

CASTNET Modernization Plan (2024-2027)

Introduction

After over thirty years of monitoring, the EPA initiated the development of a CASTNET modernization plan to adapt to programmatic changes and meet evolving data needs. The Plan supports implementation amid resource uncertainty and changing environmental conditions. This document outlines a series of steps used by EPA to develop the modernization plan including:

- hosting external stakeholder meetings to identify actions that would reduce annual operating costs;
- conducting a scientific review of the CASTNET program;
- using the recommendations, evaluation criteria, and scoring metrics provided by the review panel to develop immediate and longer-term steps the program would take to modernize the network while achieving cost savings;
- evaluating lower cost monitoring methods to continue to provide multipollutant air quality data in rural America; and
- engaging with organizations to expand cost-sharing relationships and fill spatial gaps in EPA's air quality program.

Over the next three years, the EPA will periodically update the CASTNET website to share progress on the implementation of these investments, results from testing and evaluation of new equipment, and to reflect necessary adjustments to the plan as resources change.

Background

The Clean Air Status and Trends Network (CASTNET) is a national multipollutant air monitoring program that provides data to characterize air pollutant concentrations in rural communities, estimate the deposition of air pollutants to quantify their ecological effects, and assess the health and environmental effectiveness of the Agency's regulatory programs. Rural in scope, CASTNET provides information on air pollution trends in rural State and Tribal lands and in national parks and other Federal lands. Launched over 30 years ago in response to the Clean Air Act Amendments of 1990, CASTNET has consistently provided valuable, nationwide data on atmospheric concentrations of nitrogen and sulfur species, their precursors, ozone levels, and ammonia. This extensive database has been crucial for reporting long-term and spatial trends in air quality across the contiguous U.S.

CASTNET has evolved to address the emerging scientific and policy needs, while maintaining key long-term consistent air quality measurements. To achieve early cost savings over the past two decades, EPA developed lower-cost sites (small-footprint), deferred routine maintenance activities, and reduced frequency of field surveys. The program continued to address spatial gaps in the network by leveraging external resources to operate Tribal and State Agency supported sites.

In 2022, EPA advanced a strategic initiative to modernize CASTNET and reassess the long-term plan while addressing the emerging data needs of rural communities. The CASTNET team initiated a rigorous, science-based evaluation of the program led by an expert scientific panel assembled under EPA's Science Advisory Board (SAB). In addition, the CASTNET team solicited input from OAR Tribal experts and ORD researchers, and engaged a diverse set of monitoring stakeholders, including Federal, State, and Tribal agencies.

The modernization plan described in this document provides a solid foundation for optimizing CASTNET's scientific contributions and adapting to emerging priorities, providing data that supports cleaner air for rural populations for years to come. As resources continue to evolve, the modernization plan will likely evolve as well.

The SAB Review of CASTNET

In 2022, EPA requested that the Science Advisory Board (SAB) ¹convene a panel of experts that would advise the Agency on how to transform the network, achieve cost-savings, and ensure it continues to provide data for regulatory assessments and policy development and support the scientific community. The Agency asked the CASTNET SAB panel to provide their perspectives on future network configurations and priorities that would enhance the value of the program. The panel and members of the public who offered comments during the deliberations were overwhelmingly supportive of the program, noting that CASTNET is the Agency's premier network for rural and background measurements, providing information on regional pollutant transport, validating chemical transport models, and reporting atmospheric deposition.

