Chesapeake Bay Program
Climate-Smart Framework and Decision-Support Tool
Final Report

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Chesapeake Bay Program: Climate-Smart Framework and Decision-Support Tool

Introduction

Project Background

This project was initiated by the Chesapeake Bay Program (CBP)[1] Climate Resiliency Workgroup to develop a structured, science-based framework through which the principles of climate-smart adaptation planning can be effectively applied to all Chesapeake Bay Agreement Goals and Outcomes. As such, this project directly supports a key goal of the workgroup, which is to increase the resiliency of the Chesapeake Bay watershed to adverse impacts from changing environmental and climate conditions. The goal of the project is to support the integration of climate-smart principles throughout the CBP at multiple levels, from place-based management actions to restoration strategies and development of partnerships. Objectives of this project are to:

- Advance climate resilience objectives of the Chesapeake Bay Watershed Agreement, including application of climate-smart conservation.
- Develop a structured framework and process to integrate climate change into CBP management strategies and actions.
- Engage with selected CBP Goal Implementation Teams (GITs)/workgroups as case studies.
- Develop a climate-smart decision methodology that will work across all Chesapeake Bay Watershed Agreement Goals and Outcomes through implementation by select CBP GITs and workgroups.

Why Climate-Smart Adaptation?

Climate change will influence the success and effectiveness of Chesapeake Bay restoration work on many levels. Accordingly, the CBP recognized the need for making management and restoration decisions at multiple levels—from place- and method-specific actions to higher-level restoration goals and strategies—more climate resilient. Climate-smart planning fulfills this need by offering a pathway for increasing the climate resiliency of the Chesapeake Bay watershed through management actions at many points in the adaptive management cycle (Figure 1).

The climate-smart guide (Stein et al. 2015) presents a comprehensive review and synthesis of ecologically based principles for ecosystem management and adaptation to climate change vulnerabilities. It presents the underpinnings of a general framework for integrating climate change information into each step of the management planning cycle (Figure 1).

[1] See Attachment 1 for an acronym list that applies to this report as well as all workshop materials.

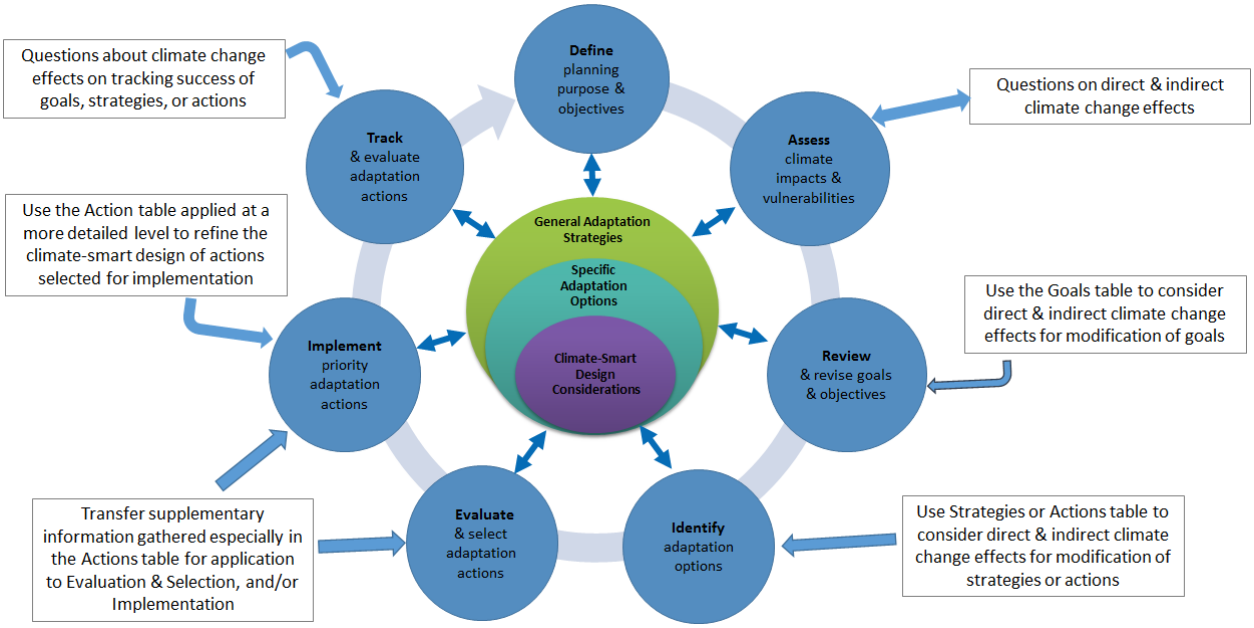

Figure 1. The Climate-Smart Cycle with the Adaptation Design Framework (adapted from West et al. 2017) showing how different levels of the CBP Climate-smart Decision Tables inform different management steps. As presented in the Design Tool Guide (Parker et al. 2017), the Design Tool provides a systematic approach to help users: (1) integrate climate-smart design considerations (inner circle) into their existing management actions or strategies; and (2) expand on existing actions or strategies based on options (from the literature or expert input) (middle circle) found under general adaptation strategies (from the Climate-Smart guide [Stein et al. 2014]) (outer circle).

It includes general adaptation strategies to aid in brainstorming specific actions, as well as rules for designing management actions to be "climate-smart." Climate-smart design considerations (Stein et al. 2014) fall into two categories:

1. How will climate change directly or indirectly affect how the stressor of concern affects the system?
2. How will climate change affect the functionality of the management action (through its effects on the stressor and/or its effects on the action directly), and as a result how will the action need to be adjusted (in terms of location, timing, or engineering design)?

The first category of climate-smart questions addresses the expected climate change effects on the stressors or environmental problems (targets) of the goal, strategy, or action so in the next step (category 2 questions), one can explore how the feasibility, functionality, and/or practicality of the goal, strategy, or action will be affected and how it could be modified to remain achievable despite climate change effects.

To pursue the objective of this project, the Project Team started with the Adaptation Design Tool (West et al. 2016) that is being developed as a partnership between EPA's Exposure Analysis and Risk Characterization Group (EARCG), NOAA, The Nature Conservancy, the Department of the Interior, and Tetra Tech, as an application of the generic climate-smart approach. This tool was originally developed in the context of coral reef management, but is highly applicable for incorporating climate change vulnerability considerations into other ecosystem types and resource management contexts. This project applies this tool to the CBP for the purposes of developing a tailored, CBP-specific climate-smart

framework and decision-support tool, with an associated set of climate change adaptation decision tables.

The value of such a structured approach is that it elicits the required climate change effects and vulnerability information in a sequence that builds to recognition of what would be needed to redesign a management action or reformulate an approach, strategy, or goal to make them climate-smart. That is, it systematically helps to understand what changes are needed for any level of management action or decision to remain effective in the face of climate change. Using the climate-smart decision tables from this project, integration of climate-smart adaptation planning into the CBP can occur at multiple scales of application.

Developing the Framework and Decision Tool

Development and testing of the framework started with the Adaptation Design Tool (West et al. 2016), a structured series of questions that was developed and tested by a partnership between EPA, NOAA, TNC, DOI, and Tetra Tech, as an ecosystem-specific application of the generic climate-smart approach. During this project, Tetra Tech worked closely with the CBP Climate Resiliency Workgroup to revise the Adaptation Design Tool specifically for CBP GITs and workgroups. Initial development and testing was accomplished through interactions with two pilot groups that were identified during initial phases of the project – the Submerged Aquatic Vegetation (SAV) Workgroup and the Black Duck Action Team/Wetlands Workgroup. A workshop held with these groups November 15-16, 2016, provided a forum for piloting the draft framework and decision tables through several example management actions relevant to each group. Revision and further development of the CBP framework was implemented based on outcomes from this first workshop, and a revised set of climate-smart decision-support tables targeting multiple management planning levels were piloted and tested in a second workshop focusing on the CBP Toxic Contaminants Workgroup, held July 31-August 1, 2017.

Workshop Outcomes Informing Climate-Smart Decision Table Revisions

The desire for specific guidance for implementing climate-smart adaptation at 'higher' decision levels (e.g., strategies, approaches, goals/outcomes) was made clear at the first workshop, and became a focus of subsequent revisions of the framework. Other characteristics requested by workshop participants to make the process and tools most useful to CBP GITs/workgroups/action teams were:

- Keep the format of the decision tables as simple as possible, and provide guidance on its use.
- Clarify the concept of the 'stressor' that a management action or strategy may be addressing or accounting for within the context of each GIT/workgroup.
- Consider the need to list stressors separately by their sources or associated medium for some applications (i.e. for some workgroups) or at higher levels of organization.
- Design (modify) the framework to encourage and help facilitate needed cross-group interactions/collaboration.
- Retain and reemphasize the importance of information on uncertainty associated with questions about climate change influences.
- Retain documentation of information (captured in 'notes' sections) generated during use of the decision-support tables on:

- Insights or information from the action level (the most detailed/site-specific climate-smart application) that would inform higher decision levels.
- Information exchanges or other interactions needed with other GITs or workgroups to ensure that restoration decisions that might be within the purview of one group but are key to the success of actions/strategies in another group are coordinated.
- Capturing information gaps/research needs.
- Identifying any missing key actions or strategies.

These requests were incorporated into the final revisions of the multilevel decision-support tables.

Perceived Benefits of the Decision Tables

Participating CBP workgroup members saw value in structured thinking and encouraging reformulation of decisions while simultaneously allowing flexibility in scope and timing of application. Additional benefits of this process that were expressed include:

- Helping intergroup collaboration, and thereby helping to move toward common goals with a climate change lens.
- Making consideration of climate change effects explicit, which individual groups have previously been thinking about informally.

Concerns with Using the Decision-Support Tables

- Using the climate-smart decision tables would be good at the goal or outcome level, making things climate-smart through resilience and interconnectedness; but would not be sufficient without making actions climate-smart as well.
- Using this process to set priorities and thus 'target' restoration actions would be beneficial, but for some workgroups, project identification is mainly opportunity driven, making *a priori* selection of priority actions or restoration locations based on climate difficult.

