

Tools & Resources for Resilient BMPs



**Monitoring and Assessing Impacts of Changes in Weather Patterns and
Extreme Events on BMP Siting and Design**

September 7-8, 2017

**Zoë Johnson
NOAA Chesapeake Bay Office**



Chesapeake Bay Program
Science. Restoration. Partnership.

Compendium of General Climate Adaptation Resources



Climate Change Research and Adaptation in the Chesapeake Bay Watershed

A compilation of recent and ongoing efforts compiled by the Chesapeake Bay Program Partnership's Climate Resiliency Working Group
July, 2016



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RESILIENT BMPs:

SITING & DESIGN RESOURCES

Planning Tools and Resources

Resources

- [Fact Sheet: Legal Tools for Climate Resilient Siting](#) *Environmental Law Institute*
Suggests legal strategies for implementing climate resilient green infrastructure in Virginia and Maryland.
- [Stormwater Management in Response to Climate Change Impacts: Lessons from the Chesapeake Bay and Great Lakes Regions](#) *Environmental Protection Agency* - A report on strategies and tools to incorporate climate resiliency into community planning.
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The guide includes videos and flood maps to help protect small to medium water and wastewater utilities from flooding.
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A presentation showing how DC heat index, heat wave, and precipitation projections will influence design storm events.
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A list of techniques and BMPs to help local governments adapt to future changes in climate.
- [Managing Water Quality in the Face of Uncertainty](#) *RAND Corporation*
A report describing how to use Robust Decision Making (RDM) when managing future uncertainties such as climate change and evolving land use patterns. A RDM case study on the Patuxent River in Maryland is included.
- [Building Resilience through Habitat Restoration](#) *MD DNR Chesapeake and Coastal Service*
Recommendations on how to incorporate climate change consideration into the restoration decision-making process in Maryland.
- [Implementation of BMP Strategies for Adaptation to Climate Change and Land Use in a Pasture-Dominated Watershed](#) *Chiang et al.*
Paper predicts the impact of climate change on 171 pastoral BMP combinations and recommends those that are the most resilient.
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Tools

- [Storm Water Management Model with Climate Assessment Tool \(SWMM-CAT\)](#) *EPA*
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Guidance on climate projections & scenarios



Sea Level Rise, Temperature,
Precipitation

Resources



- Chesapeake Bay Program, 2016. Climate Resiliency Workgroup. [Recommendations on Incorporating Climate-Related Data Inputs and Assessments: Selection of Sea Level Rise Scenarios and Tidal Marsh Change Models to Inform the Chesapeake Bay TMDL 2017 Mid-Point Assessment](#) (August 5, 2016).
- Johnson, Z., M. Bennett, L. Linker, S. Julius, R. Najjar, M. Mitchell, D. Montali, R. Dixon, 2016. [*The Development of Climate Projections for Use in Chesapeake Bay Program Assessments*](#).

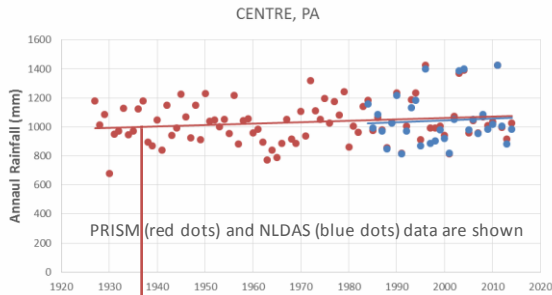
Recommended 2025 Modeling Climate Inputs

Variable	Input	Modeling Run Completed	Uncertainty Analysis Component
CO2	427 ppm	Watershed Model	No
Potential Evapotranspiration	Hargreaves-Samani	Watershed Model	Yes
	Hamon	Watershed Model	Yes
Temperature	RCP 2.6 Ensemble Median		Yes
	RCP 4.5 Ensemble Median	Watershed Model, WQSTM	Yes
	RCP 8.5 Ensemble Median		Yes
Precipitation	Historical Trend (+3.1%) with no Δ Intensity	Watershed Model	Yes
	Historical Trend (+3.1%) with Δ Intensity	Watershed Model	Yes
Sea Level Rise	0.17 meters		Yes
	0.3 meters	WQSTM	Yes
Wetland Loss	NWF SLAMM Model Runs (2008)	WQSTM	Yes
	NOAA SLR Viewer (Marsh Migration)		Yes

