pennsylvania State University and Susquehanna River Basin Commission
Challenge: Managing stormwater treatment systems to protect and to restore water quality in the Chesapeake Bay
Resource: Center for Green Infrastructure and Stormwater Management
Project Period: 2016-2018

"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

The EPA ORD-supported Center for Green Infrastructure and Stormwater Management was established to conduct interdisciplinary research to understand and to influence how decisions are made at multiple spatial and jurisdictional scales to manage stormwater treatment systems that protect and restore water quality in the Chesapeake Bay. By the time indicators of impairment are measured within the Chesapeake Bay, the opportunity for adaptive management to alleviate the degradation of water quality may have already passed. It is therefore imperative to identify headwater landscapes that are particularly vulnerable to stress from high pollutant loads, population growth and changes in land management.

The Center serves as a focal point to bring together stakeholders and researchers from multiple disciplines to improve stormwater management in urban and suburban settings; to reduce pollutant loads of nutrients, sediments, organics and metals; and to minimize stormwater volume and energy use across a range of storm event magnitudes. To accomplish these objectives, the Center identified the cognitive and institutional barriers preventing communities from adopting green infrastructure measures to manage stormwater. Additionally, the Center designed green infrastructure and developed methods to help stakeholders visualize alternative infrastructures. It modeled the environmental and financial benefits of these alternative infrastructures and served as a forum for stakeholder discussions.

More information on the research projects at the Center for Green Infrastructure and Stormwater Management.

Partners: Stafford County, VA; City of Baltimore, MD; York, PA
Challenge: Methods to address the effects of current and future changes in storm intensity, heavy precipitation events, and more frequent and severe floods in stormwater management planning
Resource: Technical support to identify barriers and provide tools, data, methods and actions to facilitate planning for impacts of more frequent and severe storms and floods in collaboration with the National Oceanic and Atmospheric Administration (NOAA) and their partners
Project Period: 2015

"Effective planning requires a clear understanding of the science. To that end, the help we are receiving from EPA scientists is critical to enabling us to come up with short and long- range plans that will protect our lands and our waterways." – VA Department of Environmental Quality Director David Paylor

Changes in storms and heavy precipitation events, along with land use changes such as development, can significantly affect the volume of stormwater runoff that municipalities must manage to protect public health and water quality. Local decision makers have identified the need for information that would be useful for planning and adapting local stormwater management plans and controls to account for these changes.

To address this need, EPA ORD scientists and colleagues from NOAA held workshops and led other community- level efforts across states within the Chesapeake Bay and Great Lakes regions. The collaborations resulted in jointly derived insights into how scientific information on weather and climate can be most effectively disseminated to help communities increase the resiliency of stormwater systems in the face of current and future land use changes and more intense storms and floods. In particular, discussions focused on opportunities to implement infrastructure based on low-impact development practices, such as rain gardens that collect and absorb runoff from rooftops, sidewalks and streets, and other alternative management strategies.

A summary report of the workshop was prepared to inform states and communities on implementing their own stormwater management plans.

WATER – WASTEWATER/WATER REUSE

Partners: State of California and San Francisco Public Utilities Commission (SFPUC)
Challenge: Providing sufficient, quality water to meet increasing demands
Resource: Assessment modeling for introduction of novel water reuse technologies
Project Period: 2017-Present

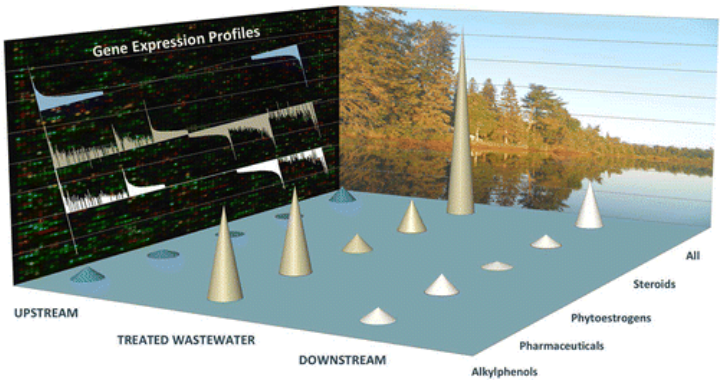
"SFPUC values the research being done by EPA ORD in the field of decentralized non-potable water systems. ORD is building upon completed research to provide much needed, additional support—in terms of characterizing pathogen concentrations and identifying potential surrogates that can be used to monitor treatment process performance—towards the goal of reducing exposure to pathogens." – SFPUC Director of Water Resources Paula Kehoe

Through our collaborations with the state of California and the SFPUC, EPA ORD is developing and testing assessment methods to identify optimum technologies for using alternative waters (sources) for non-potable and potable purposes. Changes in drinking water and wastewater management strategies to meet state and local demands has led to new approaches (e.g. membrane bio-reactors) for developing and implementing additions and improvement to current water treatment and delivery schemes. In addition to these approaches, there is also interest in utilizing alternative waters (sources) in community water systems. To utilize these alternative waters, communities are now faced with additional challenges to ensure the same water quality is delivered, as well as optimizing resource recovery and system efficiency when using alternative waters for non-potable and potable purposes.

