

SHA Climate Change Adaptation Plan with Detailed Vulnerability Assessment



MOITS

December 9, 2014

Discussion



- Objectives
- Framework
- Data, Tools
- Methodology
- Results
- Next Steps

Pilot Study Objectives

- Assess Vulnerability to SHA's Assets
- Develop Approaches to Address Current and Future Risk
- Provide Recommendations for Policy or Process Changes

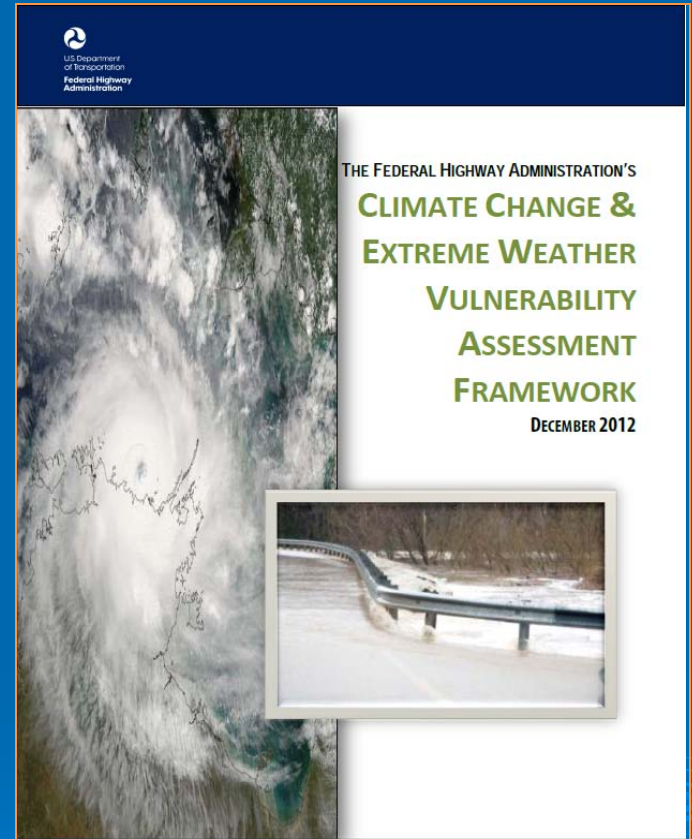


Floating Debris Lodged in a Bridge during Flood Event at Seneca Creek in Germantown, MD
Photo Source: (FEMA/Skolnik 2006)

“Improve Resiliency of Maryland's
Transportation System”

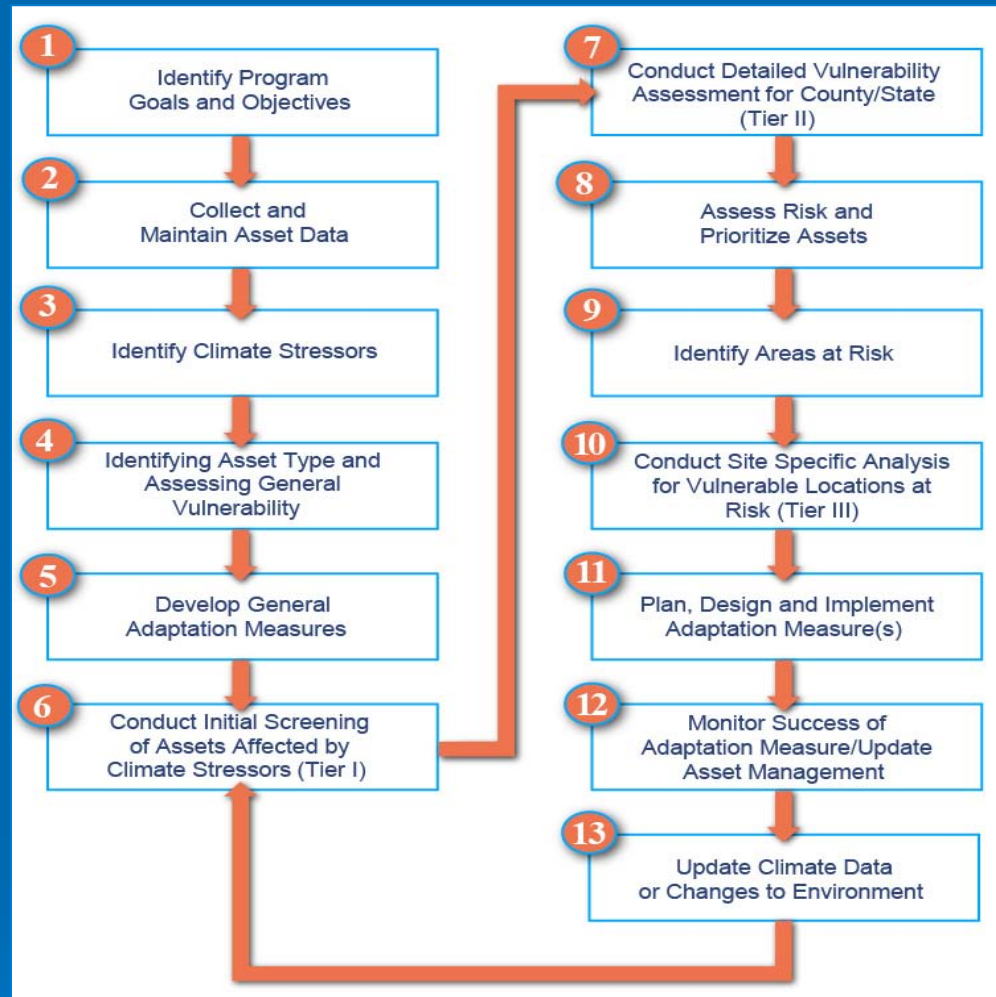
Develop Framework

- Modified Framework
 - Conducted General Assessment of Asset Vulnerabilities and Adaptation Measures
- Incorporated Different Screening Approaches
 - Climate Change Impact Zone
- Process Repeatable



“Draft” Framework

Process
repeatable when
new climate data
is available or
changes to the
environment
occur



Identify Climate Stressors

Studied in Detail for Maryland

Sea Level Change

- USACE Procedures Established in Circular No. 1165-2-212 (2013)
- Newer LiDAR and Assign Nearest Tidal Station

Storm Surge

- HAZUS-MH 2.1 (Category 3 Storm Used)
- Stillwater Depth Grids Developed

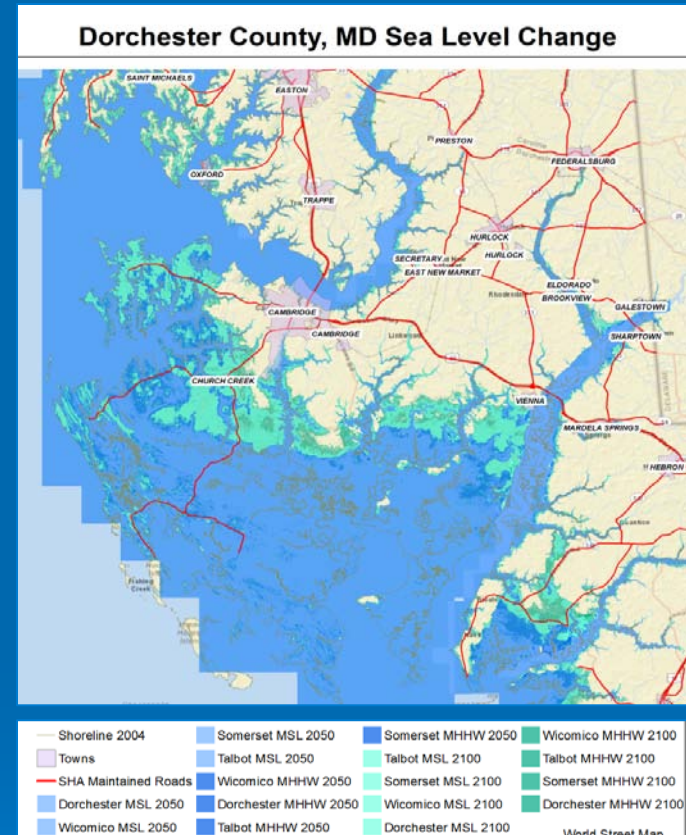
Precipitation

- Micro-scale Data Obtained from C-MIP
- Riverine Modeling in HAZUS-MH2.1 (future)

2050 & 2100 Sea Level Change

Eastern Shore Regional GIS Cooperative – Salisbury University

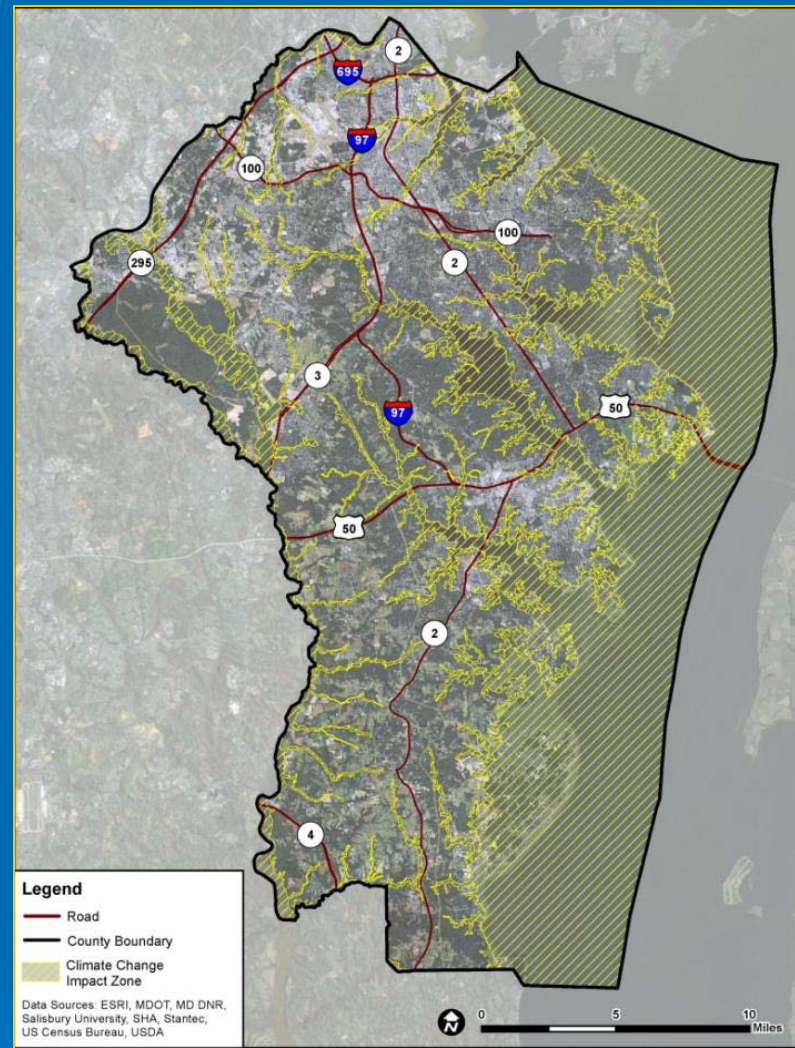
County	Tidal Station	2050		2100	
		MSL	MHHW	MSL	MHHW
Allegany	None	-	-	-	-
Anne Arundel	Annapolis	2.08	2.79	5.7	6.41
Baltimore	Baltimore	2.01	2.87	5.59	6.45
Baltimore City	Baltimore	2.01	2.87	5.59	6.45
Calvert	Solomons Island	2.1	2.82	5.76	6.48
Caroline	Cambridge	2.11	3.13	5.78	6.8
Carroll	None	-	-	-	-
Cecil	Chesapeake City	1.98	3.63	5.56	7.21
Charles	Washington DC	2.21	3.83	5.78	7.4
Dorchester	Cambridge	2.11	3.13	5.78	6.8
Frederick	None	-	-	-	-
Garrett	None	-	-	-	-
Harford	Baltimore	2.01	2.87	5.59	6.45
Howard	None	-	-	-	-
Kent	Annapolis	2.08	2.79	5.7	6.41
Montgomery	None	-	-	-	-
Prince Georges	Washington DC	2.21	3.83	5.78	7.4
Queen Annes	Annapolis	2.08	2.79	5.7	6.41
Somerset	Cambridge	2.11	3.13	5.78	6.8
St. Mary's	Solomons Island	2.1	2.82	5.76	6.48
Talbot	Cambridge	2.11	3.13	5.78	6.8
Washington	None	-	-	-	-
Wicomico	Cambridge	2.11	3.13	5.78	6.8
Worcester	Ocean City	2.06	3.25	5.86	7.05



Methodology – USACE: Sea-Level Change Considerations for Civil Works Programs, October 2013

Initial Screening

- Climate Change Impact Zone Map Created Using GIS
- Eliminate assets at low to no risk prior to use of VAST
- Used SLOSH (Cat 3), 2100 MHHW, FEMA 100 year Floodplain, plus 50 ft. buffer



