ENVIRONMENTAL MONITORING PLAN

FOR

DELAWARE'S INLAND BAYS

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The Delaware Center for the Inland Bays is a nonprofit organization and a National Estuary Program. It was created to promote the wise use and enhancement of the Inland Bays watershed by conducting public outreach and education, developing and implementing restoration projects, encouraging scientific inquiry and sponsoring needed research, and establishing a long-term process for the protection and preservation of the Inland Bays watershed.

EXECUTIVE SUMMARY

The purpose of the Inland Bays Environmental Monitoring Plan (IBEMP) is to track the status and trends of key environmental indicators used to assess the chemical, physical, and biological integrity of the estuary and surrounding study area, and to evaluate whether the goals of the Inland Bays Comprehensive Conservation and Management Plan (CCMP) are being met. It is a comprehensive inventory of existing, new, and proposed monitoring activities to meet these objectives and is intended to guide future research and monitoring efforts. The plan is also intended to lead to increased integration of work and consolidation of resources.

The original Monitoring Plan for the Delaware Inland Bays was written in 1995 and last updated in 2020. Over time, the collection of relevant parameters, responsibilities for collection, and both monitoring technology and the scientific understanding of the Bays have evolved significantly, but have been guided by the presence of the IBEMP. The Center for the Inland Bays (Center) manages or supports some of these programs, but most are led and supported financially by academic, county, state, and federal partners. It is the Center's role to facilitate these partnerships and regularly synthesize, analyze, and report indicator data for the Inland Bays. Periodic review and revision of the IBEMP provides an opportunity to re-engage stakeholders around its cooperative implementation. The Center for the Inland Bays Scientific and Technical Advisory Committee (STAC) will be responsible for ensuring the implementation of this plan. This includes engagement of all partners collecting data and ensuring that data are submitted to the Center for State of the Bays reporting.

This IBEMP has two parts, first an inventory of existing projects and programs that conduct ongoing, long-term environmental monitoring in Delaware's Inland Bays. Many of these programs contribute data that are used by the Center to develop *State of the Delaware Inland Bays* reports every five years. Other entities produce data that may illuminate progress toward achieving goals of the CCMP, provide data for new environmental models, or may be useful for development of new indicators in the future. For each program we identify CCMP objectives addressed, responsible entities, data collected, data gaps, frequency of data collection and reporting, and how the data are shared, reported and used. The programs are organized into seven sections that cover monitoring of: (1) surface water; (2) groundwater; (3) wastewater; (4) atmospheric deposition; (5) wetlands; (6) living resources and habitat and (7) climate.

Secondarily, the IBEMP makes recommendations for new monitoring programs, enhancement of existing programs, or the phase out of past parameters. The recommendations reflect changing priorities, new technology or new partnerships. Many of these suggestions are still in the concept phase and will undergo a feasibility analysis, where others are "shovel-ready" modifications of work done elsewhere, or having undergone pilot testing. Previous years' recommendations are also discussed, with short updates of their current status. These recommendations are made based upon critical data gaps (including emerging issues), the availability of new methods or technologies, and/or changes needed to make programs sustainable over the long term.

Current Recommendations are across four broad categories including:

(1) Condition assessments: Seagrass beds, salt marshes, shorelines, riparian buffers and forests are critical habitats in the watershed, however, metrics that are associated with acreage alone do not capture the variation in function that results from variation in quality
(2) Economic/Recreation Tracking: Metrics of human use of watershed resources have reflected traditional economic pathways (commercial harvest). However, the watershed has experienced an increase in tourism and recreational uses of the Inland Bays.
(3) Environmental Quality: National budget cuts/shifts in priorities have removed some local monitoring resources, leaving gaps in tracking nutrient/pollutant inputs into the watershed

(4) Emerging Stressors: As the watershed becomes more developed, and climate change occurs, new stressors, or existing parameters may interact in new ways

For each recommended program, partner organizations or agencies are identified to be responsible for, or participate in, its implementation. Where possible, estimated costs and potential funding sources are provided. Coordination among organizations involved in data collection, processing and analysis, storage and provision, and presentation is key to the success of adding a parameter to the monitoring program in the Inland Bays.

The IBEMP is a living document intended to evolve to meet future needs for tracking the status and trends of conditions within the Inland Bays and the progress toward meeting the goals of each of the CCMP focus areas. As the CCMP is revised, or new monitoring opportunities or technologies appear, revisions to the plan may need to be made. In order to ensure that monitoring programs are implemented and coordinated, and that the IBEMP is kept up to date, a CCMP/Monitoring subcommittee of the STAC is responsible for assisting the Center with a biannual review/update.

This version of the document represents the second update, completed in July 2023. The reader is encouraged to review the January 2021 update to understand history and process. The inventory of existing long-term monitoring programs in the Inland Bays study area was updated to reflect current program status and recent changes. Summaries of progress to date on each of the report's recommendations for new or enhanced monitoring programs were added.

Figure 1. Map of the Delaware Inland Bays Watershed.

INTRODUCTION

THE INLAND BAYS AND THEIR WATERSHED

Delaware's Inland Bays (the Bays) refers to all tidal waters and tidal wetlands encompassing the Indian River Bay, Indian River, Rehoboth Bay, and Little Assawoman Bay (Figure 1). The 292-square mile Inland Bays watershed is located in southeastern Sussex County, and drains to 35 square miles of bays and tidal tributaries. Rehoboth Bay and Indian River Bay are tidally connected to the Atlantic Ocean by the Indian River Inlet. Little Assawoman Bay is connected by the Ocean City Inlet, 10 miles to the south in Maryland. As of 2017, agriculture represented the largest land use in the watershed (28.9%), followed by developed/developing lands (22.3%), forested lands (13.9%), wetlands (19.5%), and open water (12.3%) (Figure 2).

Historically, the Bays have been dynamic. Prior to the 1930's the Indian River system consisted entirely of freshwater with the only connection to the Atlantic occurring during storm surges when the barrier island was breached, at various locations. The Indian River Inlet, as it exists today, was stabilized in the late 1930's and has deepened over time, passing greater volumes of water and increasing the tidal range of the Bays. This has led to a long-term increase in the salinity of the Bays. The greatest impacts of the salinity shift are evident in the upper reaches of the tributaries where tidal freshwater segments have been virtually eliminated. The dynamic flux of the Inland Bays poses an exceptional challenge to those responsible for monitoring the health of the system and establishing scientifically defensible status and trends data and analyses.

The degradation of the Bays has been a gradual process occurring over many decades, and it is anticipated that the recovery process will proceed over a similar period of time. Nutrient contaminated groundwater in the Inland Bays watershed, for example, moves very slowly, and the contamination reaches depths of just over 100 feet. If all contamination of the aquifer were to stop immediately, it is predicted that it would take 75 to over 100 years for replacement water to purge the system and reach the Bays.

While there are other issues raised in the Comprehensive Conservation and Management Plan (CCMP), two areas of priority problems have been identified in the Inland Bays: eutrophication caused by excessive nutrient loading, and habitat loss and modification.

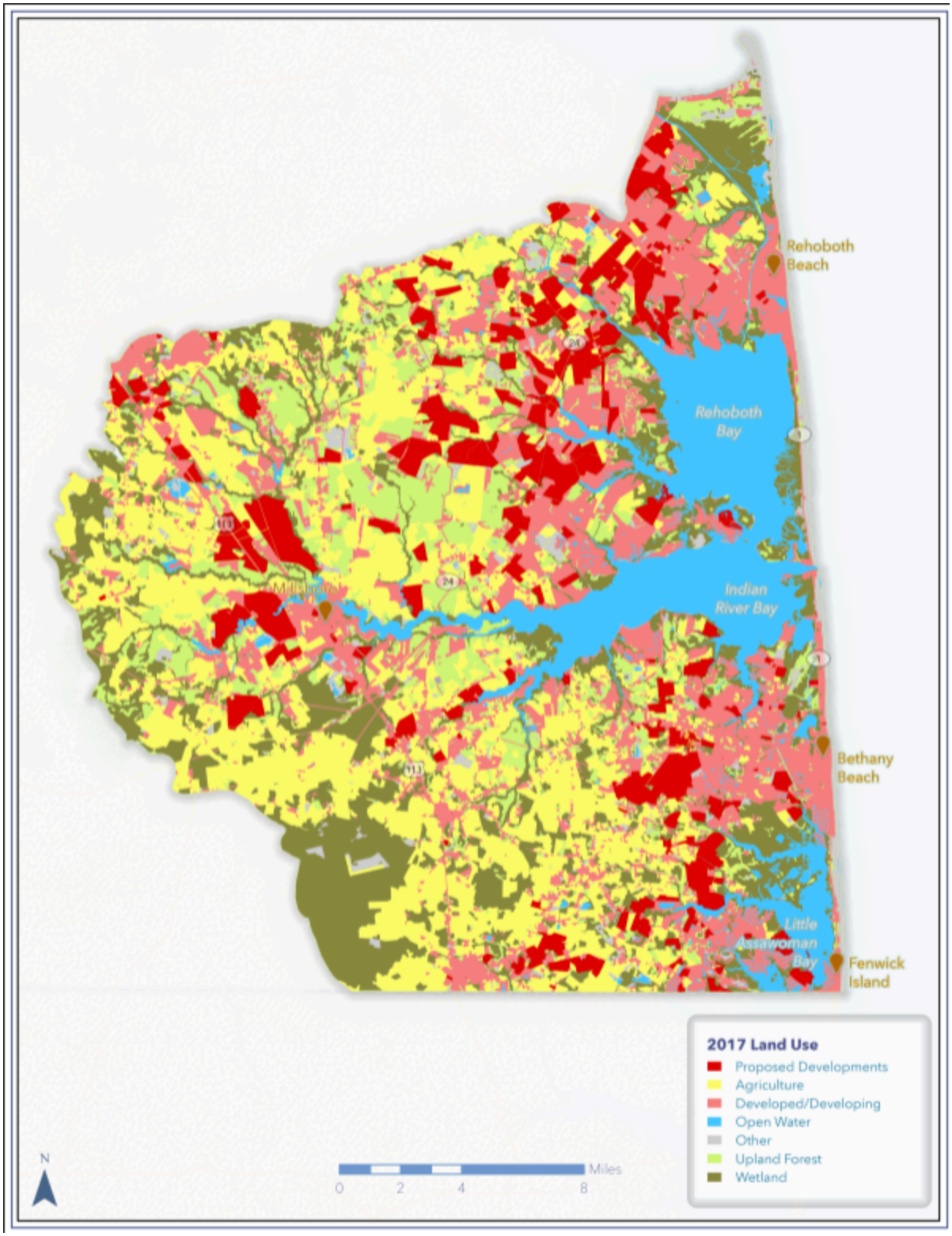

Figure 2. Watershed Land use (2017).

THE INLAND BAYS ENVIRONMENTAL MONITORING PLAN

Background

A key requirement of National Estuary Programs is to monitor the effectiveness of actions taken to implement their CCMPs. This type of research must include the understanding of the natural variability of the ecosystems and populations that make up the estuary and its watershed.

The original Inland Bays CCMP was developed in 1995 to guide the work of the partners and cooperators charged with its implementation. Subsequent to this, Total Maximum Daily Load (TMDL) regulations for nitrogen and phosphorus were established for Indian River, Indian River Bay, and Rehoboth Bay in 1998, and for Little Assawoman Bay and the major tributaries of the Inland Bays in 2005. In 2008 the Inland Bays Pollution Control Strategy (PCS) was promulgated with the intention to implement the TMDLs. Furthermore, since 1995 population growth and development have brought significant changes to the watershed.

A comprehensive update to the Inland Bays CCMP was published in 2012 as an addendum to the original plan (Delaware Center for the Inland Bays, 2012) and further updated in 2021 (Delaware Center for the Inland Bays, 2021). The 2021 update captured the shift in land development such that the impacts from the two dominant types (agriculture and developed lands) can be evaluated separately. The Update includes 20 objectives and 93 action items, organized under six core elements:

- Living with a Changing Climate
- Clean Waters: Healthy Agricultural Landscapes
- Clean Waters: Reducing Pollution from the Developed Landscape
- Healthy Bay Ecosystems: Protect and Restore thriving habitats for abundant fish and wildlife
- Coordinated Land and Water Use Management
- Education, Outreach and Marketing

Actions that would be required to accomplish the goals and objectives, as well as performance measures that could be used to track progress are summarized in Appendix A. The 2012 actions, goals, objectives and performance measures are also included, as many of these triggered long-term environmental monitoring objectives.

During the Center for the Inland Bays (Center's) original CCMP development process that culminated in 1995, a *Plan for Inland Bays Environmental Monitoring* was produced and included as Appendix G of that report. The plan assembled the metadata of relevant environmental parameters collected at the time and put forth hypotheses for their change based on CCMP implementation. An updated *Monitoring and Assessment Plan for Delaware's Inland Bays (1996-2000)* was published in December 1996.

Since then, collection of additional relevant parameters has been initiated, responsibilities for collection have changed, and both monitoring technology and the scientific understanding of the Bays have evolved significantly. This requires that the Plan be revised regularly, and provides an opportunity to re-engage stakeholders around its cooperative implementation. The IBEMP provides the framework for the five-year State of the Bays report.

The current version of the IBEMP was developed with input from the Center's Scientific and Technical Advisory Committee (STAC) during the Spring of 2023. These participants included representatives from the Delaware Department of Natural Resources and Environmental Control (DNREC), the University of Delaware, and the U.S. Geological Survey.

Objectives

The purpose of the Inland Bays Environmental Monitoring Plan (IBEMP) is to guide monitoring of the conditions of the Inland Bays Estuary and Watershed used to evaluate the overall effectiveness of the CCMP.

The IBEMP is a living document intended to adapt to meet needs for understanding the status and trends of eutrophication, habitat loss/modification, and emerging stressors within the Inland Bays. It is supplemental to the CCMP (Appendix A). It is a comprehensive inventory of projects that are ongoing, or are needed to fill data gaps, to monitor progress toward meeting the CCMP goals. The plan is intended to guide research, monitoring, and assessment efforts, and may lead to increased integration of work and consolidation of resources. The IBEMP will be reviewed and revised, biennially, to reflect the changing needs of the Bays.

The primary objectives of the IBEMP are to:

- Identify monitoring needed to track progress toward meeting the goals for improving water quality and living resources within the Bays;
- Measure the effectiveness of CCMP actions in bringing about environmental change;
- Identify projects/programs/agencies that are conducting monitoring that meets these goals;
- Identify gaps where data and information are needed (including emerging issues), and suggest alternatives for filling those gaps where possible through integration of work being carried out under active projects;
- Make recommendations for data synthesis, and for coordination among those organizations involved in data collection, processing and analysis, storage and provision, and presentation;
- Identify funding needs and strategies to address data gaps and implement the IBEMP.

