# VIII. Climate Change

## Background: PSC Three-Part Strategy

The Chesapeake Bay region is projected to experience changes in temperature, sea level, and precipitation as a result of climate change (Najjar, et al. 2010; Johnson et al., 2016). These changes are expected to affect nutrient and sediment loads to the Chesapeake Bay, and in turn, affect the Bay's health (Sinha et al., 2017, Wang et al., 2017; Irby, et al. 2018; Herman, et al. 2018; Linker, et al., 2018). Preliminary estimates show that Bay watershed jurisdictions need to reduce an additional 9 million pounds of nitrogen and 0.5 million pounds of phosphorus to respond to both current reduction goals and climate change. Models attribute an estimated 2.2 million pounds of the watershed-wide nitrogen load to Maryland. The CBP Partnership is still refining these preliminary estimates.

Members of the Principals Staff Committee (PSC), who represent the Bay-state governors, agreed to a three-part adaptive management process in March, 2018. This process recognizes that information is needed to refine estimates of future changes in nutrient and sediment loads and their impact on Bay water quality. Similarly, more information is needed to quantify changes in the effectiveness of pollution control BMPs resulting from climate change.

**The PSC's three-part strategy going forward includes:**

1. **Incorporate Climate Change into Phase III WIPs:** Include a narrative strategy in the Phase III WIPs that describes Bay watershed and local jurisdictions' current action plans and strategies to address climate change.
2. **Understand Climate Change Science:** The CBP Partnership will sharpen the understanding of the impacts of climate change on the Bay and identify research needs, improve the understanding of BMPs, and refine nutrient and sediment load estimates for each jurisdiction in March 2021.
3. **Incorporate Climate Change into Milestones:** Bay jurisdictions will account for additional nutrient and sediment loads, as well as improved understanding of BMPs, beginning in September 2021. A Phase III WIP addendum, 2022-2023 two-year milestones, or both will reflect these changes.

Although climate adaptation is the primary climate-change-related directive for the Phase III WIP, mitigation of greenhouse gases is also of pressing importance. Consequently, in developing Maryland's Phase III WIP, MDE sought to identify nutrient and sediment control strategies that can both help mitigate the increase in greenhouse gases and help adapt to anticipated climate impacts where possible.

# Trends

## Climate Science: Historic Trends & Projections

Greenhouse gasses, including carbon dioxide (CO2) and methane (CH4), trap the sun's heat in Earth's atmosphere (Wogan, 2013). This natural process, by which gasses trap heat in the Earth's atmosphere, is called the greenhouse effect and is necessary to sustain most life on the planet. However, since the industrial revolution, humans have radically increased the amount of these gasses in the atmosphere and are causing the greenhouse effect to trap more heat. This increased thermal energy is leading to gradual, long term changes to regional climates, such as increased air temperatures and changes in precipitation.

Of particular concern, the greenhouse effect is expected to cause more variable and extreme day-to-day weather, including more intense storms. In 2016 and 2018, two such storms hit old town Ellicott City, Maryland. These storms produced an extraordinary one in one thousand years rainfall, a 0.1% per year probability, twice in the same city in only two years. Maryland can also expect to experience periodic, intense dry spells and heat waves.

