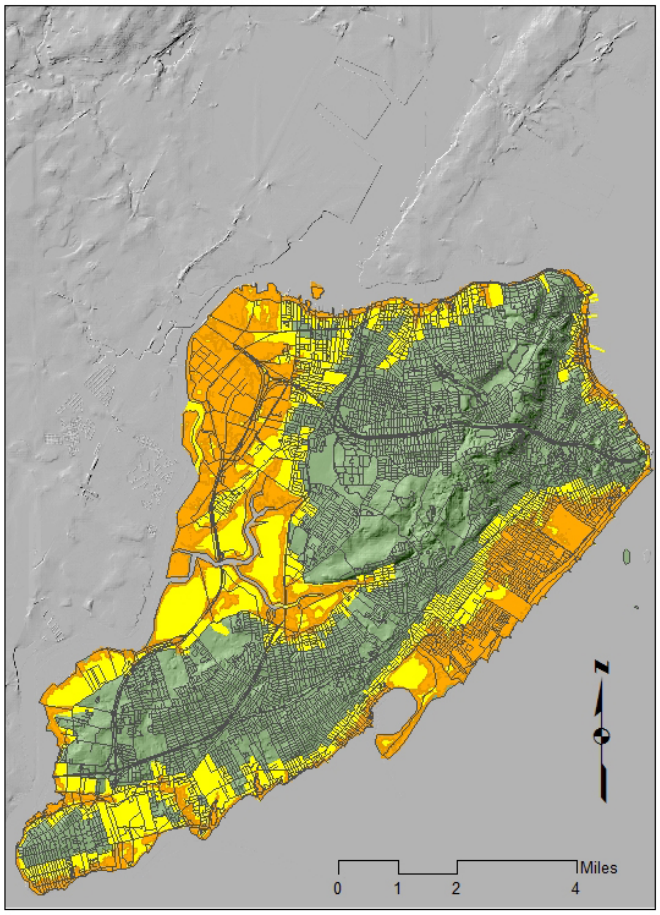
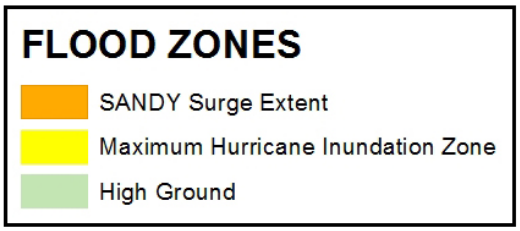
GO TO HIGH GROUND REPORT





Prepared by the College of Staten Island/City University of New York
on behalf of
The Governor's Office of Storm Recovery

September 2017

GO TO HIGH GROUND (GTHG) REPORT

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on behalf of the Governor's Office of Storm Recovery

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FINAL REPORT

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Executive Summary

Low-laying, coastal areas in New York City are in hurricane evacuation zones. Staten Island is one of the most vulnerable parts of the city with respect to hurricanes. Therefore people on Staten Island need to be prepared and able to adopt the most effective strategy for surviving a hurricane: moving to high ground. This report describes various issues surrounding how this can be done, focusing primarily on moving vehicles to safe and appropriate parking spaces on the high ground of Staten Island.

Going to high ground, early, is your best and only option in a hurricane. Get in your car and go as soon as you are ordered to leave. This simple statement of strategy is the overarching theme of this report. Hurricanes are very dangerous events and there is no fail-safe method to avoid the risks they pose except to get away from them as quickly and as soon as possible. On Staten Island the car is the travel mode of choice for most residents and high ground above storm surge zones is the safest place to go.

The following ideas and recommendations are offered.

(1) Signage. Content and placements of signs on the Island have been changed as a result of both this effort and a study of fatality patterns during Sandy. For example, there are now two signs in Tottenville whereas before there were none (two people died in Tottenville during Sandy and hence a need for signs in that area was determined to exist.) Signs also used to direct Staten Islanders to routes parallel to flood zones, while now they direct people away from flooding and towards high ground. Figures 1-1 and 1-2 show the changes to sign content. Before and after sign location maps here are provided in Figure 1-3.

As for possible future changes, signs could be added to indicate when people have actually reached high ground; flood gauges or other signage could indicate where flooding risk is present so people incorporate this into their general knowledge during “blue-sky days”; and electronic signs could be programmed to indicate various stages of hurricane watch, warning and evacuation.

(2) Wayfinding. Signage is only one form of wayfinding. Communication mechanisms are part of a wider portfolio of methods that can be both redundant to each other in the case of failure in one part of a system and also reinforcement for one another to ensure people get the information they need when they need it. Maps, directions, and other information about origin routes and destinations is another major and important tool. NYCEM already continuously updates its maps, but consideration should be given to: development of an internet or smartphone app, or use of an existing app, to make all this immediately accessible; greater use of cellphone broadcast texts (as currently used by the National Weather Service, for example); and regular public service announcements on radio and television.

(3) Parking. If vehicles are to be moved out of flood zones, they must also have a viable and legitimate place to be parked. This effort has identified and mapped out physical parking spaces that currently exist on Staten Island high ground and has simulated and modeled traffic movements to parking spaces once travelers have reached high ground. (This represents the other half of the evacuation journey out of low ground that has been

extensively modeled by NYCEM). Staten Island fortunately has a good deal of high ground, relatively close to Emergency Zones and with enough physical space on that ground to accommodate one evacuating vehicle per household.

However, there are many legal, institutional and planning issues to be worked out to ensure that these spaces are viable and available during an emergency. These include working out "good neighbor agreements," where private parking spots (such as those of a church or shopping mall) are offered for emergency use with liability, security and other issues worked out in advance; creative use of "dead space" for emergency parking (such as space around un-used government buildings); and dynamic tracking of parking capacity over time with real-time information provided during emergencies to ensure people know where available spaces are and which one is best suited to their circumstances. Actual development and implementation of such an effort is a major undertaking but technology for it is potentially available and work towards this goal should begin as soon as possible.

(4) Traffic movements on high ground. Staten Island is a densely populated borough with a road network that can be at, or over, capacity during the best of times. It is also a place where people will overwhelmingly rely on their vehicles to move to safety and where viable and timely transit alternatives are often unavailable. NYCEM analyzes clearance rates from evacuation zones. The first critical task in a hurricane is to ensure vehicles leave flood zones in the first instance, i.e. get clear of the danger. Using conservative assumptions NYCEM has modelled evacuation scenarios that indicate that with early evacuation, people can get safely away from storm surges in an emergency.

This study used that analysis and then examined and modeled the other side of the evacuation journey by modeling the traffic flows and bottlenecks that might occur once vehicles reach high ground. In other words, while NYCEM is rightly concerned with ensuring vehicles get to safety, this study looks at whether those vehicles will be able to reach a parking space once they are out of immediate danger. Taken together the two models – NYCEM clearance rates from evacuation zones and this effort's modeling of bottlenecks, clearance, and parking on high ground – provide a complete picture of the traffic and parking situation on Staten Island during a hurricane. There are bottlenecks and issues around high-ground parking that need to be considered for the future. But provisionally the analysis suggests that early and orderly evacuation and parking of cars and movement to final sheltering locations can be accomplished, with proper advance planning.

(5) Educating the public. The primary task for any outreach is to convince all people of the deadly nature of hurricanes and motivate them to follow evacuation orders immediately. Having impressed upon people the imperatives of following evacuation orders quickly, they must then be informed of what they need to do when a hurricane comes, and how to access needed information, especially about evacuation routes and parking options. Key information to transmit includes clear and up-to-date evacuation route maps, real-time information about traffic conditions and parking availability, and simple elaboration of steps to follow in an emergency. Not to be ignored is the provision of people with basic items, such as flashlights, that can be readily accessed and taken with them in an evacuation. For this effort a number of means were developed to accomplish these goals tailored to the unique context of Staten Island. Brochures, social media, websites, pre-K – 12 outreach, education fairs, curriculum materials and field trips have all been created and are continuing to be rolled out.

There is also a distinction between the general population and those with particular needs and characteristics that might affect the motivation and ability to move to higher ground when a storm comes. Elderly residents and those with limited mobility, hearing and low vision issues and disabilities and access and functional needs may need assistance in evacuation as may require additional care. A separate focus on Staten Island vulnerable populations has been part of the current effort with preparation of a guide for populations with special needs that also provides a lanyard of emergency supplies to meet those needs. Materials such as these have not just been produced but have been disseminated through various workshops and events.

(6) Understanding risk. It is important to emphasize the difference between safety and relative risk. No policy or strategy is ever completely 100% safe. Rather, an action taken changes the relative level of risk faced. Evacuating to high ground considerably lessens the risk of injury or death during a Hurricane but does not eliminate the risk. Similarly, remediation measures lessen but do not remove danger. Thus public education needs to communicate the fact that even if storm barriers, such as seawalls, are in place, these are not fail-safe and people must still evacuated when ordered to do so. Terms such as 'one hundred year storm' may misleadingly suggest that once such an event has occurred people are safe for the next hundred years. Alternative terms such as "1 percent storm" should be considered instead.

(7) Interagency coordination on parking. New York City already has a time-frame for hurricane planning and evacuation. For Staten Island (and perhaps other areas of the City) a similar framework is recommended for parking. There might be a planning subcommittee, or committee on Staten Island, that convenes as soon as a particular storm time point is hit, mobilizing to put out the needed public information, coordinating permissions to park and so forth. This effort, of course, would be ideally integrated closely with larger storm response across government and with other organizations. The creation of a Vehicle Evacuation Liaison as a key point of contact and coordination should be considered. The details of the exact structure, e.g. which is the best lead agency and the specifics of changes to agency policies, need to be worked out at a policy level.

(8) Covering the costs of parking. Even if publicly planned, parking provision need not necessarily be publicly managed but could be sourced to a private entity or partnership. There is a well evolved network of responsibilities and capabilities for evacuation and emergency management which must be extended to parking. Government can engage local business owners with a consensus list of parking lots, and canvass business owners on their openness to providing their lot for use during an evacuation.

And who should pay the costs? There is, in fact, a continuum of funding and financing possibilities, ranging from purely public (e.g. having a clear government reimbursement schedule for private costs incurred or having direct public provision of parking services) to purely private (e.g. every parking cost incurred by private parties is out-of-pocket) with various hybrids in between (e.g. some kind of public-private partnership for provision of high ground parking places during a storm).

(9) Community and stakeholder engagement and the need for a government champion. Overall planning for hurricanes in New York does not consider parking because this is

generally a private affair and because in many areas of the city evacuations will be primarily done on foot or by transit. Staten Island is different from many parts of the City because of its dependence on cars which makes parking a key component of any evacuation. Coordination and planning of parking during an emergency needs to take place on a system-wide level. A governmental champion is essential. The continued support of the Governor's Office is obviously critical. In addition there needs to be ongoing follow up through the Staten Island Borough President's Office, the Island's legislative representatives, and the City of New York, working with community and civic groups, creating a sense of urgency and making a continuing commitment of time, attention and money on planning for the next storm, when it comes. As it will. But next time, hopefully, the result will be an orderly and timely movement of cars and people with minimal loss of life and injury.

Introduction

Low-laying, coastal areas in New York City are in hurricane evacuation zones. Staten Island is one of the most vulnerable parts of the city with respect to hurricanes. Therefore people on Staten Island need to be prepared and able to adopt the most effective strategy for surviving a hurricane: moving to high ground. This report describes various elements of how this can be done.

In terms of geography, New York City is extremely vulnerable to hurricanes because of the nearly right angle in the coastline between Long Island and New Jersey. Hurricane winds are counterclockwise in the northern hemisphere and any hurricanes such as Sandy striking the New Jersey coastline at a right angle will put the city in the northeast quadrant of a storm. There hurricane winds and forward speed combine for maximum storm surge. Staten Island is in the apex of this quadrant and thus especially vulnerable.

Hurricanes present various storm hazards. These include storm surges before the hurricane makes landfall; pre-landfall rainfall flooding; flying debris; and falling trees and power lines. This report focuses on storm surges which are what trigger hurricane evacuation orders. The effective response always is to leave vulnerable areas well before the storm hits and get to adequate and safe shelter.

This report focuses primarily on moving vehicles to safe and appropriate parking spaces on the high ground of Staten Island. Some related issues, such as what constitutes safe shelter during a storm, will be touched upon as they relate to evacuation and parking. Substantive discussions of such aspects however remain beyond the scope of this report and readers are referred to more authoritative sources as needed.

There are several ways in which this report has a different focus than the many other studies of hurricane response in New York City and in the US.

(1) A Staten Island focus. Staten Island has many unique characteristics relative to the other boroughs of New York. In particular people overwhelmingly will evacuate using their own personal automobile. They also will be very likely to go to friends and family rather than a shelter. Finally, Staten Island has a relative abundance of high ground fairly close to flood zones in a relatively compact space.

New York City Emergency Management (NYCEM) has a gradation of Evacuation Zones, running from Zone 1 through Zone 6, ranked in order of degree of storm surge flooding, with Zone 1 being the highest. Getting to high ground is always the imperative, but the extent and timing of NYCEM evacuation orders and priority depends upon which zone you are in. For these reasons Staten Island's situation merits separate investigation suited to its particularities in an emergency. (See Figure 0-1; areas outside of the specified evacuation zones are on high ground).

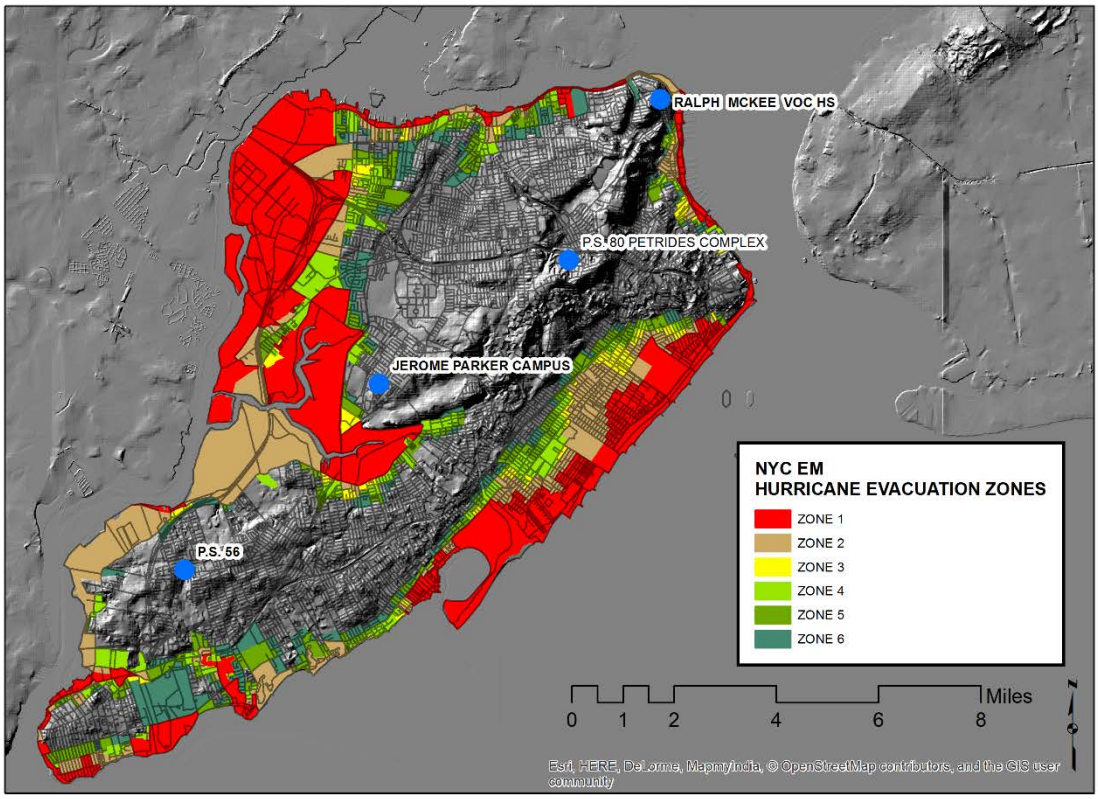

Figure 0- 1: High Ground on Staten Island. (Note: specified evacuation centers are subject to change).

(2) A focus on moving vehicles rather than people. Of course saving lives is the imperative in any evacuation. For most Staten Islanders moving their personal vehicles will be the means to this end. If the vehicles cannot be moved -- and, almost as important, if they cannot be sustainably parked when they reach high ground -- then lives could be put in jeopardy. This will be the core element of analysis here, distinguishing it from other studies that look at things such as public shelter issues and transit planning. Where relevant these dimensions will be touched upon. But Staten Island's unique circumstances dictate an emphasis on vehicle movement and parking before, during and after a hurricane.

(3) *Going to high ground, early, is your best and only option in a hurricane. Get in your car and go as soon as you are ordered to leave.* This simple statement of strategy will be repeated throughout the following chapters. Hurricanes are very dangerous events and there is no fail-safe method to avoid the risks they pose except to get away from them as quickly and as soon as possible. On Staten Island the car is the travel mode of choice for most residents and high ground above storm surge zones is the safest place to go. (Granted not everyone evacuating will have access to cars and will require alternative accessible means of

egress; but on Staten Island 84% of households own at least one vehicle and most will be using it to leave.[i] Also, residents can enter their address into the NYCEM website, https://maps.nyc.gov/hurricane , and get specific guidance on whether an order has been issued for the Zone and how to evacuate by non-auto transportation modes, such as on foot).

All this is relative of course: winds and high rains from hurricanes can cause damage any place during a storm. But staying in low lying areas affected by storm surge is definitely extremely hazardous. The analysis presented here will be built around this core survival regimen.

In general, residents who live in flood zones need to know that they must make plans to move their cars and evacuate immediately. They also need to know that they will have a place to park their car when they get to high ground and should have a definite plan of where they will shelter (e.g. with a close friend or relative living at higher elevation). That place of shelter should not be the vehicle, except as a total last resort. As always human life takes precedence over property loss, which is why it is so important to leave as soon as ordered to do so.

The rest of this report will consider these specific challenges faced by Staten Islanders. The dimensions of the challenges will be described and analyzed and ideas for possible solutions will be presented.

