

Hurricane Evacuation Study

May 2020

Slides from CDM Smith, VDEM, UACE, FEMA RIII

NATIONAL HURRICANE PROGRAM

Hurricane Evacuation Studies (HES)

Goal: To provide emergency management officials sound data that will inform them in hurricane evacuation planning and decision-making



Tom Laczó (USACE)

Hurricane Evacuation Study (HES) Components



- **Hazard Analysis**
*What will be wet and what stays dry?
How high will the water get?
How far inland?*
- **Vulnerability Analysis**
*Who will be affected in your community?
Any critical facilities at risk?*
- **Behavioral Analysis**
*Will the Public evacuate?
Where will they go? How? When?
Do they understand the threat?*
- **Shelter Analysis**
*What are your shelter needs? Potential Demand?
Identification of Deficits/Gaps*
- **Transportation Analysis**
*Where is traffic going to back up?
Where will traffic backup?
What is the road capacity?
How long will it take to evacuate?*



Purpose

- Develop an updated transportation study in coordination with US Army Corps of Engineers (USACE), the Virginia Department of Emergency Management (VDEM) and the Federal Emergency Management Agency (FEMA).
- The data and analyses from these studies are used to:
 - Inform local stakeholders which populations are vulnerable for their emergency planning purposes
 - Develop evacuation clearance times for Virginia
 - Assess public shelter capacities for hurricane evacuation purposes



Overview of Storm Surge and Evacuation Zones

Storm Surge Inundation Areas

- Identify areas of likely flooding during a hurricane event
 - SLOSH Model – Sea, Lake and Overland Surges from Hurricanes Model
 - Directional MEOWs (Maximum Envelope of Water)
- 7 directions, 6 forward speeds, 4 categories, 40 to 56 different tracks = 16,320 SLOSH runs

