Stream Health

Management Strategy

2015–2025, v.3

I. Introduction

Restoring health to local rivers and streams not only benefits the fish, wildlife and people using them, but is a necessary step toward meeting water quality standards in the Chesapeake Bay. Over 100,000 stream miles drain from the vast Chesapeake watershed and connect it to its receiving water body—the Bay. Many of these streams are impaired, and management actions are needed to improve the physical, chemical and biological functions of such streams while continuing to maintain the health of pristine streams. This increases the total number of healthy streams across the watershed. Because stream health is affected by numerous factors, both on the land and in the water and resulting directly or indirectly from human activities, the success of this strategy recognizes an inherent connection to actions under other outcomes, such as wetlands, forest buffers, brook trout, healthy watersheds, toxic contaminants and implementation of water quality best management practices (BMPs).

II. Goal, Outcome and Baseline

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

Vital Habitats Goal

Restore, enhance and protect a network of land and water habitats to support fish and wildlife, and to afford other public benefits, including water quality, recreational uses and scenic value across the watershed.

Stream Health Outcome

Continually improve stream health and function throughout the watershed. Improve health and function of 10% of stream miles above the 2008 baseline for the Chesapeake Bay watershed.

This outcome will be tracked via improvements in the Chesapeake Basin-wide Index of Biotic Integrity (Chessie BIBI). The Chessie BIBI is derived using individual federal, state, county and volunteer benthic macroinvertebrate datasets collected with similar procedures and analyzed with a common method agreed to by the Bay Program's Stream Health Workgroup.

For purposes of this strategy, the goal for stream health and function is to improve 10% of stream miles above the 2008 baseline for the Chesapeake Bay watershed. As the Stream Health outcome includes a Basin scale metric to measure the improvement in stream health and function, this Management Strategy offers a complementary function-based approach to stream health addressing watershed level stressors and reach-level stream functions. The function-based definition provides the ability to report and track incremental improvements in stream health achieved from addressing stressors and improving stream function. In addition to reducing erosion and improving habitat for wildlife, fish, and other aquatic species, stream restoration also is a recognized BMP for water quality and will provide a benefit of reducing nutrient and sediment loads to achieve the target load reductions as part of the Chesapeake Bay Total Maximum Daily Load (TMDL) (Table 1).

Table 1: Chesapeake Bay Watershed Implementation Plan (WIP) progress and 2025 targets for stream restoration (units in feet). Source CBP

		2009 Progress	**2011** Progress	**2013** Progress	**2015** Progress	**2017** Progress	**2025 WIP** Commitment
Urban Stream Restoration		32,199	61,812	119,158	142,741	158,140 (6%)	2,608,476
Non-Urban Stream Restoration		988,575	1,448,109	1,514,798	1,592,186	1,399,642 (65%)	2,152,307
Total		**1,020,774**	1,509,921	1,633,956	1,734,927	1,557,782 (33%)	4,760,784

Baseline and Current Condition

At a 2018 workshop, the baseline period was defined as the six-year period from 2006 to 2011 by the Interstate Commission on the Potomac River Basin (ICPRB) and an ad-hoc team formed from various area monitoring programs. It was also agreed that results from a watershed model could be combined with monitoring results to fill in gaps in spatial coverage. The model successfully uses landscape features (including upstream imperviousness and canopy cover) to predict Chessie BIBI ratings (Maloney et al. 2018). The combined monitoring and model results, proportionally weighted by catchment area, indicate approximately 60% of the Bay watershed area supported streams with fair, good, or excellent ("acceptable") ratings during the baseline period (Buchanan et al. 2018). This is a preliminary baseline for the Bay Program's stream health outcome. A final baseline estimate will be produced after a higher resolution stream layer becomes available and an acceptable method is determined to translate the metric as a percent of the basin's stream miles.

CBP uses the Chessie BIBI as a "stream health indicator". The Chessie BIBI is mentioned specifically as a measure of stream restoration progress in the 2009 Executive Order 13508, *Draft Strategy for Protecting and Restoring the Chesapeake Bay*. It is a biological endpoint that will reflect the improvements in stream health and function called for in the 2014 *Chesapeake Bay Watershed Agreement*. The database used to generate index values is currently being updated with the most recent macroinvertebrate data from states and local jurisdictions. Previously, analyses were performed to develop order-, family-, and genus-level metrics and compare their sensitivity to degradation, refine the metric scoring thresholds, and improve procedures for rating the final index (Smith et al. 2017). Future work includes further testing of the index's sensitivity to various stressors.