SFPUC leads an effort to implement decentralized non-potable water systems that involves a group of stakeholders from across the country, including a range of water utilities (Austin, Denver, Los Angeles, Portland, Seattle and Washington, DC) and public health departments (California, Colorado, Hawaii, Minnesota, Washington and New York City). EPA ORD is assisting by developing and assessing the risk-based log reduction targets related to fit-for-purpose water use. This integrated assessment also includes life cycle costs, and potential environmental (particularly energy) and human health impacts. EPA ORD's work will provide the state and various utilities and public health departments with a system-level approach and framework that will quantitatively evaluate the tradeoffs that exist among alternative processes and identify which configuration delivers a robust and sustainable water system design.

More information on EPA's research on non-potable water reuse can be found here.

Partners: Minnesota Pollution Control Agency (MPCA), Western Lake Superior Sanitary District
Challenge: Complexity of wastewater treatment plant (WWTP) effluents and lack of available water quality guidelines or reference values for many of the chemicals
Resource: Biological effects-based monitoring of WWTP effluents using new science tools in collaboration with the St. Cloud State University, the University of St. Thomas, the National Park Service and USGS Toxic Substances Hydrology Program
Project Period: 2010-2016



"The information generated through this collaborative work will help MPCA and local wastewater treatment facilities better address the contaminants in sewage treatment discharges. Managing impacts of chemicals in surface waters is especially important for MPCA as Minnesotans highly value lakes and streams."
– MPCA John Linc Stine (former Commissioner)

While wastewater treatment infrastructure has been critical for the improvement of water quality nationwide, effluent from wastewater treatment plants (WWTPs) often represents a highly complex mix of chemical contaminants whose composition can vary daily and seasonally with human inputs as well as plant operations. Due to both their complexity and the lack of available water quality guidelines or reference values for many of the chemicals found in WWTP effluents, these sources pose a challenge for determining what biological impacts these effluents may cause, which chemicals may be driving those responses, and where and how to best allocate limited resources available for monitoring and management.

In collaboration with partners at the Western Lake Superior Sanitary District in Duluth, Minnesota, MPCA and other federal and academic partners, EPA ORD studied WWTP effluents discharging into a diversity of surface waters across Minnesota, ranging from urban and agriculture influenced watersheds, to large Great Lakes tributary streams, to a highly pristine national scenic waterway. The group employed novel tools akin to clinical diagnostic tests to look at fish caged in effluent impacted waters, and to estimate and measure both potential and observed biological effects of tens to hundreds of chemicals. By comparing the observed effects of these complex mixtures to expected effects housed in on-line databases, the scientists can better identify which chemicals and biological effects might be of greatest concern, and also identify whether unknown constituents may be contributing significantly to the responses. With this information, decision makers in Minnesota will be able to strategically target follow up investigations that can generate solutions to these challenges.

Partners: NC Department of Environmental Quality, City of Charlotte, City of Raleigh
Challenge: Acceptance of bio-contaminated wastewater by Publicly Owned Treatment Works (POTWs)
Resource: Technical support around pathogens in wastewater infrastructure
Project Period: 2016-2019

"The question of how wastewater plants deal with bio- contaminated waste needs to be addressed before a potential health emergency surfaces. EPA's proactive work to assist wastewater operators before the next emergency occurs is not only prudent, but critical in order to protect public health." – NC DEQ Assistant Secretary Sheila Holman

In October 2014, EPA held a forum on high consequence pathogens in wastewater infrastructure for state and POTW representatives. The forum focused on providing recommendations, technical information, and potential solutions to the wastewater industry, particularly for emergencies.

EPA is investigating data needs that, if filled, would assist wastewater plant operators in making decisions about whether and how to accept wastewater contaminated with high consequence pathogens (e.g. anthrax bacteria, Ebola virus) during an emergency. EPA is also in the process of performing research projects to address needs associated with POTW acceptance of wastewater potentially contaminated with such pathogens.