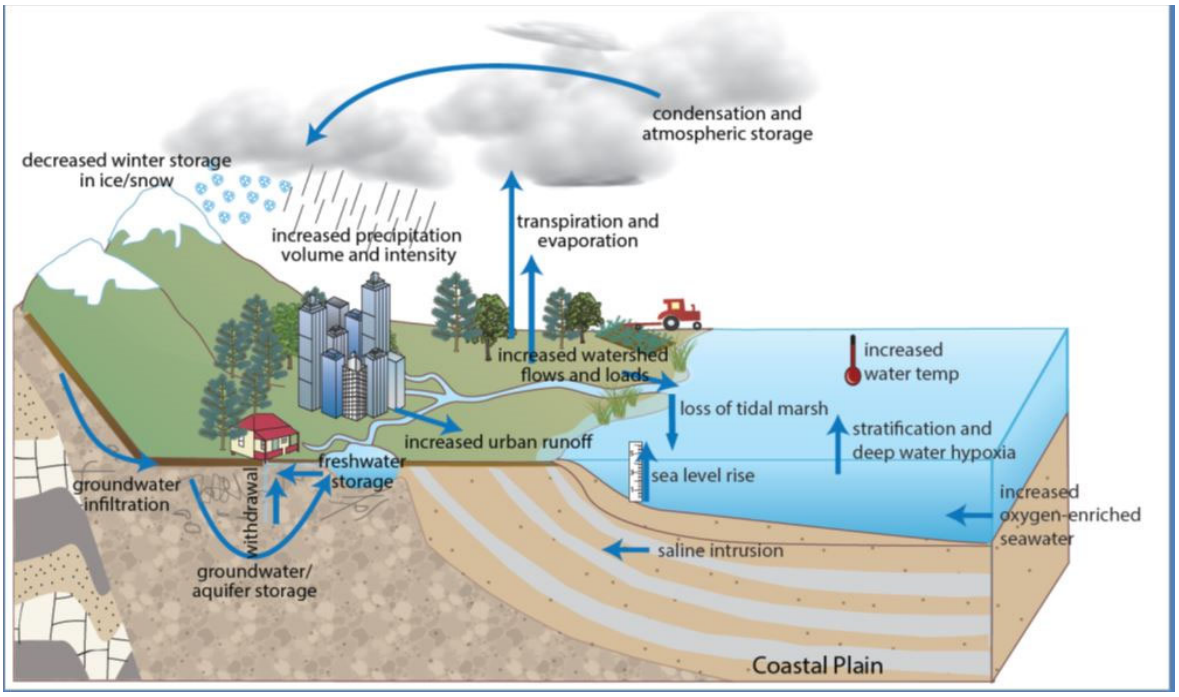


***Figure 10:*** *Key changes on the land and in the water that are expected to impact the Chesapeake Bay. (Source: CBP modified, Univ. MD IAN 2011).*

On the land, increased precipitation volume and intensity are expected to cause more nutrient and sediment runoff into the Bay. As of 2017, the average annual precipitation in parts of Maryland has already increased as much as 10 percent compared to the first half of the 1900s (Easterling et al.). Maryland's average annual precipitation is projected to increase an additional 10 percent from current

amounts by 2100 (Easterling et al.). Additionally, more intense storms are expected to change the effectiveness of BMPs to control pollution runoff. Watershed computer models are used by the CBP partnership to estimate future changes like these on the landscape.

In the Chesapeake Bay, more pollution runoff from the land, increased water temperatures, changes in salinity, sea level rise,[16] and changes in pH, among other things, interact in complex ways to impact water quality (Figure 10). These changes impact algal growth, water clarity, and dissolved oxygen levels, all of which affect fish, crabs, oysters, and other living resources. Hydrodynamic and water quality modeling tools are used to estimate some of these changes in the Bay.

The costs to human life, livelihoods, and the economy from climate-induced extreme weather are severe and increasing. Figure 11, sometimes called a Haywood Plot, depicts by month and year the accumulated number of weather-related disaster events costing more than $1 billion. Six of the last ten years exceeded the average number of storms costing more than $1 billion. Years 2011 and 2017 tied for the national record of 16 $1 billion storms, with 2017 setting record overall storm costs of $306.2 billion. This record year shattered the previous record of $214.8 billion (CPI-adjusted) in 2005 from the impacts of Hurricanes Dennis, Katrina, Rita, and Wilma[17].

These enormous costs are raising questions, nationally and in Maryland, whether building and rebuilding should continue in areas with repeat catastrophic weather events. As the State continues to invest in BMPs to restore the Bay, it must carefully consider their placement to avoid areas that are at risk from the most severe climate impacts

[16] For planning purposes, the likely range (66% probability) of the relative rise of mean sea level expected in Maryland between 2000 and 2050 is 0.8 to 1.6 feet, with about a one-in-twenty chance it could exceed 2 feet and about a one-in one hundred chance it could exceed 2.3 feet. Later this century, rates of sea level rise increasingly depend on the future pathway of global emissions of greenhouse gases during the next sixty years: mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/sea levelRiseProjectionsMaryland2018.pdf