III. Participating Partners

Team Lead: Vital Habitats Goal Team

Workgroup Lead: Stream Health Workgroup

Opportunities for Cross-Goal Team Collaboration: Fisheries Goal Team, Water Quality Goal Team and Healthy Watersheds Goal Team, Wetlands Workgroup, Fish passage, Riparian Forest buffers

(**Signatory agencies in bold**)

Level of Participation: High

- Interstate Commission on the Potomac River Basin (ICPRB)
  - *Develop and refine Chessie BIBI index, compile and evaluate raw monitoring data*
- U.S. Geological Survey (USGS)
  - *Provide technical support to assist with workplan*
  - Develop model to predict Chessie BIBI ratings for unsampled streams and assist ICPRB in refining the selection of reference sites in the Chessie BIBI
- U.S. Fish & Wildlife Service (USFWS)
  - *Manage and implement stream restoration projects, provide training on stream restoration assessment methods and development of guidance*
- U.S. Army Corps of Engineers (USACE)

  - *Review and approve stream restoration projects.*
  - *Cost-shares stream and floodplain habitat restoration projects under its ecosystem restoration mission. Under administration policy, USACE does not generally cost-share projects undertaken for principal purpose of water quality improvement.*
- **Environmental Protection Agency (EPA) Region III**
  - *Reviews and approves stream restoration projects.*
- **Chesapeake Bay Program Office (CBPO)**
- Center for Watershed Protection (CWP)
  - *Chair Stream Health Work Group.*
  - *Development and training on stream restoration protocols.*
- Virginia Tech (VT)
  - *Member of CBP Science and Technical Advisory Committee (STAC), Stream Health Workgroup Drafting Team.*
- **Chesapeake Bay states (VA, MD, WV, DE, PA, NY) and District of Columbia natural resource, stormwater and permit approval agencies**
  - *Monitor stream conditions and health, implement/manage stream restoration projects and other best management practices (BMPs), provide funding to support project implementation. Provide guidance on stream restoration. Provide permit review and approval of stream restoration projects*
- Chesapeake Bay Trust (CBT)
  - *Lead effort to organize pooled monitoring approach*
- National Fish and Wildlife Foundation (NFWF)
  - *Provides funding for stream restoration projects and BMPs to reduce nutrient and sediment loadings.*
- Local governments
  - *Responsible for implementation of BMPs to include stream restoration projects as part of the Watershed Implementation Plans (WIPs).*
- Urban Stream Restoration BMP Expert Panel Members
  - *Develop protocols and nutrient and stream restoration BMPs*

Level of Participation: Medium

- Natural Resources Conservation Service U.S. Department of Agriculture (USDA)
- University of Maryland, University of Maryland Center for Environmental Science (UMCES)
- Stroud Research Center
- Chesapeake Bay Foundation
- Johns Hopkins University
- Franklin & Marshall University
- Severn Riverkeeper: Manages/Implements Stream Restoration Projects
- American Rivers: Manages/Implements Stream Restoration/Dam Removal Projects
- Maryland Stream Restoration Association (MSRA)

Local Engagement

Local governments are responsible for the implementation of BMPs to include stream restoration projects as part of the Phase III Watershed Implementation Plans (WIPs).

IV. Factors Influencing Success

To fully achieve this outcome, it is critical to address priority stressors to restore and maintain stream functions and improve local stream health, which will ultimately benefit the Bay. A stressor in the context of this strategy is any factor limiting to aquatic life, or stream processes, that occurs as a direct or indirect impact of current or past human actions. Stressors refer to both biological and physical properties. While there are a number of ways in which stream functions may be defined (Supplementary Table 1), they are synergistic, or hierarchical in their function such that the quality and condition of each stream process impact others. Therefore, the processes and functions that are most critical to improve stream health will vary depending on what the stressors are for a stream and which of those stressors must be reduced or removed (Supplementary Table 1).

A thorough understanding of ecological stressors and factors, policy/and administrative factors, and scientific knowledge and the application of research, is necessary to maintain and improve stream health and function at both the local and Bay-wide scale.

1. **Ecological stressors and factors** are the physical, chemical and biological elements that impair or limit stream health recover. Further, these factors affect stream health at two scales—local and downstream waters to the Bay. Many of the factors listed are contributing pollutants to Clean Water Act Section 303(d) listed impaired waters for which local TMDLs are established. Ecological stressors and factors influencing the outcome include:

   Within the stream channel and floodplain factors:

   - Excessive sediment and nutrients in-stream from unstable stream banks and legacy sediments in the floodplain.
   - Limited nutrient and organic processing-instream.
   - Alteration in channel form
   - Concentrated flows and reduction in baseflows.
   - Piped and channelized streams; undersized culverts.
   - Removal/Loss of forested riparian or wetland areas
   - Degraded soils in riparian area
   - Physical loss of streams due to mining activities

   Watershed-based factors:

   - Impervious cover and increases in stormwater runoff.
   - Flow alteration and flashy hydrology.
   - Excessive nutrient loading to streams from untreated runoff (agricultural and urban) from the upland areas in the watershed and groundwater.
   - Inadequate stormwater management controls (e.g. BMPs).
   - Leaky wastewater infrastructure.

- Toxicity of effluent from resource extraction activities (i.e., acid mine drainage, fracking).
- Road de-icing practices (salt).
- Thermal impacts.
- Invasive species.
- Endocrine disrupting chemicals and other contaminants (e.g. metals, pesticides).

