




Low-lying Roads: Chatham

Project funded by the
Municipal Vulnerability
Preparedness Program



Purpose and Objectives of Workshop

- 
- **Review flood projections and impacts on roadways for the town under future scenarios**
 - **Discuss vulnerable low-lying roads or other transportation infrastructure**
 - **Prepare the town to address priority road segments for design and permitting**

Agenda

- Project Overview – CCC
- Vulnerability and Risk Assessment – WHG
- Results of Low-Lying Roads Screening & Prioritization – WHG
- Discussion – CCC & WHG
- Next Steps – CCC
- Workshop concludes ~ 8:30 pm

Low-Lying Roads 2

5

TOWNS

Chatham
Falmouth
Harwich

Mashpee
Provincetown



Flooding vulnerability assessment of low-lying roads and transportation infrastructure



Support municipal road segment prioritization



Identify range of potential design solutions, costs

Work performed by Cape Cod Commission and Woods Hole Group



Hazards

Storms,
Sea Level Rise,
& Flooding



Adaptation Strategies



- | Gray Infrastructure, or Traditional Engineering Structures
- | Green Infrastructure, or Nature-based Solutions
- | Other approaches – Hybrid, Planned Relocation, Abandonment



PROJECT TIMELINE & ELEMENTS

Vulnerability Assessment:
Roads and Bridges
3 Future Time Horizons -
2030, 2050, 2070

Criticality
Assessment:
Prioritize
Roadway
Segments

1st Workshop:
Vulnerable &
At-Risk Roads

Roadway
analysis &
solutions ID

2nd Workshop:
Present
alternatives

March 2023

April 2023

May 2023

Summer 2023

Spring 2024

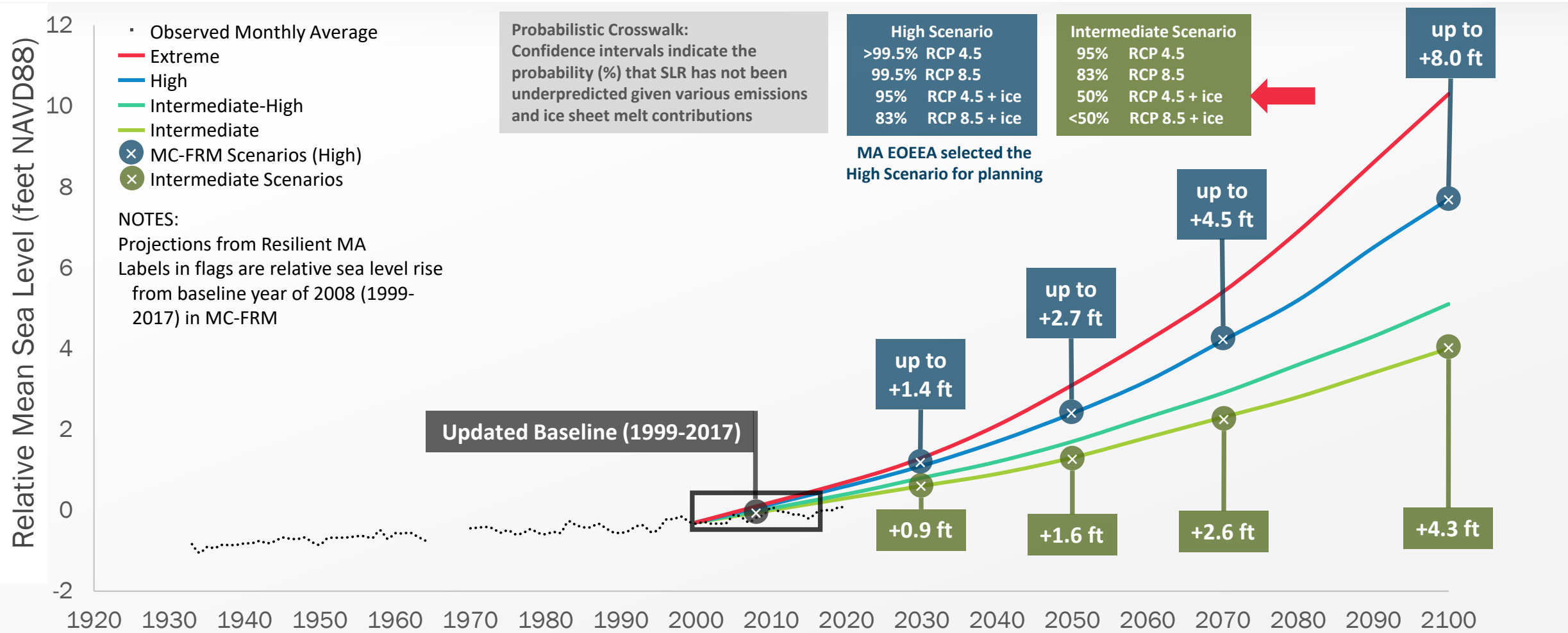


Questions?

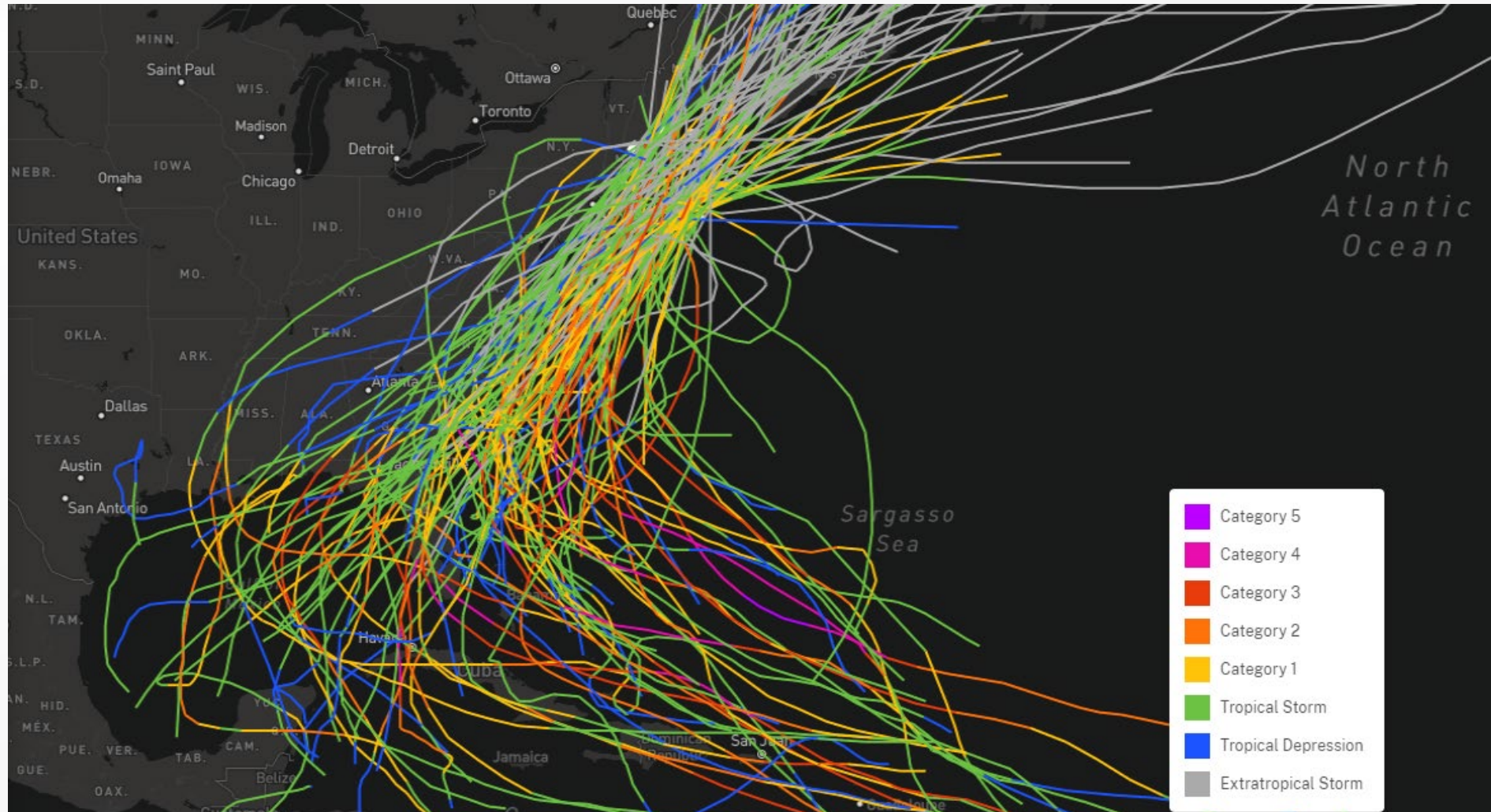
- Workshop Purpose or Objectives
- Low Lying Roads project
 - Key components
 - Vulnerability Assessment - Identify Potential Sites
 - Public Outreach and Engagement
 - Roadway Feasibility and Alternative Solutions
 - Solutions Identification
 - Timeline

MA EOEEA Probabilistic Sea Level Rise Projections

MC-FRM SOUTH (DeConto & Kopp, 2017)

