Findings of the 2022 Biennial ERIS Survey on State Environmental Agency Research Needs

Introduction

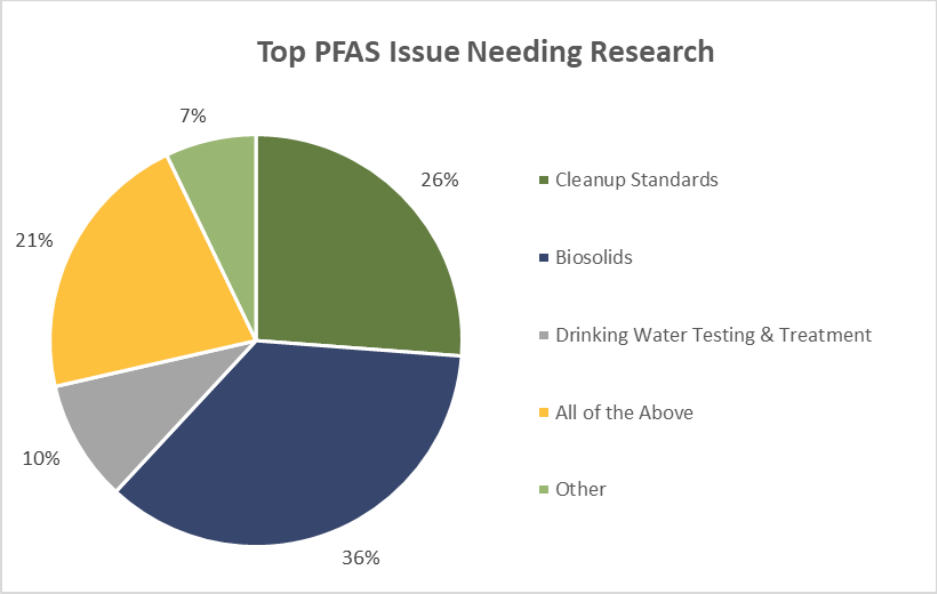
In September 2022, the Environmental Research Institute of the States (ERIS) conducted its fifth biennial survey of state environmental agency research needs. ERIS use the survey as an opportunity to identify states' key research priorities and convey those research needs to the U.S. Environmental Protection Agency's (EPA) Office of Research and Development and other federal partners.

The 2022 survey asked state environmental agency leaders to identify their priority issues requiring additional research on per-and polyfluoroalkyl substances (PFAS), air quality, drinking water, water quality, waste and remediation, adaptation, and cross-media. In each category, respondents selected from several options with the opportunity to describe "other" issues. 43 states and territories responded to the survey.

Throughout the fourth quarter of 2022, ECOS staff spoke with state environmental agency subject-matter experts to gather details on the research needs identified by their agency leaders. Information gathered from the survey and follow-up conversations is compiled below.

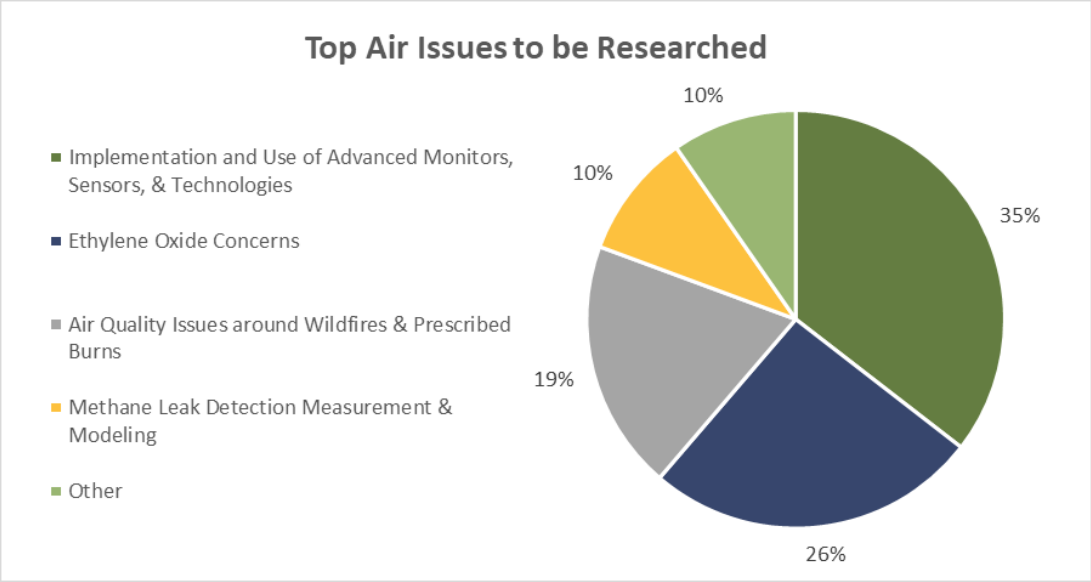
Summary

These pie charts reflect the percent of state and territorial environmental agency leaders (ECOS Members) who identified each issue as a challenge and/or priority requiring additional research in each environmental media. More specifics on each area are described in more detail following this summary.