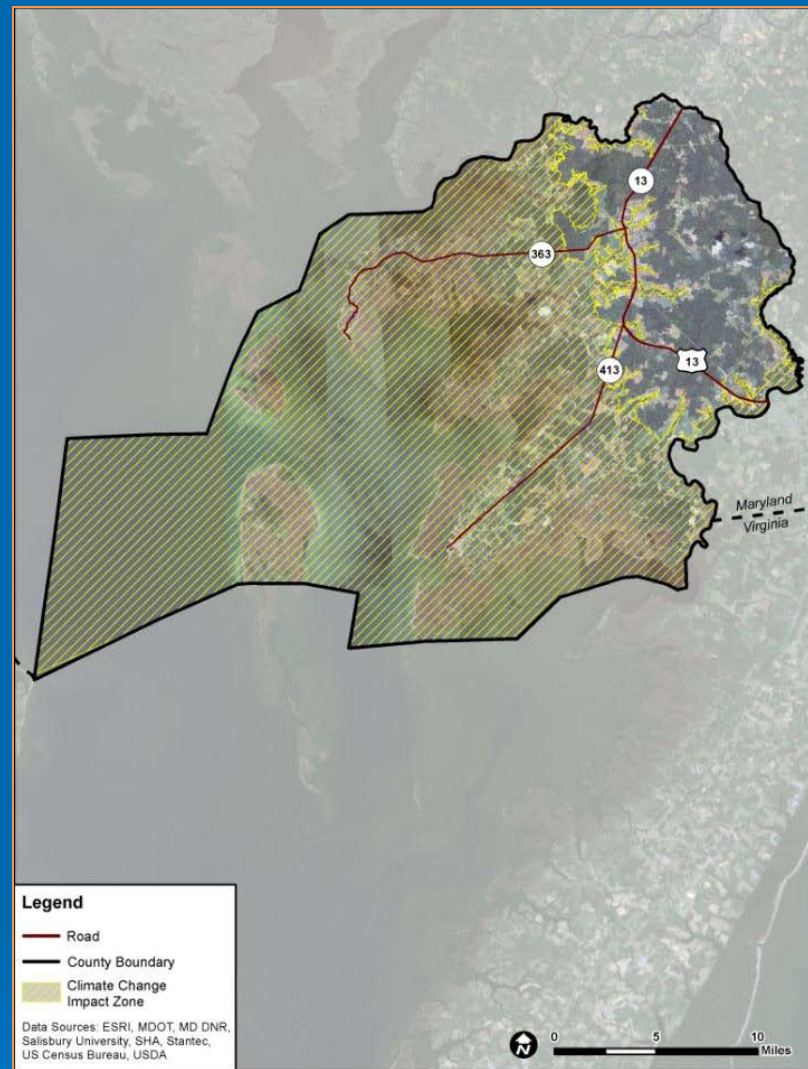
Climate Change Impact Zone
Anne Arundel, MD

Results of Screening

Assets	Anne Arundel County		Somerset County	
	Number of Assets	Evaluated in More Detail	Number of Assets	Evaluated in More Detail
Bridges including large culverts	517	150	86	72
Small culverts and conveyances	Culverts- 12,024 Conveyances- 8,601	Culverts- 1,174 Conveyances- 843	Culverts- 1153 Conveyances 1135	Culverts- 739 Conveyances 847
Miles of roadway	2,554.28 miles	114.99 miles	503.92 miles	285.2 miles

Assess Vulnerability

- Two Pilot Counties
- Initial Screening of Assets
- SLC – Permanent Inundation
- Tools Used
 - Hazard Vulnerability Index
 - VAST



Change Impact Zone
Somerset County, MD

Results - Roadways

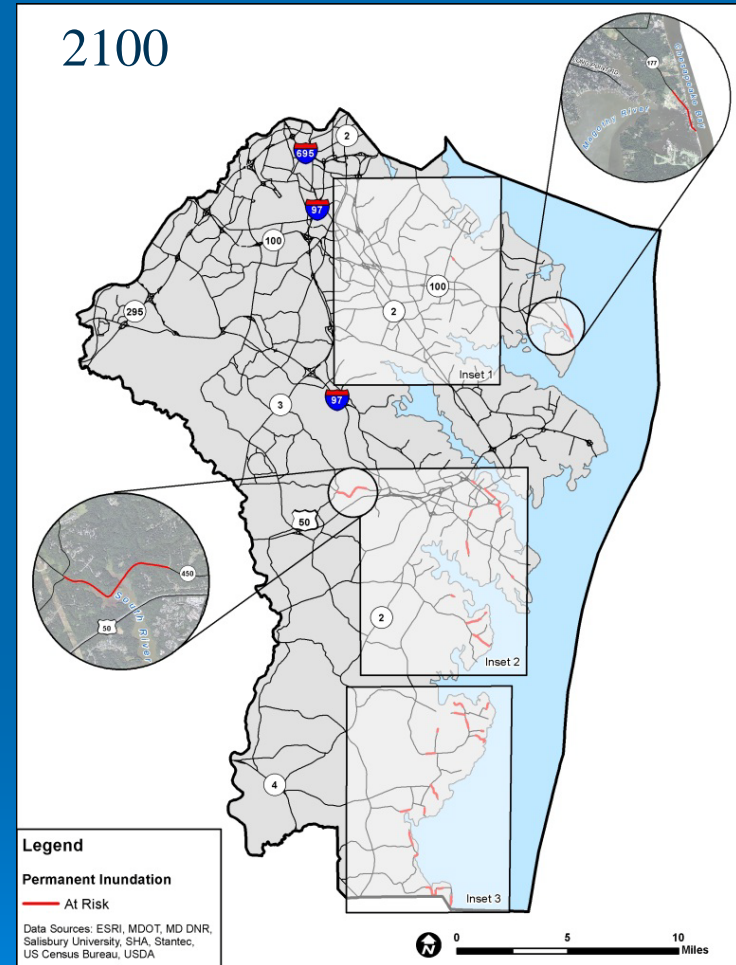
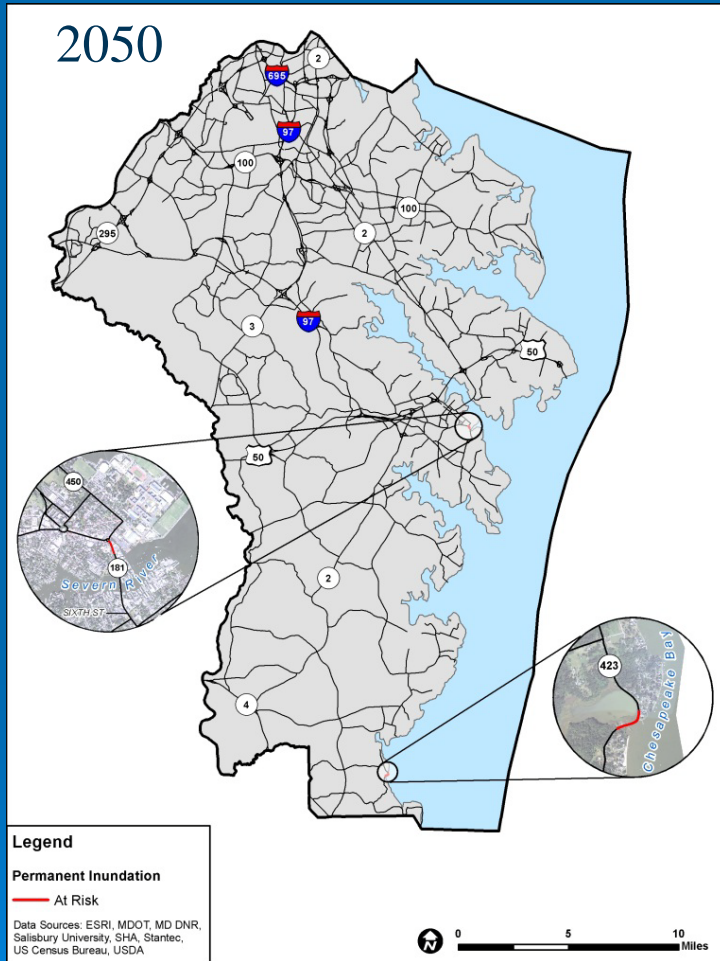
➤ Permanent Inundation

- Anne Arundel County 2050 & 2100 Sea Level Change (USACE)
- Somerset County 2050 & 2100 Sea Level Change (USACE)

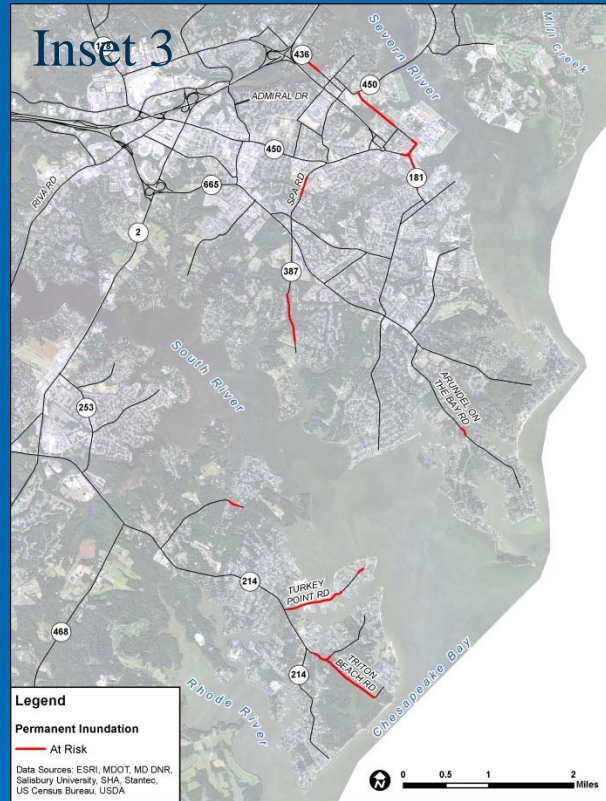
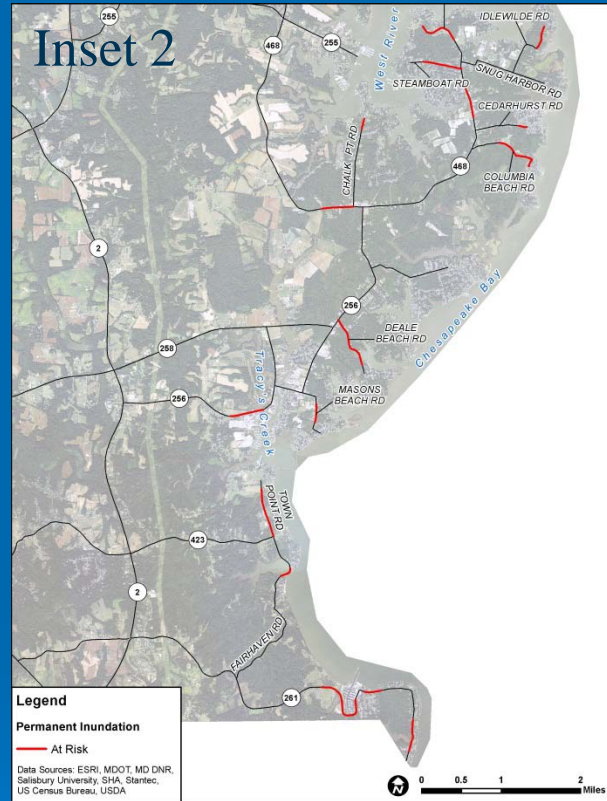
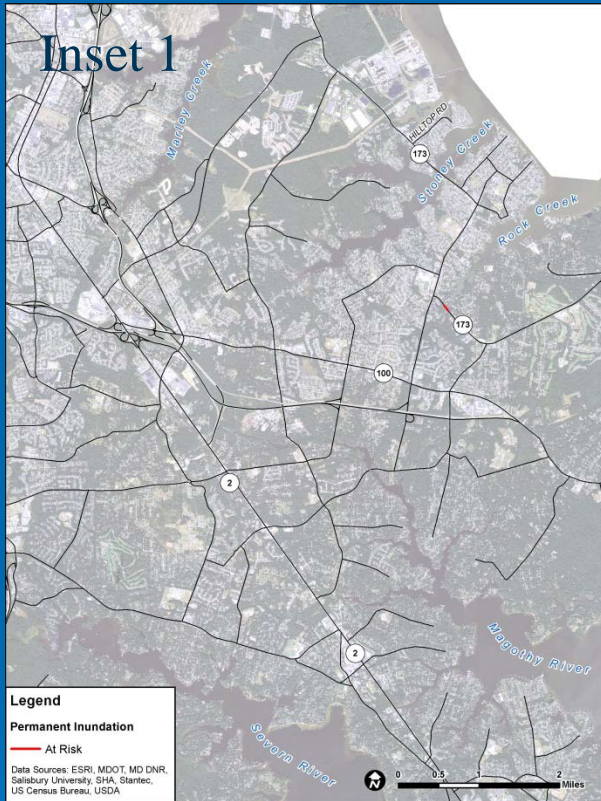
➤ Hazard Vulnerability Index (HVI)

- Anne Arundel County 2050 & 2100 Sea Level Change with 100 Year Storm Event (HAZUS-MH)
 - Storm Surge Considerations (Still Water)
- Somerset County 2050 & 2100 Sea Level Change with 100 Year Storm Event (HAZUS-MH)
 - Storm Surge Considerations (Still Water)