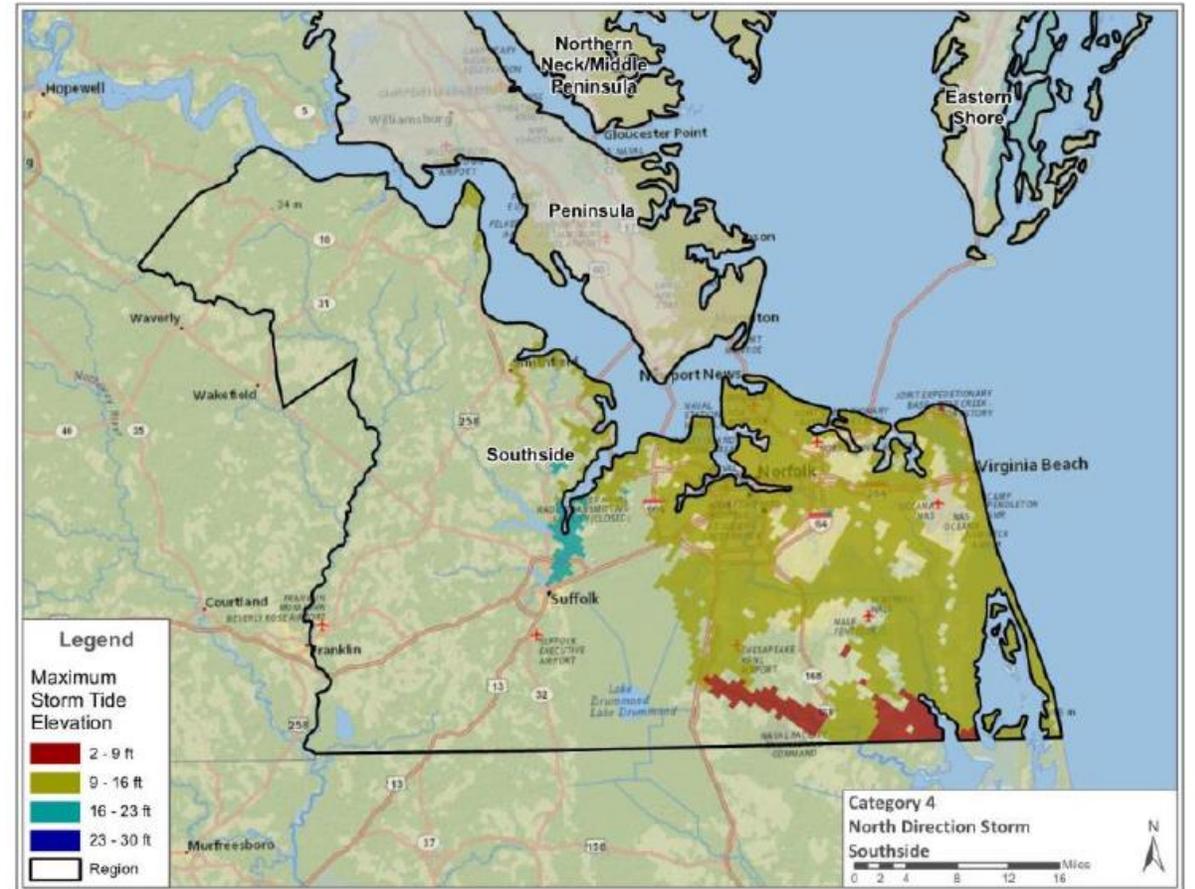
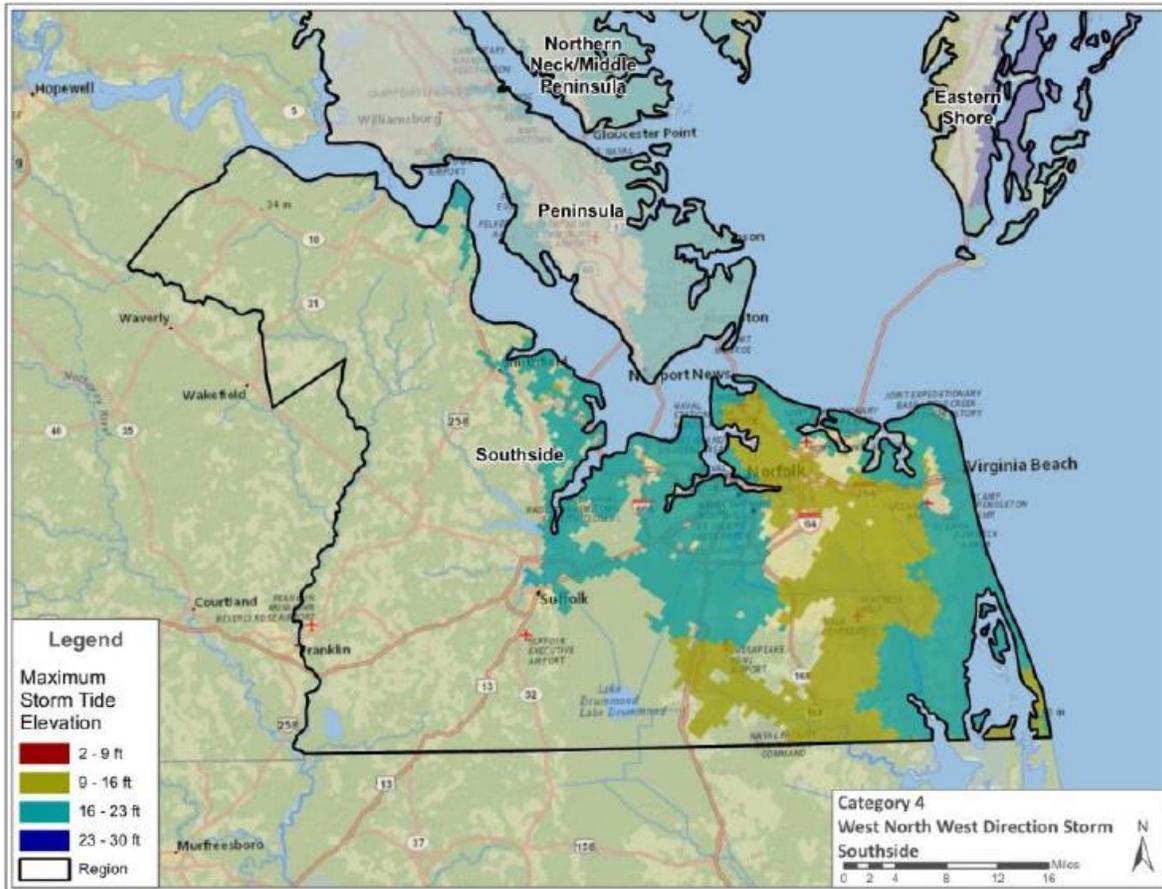
Table of water surface elevations from SLOSH runs

Storm Intensity /Direction	Water Surface Elevation (ft NAVD88)						
	WNW	NW	NNW	P	N	NNE	NE
Category 1	2.0-9.5	2.0-9.2	2.0-8.8	2.0-9.3	2.0-7.4	2.0-6.0	2.0-6.9
Category 2	3.8-16.7	3.2-16.4	2.9-15.8	3.7-16.2	2-11.9	2.5-9.6	2.0-8.2
Category 3	5.1-23.3	5.0-22.7	4.9-22.4	5.1-22.7	4.4-17.8	2.0-13.0	2.0-10.3
Category 4	7.3-29.5	7.2-28.3	5.2-28.1	4.1-28.5	7.4-24.2	3.7-16.4	3-13.1