[17] **Smith, A B, NOAA Climate.gov**

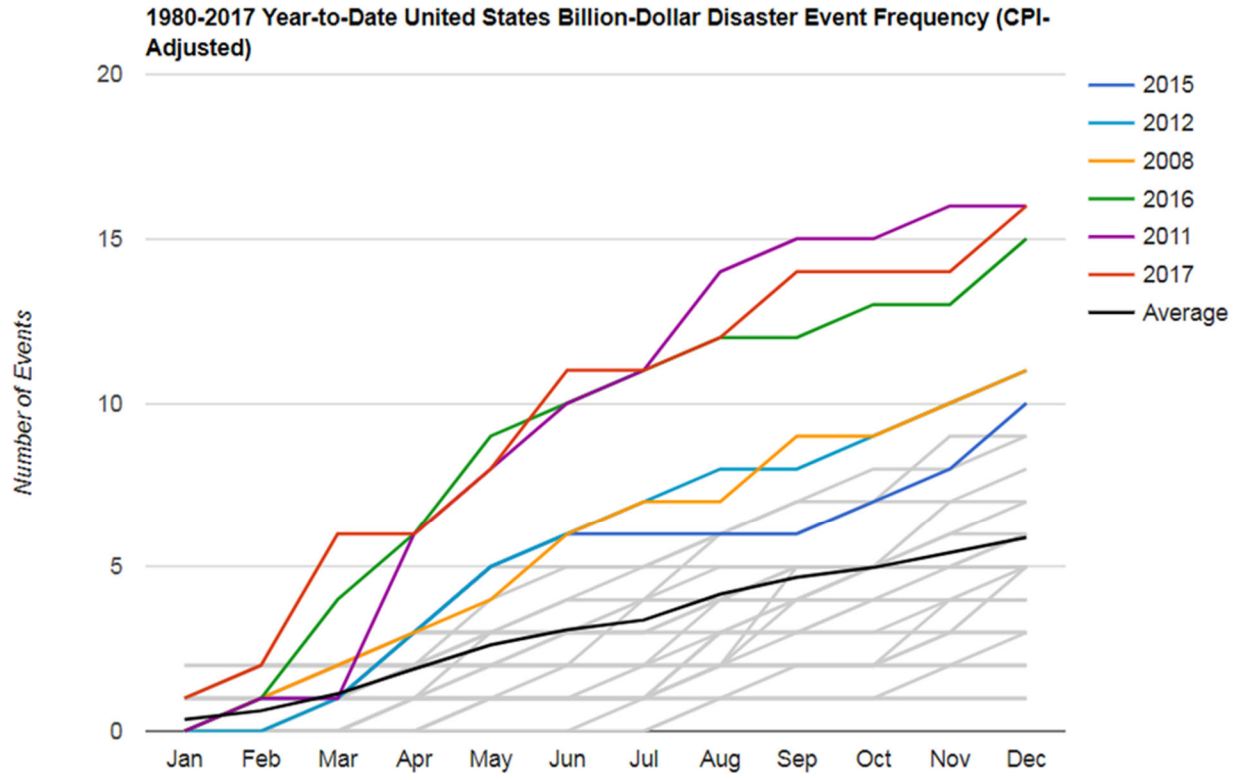


***Figure 11:*** *Cumulative number of disaster events, in a given year, that exceed one billion dollars in damage. Source: Smith, A B, NOAA Climate.gov.*

The United Nations' International Panel on Climate Change (IPCC) issued a special report in October 2018 on a 1.5 degree centigrade (1.5°C) temperature increase from pre-industrial levels. It highlighted the devastating climate impacts that could be avoided by limiting the temperature rise to 1.5°C. Limiting the rise to 1.5°C requires a 45 percent reduction of anthropogenic greenhouse gas (GHG) emissions from the 2010 baseline by 2030 and achievement of zero net emissions[18] by 2050 (UN IPCC 2018).

The urgency of this scientific finding has driven Maryland to elevate the importance of GHG mitigation in the Bay restoration strategy. Fortunately, broadening the lens to consider the intersection of climate mitigation, climate adaptation, and nutrient reduction offers new management efficiencies and financing opportunities.

# Strategies

The State identified strategies that address both climate change management and Bay restoration including the existing foundation of climate change plans, action strategies, legal authorities, and governance structures. This comprehensive foundation will help assure integration of climate change management with Chesapeake Bay WIP implementation.

[18] According to the IPCC definition, net zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period.

# 1. WIP Strategies that Address Climate Change

Maryland's Phase III WIP includes actions that primarily reduce nutrients and sediments while also mitigating or adapting to a changing climate. These State actions also provide information to develop BMP implementation scenarios that better address nutrient and sediment loads resulting from climate change.

## General Climate Strategies

Several strategies apply broadly, including developing new science and several aspects of funding the Phase III WIP. These general strategies are:

### Strategy 1: Climate Science & Research

Maryland is committed to adopting improved climate science by including refined nutrient reduction goals in 2021, BMP efficiencies into a future WIP addendum, two-year milestone commitments in 2022, or both. Research may be needed to meet future load requirements and understand how future conditions affect the State's ability to meet its water quality targets. The State will pursue:

- **BMP Site Selection and Design:** Design and site BMPs that are expected to persist and perform in a changing climate. The State's early efforts reflect this commitment, including 2013 guidance, *Best Management Practices: Preserving Clean Water in a Changing Climate*. Part of Maryland's strategy is to engage with the CBP partnership in ongoing BMP design and siting research[19].

- **Trends Analyses:** Review current climate data and trends that may affect load targets, including sea level, precipitation patterns, temperature, and ecosystem response.

- **Saltwater Intrusion:** Investigate the impact of saltwater intrusion on soil composition and the potential for nutrient leaching from soils. Maryland will also investigate adaptation options, like salt-tolerant plants that soak or take up nutrients.

- **Beyond 2025:** Acknowledge that climate conditions will continue to change after 2025. The State anticipates that 2050 climate projections will inform future Bay restoration strategies.

### Strategy 2: Local Engagement and Education

Maryland is committed to advancing the capacity of State and local government agencies, infrastructure organizations, and businesses to develop and implement sound climate change initiatives. These climate initiatives will ensure current and future public health, security, and economic prosperity. To achieve this vision, the State, in partnership with the Association of Climate Change Officers, has established the Maryland Climate Leadership Academy.

[19] In 2017 the Chesapeake Bay Program Science and Technology Advisory Committee (STAC) Workshop released a Report, *Monitoring and Assessing Impacts of Changes in Weather Patterns and Extreme Events on BMP Siting and Design*. Although it was inconclusive about the quantitative impacts of climate change on BMPs, it laid the foundation for continued evaluation of this subject.

The Maryland Commission on Climate Change (MCCC) workgroup on Education, Communication, and Outreach (ECO) is another institutionalized avenue for local engagement. The MCCC Adaptation and Response Working Group (ARWG) coordinates closely with Maryland's Bay restoration process and includes local engagement in its annual work plan.

