Chesapeake Bay Program
*Science. Restoration. Partnership.*

# 2025 WIP and Water Quality Standards Attainment & Monitoring Outcomes Management Strategy

2020–2025, Updated Nov 2022

***The Wicomico River, top, and Whites Neck Creek, bottom, flow toward the Potomac River in Charles County, Md., on June 5, 2018. (Photo by Will Parson/Chesapeake Bay Program)***

## I. Introduction

For the past 35 years, the Chesapeake Bay Program (CBP) partnership has been committed to achieving and maintaining the water quality conditions necessary to support living resources throughout the Chesapeake Bay watershed. Building off these commitments and using the best scientific information available, the CBP partnership agreed to the nutrient and sediment allocations in the 2010 Chesapeake Bay Total Maximum Daily Load (TMDL), a historic and comprehensive pollution reduction effort in the Chesapeake Bay watershed, and the subsequent Phase II and Phase III planning targets.[1]

The Bay TMDL identifies the necessary pollution reductions of nitrogen, phosphorus, and sediment across the seven Bay watershed jurisdictions of Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia to meet applicable water quality standards in the Bay and its tidal waters. Reducing pollution is critical to restoring the Chesapeake Bay watershed because clean water is the foundation for healthy fisheries, habitats and communities across the region. All partners

and source sectors must contribute substantial efforts to achieve our shared water quality goals.

The CBP developed distinct outcomes in the Watershed Agreement's water-quality goal, including:

- **2025 Watershed implementation Plan Outcome**: By 2025, have all practices and controls installed to achieve the Bay's dissolved oxygen, water clarity/submerged aquatic vegetation, and chlorophyll-*a* standards as articulated in the Chesapeake Bay TMDL document.
- **Water Quality Standards Attainment and Monitoring Outcome:** Continually improve the capacity to monitor and assess the effects of management actions being undertaken to implement the Bay TMDL and improve water quality. Use the monitoring results to report annually to the public on progress made in attaining established Bay water quality standards and trends in reducing nutrients and sediment in the watershed;

The Watershed Implementation Plans (WIPs), developed by the seven Bay watershed jurisdictions, provide a roadmap for how the jurisdictions, in partnership with federal and local governments, will achieve the Phase III planning targets.[2] As such, the WIPs collectively serve as the foundation of the management strategy for the 2025 WIP outcome. The jurisdictions developed WIPs over three Phases. Phase I and Phase II WIPs, developed and submitted to Environmental Protection Agency (EPA) in 2010 and 2012, respectively, describe actions and controls to be implemented by 2017 and 2025 to achieve applicable water quality standards.[2] The Phase II WIPs build on the initial Phase I WIPs by providing more specific local actions. As part of the accountability framework established in the Bay TMDL document, jurisdictions also establish short-term goals in the form of two-year milestones which are based on the WIPs and have been reported to EPA since 2011.

In 2019, the seven Bay watershed jurisdictions developed Phase III WIPs that provide more information on what actions the jurisdictions intend to implement between 2019 and 2025. Based on a midpoint assessment of progress and scientific analyses that was completed in 2018, the Phase III WIPs were developed so that by 2025 all practices are in place that are necessary to meet applicable water quality standards in the Bay and its tidal tributaries.

In conjunction with the implementation of the WIPs, the CBP partnership under the Attainment and Monitoring Outcome, is engaged in monitoring and evaluating water-quality changes to assess progress toward meeting water quality standards and explain water-quality response to implementation of nutrient and sediment reduction efforts. Activities under this outcome include:

- monitoring of tidal and non-tidal water quality,
- assessing and reporting nutrients and sediment changes in the Bay watershed, water-quality trends in tidal waters, and attainment of water-quality standards including improved methods to assess incremental progress towards attaining water-quality standards,
- analyzing and communicating the factors affecting water-quality response, including their relation to nutrient and sediment reduction efforts, and,
- working with other Goal Implementation Teams (GITs) to better understand water-quality changes and potential multiple benefits for estuary and watershed habitats (such as SAV and

streams), associated fisheries and wildlife, and the benefits to the people living in the watershed.

Further incorporation and use of monitoring information to assess progress is critical to better understand how on the ground actions have an impact toward meeting the 2025 WIP outcome, particularly since monitoring assessments will ultimately determine when the jurisdictions' water quality standards are achieved.

# II. Goal, Outcome and Baseline

This management strategy identifies approaches for achieving the following goal and outcomes:

***Water Quality Goal:*** Reduce pollutants to achieve water quality necessary to support the aquatic living resources of the Bay and its tributaries and protect human health.

***2017 WIP Outcome - (Outcome Retired due to Completion of Midpoint Assessment)***

By 2017, have practices and controls in place that are expected to achieve 60 percent of the nutrient and sediment pollution load reductions necessary to achieve applicable water quality standards compared to 2009 levels.

***2025 WIP Outcome***

By 2025, have all practices and controls installed to achieve the Bay's dissolved oxygen, water clarity/submerged aquatic vegetation and chlorophyll-*a* standards as articulated in the Chesapeake Bay TMDL document.

***Water Quality Standards Attainment & Monitoring Outcome***

Continually improve the capacity to monitor and assess the effects of management actions being undertaken to implement the Bay TMDL and improve water quality. Use the monitoring results to report annually to the public on progress made in attaining established Bay water quality standards and trends in reducing nutrients and sediment in the watershed; as well as explanations for where progress is lagging or new science is changing our understanding of water quality responses.

## Baseline and Current Condition

### Background

In 2009, the Chesapeake Executive Council established the goal that all practices for a clean Chesapeake Bay be in place by 2025. The Bay TMDL document describes this goal, as well as the interim goal that practices be in place by 2017 to achieve 60 percent of the necessary reductions compared to 2009.[1] However, the interim and final deadlines are those agreed to by the Executive Council, and not formally part of the TMDL itself. The baseline for the 2017 goal is the 2009 estimates of nitrogen, phosphorus, and sediment loads (in pounds per year) in the Chesapeake Bay watershed. These estimates were obtained from the partnership's modeling tools that are calibrated to monitoring data and use implementation data collected from the seven Bay watershed jurisdictions. The year 2009 was

established as the baseline year because it is the last year for which pollution reduction progress was assessed prior to EPA establishing the Bay TMDL in 2010.

The Chesapeake Bay's tidal waters are divided into 92 segments, and each segment has up to five designated aquatic life uses which equates to a total of 291 segment-designated use pairs. The CBP partners have endorsed an integrated approach that includes three primary pieces of information to measure progress toward water quality standards:

- Reporting of water quality management practices.
- Analyzing trends of nitrogen, phosphorus, and sediment in the watershed.
- Assessing attainment of dissolved oxygen, chlorophyll-*a*, and water clarity/SAV standards.

The integrated approach to quantify and explain water quality trends in the Bay and its watershed relies on monitoring information, enhanced BMP implementation data and use of several analytical tools (including statistical tools, CBP Watershed Model and estuary models, USGS SPARROW model and groundwater models, and high-resolution land use/land change data). The measure of success for this integrated approach is to meet all applicable nutrient- and sediment-related water quality standards in the tidal Chesapeake Bay necessary to protect the designated uses for those 92 segments.

### Progress to Date

The WIPs identify how the seven Bay watershed jurisdictions are putting measures in place by 2025 that are needed to restore the Bay, and by 2017 to achieve at least 60 percent of the necessary nitrogen, phosphorus, and sediment reductions compared to 2009 levels. While the Chesapeake Bay partnership exceeded the 60 percent goals for reducing phosphorus and sediment, it fell short of the 2017 target for reducing nitrogen by 15 million pounds. The implementation of BMPs specifically in the agricultural and urban sectors will need to accelerate to close this gap.

As of 2021, based on the partnership's modeling tool estimates, BMPs in place to reduce pollution are estimated to achieve 49% of the nitrogen reductions, 64% of the phosphorus reductions and 100% of the sediment reductions needed to attain applicable water quality standards when compared to the 2009 baseline established in the Bay TMDL. [3,1]

Attaining water quality standards is essential to other CBP goal areas including habitat and fisheries. Attaining the standards also provides substantial benefits for protection of human health, aesthetic and recreational uses. The Water Quality Standards Attainment and Monitoring Outcome will require the monitoring of water quality conditions to assess progress towards achieving applicable water quality standards in Bay and tidal water restoration to support aquatic living resources. Achieving those water quality standards is also a critical component of achieving many local water quality objectives and local TMDLs.

During the 2018 – 2020 assessment of water quality standards attainment, the partnership estimates that 30% percent of the Bay and its tidal waters were attaining applicable water quality standards.[4] This score is lower than the previous score of 33.1 % received during the 2017 – 2019 assessment period and marks a consecutive decline in the assessment status since the record high of 42.2% during the 2015-2017 assessment period. Two recent above-average flow years (2018 – 2019) likely played a large role in

this short-term decrease, and water quality standards attainment has not declined below the starting point of the indicator despite pressures from climate change, significant population growth, and growth of impervious surfaces, among other factors.