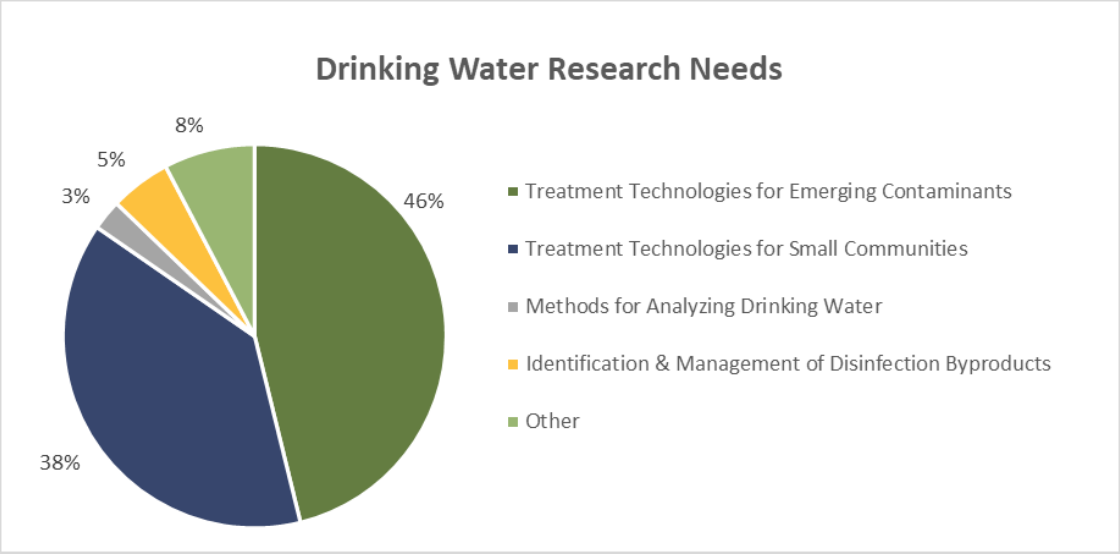


Given the high-profile nature of PFAS pollution, respondents were asked a simple yes-or-no question on whether additional research around PFAS is a priority for their state. 42 of the 43 responding state agencies indicated that it is.

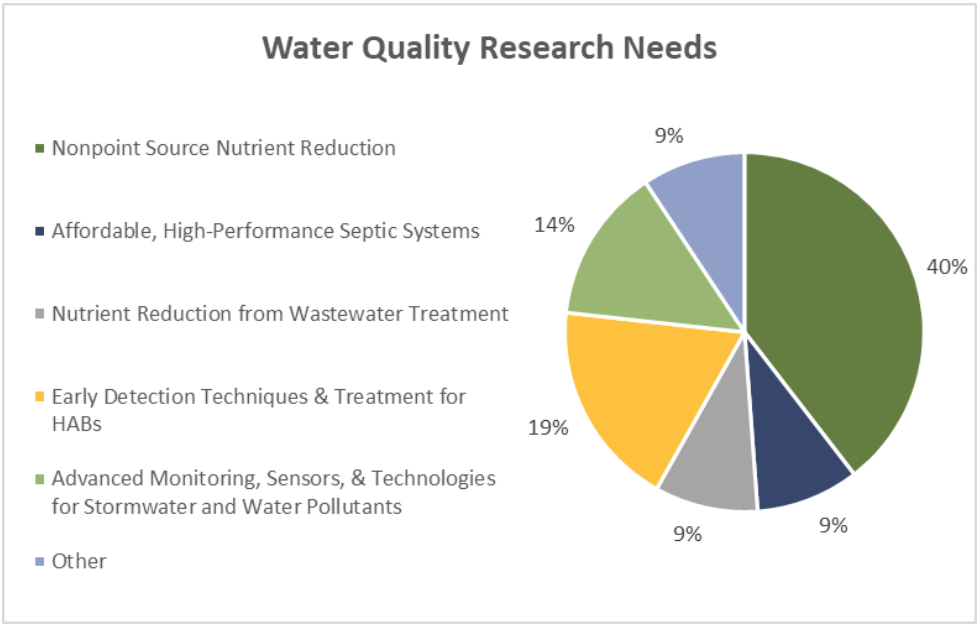
The 42 states and territories that indicated PFAS is a priority research area were asked to select a specific issue that needs additional research. Although "all of the above" was not one of the options, enough respondents wrote that in the comment box to warrant a separate category reflected in the chart below. About a quarter of the states responded "other" and were asked to explain what specifically they needed assistance with. The comments included needing additional research on destruction and disposal methods, source identification methods, treatment methods for PFAS in publicly owned treatment works, and safer alternatives, among other research needs.