The forum was organized around the following questions: How do we deal with wastewater contaminated with biological agents such as *Bacillus anthracis* or Ebola virus? What is needed/required for utilities to accept bio-contaminated wastewaters? What sorts of tests, protocols and regulatory guidance are needed? What is needed for permit authorities in NC to guide/allow utilities to accept these wastes? How should these (tests, protocols and regulatory guidance) be designed or implemented? Who should design and evaluate these? Are there other "simpler" tests and protocols? What is needed to address concerns and issues raised by the public, wastewater workers and operators? What are the data gaps and what type of research is needed?

As a result of this forum, EPA and the Water Environment Research Foundation (currently known as the Water Research Foundation) held a national workshop on this topic in 2016. In turn, this led to several research projects being planned and implemented to address the key research gaps and needs brought up in the workshop.

Read the published report from the 2016 workshop titled *Collaborative Workshop on Handling, Management, and Treatment of High-Consequence Biocontaminated Wastewater by Water Resource Recovery Facilities.*

WATER – QUALITY

Partner: Michigan Department of Environment, Great Lakes and Energy (EGLE)
Challenge: Timely public notification of microbiological water quality at inland and Great Lakes recreational beaches
Resource: Validate and implement rapid water monitoring technology for *E. coli* fecal indicator bacteria
Project Period: 2016-Present

"Michigan is excited to be the first state to use qPCR methods for testing beach water across the entire state and to be a pioneer in using this method for a new water quality indicator at beaches. Our citizens and visitors will know before they swim that it is safe to do so, and beaches will open sooner after an advisory. We are pleased that the US EPA is a partner in helping us achieve this goal." – Michigan EGLE's Water Resources Division Director Teresa Seidel

Michigan uses *E. coli* to set water quality standards for recreational use, for both total and partial body contact. Current culture-based methods for detecting *E. coli* in the water are not timely, typically providing results after people may have been exposed to contaminated water or long after "safe" beaches were closed awaiting results. Michigan initiated a statewide effort to change this, instead using a rapid quantitative polymerase chain reaction (qPCR) method to monitor inland and coastal freshwater beaches. In 2012 EPA provided water quality criteria for both culture and qPCR methods for another fecal indicator bacteria group, enterococci, but not for *E. coli*.

EPA has been collaborating with EGLE and Michigan State University to conduct studies to validate EPA draft Method C: a rapid qPCR method developed by EPA ORD for quantitative detection of the state-approved water quality indicator organism, *E. coli*. EPA ORD has also provided training to labs in the use of this new method.

Another part of this collaborative effort between EPA and EGLE is to establish *E. coli* values as measured with draft Method C that are equivalent to current culture-based beach notification values at over 100 inland and Great Lakes beaches throughout the state. Data collected both by the ORD and local Michigan laboratories have been used in making this determination. A collaborative effort between EGLE, ORD and EPA Office of Water led to the establishment of Michigan-wide beach notification value using EPA E. coli qPCR method (draft method C) that was implemented for the 2019 beach season. These efforts led to the use of a more rapid, validated method being put in the hands of university, water quality, and public health laboratories throughout the state.

Read the final report titled *Evaluation of multiple laboratory performance and variability in analysis of recreational freshwaters by a rapid Escherichia coli qPCR method (Draft Method C).*

Partner: Minnesota Pollution Control Agency (MPCA)
Challenge: Development of an updated sulfate standard
Resource: Technical support to the state by expert consultation and peer review
Project Dates: 2011-2018

"MPCA values the scientific expertise and partnership of EPA ORD, as we have worked to understand the complex physical, chemical and biological relationships that impact wild rice growth in Minnesota's lakes, stream and wetlands. By cooperating with the ORD's Mid-Continent Ecology Division and other scientific experts, the MPCA has developed ground- breaking improvements in our understanding of these relationships." – MPCA John Linc Stine (former Commissioner)

EPA ORD scientists supported an ongoing effort in Minnesota to better understand and address the effects of sulfate and other substances on wild rice, which is an important component of many of Minnesota's lake and stream ecosystems, and a highly valuable economic and cultural resource for many state residents. ORD researchers consulted with lead scientists from MPCA on both the original study protocol and the technical aspects of the study, and then on the analysis and interpretation of the resulting data. ORD also consulted with EPA Region 5 on aspects of sulfate water quality standards.

In May 2018, MPCA withdrew its proposal to amend the sulfate water quality standard. EPA ORD's technical support improved understanding of how to protect Minnesota's wild rice that will be valuable for decision makers for any future determination.