Summary of Plan Development Process

The Scientific and Technical Advisory Committee, composed of stakeholders and partners, assisted the Center in the development of this IBEMP update. The Center tracked suggestions as they arose between 2021 and 2023. In addition, the STAC provided written and oral comment during a six-week review period that included two STAC meetings. The February and April 2023 meetings of the full STAC included discussion of the IBEMP, with a survey occurring between the two meetings to get further feedback. STAC was then asked to review a prior draft of this document, before it was finalized by the Board of Directors in August 2023.

MONITORING PLAN UPDATES

Periodic reevaluation of the IBEMP must be conducted to ensure that the plan is addressing current and critical data gaps (Appendix B). During this reevaluation, monitoring programs will be checked for relevance, applicability to emerging needs, and improvements in technology. If necessary, the Center will revise the IBEMP to reflect any updates. This version of the IBEMP represents the second revision, completed in 2023.

Metrics without questions are just measurements, and the guiding questions may be refined through time (Table 1). A summary of the recommendations from the 2020 update as well as the recommendations in this update are in Table 2. Where revisions to existing parameters are recommended, a note is added to their record in Table 3.

The STAC is responsible for a biannual review of, and updates to, the Inland Bays Environmental Monitoring Plan, as well as development of strategies for implementation. Initially, the biannual period

for review was selected to correspond with the State's Combined 305(b) and 303(d) reports to EPA, however, the 2023 revision was off schedule, thus desynchronizing the reports. The next revision is due in 2025. At a minimum, review and comments should be requested from representatives from the Center for the Inland Bays, DNREC Watershed Assessment Section, DNREC Environmental Laboratory, University of Delaware Citizen Monitoring Program, Center for Environmental Monitoring and Analysis (CEMA), and the Delaware Geological Survey.

The 2023 update was undertaken by the entire Scientific and Technical Advisory Committee. A standing subcommittee is recommended for future updates.

Summaries of progress and new data needs have been added to the 'Recommendations for Additional Supporting Programs' section of this updated document.

Table 1. Guiding questions to direct the Environmental Monitoring Program. New questions in 2023 revision are in bold.

MONITORING QUESTIONS
Focus Area: Nutrient Management
Do nutrient loadings from nonpoint and atmospheric sources meet established TMDL targets?
Are nutrient loadings from the watershed decreasing, increasing or remaining stable?
Focus Area: Wastewater Management
Do nutrient loadings from point sources meet established TMDL targets?
Are the frequency and spatial distribution of emerging contaminants of concern increasing, decreasing, or remaining stable?
Focus Area: Stormwater Management
Is the areal coverage of effective impervious surfaces in the watershed increasing, decreasing, or remaining stable?
Focus Area: Water Quality Management
Is tributary water quality improving, declining, or remaining stable?
Are phytoplankton biomass levels (as indicated by chlorophyll-a concentrations) above, below, or consistent with established targets?
Are water column nutrient concentrations above, below, or consistent with established targets?
Is water clarity above, below, or consistent with established targets?

MONITORING QUESTIONS
Is the areal extent of low dissolved oxygen concentrations increasing, decreasing, or remaining stable?
Are the frequency and spatial distribution of macroalgal blooms increasing, decreasing, or remaining stable?
Are the concentrations and spatial distribution of fecal bacteria increasing, decreasing, or remaining stable?
Do concentrations of toxics in water and sediment meet water quality standards?
Are emerging contaminants affecting the resiliency of the Bays to meet water quality standards?
Focus Area: Managing Living Resources and their Habitat
Is the acreage of bay grasses increasing, decreasing or remaining stable?
Is the acreage and condition of freshwater wetlands, including isolated wetlands, increasing, decreasing or remaining stable?
Is the acreage and condition of tidal wetlands increasing, decreasing or remaining stable?
Is the average width of vegetated buffers on waterways increasing, decreasing, or remaining stable?
Is the percentage of hardened shorelines in the Inland Bays increasing, decreasing, or remaining stable?
Are populations of migratory fish increasing, decreasing or remaining stable?
Is the acreage of approved shellfishing waters increasing, decreasing or remaining stable?
Are the density and distribution of shellfish, potentially available for harvest (oysters, hard clams, blue crabs) increasing, decreasing or remaining stable?
Are the density and distribution of invasive plant and animal species increasing, decreasing or remaining stable?
What is the condition of the dominant habitats, is this increasing, decreasing or remaining stable?
Is suitable area available to allow for migration, creation or enhancement of desired habitats?
Focus Area: Planning for Climate Change
Are water levels in the estuary increasing, decreasing, or remaining stable?
Are water temperatures increasing, decreasing, or remaining stable?
Are pH conditions in the estuary increasing, decreasing, or remaining stable?

MONITORING QUESTIONS
Are expected effects of climate change going to exacerbate, mitigate, or not change current issues?
Are shifts of dominant aquatic species changing over time in response to long-term temperature, pH, or salinity changes?
Focus Area: Coordinating Land and Water Use Decisions
Is the acreage of natural habitat protected or restored increasing, decreasing, or remaining stable?
Are populations of Species of Greatest Conservation Need (as defined by the Delaware Wildlife Action Plan) in the watershed increasing, decreasing or remaining stable?

PREVIOUS RECOMMENDATIONS and CURRENT STATUS

Table 2. Summary of priority recommendations from the IBEMP 2020 and new actions from the current revision. H= High, M=Medium priority levels.

Priority/Year	Recommendation	Actions	Next Steps
H20	Development of a new hydrodynamic/watershed model for the Inland Bays	White Paper (2020); Grant Search (ongoing); Partial Funding (FY23); Prioritization (ongoing)	Release RFP to create an updated hydrodynamic model; Explore funding for the water quality and additional models as needed
H20	Upgrade of the University of Delaware's Citizen Monitoring Program database to a format that is sustainable long-term and can serve data to the public through STORET and/or the state's Water Quality Portal	Data from 2016-2020 is now accessible to the public.	Continue to add data as it becomes available after 2020. Add historic data from 2010-2016.
H20/H23	Long-term, continuous monitoring of dissolved oxygen and chlorophyll at key stations	Established 6 stations DO, Temperature, Salinity, pH, Turbidity, and Chlorophyll a (2022); 2 more stations for 2023	Add Chlorophyll; Identify long-term funding
H20	Monitoring of submerged aquatic vegetation in tidal regions of the Inland Bays	Mapped existing SAV (2021), added to Indicator and Measurements Matrix	Remap entire bay in 2031 unless conditions change; Expand metric to locate and monitor suitable habitat; Establish self-sustaining populations at 3 separate locations by 2030
H20	Monitoring of local indicators of sea level rise	Continued Surface Elevation Table (SET) monitoring (ongoing), Determine status of beneficial reuse for restoration purposes	Evaluation of alternate indicators for inclusion

M20	Continued monitoring of the tidal prism at the Indian River Inlet	Shi model of tidal prism (2021)	Survey of physical condition by 2026, explore DELDOT, USACE partners.
Priority/Year	Recommendation	Actions	Next Steps
M20	Long-term monitoring of oyster recruitment and growth in the Bays, particularly as aquaculture begins, and shellfish restoration and enhancement projects are undertaken	Established spat monitoring protocol. Annual monitoring of pilot oyster reefs (ongoing).	Expand to include Citizen Science spat monitoring
M20	Shoreline condition and modification monitoring to evaluate the effectiveness of living shoreline initiatives	Initiated shoreline condition assessment of 2022 aerial imagery to compare with 2012 survey (2023)	Complete assessment, analyze for change
M20/H23	Continued analyses of tidal marsh acreage and condition using GIS methodology established in a 2014 study conducted by the University of Delaware	No actions to report.	Expand from GIS methodologies to develop on the ground indicators based on established protocols.
M20	Monitoring of estuary acidification	Gonski initiated research into Bays, established a monitoring network.	Monitor national efforts.
M20	Monitoring of recreational Blue Crab and Hard Clam harvests from the Inland Bays	Identified challenges to data collection	Needs funding.
M20	Build and maintain a list of research and monitoring activities focused on emerging contaminants in the Inland Bays	No actions to report.	Needs capacity.
H23	Seagrass Suitability Monitoring	Pilot study (2022). Full study of 5 locations to identify areas for SAV restoration (2023).	Expand areas; consider other species with similar requirements; explore remote sensing technologies

H23	Expansion of nutrient input monitoring in tributaries	Only a fraction of the tributaries have been monitored in the last 30 years	Establish a plan/system to monitor all tributaries through time so that nutrient sources are not overlooked
Priority/Year	Recommendation	Actions	Next Steps
H23	Forest Quality Assessment	Over 150 acres of forest have been planted by Center, not all of the acreage has survived	Establish metrics for understanding healthy forest and buffers and adjust restoration efforts to promote high quality forests
M23	Living resource metrics	The Center has established protocols on inshore forage fish and horseshoe crab sex ratios.	Support establishment of population or subpopulation surveys of relevant faunal metrics, aquatic, terrestrial and avian.
M23	Emerging Contaminant Focus: Plastics	Numerous protocols and research documenting extent of plastic pollution globally	Understand role in the Bays
M23	Disease load in Aquaculture Oysters/Wild Oysters	New action.	Continue current disease load testing in aquaculture oysters; Establish load in wild oysters

ASSESSMENT AND REPORTING

ENVIRONMENTAL INDICATORS AND STATE OF THE ESTUARY REPORTS

Conditions in the Inland Bays are dynamic and it is essential to monitor temporal and spatial changes in water quality across the watershed and understand how changes relate to the health of the estuary.

Comprehensive assessments of the condition of the Inland Bays were published in 1995, 2004, 2011, 2016, and 2023 (2021 reporting year). The *State of the Delaware Inland Bays* report is updated and published every five years. The 2021 report included assessment of 39 individual environmental indicators, which are included in the IBEMP and identified in Table 3. The indicators are used to assess the status and trends of water quality and the health of Inland Bays habitats and living resources. Status and trends are assigned using best professional judgment and reviewed by scientists knowledgeable in these areas. For each indicator, long-term trends are addressed, as well as short-term changes that have occurred since the previous report was published.

The IBEMP is intended, in part, to ensure that long-term collection of data needed to develop these environmental indicators for the Bays is continued. The next *State of the Delaware Inland Bays* report will be published in fall 2026. Changes to the list of indicators used in that report will be reflected in the next biannual update of the IBEMP, scheduled to be completed in 2025.

TMDL REPORTING AND BENCHMARK GOALS

Section 305(b) of the Federal Clean Water Act requires that states prepare and submit a Watershed Assessment Report to EPA on April 1st of every even numbered year. The 305(b) reports and monitoring data are used to compile a list of impaired waters, commonly referred to as the 303(d) list. When waters are identified as impaired on 303(d) lists, a Total Maximum Daily Load (TMDL) must be developed.

All of the 305(b) Reports and 303(d) lists that Delaware has submitted to EPA are available on the DNREC website (https://dnrec.alpha.delaware.gov/watershed-stewardship/assessment/reports/). Core Documents for the 2022 305(b)/303(d) Integrated Report were posted at the time of completion of this monitoring plan update.

INLAND BAYS MONITORING PROGRAMS

QUESTIONS ADDRESSED BY MONITORING

Two types of monitoring are used to track progress toward meeting goals of the CCMP – programmatic and environmental. The IBEMP focuses on environmental outcomes, i.e., changes in environmental conditions, ecological functions, and biological populations.

The objectives of the 2012 Addendum to the CCMP were expressed as monitoring questions, which drove the establishment of the current environmental monitoring program conducted by the Center and its partners. Understanding of both responses to stressors and natural variability is critical for determining relationships between actions taken and responses within the estuary system. The 2021 CCMP expanded to include legislative, watershed planning and outreach goals. The environmental monitoring program reflects both the 2012 and 2021 CCMP, with references to the question or action items cited in both documents the Monitoring and Indicator Matrix (Table 3).

EXISTING MONITORING PROGRAMS

The IBEMP provides a framework that builds upon existing programs that are conducting ongoing, long-term environmental monitoring within the Delaware's Inland Bays study area. Many of these programs contribute data that are used to develop *State of the Delaware Inland Bays* reports. Others produce data that may illuminate progress toward achieving goals of the CCMP and/or Pollution Control Strategy, provide data for new environmental models, or may be useful for development of new indicators in the future. Emerging programs and questions are also present, and including these in Table 2 allows for evaluation before adopting them in the ongoing monitoring program. Typically a proposed metric will have a minimum of 5-years to be reviewed before it is confirmed thar the metric is a new environmental quality indicator. Where possible, locally produced data from regional monitoring is preferred, however this is not always available, as such, the next most appropriate source is used.

CCMP objectives and monitoring questions addressed by these programs, responsible entities, data collected, data gaps, frequency of data collection and reporting, and how the data are shared, reported and used are summarized in the Monitoring and Indicators Matrix (Table 3).

The monitoring programs listed in the Matrix are organized into the following sections:

1. Surface Water
2. Groundwater
3. Wastewater
4. Atmospheric Deposition
5. Wetlands
6. Living Resources
7. Climate

Many of the monitoring programs in Table 3 are described in greater detail in the 2020 IBEMP. Cross-references to sections of the 2021 and 2012 CCMP are provided in columns two and three of the Table. Appendix C provides the 2021 State of the Bays Technical Report which updates the description of the monitoring programs and how the data is used.

The recommendation of this Plan is that these programs will continue to be funded and conducted long-term. In many cases, funding of these programs is beyond what the Center or partners can control. Coordination, collaboration, and long-term support for these monitoring programs are critical for the success of the IBEMP. Communication with partners regarding the status of monitoring recommendations is encouraged prior to the review and revision process.

The Center funds and leads the following monitoring programs:

- Long-term salt marsh monitoring
- Seaweed abundance
- Inshore fish and blue crab surveys
- Horseshoe crab surveys and tagging
- Diamondback terrapin surveys (added in 2020, set to expire in 2025)
- Continuous water quality monitoring (6 stations in 2022, and 9 stations by 2024)

In 2023/2024, the Center will explore additional metrics associated with:

- Background oyster spat amount and frequency
- Habitat condition monitoring (salt marsh and forest)
- Seagrass suitability monitoring

Responsibility for implementation of the remaining programs lies primarily with other entities, as noted in Table 3. The Center will work with these entities, as needed, to facilitate partnerships and funding that ensure the sustainability of these programs. Through the STAC and state/regional workgroups such as the Delaware Environmental Coordination Council (https://delawaremonitoringcouncil.org/), the Center will ensure that data gaps are discussed and addressed in each biannual review of the IBEMP. The Center also will continue to synthesize Inland Bays monitoring data and communicate findings to the public, stakeholders, and decision makers through State of the Bays reports and other media (Summary in Appendix D).