The Structured Decision-Support Tables

Explanation of the Structure of the Tables and the Flow of Information

The decision tables tailored for the CBP GITs and workgroups are 'structured' to explicitly direct the nature and sequence of questions being asked to deliberately build on each other and lead to recognition of any needed redesign of an action or project, or reformulation of a strategy, approach, or anticipated goal outcome. The decision tables follow a similar structure no matter what level they apply to:

- Step 1 – Screening
  - Actions, strategies, etc., to be put through the climate-smart process
- Step 2 – Category 1 Climate-Smart Design Considerations
  - Climate change effects on the stressors and systems
- Step 3 – Category 2 Climate-Smart Design Considerations
  - Climate change implications for functionality/effectiveness of action, strategy or goal/outcome
- Step 4 – Climate-smart Redesign

    - Changes needed to adapt the action or strategy to make it climate-smart
- Other
    - Notes needed on information gaps/research needs
    - Notes on needed interactions with other groups
    - Notes that inform climate questions at higher levels
    - Consideration of what actions or strategies might be missing

Step 1 – Screening. Application of these climate-smart decision tables takes time and effort, and it is clear that not all actions or strategies included in the work plans of the various CBP workgroups are equally likely to be influenced by climate change. Therefore they will not all benefit equally from being taken through this framework. For example, many CBP work plans include education or outreach components, and while it may be important to include information on climate change influences within the content of the education or outreach materials, the process of developing and implementing such education or outreach does not otherwise need to be modified due to climate influences. The screening step, comprising the questions shown in Box 1, allows CBP managers to select a subset of planned management actions or strategies, etc., that would be most urgent and useful to take through the decision tables, thereby limiting and focusing the level of effort that must be committed to the climate-smart endeavor.

Box 1 - Step 1 Questions:

Screening

What is the CBP key action being considered?

Will the action be substantially influenced by climate change?

Step 2 – Category 1 Climate-smart Considerations. In this step, information is gathered on the direct and indirect climate change effects related to the action or strategy/approach/goal/outcome being considered (see the designated series of questions for this step in Box 2).

In many cases, an action, strategy, approach, or even a goal or outcome is focused on addressing or accounting for a particular stressor. The term 'stressor' may be understood differently depending on context, which in this case would be dictated by which GIT or workgroup is applying the framework. Thus, the terms 'addressing' and 'accounting for' are both included, because one or the other may seem more applicable under different circumstances. For example, the Agriculture Workgroup may consider an action such as adding a filter strip best management practice (BMP) to reduce sediment in runoff and loading to the Bay. This action directly addresses a specified stressor (excess sediments). On the other hand, the SAV Workgroup may consider an action to replant an SAV bed at a particular location. Such an action would focus on replacing propagule material in order to reestablish SAV as habitat, not on reducing the original causes of SAV loss. Nevertheless, such an action should be viewed as 'accounting for' climate change effects on

Box 2 - Step 2 Questions:

Climate Change Effects on the Stressors and Systems*

What stressor(s) need to be addressed by or accounted for in the action (e.g., water quality, habitat loss)?

What are the key climate change impacts (direction, magnitude, mechanism, uncertainty) on the stressor(s)?

Over what timeframe will key climate change impacts affect key actions? Are there seasonal patterns or other short- or long-term temporal factors of the climate change effects of concern?

How is progress toward key action/performance targets measured?

*listed from the Action-level climate-smart decision tool

the stressors that contributed to the original habitat loss, and which would likely still threaten a new SAV bed, such as excess nutrient and sediment loading that can contribute to impaired water clarity, physical damage from boating, or local shoreline hardening that alters SAV habitat quality and prevents migration. By considering stressors in both lights, in subsequent questions, they can all be assessed for potential changes due to the influence of climate change. As an additional decision table modification, it was discovered that in some contexts, simply listing a stressor was not sufficient. For example, in the Toxic Contaminants Workgroup, any particular contaminant, such as PCBs, would be considered a stressor. However, to consider climate change influences on that stressor, one would also need to know the medium or source it is associated with (e.g., PCB-contaminated soils, or air deposition). This separation is thus also included in Step 2 questions.

In the Step 2 series of questions, the sometimes-confusing concepts of direct and indirect influences of climate change are separated. Figure 2 visualizes the distinction. In the original process of planning the restoration of the Chesapeake Bay, key resources were identified, and the problems affecting those resources were assessed and described, so that goals, strategies, and actions to address those problems could be developed (shown in the upper tier of Figure 2). However, climate change can affect the target resources directly (for example, increasing temperatures could increase the mortality of a particular species) or the actions (or strategies, etc.) directly (for example, increasing storm surge could erode and damage rock breakwaters) in ways that increase the problem or decrease the functionality or effectiveness of the solution. In addition, indirect effects of climate change on the stressor that an action or strategy addresses or accounts for (for example, increasingly severe storms could increase nutrient and sediment runoff) can also increase the problem or decrease the functionality or effectiveness of the solution (shown in the lower tier of Figure 2). Though not all three sources may be pertinent to every case being considered, all three are investigated through the Step 2 questions and potentially accounted for in Step 3 in order to make appropriate climate-smart adjustments.

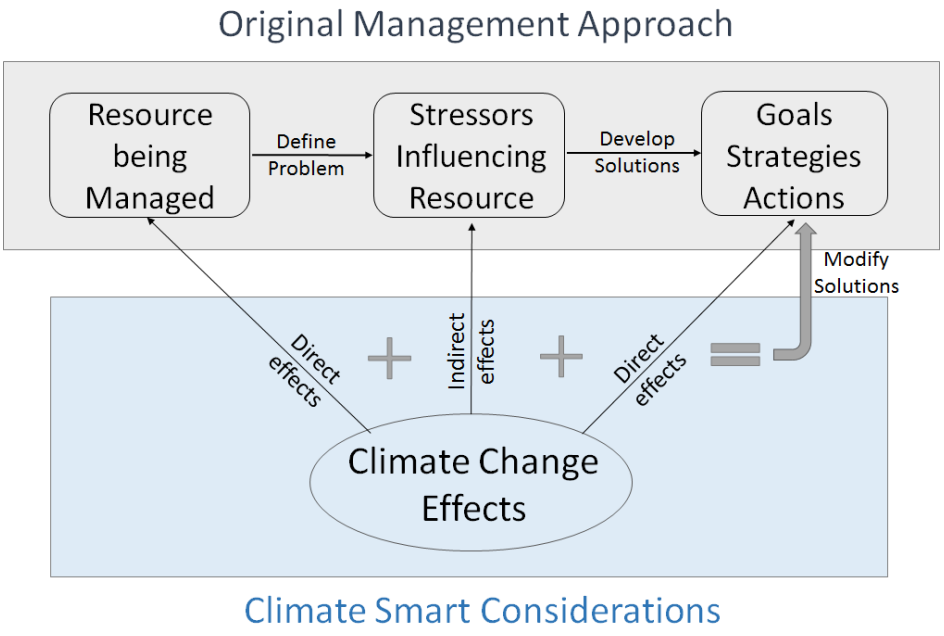

Figure 2. How direct and indirect effects of climate change are used to modify actions, strategies, or goals to make them climate-smart.

The Step 2 question on timing of anticipated climate change effects is intended to inform plan formulation or evaluation and selection considerations, such as when the action is needed, sequencing with other actions, or the time frame under which effectiveness should be evaluated. The question on how progress toward performance targets should be measured is intended to encourage consideration of how the climate change effects, documented in the previous Step 2 questions, would influence the selection of effectiveness metrics and how to measure them.

Step 3 – Category 2 Climate-smart Considerations. The questions in Step 3 (shown in Box 3) build from the information documented in Step 2 to document how climate change is likely to change the effectiveness, functionality, durability of, or ability to achieve the action, strategy, or goal outcome. In this step information is taken from Step 2 on the stressors of interest and climate change effects on those stressors to ask how those climate change effects on the stressor, on the action (or higher level), or on the resource being managed might change the effectiveness of the action (or the strategy or higher level decision). As a simple example, if the action being reviewed is a particular sediment runoff reduction BMP, and climate change is expected to increase the magnitude of sediment runoff due to increased intensity and frequency of storms, will this reduce the efficiency of the proposed BMP in filtering sediment out of the runoff or overwhelm the capacity of the BMP? The comparable question is asked about how direct effects on the resource or the action (or strategy) might change the functionality of the action (or strategy).

Box 3 - Step 3 Questions:

Climate Change Implications for Functionality of Actions*

How will climate change impacts on the stressor(s) affect effectiveness of the action?

How will climate change impacts directly on the resource or the action alter effectiveness of the action?

What are climate change-related time frame considerations or constraints on achieving or implementing the key action/performance target (e.g., urgency, synergies or dependencies on other work plans/actions)?

What changes are needed to adapt the action to accommodate the combination of direct and indirect climate change effects over the target periods for implementing the action or work plan? Or are there other ideas for actions suggested by these results?

*listed from the Action-level climate-smart decision tool

The final question of Step 3 is intended to be a synthesis of the information from the preceding climate-smart decision table questions, resulting in a summary of what changes are needed to adapt the action or strategy (or other higher-level decision) to make it climate-smart, potentially including modifications in location, timing, and/or engineering design. This is then translated into a statement of the redesigned action or reformulated strategy in Step 4.

It is often this set of (Step 3) questions, when applied at the action level, that generates outputs and insights that are broadly applicable (e.g., to other similar actions, or other areas of the Bay) and therefore informative to making strategies, approaches, or goal outcomes more climate-smart. These are the insights that should be captured in the notes at the end of the decision table and applied when using the higher-level decision table. For example, during the first workshop, when the Black Duck Action Team evaluated a case study involving the eradication of *Phragmites* to improve the quality of a marsh as duck habitat, they questioned (and recorded in the notes column) whether other vegetation would come in and replace the removed *Phragmites*. If not, marsh platform could be lost, and this general strategy would have to be modified. As a result, while the decision-support tables for each level

can be used independently, it is suggested that application at the action level be done first, whenever possible. In general, the notes included as the decision tables are completed can play an important role in documenting the reasoning for decisions, as well as providing supplementary information on research gaps and potential interactions among actions/strategies or among workgroups that together will enhance the CBP management and restoration efforts.