The CBP partnership uses the 123 stations in the nontidal water quality network in the watershed to assess response to implementation of nutrient and sediment practices. The latest trend updated (2011-2020) revealed mixed results of 10-year trends for nitrogen, phosphorus, and sediment:

- For nitrogen, approximately 37 % of the sites had improving trends, approximately 40 % had degrading trends, and approximately 23% showed no trend.
- For phosphorous, approximately 44% of the sites had improving trends, approximately 23% were degrading, and approximately 33% had no trend.
- For sediment: approximately 18% of the stations were improving, approximately 46% degrading, and approximately 36% showed no trend.

**Partners**

The following partners have participated in the development of this strategy.

- District of Columbia
- Delaware
- Maryland
- New York
- Pennsylvania
- Virginia
- West Virginia
- U.S Environmental Protection Agency
- Chesapeake Bay Commission
- U. S. Department of Agricultural (including NRCS, FSA, and USFS).
- U.S. Geological Survey
- Other members of the partnership's Water Quality Goal Implementation Team (WQGIT) and the Science, Technical Assessment and Reporting team (STAR)

## Local Engagement

The Bay TMDL document, which describes an accountability framework including the 2017 and 2025 WIP outcomes, was developed through a highly transparent and engaging process.[1] The outreach effort included hundreds of meetings with interested groups; two rounds of public meetings, stakeholder sessions and media interviews in all Bay watershed jurisdictions in fall of 2009 and 2010; a dedicated EPA website; a series of monthly interactive webinars; notices published in the Federal Register; EPA response to all TMDL comments; and a close working relationship with CBP committees representing citizens, local governments, and the scientific community. It was at the discretion of the Bay watershed jurisdictions to hold their own public meetings and public comment period for their respective WIPs, as these were state-developed documents.

A substantial portion of the nitrogen, phosphorus, and sediment controls necessary to meet the Bay

TMDL allocations and the subsequent Phase III WIP planning targets is expected to be implemented at the local level by CBP partners including conservation districts, local governments, planning commissions, utilities and watershed associations. Outreach to a variety of local entities may help the CBP partners assess and determine the ideal scale at which implementation will be reflected in the CBP modeling tools and where appropriate, quantify local planning goals[1] within the WIPs. The partnership recognizes that individual jurisdictions may pursue somewhat different approaches to this local outreach.

The Phase III WIP local engagement strategies provide a strong foundation for success: supported by sound science built on government leadership, strategically aligned federal-state-local priorities, strong networks; and clear communication of roles and responsibilities.

The CBP partnership is engaging each state jurisdiction on how to better apply monitoring results to assess response to nutrient and sediment reduction efforts. These technical meetings will likely involve local jurisdictions also in future sessions. Local jurisdictions have also implemented more local monitoring programs to help assess response to their implementation efforts.

## III. Factors Influencing Success

The factors for the 2025 WIP outcome and Attainment and Monitoring outcome have been updated and are provided below.

The factors for the 2025 WIP outcome were updated by the Water-Quality Goal Implementation Team, with more details in the associated Logic and Action Plan:

1. **Best Management Practice Implementation.** Technical assistance with implementing, tracking, reporting, and verifying source control and mitigation practices.
2. **Funding for Implementation.** Assistance in the major source sectors to implement local-scale programs, plans, and practices. Likely emphasis will be in the agricultural sector.
3. **Communication and Coordination.** Consistent efforts with diverse stakeholders. Other potential audiences include states and DC; local jurisdictions; and federal agencies such as USDA, DoD and EPA
4. **Chesapeake Assessment Scenario Tool (CAST) and other Model Updates.** Incorporating new science and data into models and decision support tools.[6]
5. **Water Quality Monitoring: Sustain and enhance monitoring and interpretation of results to help understand water quality response to management actions**. It is important to demonstrate progress towards attainment of water quality standards.

[1] After release of the final Phase III planning targets, the jurisdictions developed local area planning goals based on those planning targets that are reflected in the Phase III WIPs.

6. **Using Co-Benefits as a catalyst to increase implementation by aligning with priorities and goals beyond water quality.** Characterization of benefits beyond water quality improvements associated with existing BMPs to identify new funding opportunities and opportunities to increase implementation.

7. **Climate Change.** Understanding and allocating impacts of climate change induced watershed loads for 2022-2023 milestones.

The factors for the Water Quality Standards Attainment and Monitoring Outcome have been updated based on needs of the Water-Quality Goal Implementation Team and input from STAR. The factors are considered to have equal priority, and some additional details are in the associated Logic and Action Plan:

- **Enhanced Monitoring:** Enhanced monitoring is needed to adequately assess water-quality standards in all tidal segments and better detect and link watershed changes to management actions. It is necessary to sustain and grow the CBP monitoring program's capacity in order to meet the partnership's needs. Inflation, replacing aging infrastructure and lost partnerships have all put pressure on the existing monitoring program. The Scientific, Technical Assessment and Reporting (STAR) team and its workgroups have discussed gap-filling opportunities in meetings and Scientific and Technical Advisory Committee (STAC) workshops. Commitments to incorporating new partners, technologies and assessment protocols that leverage existing programming while adapting and enhancing approaches will be necessary to sustain the monitoring capacity into the future.

- **Improved analysis and reporting of water quality attainment and nontidal and tidal trend results:** Information is needed to better assess incremental progress toward water quality standards attainment and load reductions. There is significant CBP partnership investment in updating the science that underpins advances in modeling, monitoring, and management tools and assessments. Substantial publication efforts were initiated under the Bay TMDL's midpoint assessment. Synthesis and communication of science findings and needs will be linked to CAST and the CBP Watershed Data Dashboard.[6,7] Appropriate information, including presentations, will be posted to the Integrated Trends Analysis Team (ITAT) webpage and Phase III WIP webpage on chesapeakebay.net. While key products were provided, there is still a need for additional synthesis and communications of new findings to explain factors affecting water quality trends and linkages between sources and ecosystem response to support adaptive management.

- **Improved understanding and communication of the factors affecting the water quality and influence of management practices:** More in-depth analysis and communication is needed to inform jurisdictional decisions on nutrient and sediment practices for the WIP 2025 outcome. Based on the current science and the associated CBP modeling system, the CBP partnership has projected that implementing practices for reducing nitrogen, phosphorus, and sediment loads should achieve applicable water quality standards in the Bay. Improved understanding of the following elements could further enhance decision-making and implementation for the Phase III WIPs:
    - The factors affecting the time it will take to see improvements (i.e., "lag times") between implementation of practices and responses in water quality.
    - Factors in addition to nitrogen, phosphorus, and sediment pollutant load reduction that affect response of dissolved oxygen, water clarity, SAV and chlorophyll-a.

  - The relationships between water quality improvements and the recovery of habitat conditions for fish and shellfish populations.
  - How population changes and economic influences impact restoration activities.
  - The effects of climate change due to increased temperatures and sea level rise in the estuary and changes in precipitation and runoff in the streams.
  - How increases in plant and animal biomass in response to improved water quality improves the assimilative capacity of the system for nutrients and sediment.
  - Uncertainty associated with model projections.

- **Improved understanding and communication of multiple benefits between water-quality restoration and other CBP outcomes**. Address gaps in knowledge of multiple benefits to selected CBP outcomes including toxic contaminants, SAV, fish habitat, and climate resiliency that are created through implementation of practices designed to reduce nutrients and sediment.

# IV. Current Efforts and Gaps

The CBP partnership made progress on both outcomes, but gaps remain to be addressed both leading up to 2025, and over the next two years. In leading up to 2025, there will be a need for communication of the message "all practices are in place, but water-quality standards and improvements will take longer to be achieved".

**2025 WIP Outcome**

The CBP partnership did not meet its 2017 nitrogen target, but it continues to improve tracking, reporting and assessing the effectiveness of implementation actions. In addition, the Bay watershed jurisdictions are implementing BMP tracking, verification and reporting protocols and programs. As the CBP tracks partners' progress toward goals for cleaner waters, verifying that practices are being implemented correctly and are reducing nutrient and sediment pollution as expected will be critical in measuring success. EPA, the Bay watershed jurisdictions, local governments, the private sector and nongovernmental organizations use these data to inform accountability and adaptive decision-making and redirect management actions and resources.

Future specific management approaches to support BMP tracking, reporting, assessment and verification include:

- Annual implementation progress reporting for inclusion in modeling tools and annual reporting on progress on programmatic milestones.
- Evaluation of BMP implementation and maintenance costs and actual nutrient and sediment reductions.
- Support for continued and improved BMP implementation, tracking and reporting on agricultural loads.