Management actions are needed to reduce stressors to improve stream health. Where appropriate and feasible, measures should be implemented outside of the stream and associated riparian area itself to correct or limit the stress to the aquatic ecosystem. A combination of measures may be highly effective as well, with practices put in place close to the source of stressor, as well as actions within the stream corridor. In cases where that is not practical, or where the problem originates physically only in the stream channel or valley itself, stream channel and floodplain restoration work might be optimal management measures. Improvement in local streams overall, not just for nutrient and sediment reductions, is paramount to achieving this outcome.

2. **Policy and Political factors** limit the implementation potential of an action. Stressors degrading streams that originate from land uses or from leaky public and private wastewater infrastructure, are often very challenging to address because of the scale of the problem, cost of remediation, difficulty of acquiring space for remediation projects and other challenges. With regard to stream restoration, key among these factors are related to the permit application and approval process. Despite approval of many projects throughout the Chesapeake Bay, there are projects that encounter delays during the permit review process that often may be attributed to the additional information needed to support an application and its interpretation by either the regulatory or practitioner community. Uncovering factors that are common to both the practitioner and regulator need to be overcome to address this barrier to implementation. The current assessment of jurisdictions to meet their 2025 WIP targets heightens the need to address these factors to implement projects that meet the sediment and nutrient loads reductions necessary to improve stream health and consequently the Bay, as well as meeting other requirements. Policy and Political factors that influence the outcome include:
   - Review and approval of stream restoration projects for WIP implementation.
   - Lack of common watershed, stressor and stream assessment and restoration guidelines.
   - Integration of water quality and living resource goals during WIP stream restoration.
   - Municipal Separate Storm Sewage System (MS4) permits focus on water quality.
   - Adequate financial resources to support local implementation efforts.
   - Adequate extension infrastructure to communicate newest research and technical guidance to jurisdictions.
   - Availability of urban land to retrofit and implement upland BMPs.
   - Increases in flooding and potential loss of federal flood insurance coverage
   - Current lack of crediting for stream health beyond modeled nutrient and sediment reductions

3. **Scientific knowledge and research application factors** are related to our current understanding of streams and their response to management interventions. It also cover our ability to effectively use the most up-to-date scientific understanding to address *Watershed Agreement* outcomes and regulatory guidance. Factors that influence this outcome include as well as regulatory guidance:
    - Stressor identification and prioritization procedures.
    - Metrics that correlate with priority stressors.
    - Robust stream restoration monitoring to evaluate potential improvement in stream health/functions from BMP implementation.
    - Possible lag times that affect the ability to evaluate the effect of upland BMPs on stream health.
    - Research is needed to guide the selection of achievable reference conditions and design approaches based on watershed and stream functions.
    - Insufficient data to develop Bay-wide fish-based indicator to complement the macroinvertebrate indicator (the Chessie BIBI).
    - Lengthy timeframe for adjusting BMP credit or recognizing new BMPs.
    - Limitations of the applicability of the Chessie BIBI (and other similar ecological data) to streams where restoration work is being conducted on an annual basis.
    - Identification of nutrient hotspots in stream valleys where erodible geologic materials and soils contain excess nutrients.

4. **Partner coordination** is an important factor influencing success across state and jurisdictional borders. With streams such an integrated part of the ecosystem, there are many additional CBP outcomes that rely on stream health. Efforts in the current Logic and Action Plan highlight the importance of coordinating, not only within the workgroup, but also across workgroups to achieve functional improvement across the stream habitat. Additionally, the linear nature of streams causes them to cross borders into different states or jurisdictions. It is important to ensure that efforts are coordinated up and downstream.

5. **Funding** sources in the watershed are diverse. The current Logic and Action plan aims to take advantage of several different sources to research support for functional improvement and other stream health cornerstones.

V. Current Efforts and Gaps

Gaps:

Information & Data

The Habitat Goal Implementation Team (GIT), recognizes that streams are on a spectrum of health from those that are deemed impaired to those that the states have identified as being outstanding and healthy. However, there is a data gap that needs to be addressed in order to develop a method to track the improvement/degradation of the marginal streams, along with impaired streams.

- Benthic macroinvertebrate data from enough streams with enough frequency to track progress over time. Chessie BIBI provides limited capacity for annual tracking.

- Bay-wide and stream metrics other than biological indices, such as the Chessie BIBI, to assess physical and chemical health and functions of streams.
- Updated or reviewed methods to define reference conditions or endpoints for streams.
- Sufficient of data to demonstrate effectiveness of stream restoration practices.
- Sufficient of data to demonstrate restoration of stream processes following installation of upland watershed BMPs.
- Cumulative effects and interactions between stressors.
- Completion of stressor analysis for additional watersheds.

Regulatory & Programmatic

The Stream Health and Healthy Watersheds outcomes are complementary in that one focuses on improving the health of degraded streams (Stream Health outcome) while the other works to maintain 100% of state-identified current healthy waters and watersheds (Healthy Watersheds). Streams that are in the "middle"—or marginally healthy—are at potential risk of becoming the impaired or degraded stream reaches of tomorrow that could offset any progress in neighboring or downstream reaches.