Step 4 – Climate-smart Redesign. The restatement of the now climate-smart action, strategy, approach, or goal/outcome follows directly from the summation in the final question of Step 3, but should be a clear and detailed description that captures all the elements generated as a product of applying the climate-smart decision-support tables.

Box 4 - Step 4:

Statement of the Climate-Smart Redesigned Action or Reformulated Strategy

Climate-Smart Decision-Support Tables at Multiple Levels

As mentioned, a key goal arising from the first workshop was to be able to apply this structured process of directed climate-smart questioning to higher levels of planning decisions, so they would have the option of directly reviewing and revising approaches, strategies, or potentially even goal outcomes, even if specific actions had not yet been formulated. Three levels were initially characterized to represent the restoration planning information captured in CBP work plans:

- Key actions/work plans
- Strategies/management approaches
- Goals/outcomes

Decision tables tailored to each of these levels were developed following the first workshop, reviewed by the first workshop participants, and piloted at the second workshop. Two considerations emerged. First, the stated goals of the CBP GITs and workgroups tend be broad and aspirational (as would be expected). Accordingly, they are not as sensitive to becoming ineffective or inapplicable due to climate change effects as are the strategies and actions that are formulated to achieve the overarching goals. For example, a goal of the Toxic Contaminants Workgroup is to 'ensure that the Bay and its rivers are free of effects of toxic contaminants on living resources and human health.' It is unlikely such a statement would need definitive revision to accommodate climate change influences. On the other hand, the 'outcomes' associated with the goals that in the CBP work plan format are often (but not always) presented as more specific or even quantitative targets, and thus may potentially need review to assure they are realistic and achievable in light of climate change influences.

Second, during the course of level-specific climate-smart decision table development and revision, it emerged that the content and flow of the questions was similar for both of the higher levels. So at this time, only two decision tables are presented – one for key actions, activities, or projects that are location and/or method specific, and another to cover the more broadly described higher decision levels. These two tables – the 'action' level and the 'strategies/approaches or goals/outcomes' level – are presented in Attachment 2 with guidance (explanations shown in red text in each associated answer space) on what is expected for each question. Completed examples of these tables, using SAV and Black Duck case studies that were developed during the workshops, are presented for reference in Attachment 3. Blank decision-support tables are included in Attachment 4.

The flow of information is similar in both levels of climate-smart decision tables because, for any level of application, the questions are structured similarly to promote an understanding of the combination of direct and indirect climate change effects on the targeted stressors, resources, and/or the actions or higher-level decisions themselves, and then to use this understanding to direct the kinds of modifications needed for the actions or strategies (etc.) to remain achievable and effective. Key differences across the three planning levels are largely related to the spatial (and sometimes temporal) scale addressed at each level. Site- and method-specific actions (the most detailed or specific level of application of climate-smart in this case) focus on particular problems or stressors. As a result, the information sought on climate change effects and vulnerabilities similarly focuses on the location and method or approach being considered. In contrast, the goals or strategies levels of the CBP are generally not site- or method-specific, but rather reflect larger spatial scales (e.g., larger areas of land/water, multiple habitat types), broader categories of tactics, potentially longer time frames, and often a greater number of stressors/problems being considered.

Accordingly, the scope of climate change effects and vulnerabilities that need to be considered would be more diverse and cover larger spatial areas. Thus, for a decision table applicable to the goals or strategies levels of the CBP, the questions also have to address broader scales and potentially multifaceted stressors or environmental factors. Additional consideration may be needed regarding potential climate change effects directly on the managed resource, if this differs from consideration of effects on stressors or the action/strategy. Also, some CBP GITs/workgroups manage a 'habitat' (e.g., the Wetlands Workgroup), whereas others may manage a particular species or organism group (e.g., black ducks, blue crabs). For those managing species, additional consideration may need to be given to climate change effects, as well as management responsiveness, through the habitat for that species (or other ecological resources such as food sources).

Given the larger scale and broader scope of stressors and other environmental factors that are incorporated at CBP strategies, management approaches, goals, or outcomes level, the concept – captured in the second category of climate-smart considerations – of redesigning activities so they remain effective in light of climate change, must also be perceived more broadly, and can be interpreted as whether the strategies/approaches/goals/outcomes remain effective, feasible, and/or achievable in light of relevant climate change considerations. We can then ask (as we would at all levels of application) how the strategies, outcomes, etc., might need to be adjusted to accommodate the climate change influences highlighted by addressing the decision table questions in order to remain feasible, achievable, and effective.

Higher-level decisions often consider use of a particular approach that can be applied throughout the Chesapeake Bay, but are ultimately implemented at particular sites. Thus at these higher levels, a climate-smart assessment can be used to help set priorities, i.e. to use the assessment of climate change influences to recognize where more suitable locations for restoration efforts might be in the future with climate change.

The terminology used for different planning levels are not always consistent among workgroups. For example, the Toxic Contaminants Workgroup has one 'Management Approach' (or strategy) called 'Regulatory Approaches', with a 'key action' under that to pursue TMDLs. Particular TMDLs (such as the Potomac River PCB TMDL) are categorized as 'performance targets' under this key action. Despite being called a key action, a TMDL is itself not a site- or method-specific action, but rather defines a strategy and targets, which must then be implemented using a range of site- and method-specific actions. As a

contrasting example, one SAV workgroup 'management approach' is to restore SAVs in the Bay, and a 'key action' under that approach is to plant at least 20 acres each year. Although even this key action is not site-specific, it is more specific than the Toxic Contaminants Workgroup example. Such terminology differences should be recognized, but should not by themselves drive differences in application of this climate-smart methodology. This is another reason it seemed practical to present only two sets of climate-smart decision-support tables.

Tailoring for Different Workgroups

To be effective and contribute to the Climate Resiliency Workgroup's goal of increasing the resiliency of the Chesapeake Bay watershed to adverse impacts from changing environmental and climate conditions, it must be possible for as many as possible of the CBP workgroups, action teams, and committees to use this climate-smart decision process and integrate it into their ongoing decision-making. The CBP GITs and workgroups differ to varying degrees in the types of resources they manage, and therefore also in the focus and content of their work plans. Some of these differences will play into how the various GITs/workgroups apply the framework and decision tables, and how they address some of the questions.

For example, the nature of GIT/workgroup goals vary from the direct management of stressors that affect the Chesapeake Bay system (e.g., the Water Quality GIT or the Toxic Contaminants Workgroup), to managing particular ecosystem components that are affected by those stressors (e.g., the SAV, oyster, or black duck workgroups/action teams), to managing targets such as protected lands, that contribute to integrity of the Chesapeake Bay ecosystem and associated natural services valued by humans, but for which the types of stressors considered relevant may be quite different. Corresponding to these inherent differences, it became clear during the workshops and other interactions that members of different workgroups interpreted the questions in Step 2 regarding target stressors differently. This led to some confusion. For example, during the first workshop, several participants in the SAV Workgroup and the Black Duck Action Team did not view the case study actions being reviewed during the workshop as addressing a particular stressor, but rather as restoring lost habitat (and/or food sources). An initial attempt to clarify the second Step 2 question was to increase the number of terms used in the questions (i.e. "What stressor[s], environmental factor[s], or other driver[s] impacting the resource is the strategy addressing [e.g., water quality, habitat loss]?"). However, in further review of the revised tables by the participating workgroups following the first workshop, this fix seemed ineffective.

The bigger problem was that the varying contexts within which the different workgroups operate were leading to different perspectives on the objective of the question. Key to understanding the objective of the question is recognizing that to adapt to climate change, one has to understand, very specifically, how climate change can influence what you are trying to do. This can happen through three pathways – direct climate change influences on the target resources being managed, direct influences on the action (or strategy, etc.), or indirect climate change influences on the stressor that an action or strategy is trying to address or account for. To get information on this third 'indirect' component, one needs to think about and document what 'stressors' – i.e. what environmental processes, problems, or other factors – interact with the action or strategy being considered. Whether these factors are being directly addressed by the action/strategy, or whether the action/strategy is addressing a situation to which those factors contribute, they are integral to the design and functioning of an action or strategy. Given this, any climate change effects that alter these 'stressors' can also impact that success. We hope that

the explanations in this report, the additional guidance provided for the decision tables, and the expanded wording of the question - "What stressor(s) need to be addressed by or accounted for in the action (e.g., water quality, habitat loss)?" – are sufficient to help any of the GITs/workgroups to think about and answer this question effectively.

Who Should Use the Framework and Decision-Support Tables?

It is anticipated that these climate-smart decision-support tables will be used separately by each workgroup. Any or all workgroup members knowledgeable about the management actions, work plan, strategies, and/or other restoration decisions that are the focus of the workgroup can, to great benefit, participate in using this framework and decision tables. However, some interdisciplinary expertise is also required to successfully address the structured series of climate-smart questions. Beyond expertise relevant to the focus of the workgroup or GIT, climate science expertise would be beneficial, particularly regarding climate change projections for the Chesapeake Bay, and about associated vulnerabilities for the site, region, and/or resource being managed. For some workgroups, there would potentially be other relevant specialties that would be needed (for example, a sediment scientist to work with the Toxic Contaminants Workgroup, or a water quality specialist to work with the SAV Workgroup).

Another consideration is group size. Clearly there are benefits to having most members of a workgroup participate in making their work plan climate-smart. In application to coral reefs, a group size of 3-10 people was considered optimal, assuming the needed expertise was represented (Parker et al. 2017). This decision can be workgroup-specific, where considerations can balance the benefits of inclusiveness and the broader 'buy-in' of results that comes from involving a large number of workgroup members and stakeholders, against the relatively efficient performance of a smaller group. A smaller group also can be considered if a preliminary 'rough cut' review of a subset of actions or strategies is desired. In fact, preliminary application can be done by a single knowledgeable manager, which can help the group become familiar with the framework, determine information needed to complete the decision tables for that particular workgroup (or GIT, action team, etc.) context, and increase the efficiency of the larger team during subsequent workgroup efforts. For the more comprehensive evaluation that is likely to accompany the biennial Strategic Review System work plan review, a larger and more diverse team effort is probably warranted.