Recommended 2050 Modeling Climate Inputs

Variable	Input	Modeling Run Completed	Planned Uncertainty Analysis Component
CO2	487ppm	Watershed Model	No
Potential Evap.	Hargreaves-Samani	Watershed Model	Yes
	Hamon	Watershed Model	Yes
Temperature	Six GCM Analysis: 2040 and 2060	WQSTM (prior methodology but not recommended by CRWG)	No
	RCP 2.6 Ensemble Median		Yes
	RCP 4.5 Ensemble Median	Watershed Model	Yes
	RCP 8.5 Ensemble Median		Yes
Precipitation	RCP 2.6 Ensemble Median		
	RCP 4.5 Ensemble Median		Yes
	RCP 8.5 Ensemble Median		Yes
Sea Level Rise	.3 meters	WQSTM	
	0.5 meters	WQSTM	Yes
	0.8 meters		Yes
Wetland Loss	NWF SLAMM Model Runs (2008)	WQSTM	Yes
	NOAA SLR Viewer (Marsh Migration)		Yes

Rainfall projections using the trends in 88-years of annual PRISM^[1] data



2025 Rainfall Projection (percent change)

- 0.7 - 1.0
- 1.1 - 1.5
- 1.6 - 2.0
- 2.1 - 2.5
- 2.6 - 3.0
- 3.1 - 3.5
- 3.6 - 4.0
- 4.1 - 4.5
- 4.6 - 5.0
- 5.1 - 5.5
- 5.6 - 6.0