The background material including the charge questions, list of panel members, individual panelist and public comments, and the final report can be found on the CASTNET SAB review panel website². The SAB submitted its final [report](#) and recommendations to the Agency in April 2024. Below are the key CASTNET SAB Panel Recommendations:

- Maintain as many long-term multipollutant (gases and particles) measurements as possible, recognizing the importance of long-term consistent measurements over adding new pollutants
 - Prioritize sites using the evaluation criteria and metrics that align with Agency's monitoring objectives to evaluate the value of each individual site
 - Replace ozone analyzers
 - Upgrade site infrastructure
 - Continue to archive samples and provide accessible CASTNET locations for advancing air quality research
- Evaluate changes to the frequency of filter pack measurements (e.g., consider bi-weekly)
 - Consider hourly measurements and lower-cost methods as instruments/sensors become available to replace the weekly measurements
- Add PM2.5 sensors to create a more robust multipollutant monitoring network for health and environmental assessments
- Address spatial gaps in the Nation's air quality monitoring network in the Central US, with emphasis on nitrogen measurements
- Expand CASTNET tribal monitoring sites to better understand air quality driven health and environmental impacts to tribal communities

In response to the SAB recommendations, EPA developed a modernization plan that achieves network-wide cost savings while investing in sites and pollutants that are the most valuable. This plan has two major components described in detail below – 1) Implementation of Network-Wide Changes and 2)

¹ The SAB is a federal advisory committee that provides scientific advice to the EPA Administrator. More information about the SAB can be found on the website <https://sab.epa.gov/>

² Material from the SAB panel review of the CASTNET program can be accessed at this link: https://sab.epa.gov/ords/sab/r/sab_apex/sab/advisoryactivitydetail?p18_id=2626&clear=RP,18&session=4785883196892

Optimization of Existing Network Size. As we implement the plan over the next three years (2024-2027), the Agency will continue to engage with federal, Tribal, and state partners to ensure the changes applied to the EPA-sponsored CASTNET sites will have minimal impact on the overall measurement consistency across the network. EPA expects that the modernization of CASTNET will evolve as new technology becomes available and stakeholder engagement continues. EPA will continue to provide updates on the evolution of the CASTNET program.

Implementation of Network-Wide Changes

The Agency identified several network-wide changes that will achieve cost-savings while reinvesting in the program to address the current data needs. Discontinuing the measurement and reporting of pollutants that are near the detection limit (e.g., SO₂) or can be retrieved from other networks (e.g., NCore) will allow the CASTNET program to focus on implementing the highest priority changes recommended by the SAB (e.g., adding PM_{2.5} measurements).

Adjustments to the Pollutants Reported

EPA suspended SO₂ concentration measurements in July 2024 at most CASTNET sites. Currently, CASTNET sites on Tribal lands, sites sponsored by NY Department of Environmental Conservation and the Indian River Lagoon Council continue to monitor SO₂ concentrations. While SO₂ continues to be an important component of dry deposition and acidification of sensitive ecosystems, the concentrations are < 1 µg/m³, a decrease of 95% since 1990 (Figure 1). Maintaining SO₂ measurements at select sites will provide spatial coverage for model validation and trends. The cost-savings achieved by discontinuing SO₂