Process for Using the Decision-Support Tables – Facilitated or Not?

A final but big question about how to use the structured decision tables is whether groups wishing to apply this climate-smart process would achieve a better outcome by using a facilitator who is knowledgeable about the tables and the structured process. Is a facilitated process, for example in a workshop environment, necessary or recommended for the most effective use of the decision tables? The first response is that we encourage the broadest possible application of the framework and decision tables, in order to make as many CBP restoration actions and decisions as possible climate-smart and thus increase the climate resiliency of the Chesapeake Bay. Achieving this speaks to making the process as accessible and efficient as possible. For development and testing of this climate-smart framework, a facilitated process was necessary so that the Climate Resiliency Workgroup and the team helping to develop the framework could interact with the pilot workgroups, discuss strengths and weaknesses of the draft process, and get direct feedback from participants. Table 1 summarizes some pros and cons of using a more formal facilitated approach in regular application of the framework. As with any new process, some training, self-learning, or other mechanism will be needed to help interested CBP

GIT/workgroup members gain enough understanding of these decision tables to be able to use them effectively. This can certainly be accomplished using a facilitator. However, ongoing use of a facilitator should be a group-by-group decision. It is hoped that this process will become an integral component of all CBP GIT/workgroup restoration planning work, and can certainly be accomplished by any and all members of each GIT or workgroup.

Once some workgroup participants are familiar with this structure climate-smart process, the appropriate level of climate-smart decision table can be applied in many ways. This can range from a comprehensive review of existing management actions, strategies, etc., to periodic review of restoration opportunities as they arise.

Table 1. Potential pros and cons of applying the climate-smart decision tables as a more formal, facilitated process.

Pros	Cons
Knowledgeable facilitation may afford more complete application of the process.	Facilitation will be more expensive and will require a bigger time commitment.
The framework represents a relatively new and demanding addition to the familiar management planning cycle, and a facilitated process would afford a training opportunity for a spectrum of CBP managers and scientists.	A facilitated process might be most efficient or productive if most components of a work plan, particularly specific actions, are identified and reviewed in a single group, whereas for many CBP work plans, potential actions often arise opportunistically.
A facilitated process would encourage more inclusive participation by stakeholders associated with each workgroup.	Once familiar with this structured process, it would be beneficial to apply the decision tables whenever new actions, or the opportunity to review strategies, arise.

Conclusion: Using the Framework and Decision-Support Tool

Following the essence of Structured Decision Making (SDM), the process promoted by use of these decision tables is intended to be inclusive, transparent, and systematic. This process is inclusive because it can be and is encouraged to be used by any and all GITs, workgroups, and action teams. In addition, it necessitates collaboration among scientists and managers with ranges of expertise (see 'Framework and Decision-Support Tables') and promotes inclusion of other stakeholders, as well as coordination across GITs and workgroups. The process is transparent because by documenting responses to each question, GIT/workgroup members produce a transparent record of the thought process that led to the climate-smart adaptation result. Finally, the process promotes the described systematic approach to thinking about, answering, and documenting responses to the prescribed sequence of decision table questions, and thus can be reliably repeated. These characteristics represent benefits and enhancements to the existing resource management process, beyond the direct outcome of making various levels of management decisions climate-smart.

This project developed a structured, science-based framework through which the principles of climate-smart adaptation planning can be effectively applied to all Chesapeake Bay Agreement Goals and Outcomes. The decision-support tool, piloted with the Black Duck Action Team and the SAV, Tidal Wetlands and Toxic Contaminant Workgroups, is now readily available to support the integration of

climate-smart principles throughout the CBP at multiple levels, from place-based management actions to larger-scale restoration strategies.

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Attachment 1

Chesapeake Bay Program: Climate-Smart Framework and Decision-Support Tool

Acronyms used in this report.

BMP	Best Management Practice
CBL	Chesapeake Bay Laboratory
CBP	Chesapeake Bay Program
CRC	Chesapeake Research Consortium
CSO	Combined Sewer Overflow
DMR	Discharge Monitoring Report
DOEE	(Washington, D.C.) District Office of Energy and the Environment
EJ	Environmental Justice
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FCA	Fish Consumption Advisory
GCRP	Global Change Research Program
GIT	Goal Implementation Team
GW	Groundwater
MD DNR	Maryland Department of Natural Resource
NOAA	National Oceanic and Atmospheric Administration
ORD	Office of Research and Development
PA DEP	Pennsylvania Department of Environmental Protection
PCB	Polychlorinated BiPhenyl
SAV	Submerged Aquatic Vegetation
SLR	Sea Level Rise
SRS	Strategy Review System
SW	Stormwater
TCW	Toxic Contaminants Workgroup
TMDL	Total Maximum Daily Load
UMCES	University of Maryland Center for Environmental Science
U.S. EPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
USACE	United States Army Corps of Engineers
VA DGIF	Virginia Department of Game and Inland Fisheries
WG	Workgroup
WIP	Watershed Implementation Plan
WQ	Water Quality
WW	Waste water

Attachment 2

Chesapeake Bay Program: Climate-Smart Framework and Decision-Support Tool

Climate-Smart Decision-Support Tables with Instructions

CLIMATE-SMART ADAPTATION DESIGN – CBP WORK PLAN/KEY ACTIONS

Fill this out last

Climate-informed actions and performance targets – Documentation of Results *Check the appropriate box.*	
☐	Keep existing actions and performance targets without modification. *If yes, provide reasoning.*
☐	Use existing actions and performance targets but with minor modifications. *If yes, note modifications and the reasoning behind them.*
☐	Use new actions/performance targets or significantly adjust existing ones. *If yes, provide the reasoning.*

Climate-Smart Adaptation Design at the CBP Work Plan/Key Actions Level

Current Action	*What is the CBP action being considered?*	
	Current key action or specific performance target	
Step 1: Screening for Actions	*Will the action be substantially influenced by climate change?*	
	Screening for actions.[2] If yes (influenced by climate change), proceed; if no, set aside the action (check the first box in the checklist above).	

Step 2: Category 1 Considerations:	*What stressor(s), characterized by source if appropriate, are addressed by or accounted for in the action?*	
	Specific stressor(s) and source(s). (List separately; include uncertainty and relative sensitivity [low, medium, high.])	• *Identify the stressor(s) (e.g., pollutant, fishing pressure, loss of food or habitat resources, human development, etc.) that the management action addresses or in other ways seeks to account for. It is important to be specific and thorough in identifying the stressor(s) addressed or accounted for by each action, and subsequently (next question) to capture the climate effects on the stressor(s) that are relevant to the action. In some cases, specification of a stressor must also include designation of its source or the medium with which it is associated, as climate change*

[2] This is a screening question to identify and set aside (not proceed with climate-smart revision) actions not likely to be affected by climate change. For example, model improvement efforts will not themselves be directly influenced by climate change, although it would be important to include climate change into CBP models used for planning purposes.

		effects on the stressors may differ based on source. (Note – Any particular action can address or account for more than one stressor.)
	What are the key climate change impacts (direction, magnitude, mechanism, uncertainty) on the stressor(s)/source(s)?	
	Key climate influences on stressor(s)/ sources(s)	• *Describe expected climate change impacts on the specified stressors, including information on the direction, magnitude, and mechanism of change. Climate change impacts may have to be considered separately by stressor/source combinations, when applicable. When describing expected climate change effects on the stressor(s) relevant to a management action, the uncertainty associated with assessments about climate changes and their effects on the stressor(s) must also be considered. Again, specificity and detail are important, because this information is intended to support consideration, in subsequent questions, of how actions would have to be modified (e.g., scaled, placed, timed, engineered, etc.) to remain effective. Supporting materials needed to address this question include climate projections, vulnerability and resilience information, etc.*
	What is the expected timing of climate change impacts on the action? This could include seasonal patterns or temporal trends of the climate change effects of concern.	
	Timing of climate change effects	• *Describe the timing of when climate change will affect the target stressor(s) to inform when the action is needed, sequencing with other actions, and the time frame under which future effectiveness should be evaluated. Mid-century is a management-relevant time frame commonly used; however, this also could include seasonal outlooks/forecasts, or shorter-term events like El Niño.*
	Implications for how effectiveness of actions or progress towards performance targets is measured.	
	How is implementation being tracked (e.g. indicators, metrics)?	• *Management actions should be matched with measurable outcomes and appropriate metrics or indicators of changes in the target stressors or the resource, which can later be used to measure effectiveness of the action. This question is intended to capture such information. Potential changes in how to measure the success metrics should also be described here. If possible, suggest targets for quantitative or qualitative changes in the stressor or the resource metric(s) that would be used to measure effectiveness.*
	How will climate change alter the ability to carry out progress measurements or monitoring protocols?	• *Describe how monitoring (e.g., frequency, location, duration, etc.) might need to be modified to given climate change effects on the stressor.*

Step 3: Category 2	*How will climate change impacts on the stressor(s)/source(s) impact effectiveness of the action?*	
	Indirect effects on action	• *Describe how climate impacts on the stressor, considered separately by source if needed, will change the effectiveness of the management action over its implementation and functional lifetime. Will the action be able to*

		handle changes in the target stressor or other climate-driven changes to the resource?
	How will climate change impacts directly on the action impact effectiveness of the action?	
	Direct effects on action	• *Describe how climate change may directly affect the action (particularly relevant for actions that involve physical elements or structures) in ways that will change the effectiveness of the action over its implementation and functional lifetime. Could the action be physically impacted, overwhelmed, or destroyed by climate change impacts?*
	What are climate change-related time frame considerations or constraints on achieving or implementing the action [e.g., urgency, synergies or dependencies on other actions /work plans]?	
	Time frame considerations	• *Identify temporal considerations, including: (1) urgency due to anticipated time frame of climate change effects on the action and (2) temporal needs for planning and implementation of the action (including lead-time for design, permitting, construction, or other enabling conditions).*
	What changes are needed to adapt the action to accommodate the combination of direct and indirect climate change effects over the target periods for implementing the action? Or are there other ideas for actions suggested by these results?	
	Climate-driven adaptations needed	• *Describe the changes needed to adapt the design of the action in terms of place, time, or design (including engineering). Be sure to review and consider the information from all previous questions including the Notes sections.*

Step 4: Climate-Designed Action	***Climate-smart Work Plan/Action***	
	Description	• *Revise the original action to incorporate the climate-smart design considerations as described in the last question of Step 3. Be as specific and comprehensive as possible.*

Notes: What are the information/data gaps and research needs to better understand climate impacts or uncertainties, social or ecological effects, design needs, etc.
Discussions during application of the climate-smart decision tables often highlight instances where particular information that would be needed to fully address the question are not available. This notes section is intended to document these types of information gaps and research needs. In the CBP, many work plans already include strategies and key actions focused on filling recognized information needs in order to further managers' abilities to fulfill CBP goals. This additional information will be useful in subsequent evaluations, for revisiting and refining previous steps in the adaptive management cycle, and for directing future work plan revisions.