0 25 50 100 Miles

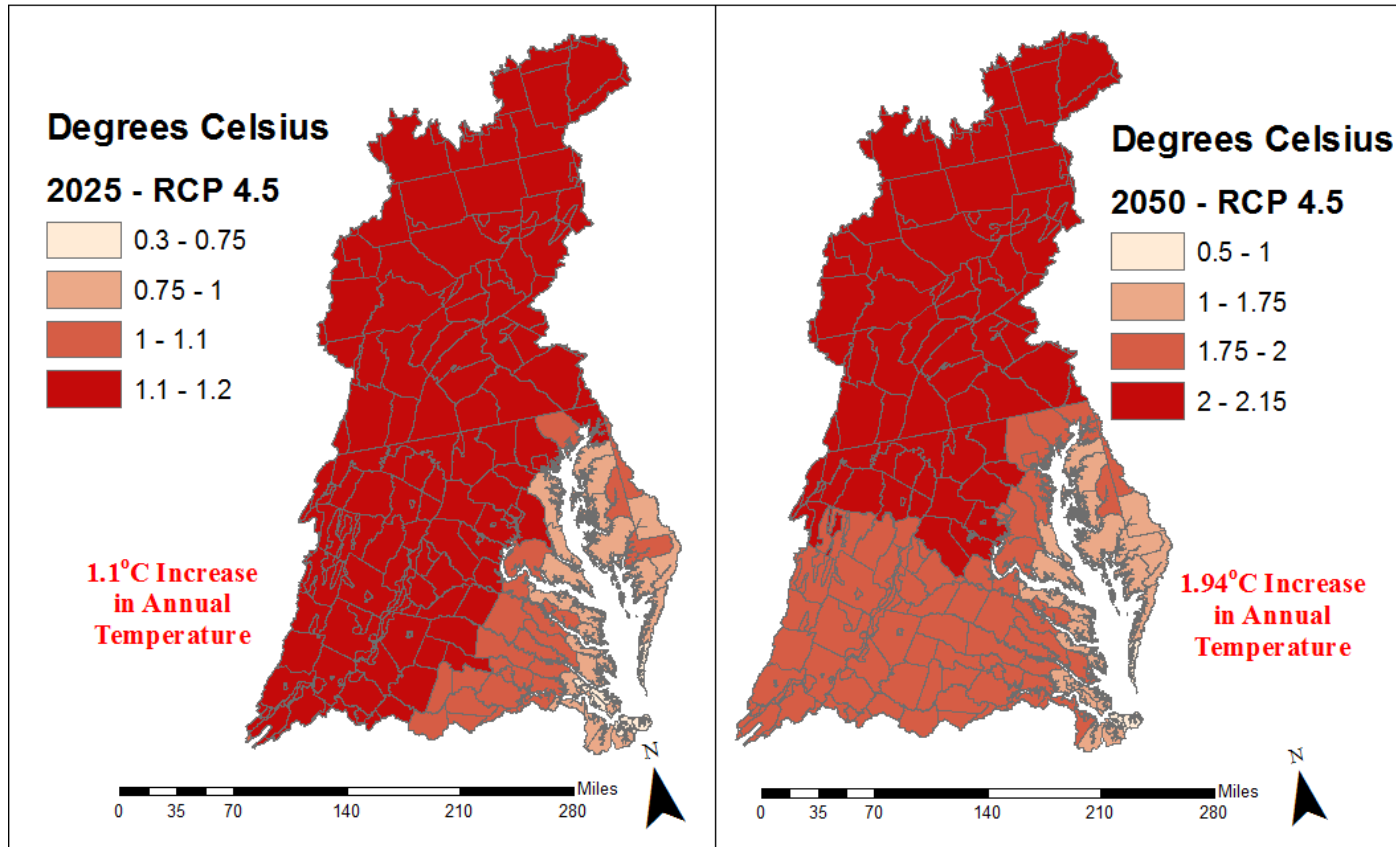
Kyle Hinson

Change in Rainfall Volume 2021-2030 vs. 1991-2000

Major Basins	PRISM Trend
Youghiogheny River	2.1%
Patuxent River Basin	3.3%
Western Shore	4.1%
Rappahannock River Basin	3.2%
York River Basin	2.6%
Eastern Shore	2.5%
James River Basin	2.2%
Potomac River Basin	2.8%
Susquehanna River Basin	3.7%
Chesapeake Bay Watershed	3.1%