Table 3. Measurements and Indicators Matrix.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entities	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
1. SURFACE WATER MONITORING PROGRAMS										
Ambient Water Quality, State of Delaware General Assessment Monitoring Network (GAMN)	CCMP: Water Quality Management, Objectives 1, 3, and 6 Questions: 1,3,5,6,7,8,9, 11,12,26,27, 28	Healthy Bay Ecosystems: Protect and Restore Thriving Habitats for Abundant Fish and Wildlife, HB 1 Actions: 1-1	Comparison with TMDL targets for nitrogen, phosphorus, and bacteria. Data used by CIB to develop a Water Quality Index (WQI) to indicate suitability for submerged aquatic vegetation reestablishment.	TP, ortho-P, ammonia N, NO2+NO3, TN, TOC, DOC, Chl a, BOD, DO, TSS, alkalinity, hardness, pH, conductivity, salinity, temperature, Secchi depth, light attenuation, turbidity, chloride, total *Enterococcus,* Cu, Pb, Zn, As	Most stations monitored 6 times/year for three years, then 12 times/year for two years.	1998 to present	DNREC Division of Water, Environmental Laboratory Section DNREC Division of Watershed Steward-ship, Watershed Assessment Section	Biannually	GAMN data entered into STORET and publically available via the Delaware Water Quality Portal. Data published biannually in 305(b) and 303(d) combined reports. Indicator in *State of the Delaware Inland Bays* reports.	Continue long-term program funding. Continuous/high frequency monitoring for DO and other parameters that fluctuate significantly over short time scales. New hydrodynamic/water quality model. Monitoring of estuary acidification Emerging contaminants of concern. May support suitability models for other species of restoration importance

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entities	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Ambient Water Quality, Citizen Monitoring Program (CMP)	CCMP: Water Quality Management, Objectives 1, 3, and 6; Outreach and Education, Objective 4 Questions: 5,6,7,8,9, 11,26,27,28	Healthy Bay Ecosystems: Protect and Restore Thriving Habitats for Abundant Fish and Wildlife, HB 1 Actions: 1-1	Used by CIB to develop a Water Quality Index (WQI) to indicate suitability for submerged aquatic vegetation reestablishment. Included in state's Combined 305(b) Report and 303(d) List, but not used in listing determinations. One metric for allowed uses in DNREC's Shellfish & Recreational Water Program	Ortho-P, TP, ammonia N, NO2+NO3, TN, DO, Chl a, TSS, pH, conductivity, salinity, temperature, Secchi depth, rainfall, harmful algal bloom	Weekly to biweekly, dependent upon parameter	Varies by station. Longest records begin in 2000. TN and TP added in 2021.	University of Delaware, Sea Grant Marine Advisory Service	Semi-monthly summary reports	Summary reports posted online. Beginning with 2019 records, CMP data now to be entered into WQX and publically available via the Delaware Water Quality Portal (2016-2020). Data published as appendix in 305(b) and 303(d) combined reports. Indicator in *State of the Delaware Inland Bays* reports.	Resources to continue data collection at priority Inland Bays stations. Upload all legacy data to WQX and state portal.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Fecal contaminants, Citizen Monitoring Program (CMP)	CCMP: Water Quality Management, Objectives 1, 3, and 6; Managing Living Resources, Objective 5; Outreach and Education, Objective 4 Questions: 11	No current objective.	Indicator derived from percentage of summer samples exceeding safe swimming standard.	Total *Enterococcus*	Biweekly	Varies by station. Longest records begin in 2000.	University of Delaware, Sea Grant Marine Advisory Service	Semi-monthly summary reports by CMP. Every five years in CIB indicator reports.	Summary reports posted online by CMP. Indicator in *State of the Delaware Inland Bays* reports.	Along with ambient WQ, data should be made publically available via STORET/WQ Portal.
Fecal contaminants, State of Delaware Coliform Monitoring Program	CCMP: Water Quality Management, Objectives 1, 3, and 6; Managing Living Resources, Objective 5; Outreach and Education, Objective 4. Questions: 11,19	No current objective.	Assess the suitability of the Inland Bays waters for shellfish harvest using federal standards.	Fecal coliforms	9-10 times per year	2008 to present. Fecal coliform collection began in 2016, phasing out total coliforms as the method to assess the suitability of waters by 2022.	DNREC Division of Watershed Stewardship Shellfish Program	Periodic updates to shellfish growing area classifications.	Shellfish growing area interactive map on DNREC website.	Refinement of source tracking. Continue current funding.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Stream/Tide Gauging	CCMP: Water Quality Management, Objectives 1 and 6; Planning for Climate Change, Objective 1. Questions: 1,25	Living with a Changing Climate: CC 1, 2 Actions 1-1, 2-1, 2-2	Tide elevation. Real-time and long-term, current and historical streamflow.	Discharge/flow, tide elevation.	Continuous	Varies by station. Longest record begins 1985.	USGS MD-DE-DC Water Science Center	Daily summary data online	Stream/tide data shared online by USGS. Delaware data also available through the Delaware Environmental Observing System (DEOS) site.	Continue funding to maintain existing stream and tide gages. Need for additional stream gauges to facilitate watershed model(s) development. Need for monitoring of local indicators of sea level rise, including establishment of a flood monitoring network.
Tidal Flushing at Indian River Inlet	CCMP: Water Quality Management, Objective 1. Questions: 5,28	Healthy Bay Ecosystems: Protect and Restore Thriving Habitats for Abundant Fish and Wildlife, HB 1 Actions: 1-1	Tidal prism calculations.	Tidal range, surface area of basin calculated from transects and bathymetry data.	No set frequency. No plans for future monitoring. Future estimates may come from numerical models.	1939-2004 (irregularly) 2021 (modeled by Shi for the 2021 State of the Bays)	U.S. Army Corps of Engineers, Coastal Planning Section	No set frequency	Technical report submitted to CIB for each monitoring event. Indicator in *State of the Delaware Inland Bays* reports.	Funding to repeat tidal prism measurements at a regular schedule. Will facilitate hydrodynamic model update.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Biological assessments of water quality in wadeable streams	CCMP: Water Quality Management, Objectives 2 and 3. Questions: 5	No current objective.	Biological Index derived to categorize stream water quality according to condition (excellent to severely degraded)	Benthic macroinvertebrates, periphyton	Biannually	2000 to present	DNREC Division of Water, Environmental Laboratory Section	Biannual	Used in 303(d) listings.	Continue current funding. Explore possibility of freshwater mussel metric. Explore the possibility of Citizen Science protocol.
2. GROUNDWATER PROGRAMS										
Delaware Groundwater Monitoring Network	CCMP: Wastewater Management, Objective 3; Water Quality Management, Objectives 1, 3, and 6; Planning for Climate Change, Objective 1. Questions: 25,28	Living with a Changing Climate: CC 1, 2 Actions 1-1, 2-2	Water levels in major aquifers, saltwater intrusion.	Long time-series of water levels. Salinity sensors installed in some wells. Groundwater quality data collected when funded.	Varies by well and parameter. A subset of wells are sampled annually with each well sampled every 5 years.	Varies by well. Records for the oldest wells go to 1957.	Delaware Geological Survey	Continuous	Data and reports shared on DGS website.	Funding to support continued groundwater quality data collection.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Agricultural Shallow Groundwater Monitoring Network	CCMP: Nutrient Management, Objective 1; Wastewater Management, Objective 3; Water Quality Management, Objective 3. Questions: 1	Clean Waters: Healthy Agricultural Landscapes AG 1,2 Actions 1-1, 2-1, 2-2	Trends in nitrate concentrations.	Nutrients, major ions, pesticides, and ground-water age.	Continuous	2014 to present.	USGS and Delaware Department of Agriculture	Annually	Reports available from Delaware Dept. of Agriculture.	Continue current funding.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Ambient Groundwater Quality, Public Water Supply Wells	CCMP: Wastewater Management, Objectives 2 and 3; Water Quality Management, Objective 3. Questions: 12	No current objective.	Results evaluated with respect to Primary Maximum Contaminant Levels (PMCLs), Secondary Maximum Contaminant Levels (SMCLs), and Health Advisories (HAs) for public water-supply systems.	Chemical data collected from public water-supply wells. Data drawn from DHSS's Safe Drinking Water Information System (SDWIS) database, DNREC's Source Water Assessment and Protection Program (SWAPP) database, and Tidewater Utilities.	Analyses conducted biannually	2008 to present	DNREC Division of Water, Water Supply Section	Biannually	*305(b) Groundwater-Quality Assessment Based on Public-Well Data reports*	Continue current funding.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
3. WASTEWATER MONITORING PROGRAMS										
Point Source Wastewater Discharges	CCMP: Wastewater Management, Objective 2; Water Quality Management, Objectives 1, 2, and 3. Questions: 2,3	Clean Waters: Healthy Agricultural Landscapes AG 2 Actions 2-1	Flow, nutrient loads, eutrophication indicators. Data used to assess progress toward TMDL goals.	Flow, BOD, TSS, TP, TN, pH, DO. Some facilities also monitor fractions of P and N.	Varies by permitted facility/outfall	Varies by permitted facility	DNREC Division of Water, Surface Water Discharges Section	Annually	Data must be requested from DNREC. Point source nutrient loads indicator in *State of the Delaware Inland Bays* reports.	Continue current funding.
Land Application of Wastewater	CCMP: Nutrient Management, Objective 1; Wastewater Management, Objectives 1 and 3; Water Quality Management, Objectives 1, 2, and 3. Questions: 1,2,3	Clean Waters: Healthy Agricultural Landscapes AG 2 Actions 2-1	Nutrient loads, eutrophication indicators. Maintenance of soil function. Compliance with drinking water standards.	Effluent: TSS, BOD, TN, TP (and fractions of nitrogen), pH, DO. Groundwater: water table depth, soluble constituents (under and adjacent to spray site).	Varies by permitted facility.	Varies by permitted facility	DNREC Division of Water, Groundwater Discharges Section, Large Systems Branch	Annually	Compliance/monitoring reports prepared by permittees.	Continue current funding.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Nutrient Management Practices	CCMP: Nutrient Management, Objective 1; Wastewater Management, Objectives 1 and 3; Stormwater Management, Objective 1; Water Quality Management, Objective 2. Questions: 1	Clean Waters: Healthy Agricultural Landscapes AG 1, 2, 3 Actions 1-3, 2-1, 2-2, 3-1, 3-3	Progress toward PCS goals	Agricultural nutrient management practices, equivalent dwelling unit's converted from septic to sewer, acres of stormwater retrofits	Annually	2005 to present	U.S. Department of Agriculture, DNREC Division of Watershed Stewardship, DNREC Division of Water, Sussex Conservation District, Sussex County	Every five years	Indicator in *State of the Delaware Inland Bays* report.	Incomplete data collection/reporting on agricultural practices in the watershed.

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4. ATMOSPHERIC DEPOSITION PROGRAMS										
Atmospheric Deposition of Nutrients	CCMP: Water Quality Management, Objectives 1 and 2. Questions: 1	Healthy Bay Ecosystems: Protect and Restore Thriving Habitats for Abundant Fish and Wildlife HB1 Actions 1-2	Wet and dry deposition rates of N and P species to open waters and contiguous marshes in the Inland Bays.	Precipitation, free acidity (H+ as pH), conductance, Ca2+, Mg2+, Na+, K+, SO42-, NO3-, Cl-, NH4+.	Daily within 24 hours of the start of precipitation.	1992 to present	University of Delaware, College of Earth, Ocean, and Environment Assateague Station	5-6 month time lag between sample collection and posting on a website.	Data from the Lewes station DE02 accessed through the main NADP/AIRMoN website or the AIRMoN Data Retrieval Site. Indicator in *State of the Delaware Inland Bays* report.	Need funding to reinstate local station.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitie s	Frequency of Reporting	Sharing/Re porting	Gaps & Funding Needs
5. WETLANDS MONITORING PROGRAMS										
State of Delaware Wetlands Monitoring and Assessment Program	CCMP: Managing Living Resources and Their Habitat, Objectives 2 and 6; Planning for Climate Change, Objective 1; Coordinating Land and Water Use Decisions, Objective 2. Questions: 14,15	Living with a Changing Climate, CC 1, 2 Healthy Bay Ecosystems : Protect and Restore Thriving Habitats for Abundant Fish and Wildlife HB4, Actions 4-1, 4-2 Actions: CC1-1, CC2-3, HB4-2	Wetland acreage, condition, and major stressors. DECAP scores for nontidal wetland functions (habitat, hydrology, buffers, soil cycling). MidTRAM scores for condition of estuarine emergent tidal wetlands, validated with biological data based on bird community and biomass levels.	Delaware Comprehens ive Assessment Procedure (DECAP) and Delaware Rapid Assessment Procedure (DERAP) for nontidal wetlands. MidAtlantic Tidal Rapid Assessment Method (MidTRAM) protocol for tidal wetlands.	Rotating basin approach planned following initial assessmen ts.	Nontidal wetlands: 2005-2006 Tidal wetlands: 2008	DNREC Division of Watershed Stewardshi p, Wetlands Monitoring and Assessment Program	Final reports issued following assessment of each basin.	Data shared on the Delaware Open Data Portal.	Funding to continue Inland Bays assessments. Synthesis of this dataset with other wetlands monitoring efforts in the Bays is needed.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitie s	Frequency of Reporting	Sharing/Re porting	Gaps & Funding Needs
Long-term Salt Marsh elevation	CCMP: Managing Living Resources and Their Habitat, Objectives 2 and 6; Planning for Climate Change, Objective 1. Questions: 15,25	Living with a Changing Climate, CC 1, 2 Actions: 1-1, 2-2	Overall marsh height change, changes in the marsh height as a result of surface accretion/er osion, changes in the root zone.	Sediment elevation, surface accretion	Semi-annu ally; 9 paired deep and shallow Surface Elevation Tables, three at three marshes	2008 to present	Delaware Center for the Inland Bays	Every five years	Project technical reports published by the CIB.	Continue current support for three Inland Bays stations. Collection of vegetation data and water level data from these sites would be useful.
Salt Marsh Acreage and Condition	CCMP: Managing Living Resources and Their Habitat, Objectives 2 and 6; Planning for Climate Change, Objective 1; Coordinating Land and Water Use Decisions, Objective 2. Questions: 15	Healthy Bay Ecosystems : Protect and Restore Thriving Habitats for Abundant Fish and Wildlife HB 4 Actions 4-2	Historic trends in the extent and condition of the tidal marshes of the Inland Bays	Extent of vegetated marsh, fractured pooling, ditching, and wetland/upl and boundary hardening. Data derived from geospatial analyses of aerial imagery and land cover data.	As needed.	Documente d data from a number of years between 1937 and 2007 (completed 2014). Study repeated in 2020 using recent datasets.	University of Delaware Water Resources Agency Delaware Center for the Inland Bays	Every five years for the State *of the Delaware Inland Bays* reporting.	Technical report produced by the University of DE. Geospatial data available. Acreage and fractured pooling used as indicators in the *State of the Delaware Inland Bays* report.	Funding to continue future analyses of tidal marsh acreage and condition. Explore increased use of updated imagery and land cover data.