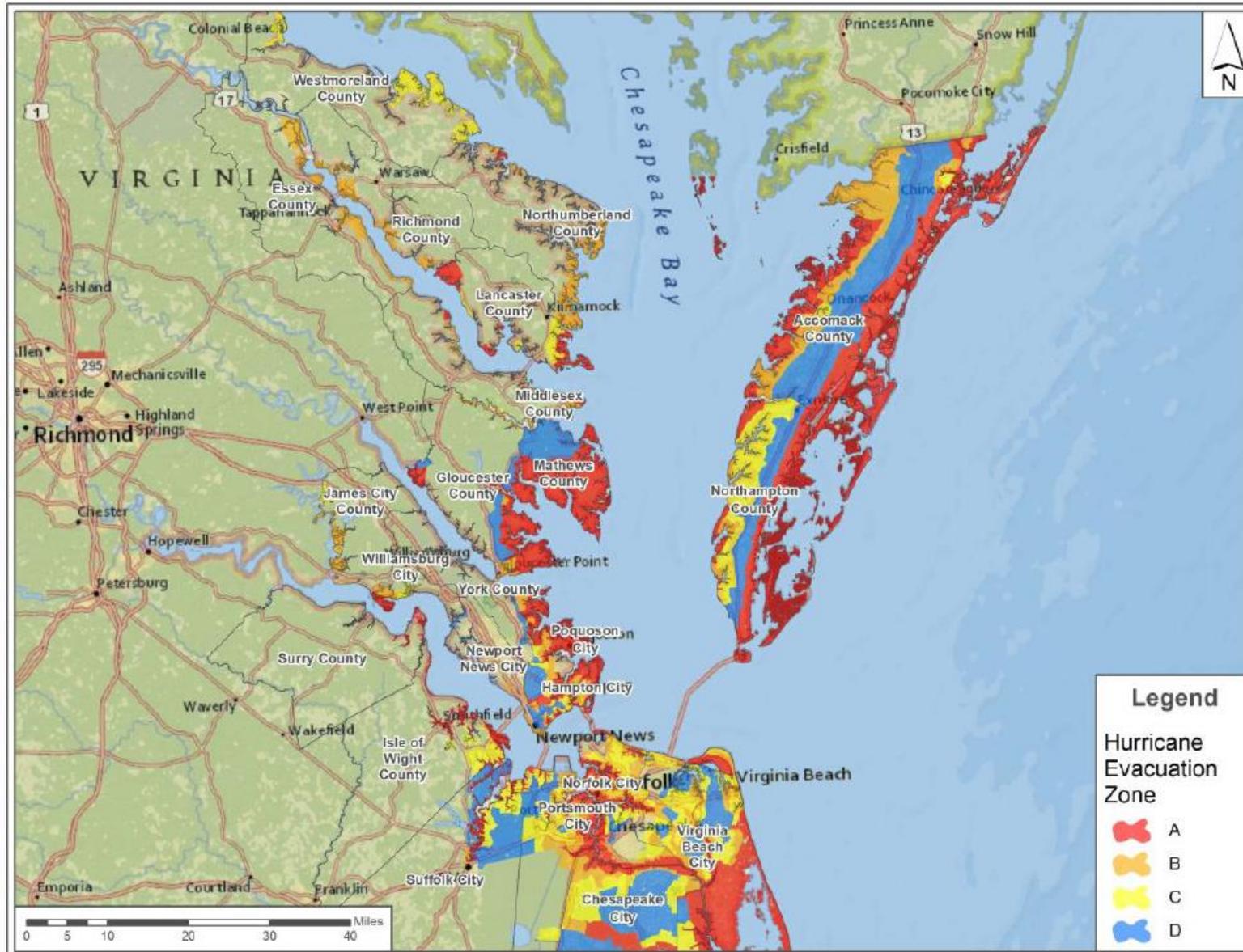
Example Products

WNW vs. N Direction / Category 4 / Southside

- Graphics developed for each direction, category of storm, and region



Evacuation Zones



- Areas delineated from storm surge inundation areas with clearly recognizable boundaries used to facilitate the communication of an evacuation order to the public
- Developed in 2017 by Atkins NA, Inc.
- Updated with new color schema

Hurricane Intensity vs. Storm Level

- Directional modeling results in directional grouping for various hurricane intensities
- Evacuation zones under order do not necessarily correlate only to a hurricane category, but also to a storm direction

Hurricane Intensity Grouping	Hurricane Track Directional Grouping	
	P to N	NNW to WNW
Category 1-2	A	B
Category 3	B	C
Category 4	C	D

* P = Parallel, N = North, NNW = North Northwest, WNW = West Northwest

Storm Level	Evacuation Zone Under Order
Level A	A
Level B	A+B
Level C	A+B+C
Level D	A+B+C+D

Participation Rates

- Participation Rates were developed to take in account shadow evacuees and are correlated with storm intensity level
- Shadow evacuees – those persons who are not ordered to evacuate, but leave due to a perceived threat. All scenarios include shadow evacuees.

