

Hampton Roads Hurricane Evacuation Plan

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Hampton Roads Hurricane Evacuation Project

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Abstract

In this project, Hurricane Evacuation Geodatabase based on Virginia Department of Transportation evacuation plan as well as based on Storm Surging Area was developed in ArcGIS. The required evacuation time for major evacuation corridors was estimated by considering the corridor capacity and number of evacuation vehicles assigning to these corridors. The performance of the evacuation plans was measured and recommendations were given.

Purpose and Scope

The purpose of this project is to develop hurricane evacuation plans in ArcGIS and evaluate the performance of these evacuation plans. Based on the visualization of the evacuation plan and analysis of the necessary evacuation time, the governments, emergency agencies and residents of Hampton Roads would be able to have better preparation when facing the threat of hurricanes during hurricane season.

It is evident that the storm surge is the most deadly cause of life and property loss. Therefore, the evacuation plan developed in this project was mainly based on storm surge.

Data Collection

Four major GIS data was collected from different sources. The shape files of counties and cities were obtained from VaCounties, which is archived in GEOSTACKS. The shape files of the census tracts were downloaded from the Tiger Data. The census table containing number of vehicles in each census tract were downloaded from <http://fisher.lib.virginia.edu/collections/stats/census/#SF3> and converted from excel table to database table in ArcGIS. The local street network was obtained by merging the roadway network shapefiles of all the

counties and cities within the study area. The storm surging area shape files were provided by US Army Corps of Engineers District. The elevation DEM data was downloaded from the American fact finder website.

Dedicated evacuation routes and evacuation area were obtained from Virginia Department of Transportation (VDOT).

Map Development

The Hampton Roads Area includes 23 counties and cities. These counties and cities were selected from the 'vacounties' shape files and exported to form Hampton Roads Counties Layer. A new field named CountyName was created in Hampton Roads Counties Layer in ArcCatalog. The names of the counties and cities were input manually.

The census tracts within the study area were obtained by applying spatial joint of US census tracts Layer with the Hampton Roads Counties Layer.

In the process of selecting the fields for downloading the census data containing number of household vehicles, the number of total, self-own and rent vehicles for each census tract was stored in the fields of H046001, H046002 and H046003 respectively, but defined as text data type. The Vehicles table was appended to the attribute table of 'HRcensustracts' Layer based on the census_tract in Arctool box. Then the new Hampton Roads Census Tracts layer was created and named as 'HRcen_vehicle'.

Next, five more fields were added in the attribute table of 'HRcen_vehicle'. They are 'Total_vehicle', 'Own_vehicle', 'Rent_vehicle', 'Demand' and 'Evacuation_Route'. 'Evacuation_Route' was defined as text data type while the other four were Long Integer. The 'Total_vehicle', 'Own_vehicle', 'Rent_vehicle' were calculated based on H046001, H046002 and H046003 respectively and just converted the text into integer.

By Reading the VDOT evacuation plan, the census tracts that need to be evacuated during Phase I and Phase II were determined. The Suggested evacuation route for each census tract was also approximated by reading this document. Then the evacuation route was manually input into the field of

'evacuation_route' in 'HRcen_vehicle' layer. Once the 'evacuation_route' was finished, the demand of each evacuation highway can be determined by calculating the statistics about the sum of 'total_vehicle' by 'evacuation_route' and input into the 'demand' field. The census tracts need to be evacuated during phase I and phase II were exported to two other files named 'Phase I' and 'Phase II' respectively.

Although many streets were considered as part of the evacuation routes, the traffic eventually enter six major arterials: I- 64, US 58, US 460, PR 10, PR 143 and US 17. As we all know that the capacity of these highways as well as I- 664, I-264, etc. within the Hampton Roads Metropolitan Area is sufficient because most of them are four-lane highways in one direction. However, bottle net is also predictable when these highways enter the western rural area and the number of lanes was reduced to two lanes in one direction. Therefore, the capacity of the highways during hurricane evacuation is mainly determined by the rural part of the highways. The number of lanes of I- 64, US 17, PR 143, PR 10 and US 58 used in this project was 2 to represent this consideration. US 460 has been expanded to four-lane highway to the west of Richmond. Therefore, the total number of lanes of US 460 is defined as 4 in this project. It is also noted that among the five two-lane per direction highways, only I- 64 is interstate highway, which makes it possible to reverse I- 64 Eastbound to double the capacity and accelerate the evacuation. It was also important to adopt different values of capacity per lane for different types of highways. The capacity of 2400 vehicles per lane per hour was used for Interstate Highway and 2000 vehicles for other arterials.

