Valley Study Area Hurricane Evacuation Study Vulnerability Analysis Report

Prepared by

Texas A&M Transportation Institute
and
Texas A&M Hazard Reduction & Recovery Center

The Texas A&M University System

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Background

A conventional vulnerability analysis focuses on determining the areas within a jurisdiction or region likely to experience some exposure to a hazard, such as flooding, and then determining the population, property, and critical facilities relative to that hazard exposure. In the case of this particular vulnerability analysis, our hazard focus is based on evacuation zones, which are themselves derived from likely surge inundation due to hurricanes. Hence, we will seek to determine the population, property, and critical facilities that are within evacuation zones. However, we are extending this general approach by undertaking the development of new data as well as bringing in relatively new data sources that should refine assessments of vulnerabilities when it comes to jobs and employee housing, identifying vulnerable populations residing in mobile homes and trailers, and identifying populations that are particularly vulnerable to hurricanes because of their social, demographic, and economic characteristics. Furthermore, as part of our vulnerability analysis we have developed a web-based GIS mapping service that can display many of the data utilized in the vulnerability analysis along with the evacuation zones, hazards layers related to surge, wind, and flooding, along with other data to facilitate evacuation planning by county and municipal governments and interested stakeholders in Willacy, Cameron, and Hidalgo counties. This website can be found the following location: http://texasatlas.arch.tamu.edu/fv/TA_HES_surge/.
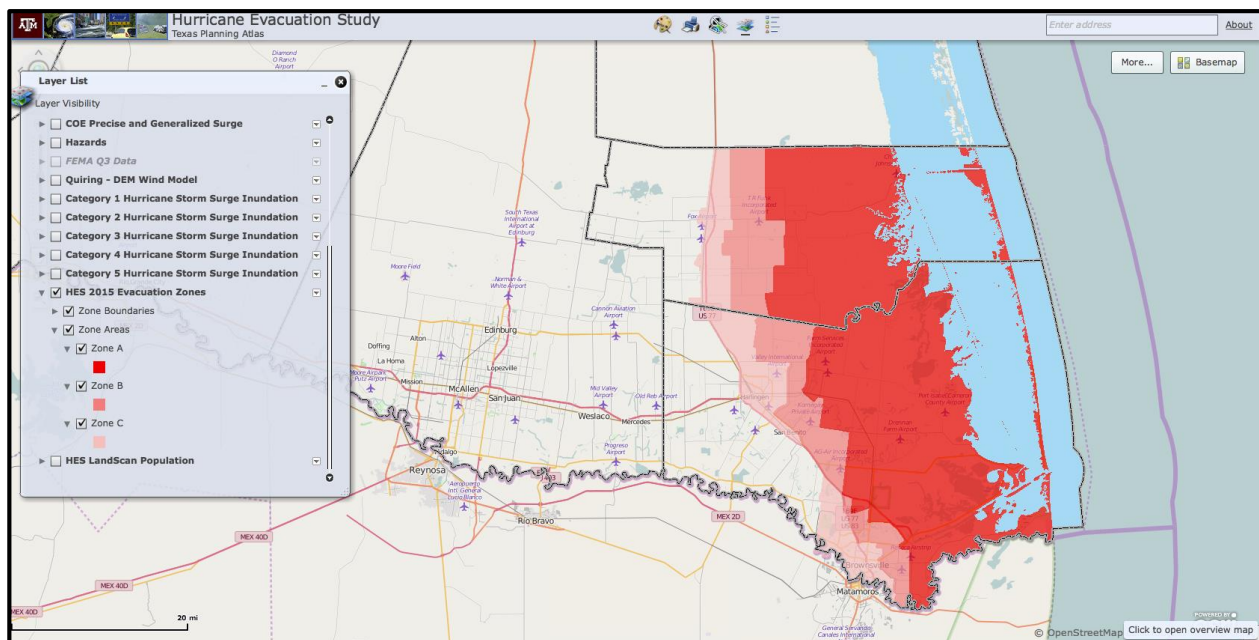
Figure 1. Evacuation Zones in Willacy and Cameron Counties.

The vulnerability analysis will be based on the new evacuation zones developed as part of the Valley Study Area's Hurricane Evacuation Study (see: Volume 1 of the final report). These zones are presented in Figure 1, where the highest risk zone, Zone A, appears on red, with Zones B, in light red and the final risk zone, C, in pink. Since these zones are only in Willacy and Cameron County, the vulnerability analysis has focused on these counties. Our vulnerability analysis begins with population and household vulnerability.

1. Population and Household Vulnerability

Estimating the population located within each evacuation zone is difficult because these zones do not correspond to the boundaries of areas defined and employed by the United States Census when it undertakes and reports it population enumerations or estimates. The evacuation zones developed for Willacy and Cameron counties were based on hurricane storm surge risk using easily identifiable roads and county boundaries to delineate zones, not the boundaries of census mapping units. As a consequence, census units such as census blocks or block groups do not neatly fit within each of these zones. Fortunately, working with the USACE, we were able to obtain and employ very high-resolution maps developed by Oak Ridge National Laboratory that estimate the numbers of individuals in very small grid cells. Utilizing these grids we were able to more easily distribute the population of Willacy and Cameron counties into and outside one of the three evacuations zones.

Table 1 presents the day and nighttime estimates for the numbers of individuals and households located in each of the evacuation zones for each of the counties and for the combined two county area. In addition, since the nighttime populations are the better estimates for the numbers of individuals and households that are subject to hurricane evacuation, we have also calculated the percentage of the total county population located in each zone and for all zones.

Table 1. Estimated individual and Household Population by Evacuation Zone (circa 2012)*

Willacy	A		B		C		A+B+C	
Day|Night pop. estimate	1,164	1,270	63	497	14,763	18,138	15,990	19,905
% County population		5.7%		2.2%		82.0%		90.0%
Estimated Households		387		152		5,530		6,069
Cameron	**A**		**B**		**C**		**A+B+C**	
Day|Night pop. estimate	64,796	60,030	74,815	96,678	214,961	177,290	354,575	334,001
% County population		14.4%		23.2%		42.6%		80.3%
Estimated Households		17,866		28,773		52,765		99,405
Both Counties	**A**		**B**		**C**		**A+B+C**	
Day|Night pop. estimate	65,960	61,300	74,878	97,175	229,724	195,428	370,565	353,906
% Total population		14.0%		22.2%		44.6%		80.8%
Estimated Households		18,267		28,957		58,235		105,459

* Household estimates based on household average size. 2010 census: Willacy – 3.28 per household and Cameron – 3.36 individuals per household.

While there are clearly considerable variations in the populations of these two counties, it is also clearly evident that both counties have sizable percentages of their total populations vulnerable to hurricane surge and therefore subject to evacuations, should such and evacuation include all three evacuation zones. In Willacy County it is estimated that only 1,270 individuals (or 387 households) reside in evacuation Zone A, representing 5.7% of the county's population. However, 82% of the county's population (18,138 individuals or 5,530 households) is located in evacuation zone C and overall 90% of the county's population (19,905 individuals or 6,069 households) are located in all three evacuation zones.

In Cameron County, the numbers are much larger, across the board, although there is a slight reduction in the percentage of the total county's population subject to evacuation. It is estimated that 61,300 individuals (18,267 households) or 14% of Cameron County's population are located in evacuation zone A. Not surprisingly, since evacuation zone C includes much of Brownsville and Harlingen, it is estimated that evacuation zone C includes 177,290 individuals (52,765 household) representing nearly 43% of the county's population. The combined population estimate for the three evacuation zones in Cameron County includes just over 334,000 individuals (99,405 households), composing 80.3% of the county's population.

In light of the LandScan data employed to derive these estimates, it should be noted that these estimates are circa 2012. While it is likely that the population for both counties has grown a bit since 2012, the overall percentages should be expected to hold for the near future.

Finally, according to the Evacuation Behavioral Survey it is anticipated that households would take 1.6 vehicles per household when evacuating (Lindell et al., 2013). More specifically, for their random sample of urban residents they estimated the average to be 1.6 vehicles per households. While a number of households do not have access to vehicles, a rough estimate of the maximum number of vehicles likely to be involved assuming 100% compliance across all evacuation zones would be 105,459 * 1.6 or 168,734 vehicles from the evacuation areas in Willacy and Cameron County. This of course does not account for possible shadow evacuation from non-evacuation zones in these counties.
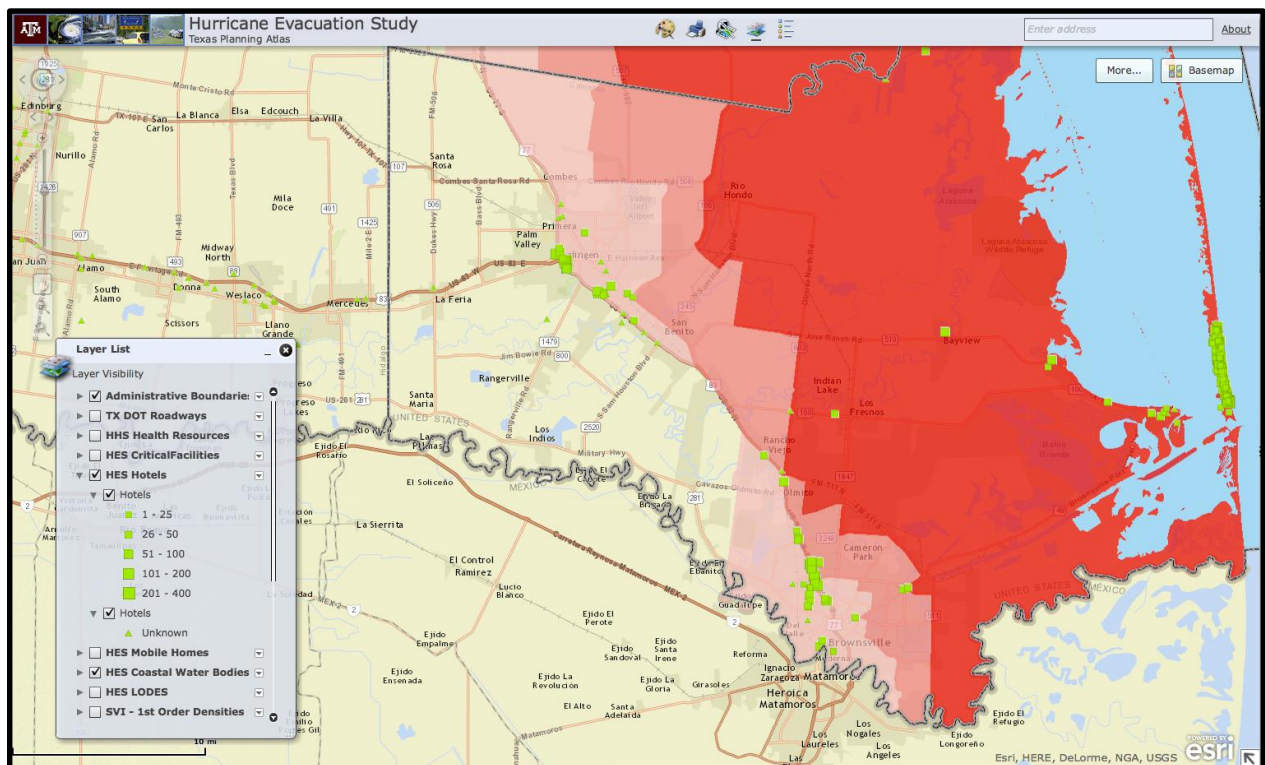