Chapter 1 - Framework development for way-finding signage program and conceptual parking plan

Going to high ground, early, is your best and only option in a hurricane. Get in your car and go as soon as you are ordered to leave

When a hurricane hits Staten Island, most people will have vehicles and thus will be evacuating through the use of their personal automobile. Although only 1.4 million households in New York City out of the total 3.0 million in 2010 owned a car, 84% of Staten Island households own at least one car, bringing it much closer to the US national average of 92%.[ii]

For this chapter there are thus three key issues to consider:

(1) Signage, i.e. content and placement of road and other signs to effectively guide people during an emergency
(2) Wayfinding, i.e. how to guide people to high ground;
(3) Parking, i.e. where to put cars on high ground in legally, institutionally and practically viable way.

New York's hurricane evacuation plans are based on storm surge inundation rather than wind or rainfall. This report follows this convention by focusing on that dimension. Other storm hazards will, however, be touched upon as relevant.

(1) Signage

The general challenge of signage is to have signs that direct people properly, clearly and effectively. There must be signs in the first place, but they also must be placed in the right locations, contain the right information, and be presented legibly and clearly.

Practice from around the country offer some ideas about signage design and placement. Keep in mind that everything is contextual. Ideas that may be good in one locale may not be effective in another. With that said, suggestions from academic literature and best practice include:

- Make signs stand out, e.g. making evacuation route signage larger or of a different color or with a specific insignia from nonemergency signs.
- Lead in a direction away from danger. In the case of hurricane storm surges, people need to be directed away from flood zones and towards high ground.
- Include other useful information as helpful, e.g. mileage to locations.
- Make signs 'active'. Signs might incorporate flashing lights when active. Flip signs also might be employed -- though they should be flip-up rather than flip-down since the latter can come down accidentally.
- Place signs at key locations. Secondary roads might require signage just as much as primary evacuation routes to ensure people get to where they are supposed to.
- Have additional languages as needed.
- Avoid sign clutter. Too much information can be as deleterious as too little especially

in an emergency when people are rushed and distracted and worried. This applies both to the information presented on the emergency sign and to its placement amongst other signs. There may be cases where there needs to be a modification of the number, type and placement of existing signage to ensure emergency signs can be clearly read and followed. Of course sign design must comply with the US Department of Transportation Manual on Uniform Traffic Control Devices (USDOT MUTCD).[iii]

- Interrelate to other transportation modes. Transit may be a major egress mode for many people and there should be appropriate signage for this as well as roads. The design is critical, and relates to public education. In Miami, for example, although transit evacuation pickup points are clearly marked, few people used them in recent storms, perhaps because of concerns about where they would be taken to.
- Leverage off of other emergency signage, where applicable. Some cities, for example, put up hurricane signs along well known and established snow or other emergency routes.
- Have signs indicate when people are in a danger zone and when they have left a danger zone. Oahu in Hawaii does this for tsunamis, for example. A related alternative is to indicate crossings into different levels of danger; in New York this could be when one has passed from one Emergency Zone in to another.
- Encourage consultation with other real-time sources of information such as emergency radio and present information about how to do this.[iv]

One key element not indicated above is whether signs should direct people to specific locations. Prior to this effort, evacuation signs on Staten Island directed people to evacuation shelters. However this can discourage people from evacuating to places better suited to their individual circumstances, such as staying with families and friends. Also, shelters may be overwhelmed in some instances if everyone goes to one place (although on Staten Island shelter capacity is overall presently adequate).

Additionally, Staten Island signs prior to this effort marked escape routes that often ran parallel to the flood zones rather than away from them. Now, NYCEM has redesigned signs to move people to high ground in the first instance (Figures 1-1 and 1-2). Thus signs on Staten Island now have clear direction to high ground. This strategy is tailored to Staten Island's unique topography, where there is lots of available high ground.

Figure 1- 1: Example of evacuation sign on Staten Island prior to study

(Photo by A. Benimoff)

Figure 1- 2: Example of evacuation sign on Staten Island after study

(Photo by A. Benimoff)

Placements of signs on the Island were also changed as a result of both this effort and a study of fatality patterns during Sandy. For example, there are now two signs in Tottenville whereas before there were none. Two people died in Tottenville during Sandy and hence a need for signs in that area was determined to exist and was addressed. Before and after sign location maps here are provided in Figure 1-3.

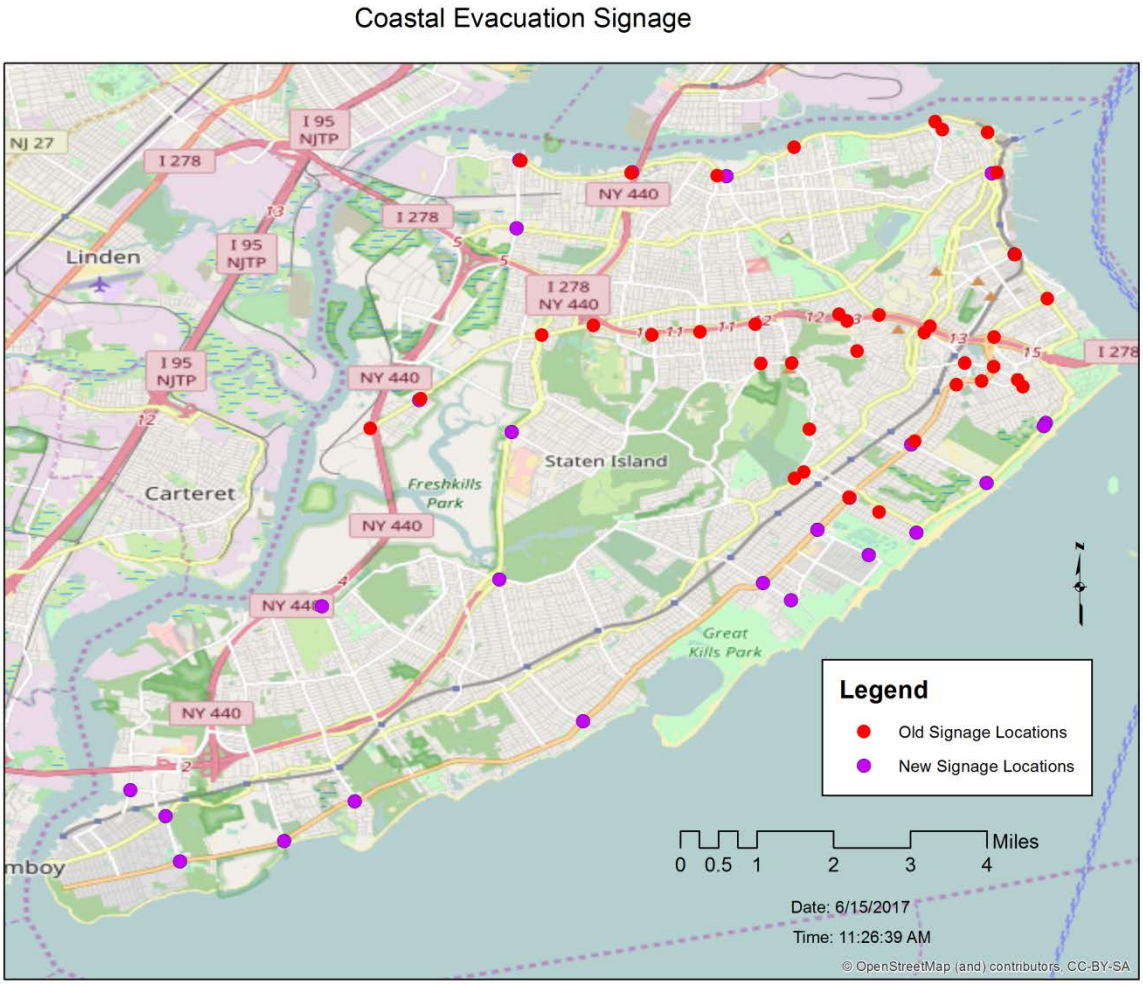

Figure 1- 3: Old and new placements of hurricane evacuation signs on Staten Island

There are institutional constraints to changing sign design and locations. As noted above, the Federal government has specifications for sign design[v]. In New York, the New York City Department of Transportation (NYCDOT) determines placement of the signs. A more general discussion of interagency coordination will be presented in Chapter 4.

This is the current state of affairs. One thing to consider going forward is how people know when they have reached safety and how to find their final parking destination (or other place) when they get there. The expectation of NYCEM is that people will plan their trip prior and that signage will help guide drivers accordingly. People might need to have more specific

guidance than this though and possibly more signs would be helpful. NYCEM is considering using initial and terminal signs starting in evacuation zones and ending inland.

Signs could also indicate the numbers of Hurricane Evacuation Zones (e.g. EZ1) as a way of showing relative danger that people are in. However not everyone knows what Zone numbers mean. Some localities have signs showing roads not to take, as well as routes to follow. Others use staff gauges at known flooding locations to inform citizens of the depth of the flood waters that a particular road is subject to, or simply providing a warning that flooding is possible. (See figures 1-4 through 1-7).

Electronic signs, with real-time updates, are another possibility. On Staten Island the electronic signs on I -278 could be programmed to include messages such as “Hurricane approaching NYC area”, “Hurricane watch in effect”, “Hurricane warning in effect” or “Evacuation order in effect”, as appropriate. (Figure 1-8 provides an example from Texas). Additional electronic signs could be placed hazard prone corridors such as along Father Capodanno Boulevard. However these signs could be subject to power interruptions. As already mentioned there is a current regulatory and institutional setting that must be considered in making such changes. These ideas may or may not be useful on Staten Island but should be investigated going forward.

Figure 1- 4: Hawaii Tsunami Area Entry Sign (Big Island of Hawaii)

(Photo by A. Benimoff)

Figure 1- 5: Hawaii Tsunami Area Exit Sign (Big Island of Hawaii)

(Photo by A. Benimoff)

Figure 1- 6: Flooding staff gauge (near Kingston, NY)

(Photo by A. Benimoff)

Figure 1- 7: Flood warning sign (near Austin, TX)

(Photo by A. Benimoff)

Figure 1- 8: Electronic Signage in Texas

(2) Wayfinding

Signage is only one form of wayfinding. Maps, directions, and other information about routes, origins, and destinations, are other major and important tools. Most localities have maps showing emergency routes. Just as signs should be clear, have useful information, be helpful and effective, and be in places where they need to be, wayfinding information needs to do the same. People must also be motivated on a continual basis to follow directions and avoid known hazards (Figure 1-9 provides an example).

Figure 1- 9: New York State Department of Transportation advertising campaign

NYCEM continuously updates its maps and these are readily available on their website (https://maps.nyc.gov/hurricane). This site includes the Hurricane Zone Finder, where residents can type in their address to see what zone they are in. Other governmental agencies offer similar maps and information. (See the chapter appendix for some relevant resources).

Development of an internet or smartphone app, or use of an existing app, to make all this immediately accessible is one possible useful extension to existing arrangements. A current example is the National Oceanic and Atmospheric Administration (NOAA) recognition of the neighborhood social networking app "Nextdoor" as a member of its Weather-Ready Nation Ambassador program, a program that focuses on delivering timely, accurate and hyperlocal weather information to communities around severe weather events.[vi] Ongoing cooperative review of the effectiveness and accuracy of updates and continuously considering improvements that improve legibility and usefulness is certainly a good idea, supplementing such efforts that already exist.

As to methods of dissemination of maps and other information about where to go and how to get there, the internet is an obvious and ubiquitous means. Google, for example, is developing "SOS alerts" that show up during crisis times, displayed along search results, and showing authoritative local information such as emergency phone numbers and translations of useful phrases. [vii] But this does raise the issue of power and connection disruptions that may occur during a hurricane. Backup communication methods include a cellphone broadcast text, for which there are existing programs, especially the storm warning system of the National Weather Service and Wireless Emergency Alerts (WEA) issued by local, state

and/or federal officials for significant emergencies. These messages are broadcast from emergency cell phone towers near an emergency and received on all cell phones that are equipped with proper software.

Public announcements over radio and television can also be used. Systems such as Notify NYC can be used for updates, and targeted to specific areas. Staten Island Borough President (SI BP) Assist and 311 can also be used to push notifications to citizens on where they should move their vehicles to. Important information might be collated into an emergency handbook and online resources for Staten Island residents and businesses, including both area-wide and Island-specific requirements, recommendations, and information sources. These various communication channels might be pilot tested to extensively estimate the amount of effort needed in responding to questions coming in at scale and providing targeted alerts. Note that citizens who choose to move their vehicles to alternate locations may also need support in coordinating their next leg of travel to safer areas.

In general, scope exists to consider communication methods as part of a wider portfolio of methods that can be both redundant to each other in the case of failure in one part of a system and also reinforcement for one another to ensure people get the information they need when they need it.

Wayfinding needs and methods are dynamic because facts on the ground change during storm events. And they also change between events, e.g. locations of shelters and available legal and safe parking spots. In a mandatory evacuation scenario where people are relying on GPS through internet apps such as Google Maps or Waze, there could be coordination with relevant government agencies to allow for dynamically re-routing of traffic when it is clear when a driver is (or is not) in a high ground location. For Waze specifically, people might conceivably be able to check that a parking spot destination was still available and re-route to an alternative if not. Google's "SOS alerts" might also offer such information.

Of course there is a significant lift for coordinating the data and agency feedback needed and how this fits with existing emergency response protocols. Google, however, has a whole crisis response team that is in place, and that works on everything from creating ways to share and update map layers without internet access and more, so there is a good deal of capacity there and elsewhere to tap into. Certainly the possibilities should be investigated.

(3) Parking

If vehicles are to be moved out of flood zones, they must also have a viable and legitimate place to be parked. This effort has identified and mapped out parking spaces that currently exist on high ground. Figure 1-10 shows the areas where cars have to leave from (shown as blue dots in the evacuation zones) to parking in safe high ground areas (shown as green dots in the high ground). The size of the dot indicates the number of cars either leaving or parking (i.e. a larger dot represents more cars than a smaller dot).

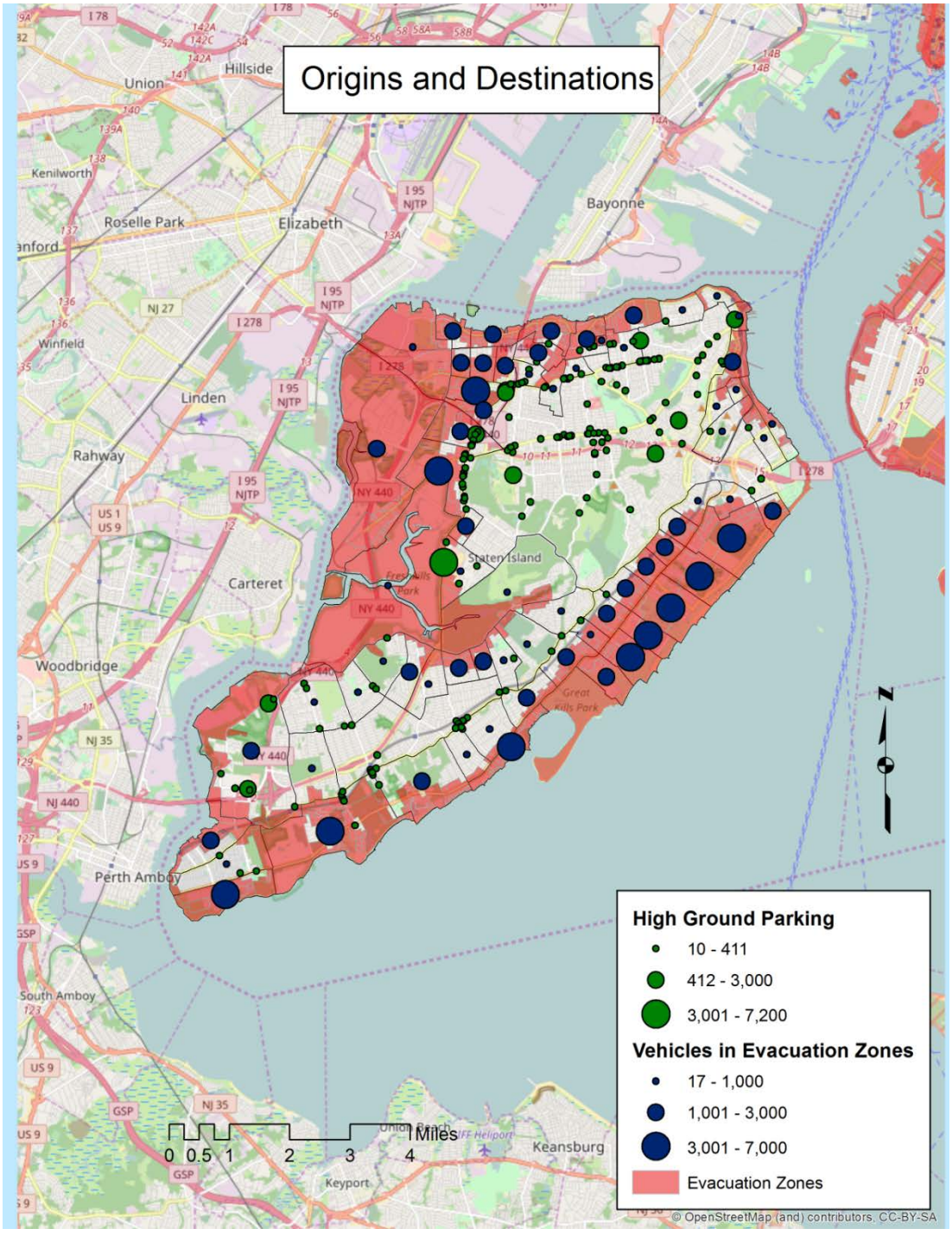

Figure 1- 10: Locations of vehicles leaving from evacuation zones and high ground parking spaces

From a purely physical perspective, the number of cars leaving must balance out with the number of cars arriving. In other words all cars leaving evacuation zones must have spaces to park in. The transportation model used for this report assumes this (described more in chapter 2) and, fortunately, Staten Island currently has enough physical parking space to ensure that at least one car per evacuating household will have a notional parking location.