The WIPs also evaluate the current legal, regulatory, programmatic, financial, staffing and technical capacity to deliver the implementation of reductions sufficient to achieve the target loads in the Bay TMDL. As part of their evaluation, the Bay watershed jurisdictions considered whether additional reductions could be achieved with existing capacity (funding, authorities and sustainability). The evaluation of existing capacity includes programs and rules, a comprehensive assessment of current

point source permitting/treatment upgrade schedules and funding programs, nonpoint source control funding, existing permitting and incentive-based programs and regulations. Specific efforts include the use of the National Environmental Information Exchange Network (NEIEN) to seamlessly exchange information between existing federal, state or district databases and the suite of CBP decision support tools. Tracking data and models will be used, along with ambient monitoring data, to assess WIP and milestone commitments and progress.

The jurisdictions and EPA, through the WIPs and evaluations of the WIPs, respectively, identified gaps between the jurisdictions current capacity and the capacity they estimate is necessary to fully attain the interim and final nutrient and sediment target loads for each of the 92 segments of the Bay TMDL. Such gaps that the jurisdictions continue to address through Phase III WIPs implementation and other efforts include:

- Financial capacity to oversee and implement municipal separate storm sewer systems (MS4s) and other stormwater programs.
- Financial, technical and regulatory capacity to deliver priority pollution reduction practices to priority watersheds.
- BMP tracking, verification and reporting programs.
- Financial capability to continue to maintain new and existing implementation practices.
- Specifically achieving the Phase III nitrogen planning targets by 2025 since the CBP partnership did not achieve the goal of 60% pollution reductions by 2017.

Necessary new capacity to address these issues includes additional incentives, new or enhanced state or local regulatory programs, market-based tools, technical or financial assistance and new legislative authorities. It also includes capacity from other federal agencies, local governments, the private sector and/or non-governmental organizations.

Through the Phase III WIP development and implementation processes, the Bay watershed jurisdictions are expected to discuss plans to work with federal, local, private sector and nonprofit partners to leverage capacity for achieving the Phase III planning targets. For specific WIP commitments, each jurisdiction's WIP is posted on its respective website:

- New York State Department of Environmental Quality[8]
- Pennsylvania Department of Environmental Protection[9]
- West Virginia Department of Environmental Protection[10]
- Maryland Department of the Environment[11]
- Delaware Department of Natural Resources and Environmental Control[12]
- D.C. Department of Energy and Environment[13]
- Virginia Department of Environmental Quality[14]

**Water Quality Standards Attainment and Monitoring Outcome**

The current efforts and gaps for each factor are presented in this section.

**Factor1: Enhance Monitoring**

Current Efforts

The partnerships to conduct monitoring between EPA, USGS, state agencies, District of Columbia and non-profit partners continue to be successful in carrying out the non-tidal and tidal monitoring network programs. The CBP oversees the tidal and nontidal monitoring networks, which are used to (1) assess water quality status in the tidal waters relative to established water quality standards and (2) measure nitrogen, phosphorus, and sediment in the watershed to help determine if practices are reducing loads to the Bay and in the watershed. The tidal monitoring network is a cooperative effort between EPA, Maryland and Virginia, and includes over 150 sites.[15] The watershed monitoring is a partnership between USGS, EPA and all seven Bay watershed jurisdictions, and includes 123 sites.[16] For both networks, data assurance and management are overseen by CBP office Quality Assurance (QA) and data management specialists. The CBP networks will be continued but associated gaps need to be addressed (see next section).

In addition to the CBP networks, monitoring is done by local entities, community groups, and government agencies in selected areas supporting new data streams and interpretation algorithms. The Chesapeake Monitoring Cooperative (CMC) manages data from Community Science monitoring and other alternative, high integrity monitoring sources (e.g., Maryland Department of the Environment) referred to as nontraditional partners.[17] That combination of resources represents enhanced capacity for assessing Bay health. The maturation of the CMC has demonstrated the utility and the importance of community science and alternative monitoring data. Investments in community science have helped generate new data streams that can support enhanced analyses of Bay health and reduce the uncertainties of present assessments. In 2019, all partner jurisdictions signed the Community Science data use Memorandum of Understanding (MOU).[18] Going forward, the jurisdictions and EPA need to include approved community science data available into water quality standards attainment assessments, thus enhancing CBP capacity and filling data gaps in space and time left by shortfalls of the long-term tidal water quality monitoring program.

Work continues across the partnership to assess the ability to use remotely sensed data in several applications including monitoring of SAV, wetlands, and forest buffers. There are also initiatives in place by others in the Bay community that use the historical satellite record to quantify changes in temporal and spatial distribution events (such as algal blooms or turbidity).

A 2019-2020 GIT funded pilot project has demonstrated the success of real-time vertical water column profilers that can improve our annual assessment of Bay hypoxia using advanced, smaller, cost-effective sensors.[19] These methods offer considerations for revising the traditional data collection approach and process to improve Bay monitoring. This is especially relevant in the open water of the mainstem Bay which has historically been limited to fixed-site, vertical, real-time measurement operations. Applying such technology can improve the accuracy of analysis and offers a new opportunity to assess all dissolved oxygen criteria for the first time in a more cost-effective monitoring portfolio.

The Hypoxia Collaborative Team is a new workgroup, formed in 2021 of the Chesapeake Bay Program that formed under CBP-STAR in 2021 out of the successful work of the pilot study https://www.chesapeakebay.net/who/group/hypoxia_collaborative_team . The group of federal, state, and academic partners is working to develop a hypoxia monitoring network that coincidentally considers data needs to fill gaps for unassessed water quality criteria, fish habitat assessment, and model

development calibration and verification. Meetings during 2021 and early 2022 focused on community input for strategic network design and initial placement of two NOAA arrays. NOAA and EPA are exploring partnership opportunities to build out a 10-array system with station locations based on recommendations from the Collaborative.

Gaps:

In 2020, the condition of the CBP monitoring networks were listed as "fair" in the context of its degree of capacity for addressing management decisions-support needs of the Partnership. An overview about the status and potential reductions of the networks was provided to the Principal's Staff Committee (PSC) at their March 2, 2021, meeting  The PSC requested a report (Monitoring Report) and recommendations on how to improve Chesapeake Bay Program (CBP) monitoring networks. The Scientific Technical Assessment and Reporting (STAR) Team interacted extensively with Goal Implementation Teams (GITs) and partners currently responsible for CBP monitoring core and partner networks to produce a report providing a roadmap to address shortcomings and enhance monitoring. The 3 major findings were: (1) monitoring is critical to assess progress toward CBP outcomes, (2) monitoring is insufficient for many CBP outcomes, and (3) there are opportunities to address these shortfalls but funding remains a challenge. One major shortfall is the CBP lacks monitoring to assess water quality criteria in tidal waters, which is a requirement of the Bay TMDL. There is a need for new investments to address significant gaps in providing decision-support for existing applications. A partnership approach is needed to address the vast scope of monitoring needs to build capacity. Partners include federal and state agencies, local governments, academic institutions, and nongovernmental agencies. While some new investments have been made toward monitoring, there is still a funding shortfall for the CBP core networks and improving multi-partner networks especially in securing long-term funding for the initial investments.

Funding remains a major challenge for meeting this outcome's goal of improving the capacity to monitor. Fixed and reduced funding levels of the Federal and State water quality monitoring program funding sources have negatively impacted the CBP partnership's ability to evaluate status and assess progress toward achieving water quality targets associated with implementing WIPs to achieve the Bay TMDL. There is an implicit assumption that Federal funding provides a substantial foundation for States to leverage to meet their monitoring requirements and that States will address cost of living adjustments needed to round out the capacity over time. However, since 2009, Federal investment to jurisdictional partner grants supporting the monitoring programs increased initially then leveled off in recent years. Without increased investments reflecting an annual rise in cost-of-living effects on the monitoring programs budgets, some States are struggling with covering the annual cost-of-living effects on sustaining the existing sampling, analysis and reporting programs. Additionally, costs of supplies needed for sampling collection and laboratory processing and analysis have increased due to inflation. Some supplies have become unavailable due to supply chain issues, leading to costly substitutions becoming necessary to continue the sampling program. The result is reduced buying power with fewer dollars available to support monitoring functions of sample collection across existing network stations, sample processing, quality assurance (QA), data management, analysis, and reporting.  Further, there has been limited opportunity available in recent years for program growth to meet additional information needs requested by the partnership.

Additionally, a change in policy by EPA to allow other categories of funding as State match against the

Federal monitoring investment has had unintended consequences. EPA implemented a change in policy allowing States to match monitoring funding using non-monitoring restoration project efforts. The 1:1 Federal:State match formula of the 117e grant leads to an expectation that produces $2 of total monitoring for every $1 invested by EPA. However, when a State chooses to match the Federal contribution with non-monitoring programs dollars, the total monitoring output per dollar invested by EPA declines. Today, because of the existing EPA policy on allowable match that the States are using to receive federal funds, the CBP is getting less than 100% of the expected monitoring specific output from its investments. A change in EPA policy about allowable matching funds could be used to improve monitoring capacity for the Chesapeake Bay Program partnership. States could also re-evaluate their policies for how they apply match funding within and across their agencies that will best leverage the available funding to the States from the Federal government to support monitoring needs evaluating the Water Quality Standards Attainment outcome and other Bay Agreement outcomes. It is noteworthy that States are starting to look at their grant formulas (e.g., Maryland) and working toward improving the monitoring-to-monitoring match applications in their grants.