Ozone nonattainment challenges is the key air issue needing more research, as 12 respondents (28%) selected it as their top priority for additional research. This was closely followed by the implementation and use of advanced air monitors, sensors, and technologies, selected by 11 (25%) of state and territorial environmental agency leaders that responded to the survey. Ethylene oxide (EtO) concerns (eight states), air quality issues around wildfires and prescribed burns (six states), methane leak detection and modeling (three states), and "other" (three states) are the other air research needs state would like assistance with. The respondents that chose the "other" option commented that research on better data for regional haze modeling; PFAS source characterization, test methods, and control technology; and tools for exceptional event determination would be most helpful to their states.

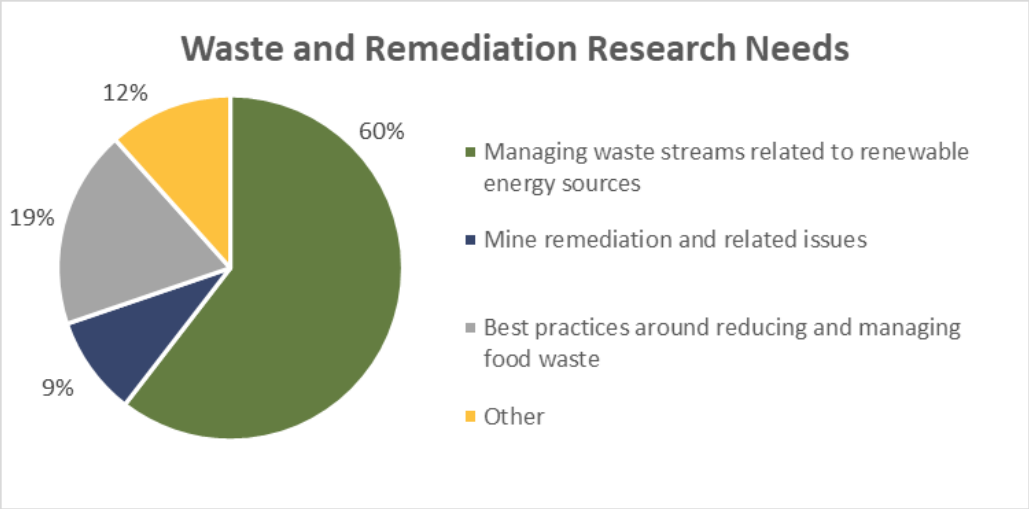


Four respondents did not provide input on drinking water research needs as they indicated that drinking water is dealt with by their state's Department of Health. Of the 39 responses gathered in the survey, 32 (84%) of states and territories selected either treatment technologies for emerging contaminants (15 states, or 42%) or for small communities (15 states, or 35%) as the top drinking water research need. Two states selected inexpensive and effective methods for analyzing drinking water as a top research priority, and one state selected identification and management of disinfection byproducts. The eight states (19%) that selected "other" commented that top drinking water research needs include developing methods for identifying cumulative risk from drinking water and developing disposal methods for drinking water treatment residuals.

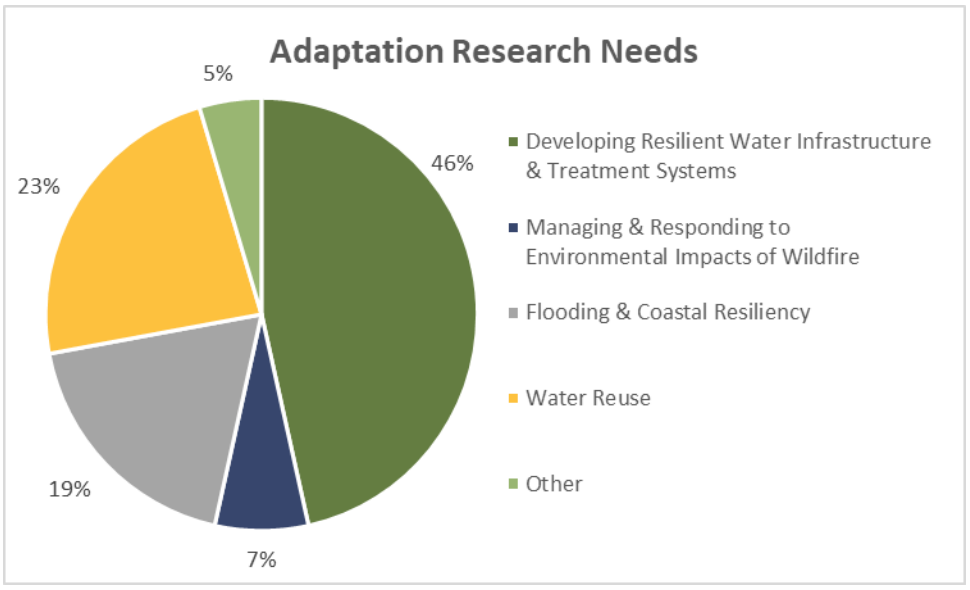


Nearly half the states and territories that responded to the survey indicated that for water quality research needs, nutrients are the priority area, with 17 states (40%) selecting nonpoint source nutrient