### Strategy 3: Incentives and Funding

Maryland anticipates Bay restoration costs to rise for at least four reasons. First, increasingly frequent and severe extreme weather events will damage BMPs and necessitate more inspections, maintenance, or replacement. Second, more BMPs need to be installed to compensate for an anticipated loss of BMP pollution reduction efficiency. Third, additional BMPs are likely needed to address increased future pollution loads. Fourth, restoration actions will entail more complex multidisciplinary considerations, as exemplified in the *Climate Smart Framework and Decision Support Tool*, developed by the Chesapeake Bay Program (Johnson, Z. 2018).

**The following are strategies that Maryland is committed to implementing:**

- **Existing Restoration Funding Sources:** Refine restoration and resource conservation criteria for grant prioritization to favor projects that include climate co-benefits. This prioritization includes review criteria for State land conservation and preservation purchases.

- **Volkswagen Settlement Funding:** Maryland received $75.7 million in settlement funds from Volkswagen's illegal pollution emissions. Much of this money will be used to electrify transportation in Maryland, which will reduce $CO_2$ emissions and decrease nitrogen deposition to the Chesapeake Bay.

- **Coast Smart Construction Criteria:** The State developed the Coast Smart Construction Infrastructure and Design Guidelines in 2014 to increase the resilience of State capital investments to sea level rise and coastal flooding. In 2018, legislation expanded the application of criteria to other projects which may create additional opportunity to implement resilient designs. Coast Smart practices include identifying, protecting, and maintaining ecological features that buffer a project from the impacts of future sea level rise, coastal flooding, or storm surge. Protecting and maintaining these ecological features is a co-benefit to Bay restoration.

- **Managing Forests:** The State plants and manages forests to capture carbon on both public and private lands. Enrolling unmanaged forests into management regimes enhances forest productivity which increases rates of carbon sequestration in forest biomass and the amount of carbon stored in harvested durable wood products. Trees in urban areas directly impact Maryland's carbon budget by helping to offset some of the greenhouse gas emissions from power production and vehicles, reducing heating and cooling costs and energy demand by moderating temperatures around buildings and slowing the formation of ground level ozone as well as the evaporation of fuel from motor vehicles. Implementation is supported by several other Maryland laws and programs that include outreach and technical assistance for municipalities to assess and

evaluate their urban tree canopy goals and plant trees to meet those goals.

- **Resiliency through Restoration Initiative:** Recognizing that coastal habitats help buffer communities from climate-related impacts, the state launched a new Resiliency through Restoration Initiative. The department state provides technical and financial assistance to restore, enhance and create coastal habitat with the goal of protecting Maryland communities and public resources from extreme weather and climate-related events.

- **Department of Natural Resources/Department of Transportation Memorandum of Understanding:** The Maryland Department of Natural Resources has partnered with the State Highway Administration (SHA) in an effort to lead by example in restoring the Chesapeake Bay and local waters. State parks will provide opportunities for the State Highway Administration to implement restoration projects required by their Federal Stormwater Permit (MS4) and their nutrient and sediment reduction goals required under the Bay Total Maximum Daily Load (TMDL). A Memorandum of Understanding was signed in 2013 to initiate this program and is currently being updated to provide additional guidance. This MOU will increase the rate of restoration projects on state and public lands and will provide opportunities to focus on projects that offer cumulative benefits for climate, water quality and habitat.

- **Innovative Technology Fund:** Expand the scope of eligible techniques and technologies to include consideration of climate aspects of Innovative Technology Fund project proposals. The State will invest in the research, development, and commercialization of solutions addressing climate mitigation to help accelerate the adoption of climate resiliency and GHG mitigation.

- **Climate Mitigation and Adaptation Synergies:** Many Bay restoration actions sequester large amounts of GHGs. These include protecting and restoring tidal wetlands and seagrass ecosystems (coastal blue carbon), forest conservation, forest management, conversion of non-forest to forest, riparian forest buffers, and healthy soils practices (collectively called terrestrial carbon removal). Maryland commits to aligning its GHG reduction strategy (i.e., the Greenhouse Gas Reduction Act (GGRA) plan) with its Bay restoration strategy to generate mutually beneficial results that are greater than the sum of their parts:

    - Better alignment of management resources used to implement and track mutually beneficial practices can result in cost efficiencies and better outcomes;
    - Recognizing that actions that generate monetary value associated with both nutrient and carbon reductions should translate to greater public and private financing opportunities and incentive frameworks.