Partners: Mississippi Department of Environmental Quality (DEQ), Turkey Creek Community Steering Committee
Challenge: Multiple sources of fecal contamination
Resource: Fecal bacterial and viral indicators for identification of pollution sources
Project Period: 2016-2019

"Along with these efforts in Turkey Creek, Mississippi DEQ feels very fortunate to have benefited from our ongoing partnership with EPA's Gulf of Mexico Program and ORD's Gulf Ecology Division. As with all successful partnerships, we attribute these successes to the dedicated staff at our respective agencies along with the community leaders and their commitment to collaboration and communication throughout the project. We look forward to future opportunities for successful collaboration." – Mississippi DEQ, Field Services Division Chief Doug Upton

Turkey Creek in Gulfport, Mississippi, is listed as impaired due to fecal contamination under the Clean Water Act. Pollution control measures are only effective if the sources are identified. In 2007, the Mississippi DEQ included three monitoring locations on Turkey Creek as part of an Ambient Recreational Monitoring Network. As this contamination issue has persisted for some time, EPA ORD began assisting in 2016 by collecting samples at the monitoring stations and employing novel viral and community microbiology techniques to compare with standard bacterial techniques.

These locations are sampled and evaluated for E. coli during both the contact (May-October) and non-contact (November-April) seasons. In August 2011, the local community's plans included the need to identify and mitigate all pollution sources for both Turkey Creek and Bayou Bernard and establish regular monitoring to ensure water quality.

EPA ORD scientists and partners are collaborating on research to identify the sources of fecal pollution in Turkey Creek, leveraging the current successful community citizens' science bacterial monitoring program established by EPA's Gulf of Mexico Program. Collaborators from the Gulf of Mexico Program are in regular communication with Mississippi DEQ. Through a monthly sampling scheme, fecal sources are being identified through characterization of viral genotypes and microbial communities in the water column and sediment. The project also evaluates land use, stream hydrology and urban sewage treatment in the landscape for the identification of point and non-point pollution sources. Data from this project will be shared to better inform decisions made by Mississippi DEQ and the local Turkey Creek Steering Committee to control fecal-contamination in Turkey Creek.

The project report was completed by October 2019 with the exception of the peer-review process for the EPA report.

Partners: Mississippi Department of Marine Resources (DMR), Grand Bay National Estuarine Research Reserve (GBNERR)
Challenge: Better understanding acute and chronic effects of industrial spills on ecosystem health in a coastal reserve
Resource: Analysis of ten years of monitoring data to describe water quality changes from industrial spills, in collaboration with the National Oceanic and Atmospheric Administration (NOAA)
Project Period: 2004-2018

"When there's an industrial spill, we want to be able to respond appropriately. Analyzing effects of prior spills on things we measure in our long-term water quality and nutrient monitoring program helps us plan for such situations by understanding the past. ORD staff has been incredibly helpful in analyzing the data – bringing both statistical and software expertise to the project. Through the process, they've helped us get a better idea of how to analyze and interpret our long-term monitoring data. This is also helping with other data analyses and will be used by other state agencies." – Mississippi DMR GBNERR Monitoring Coordinator Kimberly Cressman

Grand Bay is part of the National Estuarine Research Reserve System (GBNERR) established as a federal partnership with the Mississippi DMR to address long-term research, monitoring, education and stewardship goals. The reserve includes 18,400 acres of protected areas that cover several coastal habitats including pine savannas, salt marshes, seagrass meadows and oyster reefs. Researchers at GBNERR work collaboratively to advance science-based management and appreciation of the reserve's unique resources. Although GBNERR is relatively pristine, industrial activities have negatively affected the health of the bay. One of the largest fertilizer production facilities in Mississippi is located in the nearby city of Pascagoula. Extreme weather caused two spill events in 2004 and 2011. Highly acidic and phosphorus-rich wastewater entered GBNERR, causing dramatic changes in water quality and observed fish kills. Understanding the immediate and potentially long-term effects of these events is a priority for effective management of GBNERR.

Understanding long-term changes in water quality is critical to describing historical impacts and developing expectations of future changes of the ecosystem health of GBNERR. Research staff at GBNERR have been collecting routine monitoring data at several locations since 2004. After attending an EPA ORD workshop on time-series analysis, GBNERR staff initiated a collaborative effort to describe the response of nutrient parameters in GBNERR in relation to acute and chronic effects of each spill event, as well as spatial changes in these parameters among the monitoring sites. Previous studies have been limited in the amount and quality of data used to describe such spill events. Results from this analysis provided critical information on estuarine response to industrial impacts—most estuaries are nitrogen-limited, so the effects of phosphorus inputs are not well understood. This collaborative work not only addressed a critical research gap, but also described potential changes in GBNERR water quality that can guide Mississippi DMR in more effective management of this unique and valued ecosystem. EPA ORD scientists continue to provide technical support for model development and application.