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Shoreline condition	CCMP: Managing Living Resources and Their Habitat, Objective 2; Planning for Climate Change, Objective 1. Questions: 17	Living with a Changing Climate, CC 1,2 Actions 1-1, 2-3	Condition of tidal shorelines.	Riparian land use, bank condition, shoreline features (including hard structure)	As needed.	Rehoboth Bay: 2006, 2022; Little Assawoman Bay 2012; 2022 Indian River Bay: 2012, 2022	DNREC Division of Watershed Stewardship, Wetlands Monitoring and Assessment Program Delaware Center for the Inland Bays	N/A	Current data available on VIMS Center for Coastal Resources Management Shoreline Inventory website. Summary report published for each bay inventory. Updated shoreline inventory expected late 2023 based on 2022 aerial imagery.	Ongoing updates to shoreline data needed to assess progress of Living Shoreline Initiative. Share results publicly.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entities	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
6. LIVING RESOURCES AND HABITATS										
Land Use Land Cover	CCMP: Stormwater Management, Objective 1; Managing Living Resources and Their Habitat, Objective 2; Planning for Climate Change, Objective 1; Coordinating Land and Water Use Decisions, Objectives 1 and 2; Outreach and Education, Objective 5. Questions: 4,14,15,16, 29	Living with a Changing Climate, CC 2, Healthy Bay Ecosystems : Protect and Restore Thriving Habitats for Abundant Fish and Wildlife HB1 Actions CC2-3, HB1-5	Land use change, impervious surface coverage, mean width of forested buffers on croplands	Aerial estimates	Every five years	1992 to present. Most recent dataset is 2017. Impervious cover layer updated in 2020. Flight completed in 2022, but is not yet processed.	State of Delaware, Office of Management and Budget, Delaware Geographic Data Committee	Five-year updates	Delaware First Map. Indicator in *State of the Delaware Inland Bays* report.	More frequent updates of impervious cover layer.

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Human Population	CCMP: Wastewater Management, Objectives 1 and 3; Coordinating Land and Water Use Decisions, Objective 1. Questions: 4,29	Coordinated Land and Water Use Decisions CM 1,2 Actions 1-1, 2-1, 2-2, 2-4	Resident and seasonal population , Sussex County and watershed	U.S. census, wastewater flows	Every ten years	County: 1790 to present Watershed: 1990 to present	U.S. Census Bureau, Sussex County	Every five years.	Indicator in the *State of the Delaware Inland Bays* report.	A better estimate of seasonal population is needed.

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National Aquatic Resource Surveys (NARS)	CCMP: Water Quality Managemen t, Objectives 1 and 3; Managing Living Resources and Their Habitat, Objective 2. Questions: 5,6,7,8,9, 11,12,14, 15,18,21, 26,27,28	No current objective.	Four individual surveys that are implemente d on a rotating basis - National Coastal Condition Assessment, National Lakes Assessment, National Rivers & Streams Assessment, and National Wetland Condition Assessment. Each has Biological, chemical, physical, and human health indicators.	Biological (benthic macroinvert ebrates, Chl a, zooplankton , fish diversity), chemical (DO, salinity, pH, nutrients, sediment contaminant s/toxicity), physical (clarity, habitat complexity and disturbance) , recreational/ human health (algal toxins, cyanobacteri a, enterococci)	Five-year cycles	2007 to present	U.S. EPA, Office of Wetlands, Oceans, and Watersheds DNREC Division of Water, Environmen tal Laboratory Section	Five-year cycles for reporting status, trends for each survey.	Data, summary reports, and manuals shared on EPA website.	Continue long-term funding of the program. Evaluate the usefulness of this metric, not used in State of the Bays.

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Natural Habitat Protection/Restoration	CCMP: Managing Living Resources and Their Habitat, Objective 2. Questions: 29	Healthy Bay Ecosystems : Protect and Restore Thriving Habitats for Abundant Fish and Wildlife, HB 1, 2, 3, 4, 5, 6; Coordinate d Land and Water Use Decisions CM1 Actions: HB1-4, HB2-1, HB3-2, HB4-2, HB5-1,HB5-4, HB6-1, CM1-2	Cumulative acres	Data retrieved from U.S. EPA National Estuary Program Online Reporting Tool (NEPORT) Habitat Reporting	Annually	2003 to present	Delaware Center for the Inland Bays	Annually	Indicator in *State of the Delaware Inland Bays* reports.	NEPORT may not capture all projects in the watershed.
Vegetation Community and Land Cover Mapping	CCMP: Managing Living Resources and Their Habitat, Objectives 2 and 6. Questions: 14,30	Healthy Bay Ecosystems : Protect and Restore Thriving Habitats for Abundant Fish and Wildlife, HB 4, 6 Actions: 4-2, 6-1	Rarity and status of vegetation communitie s.	Aerial imagery analyses of public lands, combined with field data.	Delaware Statewide Vegetation Communit y Map updated approxima tely monthly.	Analyses published for 2011-2013.	DNREC Wildlife Species Conservatio n and Research Program	Monthly updates	DNREC Wildlife Species Conservatio n and Research Program, and the University of Delaware Water Resources Agency.	Continue current program funding.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Seaweed Abundance	CCMP: Water QualityManagement, Objectives 3, 5 and 6; Managing Living Resources and Their Habitats, Objective 5. Questions: 5,10	No current objective.	Macroalgae density	Volume of macroalgae collected at fixed stations by grappling hook.	From 2022? Data now collected every 5 years.	1999, 2009, 2011, and 2012. Annually between 2017 and 2022. From 2022, once every 5 years	Delaware Center for the Inland Bays	Once every 5 years in the State of the Delaware Inland Bays report.	Prior to 2017, survey reports published by DNREC. Currently annual data reports published on CIB website. Status and trend data included in *State of the Delaware Inland Bays* reports.	Coverage could be increased by using citizen scientists. Revisit purpose and applicability, explore retiring this metric.
Coastal Finfish Assessment	CCMP: Managing Living Resources and Their Habitat, Objectives 3, 4, 5, and 6. Questions: 18,21,28	No current objective.	Abundance and distribution of recreation-ally important finfish species. Annual young-of-the-year indices, catch per tow. Blue Crab abundance.	Otter trawl surveys (IR and Rehoboth Bays only). Count by species, fork length, surface temperature, salinity, and DO, tidal stage, weather conditions, water depth, engine speed.	Monthly, April to October	1986 to present	DNREC Division of Fish and Wildlife, Fisheries Section	Annually	Annual summary reports published by DNREC DFW. Status and trends for indicator species reported in the *State of the Delaware Inland Bays* reports.	Continue current program funding.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entities	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Inshore Fish and Blue Crabs	CCMP: Managing Living Resources and Their Habitat, Objectives 3, 4, 5, and 6; Outreach and Education, Objective 4. Questions: 18,20,21,28	No current objective.	Abundance and distribution of juvenile fish and Blue Crabs.	Seine counts of fish, by species; fish lengths; Blue Crab counts by size class; salinity, DO, temperature, wave height, antecedent precipitation, wind speed, tide cycle.	Semi-monthly from April to October.	2011 to present.	Delaware Center for the Inland Bays	Annually	Annual data reports published on CIB website. Five-year trend analyses published by CIB.	Continue current funding and level of effort.
Recreational Fishing	CCMP: Managing Living Resources and Their Habitat, Objective3; Coordinating Land and Water Use Decisions, Objectives 1 and 3; Outreach and Education, Objective 5. Questions: 18,28	No current objective.	Marine recreational fishing catch and effort.	Catch rates and effort, by species. Landings per year. Harvester intercept surveys conducted at Indian River Inlet.	Annually	2004 to present	NOAA Fisheries Service, Marine Recreational Information Program (MRIP) DNREC Division of Fish and Wildlife	Annually	MRIP reports, DNREC DFW reports. Status and trends for indicator species reported in the *State of the Delaware Inland Bays* reports.	Monitoring of recreational blue crab and hard clam harvests.

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Hard Clam Landings	CCMP: Managing Living Resources and Their Habitat, Objective 5; Coordinating Land and Water Use Decisions, Objectives 1 and 3; Outreach and Education, Objective 5. Questions: 20	No current objective.	Number of clams	Commercial catch	Annually	1943 to present	DNREC Division of Fish and Wildlife, Fisheries Section	Annually	Data available annually from the DNREC Div. of Fish and Wildlife. Used as an indicator in *State of the Delaware Inland Bays* reports.	Continue current program funding. Clam landings can be driven by economic as well as ecological factors, consider developing an alternate metric.

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Fish Tissue	CCMP: Wastewater Management, Objective 2; Water Quality Management, Objective 4; Managing Living Resources and Their Habitat, Objective 5. Questions: 3,12	No current objective.	Fish consumption advisories.	Contaminants in fish and shellfish.	Varies	1992-present	DNREC Division of Fish and Wildlife & Division of Watershed Steward-ship Delaware Health and Social Services, Division of Public Health	Annual updates to advisories.	Fish consumption advisory reports. Number of advisories used as indicator in *State of the Delaware Inland Bays* report.	No data to date have led DNREC and DHSS to conclude that an advisory is needed in the Inland Bays *as a result of contaminant sources within the Inland Bays*.
Fish Kills	CCMP: Water Quality Management, Objectives 5 and 6. Questions: 5,9	No current objective.	Number of kills reported.	Reports to DNREC	As reported	1981 to present	DNREC Division of Fish and Wildlife, Fisheries Section	Annually	Data shared by DNREC upon request. Indicator in the *State of the Delaware Inland Bays* reports.	Continue collection of fish kill data. Explore expansion of this metric in zones near water quality monitoring stations.

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Shellfish Abundance (Hard Clams, Scallops, Oysters)	CCMP: Managing Living Resources and Their Habitats, Objective 5. Questions: 20	No current objective.	Hard Clam/ Scallop abundance in Indian River and Rehoboth Bays, health of the Inland Bays clam shellfishery.	Density and distribution of hard clams and scallops in Indian River and Rehoboth Bays.	No set frequency	1967, 1976, 2011	DNREC Division of Watershed Steward-ship	At conclusion of each survey.	Technical report published by DNREC at conclusion of survey. Data included in *State of the Delaware Inland Bays* reports.	No long-term surveys currently exist. Hard Clam data collection repeated within the next five years for inclusion in *State of the Delaware Inland Bays* reports. Long-term monitoring of oyster recruitment and growth. Recommend to drop scallops as indicator, until habitat/ seagrass beds are established.
Horseshoe Crabs	CCMP: Managing Living Resources and Their Habitats, Objective 2; Outreach and Education, Objective 4. Questions: 17,28,30	No current objective.	Spawning surveys conducted on selected beaches.	Counts of spawning crabs along beach transects, sex ratios, wave height, wind speed, salinity, water temperature .	Semi-mont hly during spawning season, around full and new moons.	2012 to present.	Delaware Center for the Inland Bays	Annually	Annual data reports published on CIB website. Five-year trend analyses.	Protocol changed in 2015 to facilitate comparisons with Delaware Bay surveys. Inland Bays data should be incorporated into regional datasets.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitie s	Frequency of Reporting	Sharing/Re porting	Gaps & Funding Needs
Breeding Bird Atlas	CCMP: Managing Living Resources and Their Habitats, Objective2; Coordinating Land and Water Use Decisions, Objective 2; Outreach and Education, Objective4. Questions: 20,30	No current objective.	Trends in breeding bird populations, distribution, and diversity that occur with changes in land use, habitats, and climate.	Verified evidence of breeding, all species, within 10-sq. mi. blocks.	No set frequency. Two atlas surveys conducted to date, 25 years apart.	1983-1987; 2008-2012.	DNREC Division of Fish and Wildlife, Wildlife Species Conservatio n & Research Program	Report after each 5-year survey period. No set frequency for surveys.	Published as a book at the end of the atlas survey. Data shared on USGS BBA Explorer website.	As more data are collected, long-term trend analyses correlate changes with environmental factors such as disappearance of interior forest and climate change.
Mid-Winter Waterfowl	CCMP: Managing Living Resources and Their Habitats, Objective 2; Coordinating Land and Water Use Decisions, Objective 2. Questions: 13,14,15,30	No current objective.	Wintering populations of ducks and geese, by species.	Aerial survey counts for each species, by zone.	Annually	1974 to present	DNREC Wildlife Species Conservatio n and Research Program	Annually	Data shared through Delaware Open Data Portal. USFWS Atlantic Flyway annual reports. Status and trends for selected indicator species reported in *State of the Delaware Inland Bays* reports.	Continue funding for January surveys each year, at a minimum.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Bald Eagle and Osprey Nesting	CCMP: Managing Living Resources and Their Habitats, Objective 2; Coordinating Land and Water Use Decisions, Objective 2; Outreach and Education, Objective 4. Questions: 30	No current objective.	Bald Eagle and Osprey populations, measured by number of active nests.	Eagles - Aerial surveys of active nests. Ospreys - State surveys suspended in 2014; volunteer reporting only since then.	Currently every two to five years	Bald Eagles: 1987 to 2014 Ospreys: 1991 to present	DNREC Division of Fish and Wildlife, Wildlife Species Conservation & Research Program	As surveys are done	Volunteer osprey data now shared through OspreyWatch program. Indicator in *State of the Delaware Inland Bays* reports.	Funding to continue surveys at least every five years for both species.
Submerged Aquatic Vegetation	CCMP: Water Quality Management, Object 6; Managing Living Resources and Their Habitat, Objective 1. Questions: 13	Living with a Changing Climate, CC 1, 2; Healthy Bay Ecosystems: Protect and Restore Thriving Habitats for Abundant Fish and Wildlife HB 1 Actions CC 1-1, CC 2-2, HB 1-4	Acres, distribution, species.	Location, area coverage, species.	Initial survey completed 2020-2021. Should be repeated 2030-2031.	Last reported natural eelgrass bed in 1975. Acres reported since then are anecdotal. Survey completed by CIB in 2021.	Delaware Center for the Inland Bays	As surveys are done	Reported as an indicator in *State of the Delaware Inland Bays* reports.	Survey in 2020-2021 is supported by a one-time grant. Funding for periodic surveys is needed. Explore sediment record for historic evidence.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
7. CLIMATE										
Sea Level	CCMP: Planning for Climate Change, Objective 1 Questions: 25	Living with a Changing Climate, CC 1,2 Actions 1-1, 2-1, 2-3	Change in mean sea level at Lewes, DE tide gauge.	water level	Continuous	1919 to present	NOAA National Ocean Service	Real-time	Data shared on NOAA Tides and Currents website. Status and trends for this station included as an indicator in the *State of the Delaware Inland Bays* report.	Lewes gauge was offline from 2011 to 2015. Went back online in 2016. Continue long-term funding for this station. Need for monitoring of local indicators of sea level rise, including a flood monitoring network.
Ocean Acidification	CCMP: Planning for Climate Change, Objective 1 Questions: 27,28	Living with a Changing Climate, CC 2 Actions 2-2	Change in ocean pH, measured at Oahu, Hawaii.	pH, pCO2	Monthly for Hawaii data. Continuous collection of pH within the Inland Bays began in 2021. Continuous collection of pCO2 at one to two stations to begin 2022.	1988 to present for discrete pH data. Continuous data collection in Inland Bays began 2021. Research grade pH, pCO2 measurements as part of WICCED.	Hawaii Ocean Time-Series Program; University of Delaware/DNERR (continuous data)	Monthly for Hawaii pH; Continuous for Inland Bays pH/pCO2.	Hawaii pH data shared on HOT website. Status and trends for this station included as an indicator in the *State of the Delaware Inland Bays* report as indicative of global trend.	Data on estuary acidification. Improve precision and monitoring within Inland Bays.