reduction and four states (9%) selecting nutrients from wastewater treatment. Detecting and treating harmful algal blooms (HABs) (eight states, or 19%) and advanced monitoring, sensors, and technologies for stormwater and water pollutants (six states, or 14%) are the other top priorities for research among states. Affordable and high performance septic systems and "other" were selected by four states each.

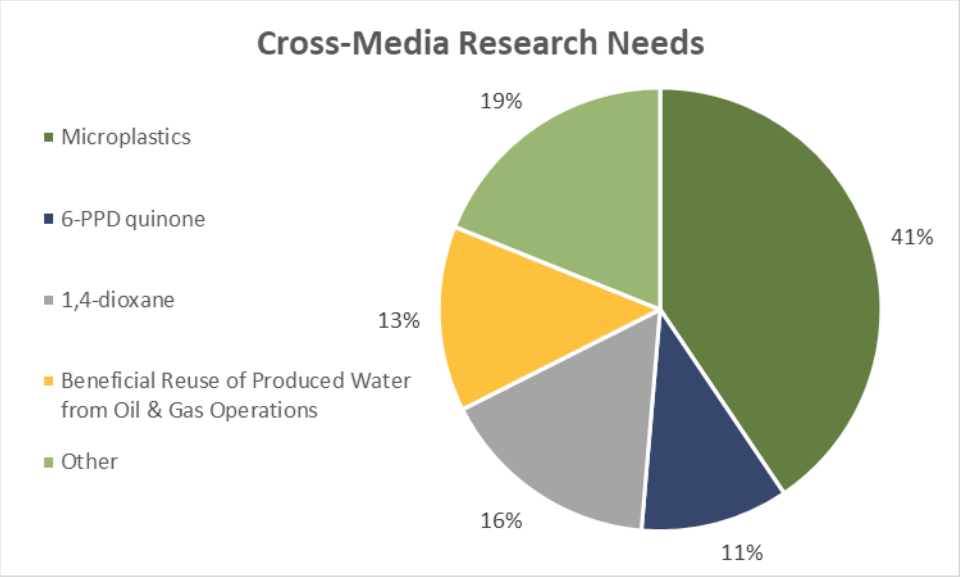


When considering research needs on waste and remediation, 26 states and territories (60%) indicated that managing waste streams related to renewable energy resources such as solar panels, wind turbines, and electric vehicle batteries is the top priority. The next most common issue identified was best practices for reducing and managing food waste (eight states, or 19%). Descriptions of "other" waste and remediation issues focused on managing PFAS waste and remediating PFAS contaminated soil.



Most states and territories selected water-related issues as the top priorities for adaptation research needs. Developing resilient wastewater and drinking water infrastructure and treatment systems received 46% of the responses (20 states), with water reuse (10 states, or 23%), and flooding and coastal

resiliency (seven states, or 19%) representing another 42% of responses. Three states identified wildfire research needs and three states identified "other" adaptation research needs as top priorities in this category.



15 of 37 states and territories (35%) responding to this question indicated that their top cross-media research need is health and environmental impacts of microplastics. States also frequently selected identification of research on the prevalence and toxicity of 1,4-dioxane (5 states, or 16%) and 6-PPD quinone (4 states, or 11%). 13% (5 states) of the respondents selected beneficial use of produced water from oil and gas operations. Descriptions of "other" cross-media research needs included beneficial reuse of biosolids, ecological remediation standards, marine debris, PFAS issues, and toxicity assessments of more chemicals in commerce.

Details from ECOS' conversations with state environmental agency subject-matter experts to gather more information on each of the priority areas their directors ranked are provided in the next section of this report.

Details on PFAS Research Needs

Since PFAS is cross-media issue that could warrant its own section of the survey, states were asked generally if additional scientific research around PFAS issues is a priority and if there is a specific research-related PFAS issue that EPA could assist with. 42 states said yes and that biosolids application, "other," cleanup standards, and drinking water testing and treatment are priorities, in that order. States that selected the "other" option would like additional PFAS research on:

- **PFAS in air**. This includes research on:
    - More robust PFAS source characterization, including finding correlations between PFAS sources and deposition to air and other environmental media, even if only for PFOA and PFOS to start.
    - Improved monitoring to be able to better model PFAS in stacks, air.
    - Developing other PFAS test methods and evaluating control technologies, and finalizing a stack test methodology. States would like a method other than Other Test Method (OTM) 45, as this covers a limited number of pollutants it can measure in a stack. Although OTM 50 can measure a few more, several states said that methods are lagging and potentially hundreds of PFAS may be emitted. It would be helpful to be able to better measure or detect total PFAS in the airstream.
    - Developing a health standard for PFAS in air.