This however is not the same thing as knowing whether such spots are viable legally and institutionally. Off-street spots attached to facilities are normally open only to those entitled to

park there (e.g. shoppers at the Staten Island Mall, or employees of a public school). Similarly on-street parking normally has various requirements such as neighborhood residency or parking only for specific periods of time. Obviously emergencies dictate adjustment of these restrictions. But how? This is not a simple question to answer and presently there is much to be worked out.

Good neighbor agreements
For off-street parking, "good neighbor agreements" could be reached. For example, a local church may agree to shelter cars during an emergency period for all who make it there and can fit in the lot. But when does this period begin and end? How is legal liability and responsibility for the parked vehicles handled? The mass movement of vehicles to a concentrated area during a hurricane requires formalized advanced planning rather than sole reliance on ad hoc and in the moment measures while hoping for the best.

Assessing potential parking capacity during an emergency
A more wide ranging analysis of potential parking spaces during a storm needs to be conducted. It may be possible, for example, to make High Occupancy Vehicle (HOV) lanes on the Staten Island Expressway available for parking during a storm, these spaces under the purview of the New York State Department of Transportation (NYSDOT) managing the roadway on behalf of the Federal government. Service roads, managed by the New York City Department of Transportation (NYCDOT), such as South and North Gannon Avenues, present similar possibilities. These may not be viable in the end; e.g. parking may not be readily accessible to other shelter (other than in-vehicle sheltering) and there may be complications determining when to switch such lanes from active service during active evacuation to out of service as parking space. But the possibilities should be investigated.

Use of 'dead' space for parking
Ideas for using generally 'dead' public space for emergency parking should be explored and may have real potential. Some examples include use of the streets along the closed buildings owned by New York State on property next to the College of Staten Island, as well as much more long-term ideas, such as parking in Fresh Kills Park when land there has compacted and stabilized after several decades. Note that some areas of City property, such as public parks, may already be used during emergencies without a Memorandum of Understanding (MOU), at the Mayor's discretion. As this all gets sorted out, definite emergency parking space locations could be mapped to make clear where people can get to without fear of complications for those parking and those providing parking.

Movements to and from the destination parking space
Movements to and from the parking space also need to be considered. Some preliminary modeling of this has already been done and is presented in Chapter 2. For those sheltering with family and friends, a shelter or a motel/hotel a good sense is required of how many will be picked up from their parking spot (requiring two trips, to and from the parking space) versus those getting themselves to shelter (requiring only one trip from the space or perhaps entailing only one direct trip in total). Some may shelter in their car, and may prefer to do so if an evacuee wants to stay with the valuables and pets they have taken with them. This is not recommended however. Medical emergencies may occur. And sheltering in a car can be dangerous even out of surge zones since there may be winds, and falling trees and power lines etc.

Use of available parking spots for emergency operations
Certain areas that at first glance may appear to be available, such as the Richmond University Medical Center and the Yukon Bus Depot, may not be ideal for car drop off because of emergency demands that may be placed on them. The Staten Island Mall, for example, has an agreement with NYCEM for use of the parking lots during emergency situations. However, as this is one of the few very large areas of open space available for use, it will more likely be used for staging purposes by multiple agencies.

Coordination across agencies and with the public is critical. For example, how much of a parking lot is NYCEM likely to use during a significant event? Is there a way for NYCEM, FEMA and other response organizations to communicate with the public or other organizations involved in preparedness and response as to what proportion of these spaces are likely to be available for private automobiles? A first step could be to draw up an operational list of such questions and then develop planning responses accordingly.

Individual parking needs
It also must be added the shelter parking capacity varies too and this interacts with what is the best spot for a particular individual. Those staying in shelters should have priority on a shelter parking spot over those who are going to shelter elsewhere. However, Evacuation Center issues, other than how they directly affect parking locations and capacity, are beyond the scope of this report.

Change in parking capacity over time
All of this is dynamic. Designated Evacuation Center locations sometimes change based on facility availability. (In general, such locations made available to the public are designed not to change, although they have been more fluid recently than in the past). The same is true of parking spaces. For example, economic development will add and subtract from available spaces over time. New facilities with new parking will be built, and available parking spaces may be converted to other uses. Even in a particular time period, policy choices, private and public, will adjust. Because of capital projects, construction, road repair, sewer work, etc., not all locations on a list of potential locations may actually be available at the time of the actual evacuation.

Keeping parking information current and available
How do we keep all this information dynamic and readily available when it is needed? Real-time information should be provided, e.g. parking spots can be put on the NYCEM maps. But one must be sure these spots are feasible legally and institutionally and, if possible, direct people to the spots best suited to their requirements at the time.

All such information, such as listing conditions for parking, time of availability and so on, could be put on the maps along with the locations if its accuracy can be assured. Ideally authorities could monitor parking real-time during an emergency and show people where available spots remain as others fill up. Such technology is used by some running parking facilities such as parking garages. For example, airports and other facilities allow people to register in advance for parking. These are possibilities to be further explored and considered. Of course evacuees must always be ready to have alternative parking plans in case the space they had planned to go to might be unavailable, for whatever reason.

Shifting transportation mode choices over time
Finally there is the issue of transportation mode shifts over time. It is possible that investments in transit infrastructure and changes in development may reduce the need for vehicles and make Staten Island more like other boroughs in using transit during emergencies. But this is clearly a very long-range change not pertinent to evacuation planning in the near and medium-term.

The common theme remains: always evacuate when ordered to do so. This chapter has considered some ideas about how to alter signage, wayfinding, communication and parking coordination to ensure this happens.

Chapter 2 – Transportation modeling and demand analysis

Going to high ground, early, is your best and only option in a hurricane. Get in your car and go as soon as you are ordered to leave

Staten Island is a densely populated borough with a road network that can be at, or over, capacity during the best of times. It is also a place where people will overwhelmingly rely on their vehicles to move to safety and where viable and timely transit alternatives are often unavailable. Therefore, ensuring that people will be able to get to high ground in their cars is critical.

Overall summary
Planning for this requires some sophisticated modeling and analysis, the elements of which are described more fully in the chapter appendix. The key aspects can be summarized as follows. NYCEM analyzes clearance rates from evacuation zones. The first critical task in a hurricane is to ensure vehicles leave flood zones in the first instance, i.e. get clear of the danger. NYCEM makes conservative assumptions about how hard this will be - a good thing to do since good planning should consider worst case circumstances.

This study used that analysis and then examined and modeled the other side of the evacuation journey by modeling the traffic and bottlenecks that might occur once vehicles reach high ground. In other words, while NYCEM is rightly concerned with ensuring vehicles get to safety, this study looks at whether those vehicles will be able to reach a parking space once they are out of immediate danger. This is especially important on Staten Island because most people here will be driving and will need a place to leave their car before going on to their ultimate sheltering destination. It would not be good to have a situation where people managed to get out of flood zones but were then caught in traffic jams or otherwise unable to find a safe, viable space for their car once the storm hits, even if on high ground.

Taken together the two models – NYCEM clearance rates from evacuation zones and this effort's modeling of bottlenecks, clearance, and parking on high ground – provide a complete picture of the traffic and parking situation on Staten Island during a hurricane.

Bottleneck analysis
A critical aspect of this analysis was to consider as fully as possible how the capacity of the road network on Staten Island might impede traffic flow and where bottlenecks are most likely to occur. Fuller details about where such bottlenecks occur are provided in the chapter appendix and in Figures 2-9 and 2-10. But Figure 2-1 provides some indication of the complexity and capacity constraints of the network, something which local drivers are well familiar with. This network can accommodate timely evacuations if choke points are known and managed well.

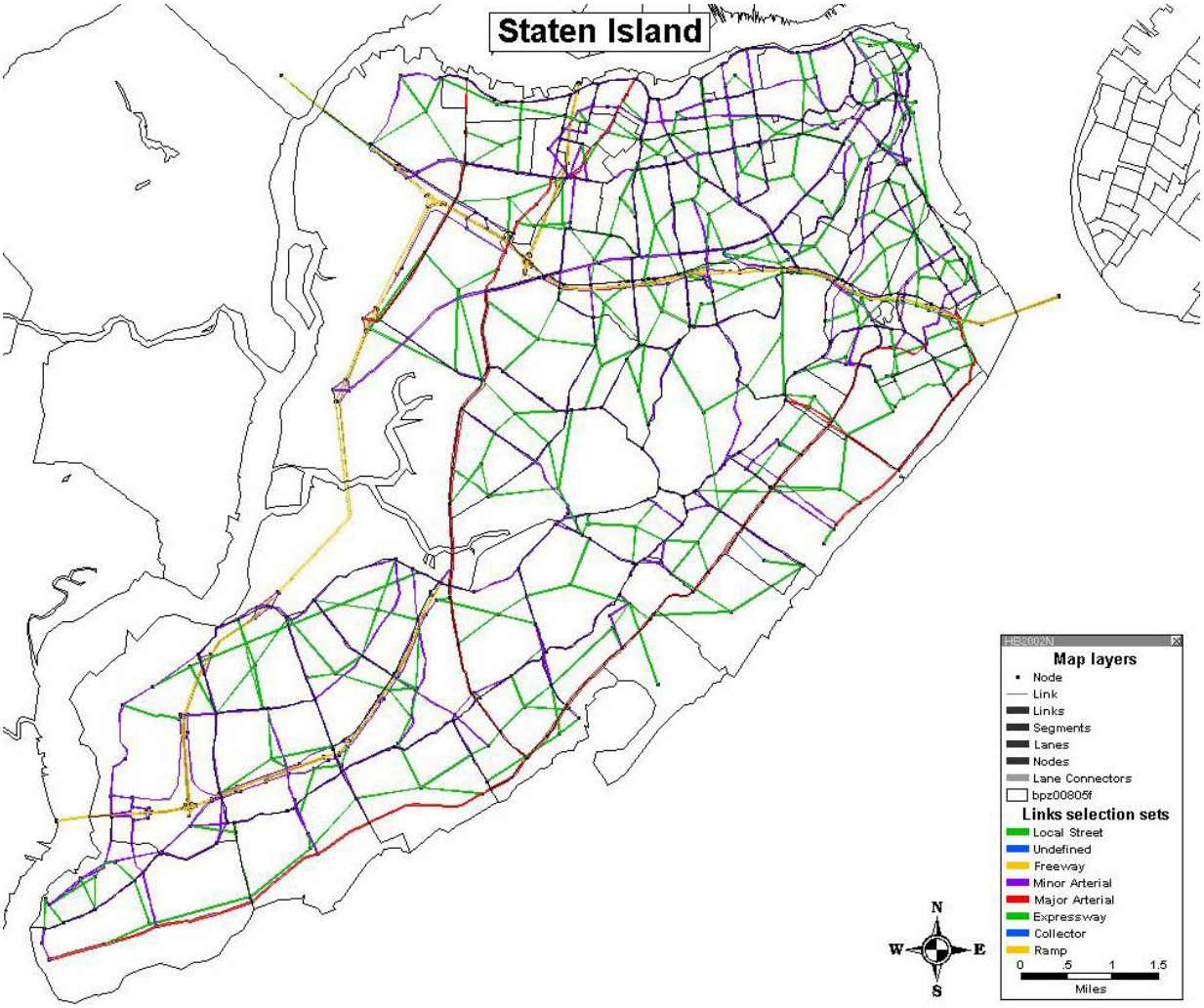

Figure 2- 1: Staten Island road network

This study also created a physical inventory of number of parking spaces and their locations on the island and mapped these using GIS. Transportation modeling was then done to simulate how cars would leave evacuation zones and how they would reach parking spaces, considering how this might be affected by the characteristics of the population evacuating as these affected the travel choices they might make. In particular some people would shelter in their vehicles, others would leave their cars to get to friends and family or hotels while still others would be picked up by friends and family from the parking spaces. Figure 2-2 shows a summary of this analysis. Fuller details are provided in the chapter appendix.

Vehicle Origins & High Ground Parking Destinations

Evacuation Strategy	High Ground Parking Category & Strategy for Reaching Final Destination		
Off-Island	N/A	N/A	
Hotels/Motels	Off-street	Park & Stay	
Shelters	Off-street	Park & Stay	
Friends & Relatives	On street	Park & Leave	Walk
			Vehicle pick up from friends or relatives
			Public transit
			Private car service, taxis, Uber
			Develop the EvacuSpots framework/model
			Combine with private vans. CERT
	Off-street	Park & Leave	Walk- (*centroid of TAZ less than mile)*
			Vehicle pick up from friends or relatives
			Public transit
			Private car service, taxis, Uber
			Develop the EvacuSpots framework/model
			Combine with private vans. CERT
		Park & Stay	Informal Shelter: (i.e. stay at community or faith-based organization or workplace)

Parking Category	Number of Spots	Pro-Rated
Off Street	32183	28965
On Street	4263	3197
Total	36446	32162

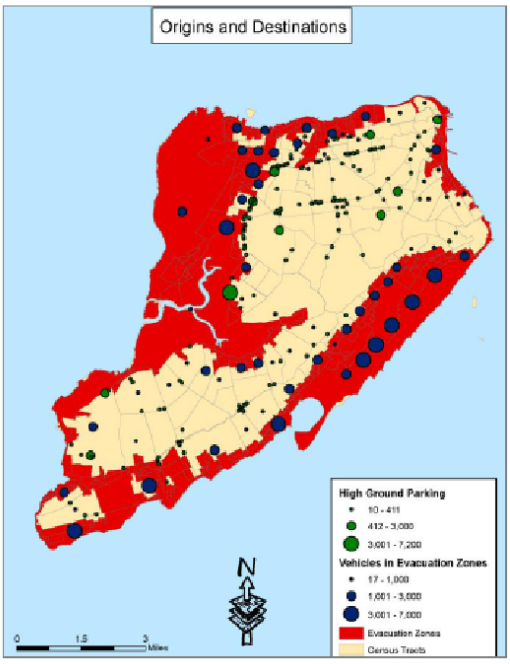

Figure 2- 2: Data and locations for high ground parking and vehicle origins on Staten Island

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Overall conclusions

The major thrust of this exercise is that traffic bottlenecks on Staten Island on both low and high ground are fairly well-known and can be ameliorated with good traffic management and awareness on the part of evacuees. Currently there appears to be sufficient inventory of physical parking to accommodate evacuating vehicles, though legal and other issues need to be worked out accordingly. However hurricanes are obviously volatile and unpredictable and any modeled outcome may not match an actual outcome as various factors, such as parking that is actually available as opposed to what is assumed available, may differ. Care has been taken to use conservative assumptions but facts on the ground should be closely monitored and assumptions changed as appropriate. Caution should be taken that evacuation of vehicles should be secondary to the safe evacuation and safety of the population. Timely following of evacuation orders is, as always, the key element.

(For more complete details, see the Chapter 2 appendix at the end of this report).

Chapter 3 - Developing and implementing a public educational campaign

Going to high ground, early, is your best and only option in a hurricane. Get in your car and go as soon as you are ordered to leave.

This is the core message that the public must incorporate into their awareness: (1) take a hurricane seriously enough to be motivated to act when an evacuation order is issued and (2) know what to do and be able to do what needs to be done when the time comes.

The primary task for any outreach is to convince all people of the deadly nature of hurricanes and motivate them to follow evacuation orders immediately. "For an evacuation order to be effective, people have to believe they are in danger." Thus says Adam Sobel, leading expert on extreme weather events[viii]. 53 people died in New York during Hurricane Sandy[ix] and some of these fatalities were due to complacency: some residents were used to periodic but relatively safe flooding and decided this storm would be no different. People also have a natural inertia about leaving their homes and legitimate concerns about the security of their homes left unattended and unpoliced. All this must be overcome to minimize -- and hopefully eliminate -- storm fatalities. There simply is no good alternative to getting out of harm's way in a timely manner.

Having impressed upon people the imperatives of following evacuation orders quickly, they must then be informed of what they need to do when a hurricane comes, and how to access needed information, especially about evacuation routes and parking options, when an order to leave is issued. Content must thus be informational, motivational, and accessible. Things that are need-to-know must be presented clearly and compellingly.

Various ideas have been offered about how to inform people and then how to motivate them to listen to directions. Key information to transmit includes clear and up-to-date evacuation route maps, real-time information about traffic conditions and parking availability, and simple elaboration of steps to follow in an emergency. And not to be ignored is the provision of people with basic items, such as flashlights, that can be readily accessed and taken with them in an evacuation. (NYCEM provides guidance on this specifically at https://www1.nyc.gov/site/em/ready/gather-supplies.page). It is very important for people to be prepared ahead of time during "blue sky days", by finding out what zone they are in, identifying where they will go in the event of an evacuation order, and preparing the requisite go-bag and emergency supply kit.

For this effort a number of devices were developed to accomplish these goals, tailored to the unique context of Staten Island. Brochures, social media, websites, pre-K – 12 outreach, education fairs, curriculum materials and field trips have all been developed and are continuing to be rolled out.

Informational materials

The "Staten Island Severe Storm Survival Guide: Go to High Ground (Storm Surge Zone)" was issued by the College of Staten Island in December 2015 and contains, in one short booklet: information to motivate residents (including a history of severe storms on Staten Island, emphasizing their relative frequency and power); to prepare them (with a three step template of close monitoring of storm warnings, pre-storm protection of property and a quick

emergency exit plan); and to inform them about how to evacuate safely in an emergency. Useful contact numbers and links of various City agencies are provided. The report provides details about Sandy's Staten Island damage totals and details about prevalence of local storm events to make a lasting impression about the real risks faced by residents.

This core guide is supplemented by additional materials such as:

- a parking guide showing where potential parking spots on high ground are located (more on parking issues are outlined in chapter 1);
- interactive social media backing up printed materials such as a Facebook page and other social networking platforms;
- A "Serious Conversation Web Site", a social media website for this “Go To High Ground” effort that contains a comprehensive list of social networking sites with information about hurricane evacuations. The site developed for this study is currently archived at http://oae.csi.cuny.edu/sandyforum/news.html . It should be continuously updated and be offered in an accessible format.