Notes: What issues, lessons, or spatial or temporal considerations emerged that might be common across other sites, or Bay-wide? How might these affect higher levels of planning (strategies, approaches)?

As key actions are put through the climate-smart decision tables, discussions on questions in steps 2 and 3 will sometimes generate insights or highlight issues that are more broadly applicable to sites or similar actions around the Bay, which may inform or help direct the revision of higher-level decisions (e.g., strategies, approaches, outcomes). This notes section is intended to capture these insights, which should be transferred to the higher-level climate-smart decision tables.

Notes: Interactions needed with other GITs/Workgroups that are key to the actions.

Use this notes section to document information exchanges or other interactions needed with other GITs or workgroups to assure that restoration decisions that might be within the purview of one group but are key to the success of actions another group are coordinated.

*Are there any key actions missing?**

The purpose of this activity is to help identify actions that could be added to a work plan by identifying any key vulnerabilities that are not sufficiently addressed, and/or types of strategies or approaches that are not utilized, in the existing plan, and to craft additional actions to fill those gaps.

* *Actions that may be needed to more comprehensively address the climate change impacts identified. The purpose is to identify any key vulnerabilities that are not sufficiently addressed in the existing plan and to craft additional actions to fill those gaps. The ecologically oriented list of general adaptation strategies from the Climate-smart guide can be used to help in brainstorming these, though actions relevant to implementing those strategies/approaches in your specific management/ecosystem context may need to be brainstormed and/or researched in the literature. Start by listing any new actions listed in the last question of Step 3.*

CLIMATE-SMART ADAPTATION DESIGN – CBP STRATEGIES/MANAGEMENT APPROACHES OR GOALS/OUTCOMES

Fill this out last

Climate-informed strategies/management approaches (or goals/outcomes)– Documentation of Results *Check the appropriate box.*	
☐	Keep existing strategies/approaches without modification. *If yes, provide reasoning.*
☐	Use existing strategies/approaches but with minor modifications. *If yes, note modifications and the reasoning behind them.*
☐	Use new strategies/approaches or significantly adjust existing ones. *If yes, provide the reasoning.*

Climate-Smart Adaptation Design at the CBP Strategy/Management Approach (or Goals/Outcomes) Level

Current Strategy	*What is the CBP strategy/management approach (or goal/outcome) being considered?*	
	Current strategy/management approach (or goal/outcome)	
Step 1: Screening for Goals/Strategies	*Will the strategy (or goal) be influenced by climate change?*	
	Screening for strategies (or goals)[3]. If yes (influenced by climate change), proceed; if no, set aside the strategy (check the first box in the checklist above).	

[3] This is a screening question to identify and set aside (not proceed with climate-smart revision) strategies/approaches (or goals/outcomes) not likely to be affected by climate change. For example, education or outreach efforts will not themselves be directly influenced by climate change, although it would be desirable to include climate change information into these types of efforts. Therefore, it would not be necessary to apply this process directly to revision of such strategies. It should be noted that strategies such as development of energetic, system, planning, or other models also are not directly impacted by climate change; however, if climate change effects have not heretofore been considered in the model, then redesign of the model would be recommended.

Step 2: Category 1 Considerations: Climate change effects on the stressors and systems	*What stressor(s), characterized by source if appropriate, are addressed by or accounted for in the strategy?*	
	Specific stressor(s) and source(s). (List separately; include uncertainty and relative sensitivity [low, medium, high.])	• *Identify the stressor(s) (e.g., pollutant, fishing pressure, loss of food or habitat resources, human development, etc.) that the strategy/ approach (or goal/outcome) addresses or in other ways seeks to account for. At this level, multiple stressors may be included and should be identified separately, with consideration of how they might vary over the region of concern. It is important to be specific and thorough in identifying the stressor(s), and subsequently (next question) to capture the climate effects on each relevant stressor.*
	What are the key climate change impacts (direction, magnitude, mechanism, uncertainty) on the stressor(s)/source(s), relevant to the resource?[4]	
	Key climate influences on stressor(s)/sources(s)	• *Describe expected climate change impacts on the specified stressors, including information on the direction, magnitude, and mechanism of change. Climate change impacts may have to be considered separately by stressor/source combinations, when applicable. Due to the often larger scale being considered at this level, this needs to consider any variations in impacts or vulnerabilities over the spatial scale of concern. The uncertainty associated with assessments about climate changes and their effects on the stressor(s) must also be considered. Specificity and detail are important, because this information is intended to support consideration, in subsequent questions, of how strategies/approaches (or goals/outcomes) would have to be modified to remain realistic, achievable, and/or effective. Supporting materials needed to address this question include climate projections, vulnerability and resilience information, etc.*
	What are the key climate change impacts directly affecting the resource (direction, magnitude, mechanism, uncertainty)?	
	Key climate influences on target resource(s)	• *Describe expected climate change impacts on the resource being managed (the management target), if this differs from and/or adds to consideration of climate change effects on the relevant stressor(s). The target resource could be a species or organism group (e.g., black ducks, oysters), a component of the ecosystem or a habitat (e.g., wetlands, SAVs, watersheds, protected lands, forests, fish habitat, sediments), a process, use, or condition (e.g., agriculture, stock assessment, land use, stream health, fish passage, federal facilities, wastewater treatment, urban stormwater), or a contaminant.*
	Over what timeframe will key climate change impacts affect targeted resources? Are there seasonal patterns or other short- or long-term temporal factors of the climate change effects of concern?	

[4] Incorporate information from the notes section of any action-level climate-smart decision tables completed on issues, lessons, or spatial or temporal considerations emerged that might be common across other sites, or be relevant Bay-wide, and how these affect higher levels of planning (strategies, approaches).

	Timing of climate change effects	• *Describe the timing of when climate change will affect the target resource or associated stressor(s). This is to inform implementation needs and the time frame under which effectiveness should be evaluated. Mid-century is a management-relevant time frame commonly used; however, this also could include seasonal outlooks/forecasts, or shorter-term events like El Niño.*
	How is progress toward strategy/management approach (or goal/outcome) measured?	
	How is implementation being tracked (e.g. indicators, metrics?	• *Most higher-level decisions, particularly strategies, approaches, and outcomes, should be matched with measurable targets and appropriate metrics or indicators of changes in the target stressors or the resource, which can later be used to measure effectiveness of the strategies/approaches (or goals/outcomes). This question is intended to capture such information. If possible, suggest targets for quantitative or qualitative changes in the stressor or the resource metric(s) that would be used to measure effectiveness.*
	How will climate change alter the ability to carry out progress measurement or monitoring protocols?	• *Potential changes in how success metrics would have to be measure because of the impacts or changes related to climate changed should also be described here.*

Step 3: Category 2 Considerations: Climate Change implications for strategies	*How will climate change impacts on the resource itself change the condition (affect the quality or quantity) of and/or trends in the target resource?*	
	Direct effects on resource condition	• *Describe how climate impacts on the resource being managed (the management target), will change the effectiveness of the strategy/management approach (or goal/outcome) over its implementation and functional lifetime. Will the strategy/management approach (or goal/outcome) be able to accommodate climate-driven changes to the resource?*
	How will climate change impacts on the stressor(s) impact the strategy/approach (or goal/outcome)?	
	Indirect effects on strategy/approach (or goal/outcome)	• *Describe how climate impacts on the stressor, considered separately by source if needed, will change the effectiveness of the strategy/ management approach (or goal/outcome). Will they be able to handle changes in the target stressor?*
	How will climate change impacts directly on the strategy/approach (or goal/outcome) impact how realistic, achievable, or effective the strategy/approach (or goal/outcome) is?	
	Direct effects on strategy/approach (or goal/outcome)	• *Describe how climate change may directly affect the strategy/ management approach (or goal/outcome) (particularly relevant to strategies/approaches (or goals/outcomes) that involve physical elements or structures) in ways that will change how realistic, achievable, or effective the strategy/ management approach (or goal/outcome) will be.*
	What are climate change-related time frame considerations or constraints on achieving or implementing the strategy/mgmt. approach [e.g., urgency, synergies or dependencies on other strategies/mgmt. approaches]?	