- **PFAS in fish tissue**. This includes research on:
    - A uniform approach for fish tissue sampling so results can be compared across states.
    - Water quality criteria for PFAS and evaluating the effects in fish tissue versus what is in the water, figuring out fate and transport in the aquatic environment, and understanding the uptake from fish to set a surface water standard. What is the acceptable concentration of PFAS from an aquatic toxicity and human health standpoint?

- **PFAS wastewater and waste management**. This includes research on:
    - Best practices and technologies for treating wastewater to reduce PFAS before it goes to other sources.
    - Landfill disposal and biosolids application as management efforts for wastewater sludge. How do these management methods work for PFAS in biosolids and what are the uptake mechanisms for PFAS to animals, crops, etc.? More information on the fate and transport of PFAS in biosolids would be helpful, as well as criteria for solid waste and land application.
    - Advising states on how to best manage PFAS concentrations in groundwater and surface water, and about the efficiency of destruction using different methods like incineration.
    - Recommending ways states can store PFAS and work around insufficient landfill capacities.

- **PFAS toxicity and analytical methods**. This includes:

  - Providing more information to states on the toxicity of different PFAS, including mixtures of PFAS.
  - Continuing to develop analytical methods to test for more PFAS in different environmental media. This includes providing recommendations to stats who do not have the ability to analyze PFAS at such low detection limits – a low-cost method that labs could use to test for PFAS across different media would be helpful and would help some states with limited capacities avoid costs and standards issues when shipping samples out of state.
  - Advising states on measuring PFAS as a class under CERCLA equivalent rules, especially in terms of using Total Organic Fluorine.

- **Aqueous Film-Forming Foam (AFFF)**. This includes research on:
  - What methods work to address AFFF contamination in soil? How do states best manage PFAS when they are required to test equipment, use and store AFFF, dig up soil in the area around where it is used, etc.?
  - Advising states on ways to incinerate or otherwise destroy AFFF, with considerations for EJ communities.

- **Other PFAS research needs**. These include:
  - Providing more information on PFAS adaptation, specifically about the potential of PFAS in water reuse.
  - Conducting more research on PFAS remediation, as well as on how PFAS control techniques can be used for drinking water supplies, control of legionella, and health effects of chloraminated byproducts.
  - Providing guidance on how states with fewer resources can advise companies on the potential for PFAS residuals, what to do with contaminated media, and how to best tackle the issue across different environmental programs.

Details on Air Quality Research Needs

States and territories would like additional research on the several priority air quality topics, details for which are outlined below.

Ethylene oxide, specifically:

- Information on environmental fate and transport, including the atmospheric half-life.
- Improved monitoring, resulting in better data. This includes:
    - Researching less-expensive monitors that are also more sensitive and accurate, allowing for real-time measurements, continuous monitoring ,and fence-line monitoring.
    - Methods for correlating monitoring data with short-term health-based concerns.
- Better standard methods for ethylene oxide testing to ensure that labs get consistent results when measuring EtO and to prevent multiple responses when running a single sample run through a gas chromatograph.
- Data on emissions from EtO sources other than sterilization facilities, such as pharmaceutical facilities and off-site storage facilities for sterilized materials.
- Better measured data on EtO emissions from sterilization facilities, as well as studies on alternatives and pollution prevention options for EtO in sterilization and other facilities.
- Management and control options for fugitive EtO emissions.
- Measurement and understanding of EtO in ambient air.

Wildfires and prescribed burns, especially in regards to:

- Identifying air toxics and other chemicals like asbestos in smoke especially when buildings burn.
- Differentiating the smoke and related health effects from wildfires and prescribed burns.
- Comparing pollution emitted from different types of fires such as pile burns, broadcast burns, and incinerators.
- Looking at whether any PM 2.5 trends can be correlated to wildfires .
- Identifying the health effects of ultrafine PM and determine whether it should be considered separate from PM 2.5.
- Studying the transport of smoke or pollution from prescribed and/or planned burns and how to manage it to prevent impacts like regional haze issues.
- Supporting simplified exceptional event demonstration and documentation.
- Researching wildfire mitigation measures such as what to do with biomass and alternatives to prescribed burns to help reduce their smoke impacts.

Improved modelling capabilities that:

- Better predict EtO emissions using AirMod.
- Better model ozone in western states where the effects of high elevation and mountains is not reflected well.
- Better model wintertime ozone, especially in western states.
- Better predict VOC and ozone contributions from outside state borders.