Figure 2. Hotel Layers for the Three County Study Area.

2. Estimates of tourist/seasonal population

Various sources of data were gathered and compiled in order to generate estimates for the total tourist/seasonal population that will need to be evacuated. Primary among these sources was information on the number of hotels and motels, along with their capacity, information about camping facilities and their capacities, and finally, the numbers of seasonal dwelling units, not associated with hotels that might be rented out to tourist/seasonal populations. The primary data for this task were acquired from the Texas Comptroller of Public Accounts (TxCPA) which has data on hotels/motels and, more often than not, their capacity (number of rooms). To these data were added hotel data from FEMA Region IV, in Denton. In addition, these data were cleaned, edited, and supplemented by data obtained from *Google, Google Maps* and *Google Imagery Web Map Services (WMS)* for Texas. We generally assumed that the data from the Texas Comptroller was the most accurate and supplemented it with data from FEMA Region IV, utilizing the Google sources to verify, edit, clean, and supplement the final dataset. The Google sources were particularly important when it came to locating camping facilities. In total the data set contains information on 455 hotels (11 in Willacy, 103 in Hidalgo, and 341 in Cameron).

These data sources were converted into GIS layers on the Hurricane Evacuation Study website. Figure 2 displays the Hotel layers for the three county area. There are actually two Hotel layers. The first layer, symbolized by squares, show the location of hotels in which we have data on the hotel capacity. The other layer, symbolized using triangles, indicates hotel locations but for these data we don't have capacity information.
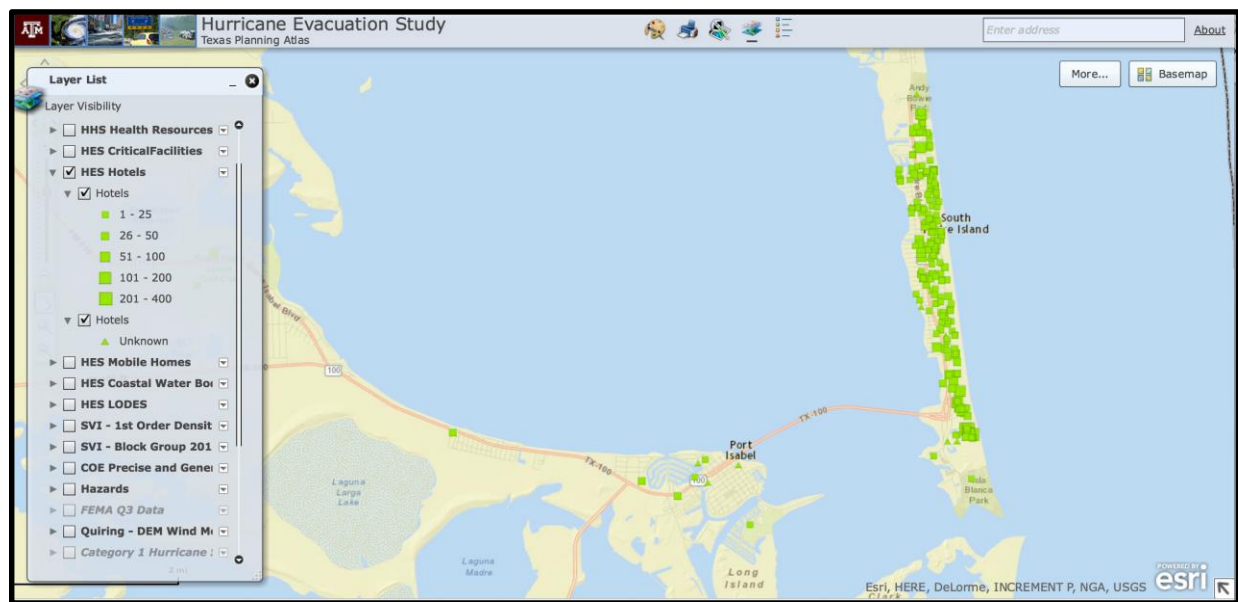
Figure 3. Hotels in Port Isabel and South Padre Island

While we obtained data on the locations of 455 hotels located in the three counties, we did not have complete data on capacities for each of these hotels. Specifically, of the 455 hotels, we had no capacity data on 149 hotels, while 142 reported having one unit, and 164 reported having two or more units. To ensure we were not undercounting units we doubled the number of units for all

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rentals reporting one unit and assigned a mean value of 67[1] to all hotels for which we had no data on capacity. Finally, the counts for seasonal units not located in hotels were estimated using the 2010 US Census block group[2] data.

Table 2 presents the data on estimate hotel and seasonal rental units located in each evacuation zone for Willacy and Cameron Counties. In Willacy we estimate that there are 830 units for seasonal/tourist rentals, with the majority of those located in evacuation Zone C, in and around the Raymondville along route 77, although there are also a nearly as many rental units in evacuation Zone A around Port Mansfield. In Cameron our estimate is 20,185 units in hotels and seasonal rentals. Unlike Willacy county, in Cameron County the vast majority of its rental units are in Evacuation Zone A (12,575), clustered on South Padre (9,677) and a number in Port Isabel (675). There is also a sizable number of these units in Evacuation Zone C (6,156) with the majority falling in and around Brownsville and Harlingen.

Table 2. Estimated hotel and Seasonal Units for Each County by Evacuation Zones

Willacy	Hotel Units	Seasonal Units	Total
Zone A	201	187	388
Zone B	0	5	5
Zone C	343	94	437
Totals	544	286	830
Cameron			
Zone A	6,214	6,361	12,575
Zone B	565	889	1,454
Zone C	4,643	1,513	6,156
Totals	11,422	8,763	20,185

On the whole, based on these estimated there are 21,015 units for tourist or seasonal visitors in the two counties. Assuming between 2 to 2.5 vehicles per unit, it might be anticipated that there would be somewhere between 42,000 to 52,538 vehicles that will be involved in the evacuation. Ideally the tourist and seasonal visitors would be encouraged to leave very early in the evacuation process.

It should also be noted that our estimation suggest that there should be just over 2,700 hotel rooms in the remainder of Cameron county, outside the evacuation zones and over 22,000 hotel rooms in Hidalgo County. If visitors to the area are encourage to leave all of the hotels, making room for locals within evacuation zones to obtain these rentals/rooms, these could be important evacuation locations for Willacy and Cameron households.

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[1] The value of 67 is the upper-limit of a 95% confidence interval around the mean number of rooms, 55.12.

[2] Each US Census block (and hence the data associated with that block) located in Willacy and Cameron counties was assigned to a specific evacuation zone based on the location of its centroid.

3. Estimate populations needing government transportation assistance

There is no established or reliable method for accurately determining the precise numbers of individuals needing government transportation assistance during an evacuation. It is generally assumed that households will employ their own private vehicles when the evacuating. Hence, one obvious way of estimating the numbers of households or individuals needing transportation assistance is to obtain estimates of households that do not have a private vehicle. However, research suggests that households without vehicles can obtain rides from family or relatives that are not immediate household members as well as from household friends. Furthermore, households may borrow vehicles from friends or non-household family members during an evacuation. Both of these cases suggest that estimates based on households not having a private vehicle may be a high. However, it should also be noted that many households that may report owning a vehicle, may not in fact have access to a reliable or even a working vehicle at the time of an evacuation. This will be particularly true for low-income households or households living at or below the poverty level who can have great difficulty maintaining their vehicles, should they own one.

In light of these issues we will first estimate the number of households that do not have a private vehicle. Additionally we will estimate the numbers of elderly households, elderly households that are living at or below the poverty level, and finally the number of households living at or below the poverty level. Data on these three types of households are presented because the literature has shown that they are 1) more likely to have difficulty evacuating, and, 2) in the case of elder households, they are likely to have difficulty driving or if they have a vehicle, are likely to have difficulty keeping a vehicle in working order.

Table 3 presents the data for Willacy County. In Willacy, it is estimated that 450 households that live in one of the three evacuation zones are without a privately owned vehicle. This represents about 8% of the total number of households in the county. Fortunately, the vast majority of the households are located in Evacuation Zone C, which places them in close proximity to the major towns along highway 77. While a relatively small percentage of household do not report owning a vehicle, sizable numbers and percentages of elderly households (2,142 and 39% respectively) and households living at or below the poverty level (2,341 or 43% respectively) are located in evacuation zones. Again, somewhat fortunately, the highest concentrations of these households are also located in urban areas along highway 77. The fact that these households tend to be concentrated in Evacuation Zone C and along Highway 77, suggest that with an organized effort, it should be relatively easy to locate these households and create central pick-up areas to facilitate their evacuation.