- Collaboration with the Healthy Watersheds GIT to identify marginal streams and various definitions for stream health (i.e., Chessie BIBI and individual state metrics).
- Project design process for stream restoration that can measure change in stream functions and project success based on project goals and objectives. Specific to the Chesapeake Bay TMDL, a design process for restoration projects to reduce nutrient and sediments loads delivered downstream while at the same time ensuring optimal habitat conditions are restored.
- Information to support innovative, effective design approaches to identify restoration potential and success for different land uses, stream types and current and future site constraints as well as causes of impairment/stressors (e.g. legacy sediment, contaminants in water and sediment, runoff volume and velocity, increased discharge from undersized culverts).
- Identification of local and watershed priority stressors that affect local steam health and management actions to result in associated functional improvement or prevention of degradation.

Prioritization

Restoration activity in marginally healthy streams should proceed carefully such that appropriate restoration designs are taken to maintain and enhance natural stream processes. As streams have degraded over time, further research is needed to understand and predict how the streams will react to anthropogenic and natural pressures. It is also likely that restoration activity to improve stream health in highly degraded streams may only result in marginal improvements (e.g. Chessie BIBI poor to fair). However, as these streams may be located in ultra-urban environments, marginal improvements may contribute towards broader societal benefits (e.g. environmental justice).

- Targeting procedures for cost-effective restoration actions and design approaches that will achieve both water quality and biological functional improvement. WIPs provide a level of analysis on the type and mix of projects to meet load reductions and associated costs. The process to identify the projects varies by jurisdiction along with cost estimates.
- Investments in research to improve the body of knowledge surrounding restoration techniques and net benefit to stream and watershed health.

Current Efforts:

Development of 2008 Baseline for the Chessie BIBI

ICPRB convened a workshop in April 2018 to identify the "2008 baseline" referred to in the Stream Health Outcome. Participants selected 2006 - 2011 as the baseline period and discussed next steps in developing the CBP stream health indicator. A spatial model was developed to predict the indicator in unsampled catchments to fill in gaps in coverage. A preliminary baseline was calculated in December 2018 from merged monitoring and modeling results. Efforts are currently underway by ICPRB and USGS to update the stream macroinvertebrate database, improve indicator sensitivity, further our understanding of land use and climate change impacts on stream health, and report on progress for the 2012-2017 interval. The Data Center at CBP is also implementing a standardized process for incorporating stream macroinvertebrate data into the Chesapeake Environmental Data Repository (CEDR) and automating calculations of the stream health indicator.

Pooled Monitoring Approach to Stream Restoration Projects

The Chesapeake Bay Trust manages the Restoration Research Award Program that began in 2015 with the issuance for the first “request for proposals” to support the pooled monitoring initiative. The Program is a multi-stakeholder effort that includes a partnership with the Maryland Department of Natural Resources, the Maryland Department of Transportation State Highway Administration, Montgomery County Department of Environmental Protection, and the National Fish and Wildlife Foundation through the Environmental Protection Agency’s Chesapeake Bay Program Office. The goal of this research program is to answer several key restoration questions that are a barrier to watershed restoration project implementation. Funding partners hope that answering these questions will ultimately lead to increased confidence in proposed restoration project outcomes, clarification of the optimal site conditions in which to apply particular restoration techniques, information useful to regulatory agencies in project permitting, and information that will help guide monitoring programs. This program supports the Pooled Monitoring Initiative that is designed to connect key stormwater and stream restoration questions posed by the regulatory and practitioner communities with researchers.

Ongoing Monitoring Efforts

There are several state and resource agency monitoring programs to support the assessment of stream health and function at the state level. These can be used along with the Chessie BIBI to track stream health toward meeting the goal of the Management Strategy. Each of the data sets have unique advantages for use in tracking. Examples of some of these efforts include:

- EPA National Rivers and Stream Assessment (NRSA): The EPA NRSA sampled between 90 and 100 randomly selected sites in the Chesapeake Bay watershed. These sites have benthic invertebrate, fish, periphyton, water quality and habitat data. The EPA NRSA surveys are conducted every five years, with data available for 2008/2009, 2013/2014, and 2018/2019 survey being recently completed.
- State 305b (Integrated Report) Reports ().
- Tidal network monitoring sites.
- Non-tidal network monitoring sites.

- National Park Service has five inventory and monitoring networks operating within the Chesapeake Bay (https://www.nps.gov/im/ncrn/index.htm, accessed November 2019).
- Maryland Biological Stream Survey: Sampled 252 randomly selected sites during 2007- 2009 to characterize Maryland's ecological condition. Round Four took place from 2014-2018 and data is not yet available (November 2019).
- County monitoring programs
- State monitoring programs not named above

MS4 permits that have incorporated Chesapeake Bay TMDL goals

MS4 permit requirements have started to reflect Chesapeake Bay TMDL goals. This effort is an example of the coordination of BMP implementation and management actions that can address multiple goals.