Communicating with special needs populations

Public education and information about hurricane evacuation needs to be broad based and widely disseminated. But it also must be tailored to specific needs and capabilities of different population groups. Population income levels, age structure, levels of car/transit accessibility, and level of need for outside care (ranging from completely independent to being resident, temporarily or permanently, in a care facility) all affect the types of information people need to receive and the types of support they require to be ready and able to evacuate when an evacuation order comes. Similarly, communication needs to be adapted for populations that speak languages other than English. And there must be consideration of people who might be unfamiliar with the local terrain, such as temporary contractors on a Staten Island job site who might not know local streets and directions.

Particular needs and characteristics can affect the motivation and ability of some groups to move to higher ground when a storm comes. For example, areas of economic and social disadvantage might contain significant numbers of people who may not be able to move quickly because they do not own a vehicle, do not have a good social support network, and do not have access to good transit. Elderly residents and those with limited mobility, hearing and low vision issues and disabilities and access and functional needs may need assistance in evacuation as may require additional care. Good communication strategy need not be complex but it does need to account for the particular needs of the audience being served.

In late 2013, a ruling was made in a vulnerable population evacuation court case against New York City which found that the City’s evacuation plans did not accommodate needs of people with disabilities, especially in high-rise evacuations. No specific remedies were proposed but the City was ordered to more fully provide for vulnerable populations with respect to accessible transportation, architecturally and programmatically accessible shelters, evacuation plans for people with disabilities, distribution of resources in aftermath of disaster, outreach and education programs to assist people with disabilities to develop a personal emergency plan, and sufficient information regarding existence and location of accessible services.[x]

Prior to this ruling the City issued a Hurricane Sandy After Action report that recommended

an improvement of accessibility of coastal storm-related information and services to make them available to New Yorkers, including people with disabilities.[xi] The report emphasized education and the importance of following evacuation orders, with suggestions including:

- publicizing the homebound evacuation system to those who cannot evacuate without assistance
- serving those evacuees who require special medical needs
- dealing with prescription medications
- handling special dietary needs
- providing required electricity-dependent care
- appropriate disposal of medical waste
- providing food that meets the diverse dietary needs of the population
- developing a vulnerable populations door-to-door Task Force and Action Plan in order to distribute necessary items and services.

Staten Island special needs preparation

A separate focus on Staten Island vulnerable populations has been part of the current effort. For example, a "Staten Island Emergency Preparedness Guide for People with Disabilities and Their Families" has been prepared by the College of Staten Island, in collaboration with New York State Senator Andrew Lanza, issued in both Spanish and English. This guide has a number of pages in which information is to be entered about personal details, health, safety and medical needs and requirements, caregiver information, and 'likes and dislikes' about preferences on how to be treated and communicated with during an emergency.

This guide also has provision for a lanyard, i.e. a waterproof emergency "go" pouch, which contains a medical diary, a pencil and notepad, a whistle and a flashlight. There is also guidance about additional items that should be at the ready for specific disabilities, e.g. a basic sign language reference guide for those with a hearing disability, or a small tire pump for an ambulatory disability. Other guidance includes emergency checklists for things such as service animals and high-rise safety.

Materials such as these have not just been produced but have been disseminated through various workshops and events. NYCEM data indicates that a total of 54 Ready New York (RNY) events, not including Community Emergency Response Team (CERT) events, were held on Staten Island from June 2016 to June 2017[xii]. There also have been a Staten Island Storm Support system, social media for vulnerable populations, and evacuation preparedness fairs for vulnerable populations. The Staten Island community in particular rose to the challenge of Sandy and continues to be well engaged (more about this in Chapter 5).

Understanding risk

Public education development continues. Much of this needs to be based on sound analysis and provision of information that will educate and motivate people to prepare and respond properly to the next storm. Two informational aspects are relevant here: (1) knowing where the greatest risks lie locally during a hurricane and (2) understanding the difference between safety and relative risk.

On the first point, researchers at the College of Staten Island, using GIS, have plotted fatality locations from Superstorm Sandy. Staten Island had 23 fatalities during that storm and the

GIS analysis shows that the fatalities can be broken down into 2 age groups: Group 1, with 18 fatalities represents ages 50 to 89 and Group 2 with 5 fatalities that represent ages 20 years old or younger. Two of the fatalities from Group 2 were children ages 2 and 4 who were swept away in their parents' vehicle. None of the fatalities were from the age group 21 to 49. All except one of the fatalities were located in pre-Sandy NYCEM Evacuation Zone "A" which was under an evacuation order. Since Sandy the NYCEM has revised the evacuation zones to six (1-6). All but two of the fatality locations plot in the new NYCEM Evacuation Zone 1. 5 of the 23 fatality locations plot inside the post-Sandy buyout zones of Governor Andrew Cuomo. Further GIS analysis shows that in all cases the distance from fatality location to high-ground was less than 1.29km. This study shows the importance of complying with emergency evacuation orders. High-ground was nearby. Since each hurricane is different it is important to evacuate when the orders are issued and educate the population on where to go to high ground [xiii].

On the second point, it is important to emphasize the difference between safety and relative risk. No policy or strategy is ever completely 100% safe. Rather, an action taken changes the relative level of risk faced. Evacuating to high ground considerably lessens the risk of injury or death during a Hurricane but does not eliminate the risk. Similarly, remediation measures lessen but do not remove all danger.

For example, around a year after Sandy, the NYC Department of Parks and Recreation built up sand dunes running from Fort Wadsworth through to Great Kills, using metal structures embedded with sand traps. The public understood this measure in contradictory ways, some believing it to be an impregnable barrier, which it is not, while others saw it as an ineffective and mere moving of sand around, which is also is not. The seawall on Staten Island planned by the US Army Corps of Engineers (USACE) will be a more formidable enterprise but it too does not eliminate risk, only potentially lowers it. In as much as sand barriers, seawalls, levees and so on can be overtopped or undermined, it will still be important to heed evacuation orders at all times. The effects of compound flooding, i.e. rain combined with a surge, can present an additional hazard[xiv].

Also, the use of the term "100 year flood" (or whatever number of years being referred to) is misunderstood by the public and it is important to educate them about this term. A 100 year flood event has a 1% chance of occurring in any one year. A 500 year flood has a 0.2% chance of occurring in any one year. The track of Sandy was considered to be a 714 year event[xv]. This means this track has a 0.14% of occurring in any one year. These are low probability but high impact events. It does not mean, as many assume, that a storm like Sandy will not track around to our area until another 714 years have passed. For this reason, alternative parlance, such as a 1% flood, may be better, since in that case what is being referred to is the probability of a particular magnitude storm occurring during a given year. The city sometimes uses the phrase "high-risk flood zone" to refer to the 1 percent annual chance flood zone (AE zone) and the "moderate-risk flood zone" to refer to the .2 percent annual chance flood zone (X zone). [xvi] Whatever term is used, people must understand that they are at risk and must choose the most risk ameliorating strategy during an event, which is timely evacuation.

Public education on Staten Island

There are other ideas out there about effective public information that can be explored further. Key motivational devices that have been put forward include the use of arresting images in

public education campaigns to show just how bad things can get, e.g. the hydrograph of the surge from Hurricane Gloria at the Manhattan Battery to show how quickly transportation routes can be cut off, and the sharing of clips of police, fire and rescue transmissions of rescues during hurricanes to show how much danger both residents and rescuers are put in during a hurricane. There are many media available to deliver such messages, e.g. audio, visual and verbal. Since people have many different learning and cognitive styles, it is important that a particular message goes out in multiple ways and in accessible formats[xvii].

Staten Island has a number of media channels closely followed by locals which is an ideal way of communicating with residents. Production of public service announcement videos and recordings, potentially using studio facilities at the College of Staten Island or elsewhere, is one possibility. Already underway is production of a live call in show on Staten Island Community Television at the start of Atlantic Hurricane season. Staff involved in this effort have produced and participated in one live show at the start of the 2017 Atlantic Hurricane on Friday June 2, 2017.

Beyond messaging, ongoing education is critical. Incorporating study and awareness of hurricanes in school curricula is one way of doing this. Proposals for incorporating emergency management or sustainability and resilience into academic programs have been floated in various places. The College of Staten Island is considering various options such as using class exercises to improve understanding of risks and emphasizing hurricane awareness through both the geologist and teacher education tracks of its Earth and Environmental Sciences program. (One such proposal for further development is contained in the chapter appendix at the end of this report).

Chapter 4 - Interagency collaboration and planning and financing

Going to high ground, early, is your best and only option in a hurricane. Get in your car and go as soon as you are ordered to leave

The New York Governor's Office of Storm Recovery (GOSR), NYCEM, the New York City Mayor's Office, and the Federal Emergency Management Administration (FEMA) amongst other agencies, do have clear protocols for what agencies should do during emergencies and how they should coordinate with one another. These protocols necessarily focus on people, as they should. But on Staten Island, it is not just the movement and management of people that is important. Cars need to be mobilized as well. In this chapter the focus is on collaboration, between agencies and with related nonprofit and business entities required to handle the movement and parking of vehicles.

This chapter describes both what has been done thus far as part of the current study and also offers some suggestions on what might be done on an ongoing basis. Thus this chapter will discuss government policy and planning issues surrounding parking including liability, good neighbor provisions, parking signage and restrictions, coordinating off-street parking and so forth. Handling costs of all this is discussed as well. (The essential aspect of community response is discussed in Chapter 5). Overall a plan is rarely followed in the actual event. But having a plan helps to think about what you know, what you don't know, and what you need to know.

There are many governmental entities potentially involved in the area of vehicle management and parking in a hurricane on Staten Island and in the city as a whole. Table 4-1 provides a partial list of relevant organizations that are involved, to varying degrees, in these areas in the City at large and on Staten Island in particular. Roles range from entity ownership of parking lots (e.g. those owned by the New York Public Library) through to coordination and management responsibilities (e.g. FEMA).

AGENCY
NYC Department of Education
NYC Transit Authority
Dormitory Authority of the State of New York
NYC Department of Citywide Administrative Services
NYC Department of Planning
NYC Department of Design and Construction
NYS Department of Environmental Conservation
NYC Department of Environmental Protection
NYCDOT
NYSDOT
NYC Department of Parks and Recreation
NYC Department of Housing Preservation and Development

Mayor's Office of Environmental Remediation
Metropolitan Transit Authority (MTA)
NYC Economic Development Corporation
NYC Housing Authority
New York City Police Department
NYCEM
Port Authority of New York and New Jersey (PANYNJ)
NYC Department of Small Business Services
NYC School Construction Authority
State University of New York
Wetlands Transfer Task Force
Staten Island Economic Development Corporation
New York Public Library
NYC Department of Courts
NYC Department of Cultural Affairs
NYC Administration for Children's Services
NYC Fire Department
NYC Sanitation
NY Department of State
Mayor's Office of Resiliency and Recovery
FEMA
National Park Service
NYS Division of Homeland Security and Emergency Services
Staten Island Borough President's Office

Table 4- 1.Government agencies with potential parking and vehicle movement roles on Staten Island during hurricanes

Planning time-lines

While this appears to be a rather bewildering array of entities, there is already a strong foundation for hurricane planning in the city. New York City already has a time-frame for hurricane planning and evacuation that begins roughly 4 days before a storm is expected to hit, designed to advise the Mayor on whether and when to issue an evacuation order, generally 2 days before the landfall is expected. This general time-line could be extended to post-evacuation activities such as parking, and also tailored to particular purposes and populations. Key things that agencies need to know about and coordinate include:

- storm characteristics and how they may affect evacuations
- agency responsibilities, requirements and action before, during and after a storm

- status of transportation infrastructure
- power and fuel issues
- languages of affected populations and capacity to reach them
- 'triage' protocols in the sense of where the worst impact/greatest need/hardest problems are. Planning should not devolve into a 'worst-first' approach but one should be aware of priority of resource allocation.
- opportunities for leveraging resources. For example systems dealing with other emergencies, e.g. terrorism or snow events, may be utilized during a hurricane or there may be better integration of such systems all year round.

Agency coordination

In general there is already substantial coordination across government on dealing with storms. Suggestions for improvements on the traffic side include regular meetings between MTA Bridges and Tunnels, NYSDOT, NYCDOT and PANYNJ to share and confirm their latest real-time wind information and coordinate guidance and response. Also these agencies might agree upon a wind speed threshold in which various actions kick in since wind gusts above 39 mph generally make bridge crossings too dangerous. For example, the public could be aware that they should consider sheltering in- rather than off-borough, based on a certain threshold of wind readings (perhaps 30 mph) (though this is a bigger problem for boroughs other than Staten Island). Emergency responders and the public should also be informed more about expected surge cutoff conditions at low lying bridges and causeways. Finally increased coordination between NYCDOT and NYSDOT to provide a list of roadway locations where rainfall flooding or ponding may affect evacuation routes could be useful.

While transportation and evacuation plans and timelines are already the focus of sustained and coordinated planning, for Staten Island (and perhaps in other areas of the City) a similar framework is recommended for parking. Thus the process and time-line used for evacuation planning could be applied to parking. There might be a planning subcommittee, or committee on Staten Island, that convenes as soon as a particular event time point is hit, mobilizing to put out the needed public information, coordinating permissions to park and so forth. This effort, of course, would be ideally integrated closely with larger storm response across government and with other organizations.

The GTHG Steering Committee

Planning must not only take place during a storm but be ongoing. The many issues identified in Chapter 1 on parking in particular are dynamic and changing and there must be continuous dialogue about them. As part of this study, a Go to Higher Ground (GTHG) Citizen's Advisory Board and Steering Committee was established, moderated through the College of Staten Island. This Committee is meant to have the major relevant stakeholder groups on the island come together regularly and share community needs and concerns with each other and interact with government agencies. More detail about this effort will be presented in the next chapter. But it is imperative to have some institutionalized discourse and planning going on at all levels.

Of course creation of new bureaucracies is not a desirable result. Formal structure is useful to keep discussion ongoing but it should be flexible, with minimal burden imposed on participants, transparent, and action-focused. It also should not be partisan or political. The task at hand in this case is simple: to make sure people evacuate to high ground, quickly, and

be able to have their vehicles safely placed for the duration of a storm. Arrangements made to do this should be least-cost both directly (e.g. the cost of providing parking) and indirectly (e.g. disruptions of business operations). Any structure should be focused on these outcomes, and organized accordingly.

Having a neutral body as an overarching host for these activities is also very important. People, in government and in the community, should feel free to speak openly. The College of Staten Island has served as the coordinator for this study and as a university it could continue to serve in an "honest broker" role. This is perhaps especially important for parking since a diverse range of issues comes up there, some of them potentially nettlesome. However, a government entity, or range of entities, could serve in an overarching capacity as well.

Costs of parking

This may all sound relatively easy in theory but parking during a storm is far from costless. There are significant costs that arise from parking, both direct and indirect. Parking costs at present are not systematically planned or provided for. Table 4-2 provides a list of direct costs that must be covered when vehicles are parked in a space during a hurricane. (For the purposes of the table it is assumed that the parking is done legally).

TYPE OF PARKING	DIRECT COST
On-street parking -- designated public parking space	Foregone parking fees (if applicable)
On-street parking -- undesignated public parking space	Public liability Foregone penalties
On-street parking -- private space	Private liability Opportunity cost to space owner Insurance costs
Off-street parking -- public property	Public liability Foregone parking fees (if applicable)
Off-street parking -- private property	Private liability Foregone parking fees (if applicable) Opportunity cost to space owner Insurance costs Security costs
All parking (during a storm)	Provision of sanitary facilities Provision of communication and internet access Phone/device charging stations Water and electricity Coordination and control (e.g. command centers)

Table 4- 2: Potential types of direct costs of emergency parking

The major potential direct costs, public or private, relate to liability, insurance premium costs and foregone revenue from parking and other fees that would be levied during normal times. For public property, insurance costs are treated as negligible, being assumed to be folded into much larger public insurance coverage costs, or perhaps being self-insured. However this may not be a fair assumption in particular circumstances.

Security costs are assumed to be substantia; mainly for private parking spaces since public spaces will be policed by NYPD and other public security forces already funded. Security costs might be substantial for some private space owners, especially large lots like those at the Staten Island Mall. Private liability and insurance can be a major expense for private entities. Even if a 'good neighbor policy' is in place (see chapter 1), owners of parking spaces need to have their expenses covered. People are also more likely to practice a good neighbor policy if they are secure in the knowledge that expenses will be dealt with.

Some costs, especially opportunity cost (i.e. the economic return to having the space available and putting it to other uses) and foregone fee revenue (which is often set at a level to cover opportunity cost) will arguably be negligible during a storm period since business and other activity levels will be low or nonexistent during a hurricane. They should not be ignored however.

The final row of the table indicates costs that can be very large for either public or private parking providers but which are often not even considered. Some provision must be made to ensure that people have adequate sanitation, power, water and possibly even food during an emergency. Since the internet is now the dissemination method of choice, providing for it is arguably no longer a luxury but a necessity. There are potentially large costs for all these things, but the tragic experience during Hurricane Katrina in New Orleans demonstrated that inadequate planning in these areas can lead to fatalities[xviii]. It is better to have planned evacuation areas and parking spaces than unplanned de facto zones, as happened in New Orleans.

Managing parking and covering the costs

Two questions arise. First, what governmental entity should be responsible for planning for, managing and overseeing parking and its associated costs? Second, who should pay the costs?

On the first question, there is a whole range of Federal, State and local governmental entities, as well as special purpose agencies (such as the MTA) that need to sort out who is in charge of what. Even if publicly planned, parking provision may not necessarily be publicly managed but could be outsourced to a private entity. The NYS Governor's office has overarching responsibility for hurricane management in the state, while City agencies such as NYCEM coordinate with others to manage city evacuations. FEMA is in charge of national policy. And other agencies then take care of their respective functions, e.g. NYCDOT takes care of the local streets.

There is a well evolved network of responsibilities and capabilities for evacuation and emergency management, but this must be extended to parking. Government could engage local business owners with a consensus list of parking lots, and canvass business owners on their openness to providing their lot for use during an evacuation. The creation of a Vehicle

Evacuation Liaison as a key point of contact and coordination should be considered. The details of the exact structure, e.g. which is the best lead agency and the specifics of changes to agency policies, need to be worked out at a policy level.

The Vehicle Evacuation Liaison could potentially serve the community ahead of an evacuation event by building relationships with local businesses and nonprofits, having an ongoing count of which lots are still available and awareness of construction and other capital works that may make previously approved locations no longer feasible during an evacuation. The Liaison could also keep the contact information for the business owners up to date.