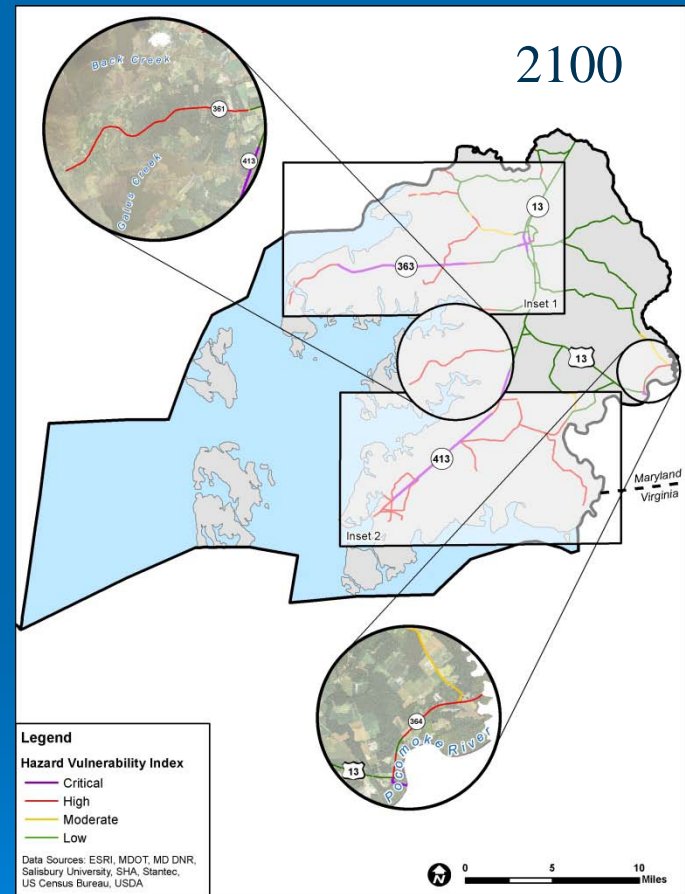
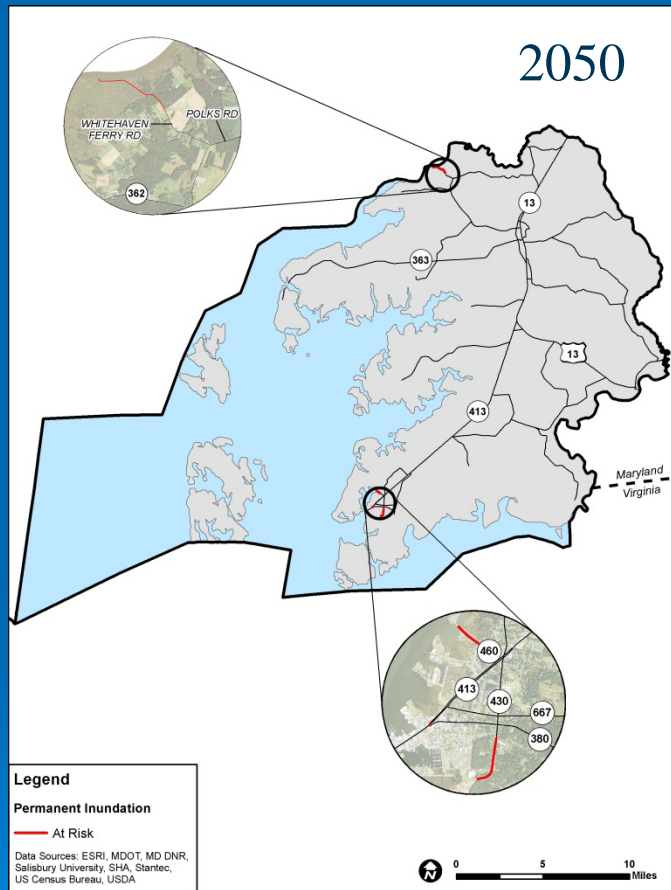
Permanent Inundation for Anne Arundel



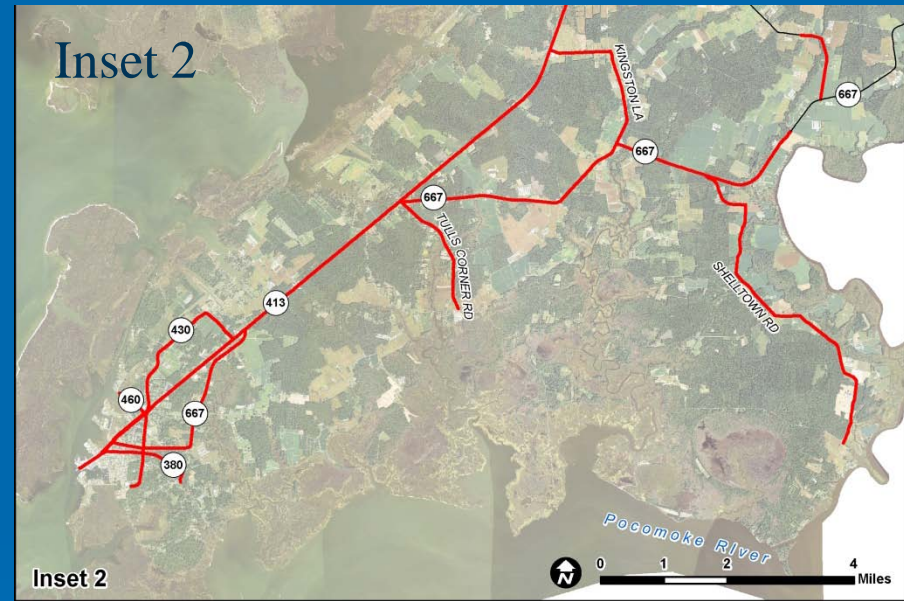
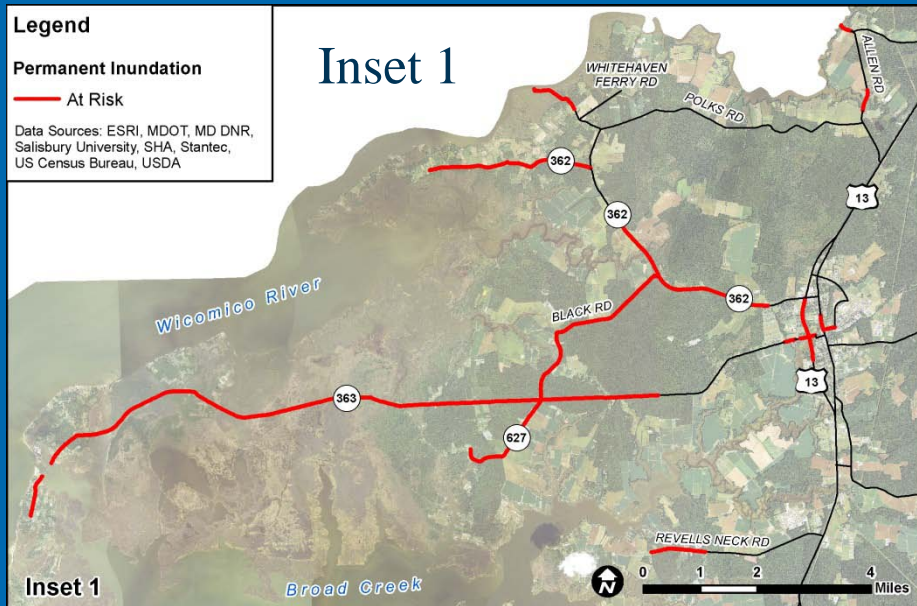
Permanent Inundation Anne Arundel 2100



Permanent Inundation Somerset County



Permanent Inundation Somerset County - 2100



Hazard Vulnerability Index (HVI)

Risk =

$$(Evacuation\ Code * 0.5 + 1) * \left(\frac{(Flood\ Depth\ Code + 0.01)}{4} \right) * \left(\frac{0.7}{Functional\ Classification} \right)$$

Evacuation	Code
No	0
Yes	1

Flood Depth (Feet)	Code
No Flood	0
0 – 0.5	1
0.5 - 1	2
1 - 2	3
>2	4

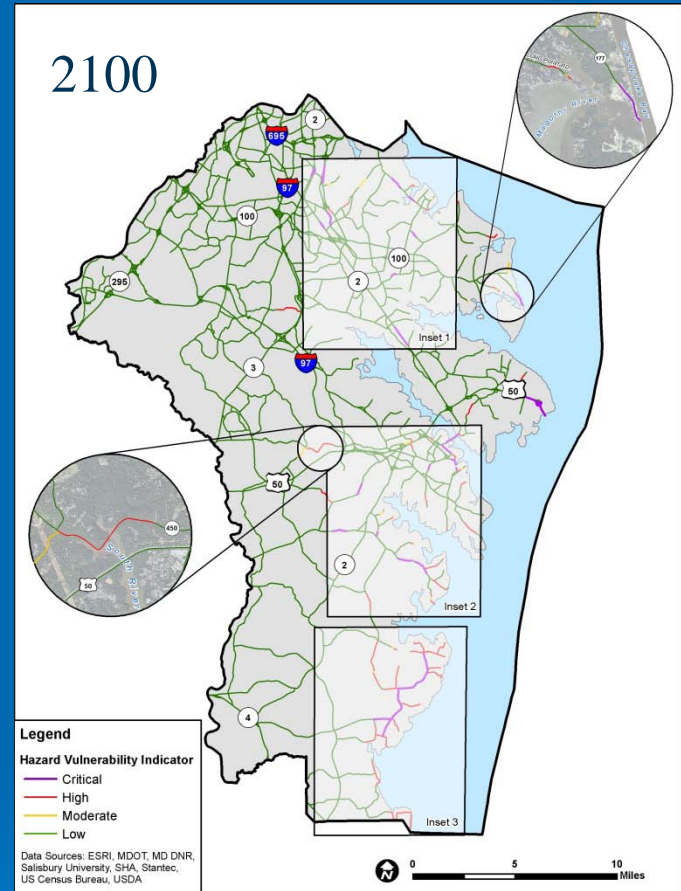
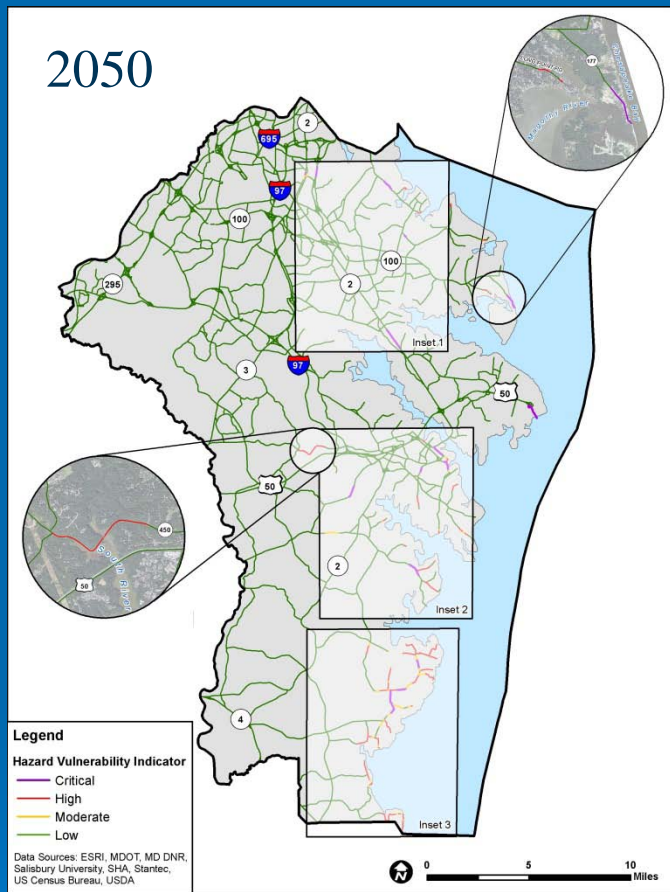
Value	SHA Functional Class
1	Interstate
2	Principal Arterial – Other Freeways and Expressways
3	Principal Arterial – Other
4	Minor Arterial
5	Major Collector
6	Minor Collector
7	Local

Hazard Vulnerability Index (HVI)

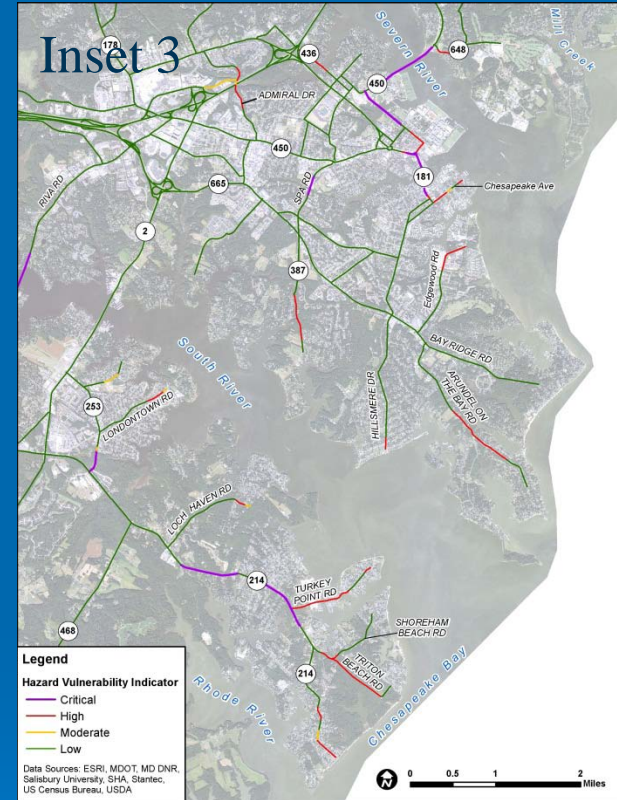
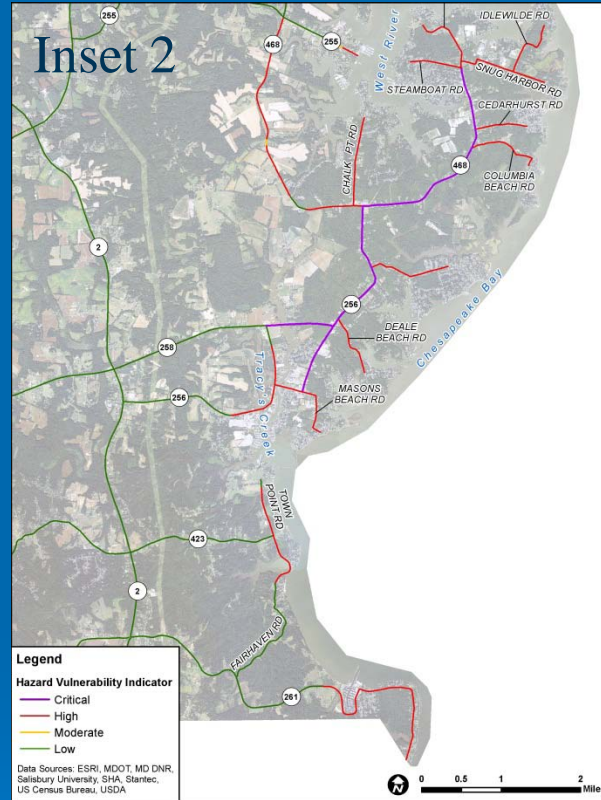
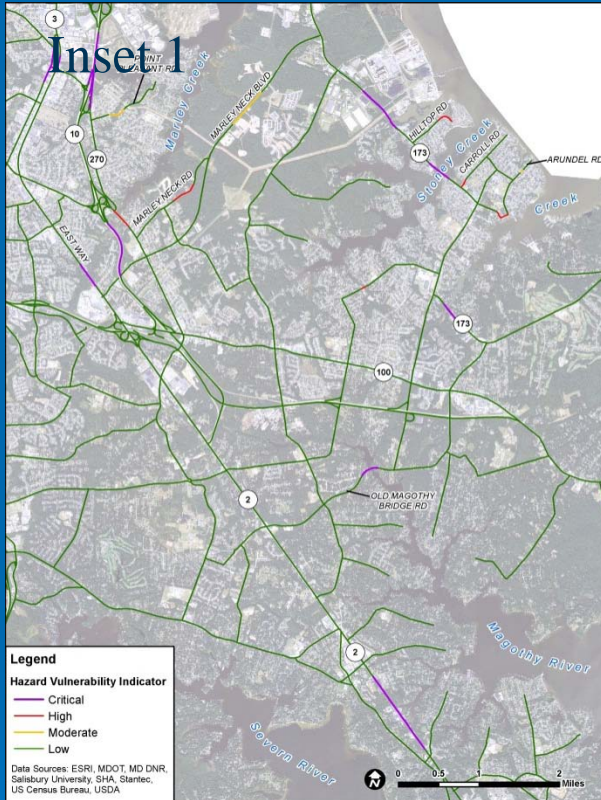
Risk	
Value	Category
> 0.15	Critical
0.1 – 0.15	High
0.01 – 0.1	Moderate
< 0.01	Low