WIP Implementation of BMPs

The Chesapeake Bay TMDL is designed to ensure that all pollution control measures needed to fully restore the Bay and its tidal rivers are in place by 2025, with all the identified practices implemented. WIPs detail how and when the Bay jurisdictions will meet their pollution load allocations. Progress in WIP implementation is reported annually to the CBP. BMPs that most notably influence stream health include runoff-reduction urban BMPs and agricultural BMPs such as stream fencing, forest buffers, grass buffers and wetland restoration.

Approximately 700 miles of stream restoration projects are expected to be implemented to achieve the nutrient and sediment load reductions required by the Chesapeake Bay TMDL (Table 1). As a result, the projected implementation rate of stream restoration projects to meet the 2025 timeline with the Bay watershed is unprecedented. Based on the planned 2025 Phase III WIPs, the CBP reports that approximately 33% of planned stream restoration projects were implemented based on the 2017 progress reported by the Chesapeake Bay jurisdictions, with 90% of the projects located in areas with non-urban land use.

Development of Chesapeake Bay BMP Verification

In August 2014, the CBP Management Board approved a framework by which the partnership will develop verification programs to ensure that implemented BMPs continue to work properly and are eligible to receive nutrient and sediment load reduction credits towards the Chesapeake Bay TMDL. The framework includes BMP verification guidance from the CBP's six technical sector and habitat workgroups (i.e.., agriculture, forestry, urban, wastewater, wetlands and streams). While the recommended verification guidance is specific to the source sector BMPs, there are over-arching principles on which the guidance is based: practice reporting, scientific rigor, public confidence, adaptive management and sector equity. The framework was approved by the Urban Stormwater Workgroup on June 18, 2019.

VI. Management Approaches

The following major points are fundamental to the Stream Health Management Strategy. This outcome recognizes that:

- The health and function of streams affects the local stream environment as well as the downstream connection and contributions from these waters to the Bay.
- Streams are a part a system that includes the stream corridor, floodplain, wetlands and watershed, and as such, stream health is affected by both in-stream and watershed functions, processes and characteristics.
- Measures that would improve stream functions may occur in the stream itself, in the floodplain or in the watershed. Some measures could serve to meet more than one outcome of the *Watershed Agreement*.
- Stream functions related to nutrient and sediment delivery to the Bay are of fundamental importance because of their explicit inclusion in the *Watershed Agreement*.

Figure 1 is a conceptual illustration of this management approach showing that improvement to stream health relies upon the ability to identify the key factors that affect critical stream functions. The key factors influencing this outcome are described in Section III and include ecological stressors and factors, policy and administration, scientific knowledge and the application of research, partner coordination and funding.