Private owners of parking, whether business or nonprofits, are a critical component of any parking emergency plan. Local businesses and others with parking should be canvassed on their openness to providing their lot for use during an evacuation. They would need to understand their responsibilities precisely, as well as what they are not responsible for, e.g. delays or damages citizens might face during the evacuation. Indemnification by the city from any liability to the property, the business or its contents by having cars parked there must be clearly posted and communicated. Owners may have concerns about increased risk of vandalism or theft of multiple cars in unattended locations. These must be carefully considered as they may deter both sides from choosing to engage in the process. For businesses and others that choose to participate, a simple letter of understanding could be shared noting that the current owner agrees to have a lot used for this purpose. This agreement would be nonbinding, so an owner can choose to rescind approval at any time. For businesses that are sold, close, or change hands the agreement would be considered void.

As to how all this is paid for, one could jump to the conclusion that all this must be covered by government. But there is, in fact, a continuum of funding and financing possibilities, ranging from purely public (e.g. having a clear government reimbursement schedule for private costs incurred or having direct public provision of parking services) to purely private (e.g. every parking cost incurred by private parties is out-of-pocket) with various hybrids in between (e.g. some kind of public-private partnership for provision of high ground parking places during a storm).

There are some arrangements already in place for hurricane costs generally. At present, NYCEM has a Memorandum of Understanding (MOU) in which certain parties are reimbursed under certain conditions. FEMA funds generally flow through the State of New York. In cases such as this timely reimbursement is critical as slow payment imposes a lost interest income cost on payees and will discourage people from offering their parking spaces for use in the first place. (Note: this report and chapter focuses only on parking and associated costs incurred during an emergency. Longer-term costs, such as lost homes or businesses due to storm damage, are beyond the scope of the study).

There are indeed many potential funding models. Businesses with fleets of cars already generally do their own pre-planning for emergencies, and pay for it themselves. Some businesses on Staten Island with vehicle fleets arranged to move them to New Jersey before Sandy, thus salvaging them. Others, in particular some car dealerships on the Island, did not make such moves and incurred substantial losses. To the extent this a normal cost of doing business, it is should be borne privately, though government can and does play a role in

helping coordinate and plan. NYC Planning has identified challenges for businesses in its Resilient Industry and Resilient Retail studies[xix]. However, development of a specific program in place to support businesses in this respect is recommended, especially in helping with reducing commercial vehicle loss. For example, perhaps the city could close some streets to traffic and designate them for commercial truck parking; or allow commercial truck fleets on some city-owned lots, especially for certain industries that are considered critical facilities and important to the storm response.

The focus in this chapter is on residential parking, and this is harder to plan for, and pay for, because of the decentralized nature of private parking decisions and, in some cases, issues of capacity to pay. There are some interesting possibilities however. For example, pre-reserved parking during hurricanes might be one option. Just as air travelers can pre-book long-term parking at airports, perhaps one could pay a small annual fee to reserve a public or private parking space, activated and available during an emergency (and limited by the period during which the emergency is current). Or perhaps parking spaces for a fee could be paid for and delivered through an app, much as car-sharing services such as Uber or Lyft provide ride services. There is much to be worked out with such regimes, including providing for those who cannot afford to pay and avoiding exploitative pricing during storms. The point is that there need not be a default to one extreme or another.

Beyond parking there is also the issue of how we pay for ongoing planning, coordination and implementation. Who is responsible for covering these costs? In what form might these costs be covered (e.g. in-kind contributions, volunteer effort etc.)? Not all activities will require a direct reimbursement or payment, and by definition many community efforts are on a volunteer basis and are stronger and more robust for it. (People who are intrinsically motivated to give their time and resources are generally much more likely to be there in a crunch than those whose primary motivation is financial).

This is where government plays a key role in bringing order and coordination to parking during a hurricane on Staten Island. Certainty is essential during emergencies. People must have a good idea of where they will be able to park and being sure that the legal, institutional and financial issues have been sorted out properly.

Planning and emergency costs are not just lost outlays but can be seen as investments which can have significant economic and noneconomic returns. Minimization of harm to life, limb and property requires investment of resources but, prudently designed and spent, it is money well worth spending. This includes measures to improve resilience of parking and other infrastructure during a storm. Some of this is already ongoing, such as efforts by Consolidated Edison to strengthen utility poles that might fail, and of the New York City Parks Department to prune damaged or diseased trees that might fall during hurricanes that might cause damage or block streets. But a more systematic approach is a good idea.

Chapter 5 - Community outreach and stakeholder engagement

Going to high ground, early, is your best and only option in a hurricane. Get in your car and go as soon as you are ordered to leave.

Hurricane response is not just a passive interaction where government issues orders and provides information and citizens fall in line. Chapter 4 focused on the critical aspect of governmental coordination and relationship to the public. But the community and its key stakeholders must be prepared, engaged and ready to act. Sometimes, in the chaotic conditions of a storm, the community must take care of itself. This is perhaps the most critical dimension of successful response to a hurricane. For example, during Sandy the community effort of 'Rockaway Helps' filled in and supplemented gaps that opened up in New York City communication and coordination efforts. Community groups were active in feeding people out in the Rockaways and other areas[xx]

This chapter will focus more narrowly on the task of mobilizing society and their role in enabling movement of vehicles to safe space on higher ground.

Community engagement: formal
Community engagement has both a formal and informal dimension. The informal connections between community members are undoubtedly far more important. But formal and semi-formal structures help keep conversations regular and practice ongoing, something very important for hurricanes which are irregular occurrences but which require skilled, well thought out and well-rehearsed responses.

For this effort, the College of Staten Island has formed a Going to Higher Ground Citizen's Advisory Board (GHTG CAB) Steering Committee. Guidelines were drawn up for participation that set out basic responsibilities and requirements. The point of this was to draw in motivated people and yet set appropriate bounds to keep focus for both the overall committee and its individual members. All this was set out in a questionnaire, which is reproduced in the chapter appendix at the end of this report.

A broad net was cast and community leaders from business, government, nonprofits, and local networks were solicited. The committee presently consists of around a dozen members, with a good mix of opinions, backgrounds and expertise. Rather than have committee leadership appointed from above or from within the committee once established, potential members in the community were solicited, as part of the questionnaire, as to their interest in such roles. The extra responsibilities entailed were clearly spelled out.

The initial committee meeting consisted of a wide range of stakeholders on Staten Island. Table 5-1 contains a list of those attending the kick-off.

GTHG Steering Committee Meeting Expected Attendees: June 22nd
1. Anthony T. Esposito, Special Assistant to Borough President Oddo
2. Paul Marrone, Chief of Staff, Office of Assembly Member Malliotakis
3. Pat Ryan, Staten Island Director, Congressman Daniel M. Donovan's Office
4. Ron Rizzotti, Senior Program Manager, Governor's Office of Storm Recovery

5. Lonnie Baron, West Shore Project Manager, Staten Island Economic Development Corporation (SIEDC)
6. Stephanie Ells, Deputy Director, Transportation & Infrastructure Unit, NYC Emergency Management
7. Peggy Marten, DOT Borough Engineering
8. Victor E. Vientos, EDFP, Director of Retail Attraction & Business Services, Staten Island Chamber of Commerce Foundation; Project Manager - Establishing East Shore Local Development Corp
9. Laura Del Prete, Program Manager, Staten Island NFP Association/SI COAD
10. Mosi London, Transportation & Infrastructure Unit, NYC Emergency Management
11. Mark Irving, Director Public Affairs, Staten Island Office, Con Ed
12. Shannon McLachlan, Acting Community Planning and Capacity Building Coordinator, FEMA Region 2
13. Dean Balsamini, Director, Small Business Development Center at the College of Staten Island

Table 5- 1 GHTG CAB Initial Meeting Committee Member Attendance

This GHTG CAB is a useful coordinating structure. But most critical is what happens at the grassroots level. Efforts such as these are hard to plan for in advance, or even predict. Formal structures serve to help prepare ground that is hopefully fertile for whole community organizing.

Community engagement: informal

There are many examples of informal community organizing and engagement that took place during Sandy. A distinguishing feature of the Staten Island community during Sandy was the strong and continuing response that occurred. These efforts included:

- Guyon Rescue Center: this began as a volunteer effort to clean out the Oakwood Veterans of Foreign Wars (VFW) Post and feed people immediately after the hurricane and which expanded into a partnership with the Catholic Charities of Staten Island, headquartered on the grounds of Mount Loretto, to provide ongoing supply and support over the course of several years following and beyond. Currently supplies are stocked to be readily available to the public during the next emergency[xxi].
- New Dorp High School: led by Principal Deidre DeAngelis, who at first coordinated more than 300 volunteers to collect and distribute clothing, cleaning supplies and food and then turned over school computers to residents so they could apply for aid. She raised money and bought dozens of mattresses and other items for victims of the storm and made sure that staffers located all of New Dorp's 2,750 students once school resumed, and that they had counselors and financial aid [xxii]
- Project Hospitality: Leader Terry Troia established many efforts, including turning Project Hospitality's food truck into a mobile commissary to distribute cleaning and household supplies, food and water in the disaster area. Project Hospitality continues to lead the long-term recovery organization for Staten Island and coordinates the services and placement of vulnerable, disabled[xxiii].
- Marybeth Melendez: a mental health studies graduate student at the College of Staten Island who is legally blind, helped with rescue and assistance to the disabled during Sandy and who continues to work in this arena [xxiv].
- The Siller Foundation: which set up a Relief Center where disaster victims received essential food items and supplies and worked with thousands of volunteers to gut

houses, provide clean up, and restore damaged homes[xxv].

The Staten Island Community Organizations Active in Disaster (SI COAD) is an example of a broad community network that may well prove essential in playing a role during the next hurricane. (The material that follows below is drawn from the SI COAD website: http://www.sinfpa.org/si-coad). SI COAD brings together not-for-profits & agencies that can provide assistance in disasters. The goal is to coordinate services across the sector to increase effectiveness, interface with federal, state and local agencies and generally promote a culture of preparedness. SI COAD is administered by The Staten Island NFP Association.

Members of the SI COAD include:
American Red Cross in Greater New York
FEMA
JCC of Staten Island
Richmond University Medical Center
Meals on Wheels of Staten Island
NYC Emergency Management
Project Hospitality
Salvation Army
Staten Island Chamber of Commerce
Staten Island Long Term Recovery Organization
Staten Island Mental Health Society
Staten Island University Hospital

The Program Manager of SI COAD is currently Laura Del Prete (who also sits on the Steering Committee).
COAD hosts regular monthly meetings of its members and also targeted events. These include:

- "Family Ready Day: A yearly event educating the community about large-scale disasters and smaller local emergencies that can happen more frequently.
- Self Care Conference: An annual event that provides support to those in the field, providing self care education, resiliency, recognizing PTSD and burn out. All skills then can then bring back to colleagues and pass onto clients."

Currently SI COAD educates and organizes the community with respect to disaster responsiveness. Much of the information it disseminates comes from various sources, including the GHG effort, and staff at the College of Staten Island. This is indicative of the symbiosis that leads to a feasibility plan with a future and ensure that it carries on after a report like this is out.

Engaging the community on planning for parking during an emergency
There are many other examples of grassroots community efforts during and after Sandy. So obviously the Staten Island community is ready to help people during the next storm. But are they ready to help with parking?

This is not a flip statement. In fact community organizations often own and manage substantial amounts of parking, e.g. faith-based institutions such as churches. They are

touchstones for many different groups, particularly those in need, such as the socioeconomically disadvantaged, the aged, and people with disabilities and others with access and functional needs. They have critical expertise and are often very experienced in providing services most needed during an emergency, such as providing food and comfort and coordination to displaced people.

Overall planning for hurricanes in New York does not consider parking because this is generally a private affair and because in many areas of the city evacuations will be primarily done on foot or by transit. Staten Island is different from many parts of the City because of its dependence on cars which makes parking a key component of any evacuation. Coordination and planning of parking during an emergency needs to take place on a system-wide level. This could take various forms, e.g. the post of Vehicle Evacuation Liaison mentioned in Chapter 4.

The impetus, competence, and social fabric and infrastructure are present. There just needs to be an extension of all this, in partnership with government, to focus on provision and coordination of parking during a hurricane.

The need for a governmental champion

A governmental champion is essential. The continued support of the Governor's Office is obviously critical. In addition there needs to be ongoing follow up through the Staten Island Borough President's Office, the Island's legislative representatives, and the City of New York, working with community and civic groups, creating a sense of urgency and making a continuing commitment of time, attention and money on planning for the next storm, when it comes. As it will. But next time, hopefully, the result will be an orderly and timely movement of cars and people with minimal loss of life and injury.

Appendices

Chapter 1 appendix – selected resources

Chapter 2 appendix – GTHGTM detailed exposition

Chapter 3 Appendix - Proposal for Earth and Environmental sciences undergraduate and graduate courses at the College of Staten Island

Chapter 5 Appendix - Citizen's Advisory Board/Steering Committee Application Go to High Ground Study

Vizalytics Analysis

Chapter 1 Appendix – Selected resources

New York City Emergency Management
www.nyc.gov/html/oem/html/home/home.shtml

National Flood Insurance Program
www.floodsmart.gov

Federal Emergency Management Agency
www.fema.gov

Ready/Fema
www.ready.gov

National Hurricane Center/Tropical Prediction Center
www.nhc.noaa.gov

National Weather Service
www.weather.gov

Notify New York City
Register for emergency notification
by visiting www.NYC.gov, calling 311, or
following @NotifyNY on Twitter.

NYCEM on Facebook and Twitter
www.facebook.com/nycemergencymanagement
www.twitter.com/nycoem

Ready New York: My Emergency Plan Guide
Search for "My Emergency Plan" at www.NYC.gov.

New York City Mayor's Office for People with Disabilities
Search for MOPD at www.NYC.gov
www.twitter.com/nycgov

City of New York on Facebook and Twitter
www.facebook.com/nycgov/nycgov
www.twitter.com/nycgov

Superstorm Sandy Forum: Resource Kit and Presentations
by Caitlyn Nichols, PhD and Michael Kress, PhD
http://oae.csi.cuny.edu/sandyforum/news.html

Chapter 2 Appendix – GTHGTM detailed exposition

The Go to High Ground Transportation Model (GTHGTM) is a micro simulation of vehicular traffic associated with evacuation including the movement of vehicles to high ground parking and transportation of evacuees to Family and Friends residences, Hotels and Motels, Public Shelters and Off Island locations[xxvi]. .

There are two separate modeling techniques used in the Go to High Ground Project. The first builds on the second:

(Model 1): The evacuation modeling used by New York City Emergency Management (NYCEM) and reported in the New York City Hurricane Evacuation Study (NYC HES) which analyses the clearance time required to evacuate people in flood zones traveling by automobile to their respective sheltering locations. The HES consists of five parts – Hazard, Vulnerability, Behavioral, Shelter and Transportation Analysis - and assumes a four stage evacuation time-line starting at the time when NYC orders an evacuation. It uses parameters to represent background traffic and road class service levels described below. For the most part, the major congestion locations studied are located along the inland perimeter of the Staten Island evacuation area. It uses fine-grained units of analysis called Transportation Evacuation Zones (TEZ) to locate evacuating people throughout the evacuation zones.

(Model 2): The (GTHGTM) focuses on identifying bottlenecks created by the flow of traffic associated with evacuating vehicles from flood zones to high ground parking locations and the transport of evacuee to sheltering locations. This model is based on a road network which was adapted from NYMTC BPM, 2005 and is run in Transmodeler Version 2.5. Figure 2-1 shows the GTHGTM network.

The GTHGTM uses centroid connectors and Transportation Analysis Zones (TAZ) are used to distribute cars being evacuated to high ground parking as well as high ground parking locations and sheltering locations for evacuees traveling by car. Therefore the GTHGTM does not align one-to-one with the NYC HES major congestion locations which are based on TEZs. This model loads the evacuating cars over time based on a normally distributed frequency. The model was run with either an 8 hours or 24 hours loading. The 8 hour loads for evacuation zones 1 through 4 provide valuable information regarding bottle necks associated with the car evacuation and provides insight to the dynamics of the vehicular evacuation process. The 8 hour load is not feasible for the evacuation of Zone 5 and Zone 6 due to catastrophic congestion. A 24 hour load handles modeling evacuating vehicles in all flood zone scenarios; however, it does not identify major congestion locations as effectively as the 8 hour load cases.

While the purpose of the two models is significantly different, the same NYC HES flood zones were used in both models. NYC HES assumptions and parameters were used in the GTHGTM for prorating the choice of sheltering locations based on socioeconomic strata. Also, for calculating clearance times the same background traffic volume, roadway service levels and road class capacity of roadways were used.

New York City Hurricane Evacuation Study (NYC HES)
A thorough analysis of hurricane evacuations in New York City including vehicular traffic

associated with the evacuation of people in designated evacuation zones is presented in the HES documentation. A key variable calculated is Clearance Time, i.e. the time to evacuate people from an evacuation zone. Details of these were provided in discussions and collaborations with NYCEM.

A basic geographic unit of the HES is the Transportation Evacuation Zone (TEZ). This is a finely grained spatial unit of analysis but defined only for the areas requiring evacuation. The areas where people are being evacuated to are not modelled at such a fine grain because the purpose of the HES model is to determine how people get out of danger in a timely fashion. The GTHGTM model on the other hand is concerned with determining how people can get to parking spaces available on high ground. For this purpose a fine grained spatial unit called a Transportation Analysis Zones (TAZ) is used for modelling in the areas that people evacuate to. These are fairly close in size but not identical.

Figure 2-3 provides an example of how Census Block data were used and then aggregated up into TAZs in the GTHGTM model. The GTHGTM uses a slightly different Census Year from NYC HES. Census block data can also be aggregated up into TEZs but this was not used for the GTHGTM model. The following GIS maps were made with ArcGis version 10.3, using TIGER shape files and data from the 2010 Census[xxvii].