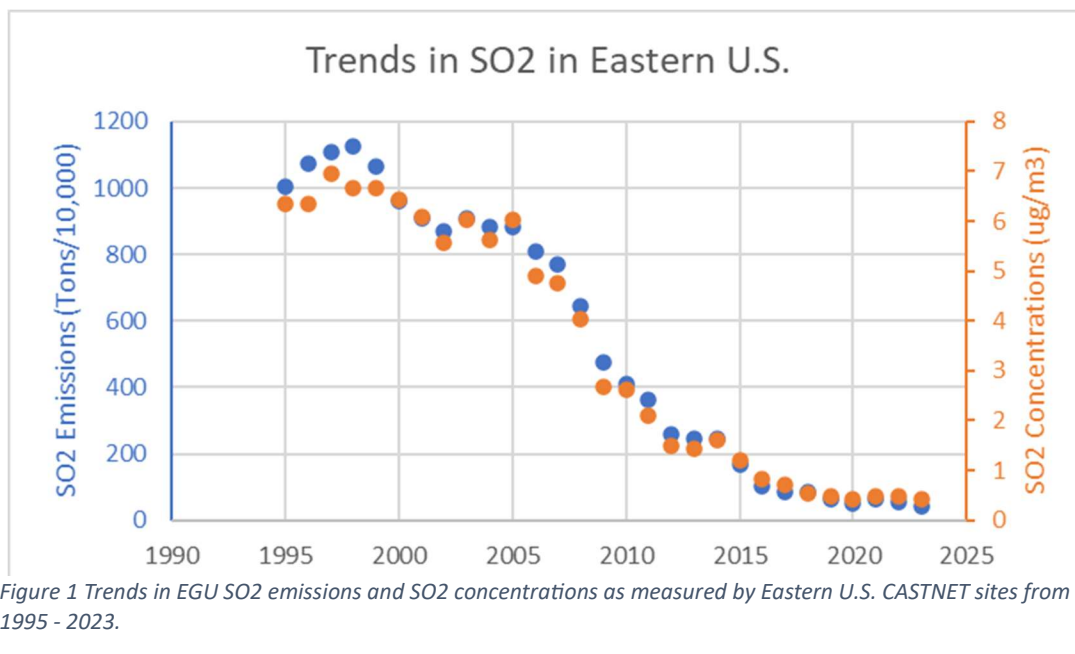


Figure 1 Trends in EGU SO₂ emissions and SO₂ concentrations as measured by Eastern U.S. CASTNET sites from 1995 - 2023.

measurements will be re-invested to maintain existing sites. The NPS-sponsored CASTNET sites discontinued SO₂ measurements in August 2022.

Five EPA-sponsored CASTNET sites measured concentrations of total oxides of nitrogen (NO_y) to assess the relationship between ozone and ozone precursors. In May 2022, EPA discontinued NO_y measurements at four of these sites: Pinedale, WY (PND165), Huntington Wildlife Forest, NY (HWF187), Pisgah National Forest, NC (PNF126), and Rocky Mountain National Park, CO (ROM206). Trace gas

measurements, including NO_y will continue at the Bondville, IL (BVL130) CASTNET site, which is also part of the EPA's NCore ("National Core") multipollutant monitoring network. Fifteen rural NCore sites operated by Tribal and State monitoring agencies will continue to provide background and regional concentrations of NO_y. The NO_y analyzers from the four CASTNET sites will be repurposed for research studies targeting specific air quality issues.

EPA also discontinued filter pack measurements³ at Ann Arbor, MI (ANA115) and Penn State Fruit Research and Extension Station, PA (PSU106) in May 2022. EPA intends to keep these two sites as ozone/PM_{2.5} sites unless external resources are provided to resume filter pack sampling.

Most CASTNET sites are co-located with National Atmospheric Deposition Program (NADP) monitoring locations. The NADP provides data on air concentrations of ammonia and other toxics (e.g., mercury) and precipitation chemistry. EPA is considering reducing the frequency of ammonia measurements at NADP/Ammonia Monitoring Network (AMoN) sites the Agency sponsors where low concentrations have been observed. The value of the ammonia concentrations provided by AMoN remains significant for evaluating trends, satellite validation, and source contributions to PM formation. The cost savings from adjusting the measurement frequency will allow EPA to maintain existing sites and re-invest to address SAB's recommendation to expand ammonia sites in the upper Midwest and Central U.S. where we see increasing trends in concentrations. At the same time, the NADP is evaluating a lower cost option for the passive samplers which may result in keeping the 2-week sample schedule. A final decision is expected in 2025.

Modernization: Repair and Replace Existing Infrastructure and Equipment

Replacing aging equipment and reinvesting in the infrastructure is critical for maintaining the highest-quality data and expanding the partnerships that help sustain the network. The monitoring community and researchers often leverage the rural CASTNET sites to deploy supplemental measurements and equipment as the sites fill a niche that supports model development, ground-based observations for satellite validation, and method evaluations for new monitoring technologies. EPA will continue to leverage these partnerships to advance the science and policy needs of the Agency as we seek additional cost-sharing opportunities.