Read the final report titled *Water quality trends following anomalous phosphorus inputs to Grand Bay, Mississippi, USA.*

Partner: Oregon Department of Agriculture (ODA)
Challenge: Managing Oregon's commercial shellfish harvests to reduce public health risk
Resource: Improved methods to forecast environmental conditions that lead to shellfish harvesting closures
Project Period: 2004-2018

"Tillamook Bay is one of the most productive and diverse commercial shellfish growing bays in Oregon. Environmental characteristics and human development in the watershed also make it one of the most complicated in terms of pollution impacts. The work EPA is doing on fecal indicator bacteria will provide valuable information on sources of water pollution at a level that has not been possible before. This information will be used to ensure safe food can continue to be produced from this bay and help maintain the livelihoods it supports." – ODA Food Safety and Animal Health Program, Food Safety Inspector & Shellfish Specialist Alex Manderson

To protect human health, state agencies close estuarine waters to shellfish harvest during periods of elevated fecal bacteria and other factors. In Tillamook Bay, Oregon, elevated bacteria levels result in shellfish harvest closures approximately 100 days a year, affecting the State's largest concentration of commercial wild-caught shellfish and oyster aquaculture operations. ODA has authority to restrict the harvesting and distribution of shellfish by commercial processors if there is potential risk for illness to consumers. ODA bases harvest closure decisions on river flow and precipitation, which works well during wet seasons when runoff may carry fecal bacteria from urban or agricultural sources into shellfish growing areas. However, these environmental variables do not predict elevated fecal bacteria levels well during dry, summer months during peak shellfish harvesting season. Season-specific criteria for determining high bacterial loads in the vicinity of shellfish beds would help ODA better ensure the safety of commercial shellfish for the benefit of consumers and the shellfish industry.

EPA scientists are collaborating with ODA shellfish managers to develop improved models to forecast environmental conditions indicative of unsafe levels of fecal bacteria within Tillamook Bay. The research involves statistical analysis of environmental drivers (such as rainfall, wind strength, temperature, river discharge, tide stage) that are associated with changes in the fecal bacteria concentrations at several locations within the estuary, using ODA's bacterial data and publicly available environmental data. The analysis revealed seasonal and locational differences of which environmental drivers had the greatest influence on bacterial levels.

Consequently, under a given set of environmental conditions, some parts of the estuary might not require harvest closure, whereas others would. High precipitation and river discharge lead to elevated bacteria levels during wet months (October to May), as expected. During dry seasons (June-September), the research revealed that elevated bacterial levels were associated with strong winds and tidal extremes, and the EPA-developed statistical models performed better than ones currently used by ODA. The models developed by EPA may be used to inform ODA's approach for shellfish harvest closures and improve the effectiveness of future bacterial monitoring efforts.

Read the final report titled *Statistical models of fecal coliform levels in Pacific Northwest estuaries for improved shellfish harvest area closure decision making*.

Partner: Pennsylvania Department of Environmental Protection (PA DEP)
Challenge: Wide-spread freshwater fish disease
Resource: Causal Analysis/Diagnosis Decision Information System (CADDIS)
Project Period: 2012-2016

"I am confident that our science-based partnership with EPA ORD and the Pennsylvania Fish and Boat Commission will help us determine the causes of impacts to aquatic health in the Susquehanna. Science guides our work in assessing the overall health of the river, and in partnership with these agencies, we will be able to create a strategy that matches our challenges to conserve and protect this river, which is important to the recreational vitality and economic prosperity of Pennsylvania." – PA DEP John Quigley (former secretary)

Unusual mortality events and outbreaks of disease have been observed annually in young-of-the-year Smallmouth Bass in the mid to lower Susquehanna River since 2005, resulting in poor recruitment of juvenile fish into the adult population. The Susquehanna River Smallmouth Bass Technical Committee, including representatives from PA DEP and the Pennsylvania Fish and Boat Commission (PFBC), was formed in 2007 to characterize the potential causes of the problems. Numerous water-quality and fish health variables were evaluated, but no definitive associations emerged. Additional research and monitoring efforts continued, and in 2012 PA DEP initiated a large study of the river. In 2014, PA DEP and its partners looked to EPA ORD's expertise and innovative tool, the Causal Analysis/Diagnosis Decision Information System (CADDIS), to help organize and synthesize the data.