Advanced air monitors, sensors, and technologies like:

- Portable, accurate, low-cost ozone sensors.
- Portable PM 10 sensors to measure dust around construction sites.

- Sensors or monitors that look at many pollutants of concern at once.
- Pesticide sensors.
- Mobile FTIR that measure a variety of pollutants.
- Low-cost, reliable, and accurate means to measure HAPs, especially in environmental justice areas.
- BTEX monitors or sensors.
- Formaldehyde monitors or sensors.
- Low-cost monitors or sensors for ultrafine particulate matter.
- Passive samplers for air toxics.

Other air quality research like:

- Ozone chemistry especially in the desert southwest environment.
- Methane emission rates from various industries to help policymakers identify the most impactful options.
- Methane leak detection options that are less expensive, allow for fence-line monitoring, and work well at landfills or other sources where methane is not concentrated or under pressure.
- Extrapolating one-time or infrequent methane leak detection measurements into annual methane emissions.
- Sharing best practices for:
    - Developing statewide carbon dioxide emissions inventories that take into account gas wells and agricultural activities, in addition to industrial and transportation emissions.
    - Industry incentives that achieve the best ozone reduction results.
    - Nonpoint source actions such as offering free public transportation that result in ozone reductions.

States seek **technical assistance** related to air quality to:

- Understand the efficacy of various EtO monitors.
- Understand the accuracy and precision of various sensors and mobile monitors including how and when they can be used to generate useful data.
- Ensure FEMs are calibrated to FRMs for particulate matter.
- Consider how to regionally deploy low-cost sensors to look at PM 2.5 impacts from wildfires and prescribed burns.

States request **communications assistance** including:

- Communicating the differences between instantaneous measurements and hourly or other longer-term averages.
- Messaging around the difference between data from low-cost sensors compared to regulatory monitors.
- Communicating risk for pollutants that do not have health-based standard.
- Educating the public on what different data means.

Details on Drinking Water Research Needs

Generally, states and territories said it would be helpful to have additional drinking water-related research on:

- The health effects of chloraminated byproducts and guidance on legionella.
- Relative risk/cumulative risk from climate issues of some drinking water treatment compared to the risk from the contaminant being treated.
- The risks of arsenic contamination from granular activated carbon used to treat PFAS.
- Recharging granular activated carbon for reuse in treating PFAS.
- Whether GAC or RO treatment for PFAS achieves other treatment co-benefits.
- How to test point source discharges to predict what will be coming to drinking water systems.
- Treatment of lead service lines to prevent lead contaminating drinking water.

States also outlined a number of additional research needs for several specific drinking water topics, details for which are listed below.

Treatment technologies, including:

- Developing treatment technologies for contaminants like PFAS (beyond GAC and reverse osmosis, and to include short-chain compounds) and manganese.
- Identifying technologies that are:
    - Scalable for small and very small drinking water systems.
    - Affordable.
    - Able to address multiple contaminants.
    - Able to be operated and maintained by staff with limited training or technical skills.
- Developing treatment technologies for nitrates that are easier and cheaper than ion exchange and other current options.
- Developing treatment technologies for arsenic that are easier and cheaper than current options, especially for small systems where technical management capacity is limited.
- Testing emerging treatment technologies to help states understand which technologies work for which contaminants in what conditions.
- Researching how new treatment technologies for new contaminants effect existing treatment options, with the goal of avoiding things like disinfection byproducts.

Test methods for PFAS, specifically in terms of:

- Developing methods for additional individual or mixtures of PFAS.
- Developing methods that are inexpensive, easy to install, and simple to maintain. Additionally, states would like ones that could be installed simply and inexpensively short-term while a system works to identify a new water source.

Details on Water Quality Research Needs

States and territories most need water quality research assistance on nutrients. This includes assistance with:

- **Nutrient management practices**, like:
  - How to build floodplains onto channelized systems to address nutrients and flows.
  - The nutrient reducing effectiveness of adding floodplains to channelized systems.
  - Studies of innovative practices to slow down systems like cascading wetlands in grass waterways.
  - Information on how climate change will impact the effectiveness of green infrastructure.
- **Nonpoint source nutrient management**, including:
  - The efficacy and cost-effectiveness of different green infrastructure.
  - Best practices for managing agricultural nutrients in different climates.
  - Best post-construction options to address nutrients.
  - Better, lower-energy, cost-effective ways to treat for nitrogen and phosphorous.
  - The effect of a changing climate on ecological systems and nutrient management taking into account the multiple factors at play that stress the oxygen levels in a waterbody. (i.e. temperature, nutrient, load, etc.).
- Other **nutrient** research needs, like:
  - Accurately identifying source contributions of different nutrient sources.
  - Studying the fate and transport of nutrients through different water systems (e.g., surface water, groundwater, fish tissue, etc.).
  - Examining how nutrient reductions in one section of a watershed effect the whole watershed.