Monitoring Program	2012 CCMP Objectives/ Monitoring Questions	2021 CCMP Objectives/ Monitoring Questions	Indicators & Measures	Data Collected	Collection Frequency	Record of Collection	Respons-ible Entity/Entitiies	Frequency of Reporting	Sharing/Reporting	Gaps & Funding Needs
Atmospheric Carbon Dioxide Concentration	CCMP: Planning for Climate Change, Objective 1 Questions: 25,27,28	Living with a Changing Climate, CC 2 Actions 2-2	Change in CO2 concentration, measured at NOAA Mauna Loa Observatory.	Mean CO2 concentration, reported as dry air mole fraction	Annually	1958 to present	NOAA Earth System Research Laboratory, Global Monitoring Division	Monthly	Data shared on NOAA website. Indicator in *State of the Delaware Inland Bays* report.	Continue status quo. Local carbon emissions data desirable.
Climate Characteristics	CCMP: Planning for Climate Change, Objective 1 Questions: 26,28	Living with a Changing Climate, CC 2 Actions 2-2	Average annual air temperature, annual rainfall, growing season length	Weather characteristics (temperature, precipitation, frost dates)	Hourly	Air temperature, precipitation: 1895 to present Growing Season Length: 1946 to present	Delaware Environ-mental Observing System (DEOS)	Daily	DEOS website. Indicator in *State of the Delaware Inland Bays* report.	Few stations in the watershed provide inadequate resolution for microclimate variations.

DATA MANAGEMENT AND QUALITY CONTROL

The data managers identified for each monitoring program (Table 3) are responsible for the following:

- Collection and analysis of data according to existing or updated monitoring plans. Changes in monitoring frequency or protocols must be communicated to the Center, and included in any updates to the *Environmental Monitoring Plan for Delaware's Inland Bays.*
- Providing data to the Center and/or its partners upon request for use in indicator reports or research projects.
- Quality Assurance Plans must be kept up to date and provided to data users (including the Center) upon request.
- All monitoring programs funded partially or in whole by the U.S. EPA must have an up to date, approved Quality Assurance Project Plan (QAPP). QAPPs are to be updated every five years. A copy of the approved QAPP must be provided to the Center for its records.

RECOMMENDATIONS FOR ADDITIONAL SUPPORTING PROGRAMS

The previous section of this plan describes high level objectives and measures of the ongoing monitoring programs in the Inland Bays and how new programs may be integrated. Many of these existing programs provide data that are used to develop the long-term indicators for the *State of the Delaware Inland Bays* reports that are published every five years by the Center.

This section of the plan provides recommendations for new monitoring programs, or enhancement of existing programs. These recommendations, developed with the original IBEMP in 2018, are made based upon critical data gaps (identified in Table 1), the availability of new methods or technologies, and/or changes needed to make programs sustainable over the long term. Some of these recommendations can potentially be met by the Center. Recommendations for new monitoring programs for the 2020 biannual update and made during this revision process were not added to the Indicators and Measures Matrix (Table 3). A summary of progress made to date for each of those indicators is included with each recommendation.

1. HYDRODYNAMIC/WATER QUALITY MODEL - H20

Recommendation*: There is a critical need for a predictive, coupled watershed, hydrodynamic, and water quality model for the Inland Bays that uses current and high-frequency data.*

2023 Update Report:

The 2020 White paper titled "Developing a Hydrodynamic/Water Quality Model for the Inland Bays: Implementation Plan" was well received and updating the HD/WQ model was incorporated into the 2021 CCMP (STAC and Walch 2020). However, efforts to fund the estimated $500,000-$1,000,000 project were not successful. The FY22/FY23 Bipartisan Infrastructure Law grant to the Center was identified as a partial funding source and in early FY23 the STAC began working on an RFP.

Progress was also made in understanding the four main priorities needed in the 2020 paper, these will be included in the RFP:

1. Better spatial coverage of high-frequency water quality measurements in the upper Indian River and tributaries, with focus on dissolved oxygen and Chlorophyll a;
2. Changes in hydrodynamics due to changes in the bathymetry of the Indian River Inlet;
3. Exchange of nutrients and oxygen between bottom sediment and the water column and the role of benthic algae;
4. Data from additional stream gages to inform a watershed loading model.

The Delaware Targeting and Planning tool, should be available soon from DNREC, and therefore the water quality portion of the modeling process was pushed to Phase 2 of implementation of this task, to allow the integration of the new tool.

2. CONTINUOUS WATER QUALITY MONITORING H20/H23

Recommendation:

Continuous monitoring networks to measure dissolved oxygen and chlorophyll should be developed and deployed in the Inland Bays, with a focus on tributaries. The Center should build upon previous work in this area and consider emerging, innovative technologies. The STAC should help guide the selection of sites and station configuration.

2023 Update Report:

The Center, working with the DNREC and USGS has now deployed 6 YSI EXO2 sonde for collection of high-frequency dissolved oxygen data and other water quality parameters. Annual monitoring at these locations now occurs from April through October.

In 2023, the Center, following guidance from the USGS, initiated transect surveys at each monitoring location to calibrate the sampling location and depth with the cross channel results. These transect surveys should occur twice a year during the sampling season.

In 2023, the Center will deploy two additional monitoring stations, with funding for a ninth station available. These stations will be deployed for a minimum of ten years. A source of long-term funding should be identified.

3. LOCAL INDICATORS OF SEA LEVEL RISE H20

Recommendation:

Expansion of the Coastal Flood Monitoring System (CFMS) into the Inland Bays will at least partly fill the need for more local indicators of climate change and sea level rise. If a successful model is developed for the Bays, it will provide a publically-accessible, real-time tool to create flood inundation potential maps and time series of forecasted tidal predictions. The CFMS itself is not meant to be a sea level rise tool, but rather its continued development is contingent

upon the availability of tidal water level data from a sensing network like the one currently deployed in the Inland Bays. The data from that same network can lend itself towards sea level rise monitoring and the development/validation of hydrodynamic models if maintained for an extended period of time.

It is recommended that support for developing this tool for the Inland Bays be continued and prioritized. A water level/flood monitoring network should be permanently installed throughout the Bays. These data are needed not only for flood alert tools, but also for development of a new hydrodynamic model for the Inland Bays.

Priority should also be given to long-term local monitoring of other indicators of climate change, such as precipitation, air temperature, and growing season length. The Inland Bays watershed experiences a range of microclimate effects, so data collected at the coast, for example, (or from outside the watershed) cannot easily be extrapolated to inland locations.

2020 Update Report:

CEMA is currently working on an expansion of the Coastal Flood Monitoring System to cover the Inland Bays and the towns along the Atlantic coastline of Sussex County. Like the Delaware Bay tool, it will include an early warning ALERTS system, storm inundation mapping for communities and important roadways, and provide flood predictions at the community level. The anticipated date for completion is September 2021. Funding for the expansion is being provided by DNREC's Division of Climate, Coastal, and Energy.

2023 Update

What is the status of CFMS

The Delaware Coastal Flood Monitoring System is operated by partners at the University of Delaware, including the State Climatologist, Delaware Environmental Observing System, Delaware Environmental Monitoring and Analysis Center and the Delaware Geological Survey. There is still broad support to understand and implement additional methods of measuring sea level rise and its impacts. The Center has proposed a holistic approach to coastal resilience that will address some of the concerns. Further exploration of methodology should be continued.

4. INDIAN RIVER INLET TIDAL FLUSHING M20

Recommendation: It is recommended that the state work with the Army Corps to repeat a standard survey every five years. Because of its interest in resiliency of coastal roadways and long-term integrity of the inlet and its bridge, DelDOT may be able to contribute to this effort.

2023 Update Report:

The Center worked with Prof. Fengyen Shi at the University of Delaware, to analyze the tidal prism with a numerical model previously developed – the nearshore community model, or NearCoM in 2021. The model shows that the estimated rate of change has slowed and the inlet is in a current dynamic equilibrium. An updated hydrodynamic model should include a survey, but that can be used to predict the trajectory of the inlet.

5. MONITORING OF OYSTER RECRUITMENT AND GROWTH IN THE BAYS M20

Recommendation:

The Center would like to see the return of a wild oyster population in the Bays.

In addition, regular, long-term surveys of oyster populations and recruitment should be developed for all three Bays. A plan for this monitoring should be a component of the Shellfish Enhancement Action Plan.

A current research project being conducted under the guidance of Dr. Gulnihal Ozbay at Delaware State University (DSU) may provide a template for this monitoring program. The focus is to develop repeatable methods that can be used later to assess the impact that aquaculture and hatchery-raised oysters have on the local wild oyster population. Components of this effort include: (a) Standardized transect surveys on riprap–armored shorelines; (b) spat collectors deployed at locations throughout the Bays; and (3) genetic analyses of spat, to determine the diversity and probable parent populations.

This should be expanded to take advantage of a strong citizen interest in the fate of Inland Bays oysters; where shoreline property owners are located, explore adding a citizen science component.

2023 Update Report:

The Center's three pilot reefs and planned additional two reefs continue to be stressed by natural recruitment. In addition, the aquaculture industry has transitioned from inception to infancy, with an estimated >431K oysters harvested from the inland bays in 2021. The importance of understanding the sources and transport of oyster larvae in the Inland Bays and the distribution and abundance of spat and adults has grown.

6. MONITORING OF SHORELINE CONDITION AND MODIFICATION M20

Recommendation:

The increased availability of aerial imagery should be used to inventory the shoreline of Little Assawoman Bay, Indian River Bay and Rehoboth Bay periodically. Ideally this would happen every five years, to correspond with release of the *State of the Delaware Inland Bay*s reports.

2023 Update Report:

Homsey is managing a graduate student to interpret aerial imagery from 2012 for Little Assawoman, as well as 2022 for all three bays. The technique will be documented so that it can be repeated in five years. As of 2023, although there is an interest in engaging citizen scientists to ground truth aerial imagery, efforts have not been successful in achieving this goal.

7. CONTINUATION OF TIDAL MARSH ACREAGE/CONDITION AS ENVIRONMENTAL INDICATORS M20/H23

Recommendation:

In order to continue to use tidal marsh acreage and extent of fractured pooling as environmental indicators for the Bays, analyses of updated aerial imagery and land cover data should be repeated at least every five years, using the established GIS methodology. The University of Delaware Water Resources Agency (WRA) is best suited, at this time, to conduct these analyses.

2020 Update Report:

The Center secured funding from Delaware Sea Grant in 2020 to support a University of Delaware student intern to update the salt marsh acreage and fractured pooling indicators for the 2021 *State of the Delaware Inland Bays* report. The intern worked under the supervision of Center staff and Andrew Homsey, Delaware Water Resources Agency, who completed the original study. The methodology followed that of the previous salt marsh acreage and condition study, but utilized new land use, aerial imagery, and wetlands layers to derive updated acreage of fractured pooling, open water, and salt marsh. The spatial analyses were finished in the fall, and the technical report was completed in 2021.

2023 Update Report:

Included in the State of the Bays report released in March 2023. Work needs to be done to identify a plan to complete an assessment by January 2026, for the 2026 State of the Bays report.

Explore if there are on the ground metrics, similar to those used in the periodic marsh assessment work that may provide an additional indicator metric.

8. RECREATIONAL BLUE CRAB AND CLAM HARVESTS M20

Recommendation:

The Division of Fish and Wildlife should develop an ongoing recreational Hard Clam and Blue Crab harvest survey in the Inland Bays similar to the MRIP survey currently used by NOAA recreational fish catch. This survey would rely on a field, 'harvester-intercept' interview survey that records catch rates for species; and a telephone (or mail survey) that is

designed to estimate effort. Average catch rates would be applied to the effort estimates to generate landings per year. These surveys would be conducted annually.

2023 Update Report:

As of 2023, no progress had been made on this recommendation. The Center is interested in exploring this metric, however no source of funding has been identified.

9. SEAGRASS SUITABILITY MONITORING H23

Recommendation:

Given the paucity of seagrass beds in the inland bays, enhancement and restoration should be considered as a management strategy. Attempts to establish seagrass beds since 1988, have not been successful, although short-term persistence has been achieved. Monitoring of potential habitats should begin to prioritize restoration efforts.

2023 Update Report:

The Center piloted an approach to habitat suitability monitoring in 2022 which will be implemented at five potential locations in 2023. In addition, the Center has identified at least one donor source for seed. The Center should continue to locate seed donor sites and explore restoration methodologies as well as potential restoration sites. In addition, understanding the historic conditions may provide insight into the predicted conditions in near term climate change.

10. EXPANSION OF NUTRIENT INPUT MONITORING IN TRIBUTARIES H23

Recommendation:

A gap in nutrient inputs in Little Assawoman has been identified. In addition, as a hydrodynamic model is updated, a water quality model is anticipated in the next several years. Identifying gaps and areas where additional nutrient input information is needed will enhance the understanding and output of those models.

2023 Update Report:

The tributaries with no nutrient input data are known. No additional action has been taken at this time.

11. FOREST QUALITY ASSESSMENT H23

Recommendation:

The Center, and others, have focused on reforestation to improve upland management of nutrient inputs. Traditional reforestation approaches take many years to mature and may have ancillary benefits in addition to water quality. Understanding the condition of existing forest resources and how to restore the highest level of desired ecosystem services will increase the return on investment.

2023 Update Report:

The Center had drafted a QAPP for reforestation based on planting survival. This should be expanded to include service delivery of at least nutrient metrics.

12. LIVING RESOURCE METRICS M23

Recommendation:

DNREC teams monitor individual species responses across the inland bays. The Center also has annual monitoring of near shore fish and crabs and horseshoe crabs, as well as terrapins. An integrated approach and selection of recorded metrics could be incorporated into this plan.