Storm Level	Evacuation Zone Under Order	Shadow Evacuees
Level A	A	Evacuation Zones B+C+D and Inland Areas
Level B	A+B	Evacuation Zones C+D and Inland Areas
Level C	A+B+C	Evacuation Zone D and Inland Areas
Level D	A+B+C+D	Inland Areas

Destination & Vehicle Usage Rates

- Destination Rates – Identifies how many evacuees will evacuate to specific locations or what direction they will take
 - This study only considered two types of destination rates—evacuation route preferences and public shelter rates
 - Evacuation route preferences identify the proportion of evacuees that prefer a particular route to use based on their location
 - Public shelter usage rates are a type of destination rate used to develop public shelter demand estimates
- For the purposes of RtePM, the average number of persons per vehicle is two.

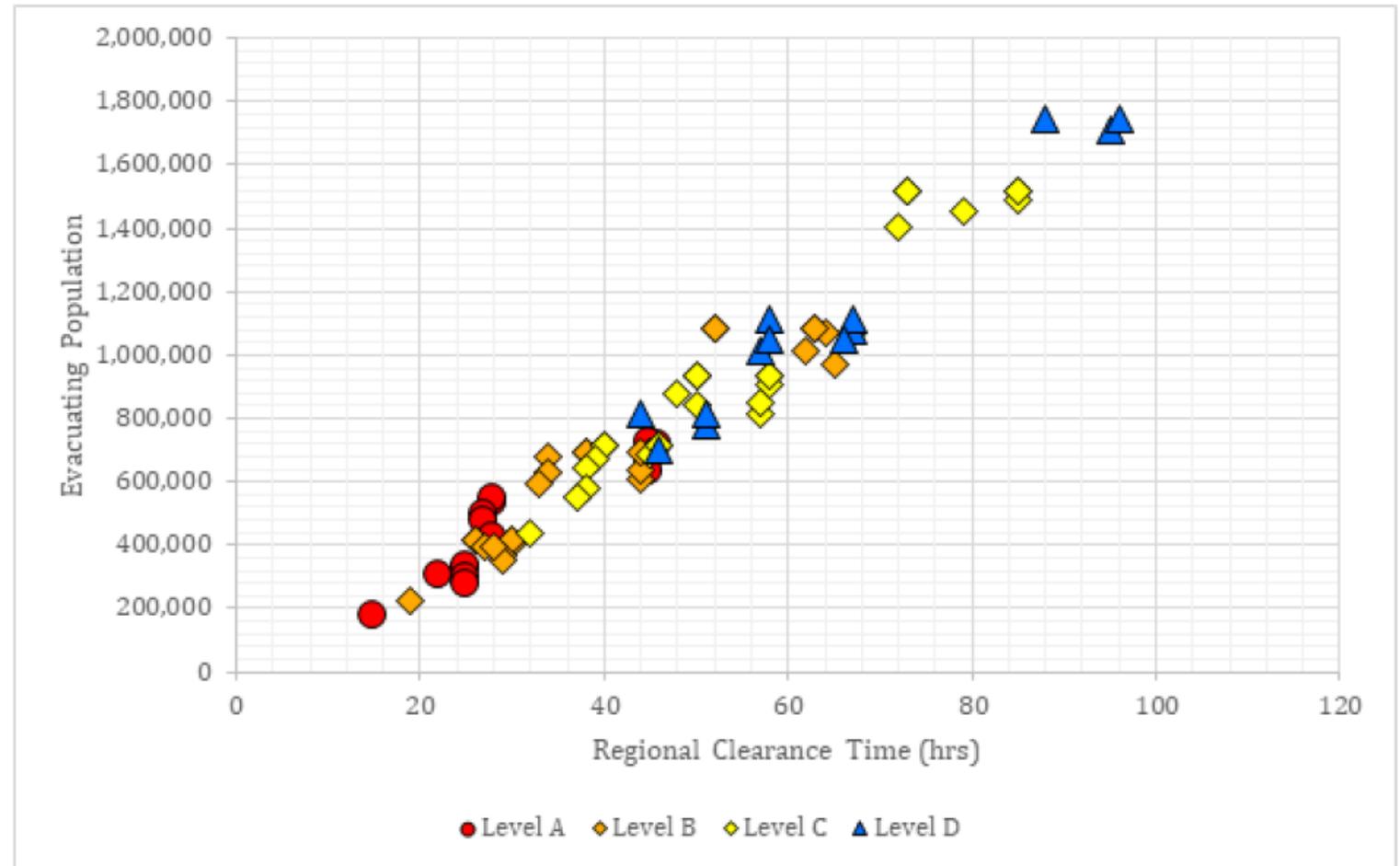
Region	Shelter Use Rate
Eastern Shore	18%
Northern Neck/Middle Peninsula	9%
Peninsula	11%
Southside	8%