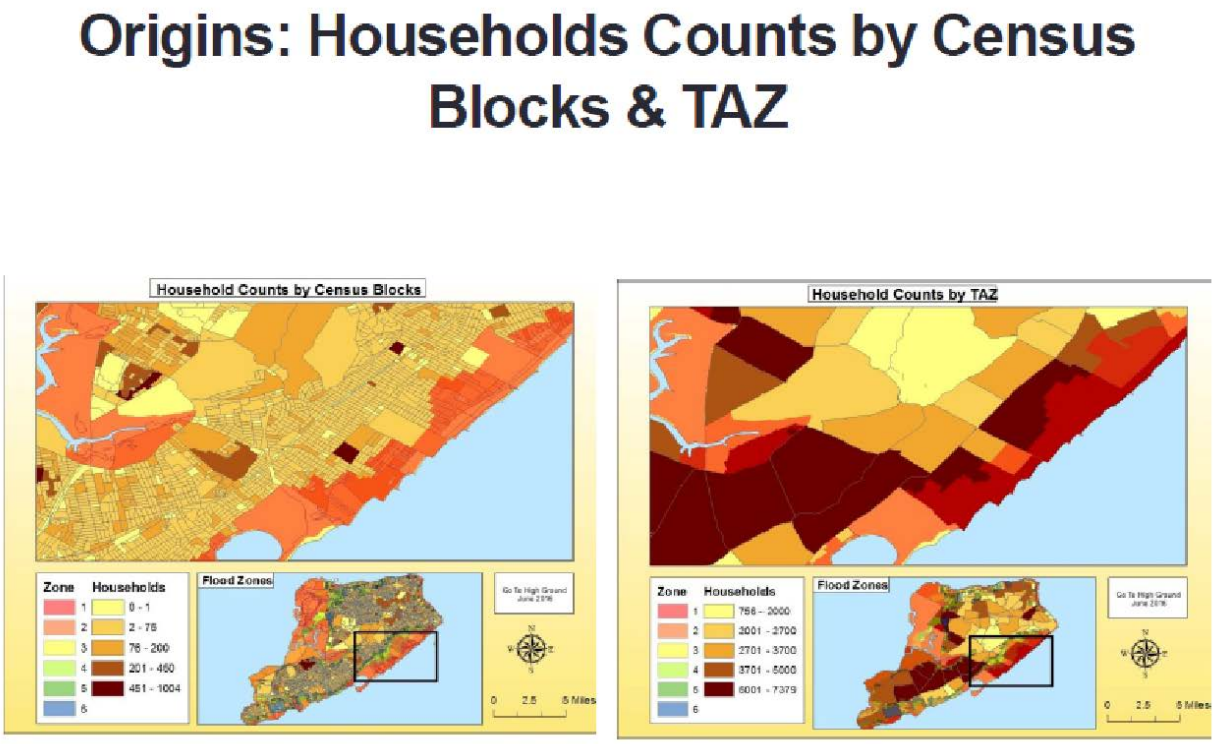

Figure 2- 3: Sample comparison of household counts by Census Blocks and TAZ

Go To High Ground Transportation Model (GTHGM) Development
The Evacuation traffic flow of the model includes the following key steps:

- *(1) Geolocation of personal vehicles in flood prone evacuation zones.* Census block

level GIS analysis were used for estimating the number of households in each of the 6 evacuation zones. (A summary table of the household breakout and socioeconomic strata summarized from U.S. Census data is used in the model. Some details on the data used are discussed at the end of this appendix). Maps of the origins and sheltering choice are shown in Figures 2-4, 2-5, 2-6, and 2-7. A more detailed explanation of the process for determining these origins and destinations follows below.

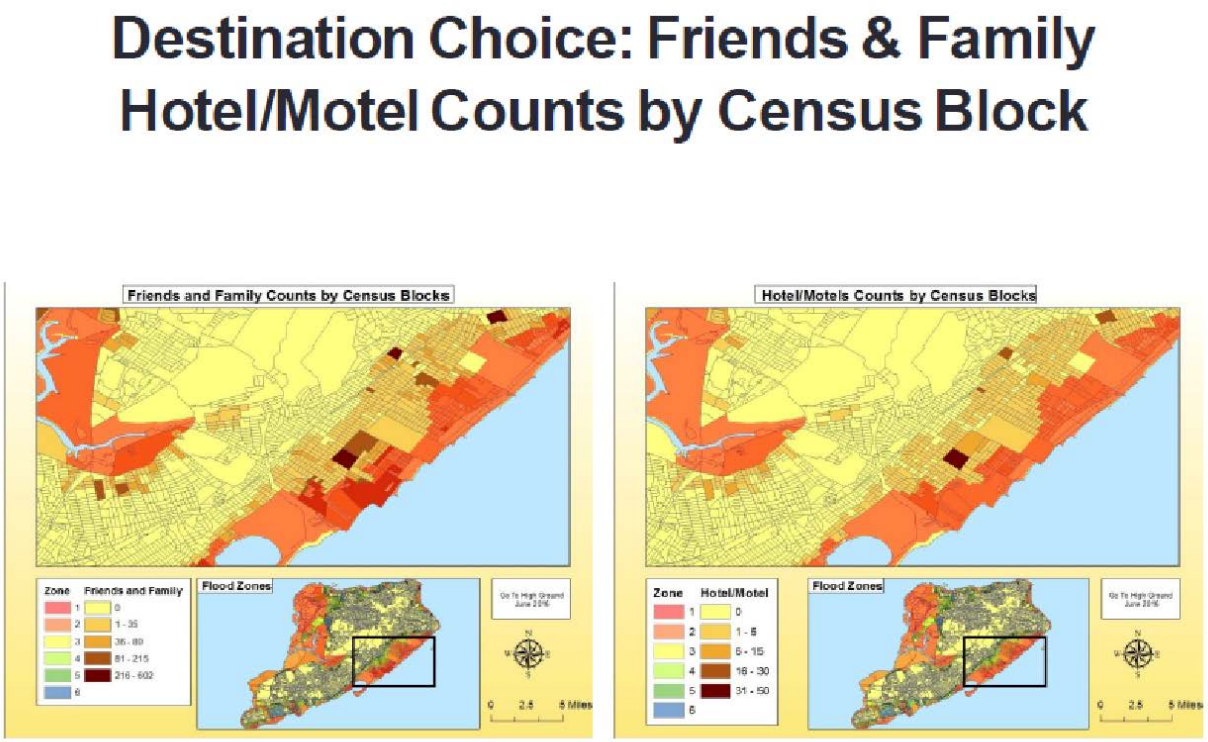

Figure 2-4: Sample comparison of destination choice – Friends and Family and Hotel/Motel counts – by Census Block

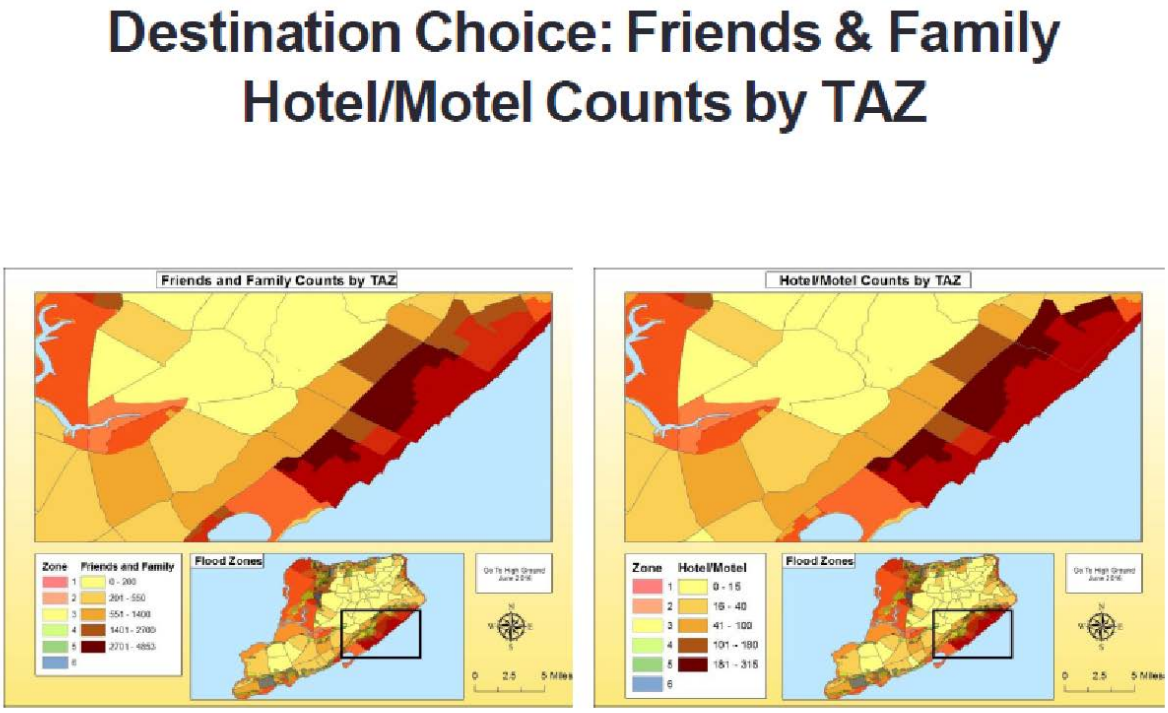

Figure 2- 5: Sample comparison of destination choice – Friends and Family and Hotel/Motel counts – by TAZ

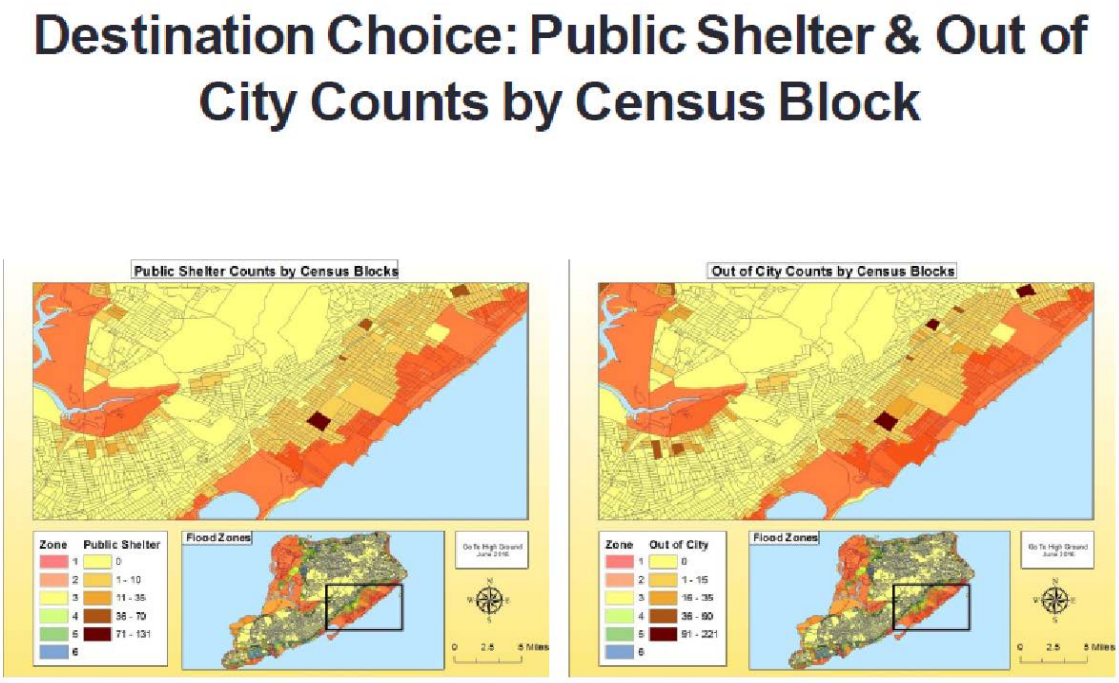

Figure 2- 6: Sample comparison of destination choice – Public Shelter and Out of City counts – by Census Block

Destination Choice: Public Shelter & Out of City Counts by TAZ

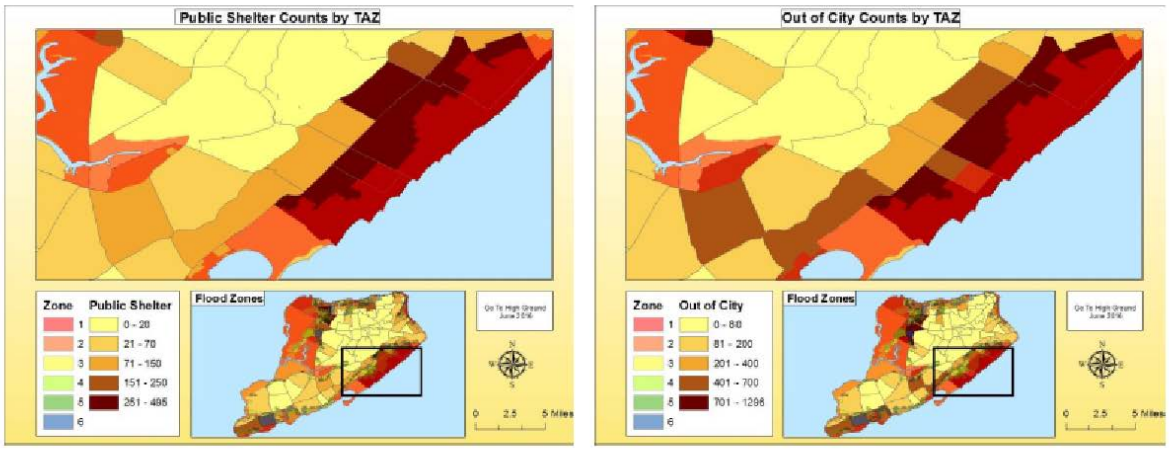

Figure 2- 7: Sample comparison of destination choice – Public Shelter and Out of City counts – by TAZ

- *(2) Geolocation of parking locations and number.* Proposed off-street locations were identified using GIS analysis. (While on-street locations, GIS analysis was done to identify on-street parking, but they have not been included at this time). This is shown in Figure 2-2 in Chapter 2.

In addition, for Zone 6 analysis, approximately 5600 additional high ground parking spots are assumed at Family and Friends Residences where evacuees shelter. The exact number of spots is set to balance and conserve the evacuating cars. They are distributed by TAZ in proportion to the number of high ground household in each TAZ.

- *(3) Create an origin destination (OD) matrix*. An OD matrix was developed for input to *Transmodeler* based on available high ground parking and vehicles to be evacuated by evacuation zone as determined above. The steps taken were as follows:
    - Based on origins located in evacuation zones and destinations located in high ground areas input files were created for conservation of cars using a gravity model.
    - Return Flows for transport from high ground parking to sheltering locations at Family and Friends residences were created, assuming that 50% of the vehicles moved will require additional vehicular transportation for the high ground parking to the Family and Friends residence and return. The origins are specified based on the parking locations and the destinations are equally distributed among high ground TAZs.

- An OD Matrix was established *in Transmodeler* format, for either a 24 hour load or for an 8 hour load. Note to self: An auxiliary routine, *HGPJNormLoadV1.R* is used to calculate the load times and percentages for 8 hour or 24 hour normal frequency distributions.

- *(4) Develop the highway network: with existing directional network flow.* The NYMTC Best Practices Model 2005 Network with GTHG revisions for speed limits, traffic lights and number of lanes was used to specify the roadways. *Transmodeler* V2.5 is used to calculate the traffic flows. Figure 2-8 depicts the model routes.

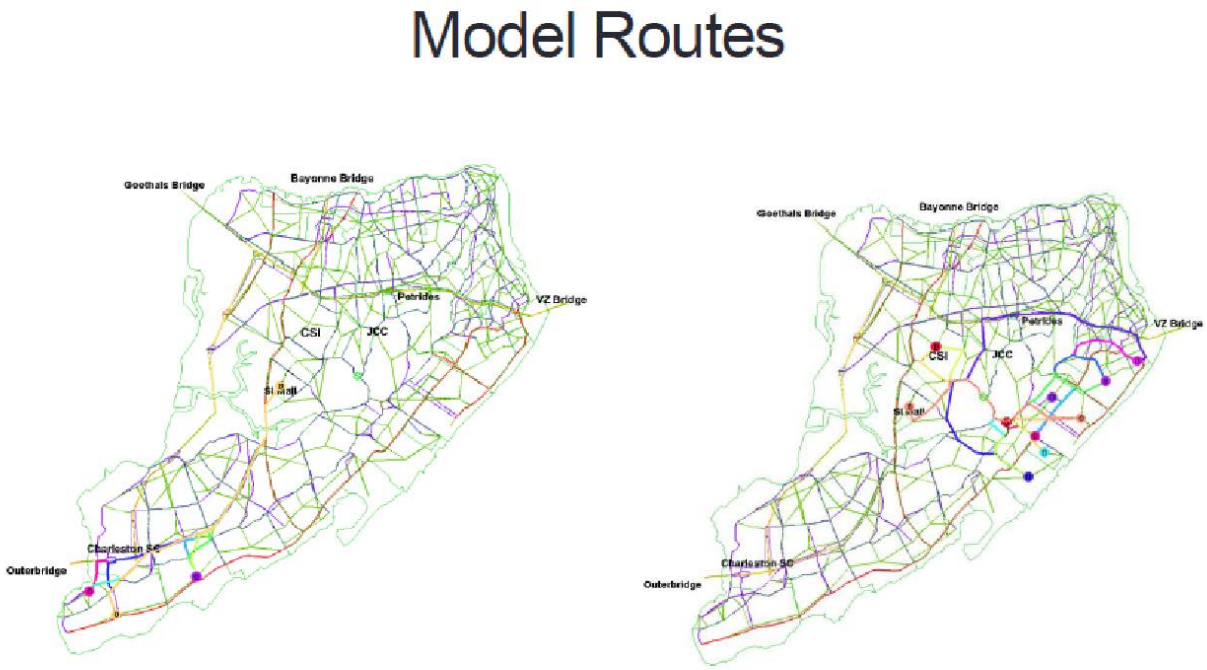

Figure 2- 8: GTHG Transportation Model routes

- *(5) Develop the highway network: feasibility with one directional network flow.* This is not feasible because the return flow and inland travel to Family and Friends does not have a dominant unidirectional flow. In addition, The NYC Police Department handles traffic flow including deploying traffic flow officers where needed at the time.