- Additional to funding constraints, other gaps identified through the SRS review include:
- The current Nontidal network generally includes stations that drain over 100 square miles. Enhanced monitoring of smaller scale watersheds would be helpful to better distinguish effects of management actions and BMP implementation from other watershed influences (like land-use and climate change). Gaps in monitoring and interpretation in below fall- line areas to understand loading to tidal segments need to be addressed.
- Processes to use additional community and local data, remote sensing, coincident software supporting assessment of alternative data streams need to be developed to help assess all applicable criteria or watershed status and changes.
- A challenge arises with a growing number of new water quality data streams and additional living resources data. Additional capacity needed for effective and timely management of these new data sources. Currently, the CBP has only one data manager.
- Quality assurance of field and laboratory methods is important to maintaining the integrity of the water quality monitoring network's data streams. In-person, streamside field audits were put on hold for two years due to the Covid-19 pandemic. They started again in August 2022 with the goal of completing field audits of all groups collecting samples for Tier 3 data during FY23. However, capacity is again an issue as there is only one person who is tasked with coordinating and completing field audits for nine nontidal agencies, six tidal agencies, and several community monitoring groups while relying on additional volunteer support to complete all the audits.

**Factor 2: Improved analysis and reporting of water quality attainment and nontidal and tidal trends results**

Current Efforts:

The Chesapeake Bay Program, led by the Scientific, Technical Analysis and Reporting (STAR) team and in partnership with federal agencies, academic institutions and the states, has made progress in analyzing the estimated water quality standards attainment, water quality trends, and water quality monitoring data. The Integrated Trends Analysis Team is an example of productive collaborations between CBP partners that result in analysis and reporting of tidal water-quality trends. ITAT also produces tributary summaries which contain a wealth of findings for 12 different portions of the Bay, combining

information on attainment of standards, tidal trends and watershed trends and characteristics. The USGS oversees analysis of nontidal loads and trends.

Good progress has been made on reporting and communicating estimated standards attainment, tidal water quality trends, and nutrient and sediment trends in the watershed. The CBP reports results from three coordinated monitoring networks. The tidal monitoring program is used annually to assess estimated attainment status related to water quality standards and changes in tidal water quality. The River –Input Monitoring program (RIM) provides annual reporting of river flow, loads, and nutrient and sediment trends at 9 key sites (one site at the tidal/nontidal boundary of each major river basin). Finally, the nontidal monitoring network of 123 sites results in such a large amount of data throughout the watershed that the USGS uses to report trends every 2 years. The CBP partnership has functioned adequately with the 2-year staged analysis and reporting approach for the nontidal water quality monitoring assessments.

The science partners under STAR and the CBP Communications office communicate the attainment and trend results to several CBP audiences. The primary audience is the WQGIT, where summaries and presentations of results are provided. Additionally, selected results are posted on the Chesapeake Progress website, and provided in press releases prepared by the CBP Communications office. A new tool, CBP Watershed Data Dashboard, has proved valuable in displaying trend results with associated information such as land use and changes in management practices.[7] Finally, some results are also provided to jurisdictions who request more details.

Gaps:

The current framework to assess water quality standards attainment in the Bay, adopted in 2003, does not allow for a full accounting of water quality standards criteria. Because of insufficient data collections relative to the information needed to assess all criteria for dissolved oxygen, SAV/water clarity, and chlorophyll-a, a multimetric water quality standards (WQS) indicator was developed. The WQS indicator is computed using a small subset of criteria assessments and a set of scientifically-based rules, but represents an approximation of the over 1000 decisions otherwise needed to create a full accounting for bay health as defined by the TMDL. More communication strategies are needed to share other ways to evaluate progress with monitoring data such as metrics that show incremental progress of water quality standards attainment. Unassessed criteria remain a hurdle for delisting decisions of State-adopted water quality standards with the existing framework.

The partnership approach for achieving attainment of water quality standards is to focus implementation of nutrient and sediment reduction practices in places that will improve waters in the deepest portion of the Bay. The CBP developed a “most-effective basins” map to guide practices to watershed areas that will provide the greatest benefit towards achieving the deep channel habitat goals. The rationale is if these waters, which are some of the most degraded, are improved, the rest of the tidal waters will also see benefits. Given the slow improvement in these deep waters, there have been discussions of identifying additional tidal waters where attainment of standards can be accelerated. These discussions have focused on shallow and open waters, which are important for living resources. The CBP has an opportunity to use the tidal and watershed water quality monitoring results to consider policies to expand the places for focusing nutrient and sediment reduction practices affecting change in these other habitats.

As we near 2025, there will be challenges in communicating the status of water-quality standards attainment given we can only estimate standards attainment under present protocols for attainment

decisions. There are further challenges in our ability to project when the estuary will reach 100% attainment. Practices to restore the estuary are to be in place by 2025, but water quality standards attainment is not expected to reach 100% by 2025. However, questions may arise why water quality standards are not being met when they would be expected to be. It needs to be better recognized that WQS attainment indicator does not incorporate the full suite of criteria necessary for a complete accounting of WQS attainment assessments. While the TMDL is based on attainment of a subset of water quality criteria, de-listing of Chesapeake Bay segments requires attainment of additional criteria for which sufficient monitoring data and/or assessment methods are not currently available. In addition to the overall WQS attainment indicator, there are benefits of quantifying and communicating the status and trends of attainment status for different water-quality criteria (i.e., dissolved oxygen, chlorophyll-a, SAV/water clarity) and designated uses (i.e., open water, deep water, deep channel, shallow water, migratory spawning and nursery).

For community science data in the tidal waters, the jurisdictions signed an MOU supporting the use of data as available, but more engagement is needed between the jurisdictions and the Chesapeake Monitoring Cooperative to integrate community science and nontraditional partner data into state assessment programs.[18]

In the watershed for the analysis of water-quality trends, the USGS and partners are striving to reduce the time needed to update trends analysis and reporting; and better comparing trends to load reduction targets. The time between collection of samples, lab analysis, quality assurance, and data verification is often 6-9 months. The compilation of data for trend analysis and results verification can take a similar amount of time. USGS and partners are examining ways to shorten the entire process.

**Factor 3: Improved understanding and communication of the factors affecting the water quality and influence of management practices**

Current Efforts:

The CBP monitoring team and partners (USGS, UMCES, MD DNR, VA DEQ, ODU, VIMS, DOEE, COG and others) increased understanding of the factors affecting water-quality changes in the watershed and estuary. Multiple synthesis reports were generated for the tidal waters and watershed. Over the past several years, good progress has been made in the development and application of more advanced techniques to assess and explain water quality changes over time across the watershed, tributaries, and mainstem bay. As a result, we are now in a better position than ever before to address questions about what is driving observed changes in key water quality and living resource indicators. In addition to developing and applying new tools, CBP, USGS, academic, and state analysts partnered to produce syntheses of the current state of knowledge on factors affecting patterns in nutrient and sediment concentrations and loads, estuarine hypoxia, water clarity, and SAV abundance. These syntheses were critical to effectively target the next cycle of analysis to address questions of management concern. CBP, USGS, and partner analysts are on track to build on the lessons learned from past work. More insights are expected through ongoing application of advanced analytical and modeling approaches. Detecting and explaining the effects of BMP implementation in the face of ongoing changes in land use, climate patterns, and other stressors, is the major focus of analysis.

The findings in these reports were communicated to the jurisdictions through a series of presentations and in-person workshops during Phase III WIP development. It was found beneficial to integrate information for each jurisdiction and work individually with each to communicate relevant results.

With the 2025 TMDL WIP implementation deadline approaching, STAC believes that now is an appropriate time to identify key areas of uncertainty within the relationship between nutrient and sediment reduction efforts and attainment of WQS. The goal of the current STAC effort Achieving Water Quality Goals in the Chesapeake Bay: Comprehensive Evaluation of System Response (CESR) is to identify where water quality programs and policies may not be yielding anticipated system responses, and to better understand possible reasons for these disparities. Recognizing and actively responding to uncertainty enables more informed and effective decision-making. This effort brings in all STAC members, with various expertise, to examine system response from 3 perspectives-- Estuarine, Watershed, and Living Resources. Members and outside experts have been gathering for the past 2 years to develop this report and it is expected to be released by the end of 2021. This effort and other STAC synthesis projects underway will provide valuable information relevant to water quality standards attainment and monitoring.

More in-depth jurisdictional meetings are being initiated to better understand trends, and factors affecting their change.

Gaps:

While efforts to understand factors affecting water quality changes made progress, they also revealed challenges where more analysis is needed to explain nontidal water quality changes and their relationship to nutrient and sediment reduction efforts, especially at sites within each jurisdiction. Additionally, more research is needed to understand tidal water quality response including understanding phytoplankton response in regions with decreasing nutrient loads and shallow water dynamics.