2023 Update Report:

The Center has QAPPs on horseshoe crab, nearshore fish and crab and terrapin metrics. DNREC teams have shifted some of their living resource metrics and these should be recalibrated with *State of the Bays* indicators moving forward.

13. EMERGING CONTAMINANT FOCUS: PLASTICS M23

Recommendation:

Plastic and microplastic pollution has become recognized as an established contaminant.

2023 Update Report:

More information and direction is needed from EPA to understand the Inland Bays role in the global plastic contamination. However, work by Cohen in the Delaware Estuary has been closely monitored and results should have a high degree of transferability. Center Outreach & Education staff have adopted Plastics as a priority subject area and have led clean-ups, outreach efforts and advocacy efforts.

14. DISEASE LOAD IN AQUACULTURE OYSTERS/WILD OYSTERS M23

Recommendation:

With the increase in aquaculture oysters in the Inland Bays, what effect is there on disease load? Would a sustainable wild oyster population negatively impact the economic resource?

2023 Update Report:

Current wild oyster populations in the inland bays are few and far between and threatened by spat availability. The Center is monitoring information gathered from a study on this topic from Long Island sound for transferability.

REFERENCES

Appledorn, M.V., and M.E. Baker. 2011. Report to the Delaware Center for the Inland Bays: Methodological Description and Medium-Resolution Results of Spatial and Temporal Changes Riparian Buffers and Implications for Stream Nitrate Concentrations. University of Maryland, Baltimore County, February 2, 2011.

Baker, M.E., D.E. Weller, and T.E. Jordan. 2006. Comparison of Automated Watershed Delineations: Effects on Land Cover Areas, Percentages, and Relationships to Nutrient Discharge. Photogrammetric Engineering and Remote Sensing 72(2):159-168.

Batiuk, R., P. Bergstrom, M. Kemp, E. Koch, L. Murray, C. Stevenson, R. Bartleson, V. Carter, N. Rybicki, J. Landwehr, C. Gallegos, L. Karrh, M. Naylor, D. Wilcox, K. Moore, S. Ailstock, and M. Teichberg. 2000. Chesapeake Bay submerged aquatic vegetation water quality and habitat-based requirements and restoration targets: A second technical synthesis. CBP/TRS 245/00. EPA/903/R-00/014. Annapolis, MD: U.S. Environmental Protection Agency, Chesapeake Bay Program.

Borsum, S. 2018. Genetics and monitoring of the eastern oyster Crassostrea virginica within Delaware Inland Bays. Master's Thesis, Delaware State University, December 2018, 64 pp.

Brady, D.C. 2014. TMDL Model and Data Evaluation for Delaware's Inland Bays: Modeling Diel-cycling Hypoxia in Delaware's Inland Bays.

CB&I Environmental & Infrastructure, Inc. 2014. Long Term Stewardship Plan Burton Island Historical Ash Disposal Area Indian River Generating Station Dagsboro, Delaware, DNREC Site Number DE-1399. CB&I Project No. 1009684052, Prepared for Indian River Power LLC, October 2014, 34 pp.

Cerco, C. F., B. Bunch, M. A. Cialone, and H. Wang. 1994. Hydrodynamic and Eutrophication Model Study of Indian River and Rehoboth Bay, Delaware. U.S. Army Corps of Engineers, Vicksburg, MS.

Cerco, C. F. and M. R. Noel. 2005. Incremental improvements in Chesapeake Bay Environmental Model Package. Journal of Environmental Engineering-ASCE 131:745-754.

Cerco, C. F. and S. P. Seitzinger. 1997. Measured and modeled effects of benthic algae on eutrophication in Indian River Rehoboth Bay, Delaware. Estuaries 20:231-248.

Cohen, J.H., A.M. Internicola, R.A. Mason, and T. Kukulka. 2019. Observations and Simulations of Microplastic Debris in a Tide, Wind, and Freshwater-Driven Estuarine Environment: the Delaware Bay. Environ. Sci. Technol. 53(24):14204-14211.

Cormier, S., S. Norton, G. Suter, and D. Reed-Judkins. Stressor Identification Guidance Document. U.S. Environmental Protection Agency, Washington, DC, EPA/822/B-00/025, 2000.

Coxe, R. 2011. Historical Analysis and Map of Vegetation Communities, Land Covers, and Habitats of Thompson Island Nature Preserve, Sussex County, Delaware: Lewes and Rehoboth Canal and Rehoboth Bay Watersheds. Delaware Natural Heritage and Endangered Species Program, November 17, 2011, 93 pp.

Coxe, R. 2012a. Historical Analysis and Map of Vegetation Communities, Land Covers, and Habitats of Assawoman Wildlife Area, Sussex County, Delaware: Little Assawoman Bay and Indian River Bay Watersheds. Delaware Natural Heritage and Endangered Species Program, July 12, 2012, 289 pp.

Coxe, R. 2012b. Historical Analysis and Map of Vegetation Communities, Land Covers, and Habitats of Delaware Seashore State Park, Sussex County, Delaware: Indian River Bay, North Atlantic Strand and Rehoboth Bay Watersheds. Delaware Natural Heritage and Endangered Species Program, July 23, 2012, 261 pp.

Coxe, R. 2012c. Historical Analysis and Map of Vegetation Communities, Land Covers, and Habitats of Fenwick Island State Park, Sussex County, Delaware: Assawoman Bay, Little Assawoman Bay, and Southern Atlantic Strand Watersheds. Delaware Natural Heritage and Endangered Species Program, July 24, 2012, 182 pp.

Coxe, R. 2012d. Historical Analysis and Map of Vegetation Communities, Land Covers, and Habitats of Cape Henlopen State Park, Sussex County, Delaware: Breakwater Harbor, Broadkill River, Lewes-Rehoboth Canal, North Atlantic Strand, and Rehoboth Bay Watersheds. Delaware Natural Heritage and Endangered Species Program, October 8, 2012, 289 pp.

Coxe, R. 2013. Historical Analysis and Map of Vegetation Communities, Land Covers, and Habitats of the James Farm Ecological Preserve, Sussex County, Delaware, 1954-2012: Indian River Bay. Delaware Natural Heritage and Endangered Species Program, October 28, 2013 (updated September 11, 2014), 158 pp.

Delaware Center for the Inland Bays. 2004. Delaware Inland Bays' environmental indicators. Rehoboth Beach, DE.

Delaware Department of Natural Resources and Environmental Control. 2008. Delaware Wetland Conservation Strategy.

Delaware Center for the Inland Bays. 2011. State of the Delaware Inland Bays. Rehoboth Beach, DE. 63 pp.

Delaware Center for the Inland Bays. 2012. Addendum to the Delaware Inland Bays Comprehensive Conservation and Management Plan. 58 pp. https://www.inlandbays.org/wp-content/documents/Final%209-27-12%20CIB%20CCMP.pdf

Delaware Center for the Inland Bays. 2016. State of the Delaware Inland Bays. Rehoboth Beach, DE. 70 pp.

Delaware Department of Natural Resources and Environmental Control's Whole Basin Management Team. 2001. Inland Bays/Atlantic Ocean Basin assessment report. Doc. 40- 01/01/01/02. Dover, DE.

Delaware Department of Natural Resources and Environmental Control. 2008. Inland Bays pollution control strategy. Dover, DE.

Delaware Department of Natural Resources and Environmental Control. 2011. Delaware Wetland Monitoring Strategy. Dover, DE, March 2011.

Delaware Department of Natural Resources and Environmental Control. 2015. State of Delaware Draft 2016 Assessment, Listing and Reporting Methodologies Pursuant to Sections 303(d) and 305(b) of the Clean Water Act.

Delaware Department of Natural Resources and Environmental Control. 2020. 2019 Delaware Inland Bays shellfish aquaculture report: Planting, harvest, and survey of participants. Division of Fish & Wildlife, Dover, DE, February 2020, 4 pp.

Delaware Sea Level Rise Advisory Committee. 2011. Preparing for Tomorrow's High Tide. A progress report of the Delaware Sea Level Rise Advisory Committee to the Delaware Coastal Programs Office, Delaware Department of Natural Resources and Environmental Control, Dover, DE.

Delaware State Game and Fish Commission, State Park Commission, State Planning Office, Marine Laboratories of the University of Delaware, Water and Air Resources Commission, and Delaware Geological Survey. 1969. Environmental study of the Rehoboth, Indian River and Assawoman Bays. Presented to Governor Russell W. Peterson. Department of Natural Resources and Environmental Control, Dover, DE.

Entrix Inc., J.E. Edinger Associates Inc., and Gahagan and Bryant Associates Inc. 2004. Hydrodynamic and wter quality modeling and feasibility analysis of Indian River, Rehoboth Bay and Little Assawoman Bay: Delaware's Inland Bays Flushing Study Project.

FDA. 1998. Bacteriological Analytical Manual, 8th Edition, Revision A. Online version https://www.fda.gov/Food/FoodScienceResearch/LaboratoryMethods/ucm2006949.htm.

Gibson, J. R., M. T. Barbour, J. B. Stribling, J. Gerritsen, and J. R. Karr. 1996. Biological criteria—technical guidance for streams and rivers, revised edition. EPA 822-B-96-001, Office of Water, U.S. Environmental Protection Agency, Washington, D.C., USA.

Greene, R. 2013. Assessment of Biota and Sediment Data Collected by the Center for the Inland Bays in Conjunction with the Burton Island Bioaccumulation Study. Delaware Department of Natural Resources and Environmental Control, Dover, DE, May 10, 2013, 26 pp.

Hess, G. K., R. L. West, M. V. Barnhill III, and L. M. Fleming. 2000. The Birds of Delaware. University of Pittsburgh Press, Pittsburgh, Pa. 635.pp

Jacobs, A., A. Rogerson, D. Fillis, and C. Bason. 2009. Wetland condition of the Inland Bays watershed. Volume 1. Delaware Department of Natural Resources and Environmental Control, Watershed Assessment Section, Dover, Delaware, USA.

Jacobs, A.D. 2010. Delaware Rapid Assessment Procedure Version 6.0. Delaware Department of Natural Resources and Environmental Control, Dover, DE. 36pp.

Jo, Y. H., K. R. Philipp, R. T. Field, A. R. Homsey, C. Bason, and K. Somers. 2014. Acreage and condition trends for marshes of Delaware's Inland Bays as an environmental indicator and management tool: A report to the Center for the Inland Bays to identify and document recent trends in the salt marshes of Rehoboth, Indian River and Little Assawoman Bays.

Moulton S. R., J.G. Kennen, R. M. Goldstein, J. A. Hambrook. 2002. Revised Protocols for sampling algal, invertebrate, and fish communities as part of the National Water Quality Assessment Program. United States Geological Survey, Open-File Report 02-150. Reston Virginia Office

Munroe et al., 2017. Early post-settlement growth in Wild eastern oyster (*Crassostrea virginica* Gemlin 1791) populations. Estuaries and Coasts 40:880-888.

Price, K.S., L.M. Valdes, B. Glazer, R. Tyler, S. Runyan, and M. Timmons. 2001. An examination of the use of the biological communities as indicators of nutrient enrichment in Middle Atlantic Coastal Estuaries-Delaware Component Final Report 1998-1999. Submitted to the Delaware Center for the Inland Bays. University of Delaware, Lewes, DE.

Rattner, B., T.G. Bean, R.S. Lazarus, P.C. McGowan, D.D. Day, R.W. Scarborough, and K. Fleming. 2017. Contaminant Exposure and Productivity of Osprey (*Pandion haliaetus*) Nesting in Delaware Bay and River in 2015. Proceedings Delaware Estuary Science and Environmental Summit 2017, Cape May, NJ, January 22-25, 2017, p.86.

Riedel, G., and B. Wilson. 2013. Final Report: Assess the Potential for Accumulation of Toxic Trace Elements in Biota near Burton Island Ash Disposal Site Indian River Bay, Delaware. Delaware Center for the Inland Bays, Rehoboth Beach, Delaware, 78 pp.

Rogerson, A., A. Howard, and A. Jacobs. 2009. Wetlands condition of the Inland Bays watershed. Volume 2. Delaware

Department of Natural Resources and Environmental Control, Watershed Assessment Section, Dover, Delaware USA.

Scarborough, R.W., and M.G. Mensinger. 2005. Evaluation of the Storm Water Sediment Control Forebay at Anchorage Canal, South Bethany, DE. Delaware Department of Natural Resources and Environmental Control, report submitted to the Delaware Department of Transportation, August 2005.

Scientific and Technical Advisory Committee and Walch, M. 2020. Developing a Hydrodynamic/Water Quality Model for the Inland Bays: Implementation Plan. White Paper prepared for the Delaware Center for the Inland Bays. 16 pages.

Shaw, 2008. Facility Evaluation Report, Indian River Generating Station, Burton Island Old Ash Landfill, Millsboro, Delaware, Site Number DE-1399. March 2008.

State of Delaware, 2014. Surface Water Quality Standards: Title 7 Natural Resources and Environmental Control, Delaware Administrative Code - 7401

Tyler, R.M., D.C. Brady, and T.E. Targett. 2009. Temporal and spatial dynamics of diel-cycling hypoxia in estuarine tributaries. Estuaries and Coasts 32(1):123-145.

Ullman, W.J., J.R. Scudlark, and J.A. Volk. 2010. Standard Operating Procedure for the Calculation of N and P Deposition from the Atmosphere to Waters of Delaware's Inland Bays. Report to the Center for the Inland Bays, July 2010. University of Delaware School of Marine Science Policy and the Delaware Department of Natural Resources and Environmental Control, Lewes, DE. 11 pp

U.S. Environmental Protection Agency. 1997. *Field and Laboratory Methods for Macroinvertebrate and Habitat Assessment of Low Gradient, Nontidal Streams*. Mid-Atlantic Coastal Streams (MACS) Workgroup, Environmental Services Division, Region 3, WV. 23 pp

Valdes-Murtha, L. 1997. Analysis of critical habitat requirements for restoration and growth of submerged vascular plants in the De3wlaware and Maryland Coastal Bays. M.S. Thesis, College of Marine Studies, University of Delaware.

Weston. 1995. Appendix F. Characterization report. A study of the status and trends in the Inland Bays. Delaware Inland Bays Comprehensive Conservation and Management Plan. Delaware Inland Bays program.