**The following are preliminary ideas that Maryland will consider:**

- **Water Quality and Climate Change Resiliency Portfolio:** Maryland works to restore the Chesapeake Bay and improve its environmental and economic resilience to a changing climate. Many of the actions needed to achieve these objectives are similar. Yet, many practitioners do not coordinate these actions as much as they could, or should, to maximize benefits to both. This effort identifies a long term portfolio of natural infrastructure projects that optimize water quality,

living resources, GHG reduction, and other environmental benefits. Moreover, this effort reduces the risks posed by a changing climate to the commercial economies and recreational opportunities essential to Maryland's working coast. Having a pipeline of identified projects better prepares Maryland and its communities to build climate resilience by taking advantage of existing and emerging funding opportunities that promote the use of natural infrastructure. The State has identified potential funding opportunities:

- **Climate Funding Sources:** There are climate and hazard mitigation oriented grants that the State has not traditionally targeted for Bay restoration outcomes or complementary water quality and climate benefits. Maryland could explore these funds for their potential to achieve restoration co-benefits. This strategy is similar to the Community Resilience Grant Program that funds climate resiliency projects with water quality benefits, as well as the new Federal Emergency Management Administration job aid that allows the use of hazard mitigation grant funding for restoration projects that build resilience.

- **Expansion of Maryland's Building Resiliency through Restoration Initiative:** Maryland could explore opportunities that expand incentives for projects that build resilience and reduce the vulnerability of communities and infrastructure from the impacts of extreme weather events, climate hazards, and flooding.

- **Strategic Energy Investment Fund (SEIF)**: Sales of CO2 credits generate funds for investments in energy efficiency, clean energy, and renewable energy. These investments reduce air emissions and associated land deposition, thus contributing to the State's climate and water quality goals. Administered by the Maryland Energy Administration, the potential exists for SEIF energy investments to provide further co-benefits by leveraging energy efficiency grants with water quality financing (e.g., funding energy efficiency grants for wastewater treatment plants to increase their financial capacity to afford pollution controls).

- **Climate Cost Estimate and Funding Options:** Maryland could investigate options for achieving additional load reductions and identifying associated costs due to climate change. As needed, the State could explore options for generating further revenue to cover any additional public sector costs. The State would outline funding options for any identified additional public sector costs when it submits its implementation strategy to reduce climate change loads in the Phase III WIP addendum, the 2022-2023 two-year milestones, or both.

- **Carbon Markets for Nutrient Reduction Practices:** Maryland's GGRA plan is accomplishing the reduction of GHG emissions. This plan includes participation in the RGGI, a cap-and-invest framework for large, fossil fuel-fired electric power generators. Furthermore, Maryland could explore the development of a carbon market that credits nutrient reduction practices with GHG co-benefits. This carbon market would augment programs that incentivize the implementation of BMPs associated with Bay restoration. Practices, such as cover crops, riparian buffers, and conservation provide water quality benefits while also improving soil health and sequestering carbon.

### Strategy 4: Accountability

Maryland includes accountability strategy elements to ensure that Bay restoration planning and implementation have climate resilience co-benefits:

- **Two-Year Milestones:** Maryland documents the adaptation of its Chesapeake Bay nutrient reduction strategies to climate change through specific actions in its two-year milestone framework.

- **Emerging (Long-Term) Strategies:** Maryland will identify incremental research and development steps in future two-year milestone commitments to ensure that emerging reduction strategy options remain on track.

- **Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change (Phase I & II):** This comprehensive strategy sets implementation targets for each adaptation action. The Adaptation and Response Workgroup of the MCCC oversees a review of progress on these implementation targets. The State will align WIP commitments with this comprehensive strategy and its accountability tracking framework.

- **BMP Verification:** Maryland's BMP verification protocols provide the foundation for the likely increased frequency of inspection and maintenance that will be necessitated by the stresses of climate change-induced extreme weather (MDE 2016).

## Climate Change Strategy Highlights by Source Sector

### Agriculture

- **Current WIP Strategies:**

    - Many traditional agricultural BMPs provide environmental benefits beyond water quality. Practices such as residue and tillage management, cover crops, crop rotations, composting, riparian buffers, biomass plantings, and rotational grazing, among others, support and enhance soil health. These practices increase organic matter, sequester carbon in the soil, reduce soil erosion, promote nutrient cycling, improve water retention, and reduce competition from weeds and pests.

- **Contingency and Long-Term Strategies:**

    - Innovative animal waste management technologies offer energy savings and GHG emissions reductions that are climate co-benefits.
    - Agricultural Wetland Incentives: Maryland could explore revising State investment prioritization criteria and policies to incentivize land conservation easements that promote the conversion of flooded or salt-impacted agricultural lands to wetlands. The process could explore the use of wetlands mitigation funds and public-private partnership opportunities with stakeholders who value diverse habitat for birds and other wildlife. Where appropriate,

Maryland could explore the introduction of salt-tolerant crops. Similar partnerships have helped accelerate trout habitat restoration and conservation in the State.

- Cropland irrigation with wastewater effluent has the potential to reduce nutrients to the Bay while creating climate resiliency by assuring a reliable supply of water for crops. Although some degree of crop irrigation with wastewater effluent is currently occurring in Maryland, it is currently not used as an explicit agricultural nutrient management practice.

- **Programmatic and Educational Outreach Strategies:**

  - In collaboration with conservation partners, MDA is developing a Healthy Soils Program focused on accelerating educational outreach and promotion of a wide variety of agricultural and climate management co-benefits.