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Table 3. Willacy County: Likely Transportation Dependent Households

Social Vulnerability	Evacuation Zone	A	B	C	A+B+C
Households with no vehicle	Count	15	10	426	450
	% of Willacy households	0%	0%	8%	8%
Elder Households	Count	128	49	1,964	2,142
	% of Willacy households	2%	1%	36%	39%
Elder Households in Poverty	Count	51	17	615	683
	% of Willacy households	1%	0%	11%	12%
Households in Poverty	Count	159	56	2,125	2,341
	% of Willacy households	3%	1%	39%	43%

Table 4 presents similar data for Cameron County. Unfortunately, while the percentages are again relatively low given Cameron's population size, it is easy to see that sizable numbers of households report that they do not own a vehicle. Overall there are nearly 10,500 households, 9% of all Cameron County's households, without their own vehicle, with 932 located in Zone A, followed by 1,914 in Zone B and 7,645 in Zone C. Remembering that the average household size in Cameron County is 3.36 individuals, households without access to a vehicle may well represent over 35,000 individuals. Furthermore, while the other characteristics do not capture definitively populations that will need transportation assistance, but rather populations with potentials for needs for evacuation assistance, these data are also suggestive of major concerns. There are an estimated 32,304 elder households in Cameron County, representing 26% of all households composed entirely of individuals 65 years or older, with substantial numbers distributed in all evacuation zones. Furthermore, nearly 7,500 of these are also at or below the poverty level. In addition, the final attribute suggests that substantial numbers of all households in Cameron County are living at or below poverty. Indeed, just over 33,000 households, or just over a quarter of households, are living in poverty and within one of the three evacuation zones in Cameron County. While 20,290 of these households are located in Evacuation Zone C, which are in and around Brownsville and Harlingen, there are also substantial numbers in the other evacuation zones as well.

Table 4. Cameron County: Likely Transportation Dependent Households

Social Vulnerability	Evacuation Zone	A	B	C	A+B+C
Households with no vehicle	Count	932	1,914	7,645	10,492
	% of Cameron households	1%	2%	6%	9%
Elder Households	Count	4,509	9,051	18,745	32,304
	% of Cameron households	4%	7%	15%	26%
Elder Households in Poverty	Count	1,081	1,458	4,809	7,348
	% of Cameron households	1%	1%	4%	6%
Households in Poverty	Count	4,951	7,819	20,290	33,060
	% of Cameron households	4%	7%	17%	28%

In light of the relatively high absolute number of households that are without their own vehicles, as well as the numbers and percentages of elder households, elder households in poverty, and simply the numbers and percentages of households living in poverty that are also located in evacuation zones, it can be important for officials to work with and through local community and neighborhood organizations, churches and other religious organizations to identify, reach out to, and help these households understand their hurricane risks and develop plans to address evacuation issues. We know that there are already registries identifying potential elders that may have difficulty evacuating; it will be important to insure that these lists are up to date as hurricane season approaches. Again, working with local community and neighborhood organizations and churches can also be critical for getting information out regarding staging areas for buses that will help move households out of harm's way, as well as targeting evacuation programs and information.

To assist officials and community organizations identify potential target areas for concentrating these efforts and for locating staging areas, as part of the Hurricane Evacuation Study's interactive GIS website (http://texasatlas.arch.tamu.edu/fv/TA_HES_surge/) the HRRC team created social vulnerability mapping tools that allows stakeholders to create maps identifying census block-group areas where socially vulnerable populations, such as households without their own vehicles, are more likely to be concentrated along with the evacuation zones to facilitate and target evacuation planning efforts. Figure 4, for example, displays Census block-group data on areas with higher concentrations of households without their own vehicle along with the boundaries for the evacuation zones (red = Zone A, light red = Zone B, and pink = Zone C). In this figure the darker the green color, the higher the concentrations (percentages) of households without access to a vehicle. Clearly there are rather dark green areas in and around Harlingen and Brownsville, as well as just north of highway 48, between Brownsville and Port Isabel/South Padre Island. Figure 5 displays areas with higher concentrations of elder households, which clearly suggest not only concentrations in and around Harlingen and Brownsville, but also concentrations to the south of highway 48 and in and around Port Isabel and South Padre Island. This map perhaps indicated higher percentages of retirees in and around Port Isabel and South Padre Island, which undoubtedly need to be considered, but perhaps not as focused an effort as might be expended among poorer elder households. Indeed, Figure 6,

perhaps refines our understanding of areas with concentrations of elder households who are also living in poverty. A comparison of the maps in Figures 5 and 6 reinforces the perceptions that many of the elder households might be better off retiree households, while areas along highway 48 and within Brownsville are more likely to be elder households that are also living in poverty. Analyzing these data can help identify areas where public officials and other stakeholders will need to work with local groups and organizations to help identify and work with different types of elder households in order to help insure appropriate responses to evacuation orders.

Figure 4. Social Vulnerability (SV) Map Showing Concentrations of Households Without their own Vehicle.
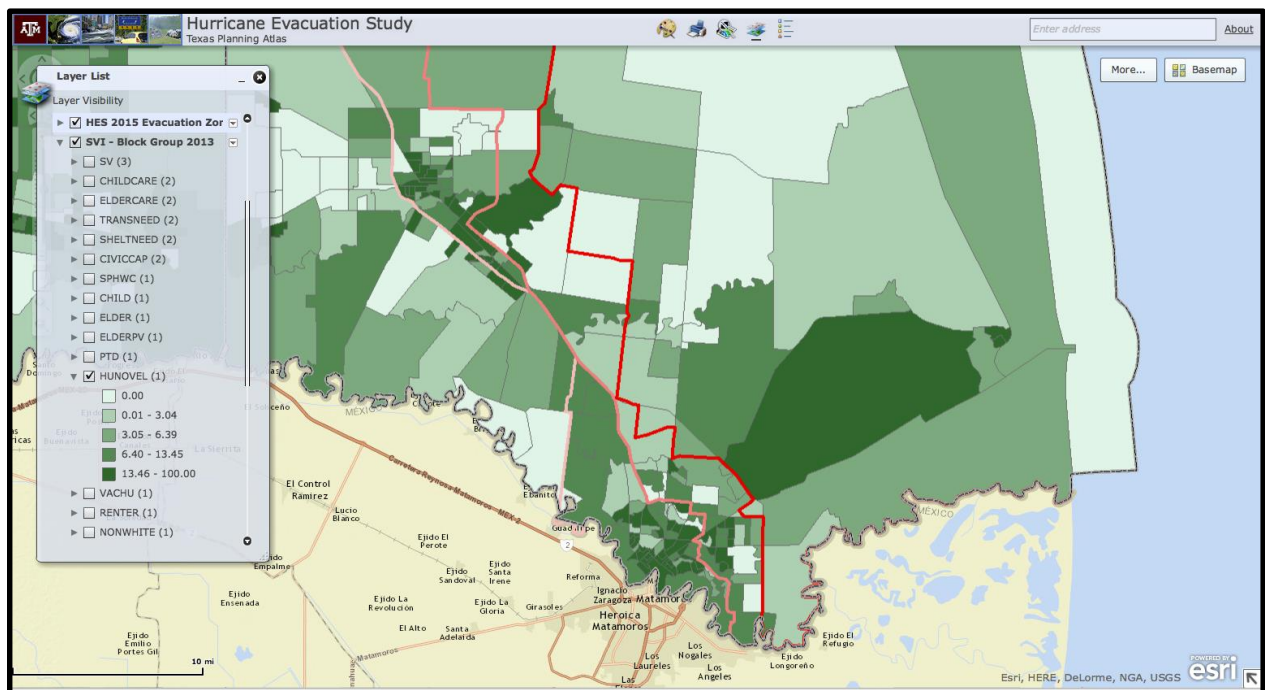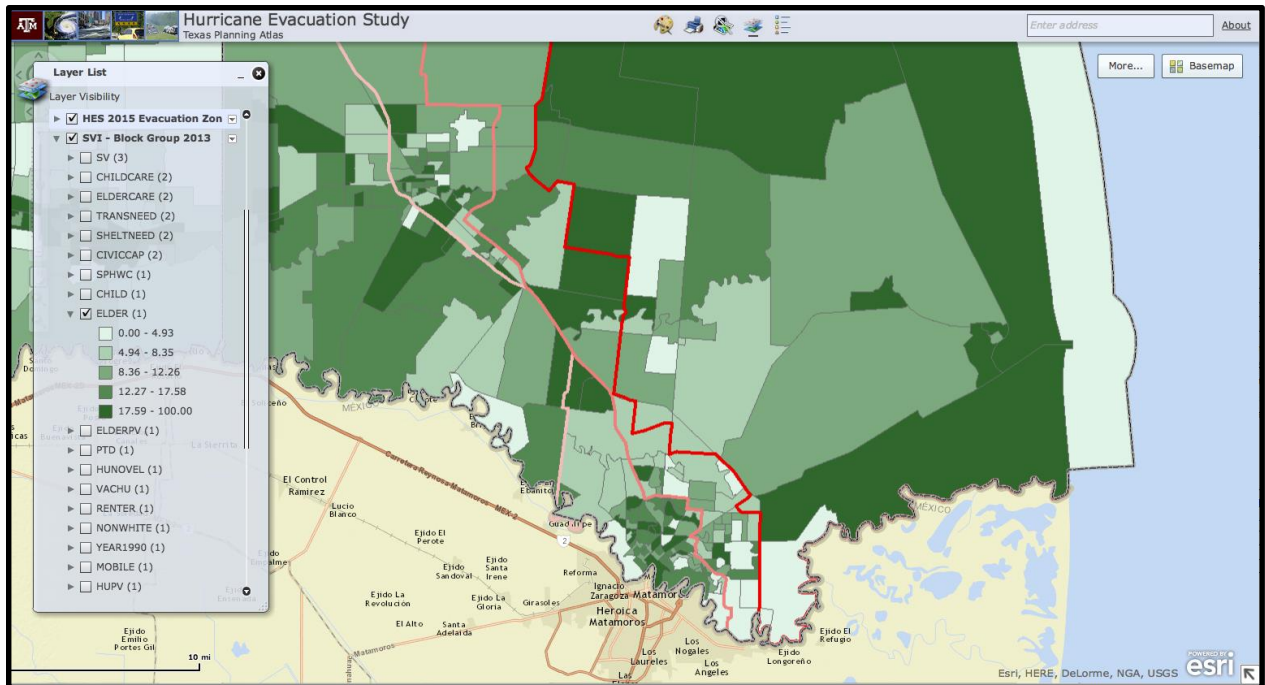
Transportation Analysis