[1] Parameter-elevation Relationships on Independent Slopes Model

Chesapeake Bay Watershed Annual Change in Temperature



GLOBAL AND REGIONAL SEA LEVEL RISE SCENARIOS FOR THE UNITED STATES



Photo: Ocean City, Maryland

Silver Spring, Maryland
January 2017



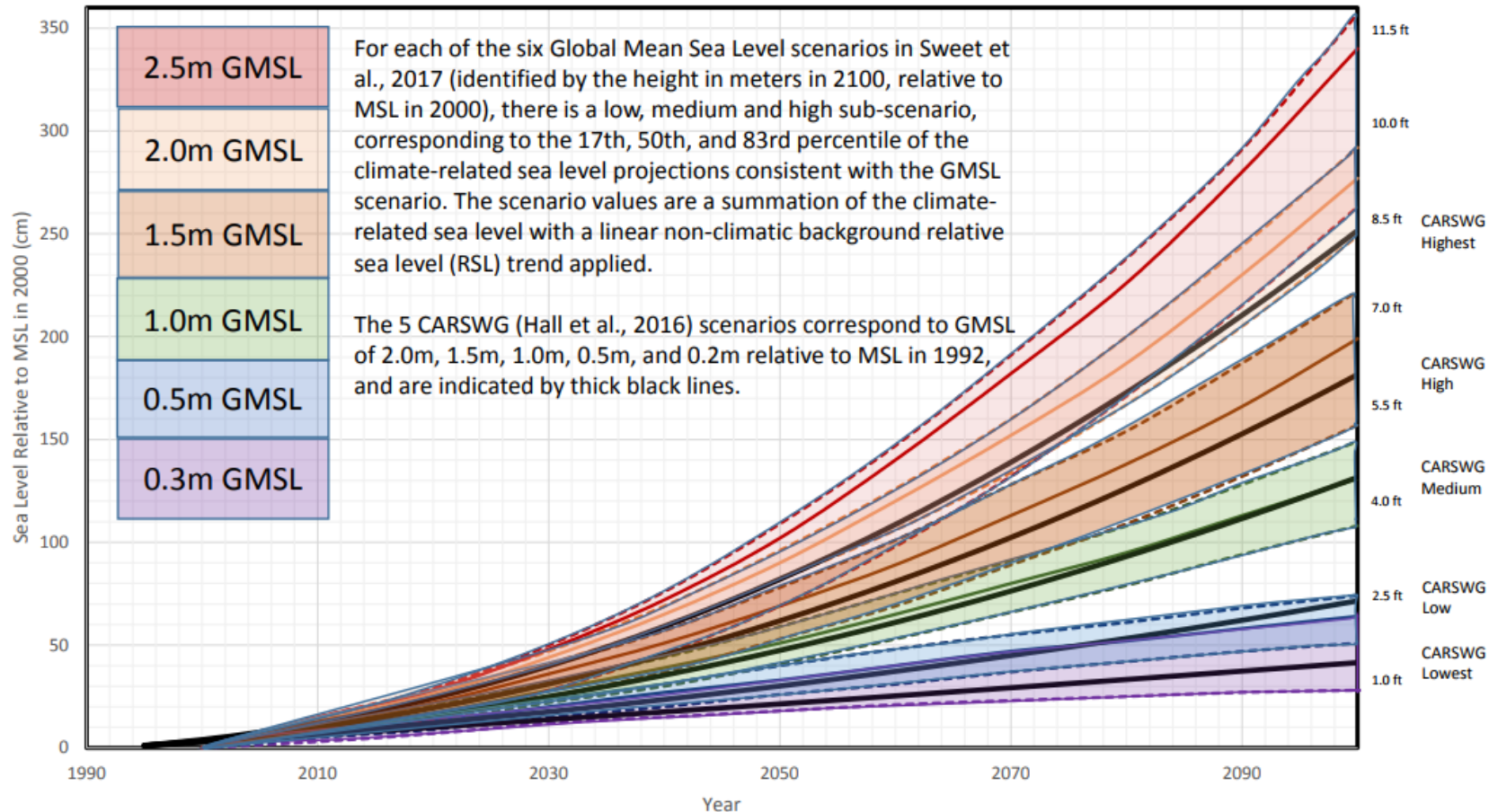
noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Products and Services

Relative Sea Level Rise (Annapolis MD)



Relative Sea Level Rise Scenarios for Annapolis from Hall et al. (2016) and Sweet et al. (2017)



USACE Sea Level Change Curve Calculator



USACE Sea Level Change Curve Calculator (2017.55)

Project Name:

Select Gauge:

Scenarios Source:

Output Units: Feet Meters

Critical Elevation #1 (ft): NAVD88 - Description:

Critical Elevation #2 (ft): NAVD88 - Description:

SLC Rate: or enter rate (ft/yr)

FEMA BFE (ft): ([Information](#)) (NAVD88) Search for BFE [here](#)

Project Start Year:

Interval Year:

Project End Year:

Output Datum: LMSL (NAVD88)

User's Index (ft): Description:

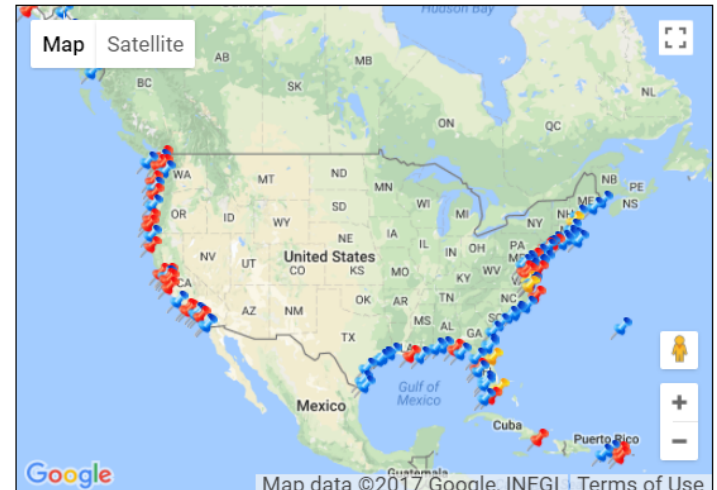
Datum Shift to MSL: (ft)