EPA assisted PA DEP and its partners in implementing the CADDIS causal assessment process, providing a means to utilize the data collected to date and winnow the long list of hypothesized causes of the poor recruitment of Smallmouth Bass. Candidate causes evaluated included abiotic stressors such as high flows, low dissolved oxygen, high pH, and toxicity from exposure to ammonia or toxic chemicals. Biotic candidate causes included food quality changes from non-native species and cyanobacteria. Diseases caused by pathogens or parasites were considered, as well as the possibility that stressors have increased Smallmouth Bass susceptibility to disease. Over 50 worksheets, comprising 400 pages, that described data collections and analyses were developed and evaluated during the course of assessment.

Pathogens and parasites were identified as likely contributors to the problem: disease prevalence was strongly and negatively correlated with survival of juvenile fish. Endocrine disruptors and herbicides were also judged to be likely contributors by increasing disease susceptibility, although only limited evidence was available to evaluate these candidate causes. The CADDIS process was particularly beneficial for optimizing further data collection and analysis efforts. The financial and personnel resources of the state were redirected to the priorities identified by assessment: endocrine disruptors, parasites and pathogens.

Read the final report titled *Causal Analysis of the Smallmouth Bass decline in the Susquehanna and Juniata Rivers.*

Partners: Washington State Department of Natural Resources, Washington State Department of Ecology, Nisqually Land Trust, Nisqually Tribe
Challenge: Improve watershed condition for salmon recovery, clean drinking water and other ecosystem services
Resource: EPA watershed restoration planning tools (VELMA, Penumbra) and technical support
Project Period: 2015-Present

"Guided by sophisticated new modeling from EPA ORD's Western Ecology Division in Corvallis, combined with modeling used by the Nisqually Tribe for salmon recovery, the community forest's management team will selectively thin the property's timber stands to encourage old-growth forest characteristics and increase stream flow during the fall spawning season." – Nisqually Land Trust Executive Director Joe Kane

Intensive forest management in the Pacific Northwest during the past century has emphasized clearcutting on short harvest intervals (40-50 years). This highly profitable practice has converted the region's vast pre- settlement old-growth forests to young forest landscapes. This has fundamentally changed the functioning forest watersheds and their capacity to sustainably provide essential ecosystem services (nature's benefits) for local and downstream communities. Provisioning of drinking water, flood protection, fish and wildlife habitat, and recreational and cultural opportunities have been significantly degraded in many places.

Indicative of these widespread changes, Puget Sound salmon populations have declined sharply from historic levels. For example, 22 of at least 37 Chinook populations are now extinct, and many other species are listed as endangered. Communities, tribes and state agencies (Departments of Natural Resources and Ecology) are now collaborating throughout the region to implement salmon recovery plans that aim to restore hydrological and ecological processes critical to salmon recovery, and more broadly, to the functioning of entire watersheds and the ecosystem services they provide. A prime example is the Nisqually Community Forest (NCF), a novel collaboration of communities in southern Puget Sound aimed at acquiring private forest industry lands from willing sellers. The NCF is a working forest owned and managed for the benefit of local communities.

EPA ORD has developed and transferred modeling tools to NCF to support their salmon-recovery planning in the Mashel River watershed, a once prime salmon producing sub-basin of the Nisqually River. NCF staff are currently using EPA's Visualizing Ecosystem Land Management Assessments (VELMA) watershed simulator to quantify long-term effects of alternative management and climate scenarios on key salmon habitat and water quality variables. A key NCF goal is to design sustainable management plans that emphasize forest thinning and robust riparian buffers, a strategy shown by VELMA simulations to restore greater summer stream flows favorable to salmon spawning. Other ongoing NCF projects using VELMA include prioritization of land acquisitions, community-based best management practices and long-term management strategies.

Access the presentation slides describing this collaborative project titled *How Visualizing Ecosystem Land Management Assessments (VELMA) modeling quantifies co-benefits and tradeoffs in Community Forest management*.

Partner: Washington State Conservation Commission
Challenge: Improving water quality impacted by fecal pollution in Washington
Resource: Collaborating on technical oversight committee concerning implementation of DNA-based microbial source tracking tools along with members from Washington State Conservation Committee, Washington Department of Agriculture, Washington State Department of Ecology, and Whatcom Conservation District
Project Period: 2017-2019

"The Washington State Conservation Commission has really appreciated and relied on ORD's help and scientific knowledge and expertise of microbial source tracking. EPA ORD gave our agency panel an informational presentation on what microbial source tracking actually is and how it can be used. The information helped our panel understand the scientific concepts around it, which in turn, helped the panel in selecting the best project." - Karla Heinitz, Management Analyst, State Conservation Commission

Every citizen, community, state, tribe and economy relies on clean, safe water. The number one biological contaminant in U.S. surface waters is fecal pollution leading to impairment of almost 10,000 water bodies across the country.