	Time frame considerations	• *Identify temporal considerations, including: (1) urgency due to anticipated time frame of climate change effects and (2) temporal needs for planning and implementation.*
	What changes are needed to modify the strategy/mgmt. approach (or goal/outcome) to accommodate the combination of direct and indirect climate change effects or the target periods for implementing the strategy? Or are there other ideas for strategies suggested by these results?	
	Climate-driven adaptations needed	• *Describe the changes needed to adapt the formulation of the strategy/ management approach (or goal/outcome) in terms of place (including, for example, selection or prioritization of locations for treatment), time, or design (including engineering). Be sure to review and consider the information from all previous questions including the Notes sections.*

Step 4: Climate-Designed Strategy	***Climate-smart Strategy/Management Approach (or Outcome)***	
	Description	• *Revise the original strategy/management approach (or goal/outcome) to incorporate the climate-smart design considerations as described in the last question of Step 3. Be as specific and comprehensive as possible.*

Notes: What are the information/data gaps and research needs to better understand climate impacts or uncertainties, social or ecological effects, design needs, etc.?
Discussions during application of the climate-smart decision tables often highlight instances where particular information that would be needed to fully address the question are not available. This notes section is intended to document these types of information gaps and research needs. In the CBP, many work plans already include strategies and key actions focused on filling recognized information needs in order to further managers' abilities to fulfill CBP goals. This additional information will be useful in subsequent evaluations, for revisiting and refining previous steps in the adaptive management cycle, and for directing future work plan revisions.

Notes on interactions needed with other GITs/Workgroups that are key to the planned strategies/approaches.
Use this notes section to document information exchanges or other interactions needed with other GITs or workgroups to assure that restoration decisions that might be within the purview of one group but are key to the success of strategies, approaches, or outcomes in another group are coordinated.

*Are there any key strategies/approaches or (goals/outcomes) missing?**
The purpose of this activity is to help identify strategies/approaches that could be added to a work plan by identifying any key vulnerabilities that are not sufficiently addressed, and/or types of strategies or approaches that are not utilized, in the existing plan, and to craft additional strategies to fill those gaps. [Note - this activity is, for the most part, not applicable to review of goal outcomes).

* *Strategies/approaches that may be needed to more comprehensively address the climate change impacts identified. The purpose is to identify any key vulnerabilities that are not sufficiently addressed in the existing plan and to craft additional strategies/approaches to fill those gaps. The ecologically oriented list of general adaptation strategies from the Climate-smart guide can be used to help in brainstorming these. Start by listing any new strategies/management approaches listed in the last question of Step 3.*

Attachment 3

Chesapeake Bay Program: Climate-Smart Framework and Decision-Support Tool

Climate-Smart Decision-Support Tables – Workshop Case Study/Strawman Examples

CLIMATE-SMART ADAPTATION DESIGN – CBP WORK PLAN/KEY ACTIONS

Fill this out last

Climate-informed actions and performance targets – Documentation of Results *Check the appropriate box.*	
☐	Keep existing actions and performance targets without modification. *If yes, provide reasoning.*
X	Use existing actions and performance targets but with minor modifications. *If yes, note modifications and the reasoning behind them.* This project can remain viable with modest additional considerations.
☐	Use new actions/performance targets or significantly adjust existing ones. *If yes, provide the reasoning.*

Climate-Smart Adaptation Design at the CBP Work Plan/Key Actions Level

Current Action	*What is the CBP action being considered?*	
	Current key action or specific performance target	(Case study/Strawman): Restore submerged aquatic vegetation (SAV) along the shoreline of Kirwans Landing Lane on Kent Island, Maryland
Step 1: Screening for Actions	*Will the action be substantially influenced by climate change?*	
	Screening for actions.[5] If yes (influenced by climate change), proceed; if no, set aside the action (check the first box in the checklist above).	Yes, this action is vulnerable to both direct and indirect climate change effects (proceed with subsequent questions).

Step 2: Category 1 Considerations: Climate change effects on	*What stressor(s), characterized by source if appropriate, are addressed by or accounted for in the action?*	
	Specific stressor(s) and source(s). (List separately; include uncertainty and relative sensitivity [low, medium, high.])	• Sediment and nutrient runoff from agricultural land and septic systems (results in excess algal growth that reduces water clarity). High magnitude, medium uncertainty. • Direct destruction (from aquaculture activities, hydraulic clam dredging, propeller scarring). Low magnitude, low uncertainty. • Armored (riprap) shoreline. Medium to high magnitude, low uncertainty. • Invasive Phragmites marsh grasses. Low magnitude, low uncertainty.

[5] This is a screening question to identify and set aside (not proceed with climate-smart revision) actions not likely to be affected by climate change. For example, model improvement efforts will not themselves be directly influenced by climate change, although it would be important to include climate change into CBP models used for planning purposes.

	What are the key climate change impacts (direction, magnitude, mechanism, uncertainty) on the stressor(s)/source(s)?	
	Key climate influences on stressor(s)/sources(s)	• Sediment and nutrient runoff from adjacent agricultural lands may increase with increasing projected winter rainfall. However, reduced summer rainfall may produce a seasonal decrease in turbidity and eutrophication. Medium magnitude, medium uncertainty. • Sea level rise (SLR) will increase coastal erosion and sedimentation in SAV habitat, increasing sediment loads. Medium magnitude, low uncertainty. • SLR will increase water depths, causing loss of optimal SAV habitat. Habitat loss will be a particular problem where shoreline hardening in response to sea level rise (SLR) and storms prevents habitat migration. High magnitude, low uncertainty. • *Phragmites* invasions may increase with increasing temperatures. However, SAV abundance is positively correlated with presence of adjacent shoreline vegetation, and it is not clear whether it matters if that is native or invasive marsh. Low magnitude, high uncertainty.
	What is the expected timing of climate change impacts on the action? This could include seasonal patterns or temporal trends of the climate change effects of concern.	
	Timing of climate change effects	• Seasonal timing of rainfall/runoff is already changing, with increased rainfall in winter, decreased in summer. • SLR is already occurring and will continue to increase. • More intense storms are already occurring and are likely to increase, though confidence in ability to project these changes is low.
	Implications for how effectiveness of actions or progress towards performance targets is measured.	
	How is implementation being tracked (e.g. indicators, metrics)?	• Acres of SAV, positive SAV growth rates, inter-annual persistence of SAV beds. • Measuring habitat metrics (e.g., water depth, turbidity, others) may also be valuable in identifying contributing factors influenced by climate change to any changes in SAV success.
	How will climate change alter the ability to carry out progress measurements or monitoring protocols?	• Monitoring SAV status following major storms and subsequent recovery period would help distinguish chronic (press) from episodic (pulse) disturbances.

Step 3: Category 2 Considerations: **CC** implications for functionality of actions	*How will climate change impacts on the stressor(s)/source(s) impact effectiveness of the action?*	
	Indirect effects on action	• Increased sediment and nutrient loads in winter and during larger episodic storms may increase turbidity and promote algal blooms, and thus decrease the viability of restored SAV beds. • Larger storms could release riprap from shore, rolling rocks over SAV beds. • Invasive marsh grass *Phragmites* may become more successful, replacing native marsh grass, with unknown consequences for SAV.
	How will climate change impacts directly on the action impact effectiveness of the action?	
	Direct effects on action	Protection of SAV could fail due to direct impacts on SAV including: • Exacerbation of exposures to mobilized sediments with increasing winter rainfall and runoff could cause mortality of SAV in some areas. • Increasingly severe winter storms could directly uproot/destroy SAV in some areas.
	What are climate change-related time frame considerations or constraints on achieving or implementing the action [e.g., urgency, synergies or dependencies on other actions /work plans]?	
	Time frame considerations	• Opportunity to partner with shoreline landowner generates urgency.
	What changes are needed to adapt the action to accommodate the combination of direct and indirect climate change effects over the target periods for implementing the action? Or are there other ideas for actions suggested by these results?	
	Climate-driven adaptations needed	• Work with Chesapeake Bay workgroups responsible for upland restoration of agricultural lands to minimize increases in sediment and nutrient runoff associated with changes in precipitation patterns and larger episodic storm events. • Along shorelines selected for SAV replanting, restore natural shoreline/marsh where hard structures (riprap) currently exist, to the extent possible, to allow migration of shallow SAV habitat in response to SLR and avoid potential physical damage to restored beds.

Step 4: Climate-Designed Action	***Climate-smart Work Plan/Action***	
	Description	• Implement SAV restoration along natural or restored (riprap removed) shorelines, including fringing marshes, of the property on Kirwans Landing Lane on Kent Island, MD. The primary method will be seeding and re-seeding of *Ruppia maritima,* due to its robust performance in a range of salinity and temperature regimes. Encourage concomitant restoration of agricultural land in the adjacent watershed to minimize increases in sediment and nutrient runoff that is otherwise projected to occur due to climate change. Define success over multiple time frames.

Notes: What are the information/data gaps and research needs to better understand climate impacts or uncertainties, social or ecological effects, design needs, etc.?

- Uncertainty of SAV restoration effectiveness needs to be addressed.
- What SAV species are expected to do best under climate change conditions at Kent Island?
- What species of SAV are most temperature- and salinity-tolerant?
- Need more information/ research on the potential application of floating wave-attenuation or similar devices in SAV beds as a means of boosting resistance to physical damage from storms.
- Need to track implementation of 'living shoreline' restorations, including 'mixed shorelines', which reduce available habitat for (occupies the same space as) SAV, and the human demand for living shorelines are likely to increase with climate change increases in SLR and storm frequency & intensity.
- Need more consideration of potential benefits of *Phragmites*; management strategies may differ.

Notes: What issues, lessons, or spatial or temporal considerations emerged that might be common across other sites, or Bay-wide? How might these affect higher levels of planning (strategies, approaches)?

- Challenge and importance of long term monitoring and coverage is emphasized.
- SAV resilience to SLR is high if there is space available for landward migration.
- Other beneficial reasons for the project such as citizen involvement and education.

Notes: What interactions are needed with other GITs/Workgroups that are key to the actions?

Interaction with WQ, any other workgroup responsible for addressing sediment/nutrient runoff from uplands (agricultural), to coordinate protections against the negative impacts to restored SAVs from expected increased sediment runoff from climate change increases in precipitation and or increases in episodic storms.