EWL Type: Highs Lows

EWL Source: NOAA (GEV) USACE (Percentile)

Plot EWL/BFE/Tides:

Select Curve:

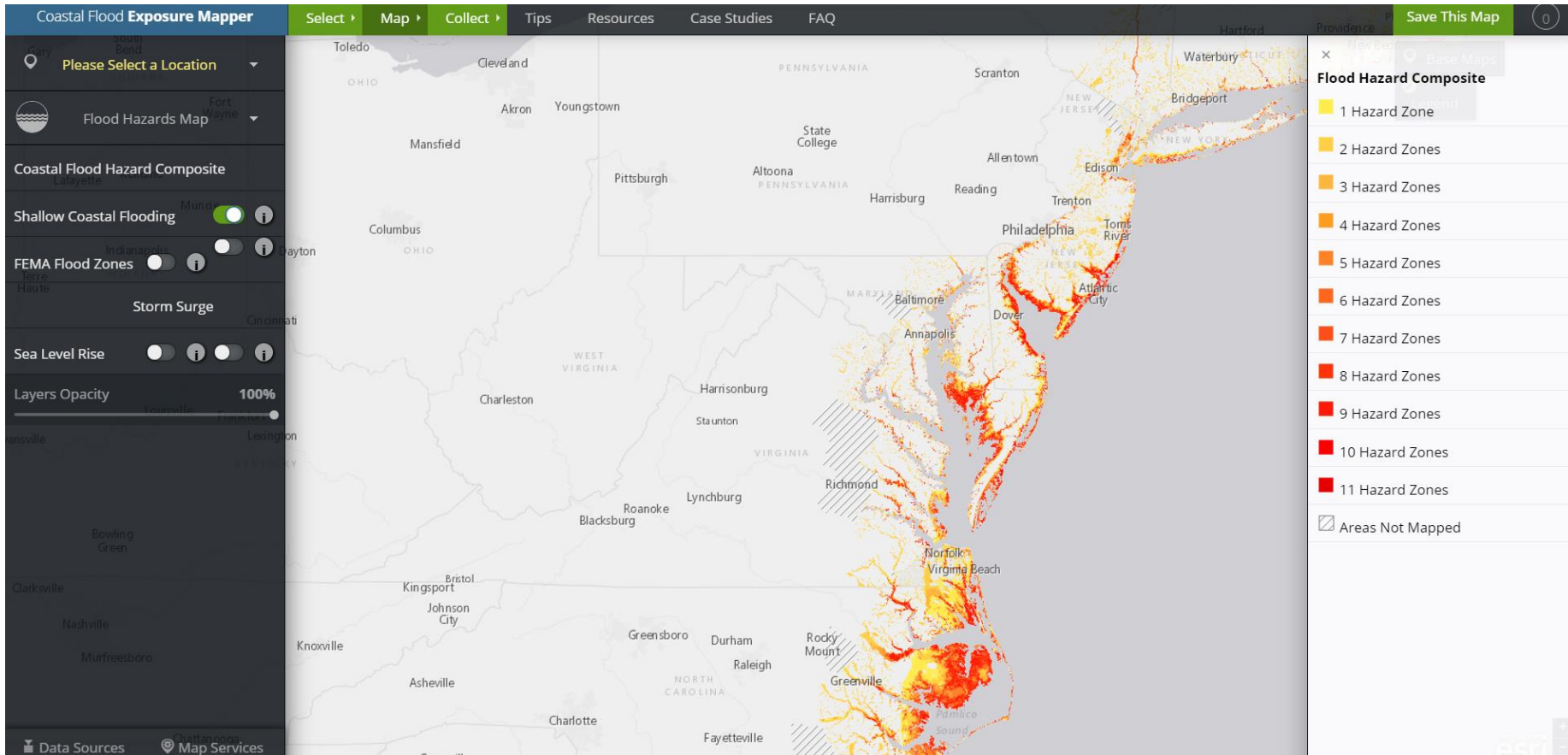


Click on project area. The nearest gauge/grid point will be used to develop RSLC curves based on the selected Scenario Source

*** note - there may be factors other than proximity to consider when selecting a gauge ***

- Compliant
- Non-Compliant
- Inactive

Coastal Flood Exposure Mapper



US Climate Resilience Toolkit



U.S. Climate
Resilience
Toolkit

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Meet the Challenges of a Changing Climate

Find information and tools to help you understand and address your climate risks.

