RESILIENT DESIGN GUIDELINES

HRPDC Coastal Resiliency Committee
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Performance standards such as design storms are based on risk.

Risk is a function of the probability of an occurrence and its consequences.

Climate-based policies should account for climate change to function as intended, so that expectations align with reality.

Principles

Resilient design guidelines should be scientifically-based, appropriate, and implementable

Scientifically-Based

Guidelines should be developed using sound data, models, and methods.

Appropriate

Guidelines for specific uses should be based on agreed-upon level of risk tolerance.

Implementable

Guidelines should be practicable and not considered impossible or overly difficult to achieve.

Resilient Design Guidelines for Stormwater Management

SEA LEVEL RISE

Regional sea level rise planning scenarios

TAILWATER ELEVATIONS

Boundary conditions based on watershed tidal elevations with sea level rise.

PRECIPITATION

Future precipitation values based on climate models.

JOINT PROBABILITY EVENTS

Design storms that pair tidal and rainfall events.

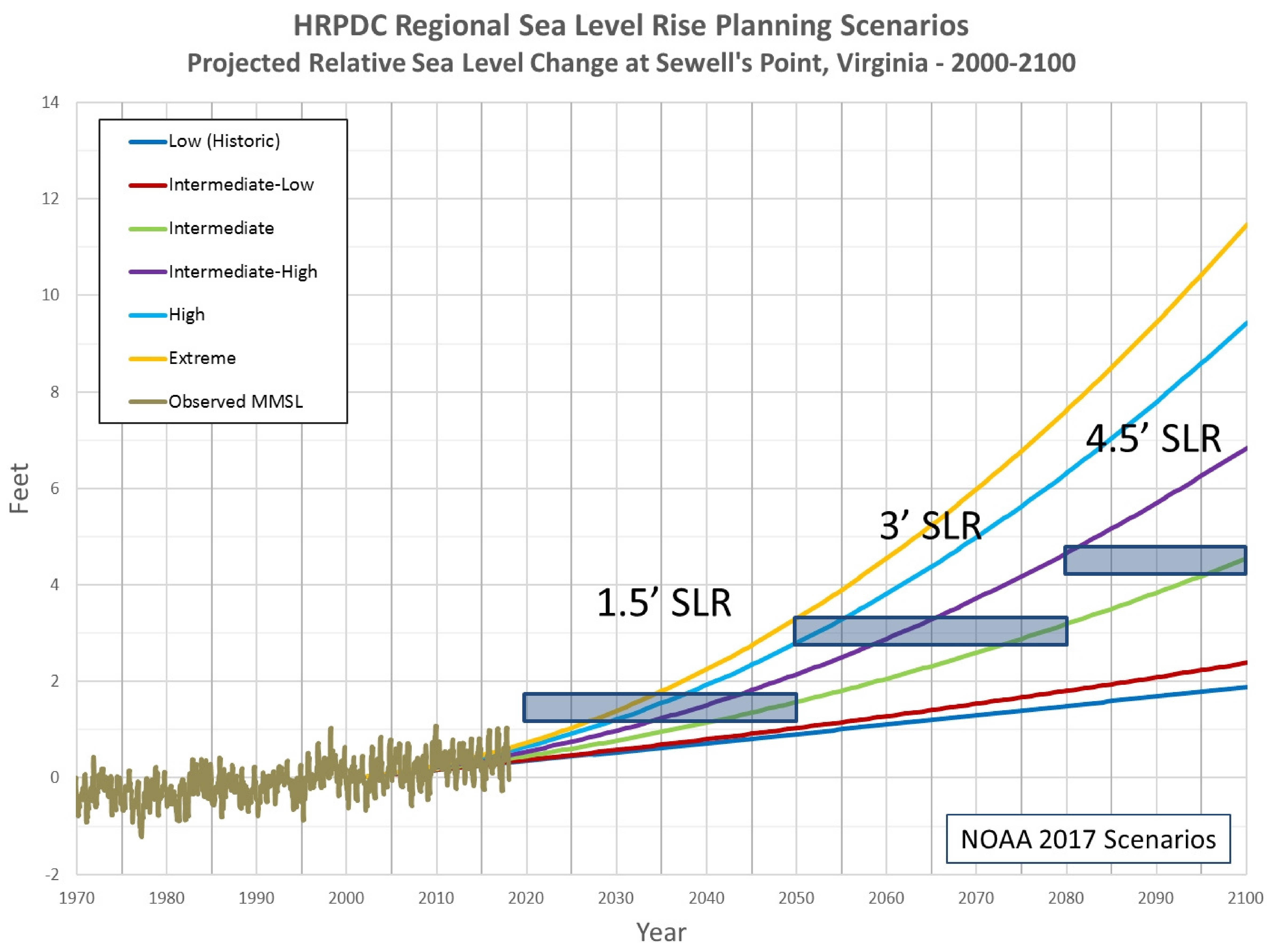
SEA LEVEL RISE

Planning Scenarios

Planning scenarios based on multiple sea level rise curves

2020-2050: 1.5'
2050-2080: 3.0'
2080-2100: 4.5'

Recommended by HRPDC board in October 2018



Sea Level Rise

Sea level rise scenarios should be revisited in 2022 to make sure they are still accurate, useful, and consistent with local, state, and federal practices

New LiDAR Data

New LiDAR and digital elevation model data recently finished for western part of region (currently data is from 2010-2011)

Consistent

New guidance from NOAA expected to be released in 2022

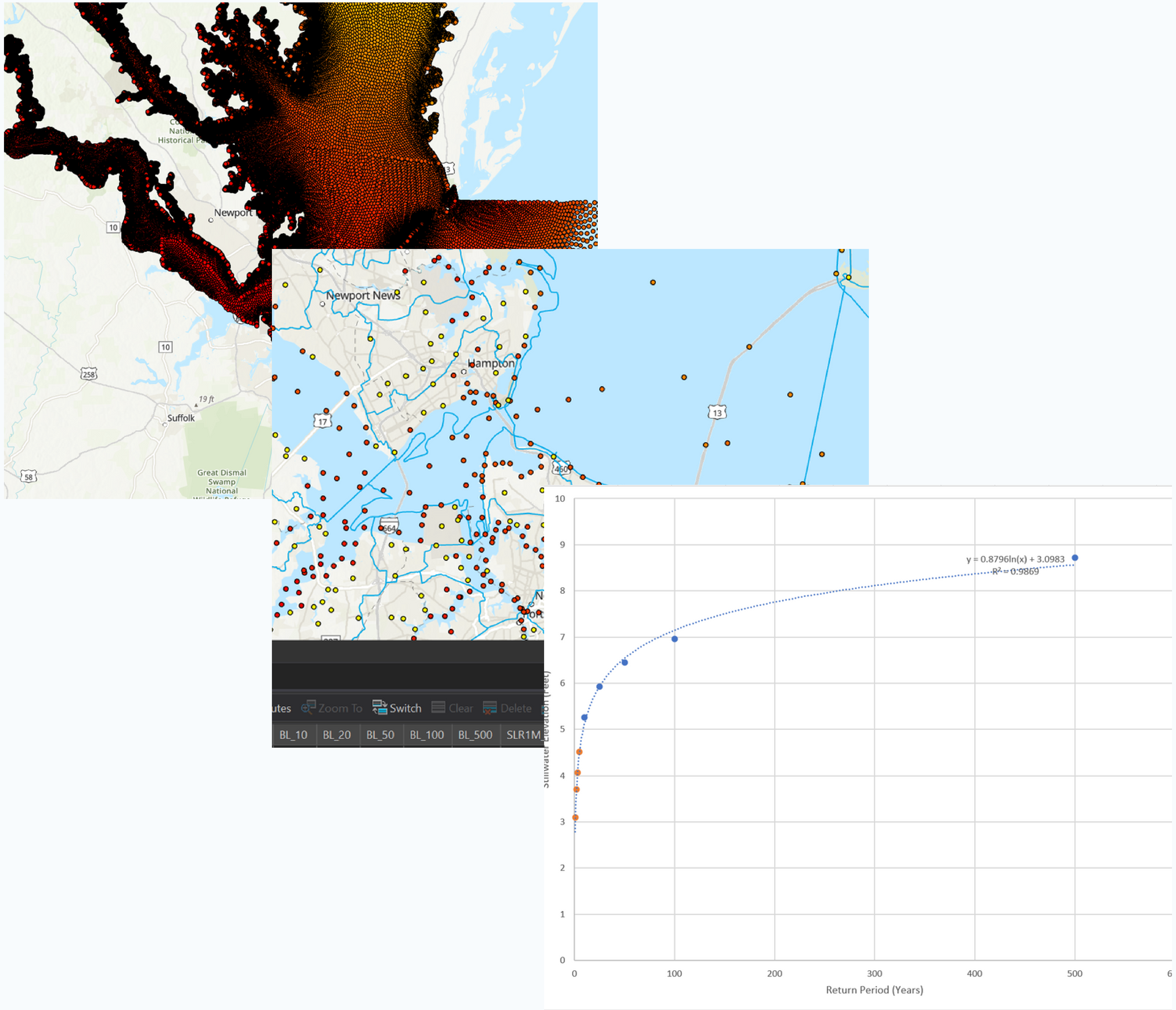
Coastal Resilience Master Plan and other state policies