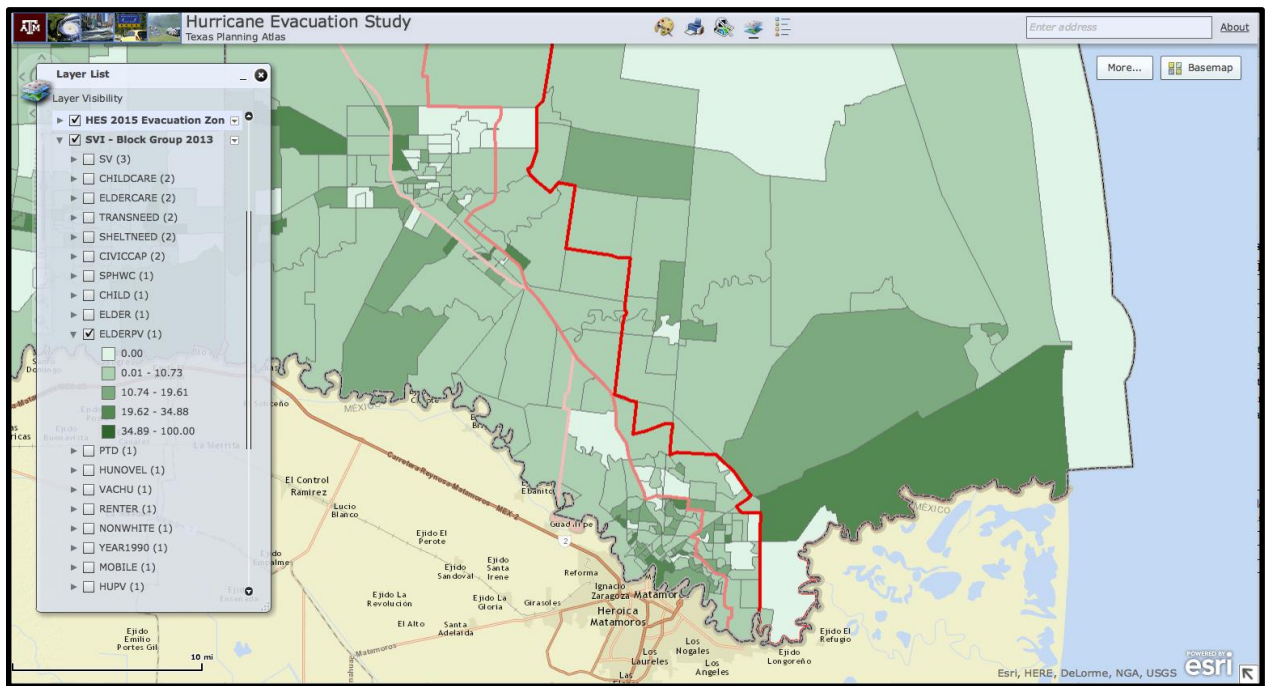Figure 5. Social Vulnerability (SV) Map Showing Concentrations of Elder Households.

Figure 6. Social Vulnerability (SV) Map Showing Concentrations of Elder Households
Living at or Below Poverty Levels.

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4. Populations in Mobile Homes, Trailers, are Recreational Vehicles

By far some of the most vulnerable populations are households residing in mobile homes, travel trailers, and even high profile recreational vehicles (RVs). Mobile homes in particular, because of their construction characteristics and the fact that they are more generally more fixed in location (not easily moved) can be particularly highly vulnerable to hurricane winds of any speed, as well as hurricane surge and inland flooding. It is therefore critical to identify locations where households are living in these types of home, whether in formal mobile home/trailer parks, informal clusters, or even in more isolated locations.

In light of the highly vulnerable nature of households residing in such structures, as part of the Hurricane Evacuation Study, considerable efforts were undertaken to identify the locations for mobile homes, trailers and even RVs throughout the Lower Rio Grande Valley counties. To identify these structures, various data were compiled and extensive work with *Google* mapping resources were undertaken. Specifically the process began with original data layers identifying "Mobile Home Parks" provided by FEMA Region IV in Denton, Texas. These data were combined with data from Cameron County. Our initial inspection of these combined data and comparisons with *Google Maps,* suggested that they were incomplete because a number of additional mobile home parks and clusters, as well as more isolated mobile homes, could be identified in and around areas where recognized formal parks were located. As a consequence, it was decided to use *Google, Google Maps, and Google Imagery Web Map Service (WMS)* to identify as many mobile parks, clusters and even more isolated mobile homes throughout the three county area as possible. In addition, as part of this process, all units/structures that were located within evacuation zones were classified into one of three types mobile homes: (i) recreational vehicles (RVs), (ii) trailer (smaller travel trailers with clearly definable wheels that could easily be transported) or (iii) mobile homes (larger mobile homes, generally appearing to be in a long-term more fixed location). Due to the predominant use of aerial photographs, an error in identifying the types of mobile homes is inherent. Nonetheless, non-systematic investigations and rechecks suggest that the data and classifications are consistent and reliable. In total 48,652 "mobile homes" were identified in the three county area.
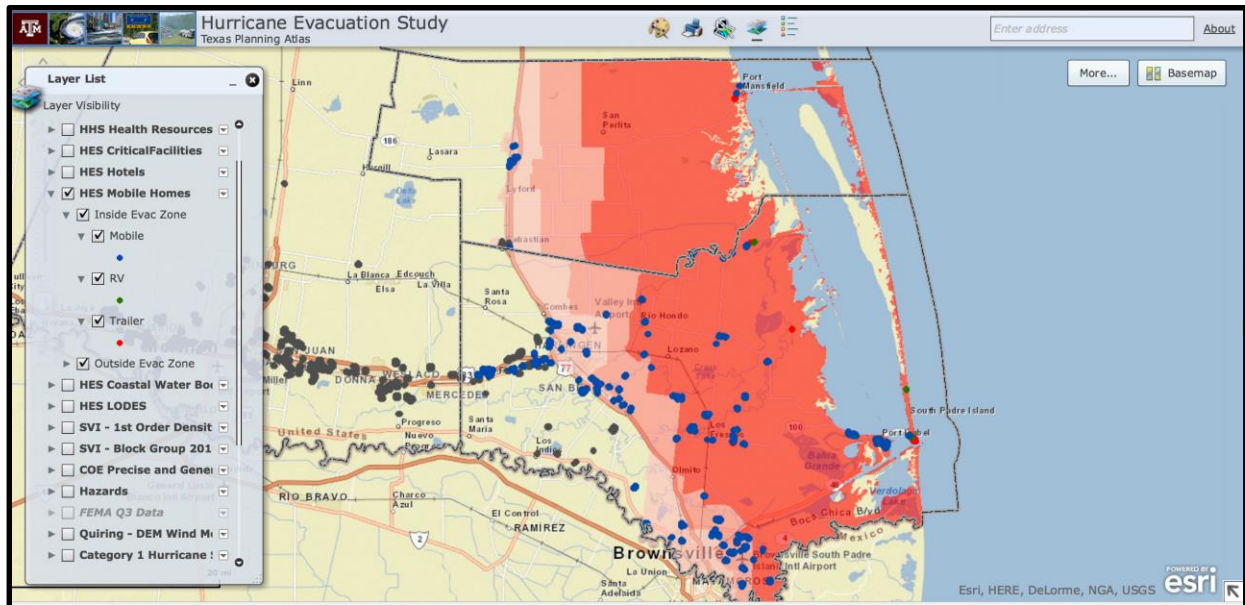
Figure 7. Mobile Home Locations in the Lower Rio Grande Valley.

Figures 7 and 8 show examples of the mobile home data from the HES website. Figure 7 displays the general data for the three county area. At this level of resolution the dots generally represent mobile home parks and clusters of mobile homes. Figure 8, on the other hand, zooms in to the Port Isabel area in Cameron County and at this resolution one can clearly see the finer resolution of these data. In this figure each dot represents a "mobile home" where mobile homes appear as blue dots, RVs as red dots, and travel trailers as green dots.

Figure 8: Detail View of Mobile Home Data for Port Isabel.