- **Critical:**
 - Lower Bound of Flood Depth Code of 4 and Evacuation Route for Any Roadway
 - Lower Bound of Any Flooding to Functional Classification 1 Roadways (Interstates)
- **High:**
 - Lower Bound is Flood Depth Code of 4 for Any Roadway
- **Moderate:**
 - Flood Depth Code 1-3 for Functional Classifications 2-7
- **Low:**
 - No Flooding

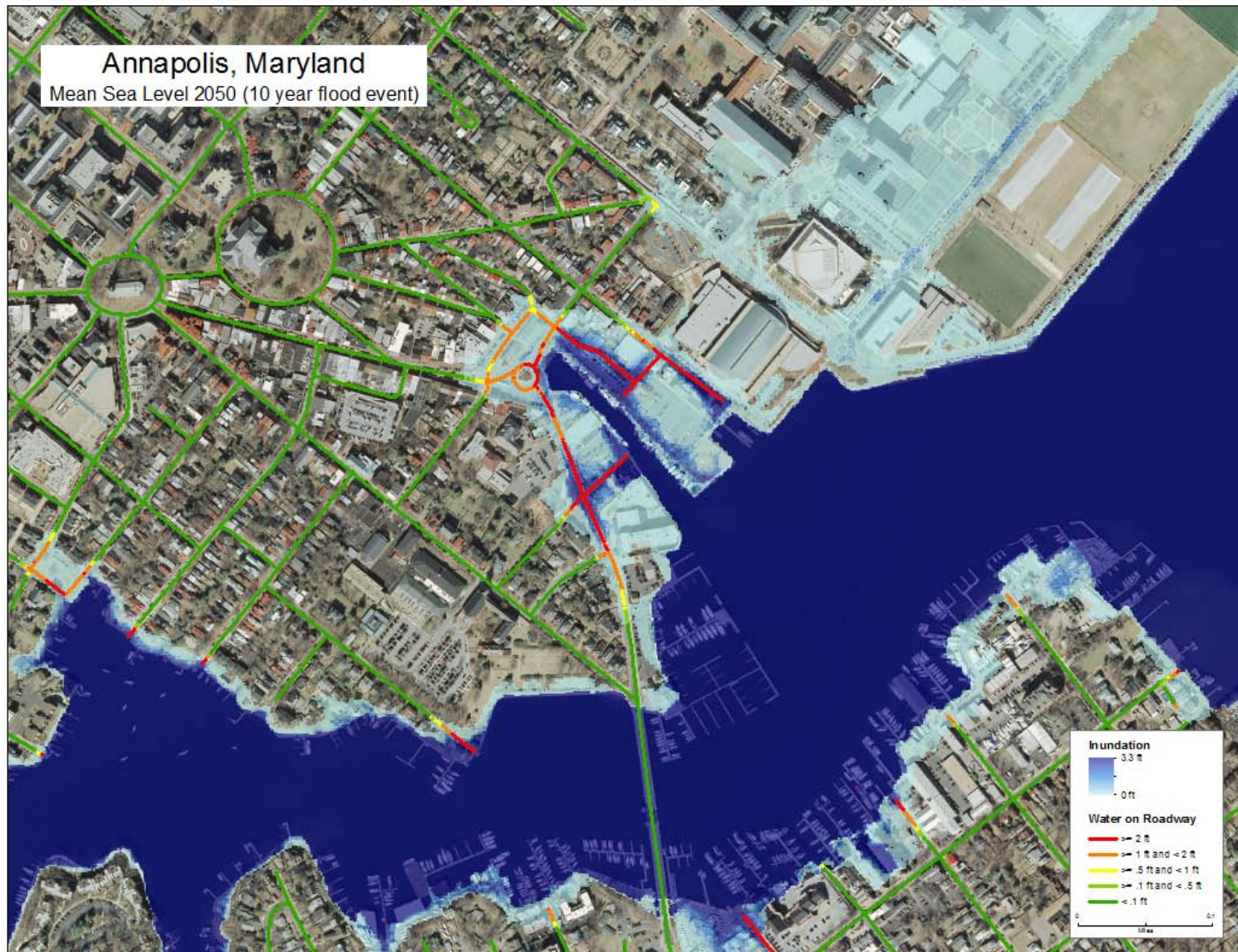
HVI for Anne Arundel County



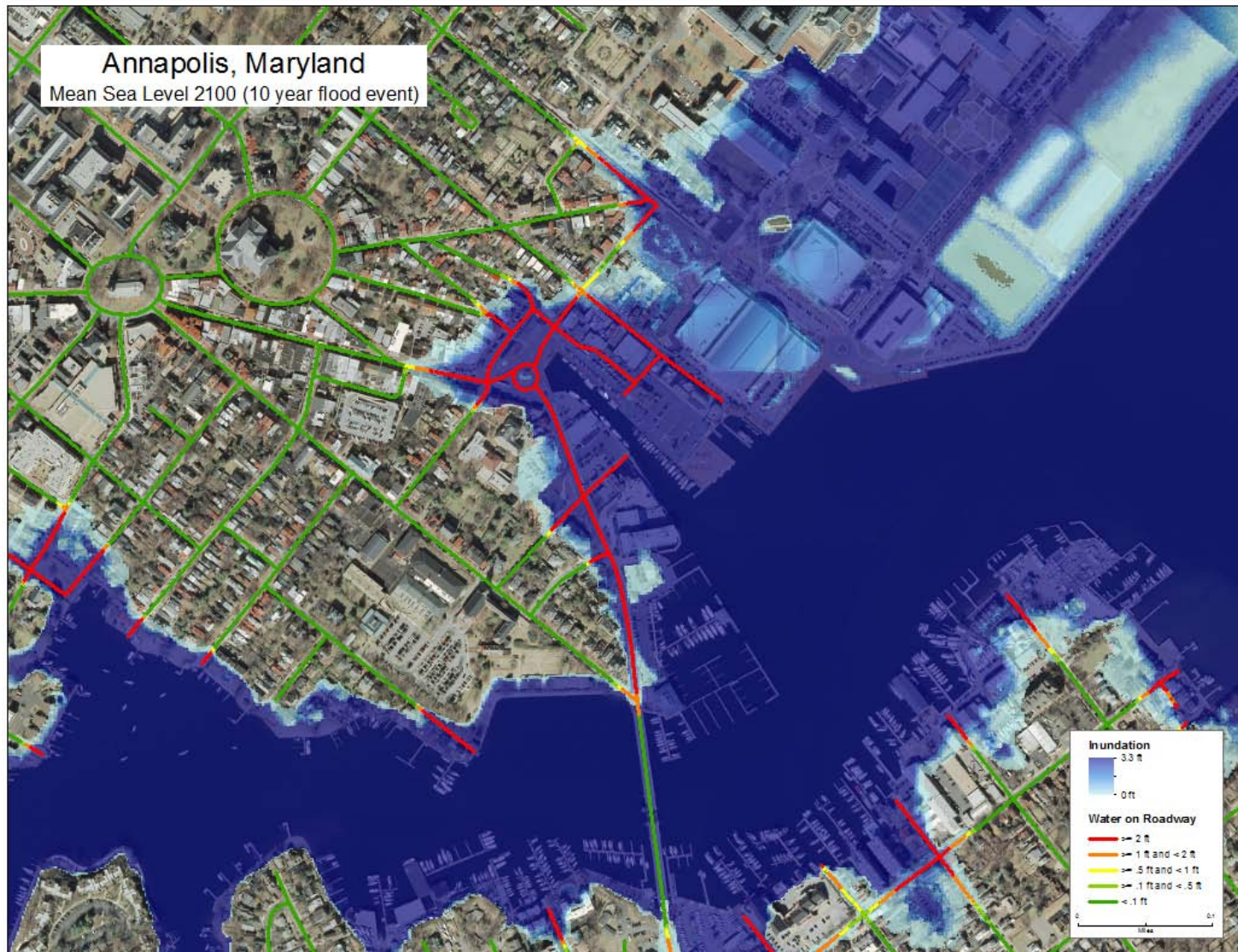
HVI for Anne Arundel County 2100



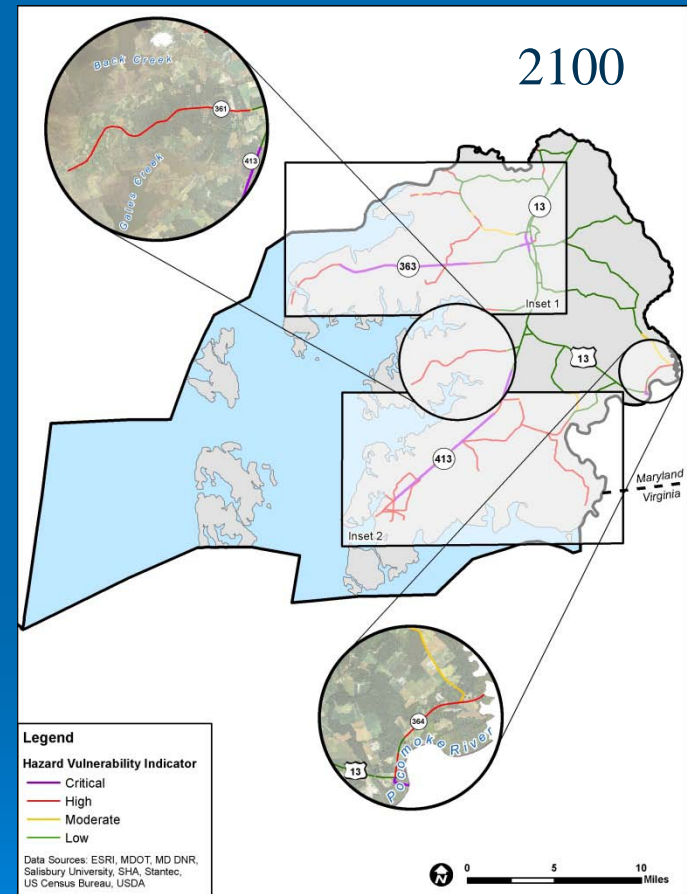
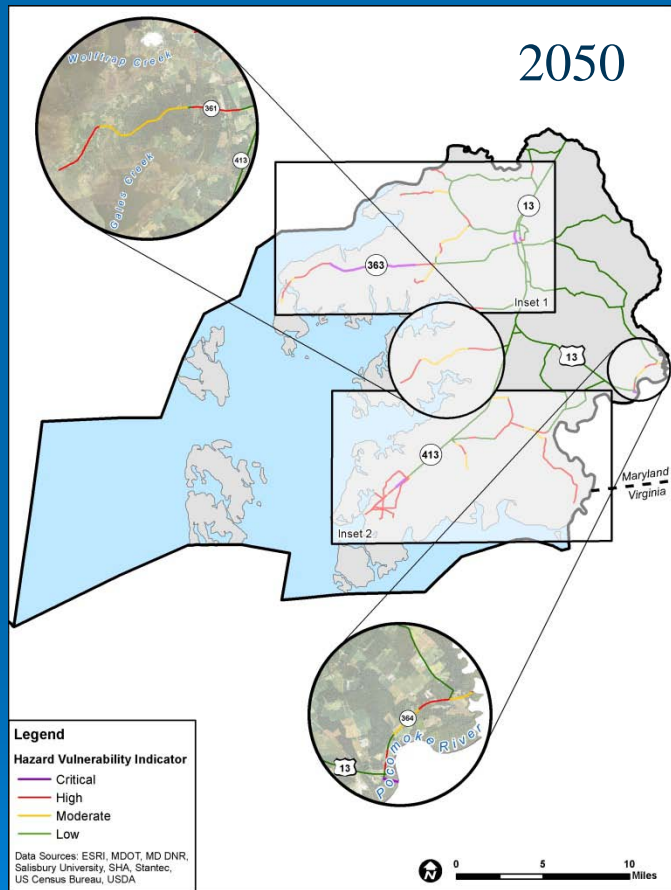
HVI for Annapolis 2050