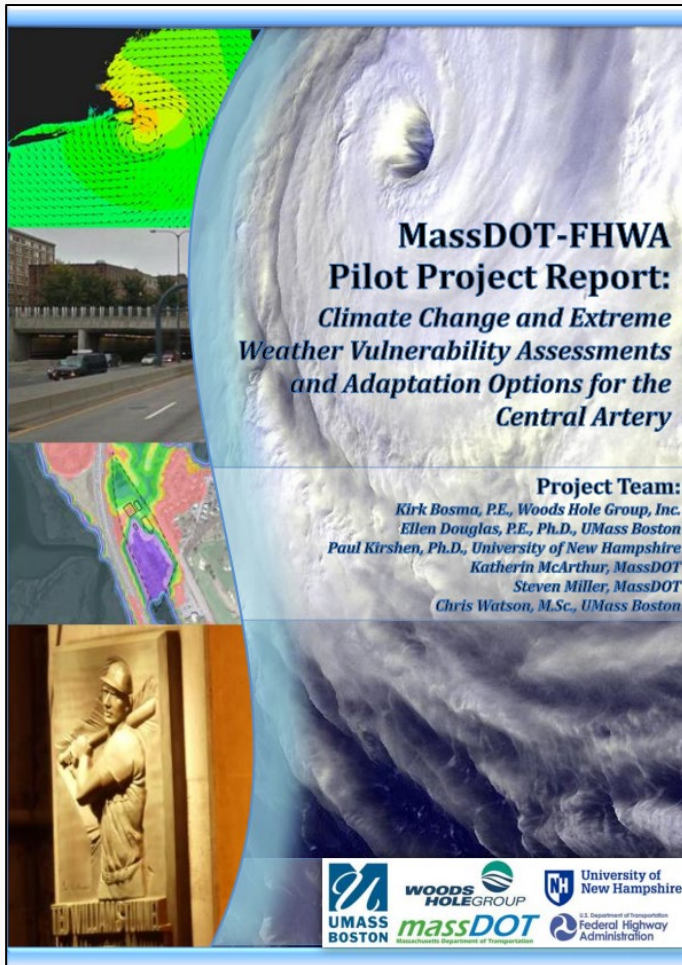


Tropical / Extra-tropical Storms



NOAA National Ocean Service

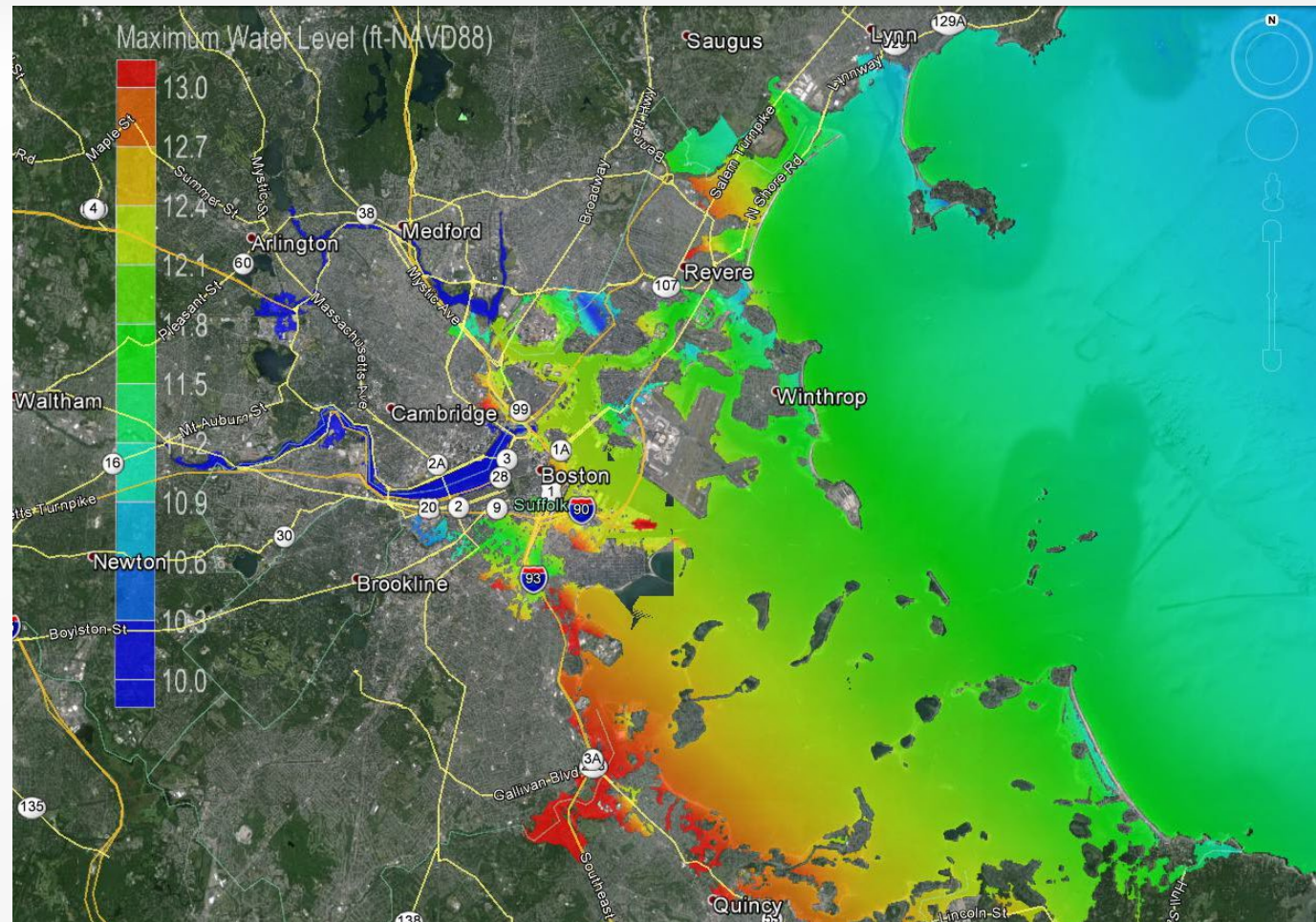
Why Hydrodynamic Modeling? Why Probabilistic?



**MassDOT-FHWA
Pilot Project Report:
Climate Change and Extreme
Weather Vulnerability Assessments
and Adaptation Options for the
Central Artery**

Project Team:
Kirk Bosma, P.E., Woods Hole Group, Inc.
Ellen Douglas, P.E., Ph.D., UMass Boston
Paul Kirshen, Ph.D., University of New Hampshire
Katherin McArthur, MassDOT
Steven Miller, MassDOT
Chris Watson, M.Sc., UMass Boston

UMASS BOSTON | WOODS HOLE GROUP | University of New Hampshire
massDOT | U.S. Department of Transportation Federal Highway Administration



Massachusetts Coast Flood Risk Model (MC-FRM)

INPUTS



SEA LEVEL
RISE



TROPICAL / EXTRA-
TROPICAL STORMS



LANDSCAPE



ELEVATION



CHANGING
CLIMATE

PROBABILISTIC /
HYDRODYNAMIC
MODEL



Includes relevant physical processes:
sea level rise, tides, storm surge, wind, wave setup
/ run-up / overtopping, future climate scenarios