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Table 5 presents data upon which we can estimate the populations residing in mobile homes for the evacuation zones in Willacy and Cameron County. Specifically these data include our estimated counts for mobile homes within each evacuation zone for Willacy and Cameron Counties (note, there were no mobile homes located in Willacy's evacuation zone B), the estimated average household size for households residing in mobile homes and the occupancy rates for mobile homes. The average household size and occupancy rates are derived from the US American Community Survey data for 2009-2013 estimates. These data suggest that there are just over 41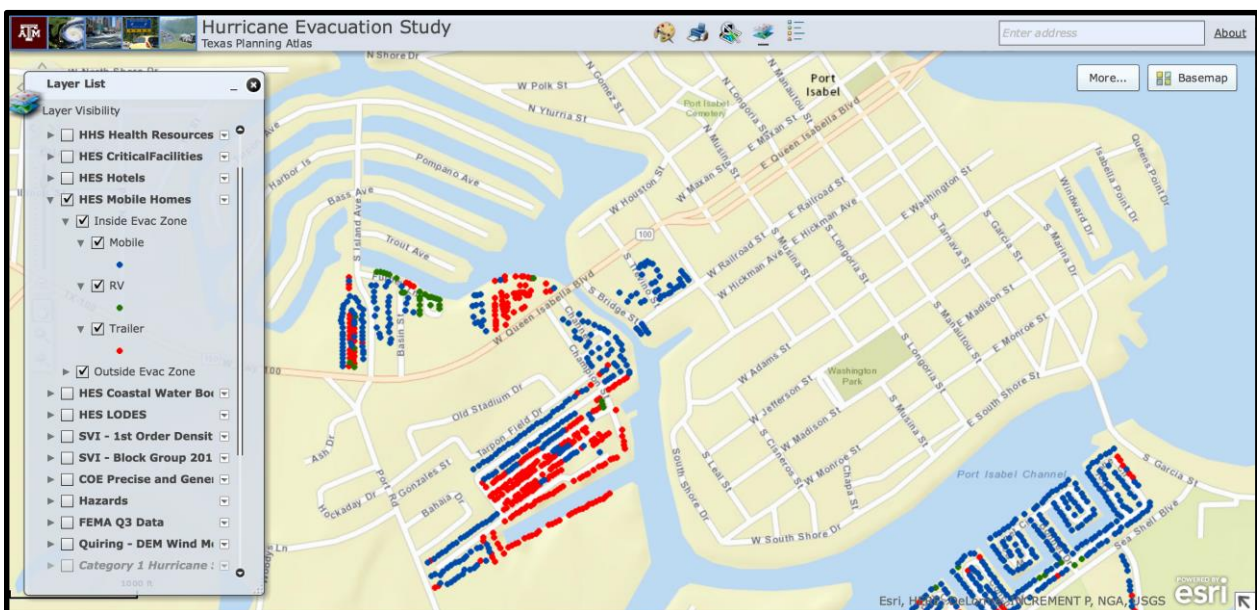0 households composed of 1,234 individuals residing in mobile homes in Willacy County. In Cameron County, on the other hand we estimate there are 7,197 households composed of 23,966 individuals residing in mobile homes located in evacuation zones. Interestingly, the highest number of individuals, nearly 10,000, are located in the highest risk zone. However, considering the extremely vulnerable nature of mobile homes for almost all levels of hurricane winds, the HRRC team strongly recommends declaring mandatory evacuation for **all** mobile home residents within Willacy and Cameron Counties whenever voluntary or mandatory evacuations are declared for these counties.

Table 5. Estimated Population Residing in Mobile Homes located Willacy and Cameron County Evacuation Zones.

	Evacuation Zone A Willacy	Evacuation Zone C Willacy	Evacuation Zone A Cameron	Evacuation Zone B Cameron	Evacuation Zone C Cameron
HES Mobile home Count	164	429	3,986	3,314	3,176
Av. HH size*	3.00	3.00	3.33	3.33	3.33
Occ. Rate*	0.694	0.694	0.687	0.687	0.687
Pop. Est.	341	893	9,119	7,581	7,266

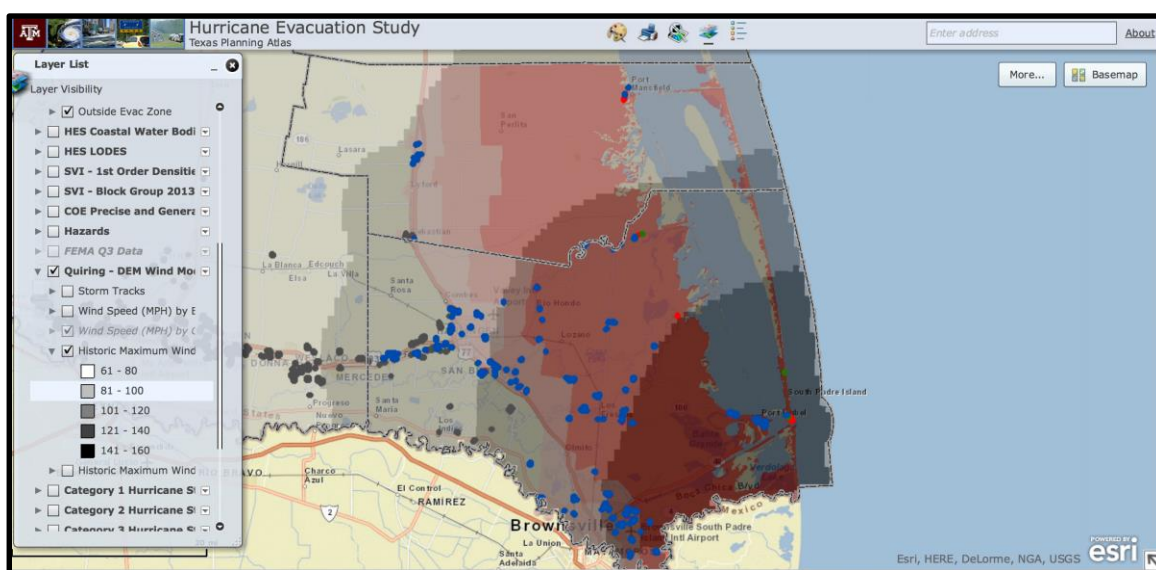* Estimates derived from the 2009-13 ACS.

Figure 9. Mobile Home Locations and Historical Maximum Winds for the Lower Rio Grande Valley Area.

When considering evacuations for mobile home residents it is important to consider what the wind hazard exposure might be. Figure 9 displays data from the HES website for maximum wind speeds based on historical storms that have struck the area. These wind fields were created by Dr. Steven Quiring in the Department of Geography at Texas A&M University for the Texas Department of Emergency Management and have been incorporated into the website developed for this project. The wind fields have been overlaid (and hence made somewhat transparent) on the mobile home data. It can be clearly seen that historical data suggest that mobile homes well into Hidalgo County can be expected to experience wind speed well into the 100 MPH range. Again, considering the nature of mobile homes and variability in tie-down systems, it might well make sense to call for evacuations of all mobile home residents in the three county area depending on the nature of the hurricane wind risks.

Table 6 displays data for estimating the number of individuals residing in mobile homes for Cameron, Willacy and Hidalgo Counties. Again, these data include our estimated numbers of mobile homed derived as part of this project along with average household sizes and occupancy rates based on the US Census American Community Survey data for 2009-13. Utilizing these data it is estimated that there are just over 1,200 individuals residing in mobile home in Willacy County, nearly 38,000 in Cameron County, and just over 75,000 in Hidalgo County. These represent individuals that are not only highly vulnerable to hurricane winds, but also tornados as well.

Table 6. Estimated Mobile Residents for Cameron, Willacy and Hidalgo Counties.

	Cameron	Willacy	Hidalgo
HES mobile home Count	16,550	595	31,507
Av. HH size	3.33	3.00	3.44
Occ. Rate	0.687	0.694	0.694
Pop. Est.	37,862	1,239	75,219

* Estimates derived from the 2009-13 ACS.

5. Critical Facility Mapping Data

The HRRC team assembled data from a variety of sources to generate critical facility data for use on the HES website. These data include data on health facilities, nursing homes, emergency responder organizations and schools. Table 7 provides the names of these data layers, as they appear on the HES website, along with a description of the data and data sources. Primary sources include the U.S. Department for Health and Human Services and FEMA Region IV. While the HRRC staff often assessed these data by comparing them to information on Google and Google Mapping Services and found them to be, in most cases, reasonable relative to our comparisons, we cannot attest to the accuracy of these data nor their geographic locations. Hence they should be used with caution.

Table 7. Summary of Critical Data Mapping Layers.

Layer/data Name	Layer description
HES_HEALTH_CENTERS	This layer shows the location of federally qualified healthcare centers in the Lower Rio Grande Valley. The data were obtained from the U.S. Department of Health & Human Services (USDHHS) and is current as of 2012. These data were checked against data provided by FEMA Region IV and other sources and it was concluded that the USDHHS data was comprehensive and better Geo-located. A federally qualified healthcare center is considered a community-based organization that provides comprehensive primary care and preventative care, including health, oral, and mental health/substance abuse services to persons of all ages, regardless of their ability to pay or health insurance status.
HES_HOSPITALS	This layer shows the location of federally qualified healthcare centers in the Lower Rio Grande Valley. The data were obtained from the U.S. Department of Health & Human Services (USDHHS) and is current as of 2012. These data were checked against data provided by FEMA Region IV and other sources and it was concluded that the USDHHS data was comprehensive and better geo-located. A hospital is considered an institution providing medical and surgical treatment and nursing care for sick or injured people.
HES_NURSING_HOME	This map shows the location of nursing homes in the Lower Rio Grande Valley. The data was provided by the U.S. Department of Health & Human Services and is current as of 2012. A nursing home is an institution that provides a type of residential care. They are a place of residence for people who require constant nursing care and have significant deficiencies with activities of daily living.
HES_URGENT_CARE	This layer provides data on the location of urgent care health facilities in the Lower Rio Grande Valley. The data were provided by the Federal Emergency Management Agency Region IV (FEMA, Denton) and is current as of 2013. Urgent care centers were considered urgent care clinics for adults, pediatrics, and family care, with extended and night hour shifts.
HES_PRIVATE_SCHOOL	The data for this layer provides information on the location of private schools in the Lower Rio Grande Valley. The data was provided by the Federal Emergency Management Agency, Region IV (Denton, Texas) and is current as of 2013. Schools can refer here to any of the following educational businesses: kindergartens, elementary schools, middle, intermediate, or junior high schools and high schools.
HES_PUBLIC_SCHOOL	This layer provides data on the location of public schools in the Lower Rio Grande Valley. The data was provided by the Texas Education Agency and is current as of 2015. Schools can refer here to an educational institution at any of the following levels: kindergarten, elementary school, middle, intermediate, or junior high school, and High schools.
HES_POLICE	This layer provides data on the location of police stations in the Lower Rio Grande Valley. A police station is a facility, which provides accommodations to police officers and other staff members. These buildings often contain offices and accommodation for personnel and vehicles, along with locker rooms, temporary holding cells and interview/interrogation rooms. This data includes Police Department headquarters, but also stations and sub-stations. It appears that these data were collected between: 01/03/2005 and 01/11/2010.