TAILWATER ELEVATIONS

Methodology

Use FEMA values for 10- to 500-year events to calculate 1-, 2-, 3-, and 5-year values using log-linear extrapolation

Incorporate non-linearity from USACE North Atlantic Coast Comprehensive Study (NACCS)



Results

Tailwater values calculated for each return period based on the 95th-percentile for a given geography for various combinations of sea level rise and storm recurrence intervals

Scenarios for 3.0' and 4.5' SLR calculated using non-linearity factor:

Future Design Tidal Elevation = Baseline Elevation + SLR x Non-Linearity Factor

Design Tidal Elevations for Chesapeake

All elevations in feet relative to the North American Vertical Datum (NAVD) of 1988

HUC12	Watershed	Design Level	1-Year	2-Year	3-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
020802080201	New Mill Creek-Southern Branch Elizabeth River	Existing Condition	3.9	4.5	4.8	5.2	5.8	6.6	7.2	7.8	9.2
		1.5 ft SLR	5.4	6.0	6.3	6.7	7.3	8.1	8.7	9.3	10.7
		3.0 ft SLR	6.8	7.4	7.7	8.1	8.7	9.5	10.1	10.7	12.1
		4.5 ft SLR	8.3	8.9	9.2	9.6	10.2	11.0	11.6	12.2	13.6
020802080203	Deep Creek-Southern Branch Elizabeth River	Existing Condition	3.4	4.1	4.5	5.1	5.9	6.7	7.3	8.0	10.0
		1.5 ft SLR	4.9	5.6	6.0	6.6	7.4	8.2	8.8	9.5	11.5
		3.0 ft SLR	6.4	7.1	7.5	8.1	8.9	9.7	10.3	11.0	13.0
		4.5 ft SLR	7.9	8.6	9.0	9.6	10.4	11.2	11.8	12.5	14.5
020802080204	Eastern Branch Elizabeth River	Existing Condition	2.9	3.7	4.2	4.8	5.9	6.6	7.3	8.0	10.4
		1.5 ft SLR	4.4	5.2	5.7	6.3	7.4	8.1	8.8	9.5	11.9
		3.0 ft SLR	6.0	6.8	7.3	7.9	9.1	9.8	10.5	11.2	13.6
		4.5 ft SLR	7.5	8.3	8.9	9.5	10.6	11.3	12.0	12.7	15.2
020802080205	Western Branch Elizabeth River	Existing Condition	3.7	4.5	4.9	5.4	6.1	7.0	7.9	8.6	10.3
		1.5 ft SLR	5.2	6.0	6.4	6.9	7.6	8.5	9.4	10.1	11.8
		3.0 ft SLR	6.9	7.7	8.1	8.6	9.3	10.2	11.2	11.9	13.6
		4.5 ft SLR	8.4	9.2	9.6	10.1	10.9	11.8	12.7	13.4	15.2
030102051104	Indian Creek-Northwest River	Existing Condition	0.1	0.5	0.7	1.0	1.4	2.0	2.4	2.8	3.8
		1.5 ft SLR	1.6	2.0	2.2	2.5	2.9	3.5	3.9	4.3	5.3
		3.0 ft SLR	3.2	3.6	3.8	4.2	4.6	5.2	5.6	6.0	7.1
		4.5 ft SLR	4.8	5.2	5.4	5.7	6.1	6.8	7.2	7.6	8.6
030102051201	Chesapeake Canal	Existing Condition	3.0	3.6	4.0	4.4	5.0	5.8	6.4	7.0	8.4
		1.5 ft SLR	4.5	5.1	5.5	5.9	6.5	7.3	7.9	8.5	9.9
		3.0 ft SLR	6.0	6.6	7.0	7.4	8.0	8.8	9.4	10.0	11.4
		4.5 ft SLR	7.5	8.1	8.5	8.9	9.5	10.3	10.9	11.5	12.9
030102051203	Upper North Landing River	Existing Condition	0.4	0.8	1.0	1.3	1.8	2.2	2.5	3.0	4.0
		1.5 ft SLR	1.9	2.3	2.5	2.8	3.3	3.7	4.0	4.5	5.5
		3.0 ft SLR	3.5	3.9	4.1	4.5	5.0	5.4	5.7	6.2	7.3
		4.5 ft SLR	5.1	5.5	5.7	6.0	6.5	7.0	7.3	7.8	8.8