Routine maintenance to refurbish aging shelters (e.g., water-damaged roofs and floors) and repair site infrastructure will occur at many sites across the network. Cost analyses have shown that repair of the shelters is more cost-effective than a replacement. An example of the shelter refurbishment from Stockton, IL (STK138) is shown in Figure 2. Over the next year, shelters will be repaired at the Caddo Valley, AR (CAD150), Connecticut Hill, NY (CTH110), Unionville, MI (UVL124), and Vincennes, IN (VIN140) CASTNET sites. These investments will result in more robust equipment that can withstand the harsh weather conditions found at many of the remote CASTNET locations and maintain data collection during extreme weather events. Upgrades to the IT infrastructure provides added security for the nation's air quality monitoring data. These investments also align with the recommendations from the GAO Report

³ The CASTNET filter pack measures the following particles and gases: Particles (SO₄²⁻, NH₄⁺, NO₃⁻, Na⁺, K⁺, Ca²⁺, Mg²⁺, Cl⁻) and Gases (SO₂, HNO₃)

(2020): Air Pollution – Opportunities to Sustain and Modernize the National Air Quality Monitoring System⁴.



Figure 2 Stockton, IL (STK138) shelter before (left) and after (right) infrastructure repairs were completed (e.g replaced floors, sealed leaks inside the monitoring shelter, etc.).

Most of the EPA-sponsored CASTNET ozone analyzers (model: Thermo 49i) were purchased in 2010. The analyzers will no longer be supported by the manufacturer after 2026, therefore the panel recommended that EPA replace the ozone systems. Several Federal Reference Method (FRM)/Federal Equivalency Method (FEM) analyzers are commercially available. The CASTNET program has purchased new FEM analyzers for testing within the ozone laboratory. EPA is working closely with the other CASTNET federal partners during the evaluation to try to maintain consistent ozone measurements across the network. The CASTNET program faces unique challenges including remote, high elevation sites, longer sample tubing to accommodate inlets at a height of 10m, and varying meteorological conditions. Once the ozone FEM evaluation is complete, EPA will deploy new analyzers at all EPA-sponsored CASTNET sites.

CASTNET will replace the precipitation collectors at NADP/National Trends Network (NTN) sites sponsored by EPA. The current collectors (Aerochem) purchased in the 1990s are no longer manufactured. Investing in the new collectors will help maintain consistency across the NTN, ensure

⁴ The GAO provided the Agency with two recommendations to maintain the air quality monitoring networks (a) develop an assessment management plan to sustain the monitoring system and (b) develop a modernization plan to address ongoing challenges in ambient air monitoring. <https://www.gao.gov/products/gao-21-38>

reliability of total atmospheric deposition trends⁵, and promote growth within NADP's emerging PFAS network with external resources.

Fill Spatial Gaps in the National Ambient Air Monitoring Network

EPA plans to purchase and install equipment to support new monitoring locations to fill in spatial gaps within the national air monitoring networks. As noted in the SAB report, there are large rural areas of the central U.S. from Texas to Minnesota that lack monitoring data, yet these communities experience local and regional air pollution linked to poor human and environmental health. EPA will explore cost-sharing partnerships to address these monitoring gaps and build capacity in rural communities. The SAB recommended that CASTNET continue to address Tribal Agency's monitoring needs by supporting additional sites in Indian Country.

EPA has already started leveraging new partnerships to fill spatial gaps and leverage new cost-sharing opportunities. For example, EPA installed a CASTNET site in collaboration with Haskell Indian Nations University located in Lawrence, KS in November 2024. The site (HAS012) will serve as a training facility for faculty, students, and other Tribal Environmental Professionals. The site will provide air quality information for the community, as well as provide the infrastructure and capacity to add additional pollutants of interest in the future. If the program is successful EPA hopes to use this model to establish additional sites at Tribal Colleges and Universities where there are data gaps.