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HES_FIRE1	This layer provides data on the location of fire stations in the Lower Rio Grande Valley. Fire Stations are any location where fire fighters are stationed or based, or where equipment that such personnel use in carrying out their jobs is stored for ready use. Fire Departments not having a permanent location are included, in which case their location has been depicted at the city/town hall or at the center of their service area if a city/town hall does not exist. This dataset includes those locations primarily engaged in forest or grasslands fire fighting, including fire lookout towers if the towers are in current use for fire protection purposes. This dataset includes both private, volunteer, and governmental entities. Fire fighting training academies are also included. These data were provided by FEMA Region IV and are actually compilations of data collected between 01/03/2005 and 01/11/2010.
HES_EMS	This layer provides data on the location of emergency medical services in the Lower Rio Grande Valley. EMS Stations were part of the Fire Stations layer, which in turn is part of the Emergency Services and the critical infrastructure category. The EMS stations dataset consists of any location where emergency medical service (EMS) personnel are stationed or based, or where equipment that these personnel use is stored. Ambulance services are included even if they only provide transportation services, but not if they are located at, and operated by, a hospital. If an independent ambulance service or EMS provider happens to be collocated with a hospital, it will be included in this dataset. The dataset includes both private and governmental entities. These data were provided by FEMA Region IV and are compiled between 12/29/2004 and 01/11/2010.
HES_EOC_LOCAL	This layer provides data on Local Emergency Operations Centers in the Lower Rio Grande Valley which are the facilities utilized by local authorities to coordinate information and resources used to address local emergency management incidences. Generally these are permanent facilities, but they may also represent temporary facilities. These data were provide by FEMA Region IV and were actually compiled through the period beginning with 08/28/2009 and ending with the newest record date of 11/18/2009.
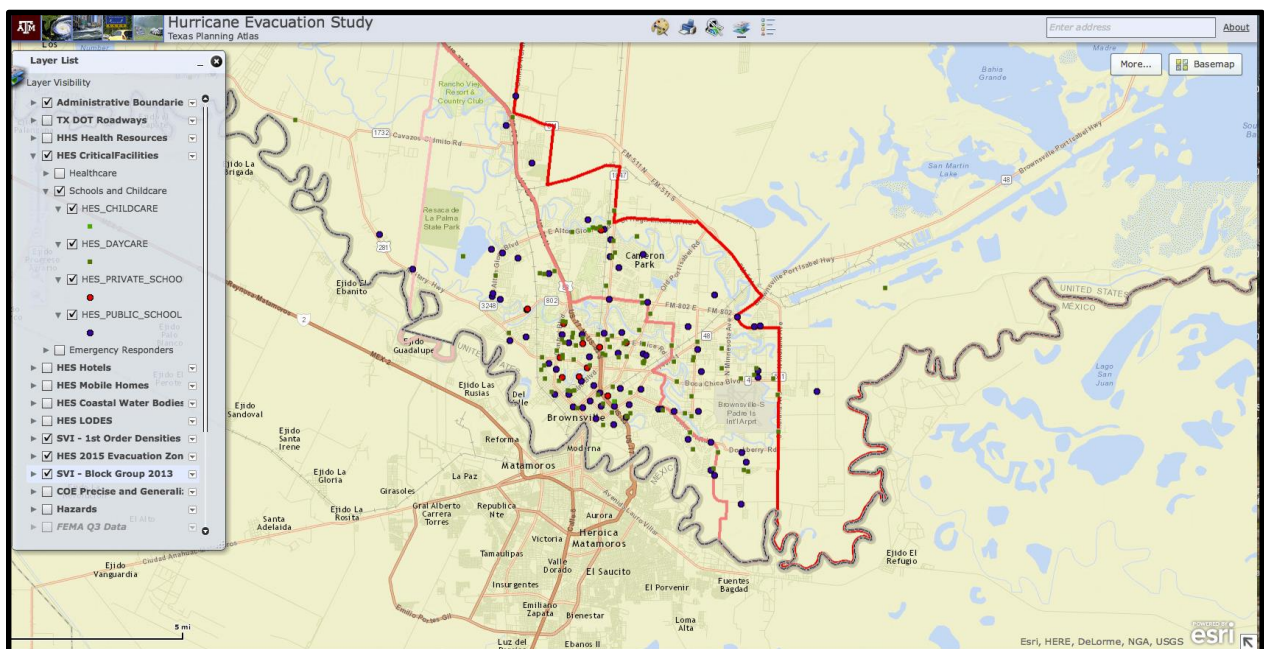
Figure 10. Critical facilities – Schools and Childcare Facilities – Brownsville, Texas.

Figure 10 displays and example of the types of maps that can be created using the critical facility data layers on the HES website. In this case, schools and childcare facilities are mapped out in the Brownsville area along with the Evacuation Zone Boundaries.

6. Estimated Job and Employee Residential Vulnerability

There is a very important new data set that is now being provided to the public by the U.S. Census's Economic Research Service that can identify job locations and employee residential locations at a very fine resolution – the census block level. With these data it is possible to get an even clearer picture of the jobs and employees at risk. Collectively these data are known as the LODES data. *LODES* stands for the **L**ongitudinal Employer-Household Dynamics program's **O**rigin-**D**estination **E**mployment **S**tatistical data. It is available for download from a website created and maintained by the U.S. Census known as *OnTheMap* (http://onthemap.ces.census.gov/). These data capture the job and residential locations of all employees for which unemployment insurance is paid by their employer – which is the vast majority of all workers in the United States. These data are available for most states for the years 2002–2013 and the data displayed on our HES website is for 2013. Specifically, within the LODES layer folder, data layers are provided for *Workplace Area Characteristics* and *Residence Area Characteristics*. The *Workplace Area Characteristics* layer provides data on the number of jobs located within a census block while the *Residence Area Characteristics* layer provides data on the worker residences located within the census block. For each layer the symbols provide an indication as to the number of jobs (yellow circles) or worker residences (orange circles) located in the census block.
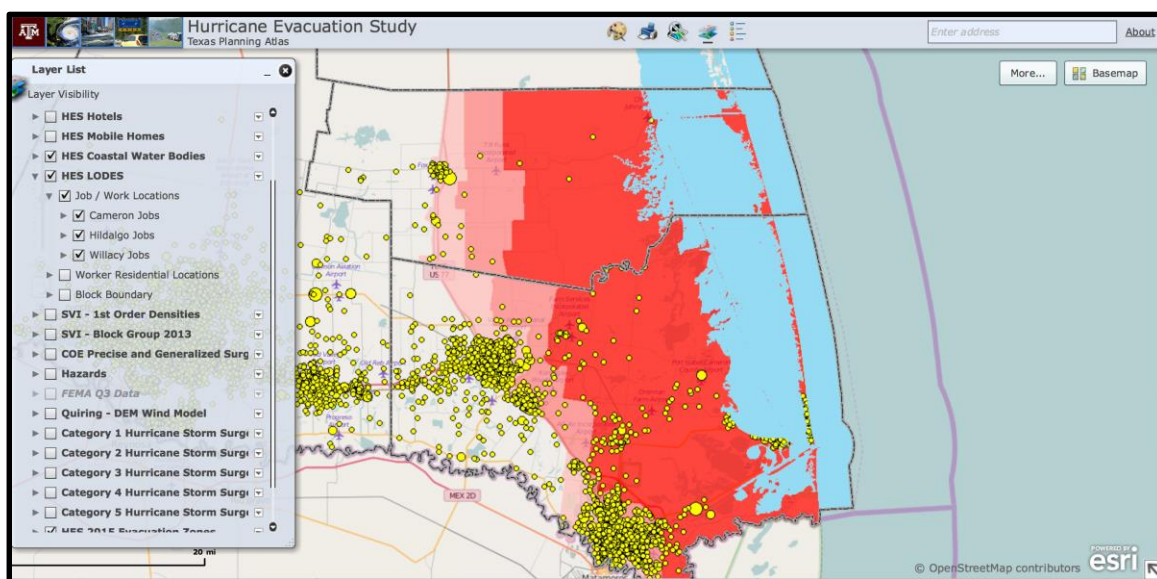
Figure 11. Job Locations and Hurricane Evacuation Zones.

Figure 11 displays the job locations overlaid on evacuation zones for Cameron, Willacy, and Hidalgo Counties. From this level of resolution it is relatively easy to see that sizable percentages of jobs in both Cameron and Willacy Counties are located in evacuation zone, particularly in Zones B and C. Figure 12 displays the job data for areas around Port Isabel and South Padre Island. Zooming in on these smaller areas makes it clear that the size of the dot reflects the number of jobs in a particular

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location. Finally, Figure 13 displays employee residential locations relative to hurricane evacuation zones.

Figure 12. Job Locations in and around Port Isabel and South Padre Island.