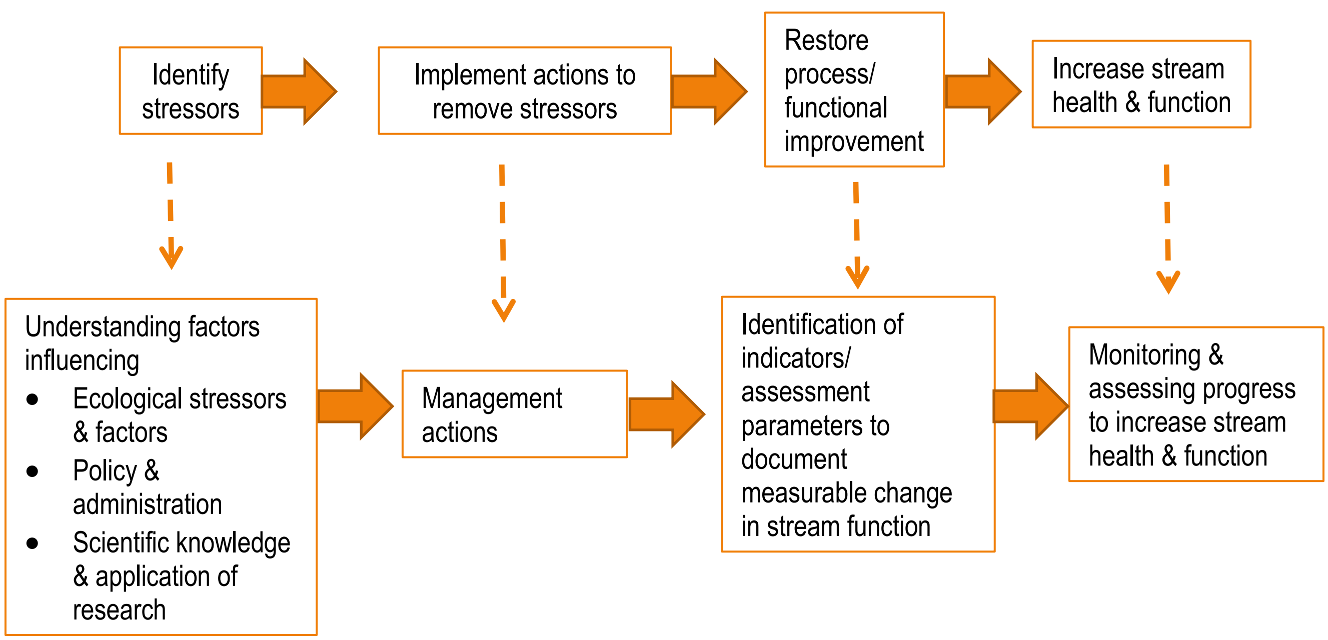

Figure 1. Schematic for Stream Health Outcome Management Strategy

Strategies to attain the outcomes underneath the Water Quality Goal (2017 WIP and 2025 WIP, Water Quality Standards and Attainment and Monitoring) complement this outcome as actions to reduce or remove stressors or factors affecting stream health may also be related to watershed activities. As such, implementation of BMPs to reduce nutrient and sediment pollution load to achieve water quality standards would contribute toward improving stream health. Perhaps more important, however, is the implementation of upland BMPs that reduce the volume and rate of stormwater runoff entering streams, assisting in efforts to restore ecologically sustainable flow regimes, supporting stream functions. Similarly, the practices and controls put into place that reduce and prevent the effects of toxic contaminants below levels that harm aquatic systems and humans, would have a similar affect (Toxic Contaminants Outcome). Further, other outcomes that increase the wetland acreage (Wetlands Outcome) and forested buffers (Forest Buffer Outcome) in the watershed would also support improvement in stream health and function as they address the removal or reduction in priority ecological stressors and factors. Overall, this Management Strategy recognizes the need to identify principal stressors affecting stream health if maximum in-stream improvement is going to be achieved, then identify and promote measures to remediate principal stressors

The following five approaches are specific to the Stream Health Outcome, focusing on a well-developed, broadened application of a function-based approach to stream restoration. A function-based approach is not only central to the permit and review process, but also is recognized by researchers as a sound approach to restoration when implemented using a well-defined project process

Approach 1:
The definition of stream health and function for this restoration-based outcome uses a Bay-wide metric, the Chessie BIBI, to measure the improvement in stream health and function. This Management Strategy proposes a function-based definition of stream health that provides a common framework for additional reporting and tracking incremental improvements in stream health at a finer scale.

Identify an appropriate suite of metrics to measure the multiple facets of stream health to complement the Chessie BIBI.

a. Develop a definition of stream health, measured as the miles of streams improved that shows the linkage between upland drainages and local stream health, and between local stream health and downstream health. This effort would work to associate metrics developed for the Chessie BIBI with individual state metrics used to track and report the Healthy Watersheds Outcome
b. Develop metrics/composite indices from routinely collected, non-biological data to measure changes in stream function to assess regional improvement
c. Include common indicators of stream functions to include (e.g. lateral stability, bedform diversity, habitat diversity, riparian corridor, nutrient and organic matter processing) as part of monitoring guidance for stream restoration projects to demonstrate functional improvement.
d. Align metrics of stream restoration protocol crediting with metrics of stream functional improvement for projects for the Chesapeake Bay TMDL
e. Collaborate with the Healthy Watersheds GIT to identify marginal streams where restoration activity may improve stream functions and health. Once identified, work with the partnership and funders to develop incentives to build on existing efforts to target beneficial restoration activity along with guidance for permits to implement the proposed activity.

Approach 2:
Provide adequate funding and technical resources to support stream functional improvement in stream restoration projects, in addition to nutrient and sediment reduction.

a. Monitor and study subwatersheds to explore how much upland retrofit is needed to optimize stream functional improvement when stream restoration and stormwater retrofits are installed as part of an integrated restoration plan.

b. Provide training to jurisdictions to implement BMP expert panel report recommendations.
c. Work with funding agencies to provide multi-year funding to monitor effects of stream restoration.
d. Adopt a pooled monitoring approach for researchers to inform stream restoration project designs that demonstrate stream functional improvement.
e. Establish of an on-going stream restoration monitoring consortium and data clearinghouse within the CBP to share project data.
f. Recommend incentives for projects that provide both stream functional improvement and water quality benefits.
g. Conduct literature review to fully document response of ecological conditions from stream restoration management actions that may be used to support a BMP expert panel similar to those available for expected nutrient and sediment reductions. Part of the BMP expert panel would address the applicability of Chessie BIBI (and other similar ecological data) to where restoration work is being conducted to improve stream functions. Recommendations could be applied to help track estimated stream improvements similarly to the way nutrient and sediment trends are already tracked by CBP. This panel could also develop guidance on how the restoration/enhancement of stream functions translates to nitrogen, phosphorus and sediment "credit" as recommended by STAC report in "Designing Sustainable Stream Restoration Projects within the Chesapeake Bay Watershed".

Approach 3:

Active and engaged participation by local communities with federal and state partners is central to Bay restoration. Executive Order 13508 states the Federal Leadership Committee shall closely coordinate actions by state and local agencies and consult with stakeholders and members of the public in the development of annual action plans and reporting progress.

a. Take action to clearly define a process for local input to advance project implementation
b. State and federal agencies shall ensure the participation of local communities in support of activities that advance project implementation.
c. Coordinate with stream restoration stakeholders to identify and remove barriers to expediate the submittal and renewal of permit applications
d. Conduct a comprehensive review of existing stream restoration permit documentation. Both permit reviewers and permittees have identified factors related to incomplete permit application submittals, monitoring requirements and inconsistent information requested (or provided) to evaluate projects as barriers.
e. Provide training and guidance on the information needed to support site selection, and design approaches.
f. Review and identify opportunities to improve stream health and function, while meeting other regulatory requirements through the coordination of multiple regulatory programs that have identified principal stressors impairing streams.