Future version to incorporate coastal erosion



FLOOD
PROBABILITY



FLOOD
DEPTH



FLOOD
DURATION



FLOOD
VOLUMES



FLOOD
PATHWAYS



WINDS



WAVES



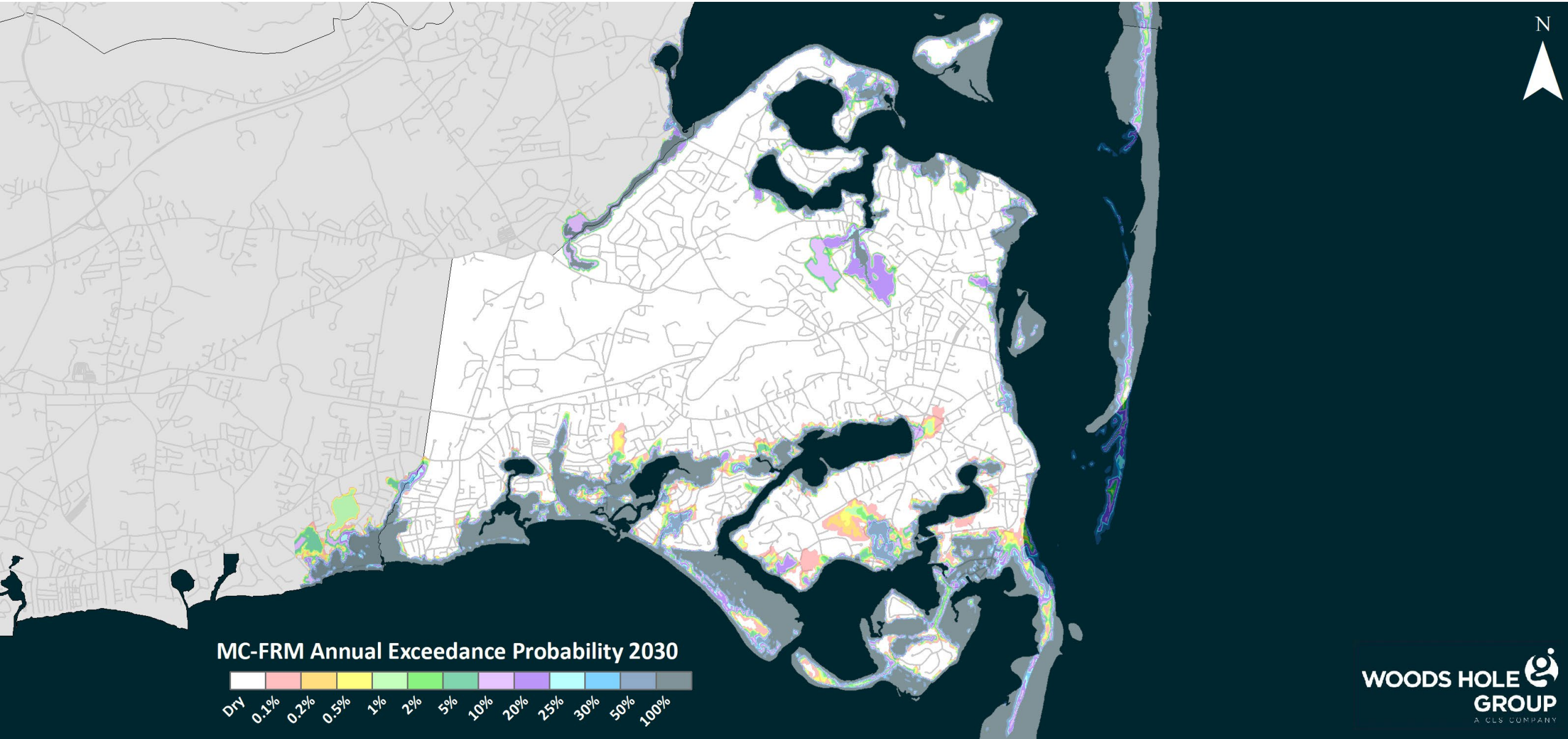
CURRENTS

OUTPUTS

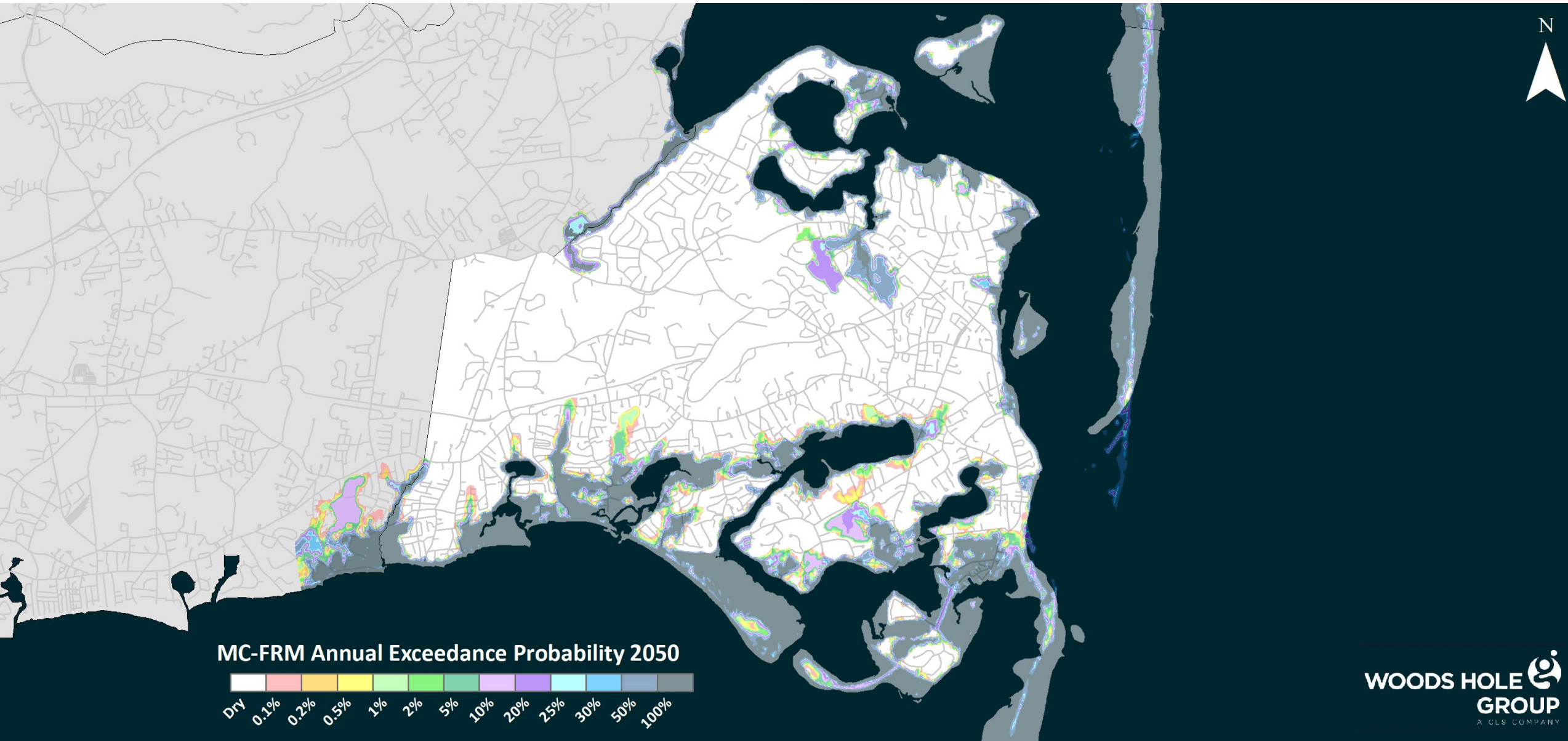
MC-FRM Resolution



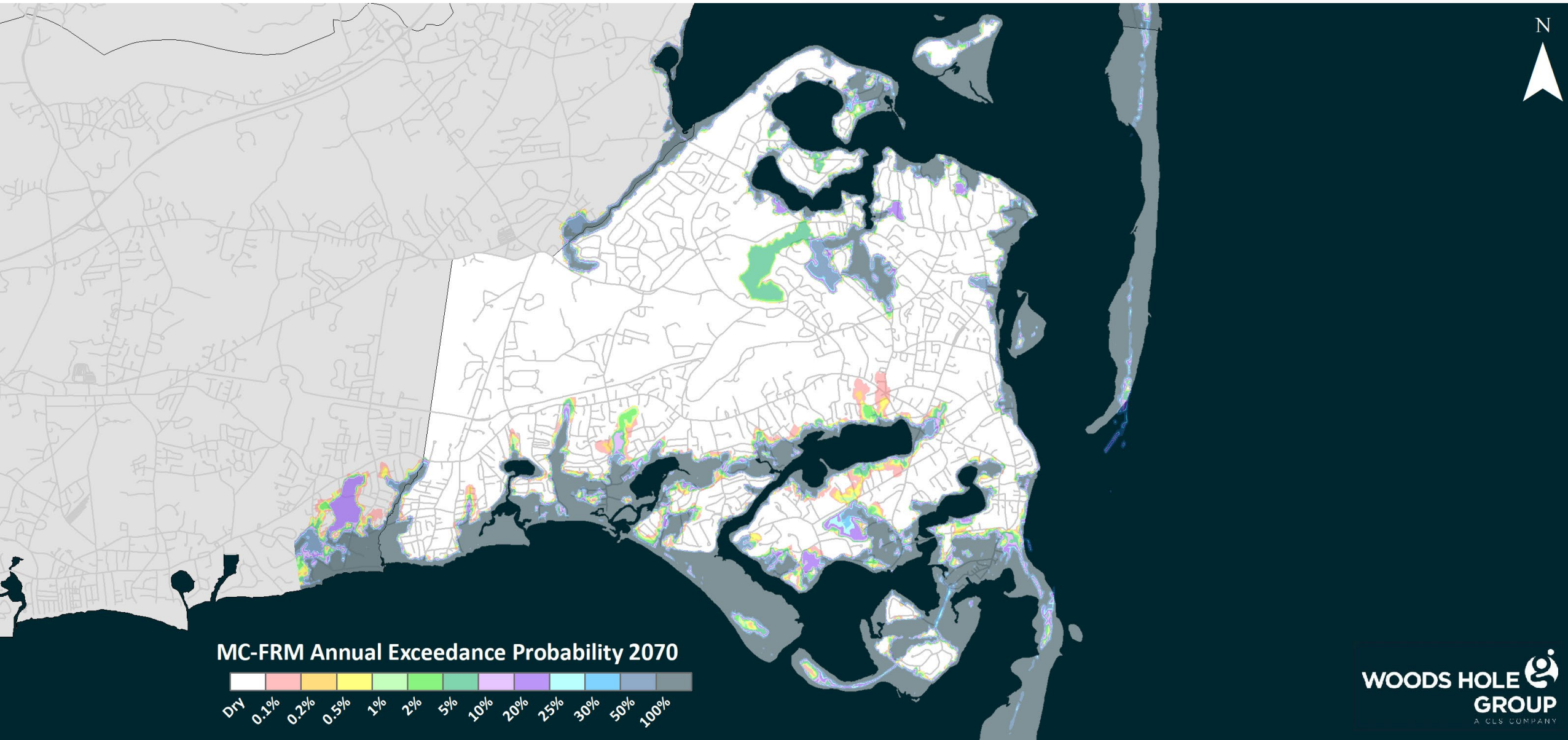
MC-FRM Annual Coastal Flood Exceedance Probability – 2030



MC-FRM Annual Coastal Flood Exceedance Probability – 2050



MC-FRM Annual Coastal Flood Exceedance Probability – 2070



MC-FRM Annual Exceedance Probabilities

	0.1%	1/1000
	0.2%	1/500
	0.5%	1/200
	1%	1/100
	2%	1/50
	5%	1/20
	10%	1/10
	20%	1/5
	25%	1/4
	30%	1/3.33
	50%	1/2
	100%	1/1

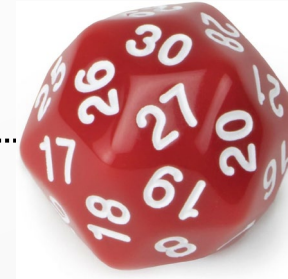


Image source: [amazon.com/stores/Brybelly](https://www.amazon.com/stores/Brybelly)



Image source: [dicegamedepot.com](https://www.dicegamedepot.com)



Image source: [dicegamedepot.com](https://www.dicegamedepot.com)

Cumulative Probability

	AEP	Return	Cumulative Probability (P_e) of 1 or more events occurring over:			
			10-yrs	25-yrs	50-yrs	100-yrs
	0.1%	1/1000	1.0%	2.5%	4.9%	9.5%
	0.2%	1/500	2.0%	4.9%	9.5%	18.1%
	0.5%	1/200	4.9%	11.8%	22.2%	39.4%
	1%	1/100	9.6%	22.2%	39.5%	63.4%
	2%	1/50	18.3%	39.7%	63.6%	86.7%
	5%	1/20	40.1%	72.3%	92.3%	99.4%
	10%	1/10	65.1%	92.8%	99.5%	100%
	20%	1/5	89.3%	99.6%	100%	100%
	25%	1/4	94.4%	99.9%	100%	100%
	30%	1/3.33	97.2%	100%	100%	100%
	50%	1/2	99.9%	100%	100%	100%
	100%	1/1	100%	100%	100%	100%

Massachusetts Coast Flood Risk Model

SUMMARY

Hydrodynamically modeled projections

Sea level rise and storm surge – combined

Annual chance of flooding under 2030/2050/2070 climate conditions

QUESTIONS?



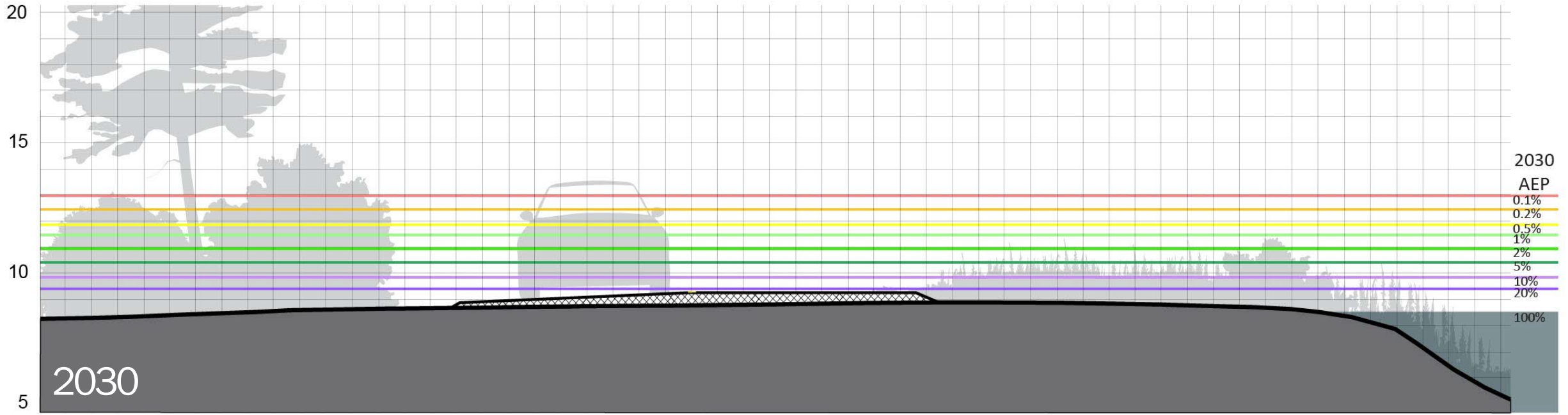
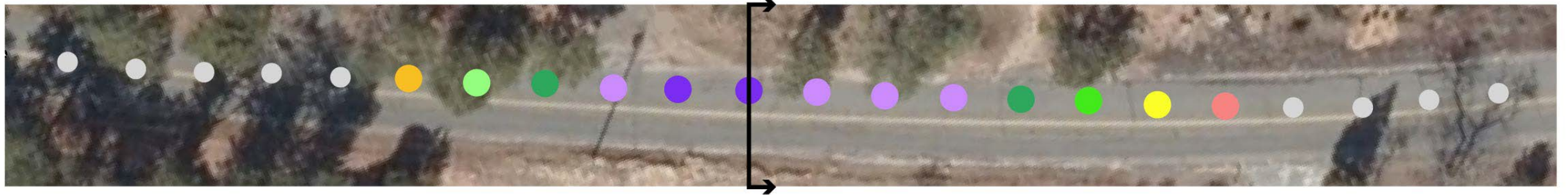
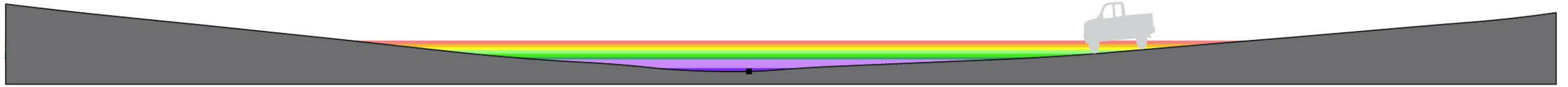
Cape Cod Low Lying Roads Vulnerability Assessment Methods

COASTAL FLOOD EXCEEDANCE PROBABILITY



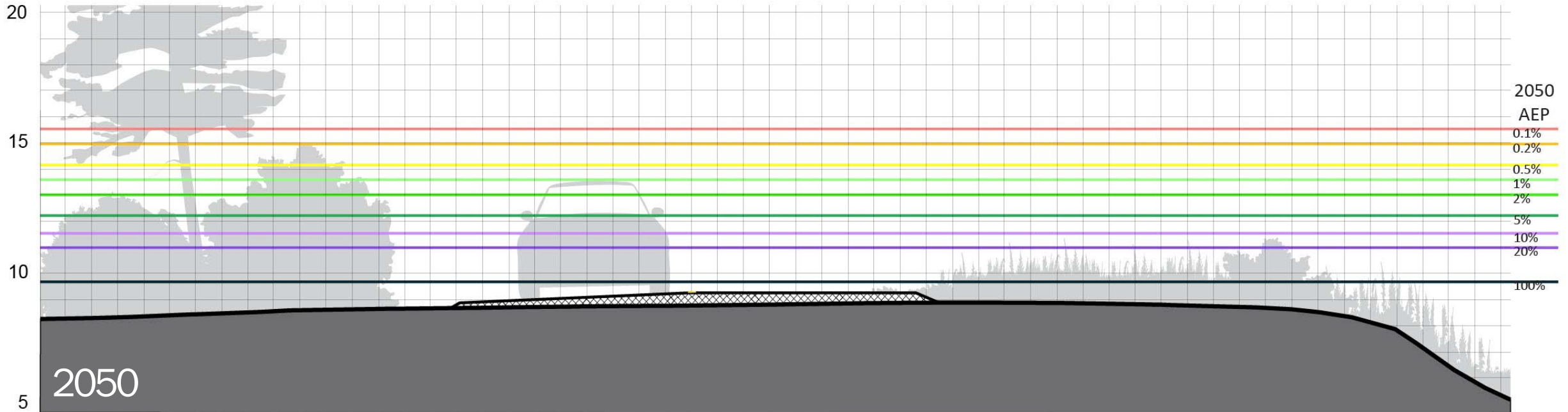
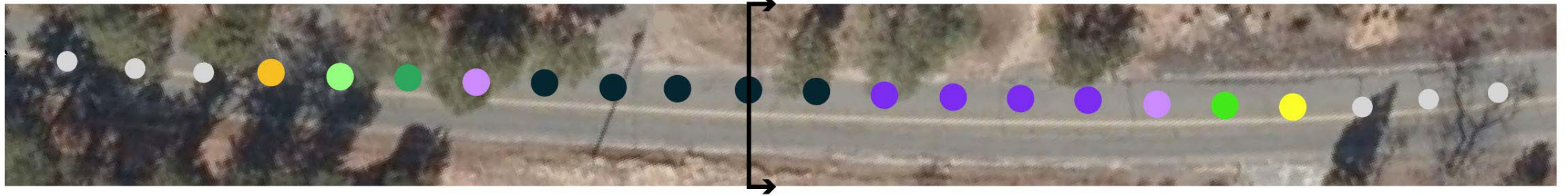
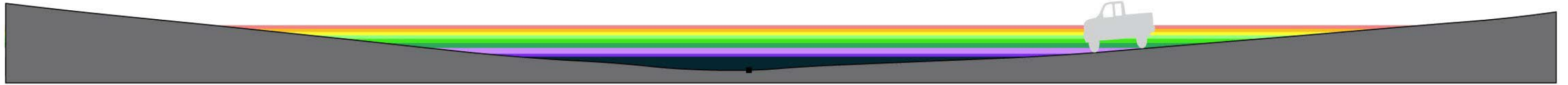
Cape Cod Low Lying Roads Vulnerability Assessment Methods