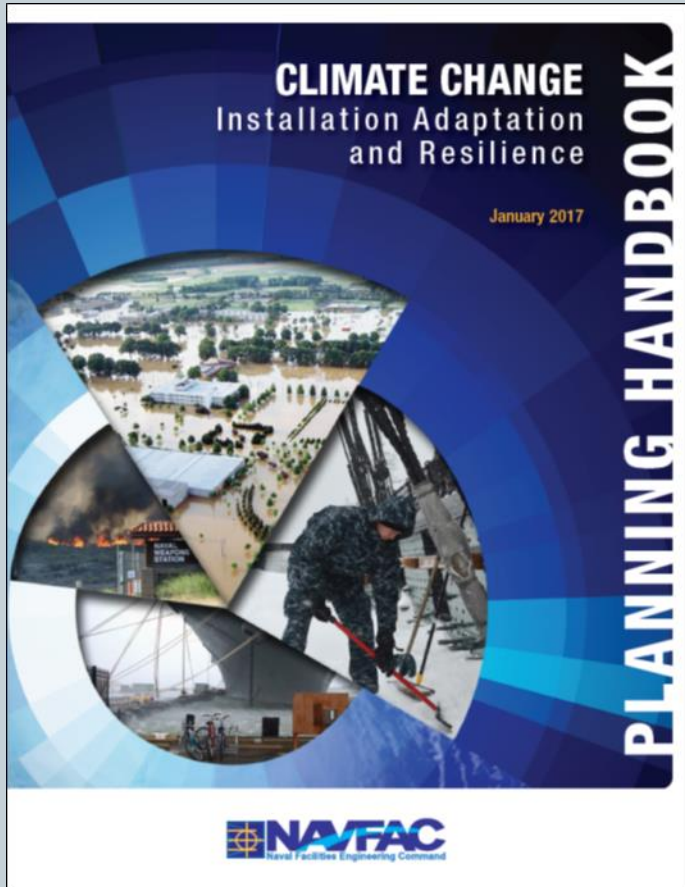
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RESILIENCE FRAMEWORK >](#)

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DOING >](#)

[USE THE CLIMATE
EXPLORER >](#)

[TOUR THE TOOLKIT ▾](#)

Siting & Design Guidance



Design Storm Events

Changes in rainfall volumes have a significant impact on infrastructure.

Design storms are the selected events that engineers use to design drainage infrastructure, bridges, culverts, etc.

Input from DC Water, DDOT and DDOE's Stormwater Management Division informed the selection of events that are used as standards for stormwater, wastewater, and transportation infrastructure.

The chart shows how rainfall volumes are projected to increase across the relevant design storm events, especially for the more extreme (100 and 200 year) events.

Design Storm	Baseline 1981-2000	2020s	2050s	2080s
1-yr 24 hr. storm (in)	1.6	1.7 (1.5 - 1.8)	1.7 (1.5 - 1.8)	2 (\pm <1)
2-yr 24 hr. storm (in)	3.2	3.4 (3.2 - 3.7)	3.7 (3.5 - 3.9)	4 (4 - 5)
15-yr 24 hr. storm (in)	5.5	6.8 (6.0 - 7.3)	7.1 (6.7 - 7.6)	8 (4 - 9)
25-yr 24 hr. storm (in)	6.3	7.9 (6.8 - 8.6)	8 (7.5 - 8.8)	10 (8 - 12)
100-yr 24 hr. storm (in)	8.1	10.5 (8.9 - 12.4)	10.3 (9.0 - 11.9)	14 (10 - 16)
200-yr 24 hr. storm (in)	9	12 (10.1 - 14.7)	11.7 (8.8 - 13.6)	15 (11 - 19)
2-yr 6 hr. storm (in)	2.3	2.4 (\pm <0.1)	2.6 (2.6 - 2.7)	3 (\pm <1)
15-yr 6 hr. storm (in)	3.6	4.6 (4.3 - 4.8)	4.7 (4.6 - 4.8)	5 (4 - 6)
100-yr 6 hr. storm (in)	5.1	6.7 (6.5 - 6.8)	6.5 (6.4 - 6.7)	9 (7 - 10)
200-yr 6 hr. storm (in)	5.6	7.5 (7.2 - 7.7)	7.2 (\pm <0.1)	10 (8 - 11)
80 th Percentile storm (in)	0.8	0.9 (0.1)	0.9 (0.1)	0.95 (0.1-0.15)
90 th Percentile storm (in)	1.14	1.24 (0.1)	1.24 - 1.34 (0.1-0.2)	1.24 - 1.39 (0.1-0.25)
95 th Percentile storm (in)	1.5	1.6 - 1.65 (0.1-0.15)	1.6 - 1.75 (0.1-0.25)	1.75 - 1.85 (0.15-0.35)