*Are there any key actions missing?**

* *Actions that may be needed to more comprehensively address the climate change impacts identified. The purpose is to identify any key vulnerabilities that are not sufficiently addressed in the existing plan and to craft additional actions to fill those gaps. The ecologically oriented list of general adaptation strategies from the Climate-smart guide can be used to help in brainstorming these, though actions relevant to implementing those strategies/approaches in your specific management/ecosystem context may need to be brainstormed and/or researched in the literature. Start by listing any new actions listed in the last question of Step 3.*

CLIMATE-SMART ADAPTATION DESIGN – CBP STRATEGIES/MANAGEMENT APPROACHES OR GOALS/OUTCOMES

Fill this out last

Climate-informed strategies/management approaches (or goals/outcomes) – Documentation of Results *Check the appropriate box.*	
☐	Keep existing strategies/approaches without modification. *If yes, provide reasoning.*
☐	Use existing strategies/approaches but with minor modifications. *If yes, note modifications and the reasoning behind them.*
X	Use new strategies/approaches or significantly adjust existing ones. *If yes, provide the reasoning.* Change the focus of the goal/outcome from the direct management of numbers of black ducks to quantity of viable black duck habitat, though including monitoring methods to confirm black duck use of the habitat.

Climate-Smart Adaptation Design at the CBP Strategy/Management Approach (or Goals/Outcomes) Level

Current Strategy	*What is the CBP strategy/approach (or goal/outcome) being considered?*	
	Current strategy/management approach (or goal/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. **Black Duck Outcome:** By 2025, restore, enhance and preserve wetland habitats that support a wintering population of 100,000 black ducks, a species representative of the health of tidal marshes across the watershed. Refine population targets through 2025 based on best available science.
Step 1: Screening for Goals/Strategies	*Will the strategy (or goal) be influenced by climate change?*	
	Screening for strategies (or goals)[6]. If yes (influenced by climate change), proceed; if no, set aside the strategy (check the first box in the checklist above).	Yes, this goal & outcome is vulnerable to both direct and indirect climate change effects (proceed with subsequent questions).

[6] This is a screening question to identify and set aside (not proceed with climate-smart revision) strategies/approaches (or goals/outcomes) not likely to be affected by climate change. For example, education or outreach efforts will not themselves be directly influenced by climate change, although it would be desirable to include climate change information into these types of efforts. Therefore, it would not be necessary to apply this process directly to revision of such strategies. It should be noted that strategies such as development of energetic, system, planning, or other models also are not directly impacted by climate change; however, if climate change effects have not heretofore been considered in the model, then redesign of the model would be recommended.

Step 2: Category 1 Considerations: Climate change effects on the stressors and systems	*What stressor(s), characterized by source if appropriate, are addressed by or accounted for in the strategy/approach (or goal/outcome)?*	
	Specific stressor(s) and source(s). (List separately; include uncertainty and relative sensitivity [low, medium, high.])	• Loss of food/foraging habitat (vegetation, tubers, bivalves). High magnitude, medium uncertainty. • Loss of wintering (& breeding) habitat (wetlands, especially tidal marshes) lost via conversion to open water accompanying ongoing sea-level rise, as well as to development and other direct anthropogenic land use conversions (though this source considered nominal). High magnitude, medium uncertainty. • Human development that results in habitat fragmentation, loss of connectivity; proximity to human disturbance. Medium magnitude, low uncertainty. • Invasive species (e.g., reed grass (*Phragmites*) and purple loose strife), resulting in degradation of habitat quality for black ducks. Medium magnitude, high uncertainty. • Interspecific competition with native invasive species (mallard and possibly resident Canada geese). Low magnitude, medium uncertainty. • Historically hunting/overharvesting was an important impact, though regulation has now made hunting largely sustainable. Low magnitude, low uncertainty.
	What are the key climate change impacts (direction, magnitude, mechanism, uncertainty) on the stressor(s)/source(s), relevant to the resource?[7]	
	Key climate influences on stressor(s)/sources(s)	• Although wetland-based foods (vegetation) are generally covered under changes in habitat quality, black ducks also utilize bivalves as an important food source. The same climate change influences of SLR, altered precipitation & storms, and temperature increases that will drive wetland quantity & quality changes are expected to affect Bay bivalve population, causing population losses and/or range shifts that will reduce food availability and alter foraging locations for black ducks. • Climate change is not likely to have a direct effect on the extent (or progression) of human development. • Increasing temperatures and altered precipitation patterns are expected to favor invasive species, including *Phragmites*, which represents poor foraging and wintering habitat for black ducks, • Climate change is not likely to have a direct effect on the extent of duck hunting activities, particularly since duck hunting is regulated, with the possibility of adapting duration of the hunting season or permissible take if, for instance, changing temperatures extended the hunting season.
	What are the key climate change impacts directly affecting the resource (direction, magnitude, mechanism, uncertainty)?	

[7] Incorporate information from the notes section of any action-level climate-smart decision tables completed on issues, lessons, or spatial or temporal considerations emerged that might be common across other sites, or be relevant Bay-wide, and how these affect higher levels of planning (strategies, approaches).

	Key climate influences on target resource(s)	• Accelerated rates of SLR in the absence of adequate accretion, which would inundate tidal wetlands and thus reduce available acreage (quantity) or quality for black duck wintering habitat. High magnitude, medium uncertainty in SLR projections (though we now have high certainty of substantial tidal wetland habitat loss in upcoming decades principally as consequence of acceleration in rate of SLR but also affected by migration space limits (topography and land use)). • Storm surge combined with SLR (as well as increases in precipitation) that increase wetland flooding and reduce overwintering wetland habitat availability. Medium magnitude, medium uncertainty. [Note: Consideration of storm surge effects is complicated, because storm surge absent accelerated SLR is often considered a plus for tidal marshes, delivering mineral sediment loads further inland than would otherwise occur. In addition, storm surge only temporarily increases flooding, unless a marsh system is already failing due to inadequate accretion.] • SLR, combined with storm surge and increases in precipitation that cause saltwater intrusion, pushing salinity zones up-Bay and resulting in salt marsh migration. • Large storm events that contribute to marsh break-up and habitat loss (for foraging and over-wintering); consider mainly as a source of 'acute' marsh loss (in contrast to chronic loss due to accelerated SLR coupled with inadequate accretion). Medium magnitude, medium to high uncertainty. Grid ditch marshes – loss of sediment • Regional changes in temperature patterns that result in changing black duck migration patterns and/or shifts in wintering range. Medium magnitude, high uncertainty.
	Over what timeframe will key climate change impacts affect targeted resources? Are there seasonal patterns or other short- or long-term temporal factors of the climate change effects of concern?	
	Timing of climate change effects	• Accelerated rates of SLR are already occurring and will continue to increase. • Temperature increases are already occurring and will continue to increase. • Seasonal timing of rainfall/runoff is already changing, with increased rainfall in winter, decreased in summer. • More intense storms are already occurring and are likely to increase, though confidence in ability to project these changes is low.
	How is progress toward strategy/approach (or goal/outcome) measured?	
	How is implementation being tracked (e.g. indicators, metrics?	• Not clear. Apparently by tracking acres of available wetland wintering habitat, though the target is specified in number of black ducks supported (and winter bird surveys are used to estimate the winter black duck population).
	How will climate change alter the ability to carry out progress measurement or monitoring protocols?	• Current methods for black duck winter surveys may become ineffective if the range (spatial distribution) of black ducks changes with climate conditions and habitat/food availability & distribution.

Step 3: Category 2 Considerations: CC implications for strategies		
	How will climate change impacts on the resource itself change the condition (affect the quality or quantity) of and/or trends in the target resource?	
	Direct effects on resource condition	Direct effects of climate change on black ducks could include: • For black ducks, lower temperatures increase metabolic food demands; it would therefore be expected that with climate change, increasing temperatures would decrease metabolic needs, which could be a benefit to black duck populations. In addition, increasing temperatures could increase the activity of some prey and could increase the SAV growing season, making both food sources more readily available. • Increased incidence of disease or parasitism, with associated increases in mortality; • Decreases in breeding/nesting success due to altered temperatures, and increased winter precipitation, increased storm intensity.
	How will climate change impacts on the stressor(s) impact the strategy/approach (or goal/outcome)?	
	Indirect effects on strategy/approach (or goal/outcome)	• Climate changes resulting in reduced total available tidal wetland habitat for wintering/foraging, as well as replacement of prime habitat with *Phragmites,* will likely cause declines in black duck population size. It also will shift the range of wetland types by salinity classification up-Bay, changing the location of preferred wetland types.
	How will climate change impacts directly on the strategy/approach (or goal/outcome) impact how realistic, achievable, or effect the strategy/approach (or goal/outcome) is?	
	Direct effects on strategy/approach (or goal/outcome)	• The key influences on black duck losses due to climate change appear to operate through impacts on wintering/foraging habitat quality & quantity, although some direct effects of climate change on black ducks will occur. In addition, black ducks can be difficult to accurately enumerate year to year, especially due to their movement and potential changes in specific locations utilized. Thus it might be recommended to manage and set outcome targets based on black duck habitat quantity & quality.
	What are climate change-related time frame considerations or constraints on achieving or implementing the strategy/mgmt. approach [e.g., urgency, synergies or dependencies on other strategies/mgmt. approaches]?	
	Time frame considerations	• Opportunities for wetland habitat of black ducks to be preserved or restored are typically opportunistic, dependent on landowner interest/cooperation.
	What changes are needed to modify the strategy/mgmt. approach (or goal/outcome) to accommodate the combination of direct and indirect climate change effects or the target periods for implementing the strategy? Or are there other ideas for strategies suggested by these results?	
	Climate-driven adaptations needed	• Change the focus of the goal/outcome from the direct management of numbers of black ducks to quantity of viable black duck habitat, though including monitoring methods to confirm black duck use of the habitat.

		• Use the black duck energetics model along with SLR mapping and/or modeling to estimate where preferred wetland types for black duck habitat and food resources might persist in the future given accelerated rates of SLR and other climate change influences. Use the results to promote, to the extent possible, a spatially targeted approach to the black duck outcome. In addition, use the results to estimate what quantity of preferred wetland habitat can realistically be expected to persist in the future with climate change, estimate what population magnitude of black ducks this would be capable of supporting, and if prudent, revise the black duck quantitative target accordingly.