States also shared a number of additional research needs for several specific water quality topics, details for which are outlined below.

Advanced stormwater monitoring solutions that:

- Sample and monitor sheet flow.
- Provide continuous monitoring.
- Remotely conducts composite sampling.

Stormwater, specifically in terms of research that:

- Provides information on how to set up a regional urban stormwater monitoring program that encompasses in-stream pollution, outfalls, and stormwater control measure effectiveness.
- Evaluates instantaneous vs. continuous sample monitoring.
- Provides information on how metals in local soil are impacting metal concentrations in stormwater.
- Identifies major nutrient sources for communities with municipal separate storm sewer systems.
- Identifies the best ways to manage the first flush from storms.
- Looks at the environmental impacts from the chlorides in road salts.

- Identifies background sediment levels to compare to stormwater levels.

Septic systems, especially in terms of research that identifies:

- Nontraditional systems such as charcoal or biotreatment that may perform better than traditional systems.
- Systems that work in tight sites.
- Solutions for dealing with septic systems in coastal areas facing sea level rise and inundation.
- Long-term performance of different systems.
- Performance differences at higher elevations and/or lower temperatures.
- Systems or technologies that treat nitrogen.

States would also like EPA to share their research on septic systems and technologies through a repository of systems that are effective in varying climates and geologies to help states better identify which systems to permit.

Harmful Algal Blooms, specifically requesting EPA's assistance with:

- Understanding and explaining the dynamics of harmful algal blooms and how they become toxic and release toxins.
- Developing tools to quickly, easily, and affordably determine in the field if toxins are present.
- Creating a simple model to predict when algal blooms become toxic.
- Researching and sharing information on innovative HABs detection and testing methods. including eDNA, metabarcoding, and in situ cameras and image flow cytobots.
- Designing in situ methods for domoic acid detection in marine environment.
- Researching and developing mitigation strategies for harmful algal blooms.
- Studying the transport of cyanotoxins through waterbodies.

E. coli, in terms of :

- Identifies better monitoring methods
- Develops easy, accessible tools to determine if bacteria in a waterway are from manure or septic systems

Other water quality research, including:

- Developing a selenium treatment technology.
- Understanding the effects of wildfires on water quality, both short-term and long-term and including turbidity and toxins.
- Identifying better monitoring methods for E. coli and developing easy, accessible tools for E. coli to determine if the bacteria in a waterway are from manure or septic systems.
- Developing a framework water quality trading markets that takes into account environmental economics.
- Developing criteria to identify when subsurface discharges are functionally equivalent to a direct discharge into surface water.

Details on Waste and Remediation Research Needs

States and territories would like additional research on the several priority waste and remediation topics, details for which are outlined below.

Renewable energy, specifically in terms of EPA:

- Developing a Toxic Characteristic Leaching Procedure (TCLP) for solar panels.
- Identifying key components of wind turbines, solar panel arrays, and electric vehicle and other batteries that are recyclable.
- Developing best practices for processing wind turbine blades that are being landfilled.
- Publishing studies on or producing research that supports:
    - Recycling options for wind turbine blades and generator towers, and solar panels.
    - The impacts to groundwater from landfilling wind turbine blades and solar panels.
    - The development of a more effective battery recycling framework, including how to efficiently collect them from the wide variety of products they are in, many of which were not developed with easy battery removal and recycling in mind.
- Ensuring that there are efficient and effective recycling markets for materials from renewable energy sources like wind turbines, solar panels, and batteries.
- Providing technical assistance with efforts like a compendium on the components in different brands of solar panels that allows them to better identify how to manage them in terms of recycling and hazardous constituents.

Abandoned mines, by establishing:

- Methods for efficiently and effectively addressing the huge amount of leachate from tailings and adits.
- Innovative ground water remediation opportunities.
- Opportunities for beneficial use of materials left at mines.
- Removal technologies for arsenic and lead from mining leachate.
- Best practices for capping material in place.

Reducing and managing food waste, especially in terms of:

- Environmentally preferable practices.
- Best practices including public communication practices to keep compost and waste separate.
- Research that informs acceptance standards for composting landfills.
- Research that leads to standards for labeling items as compostable.
- Models to help businesses project food waste quantities.
- Research on PFAS contamination in food waste and compost.

In general, states would appreciate assistance with **materials management practices** that:

- Inform how to manage fire risk with collecting and processing of batteries, especially lithium ion batteries.
- Identify best management practices for waste tires including factors that lead to spontaneous combustion in a stack.

- Identify the hazardous constituents in various batteries including electric vehicle batteries.