Source: DDOE (2016)

Planning Tools & Resources



Project-level screening tools

Climate Smart Decision-Making



Step 1: Project Screening

Screening

What is the CBP key action being considered?
Will the action be substantially influenced by climate change?

Step 2: Climate Smart Considerations (category 1)

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 action? 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?

Step 3: Climate Smart Considerations (category 2)

Climate Change Implications for Functionality of Actions

How will climate change impacts on the stressor(s) impact effectiveness of the action?
How will climate change impacts directly on the resource or the action impact 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?

Step 4: Climate Smart Redesign

Statement of the Climate-Smart Redesigned Action or Reformulated Strategy

Appendix D – Adaptation Action Alternatives Fact Sheets

This appendix contains Fact Sheets that address four broad categories of adaptation approaches:

Structural – employs a built structure to alter the flow of floodwater to protect a large area from damage (e.g., levee, storm surge barrier).

Natural and Nature-based – employs natural features to enhance resiliency (e.g., dunes, beaches, salt marshes, oyster and coral reefs, barrier islands, forests, shade trees).

Facilities – employs construction techniques to reduce flood damage to a specific asset (e.g., flood-proofing, building to a more resilient standard, small-scale structures such as a berm).

Non-facilities – employs non-construction techniques such as infrastructure siting, management, or maintenance to reduce flood damage (e.g., land use modifications, real estate actions, community coordination, operational changes, modified maintenance routines).

Structural Adaptation Approaches

1. Levees
2. Storm Surge Barrier Gates
3. Seawalls
4. Revetments
5. Off-shore Breakwaters
6. Modification of Existing Structures

Natural and Nature-based Adaptation Approaches

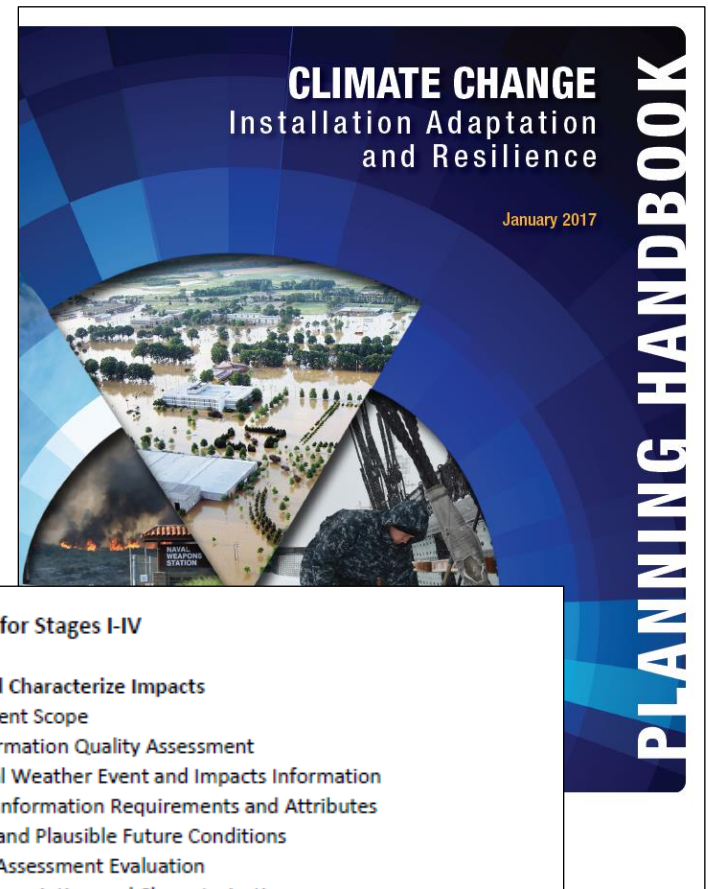
7. Preserve and Restore Natural Coastal Defenses
8. Beach Nourishment
9. Barrier Island Restoration
10. Vegetated Dunes
11. Living Shorelines (Edging and Sills)
12. Living Breakwaters (Oyster and Coral Reefs)