EPA, in collaboration with members from the Washington State Conservation Committee, Washington Department of Agriculture, Washington State Department of Ecology, and Whatcom Conservation District, were part of a technical oversight committee. This committee was organized by the Washington State Conservation Commission to support the implementation of DNA-based microbial source tracking tools across the state in 2017-2019.

The goal of the committee was to prepare a request for proposals (completed March 2018) and select a suitable project that would help educate, build laboratory capacity, and implement DNA-based microbial source tracking tools, some developed by EPA ORD, statewide (completed in August 2018). A demonstration project was then conducted over a five-month period to characterize fecal pollution sources after storm events in Vaughn Bay, WA. The project was completed in July 2019 resulting in quantitative fecal source information leading to recommended source control actions to reduce fecal pollution in Vaughn Bay, as well as a series of method protocols for cost-effective application in other Washington state watersheds.

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Advanced monitoring technologies (CA, CO, CT, KY, NH, OR)
Planning for energy and air emissions (CT, ME, MA, NH, NJ, NY, RI, VT)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)

NEW JERSEY

Determining scope of PFAS contamination
Multi-agency Long Island Sound Tropospheric Ozone Study (CT, NJ, NY, RI)
Planning for energy and air emissions (CT, ME, MA, NH, NJ, NY, RI, VT)
Reducing harmful air pollutants (CA, GA, MD, NC, NJ, NY, UT, VA)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)

NEW MEXICO

Gold King Mine Spill local waterways/sediments sampling
Persistent environmental health disparities research (AZ, CO, NM, UT)
Bacillus anthracis contamination cleanup (CA, DC, MA, NY, VA)

NEW YORK

Sampling operations following biological incidents
Multi-agency Long Island Sound Tropospheric Ozone Study (CT, NJ, NY, RI)
Planning for energy and air emissions (CT, ME, MA, NH, NJ, NY, RI, VT)
Reducing harmful air pollutants (CA, GA, MD, NC, NJ, NY, UT, VA)
Wide area radiologic contamination (CA, DC, IL, NC, NY, OH)
Management of bio-hazardous wastes (MD, NY)
Predicting water quality at beaches (IL, IN, MI, MN, NY, OH, PA, WI)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)
River Spill model (IL, IN, KY, NY, OH, PA, VA, WV)

NORTH CAROLINA

Community air quality monitoring (CT, DC, IL, KS, NC, OK, PA, TX)
Mapping PFAS levels
Science, Technology, Engineering, and Math (STEM) education
Transportable gasifier technology
Acceptance of bio-contaminated wastewater
Reducing harmful air pollutants (CA, GA, MD, NC, NJ, NY, UT, VA)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NC, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)
Wide area radiologic contamination (CA, DC, IL, NC, NY, OH)
Characterizing urban background levels for contaminated site cleanup levels (FL, GA, KY, NC, SC, TN)

NORTH DAKOTA

OHIO

Managing algal toxins
Harmful algal bloom limiting drinking water
Managing excessive nutrient runoff causing HABs
Lake Michigan's ozone formation and transport (IL, IN, MI, MN, OH, WI)
Wide area radiologic contamination (CA, DC, IL, NC, NY, OH)
Predicting water quality at beaches (IL, IN, MI, MN, NY, OH, PA, WI)
River Spill model (IL, IN, KY, NY, OH, PA, VA, WV)
Ammonia removal from drinking water (IA, IL, IN, OH)
Simulating and monitoring conditions in drinking water utilities (CO, FL, KY, MI, OH)

OKLAHOMA

Chemical composition analysis
Community air quality monitoring (CT, DC, IL, KS, NV, OK, PA, TX)
Response to ricin contamination (CO, DC, MS, OK, TN, VT, WI)

OREGON

Reducing methyl mercury levels
Coastal acidification effects on fisheries
Water nitrate contamination
Shellfish harvesting closures
Advanced monitoring technologies (CA, CO, CT, KY, NH, OR)

PENNSYLVANIA

Wide-spread freshwater fish disease
Community air quality monitoring (CT, DC, IL, KS, NV, OK, PA, TX)
Predicting water quality at beaches (IL, IN, MI, MN, NY, OH, PA, WI)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)
River Spill model (IL, IN, KY, NY, OH, PA, VA, WV)
Managing stormwater treatment systems (MD, PA, VA)
Stormwater management planning support (MD, PA, VA)