**Wastewater Treatment Plants**

- **Current WIP Strategies:**

  - Land application of wastewater treatment plant biosolids increases the organic content of sandy soils, thereby increasing carbon and water retention.
  - Energy-saving pumps lower long-term wastewater treatment implementation costs and reduce GHG emissions.

- **Contingency and Long-Term Strategies:**

  - Anaerobic digestion of food waste at WWTPs utilizes existing centralized facilities, provides an energy source, reduces a large waste stream to landfills, reduces GHG emissions, and offers cost savings[20].

**Septic Systems**

- **Current WIP Strategies:**

  - Mounting solar panels on OSDS.
  - Setback OSDS from waterbodies to prevent flooding.
  - Bermed infiltration pond removal in response to sea level rise.

**Urban and Suburban Stormwater, Including Erosion and Sediment Control**

- **Current WIP Strategies:** In addition to reducing nutrient and sediment pollution, the base mission of stormwater management provides climate resilience from erosion control, groundwater recharge, flood control, and stream channel protection. Maryland adapts its stormwater programs to climate change by maintaining and repairing critical stormwater management infrastructure, including dams.

[20] https://archive.epa.gov/region9/waterinfrastructure/web/pdf/why-anaerobic-digestion.pdf

- **Contingency and Long-Term Strategies:**

    - The State could explore establishing an emergency dam repair fund and revolving loan fund for fortifying Maryland's stormwater management infrastructure for increased precipitation events. Fortifying these structures would also ensure continued nutrient processing and uptake that occurs in impoundments.
    - Stormwater BMP Siting and Design: Based on the outcome of research into how precipitation changes will affect stormwater design storms, Maryland is considering changes to its erosion and sediment control and stormwater programs.

- **Programmatic and Educational Outreach Strategies:**

    - Maryland continues to leverage its funding to support projects that inform how climate impacts interact with stormwater management practices. The State could consider additional funding or other strategies that facilitate ongoing academic research into stormwater design guidelines for increased precipitation events.

**Conservation and Natural and Working Lands**

- **Current WIP Strategies:** Conservation and management of natural and working lands reduce nutrient loading to the Bay and promotes climate resilience. Several intentional strategies include:

    - Forest harvesting on State lands employs practices that sequester carbon. These practices include utilizing broader buffers, where half the buffer is out of an active management zone, and variable-density harvesting. Variable-density harvesting leaves different types of trees to provide habitat and seed sources. The trees left unharvested may be a combination of single trees, providing desired seed sources or serve as a future snag, or clumps of trees selected because they are in a wetter area or contain mast-bearing species (such as hickory or beech). Adaptive Silviculture for Climate Change collaborates with partners, including Baltimore City, to work on a regional effort to develop locally appropriate techniques. These efforts create more diversity in the landscape providing enhanced resiliency.
    - The Sustainable Forestry Initiative, forestry boards, and Forestry Stewardship Council are evaluating sustainable forestry certification programs for opportunities to enhance climate resiliency. MDA, U.S. Forest Service, forestry stewardship councils and University of Maryland-Cooperative Extension are developing new conservation easement mechanisms to promote adaptation stewardship activities on private lands.
    - Maryland is working to promote the use of locally produced woody biomass for generation of thermal energy and electricity. Energy from forest by-products can be used to offset fossil fuel-based energy production and associated greenhouse gas emissions. There are many end users that could potentially benefit from such a program, including Maryland's public schools which could employ wood heating and cooling; hospitals which could utilize wood as a primary heating/cooling source; municipalities which could utilize local fuel markets as a key component of their urban tree management programs; and all rural landowners who would have access to a wood fuel market.

- The "Marylanders Plant Trees" program, is a $25 coupon reimbursement program targeting individuals wishing to plant a tree. It enables very small lot owners to purchase a tree valued at $50 or more and reduce the cost by the use of the $25 coupon.
- Program Open Space (POS) directs its funding towards GreenPrint Targeted Ecological Areas. Wetlands that support coastal resilience, as well as climate change adaptation areas for future wetlands are noted as key ecological benefits. These benefits are provided by areas along the shoreline where natural habitats, such as marshes and coastal forests, have the potential to reduce the impact of coastal hazards to the adjacent coastal communities by dampening waves, stabilizing sediment and absorbing water. This recent enhancement complements existing land conservation criteria that avoids conserving lands that will be inundated by sea-level rise and targets adaptation areas important for wetland migration. The Stateside Program Open Space scorecard provides the ecological, resiliency and management justification that Maryland's Board of Public Works relies upon to approve funding for land conservation.
- The Accounting for Maryland's Ecosystem Services framework provides economic values for seven non-market ecosystem services, including carbon sequestration, nitrogen removal, groundwater recharge, and stormwater mitigation that have climate resilience value. Among the Ecological Benefits assessed are the Coastal Community Resiliency and Future Wetland Habitat scores. The Coast Community Resiliency score describes the potential of a parcel's existing natural habitats, such as marshes and coastal forests, to reduce the impact of coastal hazards to adjacent coastal communities. The Future Wetland Habitat score identifies areas important for inland wetland migration resulting from sea level rise that will support high value coastal habitats of the future. Among the Ecosystem Services assessed are the parcel-level biophysical and economic values of annual Net Carbon Sequestration in forests and wetlands. Carbon sequestration directly offsets carbon emission within the state of Maryland and represents a critical component to the GGRA workplan. This component of the tool allows for identification and conservation of natural habitats providing high carbon sequestration benefits.
- Encouraging broader riparian buffers along stream corridors to allow for channel migration resulting from increased precipitation.
- In addition to forests, wetlands are known to be very efficient at sequestering carbon. The state is planting forested stream buffers and pursuing the creation, protection and restoration of wetlands to promote carbon sequestration through several means including the Natural Filters Program, which restores wetlands and buffers on state and public lands to meet water quality goals and is provided through the Chesapeake and Atlantic Coastal Bays Trust Fund. Projects such as the Pocomoke River restoration encourages broader riparian buffers along stream corridors to allow for channel migration resulting from increased precipitation.