States noted that issues related to **renewable energy waste streams** and **mine remediation challenges** in the 2020 State Research Needs Report still need more research.

Details on Adaptation Research Needs

States and territories would like additional research on the several priority adaptation topics, details for which are outlined below.

Wastewater and drinking water systems, and methods to make them more resilient, including:

- Methods or technologies for identifying and locating breaks in distribution or collection lines.
- Information on how climate change is impacting water cycles to help facilities plan for changing water quantities.
- Options for hardening systems in different climates including treatment plant and distribution lines.
- Best practices for treatment plants to use when overloaded by large rain events.
- Information to support standards for siting of new plants to prevent climate disruptions (i.e. not in a flood plain).

Wildfires, specifically in terms of:

- **Ash and debris**:
    - The public health risks of ash after a fire before debris is removed.
    - Whether and how to use soil screening levels as a proxy for ash exposure.
    - Sensors or methods for tracking ash in the air.
    - Options for addressing ash contamination of source water.
- **Wildfire impacts to waterbodies**:
    - Modeling of flooding potential due to lack of groundcover and tree canopy.
    - The long-term impacts to fish and macroinvertebrates .
    - Any impacts of leaf litter, ash, and other debris on near-term and longer-term harmful algal blooms.
- **Wildfire impacts to water systems**:
    - Information on contaminants that get into pipes from pipes and plumbing products getting superheated by fire including VOCs.
    - Information on how to flush plumbing systems and entire water systems to clear ash and other contaminants.
- **Research** on:
    - Medium- and long-term health effects of wildfires to help them address acute health risks after a fire.
    - Indoor air quality related to fires including high levels of VOCs.

Resilience, including research on:

- The efficacy and best practices with living shorelines and other nature-based solutions.
- The beneficial reuse of dredged material for living shorelines.
- The impacts and how to mitigate them of changing habitats by creating marshes.
- Blue carbon benefits of submerged aquatic vegetation.
- Blue carbon benefits and water quality impacts of creating marshes, wetlands, or similar efforts.

- Environmental impacts and best practices related to rebuilding shorelines including the impact of using polypropylene tubes, plastic bags, etc. to help secure dredged material.
- The economic valuation of using nature-based solutions to increase resilience.
- Modeling tools that allow for basin-wide assessment of nature-based solutions and built infrastructure approaches to flooding events.

This also relates to states' requests for resiliency research related to:

- **Flooding**, including on the combined potential flooding impacts from heavy rain, storm surges, and sea level rise that allows them to better predict where water will come from and how it will move. This information should also then be used to predict impacts to infrastructure, how contaminants will move, and the resiliency of different remediation options.
- Changing **precipitation** patterns and how they are altering groundwater conditions.
- Identifying urban **heat** islands in disadvantaged communities, including best practices for reducing exposure to extreme heat health effects in them. This should include information on the efficacy of various green infrastructure and weatherization approaches.

Water reuse, specifically on best practices for:

- Direct potable reuse, including how to protect public health.
- Indirect potable reuse, including treatment standards, technologies, and other considerations.
- Industrial reuse, including how to manage contaminants within the facility and in their discharges.

States would also like additional research and information on the efficacy and geological and environmental impacts of aquifer storage and recovery efforts.

Details on Cross-Media Research Needs

States and territories would like additional research on several cross-media topics, details for which are outlined below.

Microplastics, including:

- **Risks** of:
  - The impacts on public health and ecological systems including adsorbents.
  - Characterization of microplastics that pose the greatest risk to wildlife and which receptors are most susceptible.
  - Co-contamination with microplastics such as biofilms, PFAS, and toxics.
  - The ultimate fate and transport of microplastics as they weather and break down.
  - The comparative risk of "new" vs weathered microplastics.
  - Differential risks of varying kinds of microplastics and whether they can be addressed as a single group or treated separately based on the polymer.
- **Identification and treatment**, including:
  - Treatment methods to clean up microplastic pollution.
  - Microplastic prevention and treatment methods for point sources.
  - Methods to detect and quantify both microplastic and nanoplastic pollution in water and other media.
- Research on the unintended impacts of using ground up waste plastics in asphalt used in roads.

6-PPD, specifically in terms of:

- Alternatives assessments.
- Impacts to waters nationally.
- Toxicity.
- Treatment methods.

1,4-dioxane, including:

- Efficient and cost-effective treatment methods for drinking water and wastewater.
- Additional toxicity studies.

Beneficial reuse of water from oil and gas production, including:

- Cost-effecting treatment solutions.
- Studies of possible beneficial reuse options outside of oil and gas industry such as use as road brine.

States and territories also request that EPA conduct additional research and provide technical assistance on conducting cumulative health impact analyses and on identifying best practices for renewable energy siting that reduced impacts to wetlands, forests, and other habitats.