HVI for Annapolis 2100



HVI for Somerset County

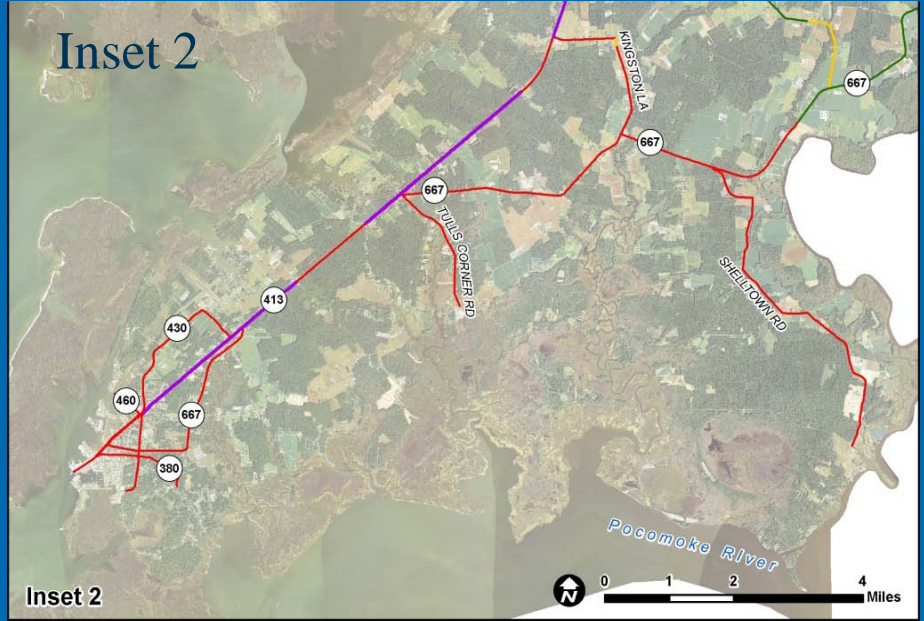
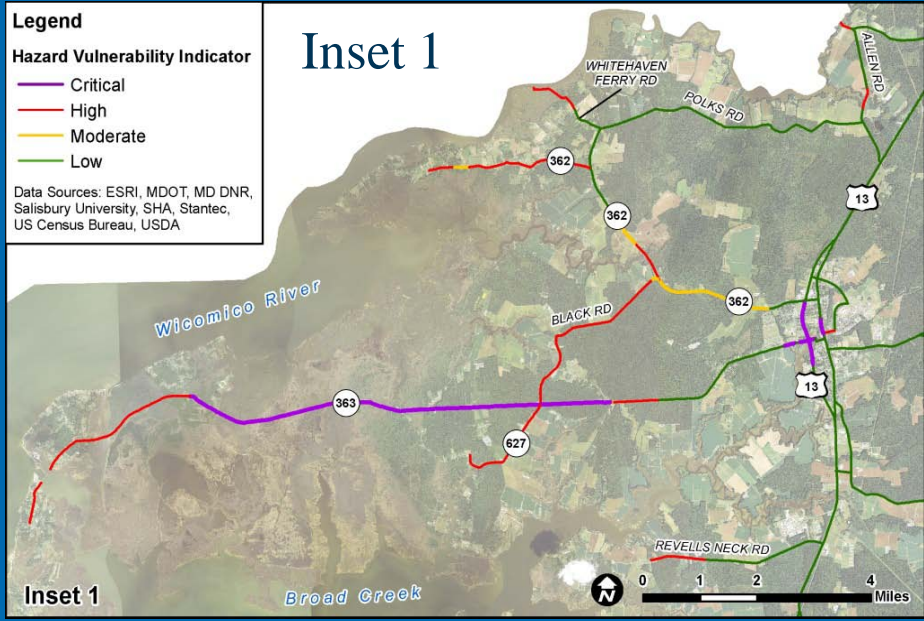


HVI for Somerset County 2100

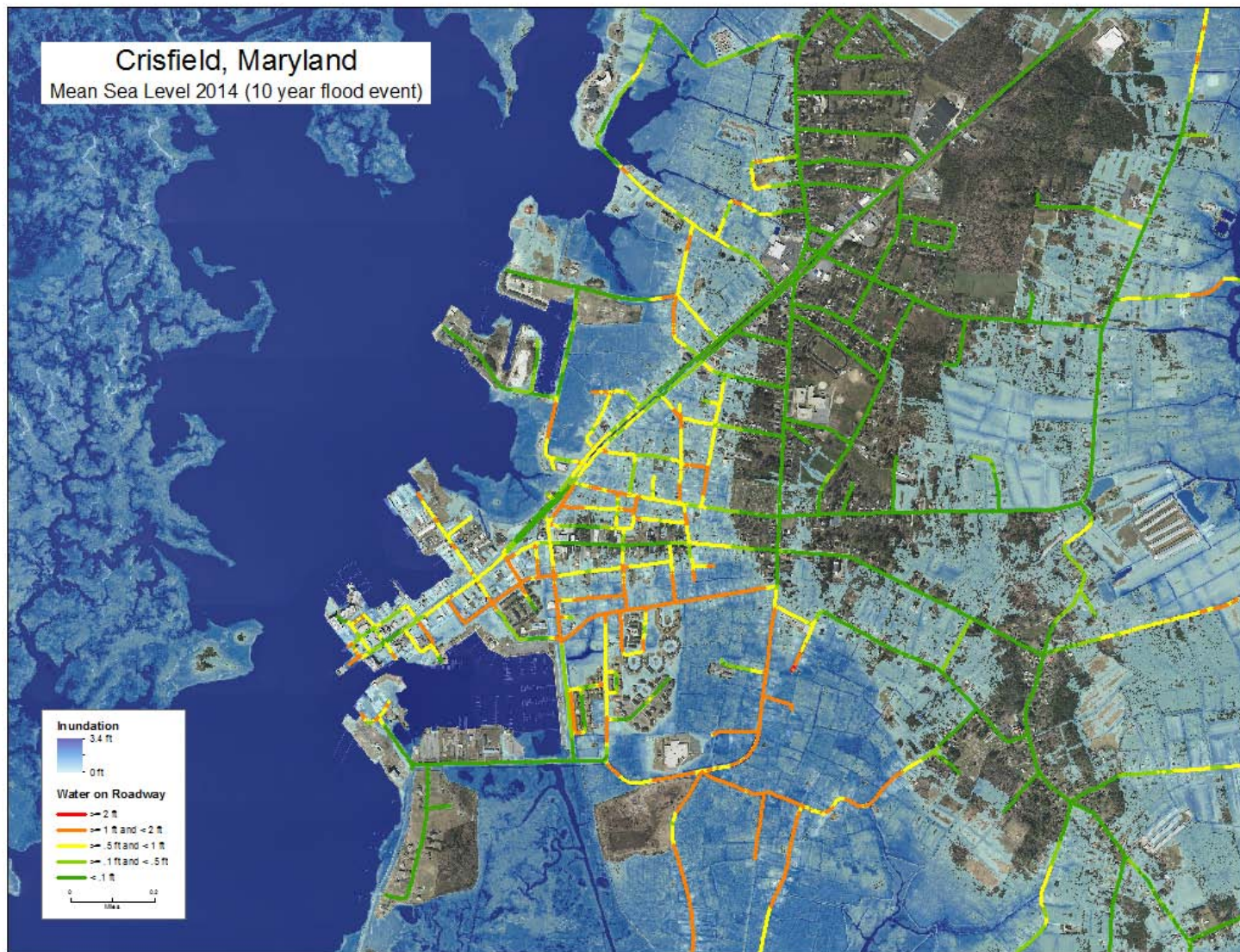
Legend
Hazard Vulnerability Indicator

- Critical
- High
- Moderate
- Low

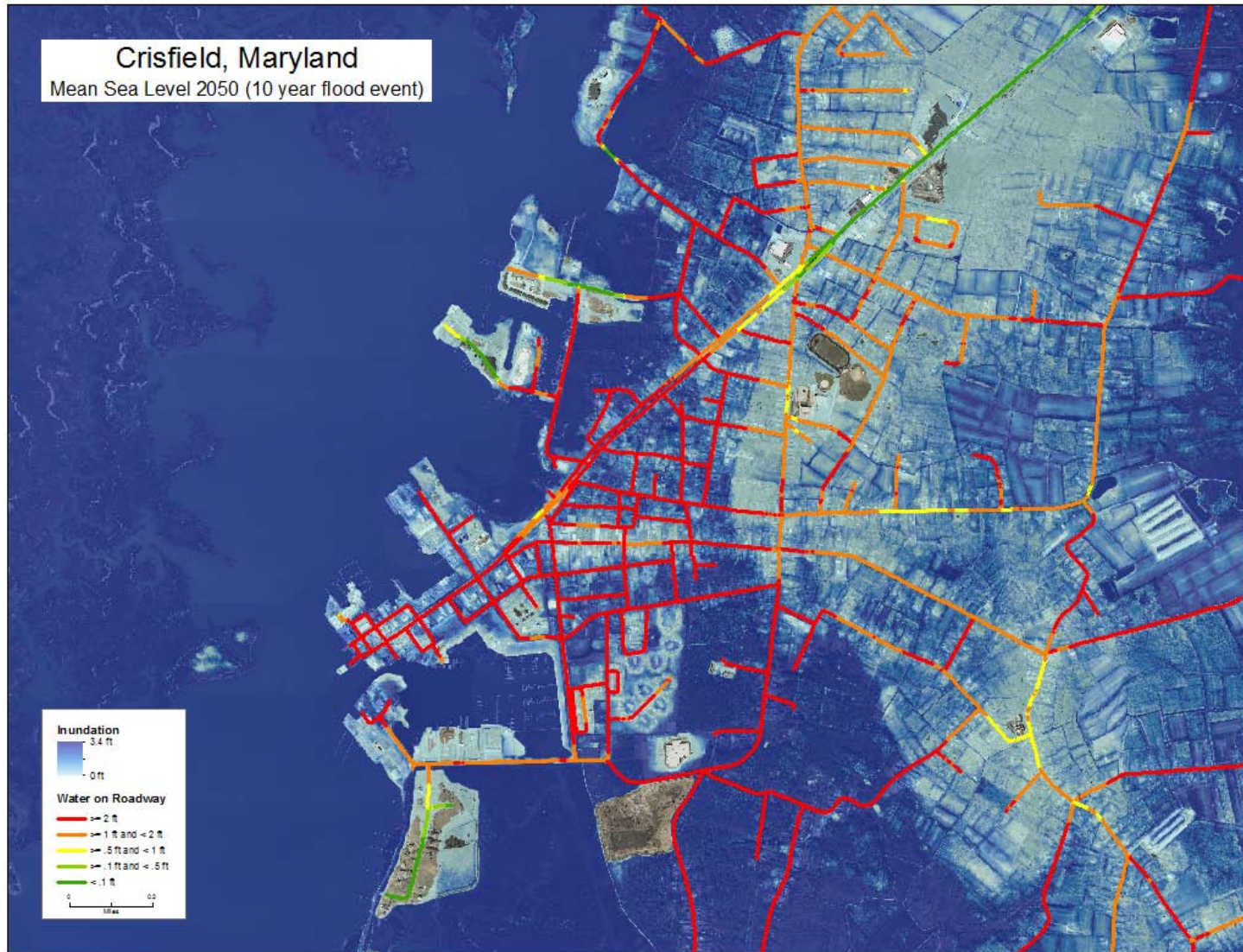
Data Sources: ESRI, MDT, MD DNR, Salisbury University, SHA, Stantec, US Census Bureau, USDA