APPENDIX A

2021 Comprehensive Conservation and Management Plan

ADDENDUM ACTIONS AND PERFORMANCE MEASURES

Index of Actions

LIVING WITH A CHANGING CLIMATE			
Objective 1: Increase community and local government understanding and help prepare communities for potential impacts of the changing climate through mitigation and adaptation actions.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
CC 1-1: Develop and implement projects, programs, and policies that encourage and support communities and governments to mitigate and adapt to the high climate change risks identified in the Vulnerability Assessment.	DNREC, Center (Lead); SCAT, CAC (Supporting)	Number of projects and programs developed and offered. Number of policy initiatives introduced on mitigation and adaptation. Demonstrate quantifiable risk reductions within the time period of this CCMP.	Ongoing.
CC 1-2: Educate the public about the benefits of and promote the use of renewable energy including wind, solar, and other sources.	DNREC (Lead); Center, CAC (Supporting)	Number of publications and educational materials produced on the benefits of renewable energy annually.	Ongoing.
Objective 2: Use research, monitoring, and modeling to analyze and project climate change impacts to the Inland Bays watershed.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
CC 2-1: Expand the Coastal Flood Monitoring System to the Inland Bays to provide a publicly-accessible, real-time tool to create flood inundation potential maps and time series of forecasted tidal predictions.	DNREC (Lead); STAC, Center (Supporting)	Online tool developed and active.	Tool developed by 2022 and maintained.
CC 2-2: Monitor the chemical, physical, and biological characteristics in the Bay to determine climate change impacts such as ocean acidification and take actions to help mitigate those impacts and communicate results to the public.	DNREC, Center (Lead); STAC (Supporting)	Results from monitoring efforts are shared with the public through various media including, but not limited to, press releases, social media posts, journal articles.	Results shared when they become available.

CC 2-3: Encourage municipalities within the Inland Bays watershed and Sussex County to complete a comprehensive climate change vulnerability assessment which identifies mitigation and adaptation strategies.	SCAT, Sussex County (Lead); DNREC (Supporting)	Percent of municipalities in the Inland Bays that complete a comprehensive vulnerability assessment. Number of strategies implemented once municipality completes assessment.	By 2030, 75% of municipalities in the Inland Bays watershed will have completed a vulnerability assessment.
CLEAN WATERS: HEALTHY AGRICULTURAL LANDSCAPES			
Objective 1: Broaden partnerships within the agricultural community.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
AG 1-1: Utilize the CCMP Implementation Committee to engage new and existing partners and improve implementation and tracking of agricultural best management practices and technology transfer.	Center (Lead); DNREC, DDA, SCD (Supporting)	Improved comprehensive tracking and implementation of agricultural BMP implementation.	Tracking system identified by 2022 and in use by 2023. Committee works to enter BMP information into tracking system annually. Complete an update of the PCS Assessment by 2024.
AG 1-2: Promote and celebrate those in the agriculture sector who are good stewards of the environment.	DDA, SCD (Lead)	Members of the agricultural sector are recognized publicly for their innovation and BMP implementation.	Annual recognition of three farmers.
AG 1-3: Conduct educational programs for the general public on best management practices employed by the agricultural sector to protect clean water and habitat.	DDA, SCD (Lead)	Number of individuals that attend programming.	Two programs hosted annually. Goal of 50 people reached.
Objective 2: Reduce nutrient and sediment loads and other contaminants entering waterways from agriculture.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
AG 2-1: Advance innovative technologies and agricultural practices that reduce nonpoint pollution from farming operations.			
AG 2-1a: Encourage agricultural utilization of treated wastewater where practicable.	SCD, DDA (Lead); STAC (Supporting)	Number of acres utilizing treated wastewater effluent on an "on demand" basis for optimum crop growth.	Ongoing.

AG 2-1b: Encourage on-farm research on nutrient best management practices with farmers.	SCD (Lead); STAC (Supporting)	Number of on-farm research opportunities annually.	Goal of 3 research opportunities by 2029.
AG 2-1c: Encourage the use of the 4R nutrient stewardship approach (right time, right place, right rate, right source) to reduce nutrient losses from cropland.	DDA (Lead)	Number of farms utilizing 4R nutrient stewardship approach.	60% of available cropland treated using 4R nutrient stewardship approach annually.
AG 2-1d: Support the development of and promote diversification of cropping systems that result in improved water quality as opportunities arise.	Center (Lead), DDA, SCD (Supporting)	Percentage of cropland with non-traditional crop rotations resulting in water quality improvement.	Ongoing. Assess opportunities for support every two years.
AG 2-2: Develop and implement a project plan to achieve the Agricultural Actions of the Inland Bays Pollution Control Strategy.	Center (Lead); SCD, DDA, DNREC (Supporting)	A detailed project plan with location, description, and estimated cost is completed. Number of projects completed annually from the Project Plan once completed.	Project plan completed by 2025. Implementation completed 5-7 years after plan is completed.
AG 2-2a: Increase the amount of cover crops planted annually in the Inland Bays watershed.	SCD (Lead)	Number of acres of cover crops planted annually.	Ongoing - goal of 60% of available acres planted annually.
AG 2-2b: Continue to use and support the construction of poultry manure storage sheds, composters, and animal mortality freezers.	SCD (Lead)	Number of new poultry manure storage sheds and composters constructed and used annually.	Ongoing - goal of 50 additional structures built. As of 2016 PCS Assessment, 28 structures have already been constructed.
AG 2-2c: Relocate poultry manure from the watershed and put into alternative use and encourage participation by integrators.	DDA (Lead)	Number of pounds of manure relocated and put into alternative uses annually.	Ongoing - goal of 20,909 tons of manure relocated annually or put into alternative use.
AG 2-2d: Implement additional water control structures to treat cropland and maintain the 1,530 acres currently treated by these structures.	SCD (Lead)	Number of acres treated by water control structures.	Ongoing.

AG 2-3: Encourage cost share providers to prioritize assistance for the highest priority BMPs.	Center (Lead); DNREC, SCD, DDA (Supporting)	Provide expertise that encourages how cost share dollars are spent when opportunities arise. Track cost share dollars spent annually.	Ongoing.
AG 2-4: Continue County-level cost sharing for voluntary nutrient management practices.	Sussex County (Lead)	Dollars appropriated by the County for cost-share for voluntary nutrient management practices.	Reported annually.
Objective 3: Protect and restore natural ecosystems in the agricultural landscape.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
AG 3-1: Plant riparian forested and grassed buffers.	Center, SCD (Lead); DNREC (Supporting)	Total number of acres of forested and grassed buffers planted.	Goal of 3,246 acres of riparian forest buffer and 1,772 acres of grassed buffers.
AG 3-2: Implement the Watershed Reforestation Plan for the Inland Bays.	Center, SCD (Lead); DNREC (Supporting)	Number of acres of trees planted on cropland included in the Plan.	Watershed Reforestation Plan fully implemented by 2025.
AG 3-3: Restore wetlands in areas that were previously converted to cropland.	SCD (Lead); Center (Support)	Number of acres of wetlands restored that were previously converted to cropland.	Ongoing - goal of 4,175 acres restored. Restoration opportunities identified through planning exercise by 2025.
AG 3-4: Restore streams in the Inland Bays watershed.	Center, SCD (Lead)	Linear feet of streams restored.	Identify areas for restoration by 2026. Restoration ongoing once identified.
CLEAN WATERS: REDUCING POLLUTION FROM THE DEVELOPED LANDSCAPE			
Objective 1: Conduct education and outreach to encourage management practices that limit pollution from nutrients, sediments, and other contaminants.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
DL 1-1: Continue certification and education of commercial nutrient managers for lawns.	DDA (Lead)	Number of commercial nutrient managers certified annually.	Ongoing.
DL 1-2: Educate homeowners and HOAs on the wise use of fertilizer to reduce nutrient runoff from lawns.	Center (Lead); DDA (Supporting)	Number of people reached through educational programming/materials.	Educational materials (presentation, flyers, targeted social media, journal articles, etc.) produced annually.

DL 1-3: Continue public education on the economic and environmental benefits of central sewerage.	Center (Lead); Sussex County (Supporting)	Number of individuals educated on the economic and environmental benefits of central sewerage.	Educational materials (presentation, flyers, targeted social media, journal articles, etc.) produced annually.
DL 1-4: Conduct an education campaign on the proper maintenance and replacement of septic systems.	DNREC (Lead); Center (Supporting)	Number of individuals educated on septic system maintenance and replacement.	Campaign initiated by 2027.
DL 1-5: Regularly report on the implementation of regulations for small on-site wastewater systems to the CCMP Implementation Committee.	DNREC (Lead)	A report is updated and presented to the CCMP Implementation Committee.	Annual report.
Objective 2: Reduce the amount of nutrients, sediments, and other contaminants entering waterways from wastewater sources.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
DL 2-1: Develop a wastewater planning committee comprised of DNREC, Sussex County, utility industry representatives, and other stakeholders to coordinate the treatment and disposal of wastewater from new and existing developments based on the TMDLs of receiving waters.	Center (Lead); DNREC, Sussex County (Supporting)	A Wastewater Planning Committee is formed with key partners and meets regularly.	Committee formed by 2023. Once formed, the Committee will decide how to handle the issue of wastewater planning, whether through the creation of a plan or other method.
DL 2-2: Enforce the waters of Exceptional Recreational and Ecological Significance (ERES) provisions of the State Water Quality Standards requiring the least environmentally damaging disposal alternatives for wastewater.	DNREC (Lead)	ERES provisions are enforced through inclusion in wastewater disposal permitting.	ERES provisions included in permitting process by 2030.
DL 2-3: Develop a nutrient budget for wastewater to determine existing and projected loads to receiving waters and report biannually; Explore the need for annual updates.	DNREC, STAC (Lead); Sussex County, Center (Supporting)	Nutrient budget for wastewater is developed and reporting is completed biannually, or annually if determined necessary.	Nutrient budget developed by 2027.

DL 2-4: Improve treatment levels at two Sussex County wastewater treatment facilities managing for improved nutrient retention, wildlife habitat, and recreation where practicable.	Sussex County (Lead); Center (Supporting)	Improve nutrient removal percentage at the Inland Bays wastewater treatment facility by 10% over the next permit cycle.	Reforestation of 360 acres of agricultural lands where treated wastewater is applied at the Wolfe Neck Regional Wastewater Facility completed by 2026. Reforestation of 60 acres of cropland at the Inland Bays Regional Wastewater Facility completed by 2026. Upgrades to both treatment plants ongoing.
DL 2-5: Continue septic system remediation and conversion projects in the Inland Bays' 10-digit hydrologic unit codes with emphasis on projects within 1,000 feet of the mean high-water line of any tidal waterbody, tidal stream, or tidal marsh.	Sussex County (Lead)	Number of equivalent dwelling units transferred to central sewerage annually.	Ongoing.
DL 2-6: Research the attenuation of nutrients and contaminants released from County-owned wastewater systems along flow paths to receiving waters.	Sussex County, STAC (Lead)	Research is coalesced and used to refine loading estimates to receiving waters and influence management activities.	Research completed by 2028.
DL 2-7: DNREC requires that applications for new or renewed groundwater discharge permits for wastewater clearly demonstrate how discharges affect nutrient loading and contribute to meeting TMDL reductions for the ultimate receiving waterbodies.	DNREC (Lead)	Permit application requirement added.	Requirement added by 2025.
DL 2-8: Explore the development of a nutrient trading or offset districts for wastewater.	Center, Sussex County, DNREC (Lead)	Stakeholders meet and discuss developing nutrient trading or offset districts for wastewater and make determination.	Stakeholders begin discussions by 2023. Determination on whether to develop a nutrient trading or offset district for wastewater made within two years of beginning discussions.

Objective 3: Reduce the amount of nutrients, sediments, and other contaminants entering waterways from stormwater sources.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
DL 3-1: Establish stormwater management offset districts to improve water quality and stormwater permit compliance efficiency.	Sussex County (Lead); SCD, Center (Supporting)	Stormwater management offset districts and associated bank are established.	Stormwater management offset districts established by 2021.
DL 3-2: Achieve actions that reduce the amount of effective impervious surface within the Inland Bays watershed.			
DL 3-2a: County and municipalities consider ordinances that minimize new and reduce existing impervious surfaces.	SCAT (Lead); Center, Sussex County, DNREC (Supporting)	Number of ordinances considered and/or adopted.	Ongoing.
DL 3-2b: Develop a plan to create stormwater retrofits to work toward a goal of treating 4,500 acres of urban and residential lands developed pre-1990.	DNREC, SCAT, Sussex County, Center (Lead)	Plan is developed. Number of acres developed pre-1990 treated by stormwater retrofits.	Plan is developed by 2024. Implementation of plan is ongoing - goal to treat 4,500 acres.
DL 3-3: Explore new ordinances to address the sale and use of fertilizers to reduce nutrient pollution from lawn application.	Center, DDA (Lead)	Number of policy changes explored that would reduce nutrient pollution from lawn fertilizer.	Ongoing.
DL 3-4: Develop a nutrient budget for stormwater to determine existing and projected loads to receiving waters and report biannually; Explore the need for annual updates.	Center, STAC (Lead); Sussex County, DNREC (Supporting)	Nutrient budget for stormwater is developed and reporting is completed biannually, or annually if determined necessary.	Nutrient budget developed by 2027.
DL 3-5: Hold MS4 roundtables to explore cost effective and coordinated approaches to meeting permit requirement should the 2020 Census indicate an MS4 permit designation is possible.	Center (Lead); Sussex County, SCAT, DNREC (Supporting)	Partners convene a discussion on cost-effective and coordinated approaches to meeting MS4 permit requirements, should it be deemed necessary.	Roundtable discussion convened by 2024, should it be deemed necessary.

HEALTHY BAY ECOSYSTEMS: PROTECT AND RESTORE THRIVING HABITATS FOR ABUNDANT FISH AND WILDLIFE			
Objective 1: Continue to use research, monitoring, and modeling to capture trends that can provide information to help protect and restore prime habitat for fish and wildlife particularly in light of the CCVA findings.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
HB 1-1: Update the Inland Bays estuarine water quality and hydrodynamic model.	STAC (Lead); Center, DNREC (Supporting)	Updated model(s) populated with best available data are functional.	Implementation plan developed in 2020. All plan components implemented by 2025.
HB 1-2: Update the Inland Bays watershed nutrient loading model.	STAC (Lead); Center, DNREC (Supporting)	Updated model populated with best available data is functional.	Model developed by 2023.
HB 1-3: Utilize updated estuarine and watershed models to evaluate if existing TMDLs are adequate to achieve water quality standards for nitrogen and phosphorus.	DNREC (Lead); Center, STAC (Supporting)	Report produced.	Report produced by 2030.
HB 1-4: Monitor the distribution of bay grasses to inform potential restoration projects, and if monitoring shows insufficient or decreasing bay grass coverage, take action to increase the acreage.	Center, STAC, DNREC (Lead)	Bay grass monitoring plan developed; Report including data/maps of areas of Bays with habitat characteristics supportive of reestablishment of SAV species produced.	Monitoring plan within two years; Water Quality Index for eelgrass updated with 2021 *State of the Bays* report; restoration suitability GIS model and report completed by 2022. Bay grass monitoring completed annually.
HB 1-5: Develop an Inland Bays Habitat Plan to protect and restore critical habitats in the Inland Bays watershed.	Center (Lead); DNREC, STAC, SCD, DDA (Supporting)	Habitat Plan produced. Number of acres or linear feet of habitat restored or protected.	Plan produced by 2024. Implementation of plan ongoing once complete.
Objective 2: Enhance and restore fish populations and their habitats in the Inland Bays.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
HB 2-1: Provide access for native migratory fish to upstream areas for use as spawning and/or nursery sites.	Center (Lead)	Number of fish passage projects completed. Number of miles of fish habitat restored.	Burton Pond dam project will be completed by 2024. Additional sites explored for more fish passage projects.