Virginia Regional Tiered Evacuation Clearance Times

Zone	Evacuation Clearance Time (hours) for Medium (80%) Participation Rate
A	28
B (A + B)	45
C (A + B + C)	58
D (A + B + C + D)	67

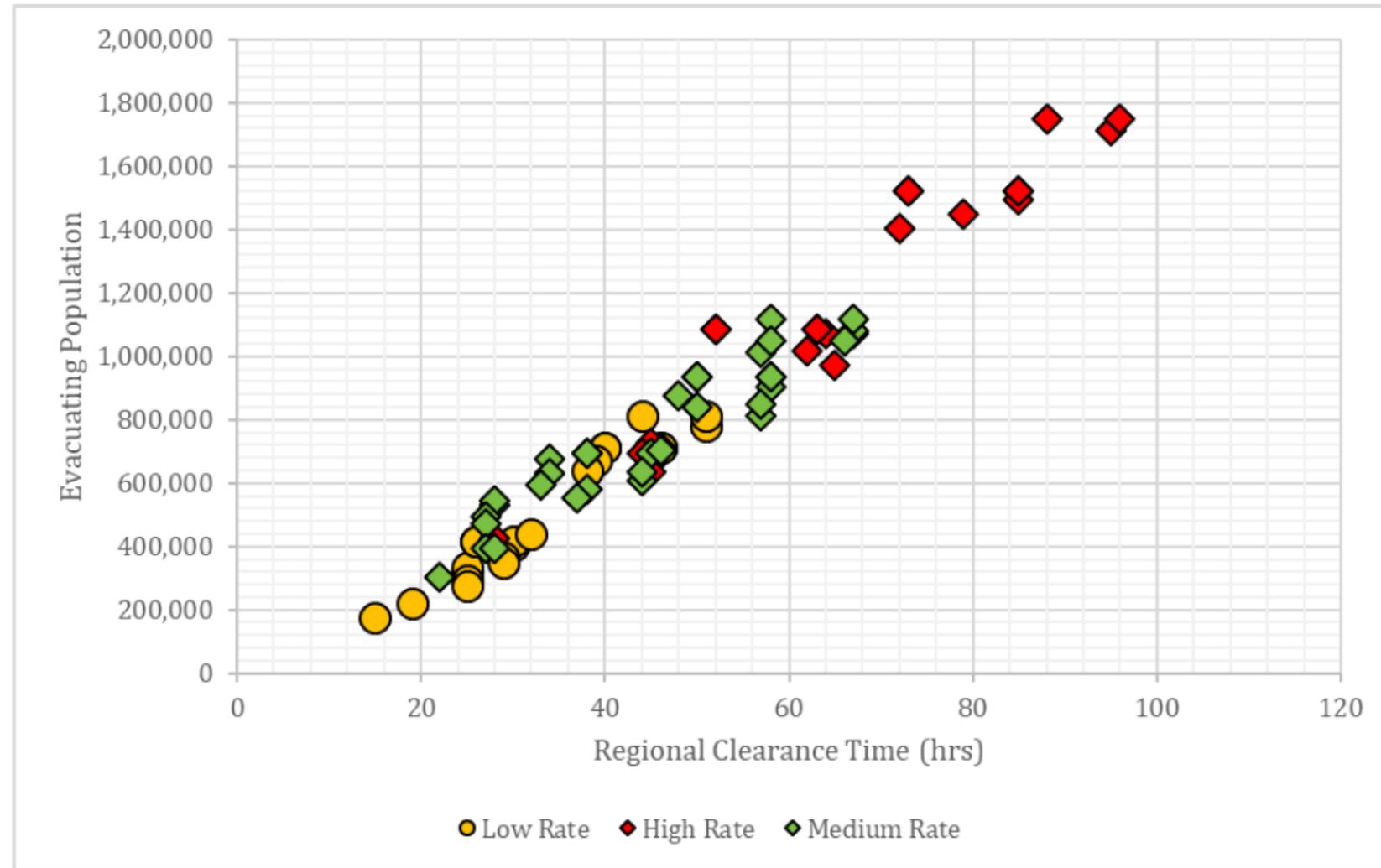
Summary of Scenarios by Storm Level

- Simplified overview of scenarios
- Observed linear relationship
- However, many parameters affect the range of regional clearance times