- **Contingency and Long-Term Strategies:**

  - Maryland could enhance shoreline suitability analyses and conduct property owner and marine contractor social marketing research to increase the adoption of living shoreline erosion techniques. Landowners simply do not recognize the value of living shorelines when compared to traditional structures like bulkheads and revetments. Likewise,

contractors play an important role in recommending the best practices to landowners, so they need to have the knowledge to confidently build and maintain living shorelines as well as to provide accurate cost estimates for installation to the public. Living shorelines provide coastal communities resilience to sea level rise while reducing erosion and ecosystem benefits.

- Maryland could evaluate the reuse of dredged material for living shorelines and other beneficial uses, including marsh elevation enhancement (i.e., thin layer placement), that help communities respond to rising sea levels, sequester carbon and provide for potential commercial or recreational uses.

## 2. Supporting State and Local Legislative, Governance and Strategic Climate Frameworks

For over a decade, Maryland has developed an extensive set of plans, action strategies, legal authorities, and governance frameworks to mitigate and adapt to climate change. This foundational framework enables more rapid progress on WIP implementation than would otherwise be possible. Elements of this framework include:

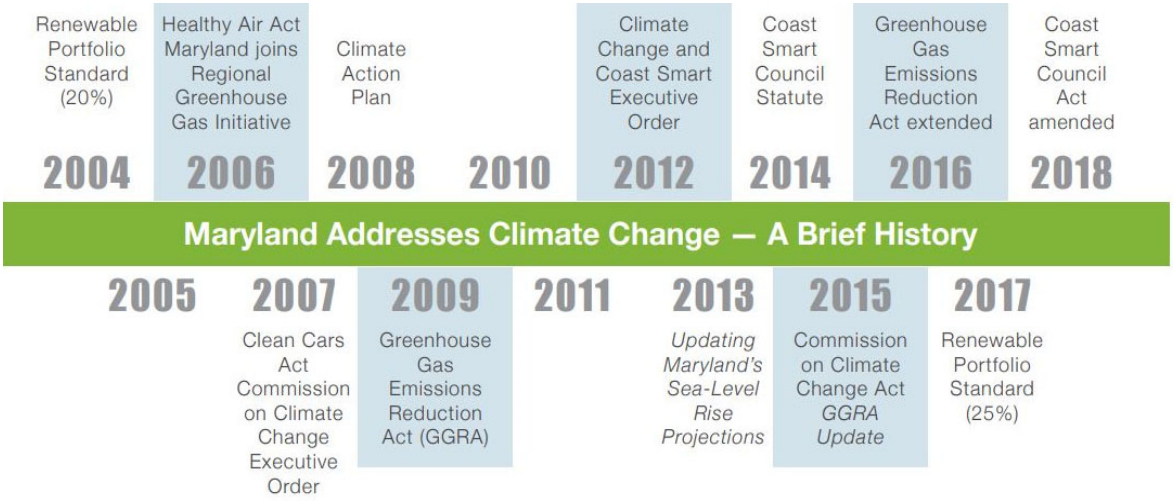


***Figure 12:*** *Brief History of Maryland's Climate Actions. Source: University of Maryland Center for Environmental Science (UMCES) Sea Level Rise Projections for Maryland 2018.*

### A. Legislative and Executive Actions

Maryland has historically been at the forefront of states taking action to address both the drivers and consequences of climate change. Over the past decades, the State has consistently advanced efforts to combat climate change with legislation and policy initiatives (Figure 12).

### B. Governance Structures for Managing Climate Change

Maryland institutionalizes its commitment to addressing climate change in governance structures that span state, regional, national, and international levels:

**State Level**

At the state level, the State charges the MCCC with advising the governor and General Assembly "on ways to mitigate the causes of, prepare for, and adapt to the consequences of climate change." An executive order established the MCCC in 2007 and the State codified it into law in 2015.

A 26 member steering committee leads the MCCC with broad representation, including State agency cabinet members. Maryland aligns the climate aspects of it Bay restoration strategy with the four workgroups of the MCCC: the Adaptation and Response Working Group; the Education, Communication, Outreach Working Group; the Mitigation Working Group; and the Scientific and Technical Working Group. The State expects the MCCC, in concert with the governor's Chesapeake Bay Cabinet, to play a central role in advancing Maryland's Chesapeake Bay climate adaptation actions.