- *(6) Run model and identify bottlenecks.* Video of the simulation runs for an 8 hour load Traffic volume and density analysis were used to identify bottle necks. Evacuation Zones 1, 2 and 3 show noticeable congestion. Zone 4 is used for bottle neck analysis for Clearance Time analysis. 24 Hour load with normal loading does not show significant bottlenecks. Figure 2- 9 shows a snapshot of the evacuation simulation. Figure 2-10 shows a snapshot of the bottleneck analysis.

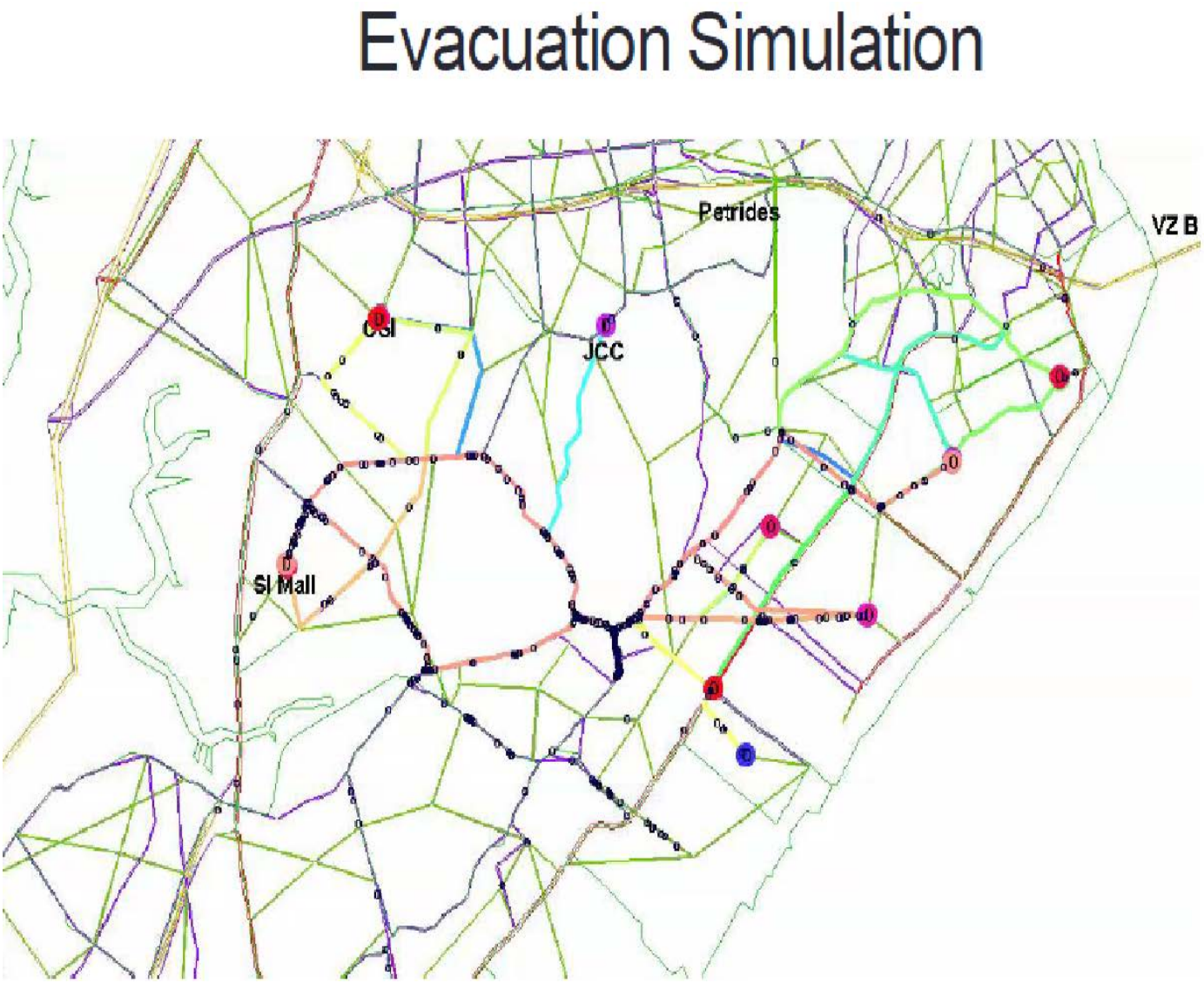

Figure 2- 9: Sample of GTHGTM evacuation simulation

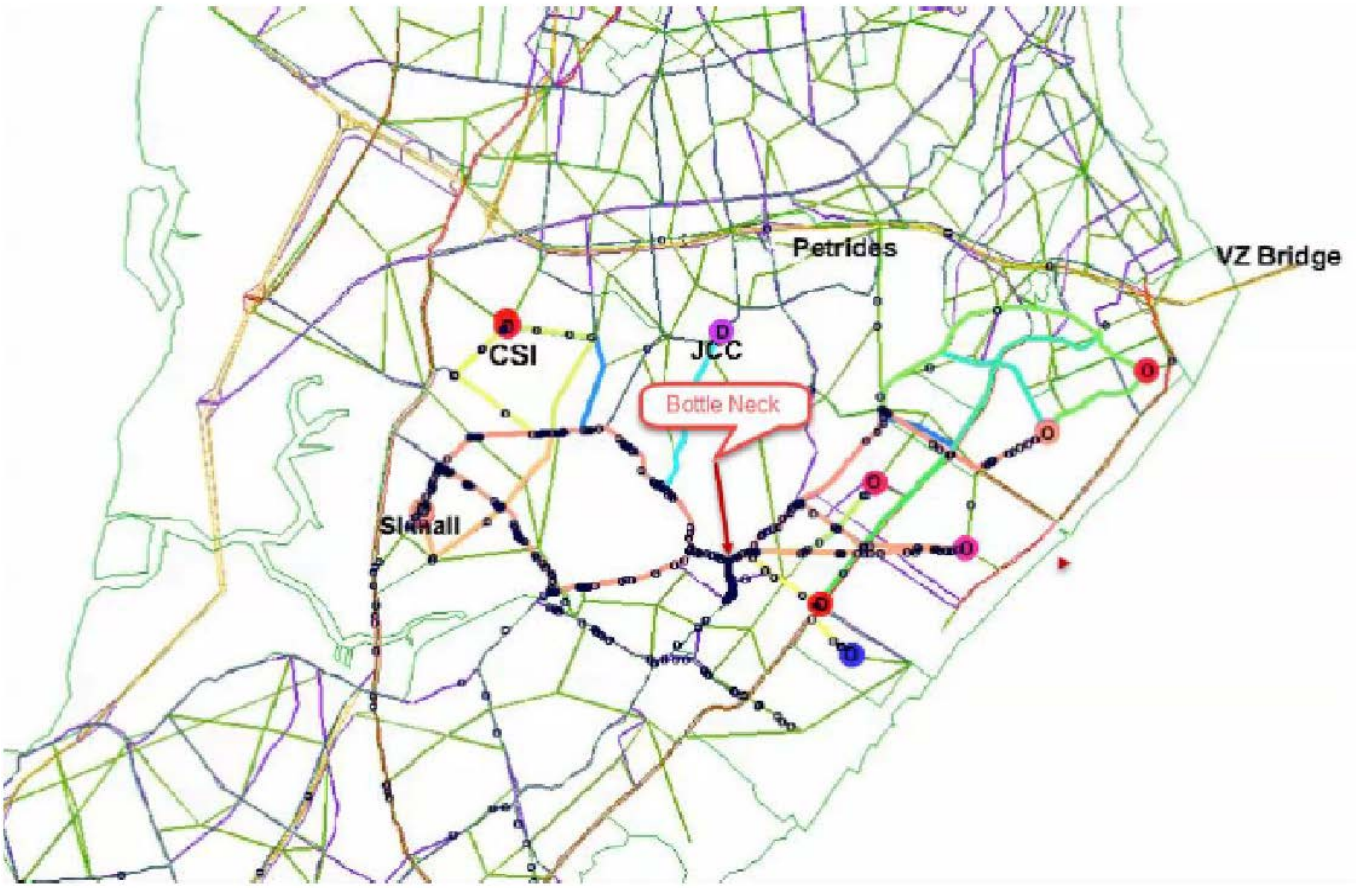

Figure 2- 10: Sample of GTHGTM bottleneck analysis

- *(7) Adjust traffic signals.* This is not a feasible activity for this project. In part because the return flow does not lend itself to a prioritized flow due to a substantial return and background flow and in part because the installation of smart traffic lights or other changes in signal timing is beyond the scope of this study.

- *(8) Reapportion the parking locations.* The number of vehicles evacuated for Zones 1 – 6 was balanced with the available high ground parking using a gravity model approach to conserve cars and pair-up the origins and destinations.

GTHGTM Validation

Based on best practices of simulation and modeling, a number of methods were used to validate the GTHGTM on a number of levels:

1. The GTHGTM network and model were compared to Staten Island traffic flows based on known congestion trouble spots and the lane and road segment details were verified by "ground truth" observation at key locations.
2. Simulations were run without background traffic for flood zones and the time series

of average speed and travel time were analyzed with videos of traffic flow. The videos showed known bottlenecks. Also, the time series were consistent with free flow in cases where the traffic loading per unit time allowed for it, and with congestion and delay where heavy loading caused significant bottlenecks and catastrophic congestion.

3. Households in evacuation zones were calculated with different assumptions and compared to NYC HES. The comparison shows that the evacuating vehicles are conservative as compared to other assumptions and in line with NYC HES with a difference ranging from 15% for Zone 1 to 2% for Zone 6. The comparison is shown in the table below.

Evacuation Zone CUMULATIVE		1	2	3	4	5	6
Max Evacuating Vehicles	NYC HES Staten Island USING DRIVE INDEX	9464	20933	24735	33031	44234	55609
Evacuation Vehicles	CBv4 Modeled	8167	18781	22350	31735	46569	56685
	Percent Difference	**15%**	**11%**	**10%**	**4%**	**5%**	**2%**

Table 2- 1: Comparison of GTHGTM evacuation estimates with HES estimates

GTHGTM Calibration

GTHGTM was calibrated by a combination of "ground truth" on the road network and comparison to NYC HES. The following list a number of key calibrations used:

1. The Go to High Ground model network was calibrated by "ground truth" field observations of lanes in major arteries and traffic lights in major intersections.
2. TAZ boundaries shape files were based on US Census TAZ Shape files and compared with the GTHGTM Staten Island network for consistence.
3. Road capacity calibration for evacuation clearance time was based on NYC HES.
4. Parking capacities were done with a Google Earth overlay comparison to ARC GIS Open Street Maps.
5. Evacuating Vehicle counts based on 1 vehicle per house hold for TAZs in flood zones were calculated based on household count in the 2009 and subsequently 2010 US Censuses and compared with NYC HES.
6. Socioeconomic properties of Census Blocks were based on American Community Survey data (ACS_14_5YR_B19013). Figure 2-11 provides an example.

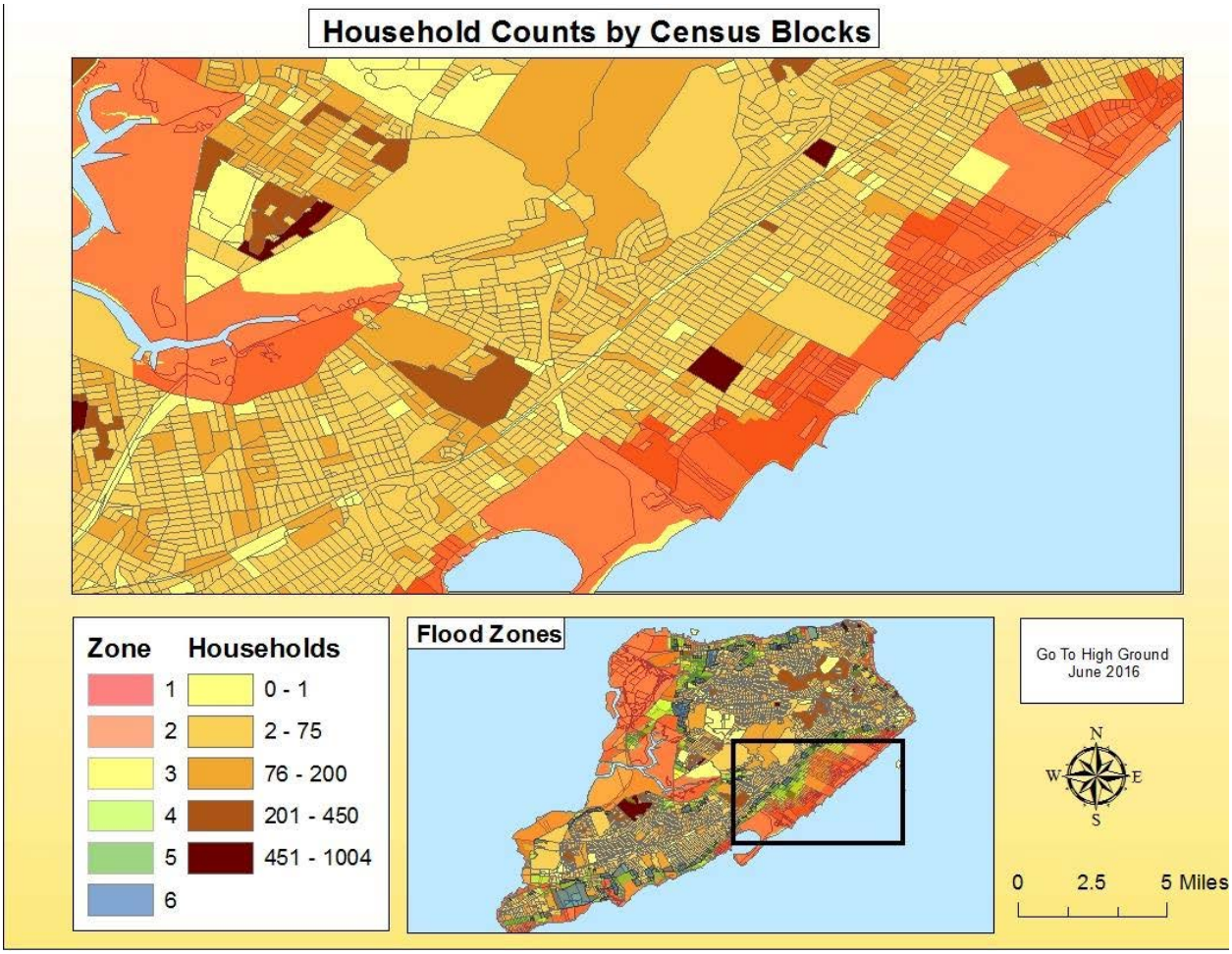

Figure 2- 11: Sample mapping of socioeconomic characteristics of Census Block households

7. Clearance time analysis parameters
   Clearance times were calculated following the Clearance Time method used in NYC HES using the same background traffic, road capacity, and 4 time period loading for the high level evacuation (100% of vehicles evacuated). The GTHGTM traffic counts were in general less than the traffic counts used in NYC HES in nearby locations due to the use of different traffic modeling methods and networks.

   Figure 2-12 illustrates the major results of this analysis. Line thickness indicates traffic densities, and colors indicate clearance times in hours. The thick purple lines show maximum densities greater than 96. White circles indicate locations at which the clearance times were calculated along with the actual calculated value of the clearance time. Further details of this process are provided below in the section entitled GTHGTM Background Traffic.

Figure 2- 12: Major results of GTHGTM analysis

Legend

GTHG HES Shared Bottlenecks

NYC HES Bottlenecks

Maximum Density >96

Maximum Clearance Time

0.000000 - 2.752606

2.752607 - 5.505213

5.505214 - 8.257819

8.257820 - 11.010426

11.010427 - 13.763032

13.763033 - 16.515639

GTHGTM Background Traffic

The GTHGTM micro simulation model focuses only on the traffic directly associated with the evacuation of vehicles from flood zones to high ground. Clearance time analysis for comparison to NYC HES assumes the same background traffic as NYC HES which is twice

the maximum evening rush hour. Table 2-2 below shows the assumed capacity, service levels and heavy background traffic load assumed in the Clearance Time estimates resulting from the GTHGTM vehicle counts.

FclassCode	ClassName	Example Id	Road Type	Capacity	ServiceLevelQ1	ServiceLevelQ2	ServiceLevelQ3	ServiceLevelQ4	HvBkTraffic
999	Centroid Connector	16223	Local Street	600	800	640	720	800	1200
998	PTZ Connector	48752	Minor Arterial	1000	1000	800	900	1000	1500
11	State HWY 440 (W Shore Expy)	90935	Freeway	2200	3020	2416	2718	3020	6040
12	State Hwy 440	90876	Frreeway	2200	3020	2416	2718	3020	6040
14	Gothles Rd N	90938	Major Arterial	1200	1100	880	990	1100	1650
16	South Ave	55245	Minor Arterial	1000	1000	800	900	1000	1500
17	Brielle Ave	55290	Minor Arterial	1000	1000	800	900	1000	1500
19	Villa Ave	55352	Minor Arterial	1000	1000	800	900	1000	1500
20	Hwy Ramp	53735	Ramp	600	800	640	720	800	1200

Table 2- 2: GTHGTM assumptions underlying clearance time estimates resulting from model vehicle counts

Clearance Time

During the evacuation model simulation total traffic counts were accumulated on the model segments. In addition, maximum volumes and densities in each direction on the segments were tracked to identify bottlenecks.

GTHGTM clearance times in the bottleneck areas range from a maximum of 16.5 hours to 6.5 hours with a mean of 7.5 hours and standard deviation of 1.2 hours. NYC HES clearance time calculated on Staten Island, excluding bridges, range from 16.8 hours to 7.6 hours with a mean of 11.1 hours and standard deviation of 2.2 hours.

A table of Clearance Times for each segment in the GTHGTM Zone 4 is shown in a supporting Excel Spreadsheet for NYC HES. Also shown there is a table of the Zone 4 NYC HES Clearance Times, roadway service times and assumed heavy background traffic.