Approach 4:
Develop and promote holistic stream restoration design guidelines that identify the level of degradation and improvement of stream functions and key factors limiting potential functional improvement.

a. Development of a function-based stream assessment framework. Current work by MDE and USFWS may be used as a template to apply in other Bay jurisdictions.
b. Develop case studies to document functional response in stream with various management interventions.
c. Add language to MS4 permits to recognize stream function improvement as part of nutrient and sediment credits towards meeting the Bay TMDL.
d. Improved stream restoration guidance through work with MDE based on Key Wildlife Habitats.

Approach 5:
Work with CBP partners, including the Enhancing Partnering, Leadership and Management GIT, to enhance the capacity of local governments, organizations and landowners of beneficial stream restoration and maintenance practices

a. Engage with local governments to inform landowners, as well as the general public, of beneficial stream restoration and maintenance practices. This includes individual homeowner practices (e.g. rain barrels, lawn care) and their impact on the community, the streams in their own backyards and public places. A programmatic approach similar to the Upper Susquehanna Coalition Emergency Stream Intervention initiative that provides outreach and technical training and assistance through a network of conservation specialists are good practices to follow
b. Provide research or documentation that identifies the nexus between improving stream functions and health, and broader societal issues such as environmental justice, in support of the Diversity outcome.
c. Commit to cooperation and coordination with other groups within the Chesapeake Bay Program, including the Health Watershed workgroup and the Communications workgroup, to assure shared resources and information and further the goals of the *Chesapeake Bay Watershed Agreement*

VII. Monitoring Progress

Monitoring programs are critical to understanding the response of streams to restoration activities Federal, state, local and natural resource agency monitoring programs generate data on the physical, chemical and biological conditions of streams. These data are used to generate the Chessie BIBI. The Chessie BIBI is key to monitoring progress toward improving 10% of stream health and function. This Management Strategy does not advocate for new monitoring programs, but rather, to monitor annual progress. To do so, the Management Strategy recommends using other existing data sources to supplement this Bay-wide indicator (e.g. jurisdiction-specific metrics). While minor differences in stream biological, physical habitat and water quality monitoring methods exist, jurisdiction assessments may also be useful in tracking stream health and function over time at individual sites. Further, the development of common stream assessment and restoration guidelines would generate comparable datasets across stream restoration projects. This would provide data to characterize stream health across all stream functions so that incremental changes in stream functional improvement can be reported, and support data needs for the Chessie BIBI.

The monitoring data would be based on routinely collected data to measure changes in stream functions for instream and floodplain conditions. Data are routinely generated from stream restoration projects as part of permit requirements, however, they are not necessarily comparable across projects, nor do they necessarily inform functional improvement or stream health, in general. The ability to adopt a pooled-monitoring approach using commonly accepted stream assessment and restoration guidelines could then demonstrate the effect of design approaches and stream functional response from case studies analyses. Post-construction monitoring would also be supported by data generated and reported from the CBP verification guidance for stream restoration BMP implementation that recommends site visits and evaluations two years after construction, and then every five years or after the

Lessons Learned

The Stream Health Workgroup updated it's Logic and Action Plan to reflect lessons learned while trying to implement key actions. The progress made on the Logic and Action Plan reflected the ability to identify a person to lead the implementation of an action.

The identification of a lead person was mostly due to an action that aligned with an organization's mission, work or directive, or because funding was provided to allocate staff time to implement an action. For example, MD DNR's work and available data on stressor identification provided a good fit to lead Action 4.2. Funding made available to ICPRB provided the resources necessary to devote staff time to address Actions 1.1 and 1.2. The CBT is the lead organization for the Pooled Monitoring Approach (Action 2.1).

The ability to leverage existing resources on mutually beneficial actions with other groups also provided an opportunity to advance actions in the Logic and Action Plan. For example, a joint meeting with the Urban Stormwater Workgroup was held in June 2018 to address cross cutting issues related to stream restoration, In addition, we provided a training in Pennsylvania led by the Center for Watershed Protection due to existing grant funding from an external funding source.

The annual review of the Logic and Action Plan also provided an opportunity to refine actions and performance targets. For example, some previously defined actions were either eliminated as they were too loosely defined, did not have an individual or organization to lead its implementation or was redundant with work underway.

Lastly, changes to the Logic and Action Plan occurred as it was more appropriate to define an action as a performance target of another action.

catastrophic event. Jurisdiction-specific verification guidance is under development.