There is no readily available street network for the entire Hampton Roads Area. As a result, the street networks for all the counties and cities of this area were obtained and merged to form the Hampton Roads Street Networks named 'roads'. Then the evacuation routes specified by VDOT was selected and exported to a new layer 'EvacuationRoute'. Similarly, another file named 'EvacuationTime' is formed by simply copying the layer file of 'EvacuationRoute'.

Then four fields were added into 'EvacuationTime': 'number of lanes', 'PhaseI_time', 'Phase_II' and 'EvacuationTime_StormSurge'.

Then, join by attribute was applied to join the 'EvacuationTime' and 'Phase I' based on 'Route_Name' and 'EvacuationRoute'. The 'PhaseI_time' in 'EvacuationTime' can then be calculated by $\text{PhaseI_time} = \text{Demand} / \text{number of lanes} / \text{capacity per lane per hour}$. Since I- 64 eastbound will be reversed during emergency evacuation. The above equation will be further divided by 2 for I- 64. Similar procedure was carried out to obtain phase II.

After completing the analysis on the VDOT evacuation Plan, the evacuation strategy solely based on the storm surge affected area was performed. The census tracts that need to be evacuated were obtained by spatial join with the surge area of Category 2, 3 and 4 hurricanes. It was found out that although the affected area of different categories of hurricane is different, the affected census tracts remain the same. Thus, the evacuation plan based on storm surge was performed only once by assuming that all the residents are required to be evacuated under the threat of a category 4 or above hurricane. It is a reasonable assumption because the evacuation demand will put the heaviest burden on current highway facilities in this circumstance.

Finally, the Dem data reflecting the elevation was obtained. Each county or city contains about 5 to 10 Dem data. All of this data was converted into raster data first. Then the raster data for entire area was created by using mosaic raster data in ArcToolbox. Then the raster data was further converted into TIN data.

The corresponding Geodatabase was created. A simple 3D scene as well as a series of thematic maps was created to illustrate the affected area and evacuation plan. The summary table of the evacuation plan was summarized in 'Sum_vehicle_storm_surge', 'Sum_vehicle_Phase_I' and 'Sum_vehicle_Phase_II'.

Findings and Recommendations

It is interesting to see that the VDOT evacuation plan neglect some census tracts in Mathews, Gloucester and Middlesex that are under the threat of

storm surge. In VDOT's evacuation plan, it is stated the evacuation begins 24 hours prior to the onset of tropical storm force winds. The second phase will begin 14 hours prior to the onset of tropical storm force winds. However, it was shown that only the residents within phase I area were able to evacuate in 24 hours due to the limitation of the roadway capacity. It is also important to allow enough time for VDOT to reverse I- 64 Eastbound before the evacuation starts. Due to the recent development of the southern part of Hampton Roads area such as Chesapeake and Virginia Beach, the growth of the population resulting in longer evacuation time in US 460 and US 58. Different assignments of the evacuation route for different census tracts were tried. The final map shows a relatively balanced assignment. In long term, it is recommended to upgrade the US 460 or US 58 to interstate level so that the populated area of southern Hampton Roads can be evacuated promptly. It is also recommended to expand the local street network of Chesapeake so that people can have more convenient access to US 58 and US 460.