HVI for Crisfield 2014

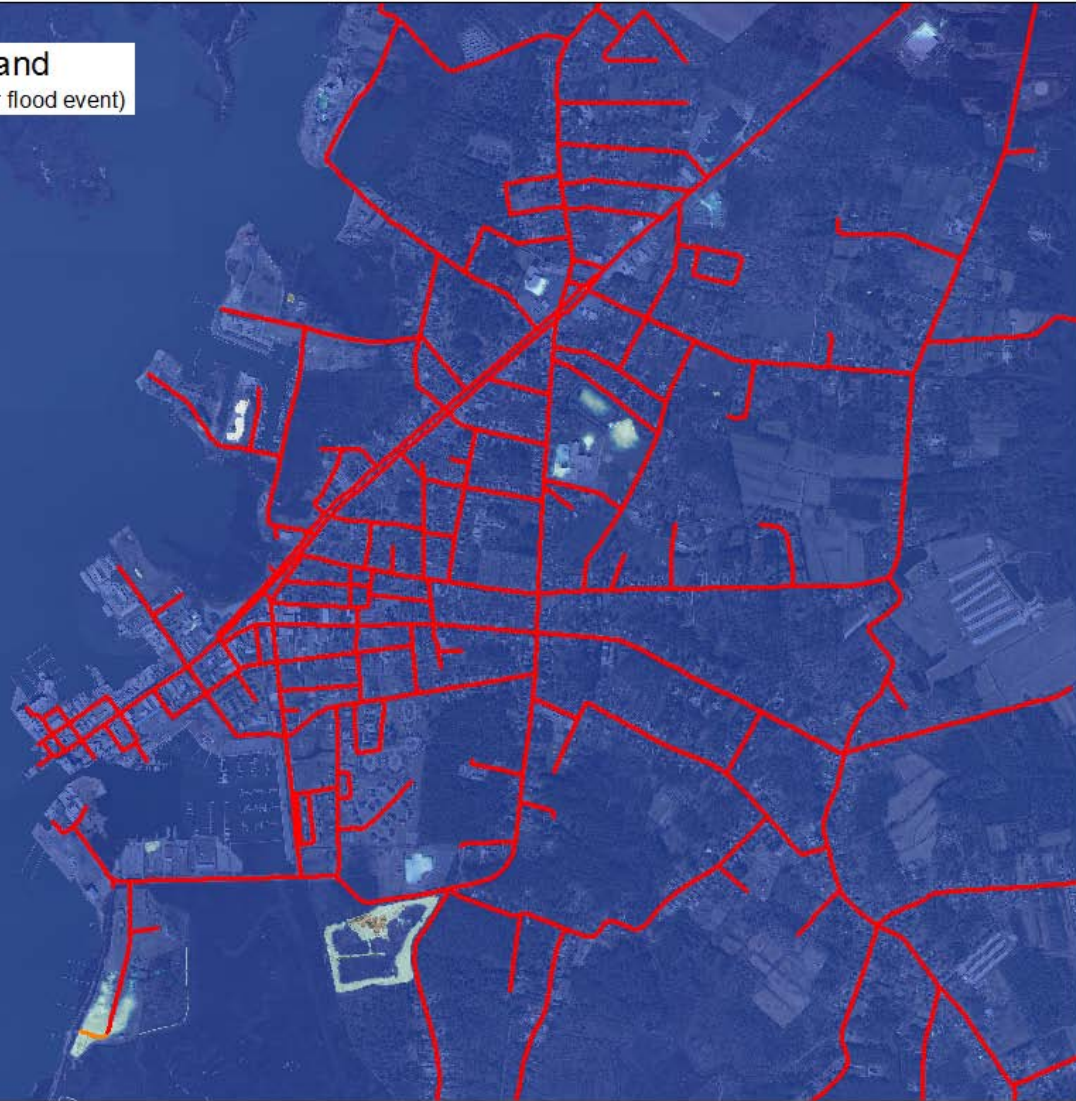


HVI for Crisfield 2050



HVI for Crisfield 2100

Crisfield, Maryland
Mean Sea Level 2100 (10 year flood event)



VAST - Input and Results

- 150 assets in Anne Arundel County (bridges and culverts)
- 72 assets in Somerset County (bridges and culverts)
- Input Information
 - Asset data
 - Exposure data
 - Sensitivity data
 - Adaptive Capacity data
- Output
 - Vulnerability Score for all structures
 - 10 most vulnerable assets to each climate stressor
 - Maps and tables showing most vulnerable structures

VAST Input – Asset Information

08152014 Somerset Vulnerability Assessment.xlsxm - Microsoft Excel

File Home Insert Page Layout Formulas Data Review View Stantec Acrobat

Clipboard Font Alignment Number Styles Cells Editing

Step 2. Enter Specific Assets

(1) Stressors and Asset Types > (2) Enter Assets > (3) Browse and Select Indicators > (4) Collect Data > (5) Adjust Scoring > (6) View Results

Back Home

For each asset type, enter the assets you wish to include in your vulnerability screen. You may enter an unlimited number of assets.

You must provide a unique Asset ID for each asset that you enter. If you do not already have IDs for your assets, a simple convention like "1," "2," "3," can be helpful.

Optional fields for asset latitude and longitude are provided to facilitate interaction with your GIS system, if desired. You can also add any other columns you want to help describe each asset (e.g., mile marker for roads or additional coordinate information for non-point assets).

Which assets to enter? How to add columns?

Once you have entered your assets, click the "Update Tool" button.

Update Tool

Step 3
Browse Indicators

Bridges Number

ID for each asset	Enter an asset name/descriptor						Ente	coo
Asset ID	Asset Name	NBI ID	Asset Type	Feature Crossed	Location	County	Lati	
1	APE HOLE ROAD	S-0025001	Stringer/Multibeam or Girder	LITTLE APE HOLE CREEK	2.5 MI SE OF CRISFIELD	Somerset		
2	CALVARY ROAD	S-0012001	Slab	JENKINS CREEK	0.6 MI S OF CRISFIELD RD	Somerset		
3	MARSH ROAD	S-0021001	Stringer/Multibeam or Girder	SHANKS CREEK	SMITH ISLAND	Somerset		
4	SMITH ISLAND ROAD	S-0022001	Stringer/Multibeam or Girder	SHANKS CREEK	0.5 MI N OF RHODES POINT	Somerset		
5	CASH CORNER ROAD	S-0009001	Slab	JOHNSON CREEK	0.35 MILES EAST OF MD 667	Somerset		
6	MD 460	190013001	Stringer/Multibeam or Girder	LITTLE ANNEMESSEX RIVER	0.52 MILE WEST OF MD 413	Somerset		
7	BYRD ROAD	S-0010001	Slab	LITTLE ANNEMESSEX RIVER	0.2 MILES WEST OF MD 358	Somerset		
8	MARUMSCO ROAD	S-0008001	Stringer/Multibeam or Girder	MARUMSCO CREEK	1.5 MI WEST OF MARUMSCO	Somerset		
9	LQ POWELL ROAD	S-0006001	Stringer/Multibeam or Girder	EAST CREEK	0.5 MI W OF TULLS CORNER	Somerset		
10	MD 667	190017X01	Culvert	BRANCH OF JONES CREEK	AT HEARTS EASE ROAD	Somerset		
11	BRYAN HALL ROAD	S-0019001	Stringer/Multibeam or Girder	MARUMSCO CREEK	1.5 MI W OF FROGEYE	Somerset		
12	MD 667	190018X01	Culvert	EAST CREEK	0.23 MI E OF WARD ROAD	Somerset		
13	COVENTRY PARISH RD	S-0018001	Slab	REHOBETH BRANCH	0.3 MI S OF REHOBETH ROAD	Somerset		
14	MD 667	190017001	Slab	REHOBETH BRANCH	4.96 MILES WEST OF US 13	Somerset		
15	MD 667	190019X01	Culvert	BRANCH OF MARUMSCO CREEK	0.1 MILE E OF LOVERS LANE	Somerset		
16	MD 667	190018001	Slab	MARUMSCO CREEK	0.47 MI E OF LOVERS LANE	Somerset		
17	MD 667	190020X01	Battery of Pipes	BR OF POCOMOKE RIVER	0.65 MI E/POWELL WHARF RD	Somerset		
18	FRENCHTOWN ROAD	S-0014001	Slab	GOOSE CREEK	1.2 MI SE OF RUMBLY	Somerset		
19	FRENCHTOWN ROAD	S-0015001	Slab	MINE CREEK	1.0 MI SE OF RUMBLY	Somerset		
20	US 13 SB	190004021	Stringer/Multibeam or Girder	NORFOLK SOUTHERN RR	0.40 MILE NORTH OF MD 364	Somerset		
21	US 13 SR	190016021	Stringer/Multibeam or Girder	POCOMOKE RIVER	ON SOMERSET CO LINE	Somerset		

Contents | 2_Enter Assets | 3_Exposure Intro | 3a_Exp Indicator Library | 3b_Exp Indicators

Ready 90%

Asset Data

08152014 Somerset Vulnerability Assessment.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data Review View Startec Acrobat

Calibri 11 A A

General

Clipboard Font Alignment Number Styles Cells Editing

J12 4 Poor Condition

Sensitivity Indicators													Adaptive Capacity Indicators		
Asset	Asset Name	Past Experience with Precipitation	Bridge Age	Scour Rating	Proximity to the Coast	Bridge Clearance	Past Experience with Tides/SLR	Condition of Bridge Substructure	Condition of Bridge Superstructure	Condition of Bridge Deck	Past Experience with Storm Surge	ADT	Function Classification	Evacuation Route	Detour Length
Data source:		Source: DMA	Source: DMA	Source: DMA	Source: Internal analysis	Source: Internal analysis	Source: DMA	Source: Internal analysis	Source: Internal analysis	Source: Internal analysis	Source: DMA	Source: National Bridge Inventory	Source: Internal analysis	Source: Internal analysis	Source: Internal analysis
Metric (if applicable):		Source: DMA	2014-year bridge water height reconstruction. Source: National Bridge Inventory	Source: DMA	Source: Internal analysis	Source: Internal analysis	Source: DMA	Source: National Bridge Inventory	Source: National Bridge Inventory	Source: National Bridge Inventory	Source: DMA	Source: National Bridge Inventory	Source: Internal analysis	Source: Internal analysis	Source: Internal analysis
Water:		Year	Year	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
1	APPE HOLE ROAD	3	43	76	2	3	3	Serious Condition	5 Fair Condition	4 Poor Condition	4	10	7	N	
2	CALVARY ROAD	3	6	6	2	2	7	Good Condition	8 Very Good Condition	8 Very Good Condition	4	307	7	N	
3	MARSH ROAD	3	30	10	2	3	4	Poor Condition	4 Poor Condition	4 Poor Condition	4	42	7	N	
4	SMITH ISLAND ROAD	3	30	21	1	2	4	Poor Condition	7 Good Condition	5 Fair Condition	4	44	7	N	
5	CASH CORNER ROAD	2	35	25	3	2	6	Satisfactory Condition	6 Satisfactory Condition	6 Satisfactory Condition	3	376	3	N	
6	MD 460	3	49	26	6	3	5	Fair Condition	6 Satisfactory Condition	6 Satisfactory Condition	4	1,210	7	N	
7	BYRD ROAD	3	30	26	3	3	8	Very Good Condition	7 Good Condition	7 Good Condition	4	455	7	N	
8	MARUMSCO ROAD	2	31	11,775	3	2	4	Poor Condition	4 Poor Condition	5 Fair Condition	4	141	7	N	
9	LQ POWELL ROAD	2	39	42	1	2	5	Fair Condition	5 Fair Condition	5 Fair Condition	4	210	7	N	
10	MD 667	3	1,958	4	3	6	Satisfactory Condition	6 Satisfactory Condition	6 Satisfactory Condition	4	1,325	7	N		
11	BRYAN HALL ROAD	3	36	10,590	2	3	4	Poor Condition	7 Good Condition	5 Fair Condition	4	138	7	N	
12	MD 667	2	2	3,118	4	2	5	Fair Condition	5 Fair Condition	5 Fair Condition	3	2,275	5	N	
13	COVENTRY PARISH RD	2	29	19	4	6	Satisfactory Condition	7 Good Condition	7 Good Condition	7	250	7	N		
14	MD 667	3	38	9	4	2	6	Satisfactory Condition	6 Satisfactory Condition	6 Satisfactory Condition	3	2,520	5	N	
15	MD 667	2	11,990	4	2	5	Fair Condition	5 Fair Condition	5 Fair Condition	5	2,275	5	N		
16	MD 667	2	38	10,819	2	2	8	Very Good Condition	5 Fair Condition	5 Fair Condition	3	2,520	5	N	
17	MD 667	2	2	2,400	7	2	6	Satisfactory Condition	6 Satisfactory Condition	6 Satisfactory Condition	3	2,275	5	N	
18	FRENCH TOWN ROAD	1	3	18	1	6	Satisfactory Condition	6 Satisfactory Condition	6 Satisfactory Condition	6	64	7	N		
19	FRENCH TOWN ROAD	1	20	4	1	5	Fair Condition	5 Satisfactory Condition	5 Satisfactory Condition	6	64	7	N		
20	US 13 SB	2	49	2,215	29	2	6	Satisfactory Condition	6 Satisfactory Condition	6 Satisfactory Condition	2	16,470	3	Y	
21	US 13 SB	2	48	144	1	2	5	Fair Condition	5 Fair Condition	5 Fair Condition	2	16,560	3	Y	
22	US 13 NB	2	8	2,311	32	2	6	Satisfactory Condition	6 Satisfactory Condition	7 Good Condition	2	16,470	2	Y	
23	US 13 NB	2	55	140	1	2	5	Fair Condition	5 Fair Condition	5 Fair Condition	2	16,560	2	Y	
24	MD 364	3	3	879	6	3	6	Satisfactory Condition	5 Fair Condition	5 Fair Condition	4	1,125	5	N	
25	MD 413	1	65	7,560	6	1	5	Fair Condition	5 Fair Condition	5 Fair Condition	1	5,670	5	N	
26	RIVER ROAD	1	26	1,050	4	7	Good Condition	7 Good Condition	7 Good Condition	7	417	7	N		
27	RUMBLEY ROAD	2	36	13	2	6	Satisfactory Condition	7 Good Condition	7 Good Condition	7	223	7	N		
28	US 13	1	48	4,353	15	1	5	Fair Condition	5 Fair Condition	5 Fair Condition	1	12,825	2	Y	
29	MD 364	3	3	1,893	9	3	7	Good Condition	7 Good Condition	7 Good Condition	3	1,125	5	N	
30	MD 364	2	4	3,005	4	2	6	Satisfactory Condition	6 Satisfactory Condition	6 Satisfactory Condition	3	1,125	5	N	
31	MD 364	3	81	27	4	3	5	Fair Condition	5 Fair Condition	5 Fair Condition	3	1,140	5	N	
32	SIGN POST ROAD	1	29	10,976	4	1	5	Fair Condition	6 Satisfactory Condition	6 Satisfactory Condition	4	794	7	N	
33	US 13 SB	1	50	11,524	12	1	7	Good Condition	7 Good Condition	7 Good Condition	1	13,630	2	Y	
34	US 13 NB	1	50	11,253	13	1	6	Satisfactory Condition	5 Fair Condition	5 Fair Condition	1	13,630	2	Y	
35	MD 413	1	11,449	13	1	1	6	Satisfactory Condition	6 Satisfactory Condition	6 Satisfactory Condition	1	4,775	5	N	
36	MILLARD LONG ROAD	2	18	18	2	7	Good Condition	7 Good Condition	7 Good Condition	7	368	7	N		
37	MD 363	3	25	723	3	3	7	Good Condition	6 Satisfactory Condition	6 Satisfactory Condition	4	375	4	N	
38	ARDEN STATION ROAD	4	23	5,757	2	6	Satisfactory Condition	6 Satisfactory Condition	6 Satisfactory Condition	6	327	7	N		
39	STEWART NECK ROAD	3	40	8,585	3	4	Poor Condition	5 Fair Condition	5 Fair Condition	5	661	7	N		
40	OLD PRINCESS ANNE	1	64	4	2	6	Satisfactory Condition	5 Fair Condition	5 Fair Condition	5	648	7	N		
41	US 13 NB	1	52	437	15	1	5	Fair Condition	5 Fair Condition	6 Satisfactory Condition	1	20,870	2	Y	
42	US 13 SB	1	52	638	14	1	6	Satisfactory Condition	4 Poor Condition	4 Poor Condition	1	20,870	2	Y	
43	MD 363	3	27	258	8	3	6	Satisfactory Condition	6 Satisfactory Condition	5 Fair Condition	4	1,322	4	N	
44	MD 363	3	8	101	4	3	7	Good Condition	7 Good Condition	7 Good Condition	4	2,225	4	N	
45	HAINES POINT ROAD	2	29	10	3	3	6	Satisfactory Condition	7 Good Condition	7 Good Condition	4	81	7	N	
46	US 13 NB	1	53	2,912	7	1	5	Fair Condition	5 Fair Condition	5 Fair Condition	1	28,970	2	Y	
47	US 13 SB	1	53	2,912	7	1	7	Good Condition	7 Good Condition	7 Good Condition	1	17,775	2	Y	
48	MD 363	3	93	98	7	3	6	Satisfactory Condition	6 Satisfactory Condition	6 Satisfactory Condition	4	1,475	4	N	