EPA will explore new partnerships with existing networks/sites. For example, CASTNET is co-located in three locations with the Atmospheric Science and Chemistry Measurement Network (ASCENT), a new network that seeks to characterize aerosol chemistry composition and physical properties using high-time resolution measurements at 12 locations. New technology deployed at these monitoring locations will be evaluated against the CASTNET measurements to determine the viability (cost savings) and stability (robustness for network-wide operations) for potential future deployment at CASTNET sites.



Figure 3 Look Rock CASTNET site located in Great Smoky National Park (GRS420, TN) is co-located with IMPROVE (Integrated Monitoring of Protected Visual Environments) and the Atmospheric Science and Chemistry Measurement Network (ASCENT). IMPROVE provides speciated measurements of PM constituents. ASCENT will provide high-time resolution measurements of black/brown carbon, PM speciation, metals and PM size fractions at three CASTNET sites.

⁵ EPA combines air quality observations from CASTNET with precipitation chemistry measurements known as wet deposition from NADP and modeled values from EPA's Community Multiscale Air Quality (CMAQ) model to report on trends in total atmospheric deposition.

Evaluation of New Equipment for Deploying Additional Measurement

The SAB panel recommended that EPA deploy PM_{2.5} sensors at CASTNET locations where existing PM mass concentrations are sparse. While CASTNET measures the major components of PM_{2.5} (SO₄, NO₃, NH₄), the network has not traditionally reported PM_{2.5} mass concentrations, one of the six criteria air pollutants the Clean Air Act requires EPA to control. The CASTNET program is evaluating commercially available low-cost sensors for accuracy, precision, robustness, support for supplemental measurements (e.g. PM₁₀, PM₁, ozone, CO), and cost. As of December 2024, EPA has deployed 22 PurpleAir⁶ low-cost sensors at a number of EPA-sponsored CASTNET sites (Figure 4). The measurements will provide a first look at ambient PM concentrations in areas that often lack other sources of ambient air quality measurements. While data provided by low-cost sensors are not used for regulatory purposes such as determining attainment of the National Ambient Air Quality Standards (NAAQS), the concentrations reported will be compared to the recently revised PM_{2.5} NAAQS, which was lowered to 9 µg/m³ in February 2024. The data will also be included in the AIRNow Fire & Smoke Map⁷ for near real-time reporting to the public. After the CASTNET sensor evaluation is complete, EPA will invest in a more robust PM monitor (e.g. Quant AQ MODULAIR™ that uses both an optical particle counter and nephelometer). The MODULAIR will be placed in select locations relevant to the PM_{2.5} NAAQS, or locations frequently impacted by wildfires or dust events to evaluate health and environmental impacts within these rural communities. The additional gases offered by the MODULAIR (CO, O₃, NO₂, NO) will be added to small footprint CASTNET sites to provide a more complete multipollutant suite of measurements. The PM_{2.5} concentrations and existing CASTNET PM precursor data will be leveraged to explore pollutant relationships during smoke and non-smoke impacted events to evaluate how trends may change over time. The analysis may be expanded using existing samples to detect wildfire tracers (e.g., black carbon, levoglucosan, organic nitrogen).

⁶ Purple Air low-cost PM sensors report near-real time PM₁, PM_{2.5} and PM₁₀ concentrations. <https://www2.purpleair.com/>

⁷ The AIRNow Fire & Smoke map was developed by EPA and U.S. Forest Service to report near-real time PM concentrations with integrated smoke plume information for the public. The Purple Air sensors are the only sensor that has been evaluated and approved for reporting to the Fire & Smoke map. <https://fire.airnow.gov/#6/41/-98>