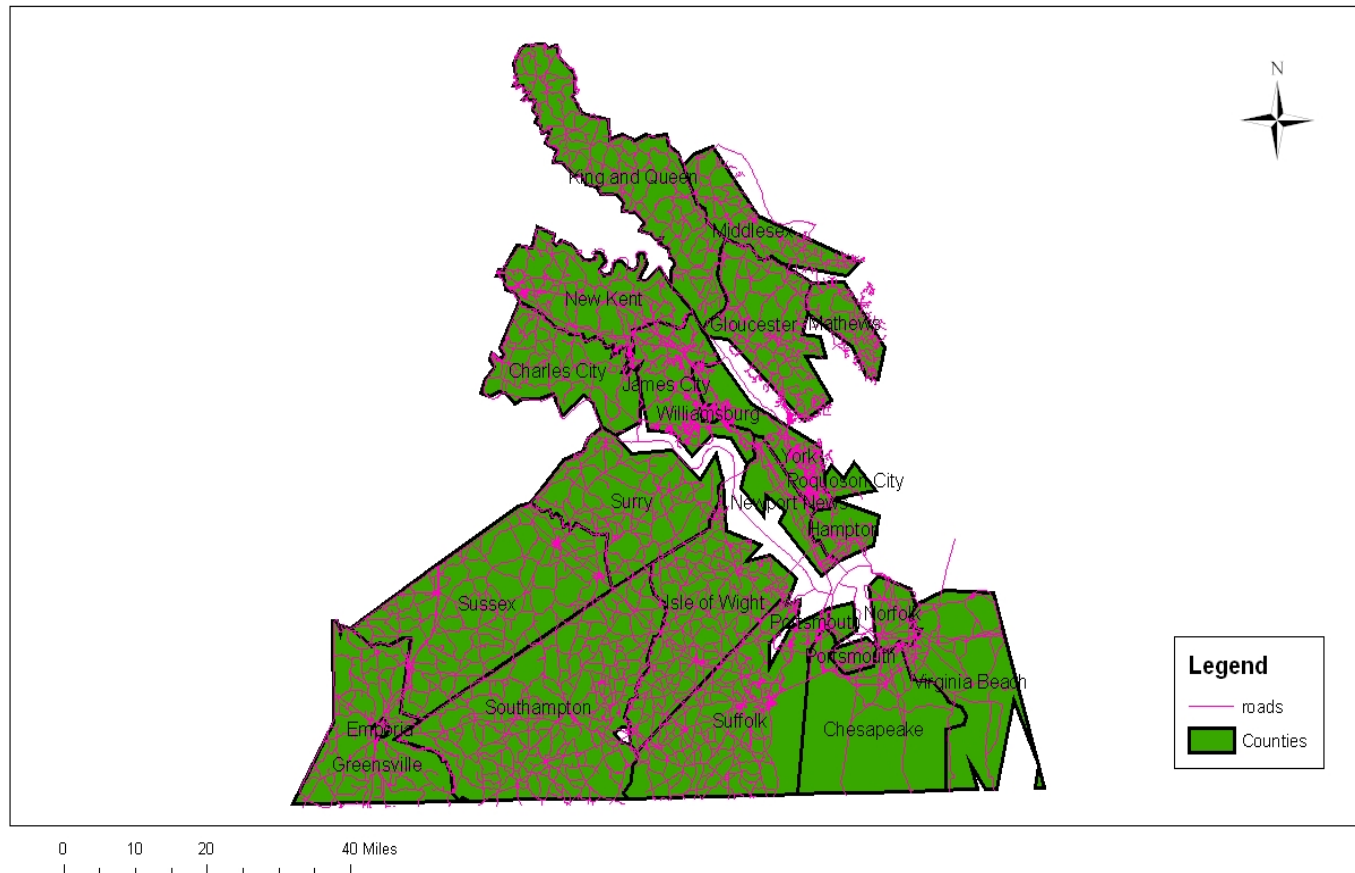
The general version of ArcGIS is more appropriate for planning as what has been done in this project. Although it does not provide the lane specific roadway, the analysis results of this study can be applied into traffic simulation software to perform more detail operation analysis.