COASTAL FLOOD EXCEEDANCE PROBABILITY



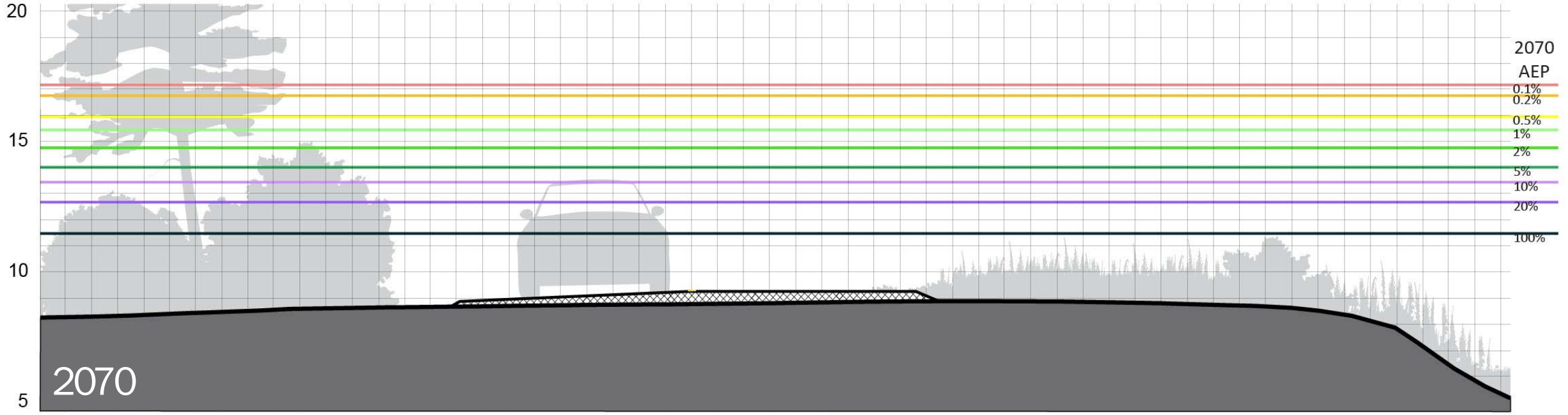
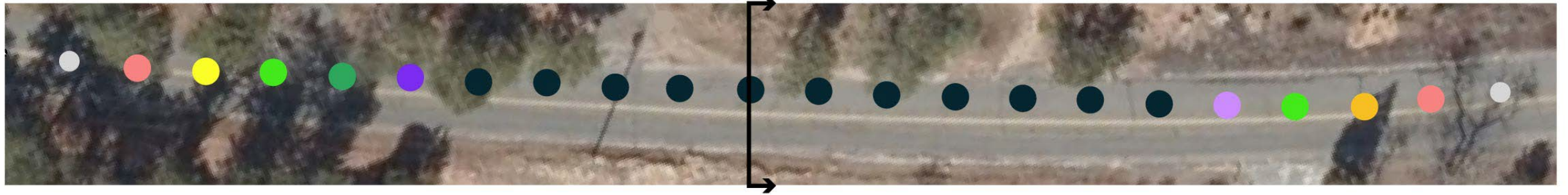
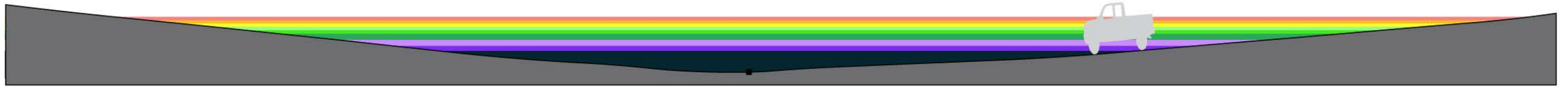
Cape Cod Low Lying Roads Vulnerability Assessment Methods

COASTAL FLOOD EXCEEDANCE PROBABILITY

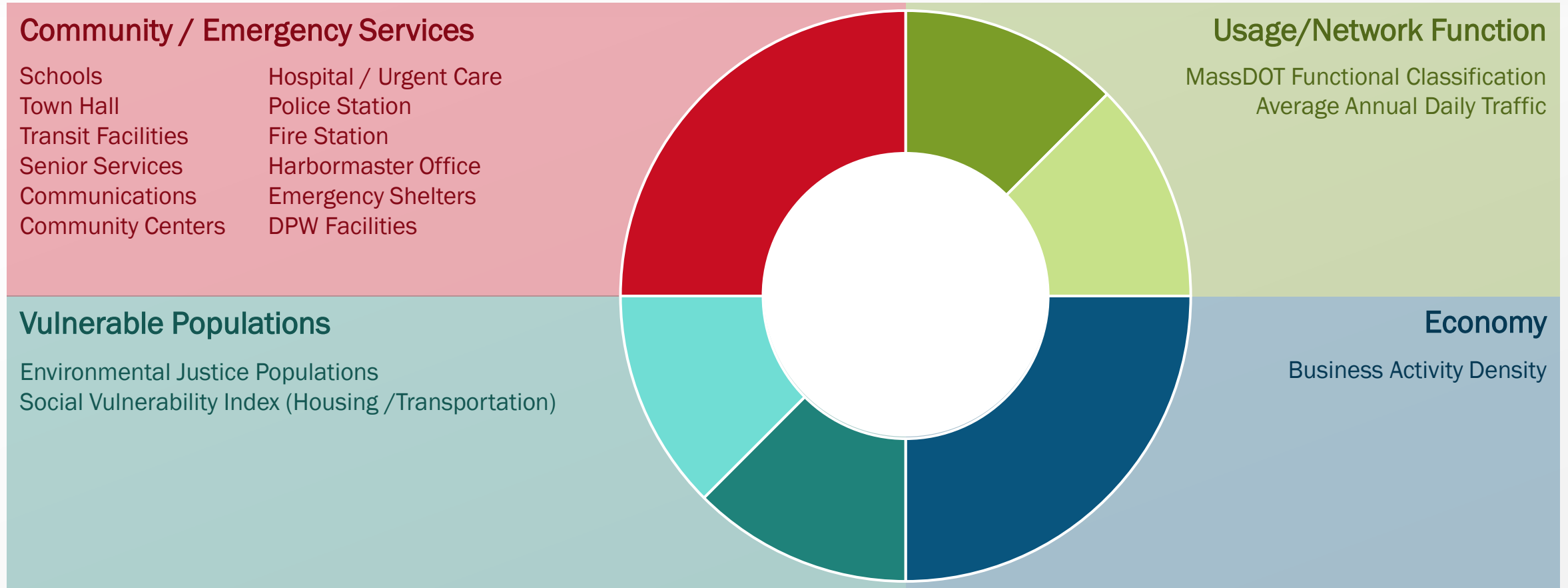


Cape Cod Low Lying Roads Vulnerability Assessment Methods

COASTAL FLOOD EXCEEDANCE PROBABILITY

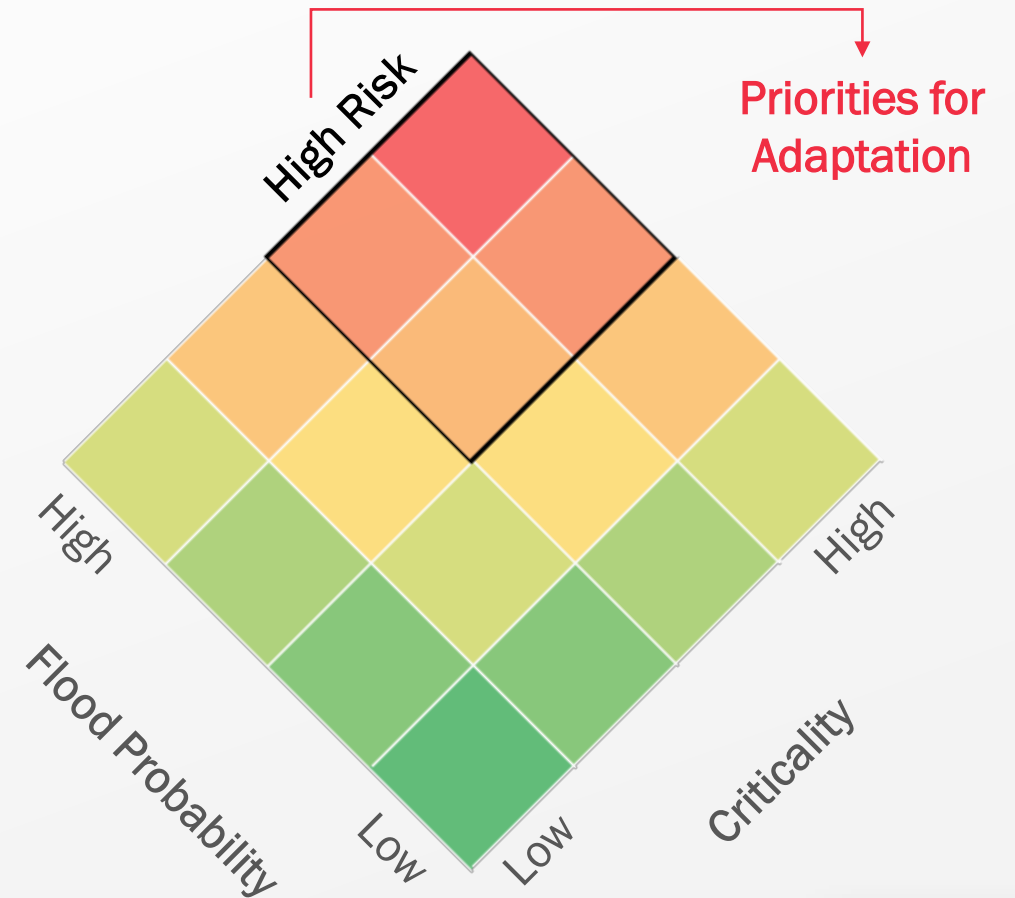


Cape Cod Low Lying Roads Criticality Scoring Framework



Cape Cod Low Lying Roads Risk Assessment Approach

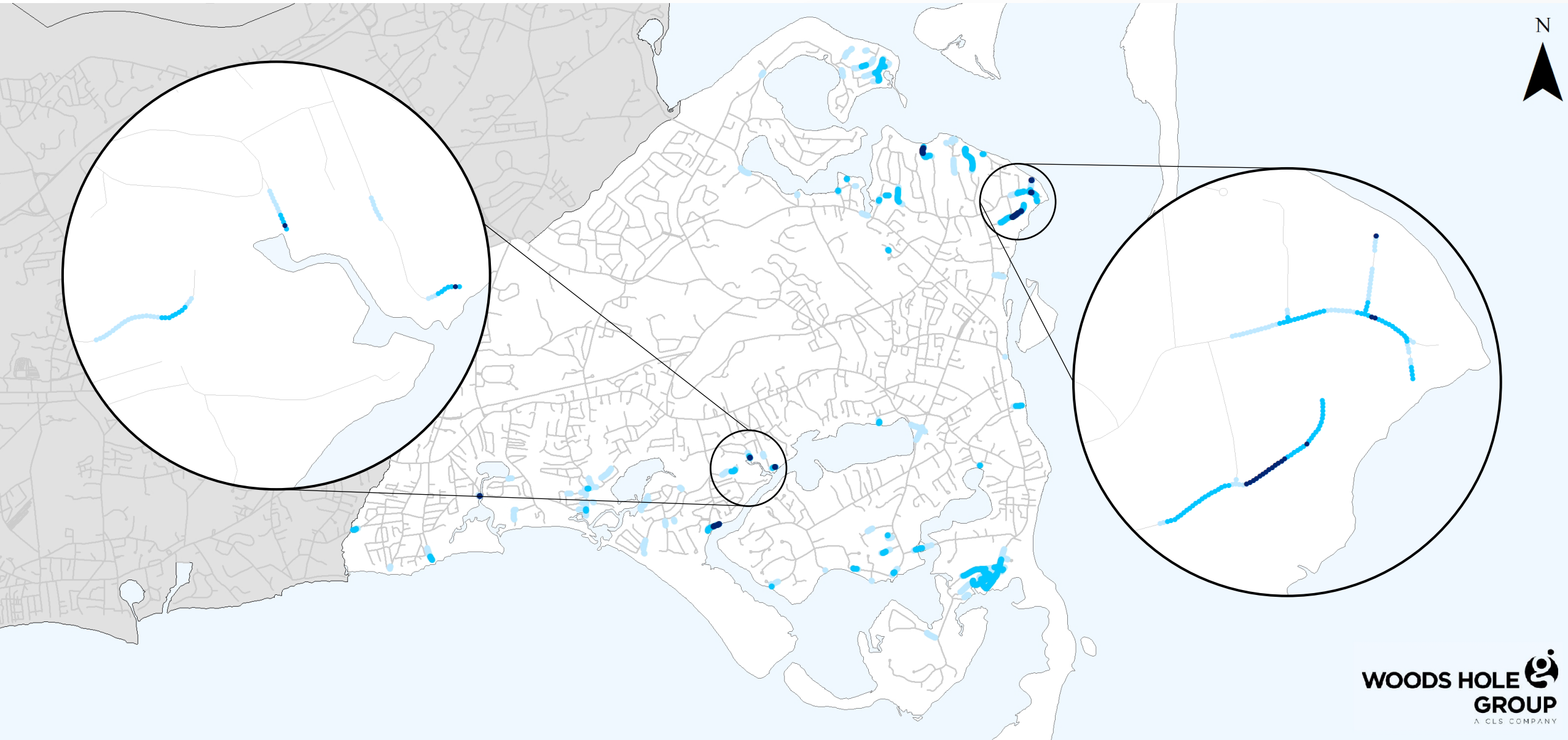
1. Extract roadway/bridge critical elevations (CEs)
2. Compile 2030/2050/2070 MC-FRM water surface elevations (WSEs)
3. Compare CEs to WSEs to determine flood probability
4. Score road segment criticality
5. **Probability * Criticality = Risk**
6. Prioritize high-risk road segments for community consideration