Facilities Adaptation Approaches

13. Flood Proofing
14. Materials Replacement
15. Relocation of Vulnerable Components
16. Protection with Small Scale Structures

Non-facilities Adaptation Approaches

17. Land Use Modifications
18. Real Estate Actions
19. Community Coordination
20. Operational Changes
21. Modified Maintenance Routines



Appendix F – Worksheets for Stages I-IV

Stage I – Establish Scope and Characterize Impacts

- WS I.1 – Assessment Scope
- WS I.2 – Site Information Quality Assessment
- WS I.3 – Historical Weather Event and Impacts Information
- WS I.4 – Climate Information Requirements and Attributes
- WS I.5 – Current and Plausible Future Conditions
- WS I.6 – Existing Assessment Evaluation
- WS I.7 – Impact Description and Characterization

Stage II – Identify and Screen Action Alternatives

- WS II.1 – Potential Action Alternatives

Stage III – Calculate Benefits and Costs Benefits of Action Alternatives

- WS III.1 – Life Cycle Cost Analysis
- WS III.2 – Cost Effectiveness Analysis
- WS III.3 – Benefits
- WS III.4 – Benefit Cost Ratio and Net Present Value (Grouping Strategy)
- WS III.4 – Benefit Cost Ratio and Net Present Value (Single Action Alternative)

Stage IV – Assemble Portfolio of Action Alternatives

- WS IV.1 – Portfolio Summary

Planning tools & resources



Reference Documents

Resilient BMPs: Capitalize on Co-Benefits



Sector	BMP Name	Climate Adaptation	Flood Control	Energy Efficiency
Urban	Urban Shoreline Management	4.0	1.0	0.5
Urban	Urban Forest Buffers	3.5	3.5	4.0
Urban	Dirt & Gravel Road Erosion & Sediment Control	2.5	1.5	0.0
Urban	Urban Stream Restoration	2.5	3.5	2.5
Urban	Bioretention/raingardens	2.0	3.5	3.0
Urban	Bioswale	2.0	3.5	3.0
Urban	Impervious Surface Reduction	2.0	3.0	1.0
Urban	Urban Grass Buffers	2.0	2.0	1.0
Urban	Urban Growth Reduction	2.0	3.0	1.0
Urban	Urban Tree Planting	2.0	2.0	4.5
Urban	Wet Ponds	2.0	3.0	1.0
Urban	Wetlands	2.0	3.5	1.0
Urban	Abandoned Mine Reclamation	1.0	3.0	3.0
Urban	Advanced Grey Infra.	1.0	0.0	1.0
Urban	Dry Detention Ponds	1.0	2.5	0.0
Urban	Dry Extended Detention Ponds	1.0	2.5	0.0
Urban	Erosion and Sediment Control	1.0	1.5	0.0
Urban	Filter Strip Runoff Reduction	1.0	3.0	0.0
Urban	Filter Strip Stormwater Treatment	1.0	3.0	0.0
Urban	Filtering Practices	1.0	1.0	1.0
Urban	Infiltration Practices	1.0	3.0	1.0
Urban	Vegetated Open Channels	1.0	3.0	1.0
Urban	Nutrient Management Plan	0.0	0.5	0.0

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