Planned actions to address other specific gaps include:

- More application of all available analysis and modeling tools to better relate water-quality response to management efforts.
- Enhanced communication of the factors affecting trends and implications to inform jurisdictional decisions on nutrient and sediment practices for the WIP 2025 outcome.
- Supply more information on the options to accelerate attainment of water quality standards in shallow tidal waters important for living resources and people.
- Better alignment and application of tidal and nontidal monitoring results to inform watershed and estuary modeling efforts.

The communication of these results with federal, state, and local stakeholders increased over the past two years. However, application of the monitoring results for water quality decision making remains limited and is still a challenge. Progress toward implementing nutrient and sediment reduction practices is still based on modeling tools, principally CAST. Therefore jurisdictions, DC, and EPA focus on these modeling tools under the TMDL framework to address the 2025 WIP outcome. The WQGIT is considering more emphasis on using monitoring since the 2025 WIP outcome also contains statements on making progress toward attaining water quality standards. Enhanced collaboration is needed to share and apply monitoring results to achieve a close connection between 1) implementing nutrient and sediment reduction practices, 2) improve water quality in the watershed, 3) reduce loads in the Bay, and 4) increase progress towards attainment of water quality standards for dissolved oxygen, SAV/water clarity and chlorophyll *a* in tidal waters.

- **Factor 4: Improved understanding of Multiple Benefits between water-quality practices and other CBP outcomes**

Current Efforts:

The development of the CBP's Strategic Science and Research Framework, led by STAR, has been very successful in tracking the science needs across the program, identifying overlapping interests between teams, and engaging additional science providers.[21] The development of the Framework was carried out with input from STAR, the GITs, and STAC, and has successfully been integrated into the Strategy Review System (SRS) process. It has shown that looking holistically across the program at science is incredibly beneficial.

Several partners have been working together on a science-based approach targeting resources to address multiple Watershed Agreement outcomes. The USGS is working with the CBP Office, USEPA, NOAA, and the Chesapeake Conservancy to provide science-based information that can be considered by agencies and organizations for a more strategic approach to targeting resources. The objective of the targeting effort is to organize science-based information so agencies and organizations can better target resources to the places, and towards the types of activities, that accelerate progress for multiple CBP outcomes and provide more local benefits. The information is organized around several topics (Figure 7) based on the goals of the Chesapeake Bay Watershed Agreement: (1) accelerate water quality improvements, (2) improve fish, wildlife populations and habitats, (3) expand land-conservation efforts, and (4) increase benefits to people, with all topics considering opportunities to enhance climate resiliency (Figure 7).

Enhanced targeting of resources will accelerate progress toward multiple CBP outcomes and increase the return on funding investments by providing more benefits to the people, fish, and wildlife across the Bay and its watershed. More information on these targeting tools can be found at: A Science-Based Approach for Targeting Resources to Achieve Multiple Chesapeake Outcome | U.S. Geological Survey (usgs.gov)

There are several previous, and on-going, efforts that provide information about the multiple benefits of water-quality practices with other CBP outcomes. The Management Board led the development of fact sheets for co-benefits between the water-quality outcome and 12 other CBP outcomes.[22] In addition, the WQGIT supported a project carried out by Tetra Tech to assess qualitative benefits of water quality BMPs with all the CBP outcomes, and selected results were included in the fact sheets overseen by the Management Board.[22] There was also a STAC workshop *Quantifying Ecosystem Services and Co-Benefits of Nutrient and Sediment Pollutant Reducing BMPs*.[23]

Climate change: The CBP continues to try and better understand the impacts of climate change on all our goals and outcomes. Gaining a better understanding of these impacts may influence where and what we need to monitor, and the analyses conducted. For example, work is currently underway to better understand the impacts of rising temperatures on shallow waters of the Bay, better understand where streams are warming and the impacts on brook trout population vulnerability, identifying current monitoring to support climate related needs, and better understand the impacts of climate change on BMP efficiency.

Gaps:

The existing CBP core networks have primarily focused on assessing water quality standards in the estuary, and changes in nutrient and sediment conditions in the watershed. The water quality monitoring programming remains a partnership priority due to regulatory mandates of the Clean Water Act. However, CBP partners further have a commitment outlined in the 2014 Watershed Agreement to assess progress toward achieving the Agreement outcomes. There is a need to continue refining analyses that improve understanding of major drivers of water quality and living resource change and to better distinguish the response of impacted resources around the watershed, within and across tidal tributaries, and along the mainstem Bay. Enhancements will put the CBP in a better position to address questions about drivers of observed water quality and living resources changes and effectively target the next cycle of analysis to address management concerns.

A vast amount of science is required to understand these major drivers. The Strategic Science and Research Framework (SSRF) was developed to increase the amount of science for the CBP. The full breath of the more than 170 science needs identified in the Science Needs Database currently cannot be addressed with existing CBP Office capacity, so we continue to engage federal and state agencies and nonprofits to expand science capacity. The engagement of the broader scientific community is needed to (1) translate and disseminate existing science and (2) inspire and implement additional research tackling new science needs providing decision-support to inform management of the Chesapeake Bay and its watershed.

Additional remaining gaps include:

- Understanding how to quantify and incorporate multiple benefits into restoration plans, programs, and decision support tools. In particular, those multiple benefits with outcomes that are important for achieving the 2025 outcome, especially forest buffers and wetlands. Both of these outcomes are identified in several of the jurisdictions' Phase III WIPs for practices needed to meet the Phase III WIP planning targets.
- Understanding impacts to restoration efforts, including nutrient and sediment load reduction responsibilities, due to 2025 and 2035 climate change conditions.
- Multiple benefits of toxic contaminant retention from nutrient and sediment practices for a wider range of contaminants in urban areas and contaminant reduction in agricultural areas
- Management Approaches

The CBP partnership will work together to carry out the following management approaches to achieve the water quality goal, and two associated outcomes. These approaches seek to address the factors affecting our ability to meet the goal and the gaps identified above. More details for are provided in the Logic and Action Plan for each outcome.

Management Approaches for 2025 WIP Outcome

### Phase III WIPs and Two-Year Milestones

The overall management approach needed for reducing nitrogen, phosphorus, and sediment are provided in the Bay TMDL document, the Phase III WIPs, and the accountability framework described in the Bay TMDL document and Executive Order 13508.[1,2,24] The Phase III WIPs describe how the seven Bay watershed jurisdictions, in collaboration with local partners and federal agencies, will refine, as

necessary, the actions and controls that will be implemented between 2018 and 2025 to meet their final load reduction targets by 2025. Attainment of these goals across the watershed is expected to result in the achievement of all applicable nutrient- and sediment-related water quality standards in the Bay and its tidal tributaries.

### Phase III WIP and Two-year milestone Implementation

There are several programmatic, management and implementation efforts underway to help achieve attainment of the water quality outcomes. In2019, the jurisdictions developed Phase III WIPs that describe the actions the jurisdictions will take to have all practices on the ground by 2025 to achieve their respective Phase III planning targets.[25]

To assist the jurisdictions in implementing the Phase III WIPs, the CBP partnership will work to (in no order of priority):

- Develop enhanced understanding of BMP performance, siting and design under climate change conditions.
- Identify and provide technical assistance and funding to the Bay jurisdictions in Phase III WIP implementation, such as exploring the expansion of a jurisdiction-based circuit rider program to provide more "boots on the ground" support.
- Support implementation of BMP verification programs, including the development of, coordination, and financial assistance provided for alternative verification methodologies
- Continue to consider the co-benefits of management practices to address other *Watershed Agreement* goals and outcomes beyond water quality.
- Continue to maintain and update Phase 6 modeling tools, with PSC approval, to reflect advances in understanding and support jurisdictions' implementation planning and tracking.
- Evaluate ways to incorporate the explicit land cover/land use data into CAST for planning purposes.
- Work with the jurisdictions to coordinate place-based research activities and insights, while considering the spatial distribution of Phase III WIP implementation.
- Expand partnership collaboration and engagement, particularly at the local level.
- Share successful approaches among partners to help inform and support implementation efforts.
- Complete and release the optimization framework and tool.
- Solicit membership from under-represented groups to participate in the WQGIT and its source sector workgroups.

### Approaches Targeted to Local Participation

- Much of the implementation of the pollution reduction practices, as articulated in the Bay TMDL and the WIPs, will be carried out at the local level. This includes municipalities, counties, soil and water conservation districts, and local private sector groups and individuals. Therefore, management approaches should be designed to include timely dialogue with the responsible local agencies and other partners, taking into consideration funding and technical support required by these local partners as well as competing financial and resource demands.