Notes:

1. Sea level rise scenarios are based on HRPDC Sea Level Rise Planning Policy and Approach (2018).
2. All elevations sourced from statistical analysis of the distribution of water elevations in each watershed from the FEMA Region III Storm Surge Study conducted by the U.S. Army Corps of Engineers Engineer Research and Development Center (2013).
3. Conditions related to the 3-ft and 4.5-ft sea level rise design levels include non-linear increases derived from numerical modeling completed by the U.S. Army Corps of Engineers as part of the North Atlantic Coast Comprehensive Study.

Comments/ Concerns

Not clear where and how tailwater elevations should be used

Will develop application guidance

Results differ from other analyses

Will investigate potential conflicts and resolve

Connection with other products (inundation maps, etc.)

Will revised inundation analysis with new LiDAR data and add additional products

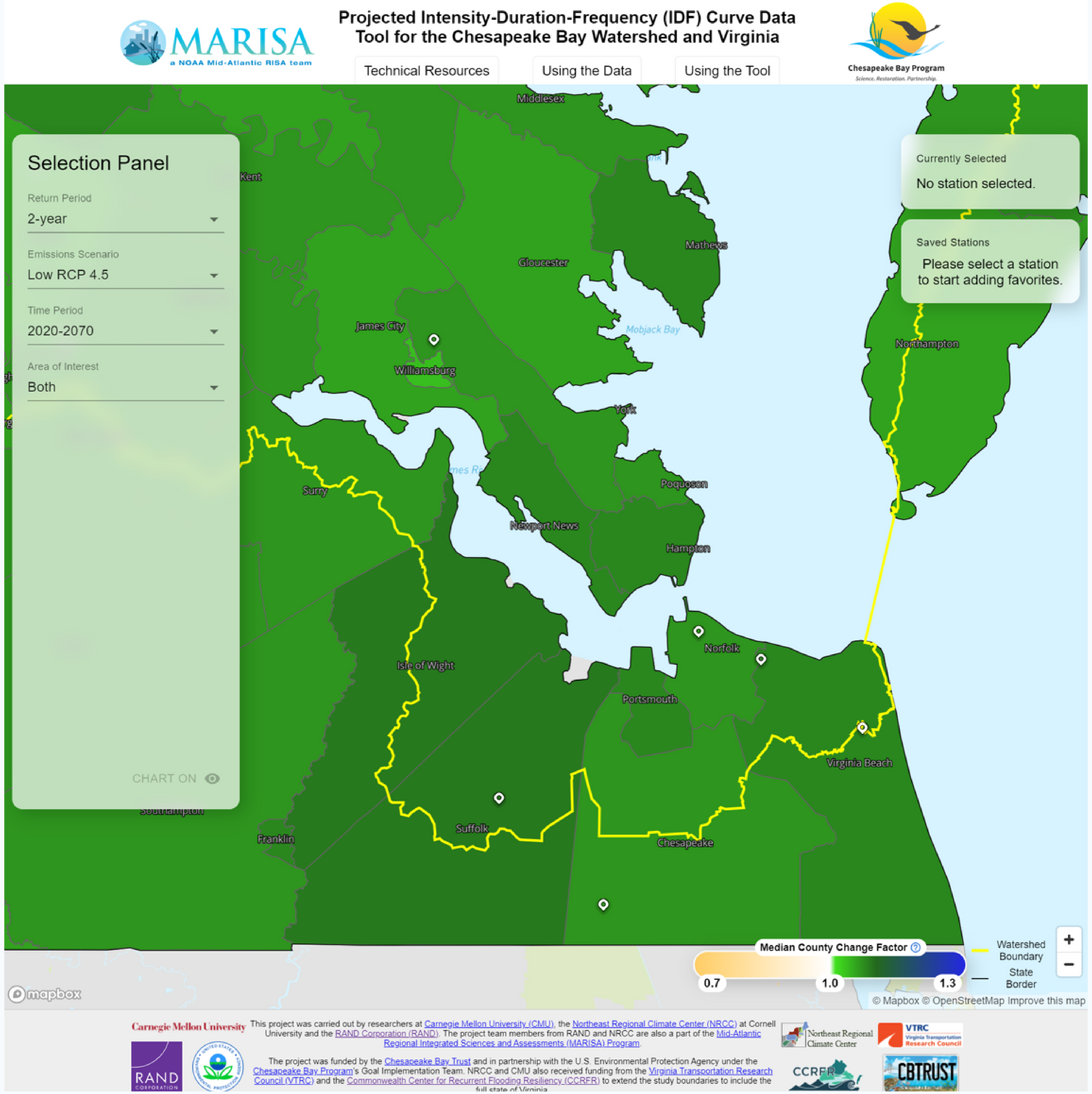
PRECIPITATION

Methodology

Analysis downscales climate models to calculate climate-informed IDF curves using "ensemble of ensembles" for different scenarios

Change factors and IDF curves calculated for stations.

Change factors calculated for counties and county equivalents.



https://midatlantic-idf.rcc-acis.org/

Methodology

Calculate baseline NOAA Atlas 14 values using NOAA precipitation grid for each return period and locality centroid

Use MARISA tool to calculate future precipitation values for selected scenarios

- RCP
- Timeframe
- Percentile

Return Periods

2-, 5-, 10-, 25-, 50-, and 100-year return periods

Emissions Scenarios

RCP 4.5 (Low)
RCP 8.5 (High)