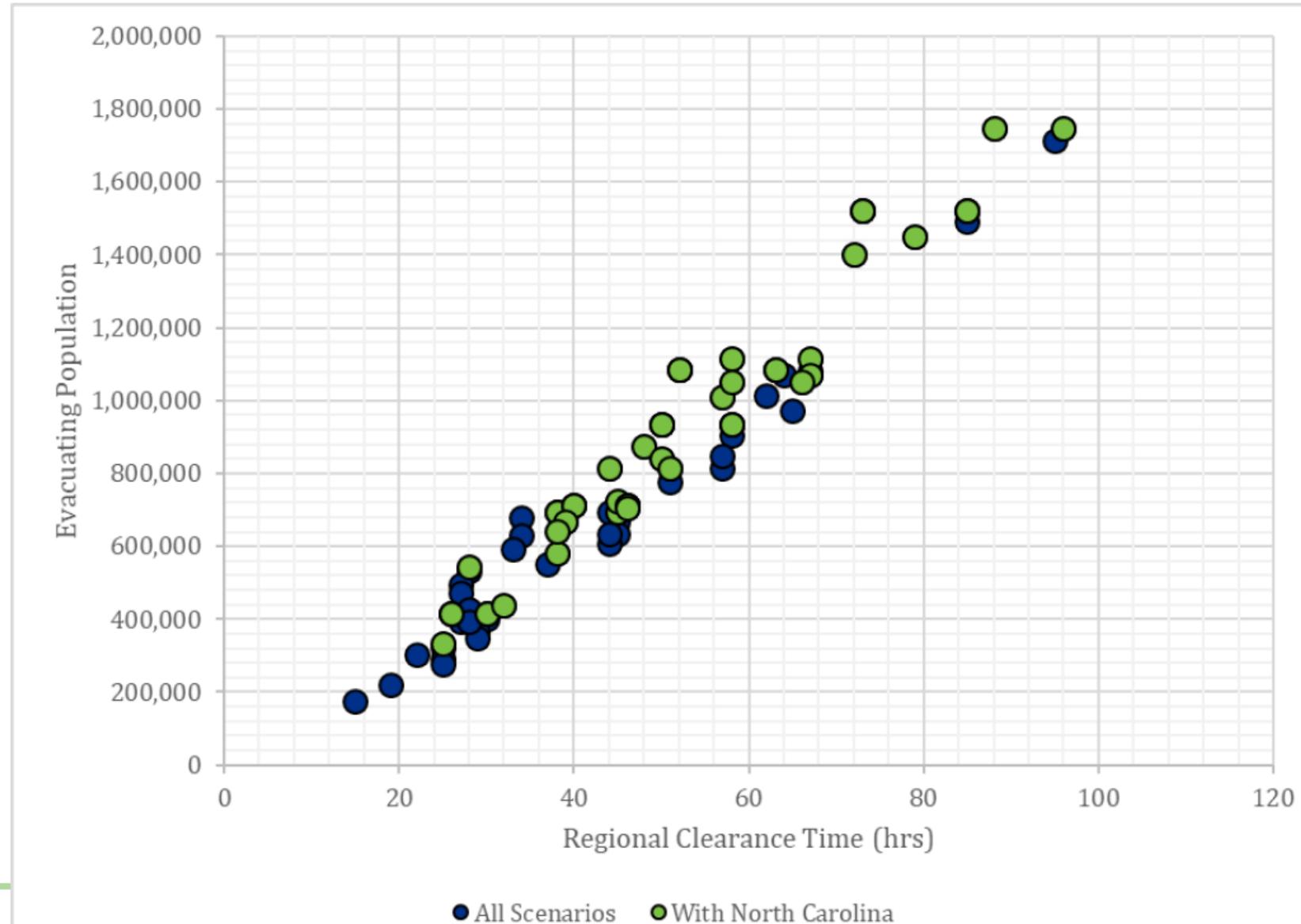
Summary of Scenarios by Participation Rate

- Simplified overview of scenarios
- Typically, high participation yields higher clearance time for higher level of event