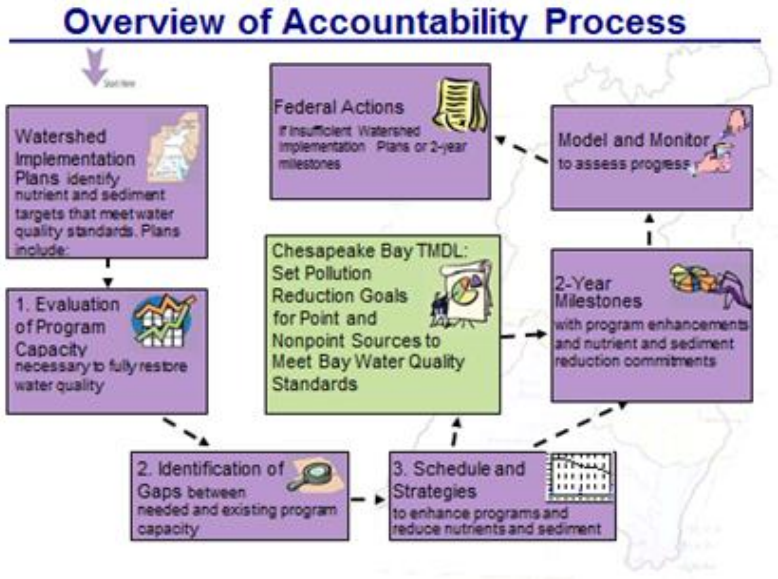
- The Chesapeake Bay jurisdictions have developed local planning goals as part of the Phase III WIPs.[26] Local planning goals are intended to enhance planning and implementation efforts at the local level. While there is flexibility in determining how local planning goals can be expressed (e.g., numeric and/or BMP implementation goals), they must be measurable and below the state-major basin scale.
- The CBP partnership will update the high-resolution land cover dataset every four years between 2018 and 2025, using state and local data from the jurisdictions. The collection of refined land use and land cover data for incorporation into the Phase 6 modeling tools is intended to improve the representation of urban, agricultural, federal and natural lands at the local scale. Trends in land use will be used to refine the future land use projections every two years through 2025. Local land use and growth projections will assist in local planning and implementation of practices to achieve the Phase III planning targets and two-year milestones.
- Use the spatially explicit land cover data in CAST to enhance CAST users' ability to improve water quality and focus measured outcomes to smaller geographic scales.[6] This enhancement will help CAST be understood and supported by non-technical people, which will expand usage of CAST to conservation project members, farmers, and farm advisors. This enhancement will negate the need for urban planners to convey their site-specific geographic information to the more general tabular geographics currently available.
- Further information is needed to fully understand and address local climate change impacts in the Chesapeake watershed. This will include assessing how climate change impacts affect Bay, tributary and local water quality standards. The CBP partnership will also collect and analyze local data to better understand implementation practice performance and resilience concerns under climate change conditions. Better understanding of implementation practice performance and resilience to climate conditions at the local level will assist in climate-smart implementation and programmatic design at the local level. The partnership will also develop techniques, collect data and perform studies through 2021 to better understand and predict impacts from climate change to Chesapeake watershed jurisdictions and local areas. Beginning in 2022, the partnership will assist the jurisdictions in applying new understandings of climate change impacts in implementation and programmatic practices through 2025.
- Recent investments by the CBP in citizen science and nontraditional partner monitoring efforts will help inform management and decision-makers with monitoring assessments, including the effects of management activities. The opportunity to expand the use of new data sources will provide key data for evaluating the work of the management strategies to understand the progress we are making, what gaps remain and what steps are needed to fill those gaps.
- Achieving water quality standards requires improving the understanding and communication of the factors affecting the water-quality to inform jurisdictional decisions on nutrient and sediment practices. The CBP enacted a Local Engagement Team to support actions related to communication, outreach, and/or engagement so this team will be working to assist in implementation of communication materials and facilitation along with connecting analysts to groups that want to implement and hear results.

**Chesapeake Bay TMDL Accountability Framework**

The Bay TMDL is supported by a rigorous accountability framework to ensure cleanup commitments are

established and met, including WIPs, short and long-term benchmarks (such as two-year milestones), a tracking and accountability system for jurisdictions' activities and federal actions that may be employed if jurisdictions do not meet their milestone and WIP commitments. Federal agencies are directed by Executive Order 13508 to consult with the seven Bay watershed jurisdictions to ensure that federal actions to protect and restore the Chesapeake Bay are closely coordinated with those actions by state and local jurisdictions in the watershed. The federal agencies have developed an Executive Order strategy to outline ways to accomplish that goal.[24] EPA and other federal agencies, such as USDA, will also continue to develop water quality two-year milestones, and EPA will incorporate federal milestones efforts into the updated Milestone Guide.

Sections 7 and 10 of the Bay TMDL document describe how the accountability framework helps provide reasonable assurance that the needed pollutant reductions will occur and how adaptive management can be used as a tool to implement those pollutant reductions within the accountability framework.[1]




As part of its efforts to carry out the Bay TMDL accountability framework, EPA interacts with the jurisdictions directly and through the CBP's WQGIT and its associated source sector workgroups. The WQGIT workgroups are focused on supporting the reduction of nitrogen, phosphorus, and sediment pollutant loads from key sources described in Section 4 of the Bay TMDL: wastewater, agriculture, urban storm water, septic systems, forests and air.[1]

EPA also works with the jurisdictions and the WQGIT on issues associated with two-year milestones, offsets and water quality trading. The WQGIT is supported by the CBP STAR team, which contains the modeling and monitoring workgroups, and other goal implementation teams, as necessary. The CBP partnership's models are used to assist the jurisdictions in assessing different options for management practices in the formulation of their WIPs and two-year milestone commitments.

**Management Approaches for the Water Quality Standards Attainment and Monitoring Outcome**

There are four management approaches for this outcome, each corresponding to a factor presented in the previous section. The approaches are:

1. Enhance monitoring for standard attainment and tidal and non-tidal water quality and produce quality data.
2. Assess and report changes in attainment of water quality standards, and nontidal and tidal trends.
3. Further explain and communicate the factors affecting trends and better understand response to management practices.
4. Contribute to better understanding and communication of multiple benefits of water-quality restoration and other CBP outcomes.

**MA 1:** Enhance monitoring for standard attainment and tidal and non-tidal water quality and produce quality data.

The CBP partnership will continue to operate their primary tidal and nontidal monitoring networks, the associated data quality and management activities. The 2021-22 review of the monitoring program requested by the PSC, and the associated summary report, identified several insights into the operations and management of the existing CBP core monitoring networks and gap filling needs to provide missing decision-support to supporting outcome assessment under the Chesapeake Bay Watershed Agreement. The report included recommendations and cost estimates needed to address shortfalls, maintenance, and enhancements of CBP core networks including the tidal and nontidal water quality networks. The challenge for the next two years will be to identify funding opportunities to address monitoring shortfalls and enhancements identified in the report recommendations.

As part of our work to incorporate additional data streams, especially real-time and other new high temporal data streams, we will need to collaborate with the research community on data sharing, model development, and uncertainty. STAR and its workgroups need to work together with EPA and the Bay community on a preferred monitoring plan to incorporate such new technologies and published research recommendations, plan for a phased approach toward revised program support with reinvesting existing funding where information return on investment can be shown to enhance capacity, garnering any new funding to support an advanced program, develop the QA plan necessary for using the new technologies, and updates for the indicator framework and processes to incorporate new community based, nontraditional partner based, and high spatial and/or temporal density data streams.

1. Community science and nontraditional partner monitoring in the watershed is expected to assist in understanding local to regional-level spatial distributions of hot spots for nutrients, sediments, contaminants and biology that can be used to guide targeting for limited resources in managing restoration efforts. Incorporating new partners with advanced technology and related protocols for assessing Bay-wide scales of conditions at high resolution are further being pursued (e.g., NASA evaluations of satellite imagery for water clarity related measures). New science on monitoring (e.g., Bever et al. 2018) proposes alternative monitoring strategies that

could be adopted if adequate in situ technology to obtain measurement profiles in the Bay in real time can be achieved.[27] Pilot studies of such technology are being proposed and pursued through the GIT-funding process.

The CBP partnership conducts annual monitoring of river flow to the Bay to help explain yearly changes in dissolved oxygen, clarity/SAV, and chlorophyll-*a* conditions. Living resources monitoring is used to assess changes in populations of lower trophic levels (SAV and invertebrates) and fisheries (crabs, oysters and selected finfish species) that are dependent on habitat conditions. The CBP nontidal water quality monitoring program monitors nutrient and sediment at 123 sites in the watershed to help document and understand the factors affecting the response to management practices. Some of the enhanced monitoring efforts are mentioned below.

- **MA 2:** Assess and report changes in attainment of water quality standards, and nontidal and tidal trends.