NYC HES Clearance Times are longer in these cases and are more conservative. We, therefore, recommend using them in locations in the low lying areas near the evacuation zones where they are available. In high ground areas, where NYC HES does not carry out clearance time analysis, GTHGTM clearance time calculations complement NYCEM HES and help identify bottleneck and traffic congestion trouble spots. As part of the Go to High Ground project, Zone 4 was used as a comparison example.

GTHGTM Evacuation Bottleneck Analysis

Major bottlenecks not identified in NYC HES have been identified including the following:

- Richmond Road and Rockland
- Amboy Road and Richmond Road
- Richmond Avenue from Victory Blvd to Arthur Kill Road and on to Amboy Road.

Summary Comparison of Go to High Ground (GTHGTM) car evacuation model and NYC HES traffic model for Staten Island evacuation

1. The purpose of the GTHG car evacuation model (GTHGTM) is to estimate the traffic flow of automobiles being moved from Evacuation Zones to high ground parking.
2. The NYC HES traffic model studies the evacuation of people from the Evacuation Zones and the corresponding traffic impact using Transportation Evacuation Zones (TEZ) for spatial distribution of the evacuee in each flood zone.
3. The GTHGTM uses Transportation Analysis Zones (TAZ) [TIGER/Line Shapefile, 2011, Series Information File for the 2010 Census Traffic Analysis Zone (TAZ) State-based Shapefile] for estimating the spatial distribution of the origins and destinations of automobiles. TAZs are finer resolution in the high ground areas than TEZs. This provides a better approximation for the high ground parking destinations.
4. TEZ are finer resolution in the Evacuation Zones. These provide a better approximation of the origins, by including finer resolution of socioeconomic census data on a Census Block Level.
5. In our first version of the GTHGTM, we used Census Tracts to estimate the origins of vehicles with a finer resolution based on the NYC Pluto Database. It assumes one vehicle per house hold. It assumes a distribution of evacuation vehicles based on the HES Socio-Economic Table 3 with an average value of Medium Income Levels for each Evacuation Zone. Based on studies, sheltering choices typically depend on which Zone people live in as well as the median income levels of the household. Detailed Census data on these were used to come up with a percentage distribution of sheltering choice by Zone (e.g. 70% of households with Median Income in the 3rd of 5 income classes in Zone 1 were assumed to shelter with family and friends.)
6. After obtaining NYC HES, we revised our model. The current version of the GTHGTM uses Census Block data and the associated Census Block Group socioeconomic data to determine the number of households and sheltering choice for the evacuees Census Block by Census Block which provided a simpler more accurate way of calculating the sheltering choice. GTHGTM uses NYC HES data to estimate the sheltering choice percentages for the following sheltering categories: Friends and Relatives, Off Island, Pubic Shelter, and Hotel-Motel and associated destinations of the cars being evacuated.
7. The GTHGTM includes a return traffic flow which represents picking up people who park their car at High Ground parking locations and shelter with Friends and Relatives in High Ground locations on the Island.
8. GIS maps were created which show TEZ and TAZ comparisons of evacuation zones. See Figure 2 above.

Detailed note on data

Category	Number; Field ID	GTHG Dataset(s)	GTHG Data source & Level	NYCEM Dataset (s)	Data source & Level
Income	B19013; B19013 e1	Median Household Income in the past 12 m	American Community Survey 5-Year Estimates —	*Median Household Income In The Past 12 Months ***(****In*	American Community Survey 5-Year Estimates — *2006-2010;* Block

		Table of Contents **Type chapter title (level 1)** ..... **1** Type chapter title (level 2)..... 2 Type chapter title (level 3) 3 **Type chapter title (level 1)** ..... **4** Type chapter title (level 2)..... 5 Type chapter title (level 3) 6 onths (In 2011 Inflation-Adjusted Dollars)	2007-2011; Block Group	*2010 Inflation-Adjusted Dollars)*	Group
Households	Summary File 1, Table H3; H003000449 B25002; B25002e1	Housing Units Occupancy Status; Occupied Housing Units	U.S. Census Bureau, 2010 Census (Summary File 1, Table H3 Occupancy Status); Block Level	Housing Units Occupancy Status: Occupied Housing Units**:** U.S. Census Bureau, 2010 Census (Summary File 1, Table H3 Occupancy Status); **Vacant Seasonal Housing Units: U.S. Census Bureau, 2010*	U.S. Census Bureau, 2010 Census (Summary File 1, Table H3 Occupancy Status); Block Level

				*Census (Summary File 1, Table H5 Vacancy Status)**	
Vehicles	B25044; B25044e1	Assumption: 1/HH?	Assumption (occupied Household units); block level	**Tenure By Vehicles Available Aggregate Number of Vehicles Available by Tenure;* *% No vehicles Available*	*American Community Survey 5-Year Estimates — 2006-2010; Block Group* *Note: 2006 - 2010 Data Profiles; or avg. for area B25046 in 2010 American Community Survey 5-Year Estimates — 2006-2010; Block Group* *B25044*
Total Population				**Total population* *Population over 75 Years Old:*	*Total Population: U.S. Census Bureau, 2010 (Summary File 1, Table P1 Total Population);* *; U.S. Census Bureau, 2010 Census (Summary File 1, Table P12 Sex by Age)*

Table 2-3: Census Dataset Comparison GTHG v. NYC HES: NYC Analyses

**Differences are shown using italics*

Summary of table

GTHG Overview:

*A combination of the **American Community Survey 5 Year Estimates 2007-2011** and the*

2010 U.S. Census *data provided estimates for median income, occupied dwelling units (households) and the number of vehicles owned on average by households in each block group, and block.*

GTHG Census data sets utilized included:

1. The **American Community Survey 5 Year Estimates 2007-2011 data utilized included the following block group level datasets:**
   - **Income:** U.S. Census Bureau, 2007-2011 American Community Survey 5 Year Estimates: Median Household Income in the Past 12 Months.
   - **Vehicles:** U.S. Census Bureau, 2007-2011 American Community Survey 5 Year Estimates: Aggregate of Number of Vehicles Available by Tenure (Calculated or B25046 in 2010)
     - **Note: revert to assumption 1 vehicle/ occupied household**

2. **The 2010 Census data sets utilized included the following block level datasets from Summary File 1:**
   - **Households:** Occupied Housing Units: U.S. Census Bureau, 2010 Census
     - Occupied dwelling units (Total Households)
     - ***use this for vehicle assumption***

Comparison to NYC HES:

The 2010 Census data provided total population, occupied dwelling units and the number of vehicles owned on average by households in each block group.

1. The **American Community Survey 5 Year Estimates 2006-2010 data utilized included the following datasets:**
   - **Income:** U.S. Census Bureau, 2006-2010 American Community Survey 5 Year Estimates (Table B19013 Median Household Income in the Past 12 Months, In 2010 Inflation-Adjusted Dollars).
   - **Vehicles:**
     a. Aggregate Number of Vehicles: U.S. Census Bureau, 2006-2010 American Community Survey 5 Year Estimates (Table B25046 Aggregate Number of Vehicles Available by Tenure);
     b. Percent of Households with No Vehicle: U.S. Census Bureau, 2006-2010 American Community Survey 5 Year Estimates (Table B25044 Tenure by Vehicles Available);

2. **The 2010 Census datasets utilized included the following datasets from Summary File**
   - **Households:**
     a. Occupied Housing Units: U.S. Census Bureau, 2010 Census (Summary File 1, Table H3 Occupancy Status);
     b. Vacant Seasonal Housing Units: U.S. Census Bureau, 2010 Census (Summary File 1, Table H5 Vacancy Status);
   - **Population:** U.S. Census Bureau, 2010 Census (Summary File 1, Table P1 Total Population);

a. Population over 75 Years Old: U.S. Census Bureau, 2010 Census (Summary File 1, Table P12 Sex by Age)

Chapter 3 Appendix - Proposal for Earth and Environmental sciences undergraduate and graduate courses at the College of Staten Island.

Undergraduate
Planet Earth GEO 100/GEO 101
Physical Geology GEO 115, GEO 116
Natural Disasters GEO 111/112

Possible Laboratory Exercise: Hurricane Risk and Resilience for Staten Island, NY
Using the Unit 5: Hurricane Risks and Coastal Development (https://serc.carleton.edu/integrate/teaching_materials/hazards/unit5.html), this unit addresses changes in hurricane risks due to coastal development. Students will calculate the risks from hurricanes and how the hazards have changed (or not) from 1901 to 2010. Students will determine how changes in coastal development have altered the risks presented by hurricanes by analyzing data. This material is from the The Science Education Resource Center at Carelton College , Northfield MN.

Graduate
Earth Science ESC 703 Discussion and exercises in the coastal topic section.

Chapter 5 Appendix - Citizen's Advisory Board/Steering Committee Application
Go to High Ground Study

Guidelines *
I understand that this is an advisory/steering committee.
I will attend each quarterly meeting (or as otherwise scheduled), during the term of the CAB (as determined by GOSR and College of Staten Island).

I will commit my time to this CAB, as necessary (estimated 4 per month).

If selected/appointed?, I understand that I will need to provide additional information required by GOSR to conduct a background check.

First Name *

Last Name *

Street address *

City *

State *

Zip Code *

Date of Birth *
Month Day Year
Email *

Telephone Number *

Race/Ethnicity (Optional)

An important component of the Go to High Ground Study planning
process and what will make the CAB a success is including a diverse range of individuals that comprise and reflect the community where the project is located. Please consider disclosing your race/ethnicity (optional).
Primary Language Spoken (Optional)

An important component of the research and planning process and what will make the CAB success is including a diverse range of individuals that comprise and reflect the community where the project is located. Please consider disclosing your primary language spoken (optional).
Gender (Optional)

Describe which component of the GTHG study or process in which you are most interested in *

Are you affiliated with any of the following types of organizations? *

1st Responder/ Emergency Services
Academic
Business
Civic
Environmental
Non-profit
Regional Planning
Vulnerable Population
Other
N/A

An important component of the GTHG study and CBDG process is the participation of a diversity of individuals that comprise and reflect the community where the project is located. Members of the CAB are expected to represent a broad range of stakeholders both locally and regionally from varied organizations and interests. To meet this goal, applicants are sought
who are affiliated with relevant organizations, some of which are listed below. Please note that being affiliated with an organization is not mandatory to be a CAB member.

If affiliated with any of the above types of organizations, please specify the name of the organization, your position, and the years you served *

Please expand on one or two of your affiliations above that is the most significant to you, or will serve you best, in your position with the CAB*

Why are you interested in joining the CAB, and how will the CAB benefit from your involvement? *

The structure of the committee is 20 representative members from stakeholder groups, with quarterly meetings.
d. Target agencies and send application?
e. Post application on website? (Confirm with Alex)
f. Selection process- GOSR involvement

3) Application, selection & appointment process
a. Draft application below (adopted from GOSR CAC process)

Co-Chairs (Optional). Or appoint/invite applicants to be co-chairs?

This CAB will be led by two co-chairs. While co-chairs will be equal to all other members of the Committee, it is expected that co-chairs will lead meetings, advise on agenda items, help schedule meetings, and serve as a primary point of contact for the CAB. [Co-chairs will be selected by GOSR/CSI?]. Please note that the co-chair position will require a more substantial time commitment. If you are interested in serving as a co-chair, please provide a brief explanation as to why you would make an exceptional co-chair.

Resume (Optional, but strongly preferred) - Please enter resume text in the space provided and email as an attachment to:

If applicable, please provide any additional information below (optional)

Statement on Conflicts of Interest *

We kindly ask all applicants to disclose all conflicts of interests that may give the appearance of impropriety, should you be chosen to sit on the GTHG Citizens' Advisory Board/ Steering Committee (e.g. if you are a marine contractor that would stand to gain financially from sitting on this Committee). Please note that you are not necessarily prohibited from sitting on the CAC if you have a conflict of interest. We will evaluate each application on a case-by-case basis to make a final determination. Should you be selected as a member CAB, we may request additional information regarding your conflict(s) of interest.

If you have any further questions regarding conflicts of interest, please email

Signature Box *

Appendix - Vizalytics Analysis

We completed and submitted shapefiles for all parking lots included in the survey of Staten Island locations. We corrected and provided accurate counts for all spaces.

Parking Lot Analysis

A spreadsheet identifying 1,097 parking lots in Staten Island that were not included in the initial set used in the traffic simulations was used and a map produced based on that spreadsheet (Figure A-1). This list was developed using parking areas identified in the Vizalytics Knowledge Graph, located in high ground areas on Staten Island. All parking areas contain a minimum of 10 parking spaces, calculated from the shape area of the parking lot polygons using a 400 sq. ft. per parking space metric. These are all off street parking areas, we did not include on street parking in our analysis.

The column structure is as follows:

ObjectId	The unique identifier for the parking area polygon in the KG.
Number of Tax Lots	The total number of tax lots intersecting and/or abutting the parking area polygon.
Tax Lot Owner	An ordered list of the names of the owning entity(ies) of the tax lot, separated by semicolons.
Address	An ordered list of the addresses of the intersecting and/or abutting tax lots, separated by semicolons.
City	In all cases equal to Staten Island.
State	In all cases equal to NY.
Zip Code	The primary zip code associated with the parking area polygon. Where the value is 0, there is no associated zip code for the lot.
Land Use Category	An ordered list of the land use categories of the intersecting and/or abutting tax lots, separated by semicolons.
Number of Parking Spaces	The estimated number of parking spaces, calculated as described above.
Latitude, Longitude	The latitude and longitude of the centroid of the parking area polygon.

There are 14 instances where no ownership, address or land use category was available for the parking areas.

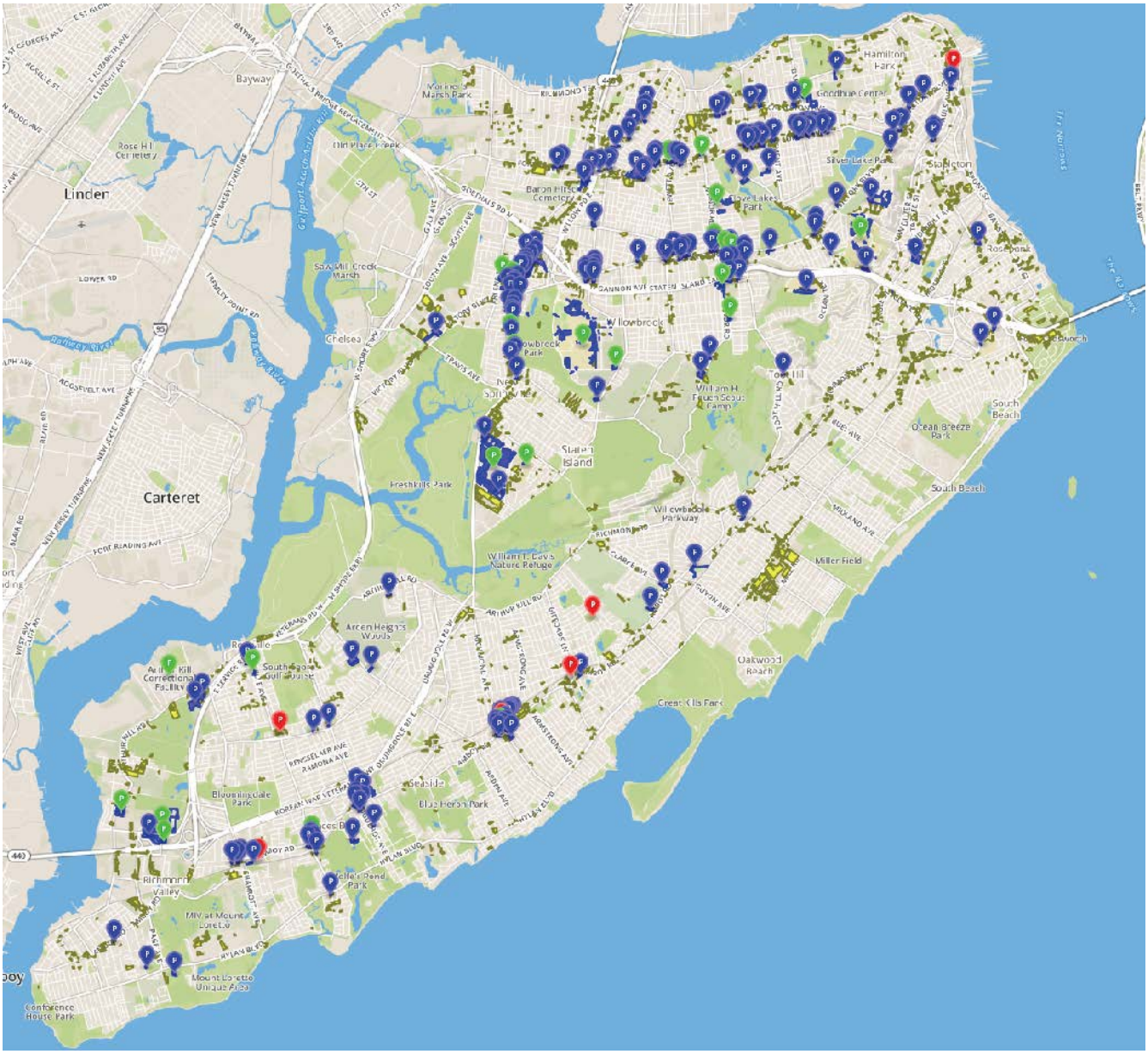

Figure A- 1: Map of selected potential off-street high ground parking spots

Observations and Caveats Based on Research to Date

- **Messaging Priority**

Citizens must be notified of the need to evacuate via multiple channels of communication. But if citizens are reluctant to leave, it may be far more critical to repeat the need to leave without complicating the choice by also recommending that cars can be moved to a separate location from the designated evacuation point.

- **Potential Negative Impact to Already Congested Areas**

To evacuate vehicles to parking lots, then assume that more vehicles will later move to those areas can put additional congestion burden on some areas. The potential for confusion and frustration is high when time is short.

- **Lot Selection and Communication**

We do not recommend including the Richmond University Medical Center and the Bus Depot in the list of potential lots. Other lots must be selected to minimize confusion and misunderstanding. Successful communication requires meaningful ongoing coordination with agencies, businesses and residents. Citizens should **not** be advised to remain in their cars during a storm, especially senior citizens, lest we complicate EMS needs.

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