4a_ Exposure Data 4b_AssetData-AType1 5a_Exposure AType1 5b_Sensitivity AType1-Stressor1 5b | 4 |

Ready Count: 3 60%

Results

08152014 Somerset Vulnerability Assessment.xlsxm - Microsoft Excel

File Home Insert Page Layout Formulas Data Review View Stantec Acrobat

Clipboard Font Alignment Number Styles Cells Editing

AT4

Adjust Vulnerability Component Weights:

Exposure	40%
Sensitivity	40%
Adaptive Capacity	20%
	100%

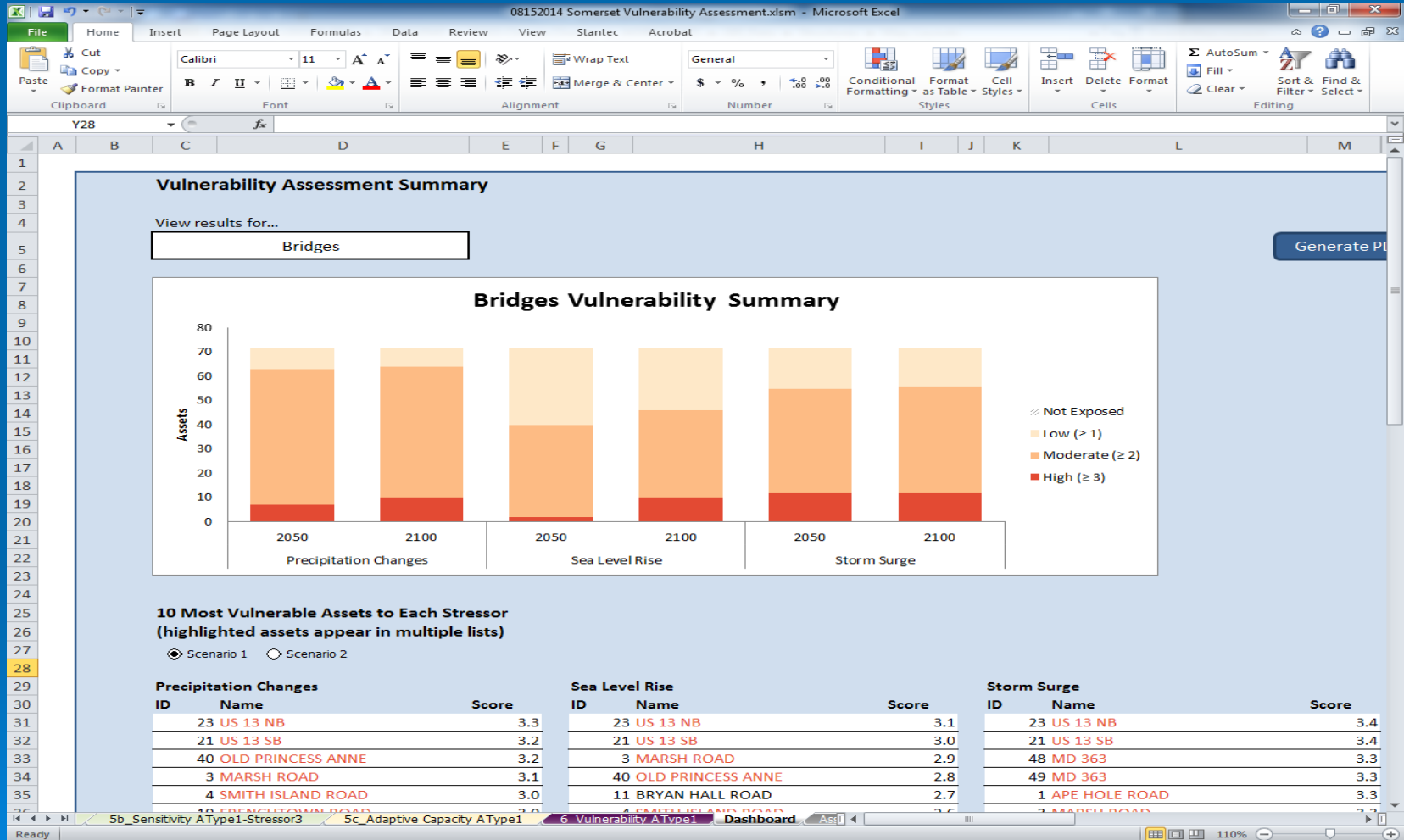
Results

Asset ID	Name	Precipitation Changes				Sea Level Rise				Storm Surge			
		2050		2100		2050		2100		2050		2100	
		"Damage"	Vulnerability	"Damage"	Vulnerability	"Damage"	Vulnerability	"Damage"	Vulnerability	"Damage"	Vulnerability	"Damage"	Vulnerability
1	APE HOLE ROAD	3.8	3.3	4.0	3.4	3.0	2.6	3.4	2.9	3.9	3.3	3.9	3.3
2	CALVARY ROAD	3.8	3.2	3.9	3.3	2.7	2.3	3.6	3.0	3.6	3.1	3.6	3.1
3	MARSH ROAD	3.8	3.2	3.9	3.4	3.3	2.9	3.8	3.2	3.9	3.3	3.9	3.3
4	SMITH ISLAND ROAD	3.7	3.2	3.9	3.3	3.0	2.6	3.4	3.0	3.5	3.0	3.5	3.0
5	CASH CORNER ROAD	3.2	2.8	3.4	2.9	2.3	2.0	3.2	2.7	3.1	2.7	3.1	2.7
6	MD 460	3.5	3.0	3.6	3.1	2.3	2.1	2.7	2.4	2.9	2.6	2.9	2.6
7	BYRD ROAD	3.8	3.2	3.9	3.4	2.7	2.4	3.2	2.7	3.3	2.8	3.3	2.8
8	MARUMSCO ROAD	3.0	2.6	3.1	2.7	2.1	1.9	3.0	2.6	3.1	2.7	3.1	2.7
9	LQ POWELL ROAD	3.3	2.8	3.4	2.9	2.8	2.4	3.2	2.8	3.8	3.2	3.8	3.2
10	MD 667	2.8	2.6	3.0	2.7	2.2	2.1	2.2	2.1	3.2	2.9	3.2	2.9
11	BRYAN HALL ROAD	3.6	3.1	3.8	3.2	3.1	2.7	3.6	3.0	3.5	3.0	3.5	3.0
12	MD 667	3.0	2.8	3.2	2.9	1.7	1.7	2.1	2.1	2.9	2.7	2.9	2.7
13	COVENTRY PARISH RD	3.4	2.9	3.6	3.0	2.2	2.0	2.7	2.3	3.0	2.6	3.0	2.6
14	MD 667	3.1	2.8	3.3	3.0	2.2	2.1	2.7	2.5	3.1	2.8	3.1	2.8
15	MD 667	3.0	2.7	3.1	2.8	1.6	1.7	1.6	1.7	2.8	2.6	2.8	2.6
16	MD 667	3.1	2.8	3.3	3.0	2.2	2.1	3.1	2.8	3.2	2.9	3.2	2.9
17	MD 667	2.1	2.0	2.2	2.1	1.7	1.7	1.7	1.7	2.0	2.0	2.0	2.0
18	FRENCHTOWN ROAD	3.7	3.1	3.8	3.3	2.9	2.5	3.3	2.9	3.4	3.0	3.4	3.0
19	FRENCHTOWN ROAD	3.7	3.2	3.9	3.3	3.0	2.6	3.4	3.0	3.5	3.0	3.5	3.0
20	US 13 SB	1.4	1.8	1.5	2.0	1.5	1.9	1.5	1.9	1.5	2.0	1.5	2.0
21	US 13 SB	3.3	3.4	3.4	3.5	2.8	3.0	3.3	3.4	3.3	3.4	3.3	3.4
22	US 13 NB	1.3	1.9	1.5	2.0	1.3	1.9	1.3	1.9	1.4	1.9	1.4	1.9
23	US 13 NB	3.3	3.4	3.4	3.6	2.8	3.1	3.3	3.4	3.3	3.4	3.3	3.4
24	MD 364	2.7	2.4	2.8	2.6	2.3	2.1	2.3	2.1	2.8	2.5	2.8	2.5
25	MD 413	2.5	2.4	2.7	2.5	1.5	1.6	2.0	1.9	2.1	2.0	2.1	2.0
26	RIVER ROAD	3.2	2.7	3.3	2.9	2.1	1.8	2.5	2.2	2.7	2.4	2.7	2.4
27	RUMBLEY ROAD	3.7	3.2	3.9	3.3	2.9	2.5	3.3	2.9	3.4	2.9	3.4	2.9
28	US 13	1.5	2.0	1.6	2.1	1.4	1.9	1.4	1.9	1.6	2.1	1.6	2.1
29	MD 364	2.6	2.4	2.8	2.5	2.1	2.0	2.1	2.0	1.9	1.8	1.9	1.8
30	MD 364	2.3	2.1	2.4	2.2	1.7	1.6	1.7	1.6	2.1	2.0	2.9	2.6
31	MD 364	3.7	3.3	3.8	3.4	2.4	2.2	2.4	2.2	3.2	2.8	3.2	2.8
32	SIGN POST ROAD	2.7	2.4	2.8	2.5	1.8	1.7	2.7	2.4	2.5	2.3	2.5	2.3
33	US 13 SB	2.2	2.5	2.3	2.6	1.2	1.7	1.2	1.7	1.5	1.9	1.5	1.9
34	US 13 NB	2.2	2.5	2.3	2.6	1.3	1.9	1.3	1.9	1.6	2.0	1.6	2.0
35	MD 413	1.4	1.4	1.5	1.6	1.2	1.3	1.2	1.3	1.5	1.6	1.5	1.6
36	MILLARD LONG ROAD	3.7	3.1	3.8	3.3	2.7	2.4	3.2	2.7	3.3	2.8	3.3	2.8