STAR is working with the WQGIT to develop an approach to integrate four key pieces of related water quality information to better assess and communicate progress towards meeting the goals of the Bay TMDL and associated water quality standards including:

- Reductions of nitrogen, phosphorus, and sediment by source, jurisdiction and overall load reduction associated with the implementation of BMPs. These load reductions are estimates from the CBP models based on BMP implementation data submitted by the jurisdictions.
- Changes of in-stream nitrogen, phosphorus, and sediment concentrations and loads as estimated by flow-adjusted trends of nitrogen, phosphorus, and sediment. These estimates show long-term (25 year) and short-term (10 year) changes by normalizing the annual effects of streamflow variability. The normalized estimates are based on monitoring data collected as part of the CBP nontidal water quality monitoring program.
- Attainment of Chesapeake water quality standards for dissolved oxygen, chlorophyll-*a* and water clarity/SAV. Attainment of these standards is based primarily on results from the CBP tidal water quality monitoring program.
- Changes in water quality and related parameters, including dissolved oxygen, chlorophyll-a, water clarity, nitrogen, phosphorus, and total suspended solids, across the CBP long-term tidal water-quality monitoring network. These estimates show long-term (up to 35-year) and shorter-term (most recent 10-year) changes by adjusting for seasonal cycles and variability in river flow or salinity.

Some of the advancements to address gaps include:

- explore new water quality standards attainment assessment frameworks that use model advances to address assessment of more water quality criteria than ever before in space and time,

- adopt new, freely available, high resolution data streams from satellite imagery, where satellite-based assessments of water quality do not measure exactly what we measure in the standards,

develop surrogate models for available measures to estimate conditions where measurements are sparse in space and time,

- develop recommendations to approve and adopt the use of surrogate measures as appropriate to leverage the data available and support management relevant decisions on Bay health status and change over time,
- explore options for revising the criteria such that a more concise definition of Bay health can be effectively assessed based on available data,
- explore options for revising the decisions on the protocol for application of existing data to assess existing standards,

STAR will use the next two years to identify ways to better engage the jurisdictions to communicate and apply standards attainment and trend results. Interactions with stakeholders focused on common questions of resource managers and how science can help additional priorities and individual local projects will strengthen relationships. Developing a more structured management outreach framework and exploring a bottom-up approach, focusing on local planning districts, couty offices, smaller watershed, etc., whole supporting data-driven decision making is the desired path forward.

**MA 3:** Further explain and communicate the factors affecting trends and better understand response to management practices.

The STAR team is continuing efforts to better measure and explain progress toward water quality improvements. These efforts will generate and improve understanding of the factors affecting system response (the Bay and its watershed) to implementation of management practices. STAR will also closely examine recommendations from STAC efforts to address science gaps for the 2025 TMDL. The CBP Modeling Workgroup and Monitoring Workgroup will document continuing efforts to better measure progress.

Specific tidal analyses we plan to undertake include:

- Analysis of shallow water and continuous monitoring data to understand impacts of climate change, local landscapes, shoreline conditions, and associated BMP implementation on water quality in tributary open waters and shallow water habitats, where the estuary model currently struggles to predict water quality standards attainment.
- Explore external and internal factors influencing the spatial and temporal trends in water quality standards attainment and the underlying tidal water-quality data.
- Explore other metrics (e.g., attainment buffer) to characterize the resiliency of the tidal segments with respect to meeting the water quality standards.
- Examine the effects of climate change (particularly temperature) on water-quality standards attainment.

Some of the nontidal analyses underway include:

- Increase technical interaction with states to identify priority needs and apply monitoring results to inform 2-year milestones.

- Summarize existing information to support technical meetings and inform associated science priorities.
- Enhance analyses of factors affecting trends in major watersheds, with emphasis on response to management efforts. The scope of activities will depend on priority science needs identified in jurisdictional meetings.
- Analysis to inform spatially targeted implementation of conservation practices (BMPs).

Some of the efforts for integrated analysis of the nontidal and tidal findings include:

- Prepare tributary summary reports that include findings from nontidal and tidal areas within the identified major tributaries.
- Improve understanding and building capacity for analysis and communication of linkage between watershed changes (including BMPs and land change), to loads to tidal waters, and estuary response.

**MA 4:** Contribute to better understanding and communication of multiple benefits of water-quality restoration and other CBP outcomes.

The development of the CBP's Strategic Science and Research Framework (SSRF), led by STAR, has been very successful in tracking the science needs across the Bay program's Watershed Agreement goal- and outcome-focused management efforts, identifying overlapping interests between teams, and engaging additional science providers to provide capacity addressing identified science needs. The current focus is to partner with academic institutions to increase those supporting the science priorities of the CBP. Academic institutions will play a strong role in advancing this understanding through their aims to strengthen the scientific leadership pipeline, support of their faculty research direction, and ability to convene a diverse team of managers and provisioners of science to tackle a shared problem. Science is continually reviewed and updated within academic institutions so fostering collaborative research and effectively providing science to advance Chesapeake Bay restoration and conservation efforts between these institutions and the CBP is a critical step in maintaining progress towards science needs. **A Science Needs Database** was recently developed that is publicly available for all potential partners to view and provides an up-to-date list of science needs from across the partnership.

Some of the supporting actions include:

- State and local jurisdictions could target the implementation of actions that not only result in water quality benefits but address other impairments (e.g., bacteria or toxic contaminants), environmental problems (e.g., threatened or endangered species), safety concerns (e.g., flooding, infrastructure) and 2014 Watershed Agreement outcomes (e.g., wetlands, forest buffers) as well. In 2018, an action team was created to look at the multiple benefits among these outcomes and the Phase III WIP. While multiple benefits could be identified for the majority of the 2014 Watershed Agreement outcomes, the action team identified the top 12 that appeared to have a stronger link to the WIP, either through their ability to facilitate messaging or to enhance implementation of the WIPs. Using the results of a comprehensive report which qualitatively ranked BMPs available in the Phase 5.3.2 modeling tools according to their benefits developed by the CBP WQGIT and Habitat GIT, the action team created a series of two-page fact sheets for these 12 high-priority outcomes. They also included narrative

descriptions from experts in the relevant GITs and workgroups on considerations for addressing these priority outcomes in Phase III WIP development, selection and siting of BMPs, and resources for additional decision-support tools and points of contact in each jurisdiction. The report, fact sheets and additional resources are available on Phase 6 CAST.[6] The qualitative rankings are currently being incorporated into an interactive web-based tool, which will allow users to explore, rank, sort and filter scores across individual BMPs, Watershed Agreement outcomes and BMP sectors.

- The CBP partnership is currently developing an optimization tool for TMDL implementation purposes, but this tool could potentially capture a broader range of ecosystem benefits beyond water quality to help inform decision making in our restoration efforts. An effort will also identify barriers to pursuing such broader benefits as well as recommendations for how to address those barriers.
- The partnership is currently exploring the development of an ecosystem services framework for BMP selection, planning and implementation. This potential framework would provide additional decision support to state and local jurisdictions in addressing local concerns and goals through the TMDL implementation process.
- The Toxics Contaminant Workgroup (TCW) needs to identify and prioritize options for toxics mitigation to help inform policy and prevention strategies that have mulitple benefits with nutrient and sediment reductions. Both PCBs and mercury have widespread extent and severity and also cause fish consumption advisories, so they are being addressed first for mitigation options. For other contaminants and their mixtures, the TCW will use the information from previous approaches on landscape settings to identify and prioritize mitigation options. Work activities will include:
    - Study of mitigating contaminants in different landscape settings.
    - Determine the efficiencies of some management practices to reduce selected contaminants.
    - Explore the use of existing nutrient and sediment tools (such as CAST and watershed model) to address selected contaminants.
    - Interact with WQGIT teams on opportunities to achieve co-benefits between nutrient and sediment practice and contaminant reductions. Share Information generated from the research strategy with the TCW and key workgroups of the WQGIT (Wastewater Treatment Workgroup, Urban Stormwater Workgroup, and Agricultural Workgroup) so they can consider options for mitigation impacts of toxic contaminants.
- Enhanced water quality monitoring will serve to support information needs of the Sustainable Fisheries GIT and its cross-cutting efforts (multiple benefits) with the Habitat GIT. Hypoxia negatively impacts water quality standards attainment, blue crab habitat, forage species (macroinvertebrates, fish and shellfish) distribution and abundance, fish habitat, fish and benthic macroinvertebrate community health, fishing success, nutrient cycling and oyster restoration siting. Reducing uncertainty in hypoxic volume estimates improves the power to detect change over time in response to management actions on shorter time scales than can be provided by present data collection strategies. Bottom measurement of temperature, salinity and dissolved oxygen were identified as needs from the recent STAC SAV, blue crab, oyster and climate workshops. Improved hypoxic volume resolution would improve habitat

characterization needed to support the data being collated for developing Chesapeake Bay regional fish habitat health assessment per the 2018 STAC workshop findings and recommendations.[28] Improved tracking of hypoxic habitat dynamics in space and time is also highlighted as a desired, cross cutting climate indicator per the 2017-18 climate indicators project by the Climate Resilience Workgroup.[29] Further monitoring program improvements are being investigated to improve water clarity acres and chlorophyll-*a* assessments.