Figure 13. Employee Residential Locations and Evacuation Zones.
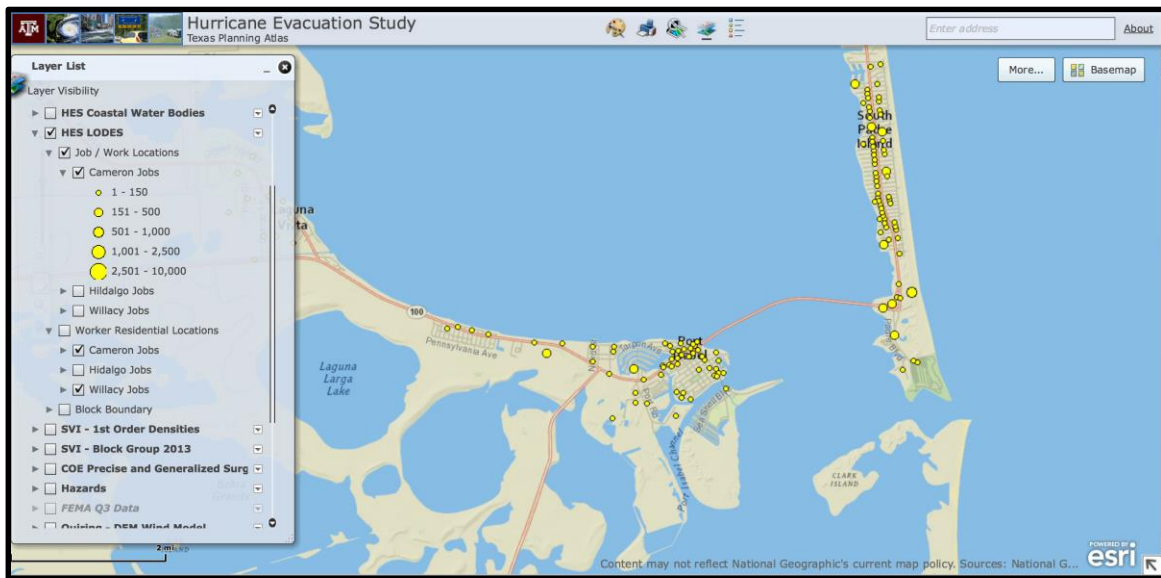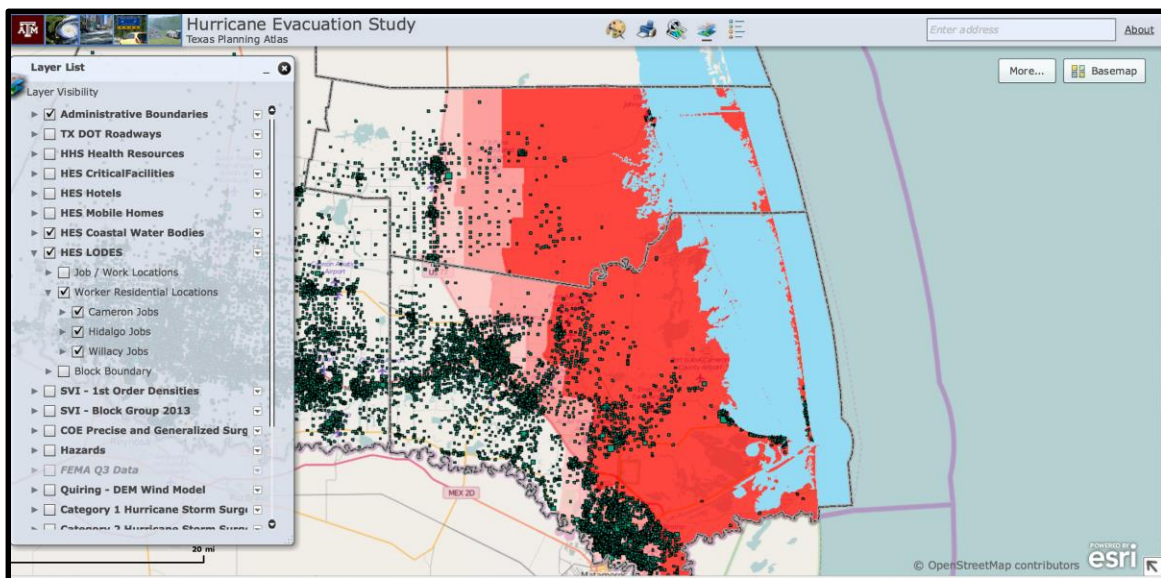
The particularly nice feature of these data is that it is relatively easy to determine the relative numbers of jobs and residences within each of the evacuation zones. Table 8 presents data on the numbers of jobs within each zone for Willacy and Cameron Counties.

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Table 8. Jobs in Evacuation Zones in Willacy and Cameron Counties.

	Evacuation Zones	A	B	C	A+B+C
Willacy	Jobs	66	46	3,096	3,208
	% of total jobs	1.9%	1.4%	91.4%	94.7%
Cameron	Jobs	13,877	17,655	84,279	115,811
	% of total jobs	10.8%	13.7%	65.4%	89.9%
Both Counties	Jobs	13,943	17,701	87,375	119,019
	% of total jobs	10.5%	13.4%	66.1%	90.0%

Table 9. Employee Residences in Evacuation Zones in Willacy and Cameron Counties.

	Evacuation Zones	A	B	C	A+B+C
Willacy	Residences	1,607	343	8,475	10,425
	% of total	12.2%	2.6%	64.3%	79.1%
Cameron	Residences	19,268	33,806	58,615	111,689
	% of total	14.0%	24.5%	42.4%	80.9%
Both Counties	Residences	20,875	34,149	67,090	122,114
	% of total	13.8%	22.6%	44.4%	80.7%

8. Estimated Vulnerable Property.

The LODES data provide an understanding of the potential economic consequences of hurricane for the study area, at least with respect to employment and employee residences. We have seen that substantial percentages of Willacy and Cameron County jobs and employee residences are located in their hurricane evacuation zones. We now turn our attention to the capital stock of these two counties and its relative hurricane vulnerability based on evacuation zones. Specifically, the HRRC team was able to acquire parcel data from both Willacy and Cameron counties allowing for us to determine the value of the buildings and other "improvements" made on property located with each evacuation zone. Table 10 presents the data on the tax appraisal for improvement to all properties split into their associated evacuation zones for both counties.

Table 10: Tax Appraisal Values of Improvements Made to all Located in Each Evacuation Zone by County.

	Cameron County		Willacy County	
Zone	Total ($)	Percentage	Total ($)	Percentage
A	1,532,043,954	17.0%	39,039,201	12.7%
B	2,061,380,467	22.9%	8,903,303	2.9%
C	3,841,460,252	42.7%	209,309,252	68.2%
A+B+C	7,434,884,674	82.6%	257,251,756	83.8%
Outside	1,562,936,104	17.4%	49,783,478	16.2%
Totals	8,997,820,778	100.0%	307,035,234	100.0%

Not surprisingly, based on the results of the LODES data, we see substantial percentages of each County's property is located in each evacuation zone. In Cameron County approximately 83% of its capital stock is located within its evacuation zones and in Willacy County the percentage is actually a bit higher at 83.8%. The vast majority of Willacy's physical capital, however, is located in evacuation Zone C, at 68.2%. However, in Cameron County, while a majority of its capital stock is also in evacuation Zone C, at 42.7%, substantial percentages are also found in Zones B (22.9%) and A (17%). These numbers clearly suggest that the capital stock of both counties is highly vulnerable to hurricane surge risk, which if impacted, will have major consequences for their economic vitality and fiscal health.

Table 11: Tax Appraisal Values of Residential Properties for Cameron County.

| | Cameron County Residential Properties | | | |
Total ($)	Single-family	Multi-family	Total	Percentage
A	1,120,380,573	125,487,514	1,245,868,087	18.8
B	1,479,340,336	93,810,130	1,573,150,466	23.8
C	2,333,081,043	294,705,136	2,627,786,179	39.7
A+B+C	4,932,801,952	514,002,780	5,446,804,732	82.2
Outside	1,147,483,562	28,108,612	1,175,592,174	17.8
Cameron	6,080,285,514	542,111,392	6,622,396,906	100.0

For Cameron County we were able to acquire more detailed appraisal data that allow us to break property down into residential categories and various forms of commercial and industrial. Table 11 displays the appraised values of residential properties – single and multi-family dwellings. Again, it can be seen that over 80% of residential property values are found in the three evacuation zones. Similarly, displayed in Table 12 are data on the appraised values of commercial and residential properties. Again over 86% these kinds of properties are found within the three evacuation zones. The picture is quite consistent – substantial percentages of the capital stock of Cameron County, as assessed by appraised values, are found in the evacuation zones.

Table 12: Tax Appraisal Values of Residential Properties for Cameron County.

| | Cameron County Commercial/Industrial Properties | | | |
Total ($)	Commercial	Industrial	Total	Percentage
A	196,267,622	15,330,546	211,598,168	10.5
B	404,898,000	25,207,859	430,105,859	21.3
C	1,067,209,697	31,428,007	1,098,637,704	54.5
A+B+C	1,668,375,319	71,966,412	1,740,341,731	86.3
Outside	252,310,986	23,592,722	275,903,708	13.7
Cameron	1,920,686,305	95,559,134	2,016,245,439	100.0

9. Social Vulnerability Mapping Layers

As mentioned above, the HRRC team has also created a number of what we are terming social vulnerability (SV) layers to help local emergency management and stakeholders when planning for evacuation as well as overall emergency response and long term recovery. The literature is quite clear

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that it is often that it is often the abilities of individuals and households to marshal resources and active their kinship and friendship networks that shapes their abilities to prepare for, respond to, and recovery from disasters (Van Zandt et al, 2012, Peacock et al, 2009 and 2001, Masterson et. al., 2014). This perspective is captured in Figure 14 which shows that social characteristics such as race/ethnicity, gender, education, and income can shape social vulnerability leading to very different levels of capacity, information (access and ability to interpret), power, and resources, which in turn generates disparities in disaster response.
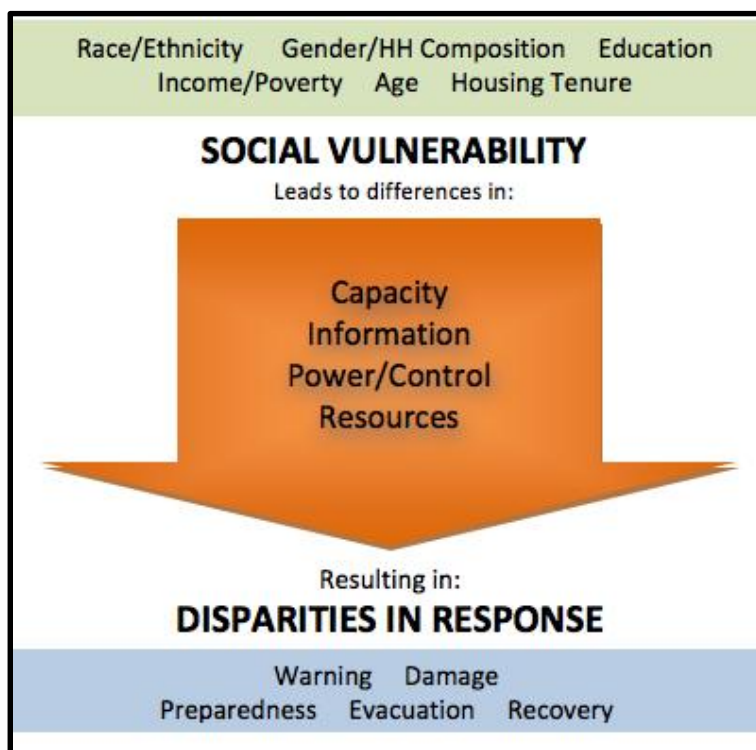

Figure 14: Social Vulnerability Shaping Response and Recovery Outcomes.