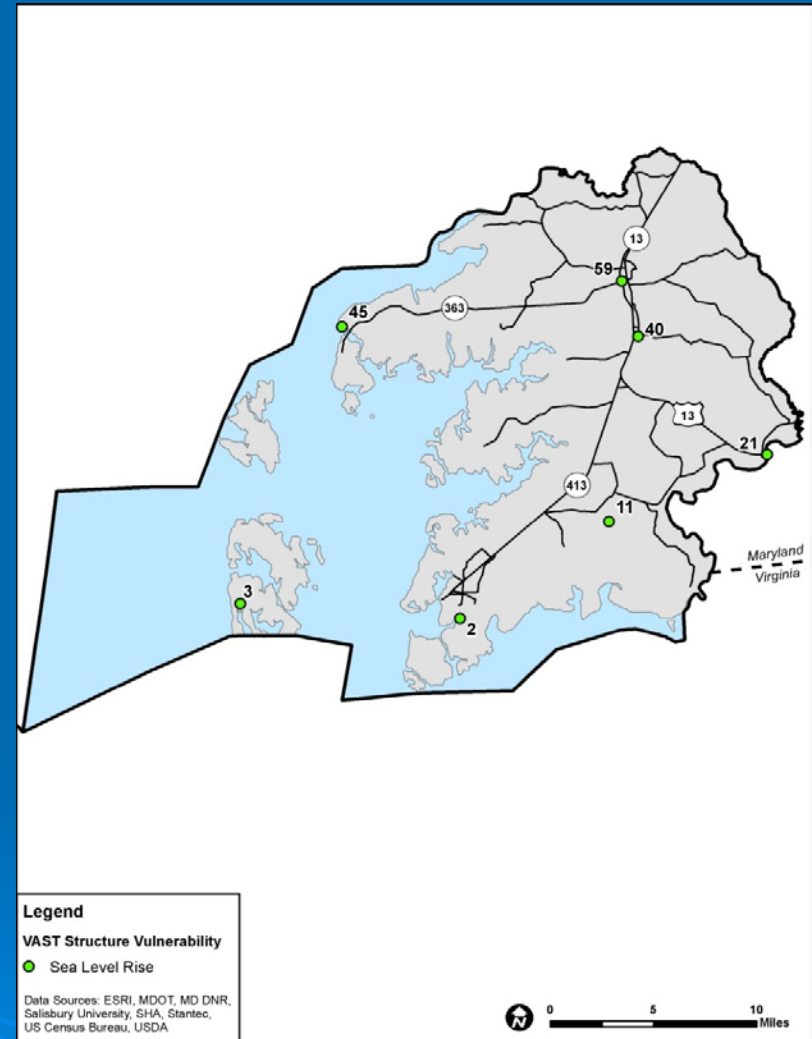
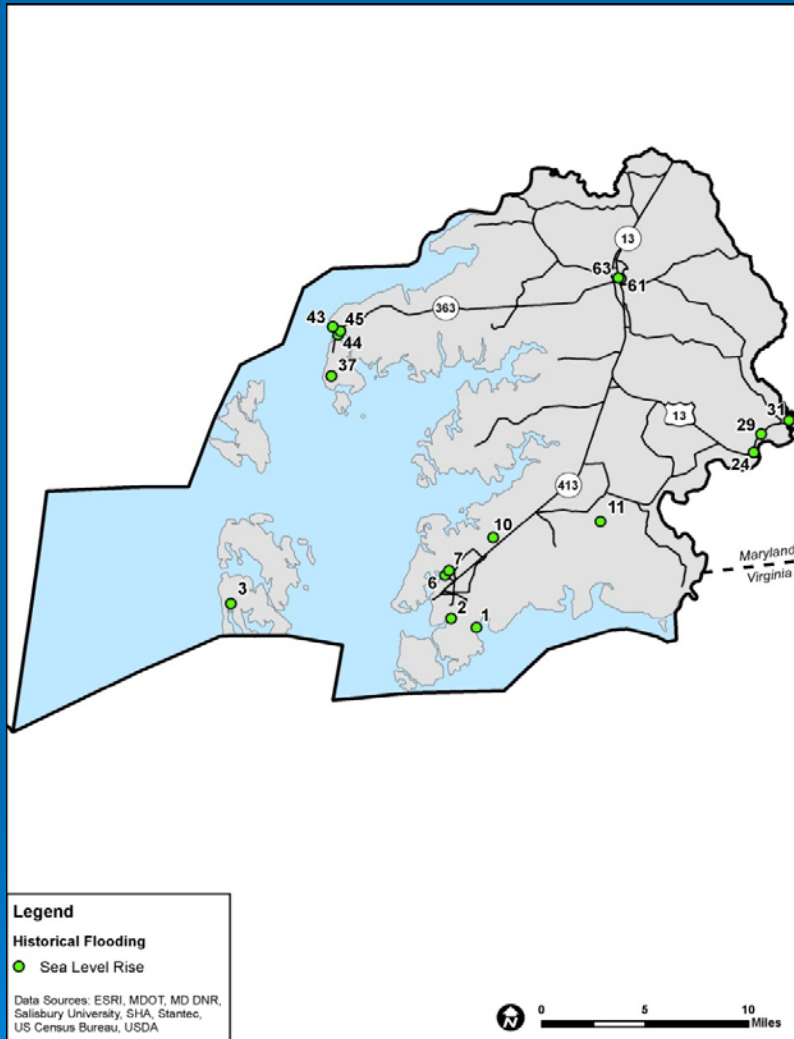
5b_Sensitivity AType1-Stressor3 5c_Adaptive Capacity AType1 6_Vulnerability AType1 Dashboard ASU

Ready Average: -18.80522639 Count: 147 Sum: -2707.9526 80%

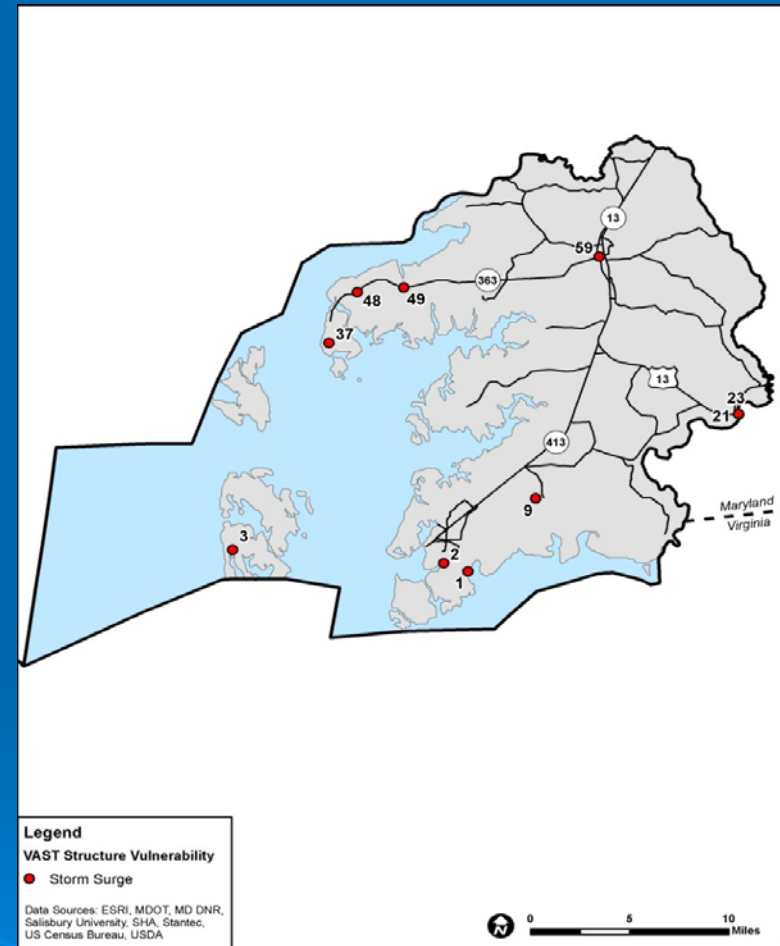
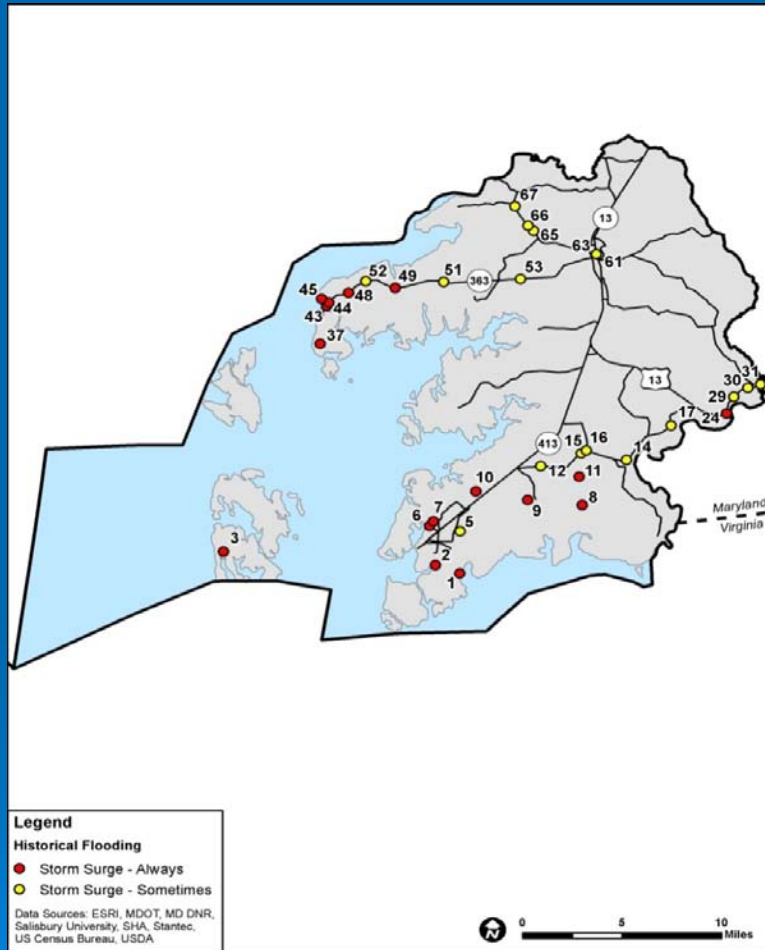
Vulnerability Assessment Summary



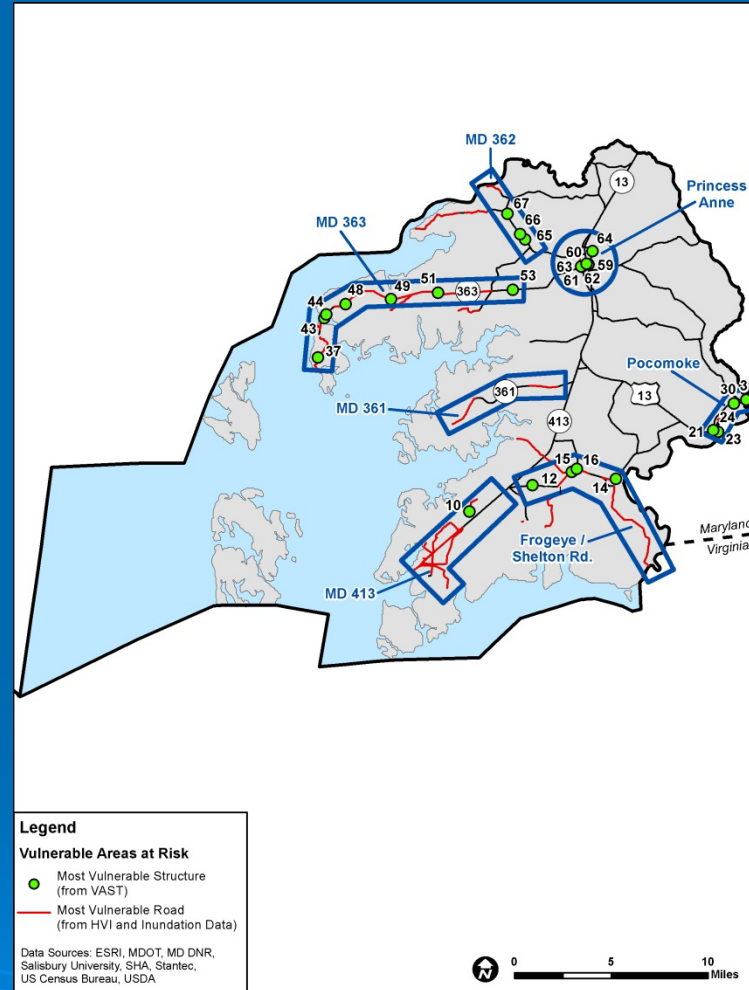
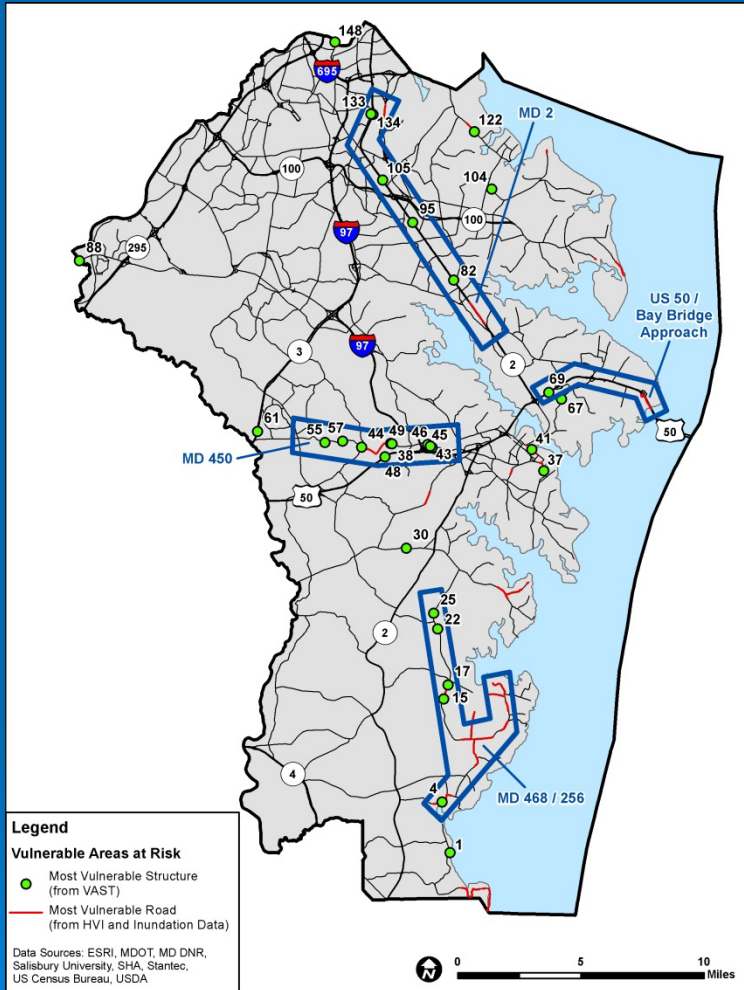
VAST vs. Historical Flooding - SLR



VAST vs. Historical Flooding – Storm Surge



Vulnerable Areas at Risk



Next Steps for SHA Climate Change Program

- Continue statewide county vulnerability assessments
- Brainstorm adaptation options for HVI categories
- Conduct Site Specific Analysis using a Holistic Approach in coordination with Local Stakeholders for “Vulnerable Locations at Risk” – Tier III Studies
- Conduct detailed Alternatives Evaluation with Cost-Benefit Analysis
- Coordination with Anne Arundel and Somerset Counties when origin to destination studies are complete