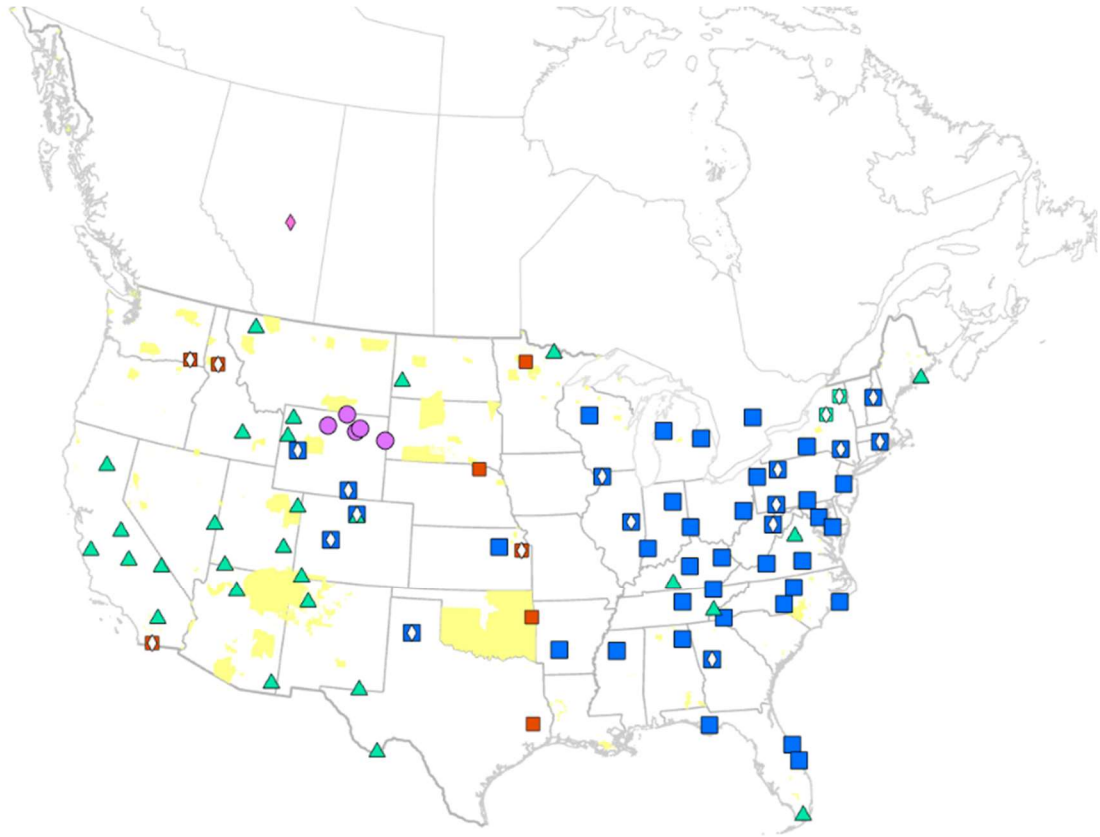


Figure 4 CASTNET site map with white diamonds representing locations where Purple Air PM2.5 sensors have already been deployed (December 2024).

Optimization of Existing Network Size

The Agency used the evaluation criteria and metrics provided in the SAB report to assess and score individual sites based on the Agency’s data needs and priorities. CASTNET also considered additional efficiencies that could be implemented to shift resources towards the modernization of the network. The CASTNET network may not include the same number of sites in every area. EPA is committed to maintaining a spatially representative network that continues to provide data to address regional and local pollution transport and support inquiry related to health and environmental impacts across rural America.

Operating Status at Individual Site Locations

In May 2022, EPA temporarily suspended monitoring at several CASTNET and co-located NADP sites to address reduction in resources and began to develop a long-term plan for the network based on engagement with stakeholders and the SAB. Most of the sites remained closed throughout the SAB review process (2022-2024). In the final report, the panel provided evaluation criteria that could be applied to each site based on evaluation criteria including consideration of the most recent design value below the NAAQS, the size of the airshed represented by the CASTNET site (e.g., using nearby multipollutant monitoring locations), and whether the site is co-located with other networks/research

activities. The Panel also recommended consideration of the length of air quality data record, the long-term stability of the site (e.g. land lease, operator), and whether it provides data for or within a Tribal or rural community.