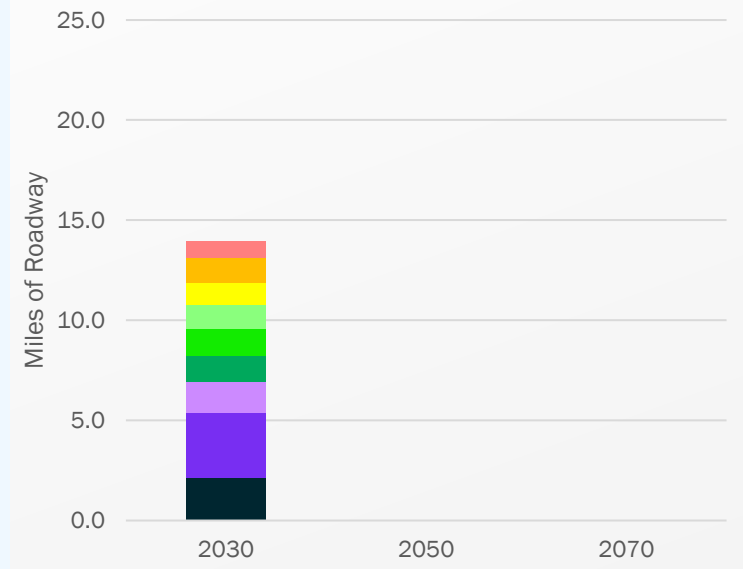
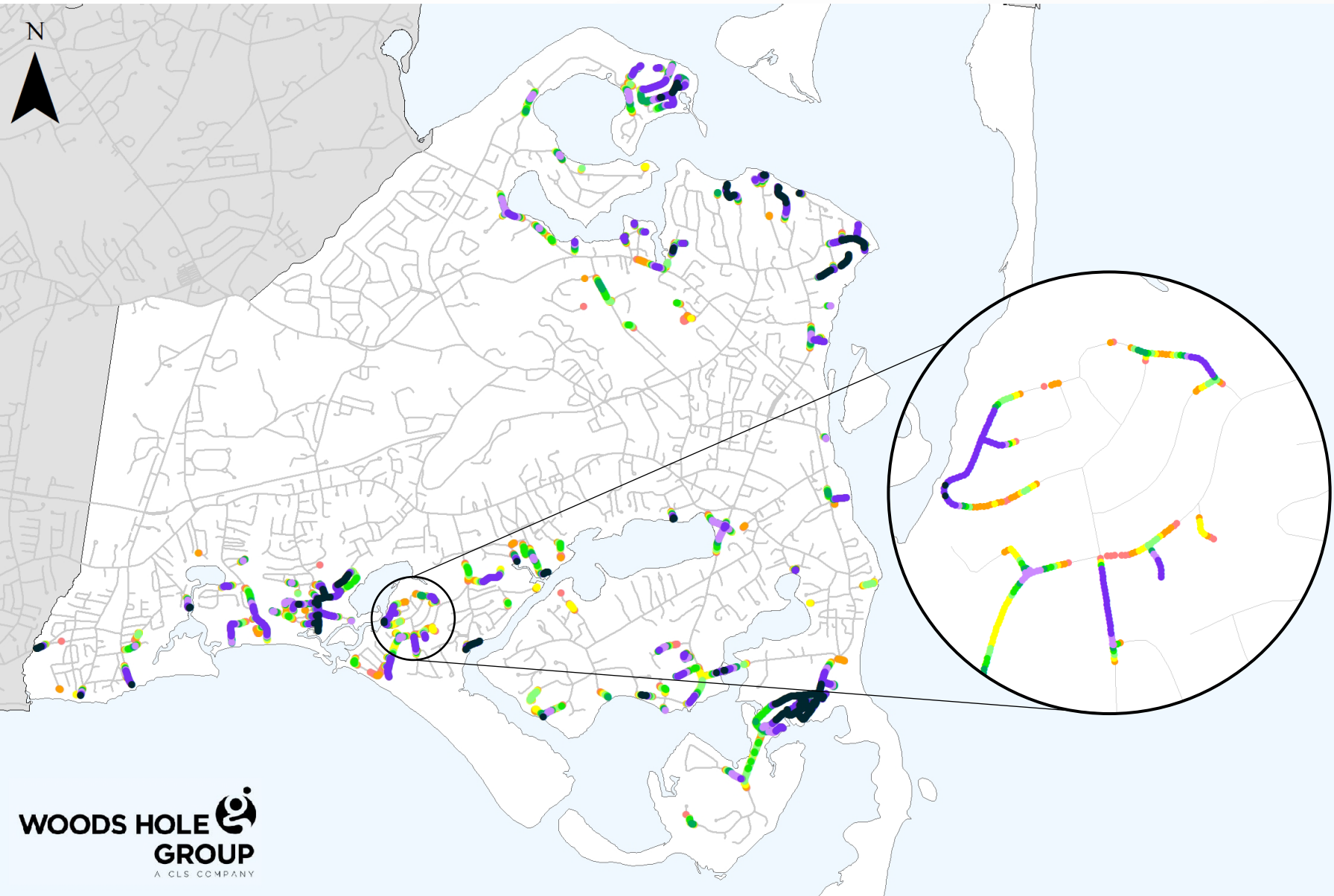
Low Lying Roads Nuisance Flooding

Road Surface Elevations Below MHW

- 2070 (5.9 mi)
- 2050 (2.4 mi)
- 2030 (0.2 mi)

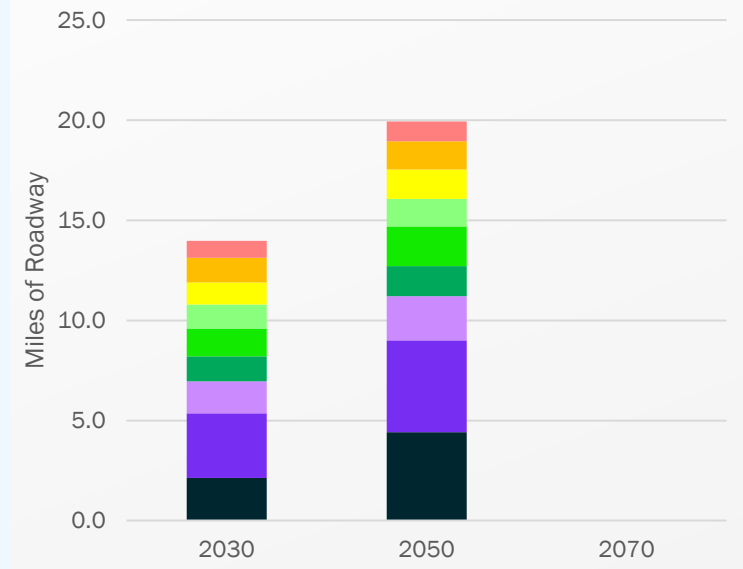
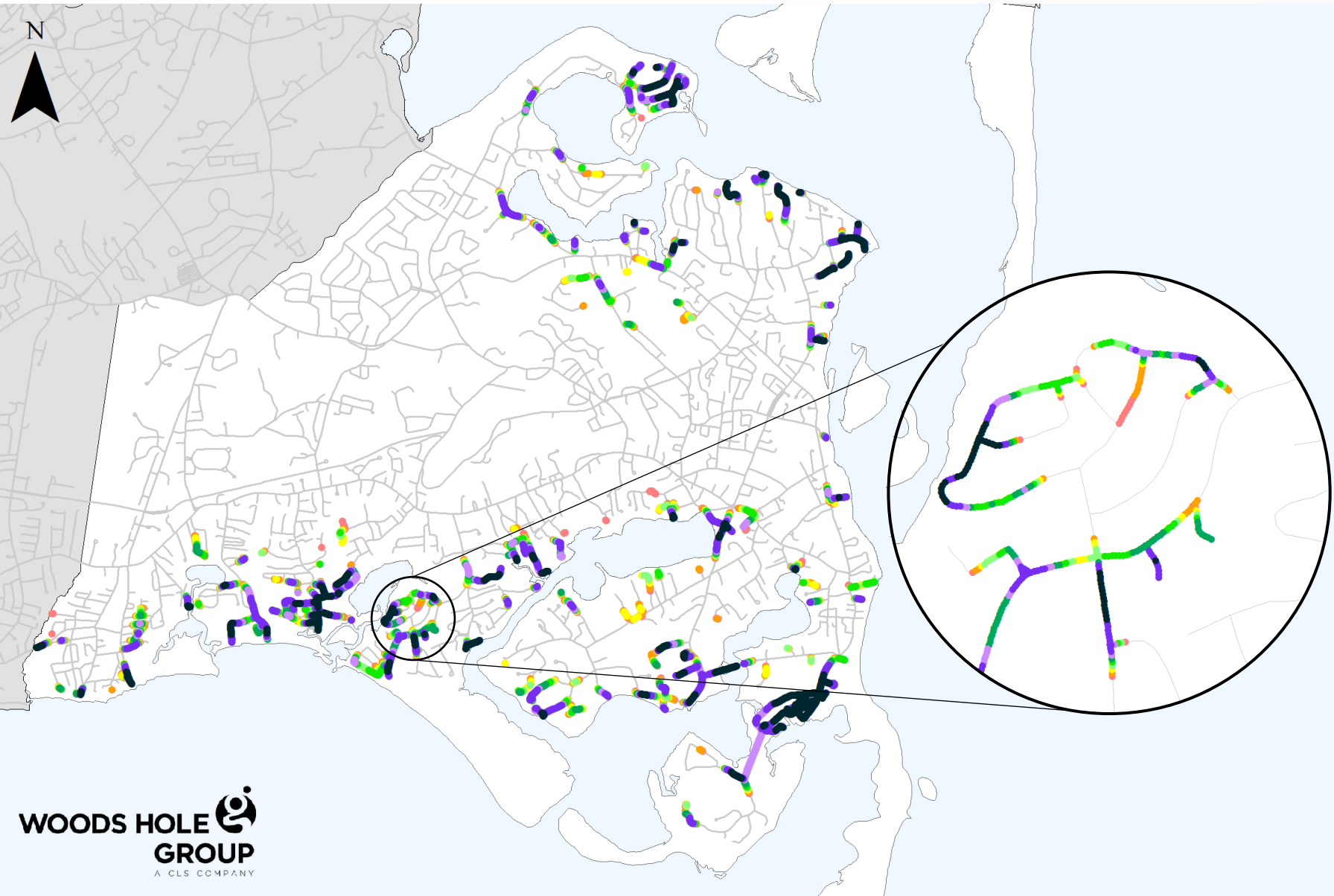


Low Lying Roads 2030 Flood Probability (Annual Exceedance Probability)