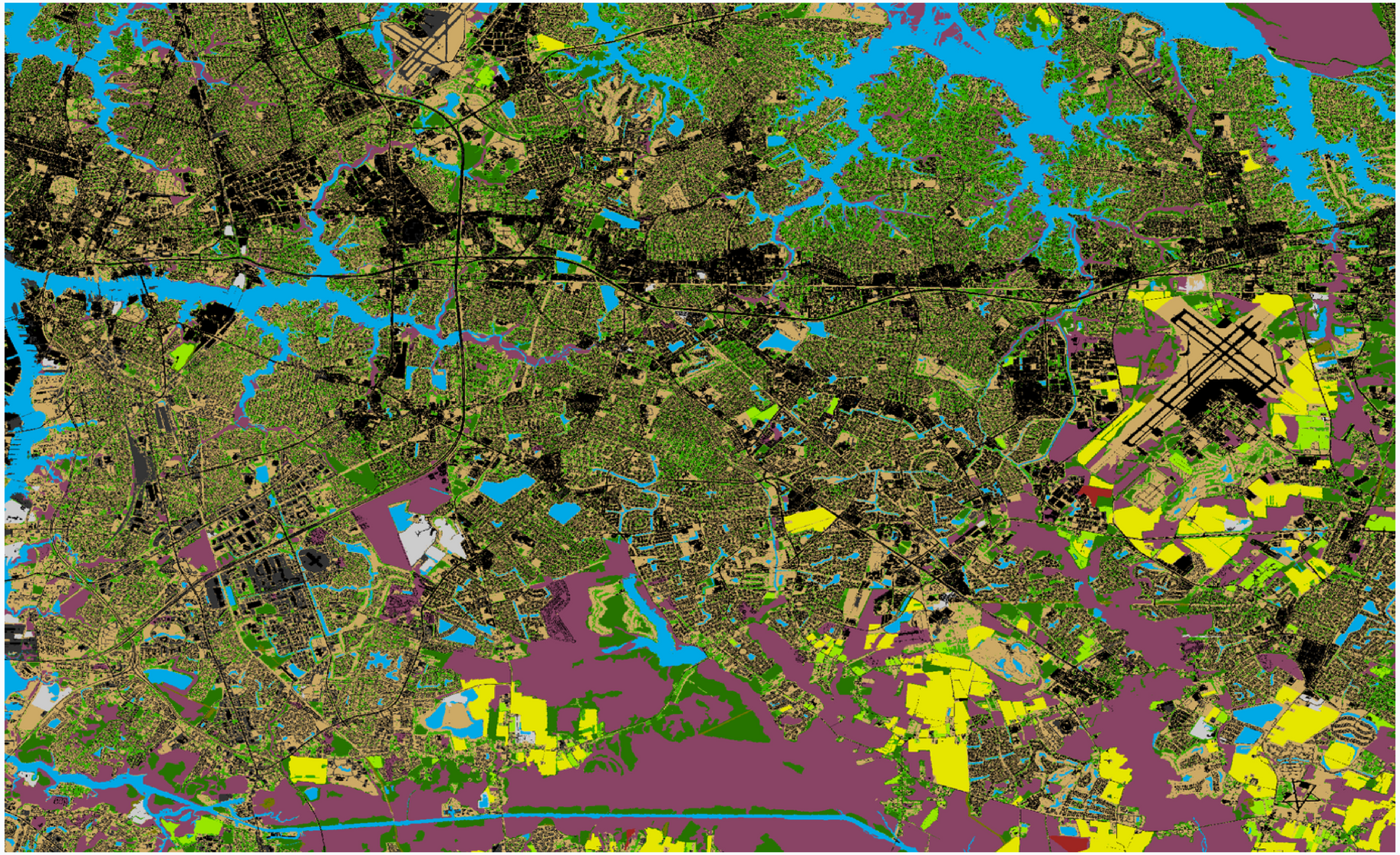
Time Periods

2020-2070
2050-2100

Methodology

Impervious cover is used as a proxy for watershed capacity to absorb rainfall.

- More impervious cover means potentially higher consequences if rainfall is greater than predicted.



Data Source: Chesapeake Bay High-Resolution Landcover

Results

Recommend single multiplier for each locality by averaging 2020-2070 values for all return periods and both emissions scenarios

Percentile selected based on local impervious cover*

- <=10% - use 50th
- > 10% - use 75th

Multiplier	Localities
1.1	Gloucester County Isle of Wight County Southampton County Surry County
1.15	James City County Suffolk Williamsburg York County
1.2	Chesapeake Franklin Hampton Newport News Norfolk Poquoson Portsmouth Smithfield Virginia Beach

Comments/ Concerns

Data access and review

Final land cover data is expected to be delivered from the Chesapeake Conservancy in early 2022

Data accuracy

Chesapeake Bay Program has also ordered an accuracy review of the new land cover data, which is expected shortly after the data is delivered

JOINT PROBABILITY EVENTS

Approach

Approach from Virginia Beach Public Works Design Standards Manual

Defines design storms as pairs of tidal and rainfall events

Different design storms are required for different projects (scale, type)

Design Storm	Tidal Elevation	Rainfall
1-Year	10-Year	1-Year
2-Year	5-Year	2-Year
10-Year	1-Year	10-Year
25-Year	2-Year	25-Year
50-Year	2-Year	50-Year
100-Year	3-Year	100-Year

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Resilient design guidelines should be scientifically-based, appropriate, and implementable

Scientifically-Based

Guidelines should be developed using sound data, models, and methods.

Appropriate

Guidelines for specific uses should be based on agreed-upon level of risk tolerance.

Implementable

Guidelines should be practicable and not considered impossible or overly difficult to achieve.

Appropriate Standards

Appropriateness is based on risk tolerance - are we using the right standard for the right use?

Appropriateness is based on cost-benefit and risk tolerance - are we using the right standard for the right use?

Different standards should be used for different types (critical infrastructure) or sizes of projects

Implementable Standards

Implementation requires considerations of practicality - can we actually do, in a cost-effective manner, what we are trying to do?

Requiring the same rules for all types of projects for how they go about achieving higher design standards may not be cost-effective

An implementable standard should have different options for meeting it

- Bigger/more pipes
- Onsite treatment - infiltration, detention, storage
- Offsite mitigation

Having solid sea level rise and precipitation forecasts is critical and should not be compromised.

Appropriate standards should be developed based on desired and affordable level of service.

Considering the extent of existing development, different options for implementation should be developed based on locality needs and conditions.

Next Steps

Resolve potential inconsistencies between local and regional products and analyses

Share new land cover and LiDAR data with localities when available

Convene working group to discuss application recommendations

Questions

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