Step 4: Climate-Designed Strategy	***Climate-smart Strategy/Management Approach (or Goal/Outcome)***	
	Description	• By 2025, restore, enhance and preserve [xx] acres of black duck wetland habitat that support a sustainable wintering population of black ducks (estimated as ~100,000 black ducks), a species representative of the health of tidal marshes across the watershed. Focus initially on high tidal marsh where substantial engineered or natural accretion occurs; potentially transition in the future to a focus on non-tidal marsh when losses of tidal marsh due to the high magnitude of future SLR lead to unaddressable landscape-scale collapse of the tidal marsh system. Use modeling of shifting range locations of preferred tidal marsh habitat and black duck energetics requirements to target restoration locations. Refine population targets through 2025 based on best available science.

Notes: What are the information/data gaps and research needs to better understand climate impacts or uncertainties, social or ecological effects, design needs, etc.?

Notes: What interactions are needed with other GITs/Workgroups that are key to the planned strategies/approaches.
With wetlands workgroup to project areas within the Bay of wetland losses and range shifts, and coordinate on targeting, evaluation and selection of wetland protection/restoration projects.

*Are there any key strategies/approaches or (goals/outcomes) missing?**

* *Strategies/approaches that may be needed to more comprehensively address the climate change impacts identified. The purpose is to identify any key vulnerabilities that are not sufficiently addressed in the existing plan and to craft additional strategies/approaches to fill those gaps. The ecologically oriented list of general adaptation strategies from the Climate-smart guide can be used to help in brainstorming these. Start by listing any new strategies/management approaches listed in the last question of Step 3.*

Attachment 4

Chesapeake Bay Program: Climate-Smart Framework and Decision-Support Tool

Climate-Smart Decision-Support Tables - Blank

CLIMATE-SMART ADAPTATION DESIGN – CBP WORK PLAN/KEY ACTIONS

Fill this out last

Climate-informed actions and performance targets – Documentation of Results *Check the appropriate box.*	
☐	Keep existing actions and performance targets without modification. *If yes, provide reasoning.*
☐	Use existing actions and performance targets but with minor modifications. *If yes, note modifications and the reasoning behind them.*
☐	Use new actions/performance targets or significantly adjust existing ones. *If yes, provide the reasoning.*

Climate-Smart Adaptation Design at the CBP Work Plan/Key Actions Level

Current Action	*What is the CBP action being considered?*	
	Current key action or specific performance target	
Step 1: Screening for Actions	*Will the action be substantially influenced by climate change?*	
	Screening for actions.[8] If yes (influenced by climate change), proceed; if no, set aside the action (check the first box in the checklist above).	

Step 2: Category 1 Considerations: Climate change effects on	*What stressor(s), characterized by source if appropriate, are addressed by or accounted for in the action?*	
	Specific stressor(s) and source(s). (List separately; include uncertainty and relative sensitivity [low, medium, high.])	
	What are the key climate change impacts (direction, magnitude, mechanism, uncertainty) on the stressor(s)/source(s)?	

[8] This is a screening question to identify and set aside (not proceed with climate-smart revision) actions not likely to be affected by climate change. For example, model improvement efforts will not themselves be directly influenced by climate change, although it would be important to include climate change into CBP models used for planning purposes.

	Key climate influences on stressor(s)/sources(s)	
	What is the expected timing of climate change impacts on the action? This could include seasonal patterns or temporal trends of the climate change effects of concern.	
	Timing of climate change effects	
	Implications for how effectiveness of actions or progress towards performance targets is measured.	
	How is implementation being tracked (e.g. indicators, metrics)?	
	How will climate change alter the ability to carry out progress measurements or monitoring protocols?	

Step 3: Category 2 Considerations: **CC** implications for functionality of actions	*How will climate change impacts on the stressor(s)/source(s) impact effectiveness of the action?*	
	Indirect effects on action	
	How will climate change impacts directly on the action impact effectiveness of the action?	
	Direct effects on action	
	What are climate change-related time frame considerations or constraints on achieving or implementing the action [e.g., urgency, synergies or dependencies on other actions /work plans]?	
	Time frame considerations	
	What changes are needed to adapt the action to accommodate the combination of direct and indirect climate change effects over the target periods for implementing the action? Or are there other ideas for actions suggested by these results?	
	Climate-driven adaptations needed	

Step 4: Climate-Designed Action	***Climate-smart Work Plan/Action***	
	Description	

Notes: What are the information/data gaps and research needs to better understand climate impacts or uncertainties, social or ecological effects, design needs, etc.?

Notes: What issues, lessons, or spatial or temporal considerations emerged that might be common across other sites, or Bay-wide? How might these affect higher levels of planning (strategies, approaches)?

Notes: Interactions needed with other GITs/Workgroups that are key to the actions?

*Are there any key actions missing?**

* *Actions that may be needed to more comprehensively address the climate change impacts identified. The purpose is to identify any key vulnerabilities that are not sufficiently addressed in the existing plan and to craft additional actions to fill those gaps. The ecologically oriented list of general adaptation strategies from the Climate-smart guide can be used to help in brainstorming these, though actions relevant to implementing those strategies/approaches in your specific management/ecosystem context may need to be brainstormed and/or researched in the literature. Start by listing any new actions listed in the last question of Step 3.*

CLIMATE-SMART ADAPTATION DESIGN – CBP STRATEGIES/MANAGEMENT APPROACHES OR GOALS/OUTCOMES

Fill this out last

Climate-informed strategies/management approaches (or goals/outcomes) – Documentation of Results *Check the appropriate box.*	
☐	Keep existing strategies/approaches without modification. *If yes, provide reasoning.*
☐	Use existing strategies/approaches but with minor modifications. *If yes, note modifications and the reasoning behind them.*
☐	Use new strategies/approaches or significantly adjust existing ones. *If yes, provide the reasoning.*

Climate-Smart Adaptation Design at the CBP Strategy/Management Approach (or Goals/Outcomes) Level

Current Strategy	*What is the CBP strategy/approach (or goal/outcome) being considered?*	
	Current strategy/management approach (or goal/outcome)	
Step 1: Screening for Goals/Strategies	*Will the strategy (or goal) be influenced by climate change?*	
	Screening for strategies (or goals)[9]. If yes (influenced by climate change), proceed; if no, set aside the strategy (check the first box in the checklist above).	

[9] This is a screening question to identify and set aside (not proceed with climate-smart revision) strategies/approaches (or goals/outcomes) not likely to be affected by climate change. For example, education or outreach efforts will not themselves be directly influenced by climate change, although it would be desirable to include climate change information into these types of efforts. Therefore, it would not be necessary to apply this process directly to revision of such strategies. It should be noted that strategies such as development of energetic, system, planning, or other models also are not directly impacted by climate change; however, if climate change effects have not heretofore been considered in the model, then redesign of the model would be recommended.

Step 2: Category 1 Considerations: Climate change effects on the stressors and systems	*What stressor(s), characterized by source if appropriate, are addressed by or accounted for in the strategy/approach (or goal/outcome)?*	
	Specific stressor(s) and source(s). (List separately; include uncertainty and relative sensitivity [low, medium, high.])	
	What are the key climate change impacts (direction, magnitude, mechanism, uncertainty) on the stressor(s)/source(s), relevant to the resource?[10]	
	Key climate influences on stressor(s)/sources(s)	
	What are the key climate change impacts directly affecting the resource (direction, magnitude, mechanism, uncertainty)?	
	Key climate influences on target resource(s)	
	Over what timeframe will key climate change impacts affect targeted resources? Are there seasonal patterns or other short- or long-term temporal factors of the climate change effects of concern?	
	Timing of climate change effects	
	How is progress toward strategy/approach (or goal/outcome) measured?	
	How is implementation being tracked (e.g. indicators, metrics?	
	How will climate change alter the ability to carry out progress measurement or monitoring protocols?	

Step 3: Category 2 Considerations	*How will climate change impacts on the resource itself change the condition (affect the quality or quantity) of and/or trends in the target resource?*	
	Direct effects on resource condition	
	How will climate change impacts on the stressor(s) impact the strategy/approach (or goal/outcome)?	

[10] Incorporate information from the notes section of any action-level climate-smart decision tables completed on issues, lessons, or spatial or temporal considerations emerged that might be common across other sites, or be relevant Bay-wide, and how these affect higher levels of planning (strategies, approaches).

	Indirect effects on strategy/approach (or goal/outcome)	
	How will climate change impacts directly on the strategy/approach (or goal/outcome) impact how realistic, achievable, or effect the strategy/approach (or goal/outcome) is?	
	Direct effects on strategy/approach (or goal/outcome)	
	What are climate change-related time frame considerations or constraints on achieving or implementing the strategy/mgmt. approach [e.g., urgency, synergies or dependencies on other strategies/mgmt. approaches]?	
	Time frame considerations	
	What changes are needed to modify the strategy/mgmt. approach (or goal/outcome) to accommodate the combination of direct and indirect climate change effects or the target periods for implementing the strategy? Or are there other ideas for strategies suggested by these results?	
	Climate-driven adaptations needed	

Step 4: Climate-Designed Strategy	***Climate-smart Strategy/Management Approach (or Goal/Outcome)***	
	Description	

Notes: What are the information/data gaps and research needs to better understand climate impacts or uncertainties, social or ecological effects, design needs, etc.?

Notes: Interactions needed with other GITs/Workgroups that are key to the planned strategies/approaches.

*Are there any key strategies/approaches or (goals/outcomes) missing?**

* *Strategies/approaches that may be needed to more comprehensively address the climate change impacts identified. The purpose is to identify any key vulnerabilities that are not sufficiently addressed in the existing plan and to craft additional strategies/approaches to fill those gaps. The ecologically oriented list of general adaptation strategies from the Climate-smart guide can be used to help in brainstorming these. Start by listing any new strategies/management approaches listed in the last question of Step 3.*