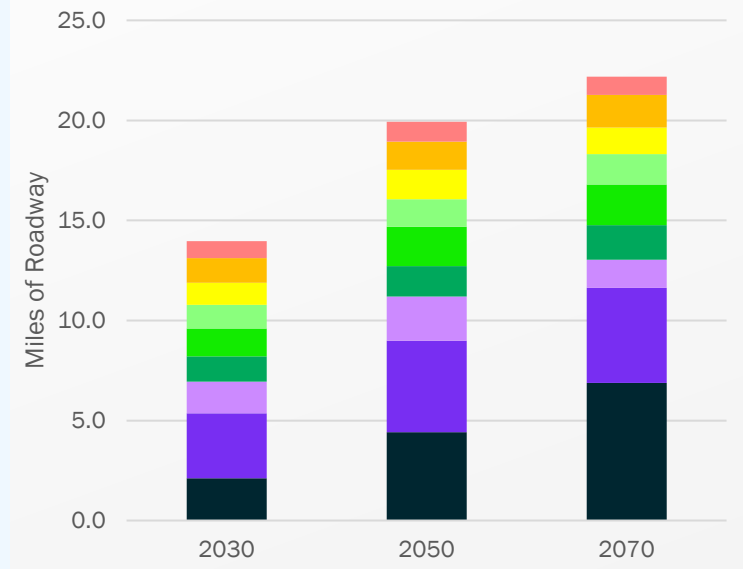
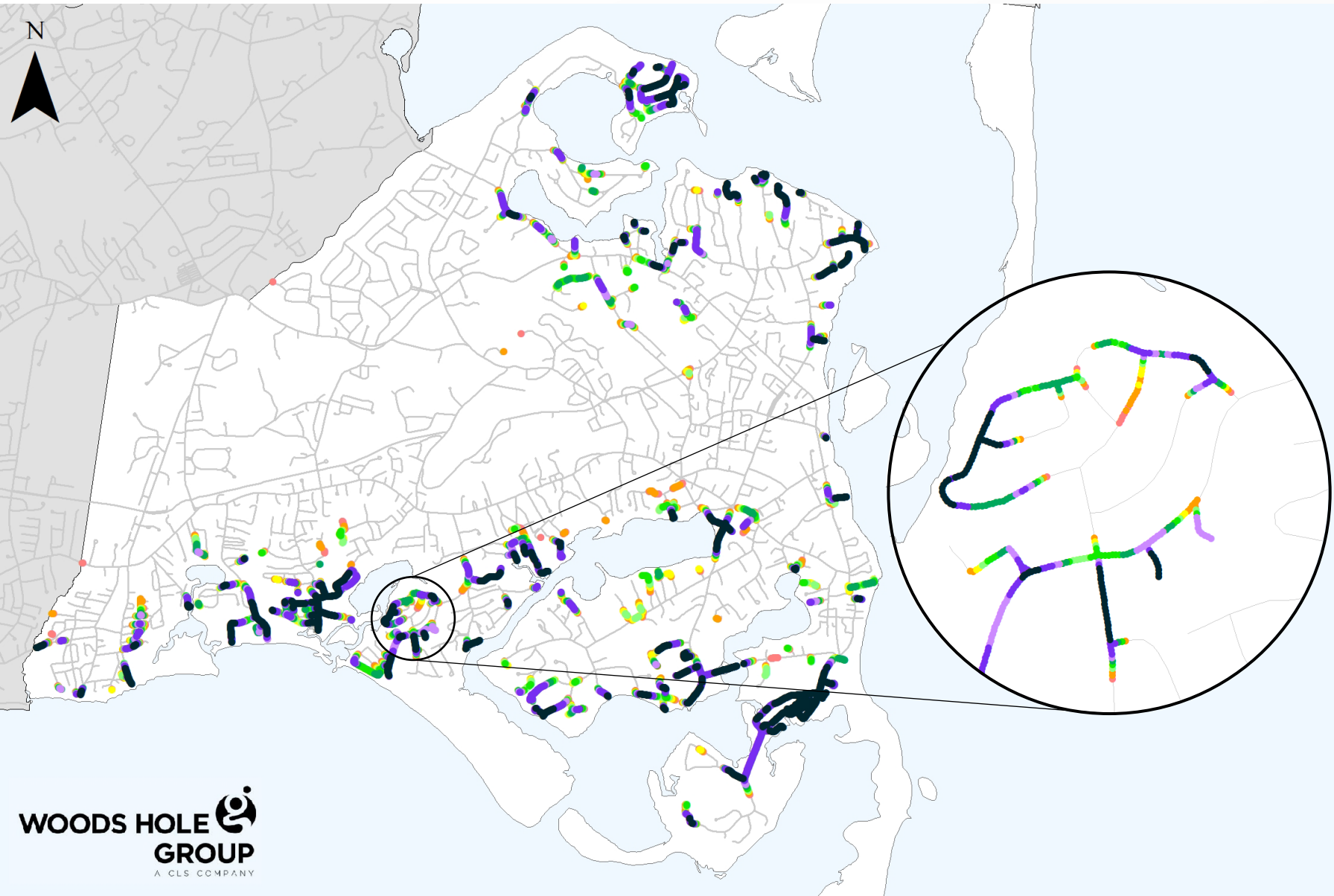
Flood Probability	Road Miles
0.1%	14.0
0.2%	13.1
0.5%	11.9
1%	10.8
2%	9.6
5%	8.2
10%	7.0
20%	5.4
100%	2.1

Low Lying Roads 2050 Flood Probability (Annual Exceedance Probability)



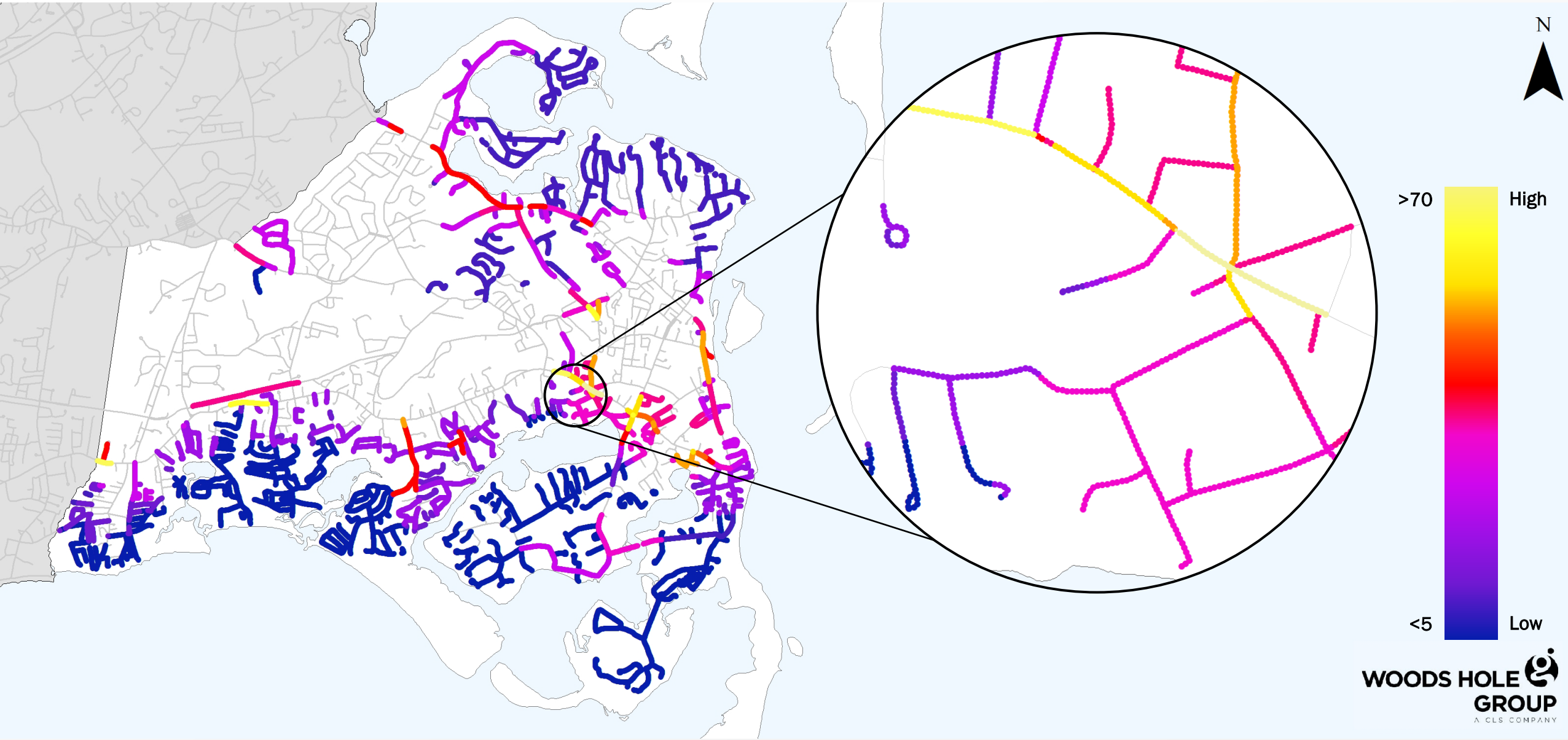
Flood Probability	Road Miles
0.1%	19.9
0.2%	18.9
0.5%	17.5
1%	16.1
2%	14.7
5%	12.7
10%	11.2
20%	9.0
100%	4.4

Low Lying Roads 2070 Flood Probability (Annual Exceedance Probability)

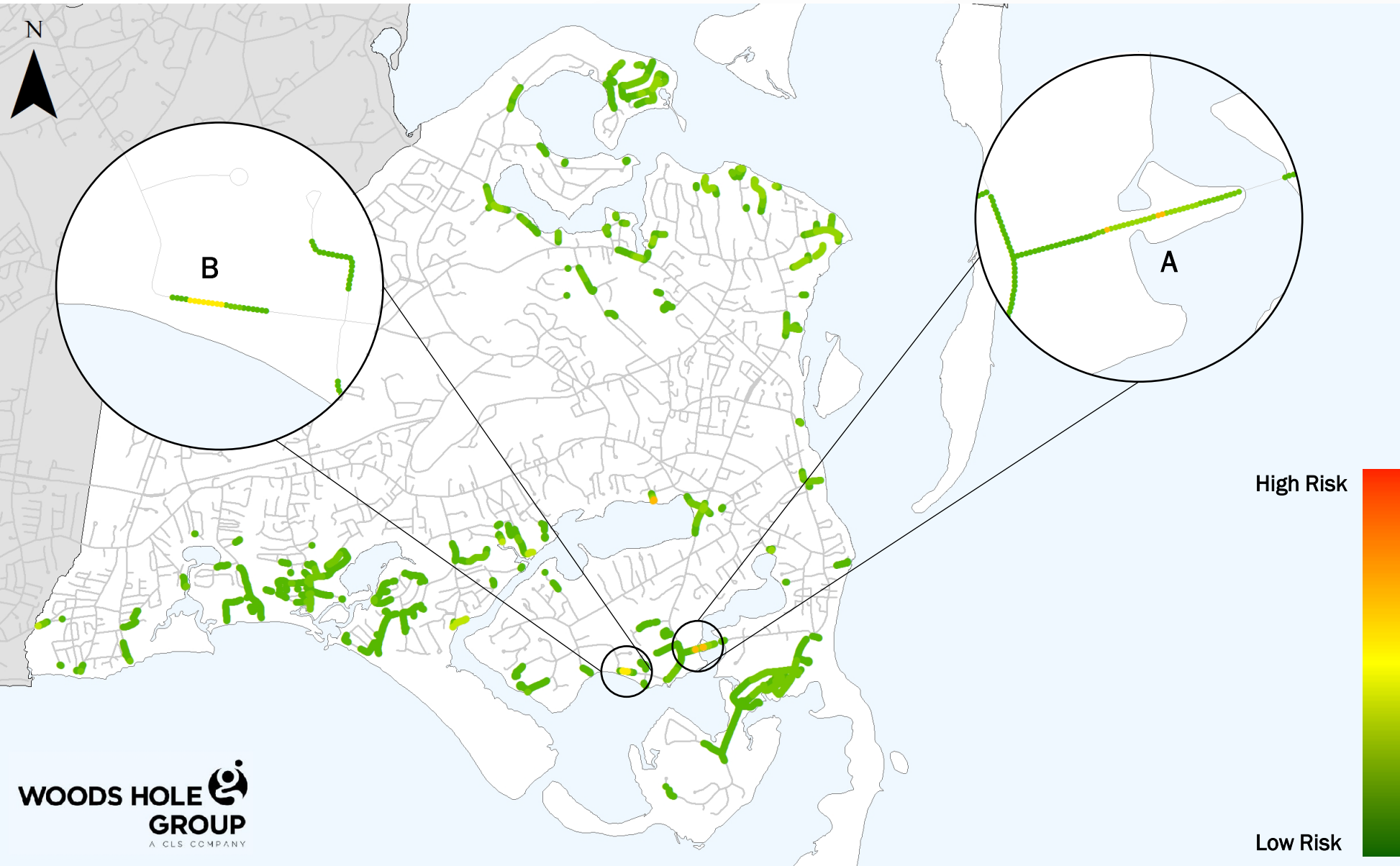


Flood Probability	Road Miles
0.1%	22.2
0.2%	21.3
0.5%	19.6
1%	18.3
2%	16.8
5%	14.8
10%	13.0
20%	11.6
100%	6.9