Reasons for the topic

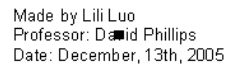
- ✦ Great loss in Katrina
- ✦ Panic and chaotic evacuation during Rita
- ✦ More detail evacuation plan is needed for Hampton Roads
- ✦ Serve as groundwork for operation analysis

Hampton Roads Jurisdictions

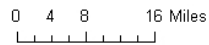
Hampton Roads Local Street Network



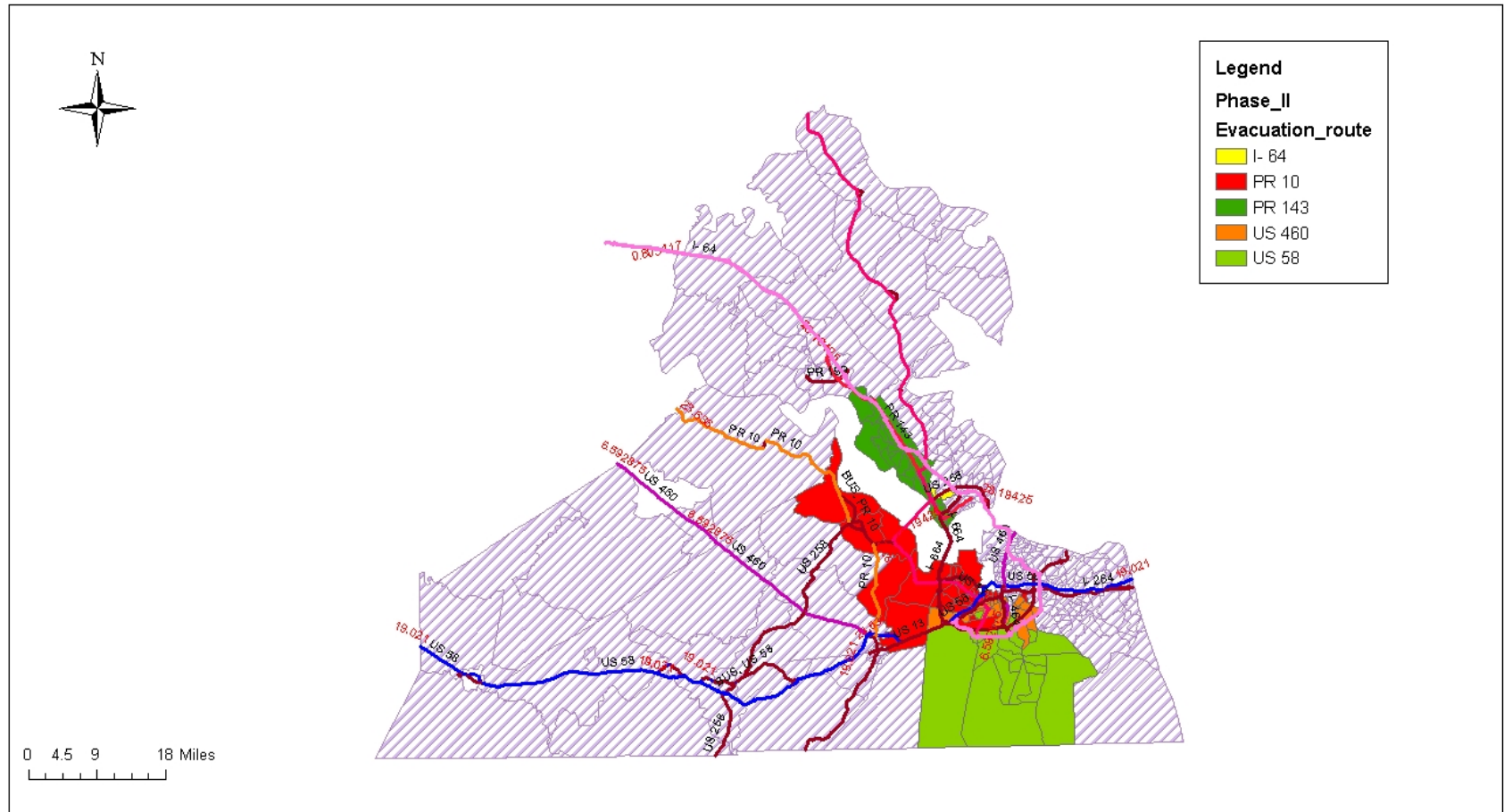
Evacuatioin Routes and Hampton Roads Census Tracts