### Communication & Outreach

Interaction between the WQGIT and STAR will be the primary approach to communicate scientific findings to inform implementation of the WIPs. Additionally, CBP partners will:

- Increase technical interaction with state agencies and other stakeholders and communitygroups to identify priority needs to apply monitoring results, and factors affecting change to inform 2-year milestones.
- Use results of jurisdictional meetings to better summarize existing information and plan new analysis to inform milestones through 2025.
- Prepare documents that provide understandable results to varying target audiences.
- Improve access to its scientific and technical information enhancing the (1) Watershed Data Dashboard, and (2) developing an open data site that catalogs, standardizes, organizes and provides access to its datasets— including geospatial data—and its tools.

Continued and more consistent scientific and technical outreach is necessary to provide managers the opportunity to incorporate science into their decision-making. Current outreach efforts surrounding Phase III WIP development should evolve in the future to (1) focus on WIP implementation support, (2) incorporate more cross-outcome technical outreach, and (3) align with management-relevant timelines such as the TMDL milestones.

# V. Monitoring Progress

### 2025 WIP Outcome

*Practices*: Since 2010, the CBP partnership solicits BMP implementation data from the jurisdictions. The WQGIT Watershed Technical Workgroup is responsible for assisting jurisdictions in developing, understanding and submitting data through the NEIEN system. The CBP partnership is working with the jurisdictions and federal partners to improve verification of reported nutrient and sediment controls.

The WQGIT also adopted a protocol for reviewing the effectiveness of BMPs based on an evaluation by expert panels and a review of the best available literature and data. Revisions to the CBP partnership's BMP Expert Panel Protocols are under development to more clearly establish a process to modify existing, or approve new, nutrient and sediment controls and how the implementation of those controls are accounted for by the CBP modeling tools.

*Modeled Loads*: The CBP partners use a suite of computer models to project pollutant loads and flow. The CBP modeling framework is designed to address questions of how Chesapeake Bay water quality will respond to changes in watershed and airshed management actions, which can inform decision-making

for reducing pollution and meeting applicable water quality standards. These modeling tools are also used to track and quantify nutrient and sediment loads as WIP implementation progresses. The estimated modeled loads, together with relevant monitoring data, are used to track progress with achieving the 2025 WIP outcome. USGS and the Modeling Workgroup are currently enhancing techniques to better compare modeled nutrient and sediment load data with that of monitored loads.

The Modeling Workgroup, in collaboration with other CBP partners, enhanced and revised the watershed modeling system structure to improve transparency, accuracy and confidence, particularly through the incorporation of more refined local land use data.

### Water Quality Standards Attainment & Monitoring Outcome

The CBP has extensive tidal and nontidal monitoring networks, which are used to monitor progress towards standards attainment and nutrient and sediment load reduction. Analysis and synthesis of the watershed and bay monitoring results are essential to understanding and communicating changes through time that supports decision-making and adaptive management.

CBP currently lacks the capacity to meet all the monitoring requirements to fully assess the attainment of tidal water quality standards. There has been progress over the past two years in preparing a report, requested by the PSC, examining current monitoring and developing recommendations for the future. The report provides a blueprint for opportunities, but challenges exist to secure new investments.

Recommendations and cost estimates were developed through shared insights from managers, technicians and program administrators based on best available information and experience as guidance to address development, maintenance and improvement of CBP core networks. The recommendations found in the report are presented as a menu of investment opportunities. Line-item cost projections for 5 years are further provided as guidance. The menu was designed to help CBP partners choose where they can support individual items that will collectively improve monitoring toward addressing the information needs of multiple outcomes. Pursuing funds for monitoring investments will require a long-term effort of increased collaboration between federal, state, academic and local monitoring programs.

## VI. Assessing Progress

The CBP accountability framework provides the foundation to assess progress towards the Bay TMDL and associated water quality standards. Enhanced knowledge of management practices and their effects will be used primarily to refine individual jurisdiction strategies to achieve the 2025 water quality goals.

### 2025 WIP Outcomes

EPA will assess the jurisdictions' progress toward reaching the Bay TMDL's ultimate nitrogen, phosphorus, and sediment reduction goals at least biennially using the jurisdictions' two-year milestones commitments. Every two years, the jurisdictions are expected to identify and commit to implement specific pollutant-reduction controls and actions in each of their successive two-year milestone periods. Under the Executive Order, the federal government also has been committing to two-year milestones.[24] EPA will measure progress annually by running implementation data collected from the jurisdictions through the CBP partnership's modeling tools.

When assessing two-year milestone commitments, EPA evaluates whether proposed actions, controls

and practices would result in estimated loads at the jurisdiction scale that will put the jurisdiction on track towards meeting its 2025 goals. EPA uses the reported BMP data and the Chesapeake Bay Watershed Model to assess the jurisdictions' progress towards meeting the Phase III planning targets. EPA also assesses the jurisdictions' and Federal Agencies' progress towards meeting its programmatic milestones (e.g., promulgation of new laws, implementation of regulations, policy development, permit issuance, compliance and enforcement commitments, etc.) at least biennially.

While the partnership exceeded the 60 percent goals for reducing phosphorus and sediment, it fell short of the 2017 target for reducing nitrogen by 15 million pounds. The implementation of BMPs specifically in the agricultural and urban sectors will need to accelerate to close this gap.[30]

With the completion of the Bay TMDL's midpoint assessment, the WQGIT will no longer include workplan actions for the 2017 WIP outcome and instead focus efforts on achieving the 2025 WIP outcome.

### Water Quality Standards Attainment and Monitoring Outcome

Analyses, science synthesis, and communication supports the CBP partners continued endorsement (PSC, May 2012) of an integrated approach that includes three primary pieces of information to measure progress toward meeting water quality standards:[31]

- Documenting, tracking, and reporting of water quality management practices.
- Analyzing trends of nitrogen, phosphorus, and sediment in the watershed.
- Assessing attainment of dissolved oxygen, chlorophyll-a and water clarity/SAV standards.

The CBP partnership analyzes monitoring data to assess progress toward:

- Annual updates of the estimated attainment of water quality standards in all the tidal waters.
- Annual reporting of total nutrient and sediment loads to the Bay.
- Annual reporting of nitrogen, phosphorus, and sediment loads and trends at the nine RIM sites.
- Reporting of nitrogen, phosphorus, and sediment loads and trends for all the NTN sites every two years.
- Produce Tributary Summaries compile information from all the water quality monitoring networks (with a larger focus on tidal data) by subbasin for technical managers and planners to summarize 1) how tidal water quality (TN, TP, DO, Chlorophyll a, Secchi Depth) has changed over time, 2) how and which factors may influence water quality change over time, and 3) recent research connecting observed changes in aquatic conditions to its drivers.

## IX. Managing Adaptively

An integrated approach is required to quantify and explain water quality trends in the Bay and its watershed, to understand the linkages between these systems and with ecosystems and living resources, and to assess the impact and results of management actions. This approach relies on monitoring information for water quality, enhanced BMP implementation data, the use of several

analytical tools (including statistical tools, CBP Watershed Model and estuary models), and interdisciplinary synthesis efforts.

The partnership will continue the following approaches to ensure adaptive management:

- In a dynamic environment like the Bay watershed, changes are inevitable. It may be possible to accommodate those changes within the existing Bay TMDL framework without the need to revise it in whole, or in part. The CBP partnership has committed to take an adaptive management approach to the Bay TMDL and incorporate new scientific understandings into the implementation planning in two-year milestones and in Phase III following the Bay TMLD's midpoint assessment. Future adjustments to WIPs and two-year milestones based on changing conditions and the availability of new information is consistent with the CBP's concept of adaptive management.
- The CBP partnership will continue to examine the following questions to address implementation challenges and opportunities, incorporate new data and scientific understandings and refine decision support tools and management strategies, as approved by the PSC, toward the achievement of the water quality outcomes in the 2014 *Chesapeake Bay Watershed Agreement*:
  - What progress had been made in implementing practices for the Bay TMDL?
  - What are the changes in water quality and progress toward applicable water quality standards?
  - Are there fundamental changes due to climate impacts or other factors that require reconsideration of the water quality standards that the Bay TMDL was originally based on?
  - What are we learning about the factors affecting water quality changes to better implement practices?
  - What refinements are needed in decision support tools, monitoring and science?
  - How do we make program decisions in a business strategy that sustains and grows monitoring programs to meet ongoing and growing CBP information needs under recognized economic constraints?
  - How do we best consider the combined impacts of land change and climate variability (storm events and long-term change) on nutrient and sediment loading and implications for the Bay TMDL?
  - What partnership actions can be taken to refine and simplify BMP verification protocols, and what support can the partnership provide to jurisdictions in addressing BMP verification and reporting needs?
  - How do we make the best implementation decisions under economic constraints at the state and local level?
  - How do we best target nutrient and sediment reduction practices to achieve the best outcomes?
  - How do we better leverage resources?

# X. Biennial Workplan

Separate biennial work plans are being prepared for the 2025 WIP outcome and the Water Quality

Standards Attainment and Monitoring Outcome. Each will include the following information:

- Updated logic section which includes factors, current efforts, and gaps.
- Updated management approaches which contains key actions, including products and the partners responsible for each action.

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