Low Lying Roads Criticality Scoring



Low Lying Roads 2030 Risk Results

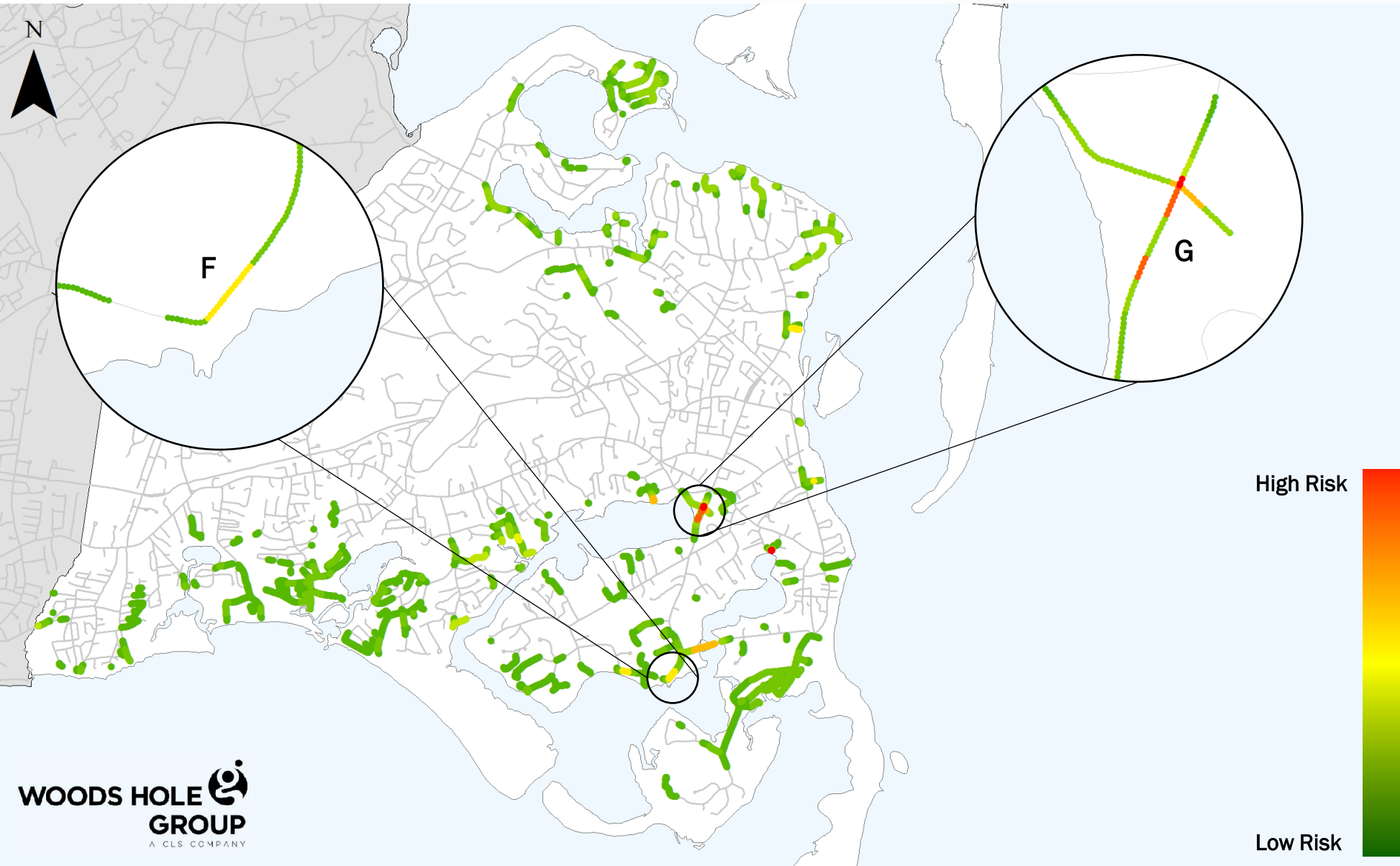


	High Risk Road Segments
A	Bridge St
B	Champlain Rd
C	Deep Hole Rd
D	Old Wharf Rd
E	Orleans Rd/Rte 28 (West)
F	Stage Harbor Rd & Pond St
G	Stage Harbor Rd & Champlain Rd
H	Morris Island Rd
I	Ridgevale Rd
J	Hardings Beach Rd
K	Orleans Rd/Rte 28 (East)
L	Fox Hill Rd
M	Seapine Rd
N	Barn Hill Rd

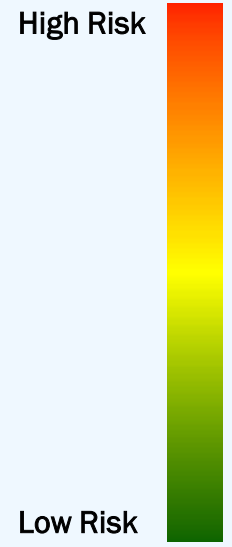
High Risk

Low Risk

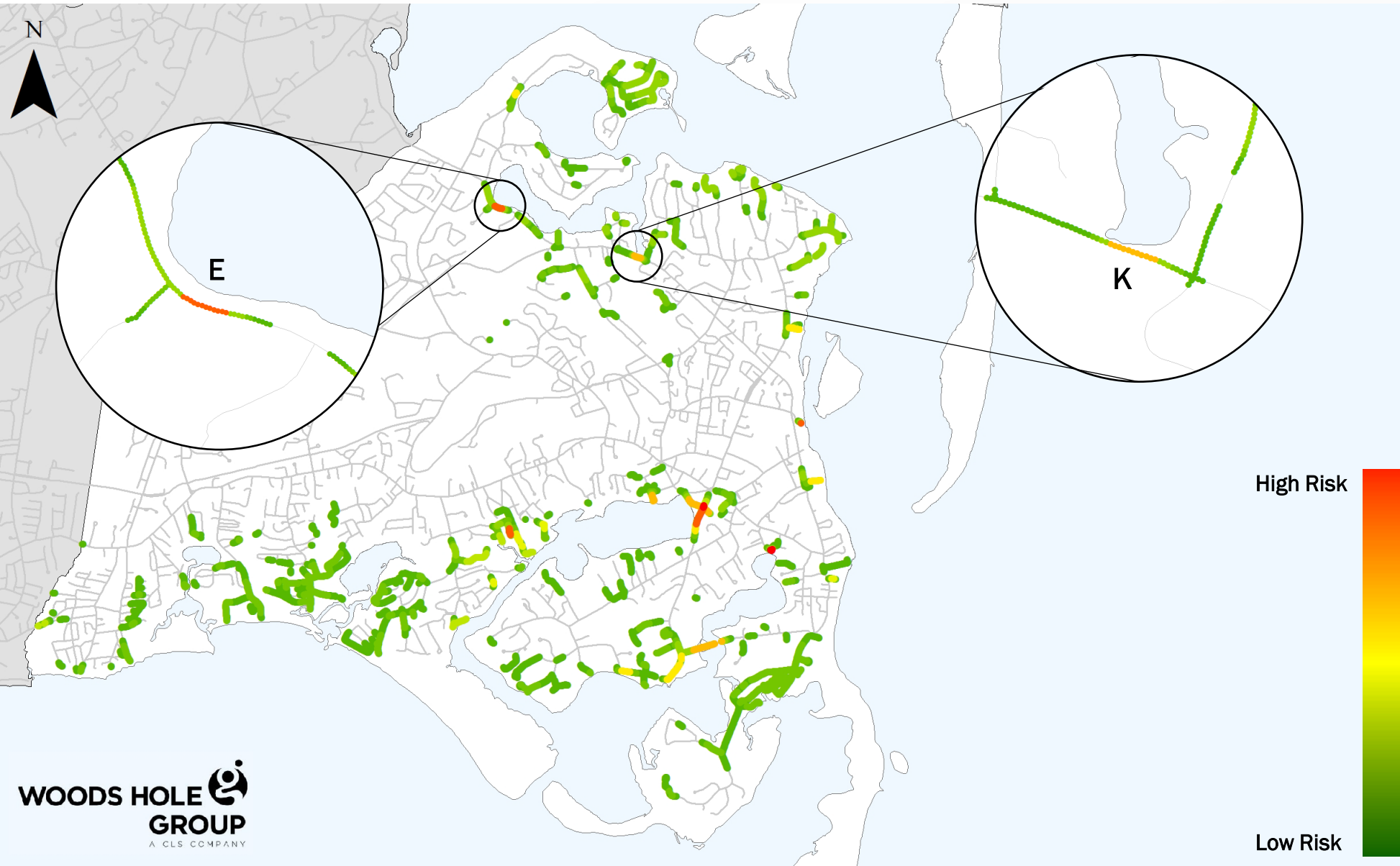
Low Lying Roads 2050 Risk Results



	High Risk Road Segments
A	Bridge St
B	Champlain Rd
C	Deep Hole Rd
D	Old Wharf Rd
E	Orleans Rd/Rte 28 (West)
F	Stage Harbor Rd & Pond St
G	Stage Harbor Rd & Champlain Rd
H	Morris Island Rd
I	Ridgevale Rd
J	Hardings Beach Rd
K	Orleans Rd/Rte 28 (East)
L	Fox Hill Rd
M	Seapine Rd
N	Barn Hill Rd



Low Lying Roads 2070 Risk Results



	High Risk Road Segments
A	Bridge St
B	Champlain Rd
C	Deep Hole Rd
D	Old Wharf Rd
E	Orleans Rd/Rte 28 (West)
F	Stage Harbor Rd & Pond St
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High Risk