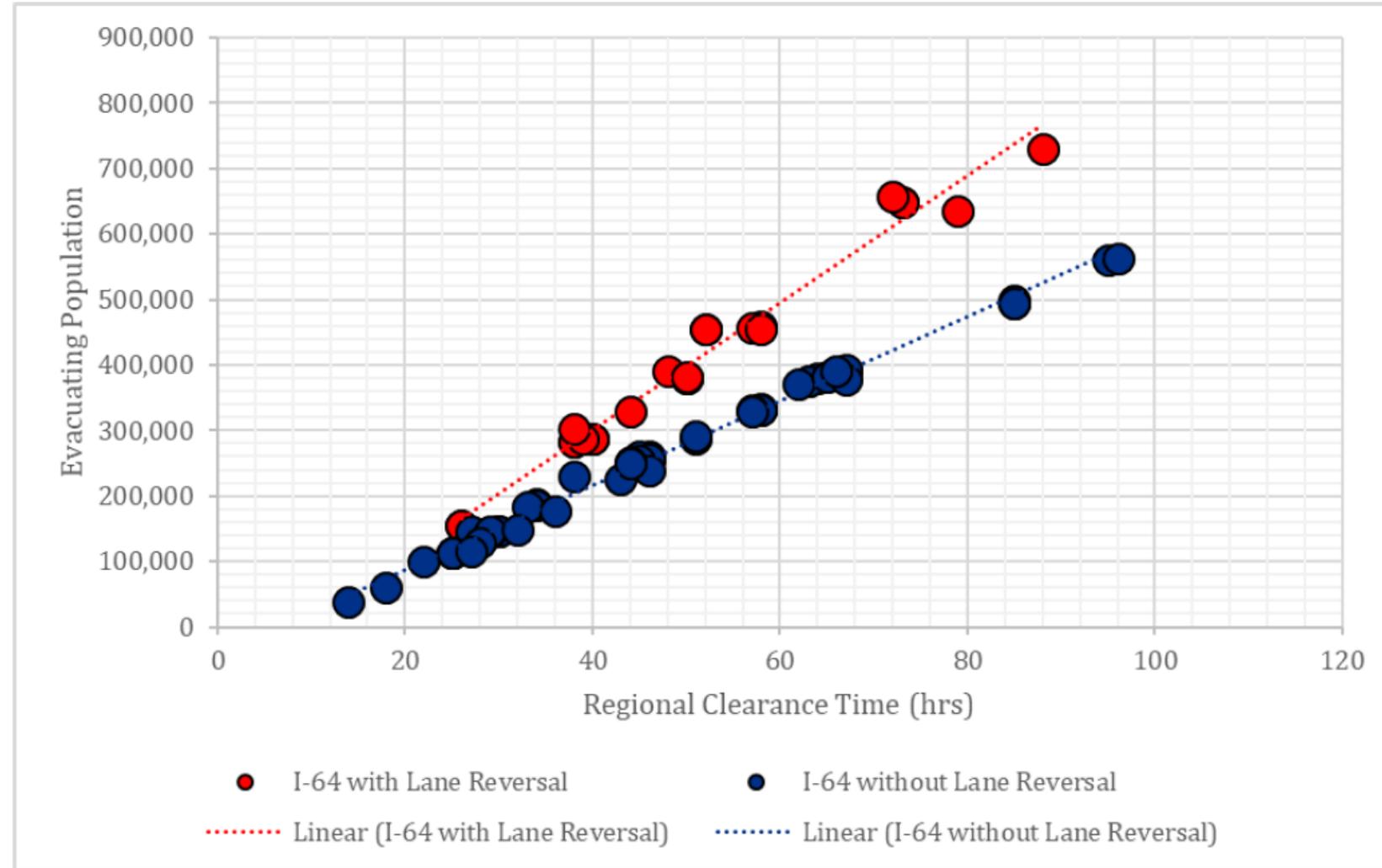
Impact of North Carolina Evacuees

- Selected scenarios with North Carolina evacuees impact regional clearance times
- RtePM moves the evacuees to dynamically to different routes.



Lane Reversal

- Observed trends in lane reversal based on I-64 response for with and without implementation.
- Improvements are observed for all scenarios that include LR.
- Range of clearance time improvement is between 4 to 12 hours.





Shelter Analysis

Shelter Demand

- Shelter demand refers to the number of evacuees who are expected to seek public shelter as a result of a hurricane event.
- As the intensity of the hurricane increases, so does demand.
- As the storm intensity increases, shelters in the exposed areas are deemed “inoperable” for public safety.

Region	Shelter Use Rate
Eastern Shore	18%
Northern Neck/Middle Peninsula	9%
Peninsula	11%
Southside	8%

Overall Public Shelter Capacity

Region/Jurisdiction		Total Shelter Capacity
Eastern Shore		11,775
	Accomack	11,775
	Chincoteague	0
	Northampton	0
Northern Neck/Middle Peninsula		8,285
	Essex	10
	Gloucester	1,654
	Lancaster	528
	Mathews	186
	Middlesex	500
	Northumberland	700
	Richmond	1,450
	Westmoreland	3,257

Peninsula		18,326
	Hampton	3,469
	James City	2,552
	Newport News	7,170
	Poquoson	800
	York	4,335
Southside		61,413
	Chesapeake	15,327
	Isle of Wight	1,953
	Norfolk	22,357
	Portsmouth	3,371
	Suffolk	6,900
	Surry	1,650
	Virginia Beach	9,855

High Participation Rate

- In a Level C/D, with high participation rate, the region as a whole runs a deficit.