Table 1 Criteria and scoring used to determine the long-term operational status at each CASTNET site. The sites included in the table have been proposed to close permanently or resume sampling based on the evaluation performed by EPA on each individual site.

CASTNET Site Location	Evaluation Criteria						Notes
	Recent Design Value Below the NAAQS	Site > 100km from other multipollutant monitoring locations	Site co-located with other networks	Length of record (yrs)	Site stability	Located within a Tribal or disadvantaged community	
Alhambra, IL (ALH157)	Yes	NA	Yes (1)	3	No	No	Land lease was not renewed. Site was permanently decommissioned in December 2022
Kickapoo Tribe of Indians of the Kickapoo Reservation Kansas, KS (KIC003)	No O ₃	NA	Yes (2)	9	No	Yes	Tribal Environmental Program requested that sampling be suspended due to staff shortages. Site was decommissioned in August 2023.
Cadiz, KY (CDZ171)	Yes	No	Yes (1)	24	No	Yes	Land lease was not renewed. Site was permanently decommissioned in August 2024.
Ashland, ME (ASH135)	Yes	No	Yes (1)	35	Yes	Yes	Site is located in a remote area with low concentrations.
Claryville, NY (CAT175)	No O ₃	Yes	Yes (1)	29	Yes	Yes	Site does not measure O ₃ . Potential relocation to the Biscuit Brook NADP/NTN site if external resources are provided

Huntington Wildlife Forest, NY (HWF187)	Yes	No	Yes (3)	21	Yes	No	NY DEC/NYSERDA provided resources for two additional sites in the Adirondack Park. Discontinued NOy measurements.
Pisgah National Forest, NC (PNF126)	Yes	No	Yes (1)	35	Yes	Yes	Nearby sites provide spatial coverage for some pollutants. Discontinued NOy measurements.
Quaker City, OH (QAK172)	Yes	No	Yes (2)	24	No	Yes	Site had highest concentrations of SO ₂ in the 1990s. Internal and external engagement will continue to determine where the IMPROVE-protocol site can be relocated.
Underhill, VT (UND002)	No O ₃	No	Yes (3)	11	Yes	No	Site was installed to address monitoring gaps identified in the 2012 Final Rule for the Secondary NAAQS for NOxSOx ⁸ .
Cedar Creek WV (CDR119)	Yes	No	Yes (2)	36	Yes	Yes	Sampling was suspended in May 2022. Site infrastructure will be refurbished before monitoring is restored.
Deer Creek, OH (DCP114)	Yes	No	Yes (2)	35	Yes	Yes	Sampling was suspended in May 2022. Site infrastructure will be refurbished before monitoring is restored.

A description of how the criteria were applied are shown in the Table 1 for the sites that are expected to close permanently and sites that may reopen after being suspended in May 2022. Outreach continues with stakeholders to determine if sites can/should re-open with external resources.

The recent and proposed changes to CASTNET monitoring site locations are shown in Figure 5.

⁸ Final rule for the secondary NAAQS for NOxSOx published in 2012. Rule describes the field pilot program developed to enhance the Agency’s understanding of the degree of protectiveness that would likely be afforded by a multipollutant standard to address deposition-related acidification of sensitive aquatic ecosystems. <https://www.govinfo.gov/content/pkg/FR-2012-04-03/pdf/2012-7679.pdf>