VDOT Hurricane Evacuation Plan Phase I

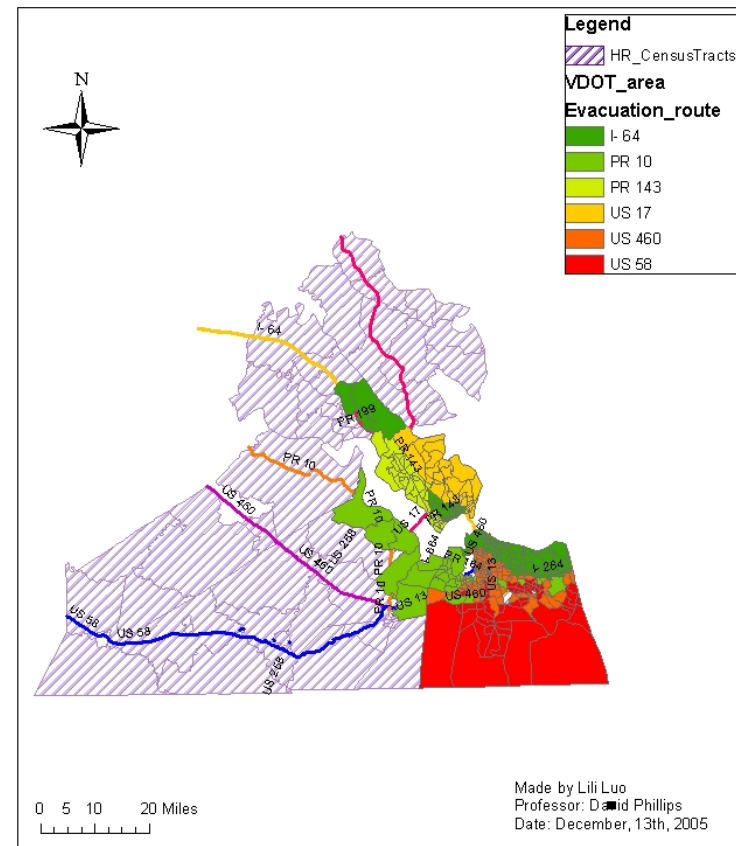
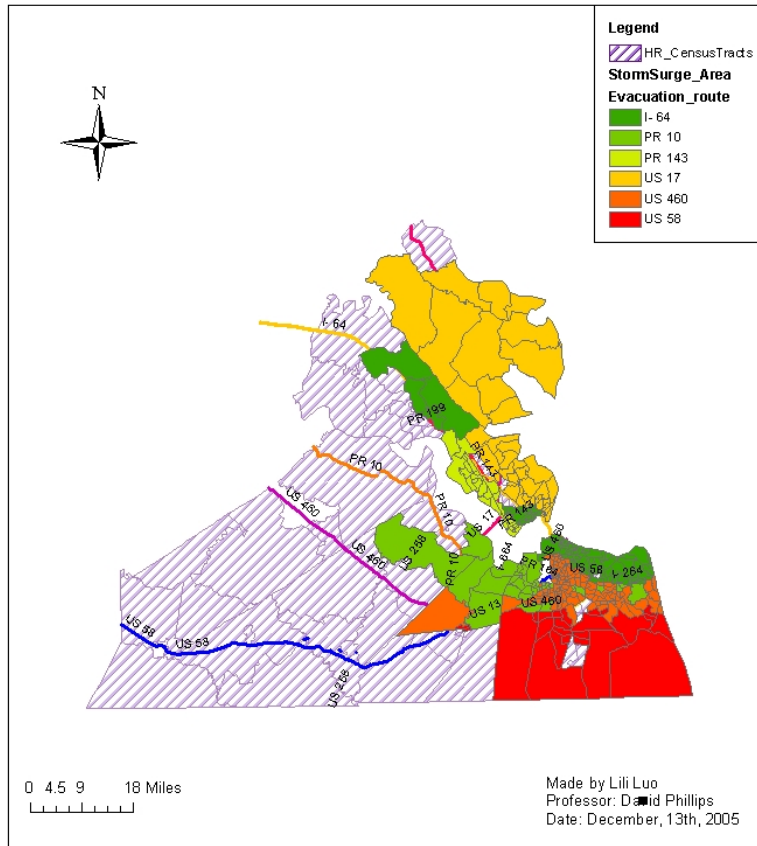