HB 2-2: Conduct education and outreach efforts on the importance of migratory fish and the benefits of fish passage restoration.	Center, DNREC (Lead)	Number of publications and/or educational materials produced, including brochures, social media campaigns, videos, infographs, etc. specifically targeting migratory fish and fish passage restoration.	Ongoing.
HB 2-3: Advocate for ecosystem-based management of fisheries.	Center (Lead)	Number of comments on management plans submitted.	Ongoing,
Objective 3: Maximize the amount of natural Inland Bays shoreline.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
HB 3-1: Conduct an education and outreach program on shoreline function and management alternatives for shoreline property owners.	Center (Lead); DNREC (Supporting)	Number of education and outreach materials produced, including guidebooks, social media posts, blog posts, brochures, etc., targeting shoreline function and management alternatives.	Ongoing, waterfront property owner's manual produced by 2021.
HB 3-2: Continue conducting living shoreline demonstration projects to encourage widespread use of this practice.	Center (Lead); DNREC (Supporting)	Create a minimum of six demonstration living shorelines in study area.	Demonstration living shoreline projects completed by 2025.
HB 3-3: Convene a stakeholder group to explore policy changes needed to require that living shoreline techniques be employed where feasible for shoreline stabilization.	Center (Lead), DNREC (Supporting)	Report developed by stakeholder group.	Stakeholder group convened by 2025. Report completed by 2026.
HB 3-4: Consider and review ways to reduce the burden for implementing living shorelines for home/landowners as opposed to installing hard structures.	DNREC (Lead)	Review is completed.	Review completed within by 2026.

Objective 4: Increase regulatory protections for wetlands and restore previously lost wetlands.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
HB 4-1: Educate on the benefits of regulating freshwater wetlands, including isolated wetlands, under state jurisdiction and permitting.	Center (Lead)	Technical expertise provided when needed to support the regulation of freshwater wetlands under state jurisdiction and permitting.	Ongoing. Technical expertise provided as opportunities arise.
HB 4-2: Work to reduce the continued loss of wetlands and reverse these loss trends by implementing projects to mitigate for previously lost wetlands and adapt to future rising sea-levels.	Center, DNREC (Lead); SCAT (Supporting)	Number of acres of restored wetlands.	Identify areas for restoration by 2027. Restoration ongoing as sites are identified and funding secured.
Objective 5: Enhance populations of eastern oysters and other shellfish species.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
HB 5-1: Implement the Shellfish Enhancement Plan.	Center (Lead)	Number of acres of oyster reefs established.	Phase 2 of Plan implementation completed by 2027.
HB 5-2: Educate about the environmental benefits of wild shellfish populations and shellfish farming.	Center, DNREC (Lead)	Number of education and outreach materials, including workshops, brochures, booklets, social media posts, blog posts, etc. produced on the benefits of wild shellfish populations and shellfish farming produced.	Ongoing. One publication biennially.
HB 5-3: Provide technical assistance for shellfish aquaculture.	DNREC (Lead); STAC (Supporting)	Technical guidance specific to the Inland Bays is published and available to shellfish farmers.	Ongoing. At least one meeting/forum or publication annually.
HB 5-4: Increase acreage of Bay bottom approved for shellfish harvest when microbial water quality, potential pollution, and conflicts with other natural resources allow.	DNREC (Lead)	Number of acres reclassified from closed to approved or seasonally approved.	Ongoing.

HB 5-5: Report the number and acreage of shellfish aquaculture leases, the number of each species harvested, and the value paid for the product at harvest by species annually.	DNREC (Lead)	Report produced as Personally Identifiable Information rules allow.	Annually.
Objective 6: Control the spread of invasive species within the Bays and their watershed.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
HB 6-1: Manage terrestrial and aquatic ecosystems to remove invasive species and prevent their establishment.	Center, DNREC, SCD (Lead)	Acres of invasive species removed annually.	Treat a minimum of 25 acres of invasive species each year.
HB 6-2: Educate property owners and bay users about the impacts of invasive species and how to control them.	Center (Lead); CAC (Supporting)	Number of educational materials produced.	Ongoing; Educational information produced when an invasive control project is completed.
HB 6-3: Support policies that prohibit the sale of invasive species.	Center (Lead)	Invasive species are prohibited from being sold for private and public use.	Produce a policy brief of the status and impacts of invasive species in the watershed by 2022. Provide expertise on best management practices as opportunities arise as it relates to invasive species.
COORDINATED LAND AND WATER USE DECISIONS			
Objective 1: Increase and improve water access and waterway management.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
CM 1-1: Increase opportunities for the public to access the water for recreation.			
CM 1-1a: Develop a comprehensive public water access inventory and water use map for the Inland Bays.	Center (Lead); DNREC (Supporting)	Inventory and map produced.	Completed by 2023.
CM 1-1b: Develop a plan to improve and provide additional public water access focused on low-impact recreation and education to the public of where current access is located.	Center (Lead); DNREC, County, SCAT (Supporting)	Additional public water access points are identified. Existing public access points are improved if needed. Plan developed and published.	Plan is produced by 2025. Plan implemented by 2030.

CM 1-2: Improve waterway and sediment management.			
CM 1-2a: Continue to develop dedicated and sustainable finances for waterway and sediment management.	DNREC (Lead)	Dedicated and sustainable finances for waterway and sediment management are developed and implemented.	Ongoing.
CM 1-2b: Increase the beneficial reuse of sediment to enhance shorelines and tidal wetlands.	DNREC (Lead); Center, SCAT (Supporting)	Tons of sediment used in wetland enhancement and living shoreline projects.	Ongoing.
CM 1-2c: Develop an Inland Bays regional sediment management project plan for Indian River and Little Assawoman Bay.	DNREC (Lead); Center (Supporting)	Regional sediment management project plan produced.	Plan developed by 2025. Implementation timeframe based on the number of projects and available funding.
CM 1-2d: Review current no-wake areas to determine and carry out a plan to designate and mark additional sensitive areas.	Center, DNREC (Lead)	Additional sensitive areas are identified. A plan to designate and mark identified sensitives areas is explored and carried out if possible.	Current no-wake areas reviewed by 2024 and additional sensitive areas identified. Plan to designate and mark additional sensitive areas carried out if possible by 2027.
Objective 2: Increase sustainable growth practices to reduce environmental impact.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
CM 2-1: Conduct tech transfer workshop(s) with municipalities on impervious surface limits.	Center, DNREC (Lead); SCAT, STAC (Supporting)	Municipalities implement impervious surface limits.	Minimum of two tech-transfer workshops held before 2026.
CM 2-2: Convene a stakeholder group to explore a transfer of development rights program that results in incentives for the preservation of environmentally sensitive areas and incentives for growth designated areas.	Center (Lead), Sussex County (Supporting)	Stakeholder group formed with regular meetings.	Stakeholder group convened by 2024.

CM 2-3: Convene a stakeholder group composed of members of the conservation community to develop a natural lands habitat protection strategy that will establish priorities and actions in the Inland Bays watershed.	Center, Sussex County (Lead); DNREC (Supporting)	Stakeholder group formed with regular meetings.	Stakeholder group convened by 2020. Land and habitat protection strategy developed by 2023.
CM 2-4: Increase protection of land through acquisition or easement for the purpose of conservation and restoration.	Center (Lead); Sussex County, DNREC, DDA (Support)	Number of acres protected relative to baseline period of 2009-2019.	GIS tool for land conservation developed by 2022. Land identified by conservation partners through planning activities ongoing. One major partnership acquisition by 2025.
CM 2-5: Revise the Sussex County Code related to buffers for improved water quality aligned with the Center's Recommendations for an Inland Bays Watershed Water Quality Buffer System (published in 2008).	Sussex County (Lead); Center (Supporting)	New ordinance introduced to County Council.	Ordinance introduced by 2022.
CM 2-6: Implement conservation landscape projects in partnership with coastal communities.	Center (Lead); DNREC (Supporting)	Number of projects implemented.	Cost and benefit analysis to determine feasibility and nutrient removal potential completed by 2023. Projects identified (pending outcome of cost and benefit analysis) by 2025. Implementation ongoing.
EDUCATION, OUTREACH, AND MARKETING			
Objective 1: Enhance the James Farm Ecological Preserve and Education Program.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
EO 1-1: Implement the James Farm Master Plan.	Center (Lead); Sussex County (Supporting)	James Farm Master Plan implemented.	Phase 2 implemented by 2022.
EO 1-2: Develop and deliver watershed education programs.			

EO 1-2a: Programs for K-12 students are offered at the James Farm Ecological Preserve and incorporate Meaningful Watershed Educational Experience, Next Gen Science, and STEM standards.	Center (Lead)	Number of students reached through educational programming annually.	Minimum of 2,000 students annually.
EO 1-2b: Programs at the James Farm Ecological Preserve are developed for and offered to intergenerational audiences.	Center (Lead)	Number of people reached through intergenerational programming annually.	Minimum of 350 people annually.
Objective 2: Educate residents, visitors, and tourists in the watershed about their impacts on water quality and how they can help improve the Bays.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
EO 2-1: Develop and implement a Public Education and Engagement Plan for the Inland Bays.	Center (Lead); CAC (Supporting)	Public Education and Engagement Plan developed. Number of actions completed annually.	Plan developed by 2022. Implementation ongoing.
EO 2-2: Reduce marine debris through source reduction programs and initiatives and debris clean-ups.	Center, DNREC (Lead)	Number of clean-ups completed annually. Marine debris reduction campaign initiated.	Marine debris reduction campaign initiated by 2023. At least one clean up event is held annually.
EO 2-3: Promote sustainable funding for water quality improvements.	Center (Lead)	Sustainable funding for water quality improvement projects is secured.	Ongoing participation in the Clean Water Alliance.
Objective 3: Communicate environmental results and raise awareness about the importance of the Inland Bays and its watershed to promote public involvement and influence behaviors and actions to foster stewardship.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
EO 3-1: Create and disseminate printed and electronic materials such as social media, video, brochures, postcards, and signage to address specific education/outreach needs to target audiences.	Center (Lead); CAC (Supporting)	Number of people reached through education and outreach.	Educational materials, including social media posts, blog posts, journal articles, etc. produced on an annual basis.
EO 3-2: Conduct field visits with decision makers to educate them on the importance of protecting and restoring natural ecosystems.	Center, DNREC (Lead); CAC (Supporting)	Number of decision makers engaged annually.	Goal of engaging three decision makers annually.

EO 3-3: Results of Inland Bays environmental studies or projects are published.	Center, DNREC, STAC (Lead)	Number of reports published through multiple mediums and outlets, including print and online.	"State of the Inland Bays" report is published and disseminated every five years. Press releases and project reports are published at the completion of projects.
EO 3-4: Communicate and provide educational information to diverse audiences on the benefits of achieving water quality goals to economic development, tourism, recreation, human health, and quality of life.	Center, CAC (Lead)	Number of educational and outreach materials produced targeting the benefits of clean water. Data and facts are shared on environmental issues of concern.	Ongoing.
EO 3-5: Complete and share publicly an economic valuation of the Inland Bays watershed.	Center (Lead)	Economic valuation completed. Economic valuation shared publicly.	Economic valuation completed by 2021.
EO 3-6: Advocate for enforcement of existing environmental regulations concerning Inland Bays restoration.	Center (Lead); CAC (Supporting)	Technical expertise provided when needed to advocate for enforcement of regulations.	Ongoing.
Objective 4: Encourage more stakeholder support through volunteerism.			
Action	*Partners*	*Performance Measure*	*Timeframe & Key Milestones*
EO 4-1: Direct a volunteer program that provides citizens with opportunities to partner with the Center.	Center (Lead)	Number of volunteers engaged annually.	Volunteer engagement increases annually.

APPENDIX B

ENVIRONMENTAL MONITORING PLAN REVISION PROCESS

ENVIRONMENTAL MONITORING PLAN REVISION PROCESS

Scientific and Technical Advisory Committee Input and Review

At its meeting on February 10, 2023, the STAC discussed the IBEMP update and set forth an aggressive schedule for review and revision. The focus of the discussion was the existing monitoring programs and anticipated monitoring needs, and the level of revision needed for this review. Generally, the 2020 IBEMP was felt to be an effective guidance and document and a minor revision was anticipated.

A questionnaire was sent to STAC members in March. STAC was asked to review the indicator metrics for current status (ongoing, needs modification, complete) and any edits. Additional questions called for creation of new parameters and metrics. Compiled results of that questionnaire and any additional comments provided in one on one discussions were discussed at the April 28, 2023 STAC meeting.

Comments from the questionnaire, STAC meetings, separate emails and a review of the full document were incorporated into the final draft reviewed by STAC in June, 2023.

Center Staff Input and Review

Center staff were included with the STAC during the review process, with staff notes incorporated with STAC notes during all the phases described above.

Executive leadership and the Management Council were provided with a document for review ___.

APPENDIX C

2021 STATE OF THE BAYS TECHNICAL REPORT

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Appendix D. Summary of Changes in this revision

The Environmental Monitoring Plan is the “how to” document for tracking the science-based metrics in the Comprehensive Conservation and Management Plan (CCMP). The Center uses it as a basis for the State of the Bays Reports. The Environmental Monitoring Plan documents what has already happened and what metrics that should be included as the Center adapts to new science, new technologies and better understanding.

The document is reviewed every other year by the Scientific and Technical Advisory Committee. This years’ highlights include a crosswalking exercise from the previous CCMP to the current CCMP. This procedural exercise was critical in planning where we will be taking Environmental Monitoring in the next two years.

Additional highlights of this years’ plan include several new performance metrics and a renewed commitment to the importance of the long-term continuous water quality monitoring program.

New metrics include:

- Habitat Restoration Suitability and Condition assessments for seagrasses, salt marshes, forests and other living resources.
- Emerging contaminants, specifically plastics and microplastics.
- Disease loads in wild vs aquaculture oysters.

Water quality Monitoring:

- Maintaining a scientifically appropriate water monitoring program for the inland bays continues to need funding, and expand to include tributaries that have not had previous monitoring efforts, especially in Little Assawoman Bay.

The Environmental Monitoring Program remains the most comprehensive assessment of metrics across the watershed, in no small part due to our partners and collaborators. The Center leads the data collection for approximately ¼ of the metrics, and could not complete this work without partner support.