The MCCC and its workgroups annually provide recommendations and strategies that align with the two-year Bay restoration milestones addressing climate change. The following link details the activities of the MCCC and its workgroups: mde.maryland.gov/programs/Marylander/Pages/mccc.aspx.

**Regional Level**

Regionally, Maryland is a signatory to the 2014 Chesapeake Bay Watershed Agreement, which includes a Climate Resiliency Goal. Maryland is committed to this goal, the monitoring and assessment outcome, and the adaptation outcome.

Maryland is also a member of the RGGI. The RGGI is a cooperative effort to cap and reduce power-sector CO2 emissions among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.

**National & International Levels**

Nationally, and internationally, Maryland is a member of the U.S. Climate Alliance of 17 states and the territory of Puerto Rico. Members of the Climate Alliance are committed to doing their share towards meeting international climate agreements. These governance structures institutionalize leadership processes and coordination that help provide avenues for accelerated learning, technology transfer, and adoption of best practices. Moreover, these structures and leadership processes support a framework of accountability.

## C. State and Local Climate Change Plans and Strategies

Maryland's commitment to addressing climate change is reflected, in part, by a variety of plans and strategies. The State's foundational adaptation strategies, which were developed by the Adaptation and Response Workgroup of the MCCC, are found within the *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change*:

- *Phase I: Sea Level Rise and Coastal Storms* (Johnson, 2008).
- *Phase II: Building Societal, Economic and Ecological Resilience* (Boicourt, 2010).

The Adaptation and Response Working Group tracks progress on the actions outlined in the comprehensive strategy. Many of the strategies recommended by the working group and implemented by the state relate to BMP implementation that reduce nutrient and sediment loads or slows the growth in loads by preserving natural lands.

The State also incorporates local plans in addressing climate change. Six local governments developed plans between 2008 and 2018 that either directly or indirectly address climate change impacts. Furthermore, 15 of Maryland's counties and Baltimore City have specifically mentioned climate change and the effects of climate change in their comprehensive plans (Maryland Department of Planning, 2018).

### 3. Implementation Guidance

Providing implementation guidance is part of Maryland's strategy for aligning Bay restoration and climate change management. Although technical materials and tools have been developed to guide restoration in the context of climate change, the field is new and rapidly evolving. The following websites provide some of the latest information:

Maryland Commission on Climate Change: The commission coordinates climate change activities for the State, including mitigation, adaptation, science and education, communication, and public outreach.

Maryland Department of Environment: The Air and Radiation Administration leads the State's efforts on greenhouse gas mitigation.

Maryland Department of Natural Resources: DNR plays a significant role in climate adaptation, with an emphasis on mitigating coastal hazards and protecting and restoring the resilience of natural resources.

Chesapeake Bay Program Climate Resiliency Workgroup: The workgroup coordinates climate-related efforts to address climate resilience for the CBP Partnership as deemed a priority of the Chesapeake Bay watershed.

## Challenges and Opportunities

Climate change presents significant challenges for achieving Bay restoration goals. However, many opportunities exist to leverage commonalities between managing climate change and Bay restoration:

- **Chesapeake Bay Water Quality will be Affected by Climate Change:** Climate change is predicted to increase nutrient and sediment loads to the Chesapeake Bay and will change water quality characteristics including water temperature, dissolved oxygen, and clarity. The CBP partnership is committed to developing refined quantified estimates of these pollution loads and water quality impacts in 2021.

- **Pollution Control Practices will be Affected by Climate Change:** BMPs used to control water pollution will likely become less effective at controlling extreme storm events and damaged from the stresses of climate change. The CBP partnership is committed to better understanding these impacts and making adjustments to management practices in 2022 via two-year milestone commitments.

- **The Cost of Achieving and Maintaining Chesapeake Bay Water Quality Goals will be Affected by Climate Change:** More restoration practices will be necessary if the water quality impacts of increased nutrient and sediment loads are not offset by climate change altering the flow and circulation of the Bay. This impact from climate change, in addition to BMPs becoming less effective and requiring more maintenance, could cause an increase in the cost of restoring the Bay. In anticipation of this, Maryland is committed to investigating ways of funding the incremental increase in cost.

- **Bay Restoration Mitigates Greenhouse Gases in Addition to Adapting to Climate Change:** The main interest in accounting for climate change in the Phase III WIP is to adapt to impending shocks from the changing conditions. However, many restoration practices that sequester carbon in soil and plant matter also have significant nutrient reduction benefits. Aligning Maryland's GHG reduction actions with Bay restoration actions offers the prospect of powerful financing synergies borne out the recognition of increased value for the same action.

- **Quantifying Maryland Specific Air Reductions:** Maryland is evaluating reductions in nutrient deposition from State-specific regulations and facilities, beyond federally mandated requirements. This line of inquiry can potentially benefit climate change and Bay restoration management goals mutually. Please see Appendix G for detailed information on Maryland's Phase III WIP air deposition strategy.

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