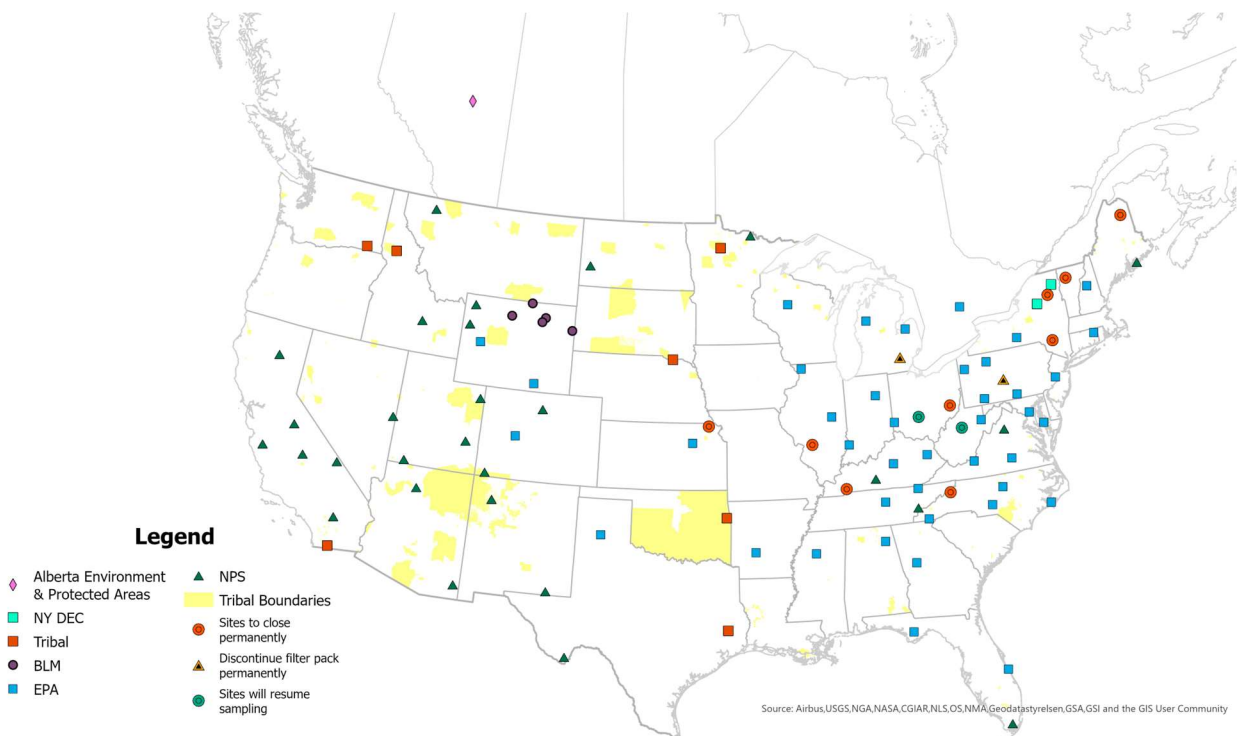


Figure 5 Current CASTNET site map showing the locations of existing sites, mothballed sites that are planned to be decommissioned or reopened and other site sponsors.

Sampling at the Hubbard Brook, NH (WST109) site was also suspended in May 2022, but in January 2024 the US Forest Service (USFS) took over staffing and maintenance at the site. This site is located within the Hubbard Brook Experimental Forest, a long-term research collaboration.

Stakeholder Engagement

EPA is engaging stakeholders to determine their interest in taking over or participating in management of sites considered for permanent closure. Collaboration and leveraging resources at sites is a key part of the modernization plan. To date CASTNET has engaged in the following successful collaborations and shared responsibilities:

- Woodstock, NH CASTNET site – USDA/US Forest Service shifted their support to cover site operations and maintenance
- Bennett Bridge, NY precipitation chemistry site – NYSERDA is supporting the analytical costs
- Whiteface Mountain, NY CASTNET – NY DEC established site and funds operation and analytical costs
- Canaveral National Seashore, FL site – Indian River Lagoon Council in collaboration with Florida Atlantic University established a new CASTNET site to evaluate air quality impacts to the estuary.

Conclusion

Over the next three years the CASTNET program will continue to evolve as the modernization plan is implemented.

EPA will update this document with new information about changes to individual sites and deployment of instrumentation. We are working on developing new data visualization tools to make it easier for data

users to view air quality in their community. The program will continue to provide publicly accessible data to the public. The Agency again thanks the SAB panel for their contributions to the CASTNET modernization plan.

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