Region	County	Total Shelter Demand by County				Shelter Demand vs County Capacity			
		Level A	Level B	Level C	Level D	Level A	Level B	Level C	Level D
Eastern Shore	Accomack	3,189	4,109	4,485	6,079	8,586	7,666	7,290	5,696
	Northampton	975	1,155	1,833	2,154	-975	-1,155	-1,833	-2,154
Northern Neck/ Middle Peninsula	Essex	212	324	434	505	-202	-314	-424	-495
	Gloucester	1,111	1,473	1,801	2,078	543	181	-147	-424
	Lancaster	318	377	550	612	210	151	-22	-84
	Mathews	590	611	646	766	-404	-425	-460	-580
	Middlesex	240	368	478	549	260	132	22	-49
	Northumberland	251	433	546	619	449	267	154	81
	Richmond	178	270	363	422	1,272	1,180	1,087	1,028
	Westmoreland	370	481	950	1,039	2,887	2,776	2,307	2,218
Peninsula	Hampton	8,117	11,159	13,425	15,317	-4,648	-7,690	-9,956	-11,848
	James City	2,243	3,012	3,795	4,467	309	-460	-1,243	-1,915
	Newport News	5,705	8,294	9,877	12,315	1,465	-1,124	-2,707	-5,145
	Poquoson	1,144	1,378	1,378	1,378	-344	-578	-578	-578
	Williamsburg	0	0	0	0	0	0	0	0
	York	2,981	3,902	4,635	5,580	1,354	433	-300	-1,245
Southside	Chesapeake	7,046	10,691	15,393	18,419	8,281	4,636	-66	-3,092
	Isle of Wight	850	992	1,500	1,644	1,103	961	453	309
	Norfolk	8,921	13,955	19,954	19,964	13,436	8,402	2,403	2,393
	Portsmouth	3,206	5,654	7,105	7,834	165	-2,283	-3,734	-4,463
	Suffolk	1,976	2,509	4,202	5,570	4,924	4,391	2,698	1,330
	Surry	102	129	180	213	1,548	1,521	1,470	1,437
	Virginia Beach	9,887	17,851	29,040	33,730	-32	-7,996	-19,185	-23,875
	TOTAL	59,612	89,129	122,569	141,254	40,187	10,670	-22,770	-41,455

Low Participation Rate

- In a Level C/D, with low participate rate, certain regions have a deficit that could be shifted where demand could be spread out.

Region	County	Total Shelter Demand by County				Shelter Demand vs County Capacity			
		Level A	Level B	Level C	Level D	Level A	Level B	Level C	Level D
Eastern Shore	Accomack	880	1,111	2,275	2,661	10,895	10,664	9,500	9,114
	Northampton	289	364	781	893	-289	-364	-781	-893
Northern Neck/ Middle Peninsula	Essex	131	184	275	317	-121	-174	-265	-307
	Gloucester	565	759	1,116	1,291	1,089	895	538	363
	Lancaster	165	220	329	376	363	308	199	152
	Mathews	227	276	395	458	-41	-90	-209	-272
	Middlesex	142	200	297	343	358	300	203	157
	Northumberland	153	217	324	376	547	483	376	324
	Richmond	110	155	230	266	1,340	1,295	1,220	1,184
Westmoreland	228	311	493	557	3,029	2,946	2,764	2,700	
Peninsula	Hampton	3,389	4,357	7,540	8,749	80	-888	-4,071	-5,280
	James City	1,155	1,612	2,764	3,181	1,397	940	-212	-629
	Newport News	2,872	3,976	6,848	7,954	4,298	3,194	322	-784
	Poquoson	422	525	853	988	378	275	-53	-188
	Williamsburg	0	0	0	0	0	0	0	0
	York	1,353	1,800	3,083	3,571	2,982	2,535	1,252	764
Southside	Chesapeake	2,655	3,480	6,880	7,951	12,672	11,847	8,447	7,376
	Isle of Wight	335	447	858	981	1,618	1,506	1,095	972
	Norfolk	3,055	3,978	7,797	8,936	19,302	18,379	14,560	13,421
	Portsmouth	1,143	1,512	2,933	3,411	2,228	1,859	438	-40
	Suffolk	843	1,114	2,223	2,558	6,057	5,786	4,677	4,342
	Surry	49	68	130	149	1,601	1,582	1,520	1,501
	Virginia Beach	4,378	5,883	11,960	13,773	5,477	3,972	-2,105	-3,918
	TOTAL	24,540	32,549	60,382	69,742	75,259	67,250	39,417	30,057

Summary

- RtePM, the current model, is a tool used to estimate evacuation clearance times. It is a macro-level analysis and provides an overview for a range of inputs and assumptions.
- For Virginia, 104 scenarios were simulated using RtePM to determine regional evacuation clearance times for an array of parameters.
- A shelter vulnerability and shelter demand analysis was conducted to provide a summary of where potential deficits may occur in different evacuating and participating conditions.
- Review and consideration of shelter demand vs. capacity should be refined for future planning efforts.
- Static maps are useful to a degree, but with the use of ArcGIS Online, dynamic mapping, and VA's Know Your Zone initiative, there is a potential to better inform the public that leverage already adopted technology (i.e, existing NOAA efforts)