VDOT Hurricane Evacuation Plan Phase II

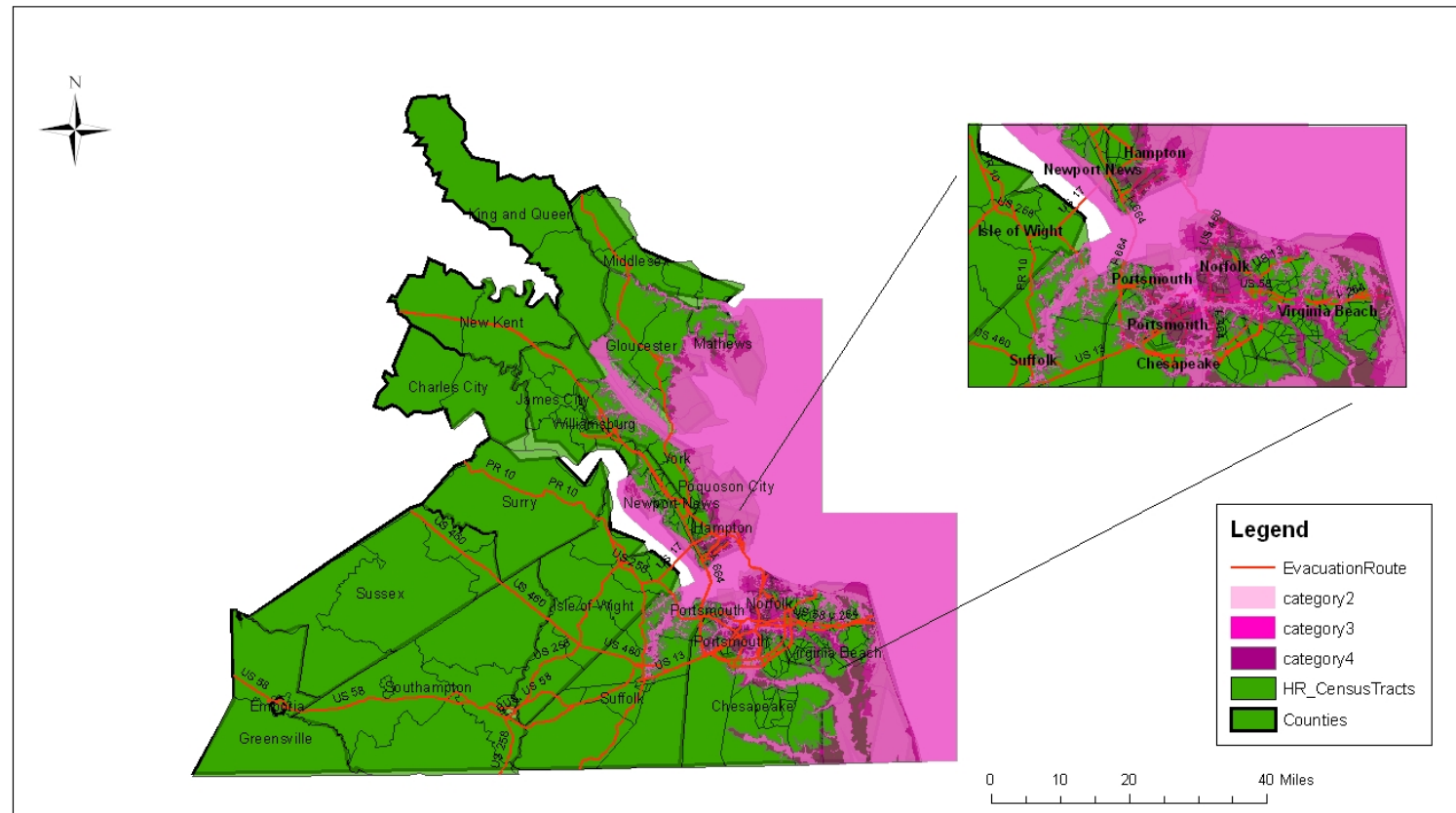


VDOT Plan Vs. Storm Surge Plan

Affected Area Of VDOT Plan VS. Storm Surge Plan

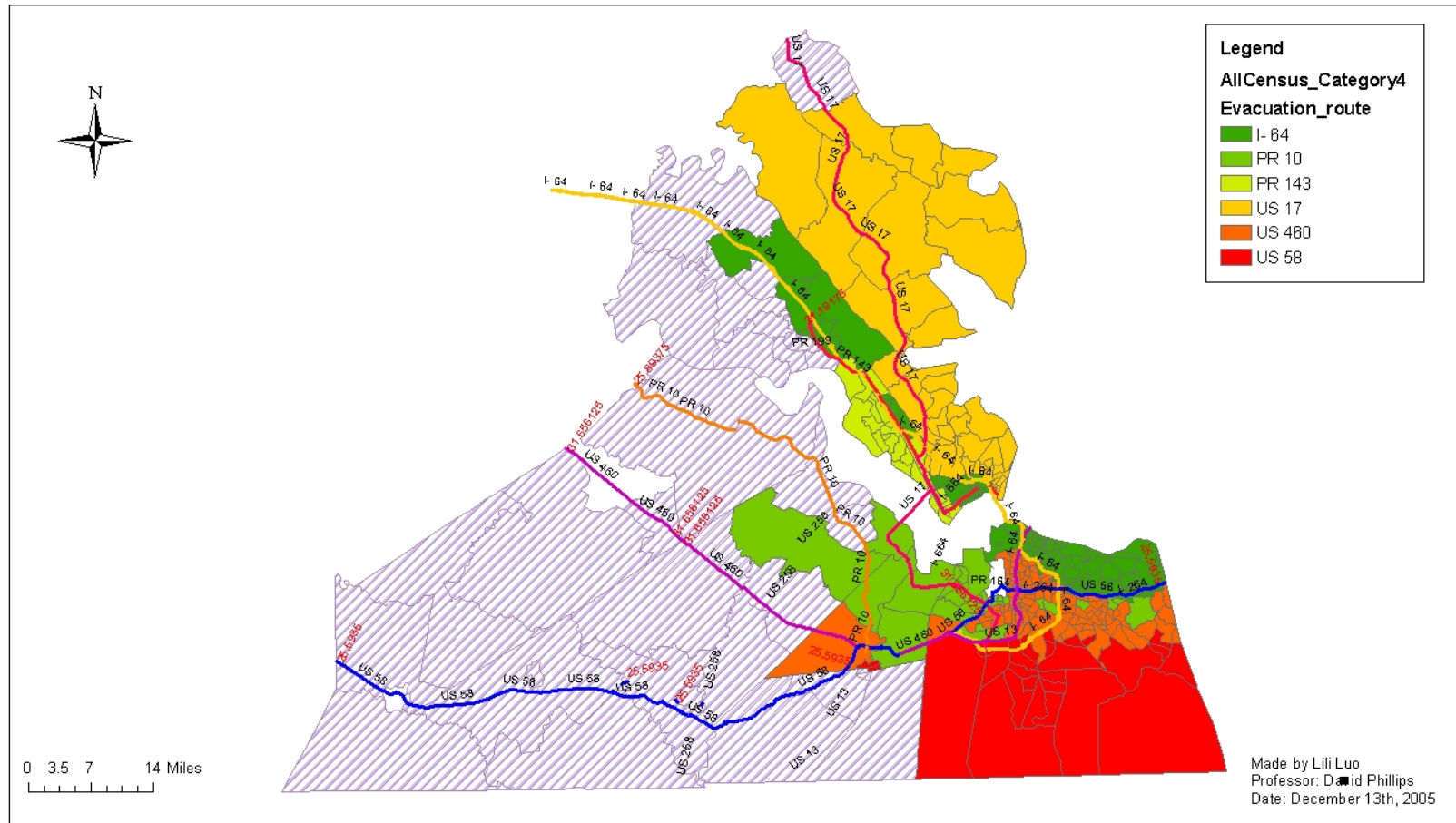


Hurricane Storm Surge



Storm Surge Plan

Hurricane Evacuation Plan Based On Storm Surge



Recommendations

- ✦ 48 hours prior to the onset of the tropical winds are required if the entire population is evacuated
- ✦ Careful assignments are required to balance the demand and capacity
- ✦ In long term, upgrade the US 460 or US 58 to interstate highway
- ✦ expand the local street network of Chesapeake