PUERTO RICO

RHODE ISLAND

Fishing sites for safe consumption
Analysis of nutrients and other parameters in water
Multi-agency Long Island Sound Tropospheric Ozone Study (CT, NJ, NY, RI)
Planning for energy and air emissions (CT, ME, MA, NH, NJ, NY, RI, VT)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)

SOUTH CAROLINA

Subsurface chlorinated solvent contamination
Food waste reduction
Characterizing urban background levels for contaminated site cleanup levels (FL, GA, KY, NC, SC, TN)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)

SOUTH DAKOTA

TENNESSEE

Response to ricin contamination (CO, DC, MS, OK, TN, VT, WI)
Characterizing urban background levels for contaminated site cleanup levels (FL, GA, KY, NC, SC, TN)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)

TEXAS

Chemical contamination risks
Community air quality monitoring (CT, DC, IL, KS, NV, OK, PA, TX)

UTAH

Fine particle air pollution
Toxicity testing for Great Salt Lake species
Emissions measurement methods (UT, CO, WV)
Reducing harmful air pollutants (CA, GA, MD, NC, NJ, NY, UT, VA)
Persistent environmental health disparities research (AZ, CO, NM, UT)

VERMONT

Impervious cover data for watersheds
Planning for energy and air emissions (CT, ME, MA, NH, NJ, NY, RI, VT)
Response to ricin contamination (CO, DC, MS, OK, TN, VT, WI)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)

VIRGINIA

Stream condition assessments
Reducing harmful air pollutants (CA, GA, MD, NC, NJ, NY, UT, VA)
Bacillus anthracis contamination cleanup (CA, DC, MA, NY, VA)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)
River Spill model (IL, IN, KY, NY, OH, PA, VA, WV)
Atmospheric deposition of nitrogen (DE, DC, MD, VA, WV)
Managing stormwater treatment systems (MD, PA, VA)
Stormwater management planning support (MD, PA, VA)

WASHINGTON

Coastal Biodiversity Risk Analysis Tool
Habitat suitability models
Stream temperature stress
Remedial investigation/feasibility study technical support
Passive remediation alternative
Superfund site technical support
Managing nutrients in riparian ecosystems
Watershed condition improvements
DNA-based microbial source tracking

WEST VIRGINIA

Emissions measurement methods (UT, CO, WV)
Environmental DNA (eDNA) for species inventory (CA, KY, MD, WV)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)
River Spill model (IL, IN, KY, NY, OH, PA, VA, WV)

Atmospheric deposition of nitrogen (DE, DC, MD, VA, WV)

WISCONSIN

Lake Michigan's ozone formation and transport (IL, IN, MI, MN, OH, WI)
Response to ricin contamination (CO, DC, MS, OK, TN, VT, WI)
Predicting water quality at beaches (IL, IN, MI, MN, NY, OH, PA, WI)

WYOMING

MJLTISTATE

Multi-agency Long Island Sound Tropospheric Ozone Study (CT, NJ, NY, RI)
Lake Michigan's ozone formation and transport (IL, IN, MI, MN, OH, WI)
Community air quality monitoring (CT, DC, IL, KS, NC, OK, PA, TX)
Emissions measurement methods (UT, CO, WV)
Planning for energy and air emissions (CT, ME, MA, NH, NJ, NY, RI, VT)
Reducing harmful air pollutants (CA, GA, MD, NC, NJ, NY, UT, VA)
Persistent environmental health disparities research (AZ, CO, NM, UT)
Environmental DNA (eDNA) for species inventory (CA, KY, MD, WV)
Bacillus anthracis contamination cleanup (CA, DC, MA, NY, VA)
Wide area radiologic contamination (CA, DC, IL, NC, NY, OH)
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Predicting water quality at beaches (IL, IN, MI, MN, NY, OH, PA, WI)
Stream monitoring network (AL, CT, DE, GA, KY, MA, MD, ME, NV, NH, NJ, NY, PA, RI, SC, TN, VA, VT, WV)
River Spill model (IL, IN, KY, NY, OH, PA, VA, WV)
Satellite derived measures of cyanobacteria (AR, AZ, CA, CO, FL, ID, IO, KS, KY, LA, MO, ND, NY, OH, OR, PA, RI, SC, SD, TN, UT, VT, WA, WI and WY)
Ammonia removal from drinking water (IA, IL, IN, OH)
Simulating and monitoring conditions in drinking water utilities (CO, FL, KY, MI, OH)
Atmospheric deposition of nitrogen (DE, DC, MD, VA, WV)
Managing stormwater treatment systems (MD, PA, VA)
Stormwater management planning support (MD, PA, VA)

ALL STATES

Performance targets for air quality sensors (all states)
Risk assessment training (all states)
Resources for small drinking water systems (all states)