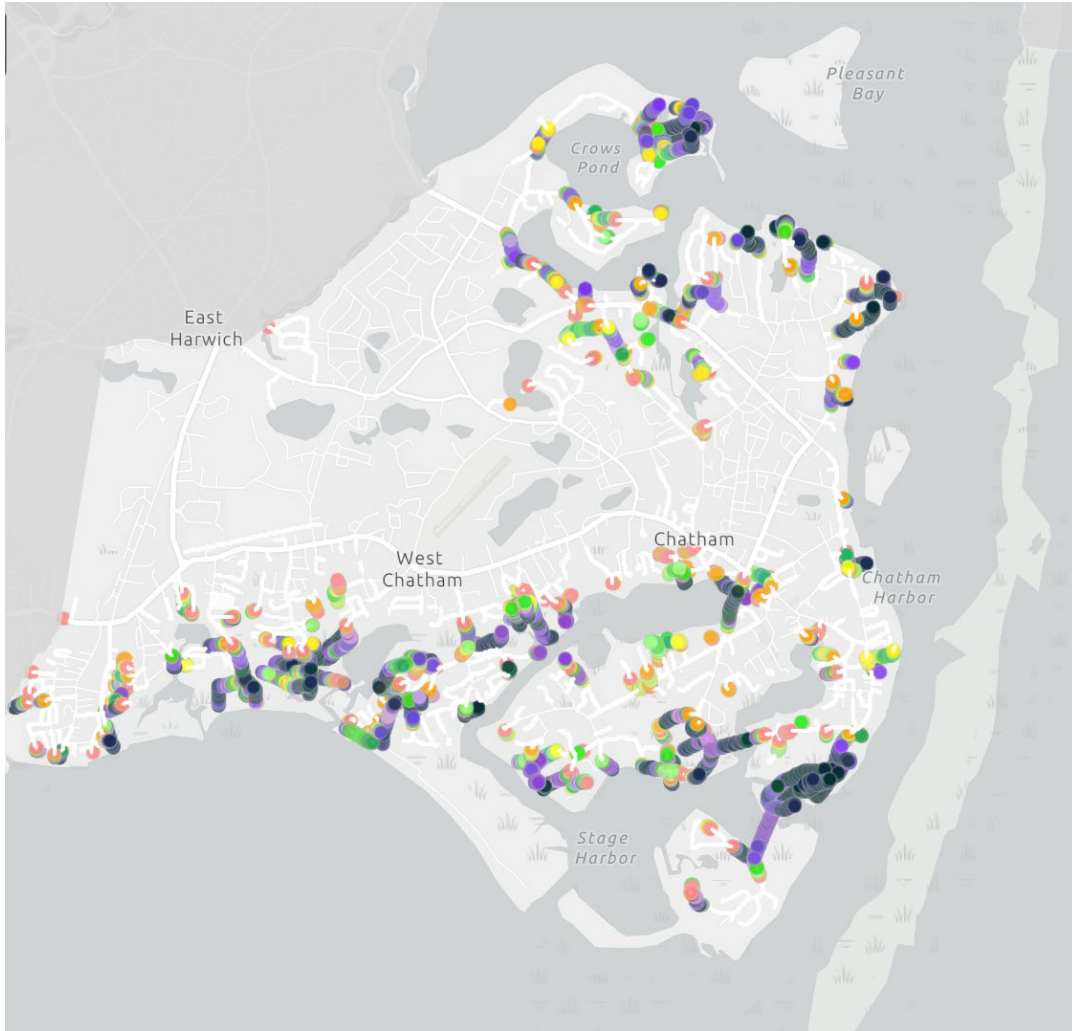
Low Risk

Summary of High Priority Road Segments

	Road Name	Length (ft)	Description	AEP 2030	Criticality Score	2030 Risk Score	Tidal Flooding Length (ft)		
							2030	2050	2070
A	Bridge St	760	western approach to Mitchell River Bridge	100	26	2600	0	260	600
B	Champlain Rd	300	west of Port Fortunes Ln	100	23	2300	0	140	220
C	Deep Hole Rd	300	eastern approach to Red River crossing at Harwich line	100	11	1100	0	120	200
D	Old Wharf Rd	600	between Old Harbor Rd and Linnell Ln	100	9	900	0	420	520
E	Orleans Rd/Rte 28 (West)	940	at top of Ryder Cove crossing Herring Brook	20	37	740	0	0	400
F	Stage Harbor Rd & Pond St	820	behind Oyster Pond Beach	20	36	720	0	0	520
G	Stage Harbor Rd & Champlain Rd	500	at Harbormaster Office and creek crossing	20	23	460	0	80	320
H	Morris Island Rd	2440	between Outermost Harbor and Tom's Neck	100	4	400	0	1280	2120
I	Ridgevale Rd	980	between Cranberry Ln and Patterson Rd	100	4	400	0	0	520
J	Hardings Beach Rd	760	between Buena Vista Rd and Howes Ln	20	4	80	0	0	380
K	Orleans Rd/Rte 28 (East)	420	at Frost Fish Creek crossing	20	27	540	0	0	260
L	Fox Hill Rd	360	connection to Nickersons Neck at Crows Pond Landing	10	20	200	0	0	140
M	Seapine Rd	300	connection to Harbor Coves along southern shore of Crows Pond	10	9	90	0	0	0
N	Barn Hill Rd	240	connection to Barn Hill at top of Sulphur Springs marsh	2	36	72	0	0	0
O	Taylor's Pond Rd	280	connection to neighborhood at Taylor's Pond landing	20	4	80	0	0	160

LOW LYING ROADS

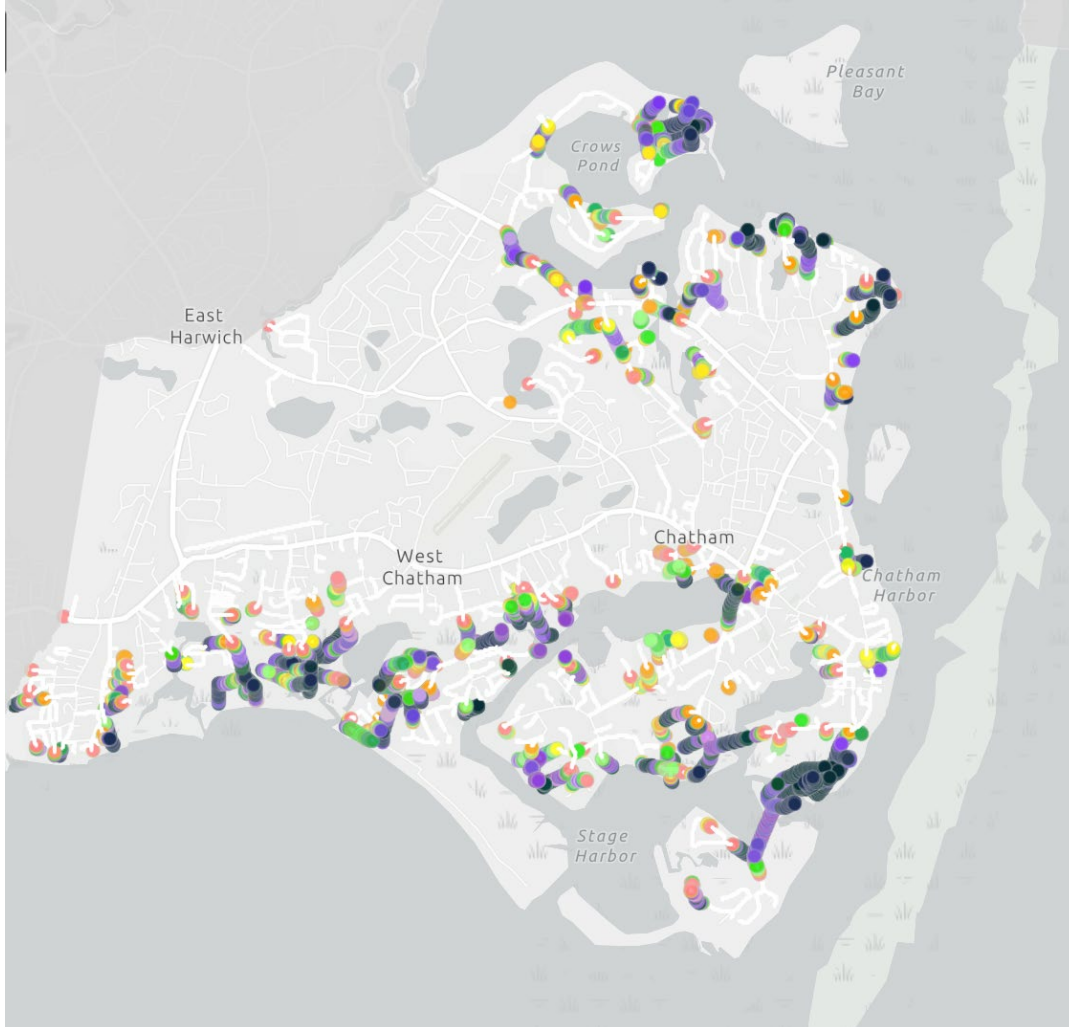
Group Discussion



**DISCUSSION
ORIENTATION**

LOW LYING ROADS

Group Discussion



DISCUSSION QUESTIONS

1. Are you more concerned with high tide flooding or storm flooding?
2. What local knowledge or concerns can you bring to the discussion?
3. How would you prioritize these road segments?

Summary of High Priority Road Segments

	Road Name	Length (ft)	Description	AEP 2030	Criticality Score	2030 Risk Score	Tidal Flooding Length (ft)		
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M	Seapine Rd	300	connection to Harbor Coves along southern shore of Crows Pond	10	9	90	0	0	0
N	Barn Hill Rd	240	connection to Barn Hill at top of Sulphur Springs marsh	2	36	72	0	0	0
O	Taylor's Pond Rd	280	connection to neighborhood at Taylor's Pond landing	20	4	80	0	0	160

NEXT STEPS

- Town staff to select 2 road segments
- Site visits and feasibility analysis
- 3 solutions + costs per segment
- 2nd Workshop date TBD – spring 2024
- Materials available to view on Low Lying Road webpage:
<https://www.capecodcommission.org/our-work/low-lying-roads-project/>



Low Lying Roads: Chatham

Home > Work > Low Lying Roads: Chatham

Start Date: 2023

[Low Lying Roads Project Homepage](#), learn more about the background and process.

Overview

Map Viewer

Overview

The Cape Cod Commission is working with all 15 Cape towns, including the **Town of Chatham**, to examine vulnerabilities in the roadway network and identify solutions.

NEXT MEETINGS

WEDNESDAY

MAY 31, 2023

Chatham Low-lying Roads Public Meeting

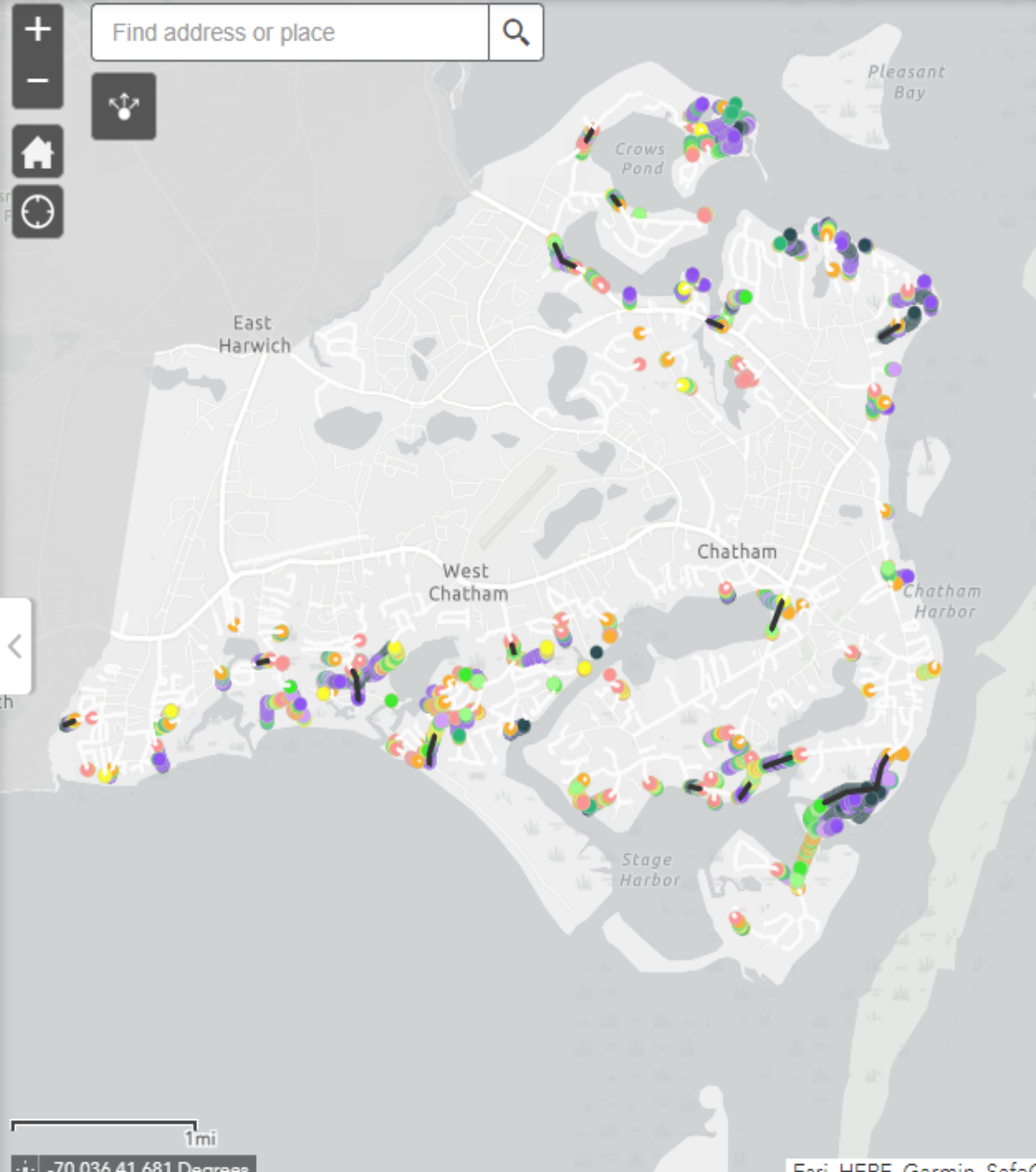
START TIME: 7:00 PM

ABOUT

With funding support from the Massachusetts Municipal Vulnerability Preparedness (MVP) program, the Commission has contracted with the Woods Hole Group (WHG) to conduct a vulnerability assessment of roadway segments, bridges, and culverts due to flooding from the combined effects of sea level rise and storm surge. WHG will employ the state-of-the-art Massachusetts Coast Flood Risk Model (MC FRM) to identify vulnerable road segments under different sea level rise scenarios and time scales. One output from this work is a projection of the probability and extent of flooding at defined future planning horizons, 2030, 2050, and 2070.

NAVIGATION

- Click the Legend to show the map key
 - Open the Layers to turn on more contextual features or create new suggestions
 - Use the Editor to provide feedback
 - Change Base Maps
 - Bookmarks help navigate Top Vulnerable Roads
 - Click on a feature to see more information. You may need to click through multiple pop ups
- (1 of 7)



Legend

- Chatham Top Vulnerable Roads
- Coastal Erosion Comments
- Coastal Flooding Comments
- Town mask
- Chatham 2030 Inundation Probability
 - Prob_2030
 - 100%
 - 20%
 - 10%
 - 5%
 - 2%
 - 1%
 - 0.5%
 - 0.2%
 - 0.1%

THANK YOU!