VIII. Assessing Progress

The CBP annual progress reports on BMP implementation, specifically BMPs identified to impact critical steam functions (e.g., stream restoration, stream fencing and forest buffers) can be used to estimate the project nutrient and sediment load reductions expected from practice implementation. Assessing progress should also focus on remediation of principal stressors and stream reach functional improvement based on stream restoration project goals and objectives. While CBP wants to encourage the remediation of priority stressors to improve stream health, or maximize functional improvement, it cannot be required given site-specific constraints and the ability to address watershed stressors affecting the health of the stream. Projects may be undertaken for the purpose of nutrient and sediment reductions under the Chesapeake Bay TMDL, but stressor identification analysis should also be considered to improve long-term stream health.

IX. Adaptively Managing

For any given restoration project, there are uncertainties in the application of even the best restoration science. At the scale of the Chesapeake Bay watershed this uncertainty is compounded by the extent of BMP implementation required to meet the Chesapeake Bay TMDL. Adaptive management of urban, agricultural, and wastewater runoff is addressed in the Water Quality goal, however it plays a key role in the Stream Health Outcome.

As the field of watershed management, stream restoration and BMP science continue to evolve, the desired ecological endpoint for any given project may also evolve. Adaptive management is necessarily to ensure that a project can perform to the best of its ability, as more information is available. Further, the response in stream health to a management action is dependent upon the interactions amongst many stream functions and similar actions may cause dissimilar responses in different projects. A process that communicates the current state of the science on efforts to improve stream health, with periodic updates, would help ensure the most successful practices are implemented throughout our watershed. Willingness to adopt new approaches and will be crucial in our attempts to adaptively manage.

Further, understanding that the response in stream health to a management action is affected by nature itself and may include lag times is crucial for adaptive management. For example, attempts to improve biological stream function will take longer time than to improve flow regimes. Monitoring efforts must occur over a long enough time period to capture functional improvement in order to adaptively manage.

X. Biennial Workplan

Biennial workplans for each management strategy will were developed in November of 2019 for 2020-2021. They included the following information:

- Each key action.

- Timeline for the action.
- Expected outcome.
- Partners responsible for each action.
- Estimated resources.

Supplementary Table 1. A summary and comparison of watershed stressors and stream functional categories.

	Harman et al 2012[1]	Fischenich 2006[2]	FISRWG 1998 (updated 2001)[3]	Stressor Categories (from MDE 2015[4] and MD DNR 2005[5])
Hydrologic Factors	**Hydrology:** Transport of water from the watershed to the channel	**Hydrologic Balance:** • Surface water storage processes; • Maintain surface/subsurface water exchange • General hydrological balance	**Conduit:** the ability of the system to transport materials, energy and organisms	• Land use land cover (urban, impervious cover, mine land use)
	Hydraulics: Transport of water in the channel, on the floodplain, and through sediments			• Flow regime
Geomorphology and Energetics	**Geomorphology:** Transport and deposition of wood and sediment to create diverse bed forms and dynamic equilibrium	**System Dynamics:** • Maintain stream evolution processes • Energy management processes • Provide for riparian succession **Sediment processes and character:** • sediment continuity, • Maintain substrate and structural processes • Quality and quantity of sediments	**Source:** a setting where the output of materials, energy and organisms exceeds input **Sink:** a setting where the input of water, energy, organisms and materials exceeds output	• Instream and riparian habitat • Habitat structure • Sediment/stream flow
Physical and Chemical Factors	**Physicochemical:** Temperature and oxygen regulation; processing of organic matter and nutrients	**Chemical processes and pathways:** • Maintain water & soil quality, • Maintain chemical processes and nutrient cycles • Maintain landscape pathways	**Filter:** the selective penetration or materials, energy and organisms **Barrier:** the stoppage of materials, energy, and organisms	• Water chemistry (dissolved oxygen, various pollutant parameters) • Energy source
Biotic Factors	**Biology**: Biodiversity and the life histories of aquatic and riparian life	**Biological support:** • Support biological communities and processes, • Provide necessary habitats for all life cycles • Maintain trophic structure and processes	**Habitat:** the spatial structure of the environment which allows species to live, reproduce, feed and move	• Biotic interactions

[1] Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. *A Function-Based Framework for Stream Assessment and Restoration Projects*. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006.

[2] Fischenich, J.C., 2006. Functional Objectives for Stream Restoration, EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-52), US Army Engineer Research and Development Center, Vicksburg, Mississippi. http://el.erdc.usace.army.mil/elpubs/pdf/sr52.pdf

[3] FISRWG (10/1998). Stream Corridor Restoration: Principles, Processes and Practices. By the Federal Interagency Stream Restoration Working Group (FISRWG). GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN3/PT.653.

[4] Maryland Department of the Environment. 2015. Biological stressor identification studies. Accessed June 2015: http://www.mde.state.md.us/programs/Water/TMDL/Pages/Programs/WaterPrograms/tmdl/bsid_studies.aspx

[5] Maryland Department of Natural Resources. 2005. Maryland Biological Stream Survey 2000-2004, Volume XIV: Stressors Affecting Maryland Streams. Accessed November 2019: https://dnr.maryland.gov/streams/Publications/ea-05-13_new_ibi.pdf