In this context understanding the social, economic, and demographic characteristics of households and individuals, relative to hazard exposure, can better enable local governments, emergency mangers and key stakeholders to help plan for and respond to disaster threats such as hurricanes. To make this possible we have created a number of data layers within the HES website that can be utilized with other data to better understand and locate high concentrations of populations with social characteristics that can result in them be more vulnerable to hurricanes and other disaster agents. Table 13 displays these data along with the layer names and a brief description of each layer. We have already employed one of these layers, in Figures 4-6, that displayed households without access to a vehicle, as well as elder households and elder households that are at or below the poverty level. In addition to these we have information on household composition (children, single-parent households), education, unemployment, English language proficiency, etc.

Table 13: Social Vulnerability Data Layers.

Field Name	Description	Unit of Analysis
SPHWC	Single Parent Household with Children	Households
CHILD	Child Population under 5 Years	Population
ELDER	Elder Population 65+ Years	Population
ELDERH	Elder Households	Households
ELDERPV	Elder Households in Poverty	Households
PTD	Public Transportation Dependent Households	Households
HUNOVEL	Households with no Vehicle Available	Households
VACHU	Vacant Housing Units	Housing Units
RENTER	Renter Households	Households
NONWHITE	Non-White Population	Population
YEAR1990	Housing Units Built before 1990	Housing Units
MOBILE	Mobile Home Households	Households
HUPV	Housing Units in Poverty	Housing Units
HUNOTEL	Housing Units with no Telephone Service Available	Housing Units
NOHS	Less than High School Graduate Population 25+ Years	Population
UNEMP	Unemployed Population in Labor Force	Population
SPENW	Population Speaking English Not Well or Not at All	Population

To further the utility of these data, we have also developed layers such as the ones seen in the figures above, which display various shades of green for block-group areas, where higher concentrations appear in darker greens. However to better capture potential locations of populations within these areas, we have also developed heat maps that show likely areas that these populating concentrations are located. It should be noted that these are but approximations, and do not necessarily reflect actual locations of populations, individuals, or households – hence, they should again be used with caution.
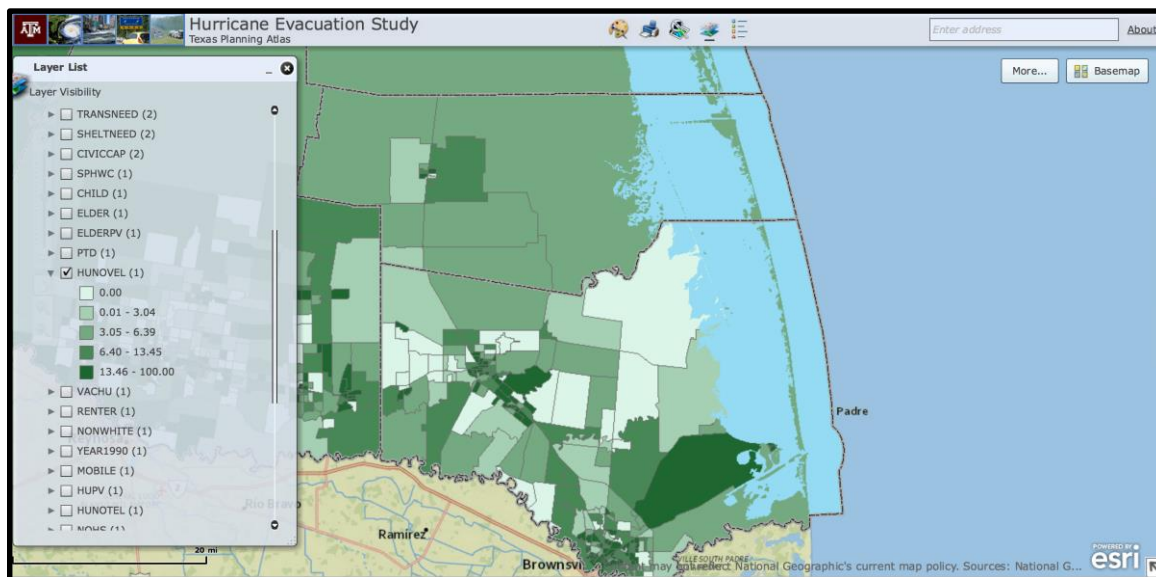

Figure 15: Households Without a Vehicle – Normal Block-Group SV Map.

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Figure 15 again displays the block-group SV map for concentrations of households without a vehicle. Some of these block-group areas are rather large, making it difficult to imagine likely areas that populations are actually located. Figure 16 on the other hand, displays the same data, overlaid on the evacuation zone data, but now they are portrayed as heat density maps, where the deeper the blue, the higher the likely concentrations of populations with the specified characteristics, which in this case is not having a vehicle. Again, these are but approximate, but the perhaps can be utilized to target areas for further investigation and where to undertake education and outreach programs.
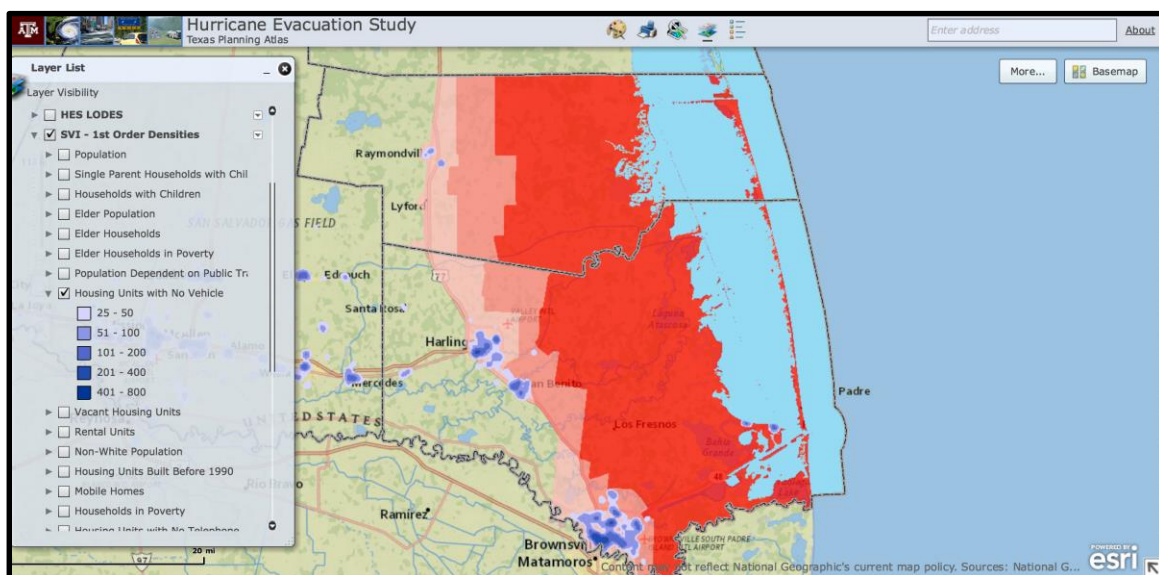

Figure 16: Heat Density Data on the Locations of Households Without a Vehicle.

10. Summary and Conclusion

In this report we have undertaken a vulnerability analysis utilizing the newly developed evacuation zones and discussed many of the new and improved data layers that we have developed to undertake this analysis. Furthermore we have described many of the data layers that have been incorporated into the Hurricane Evacuation Study (HES) website for Cameron, Willacy, and Hidalgo Counties (http://texasatlas.arch.tamu.edu/fv/TA_HES_surge/). What is quite clear from this analysis is that substantial proportions of both Willacy County's and Cameron County's populations, economic activities, and physical capital are located within their new evacuation zones and are therefore at considerable hurricane risk when it comes to surge. Furthermore, when focus is on the most vulnerable types of structures, such as mobile homes, or vulnerable individuals and households, such as those without private vehicles or living at or below the poverty level, we again see substantial proportions of these structures and populations located in evacuation zones. Thus, there is much to be concerned about when it comes to hurricane evacuation in particular and broad based hazard/disaster planning in general. But in a very real sense, the analysis presented in this report is just a start, and that is why we have created the HES website. We encourage the local participants in the HES planning process to work with and use this website to conduct their own investigations of the regions vulnerabilities and strengths. Indeed, it is important that these data and the HES website be shared with other interested stakeholders and groups throughout the region.

We have been so impressed by local participants throughout the entire HES process. Their dedication, local knowledge, and commitment to making their community and their region safe has been an inspiration to our entire team. We sincerely hope that the HES website and the data we have compiled and develop will help them in their endeavors to make their homes and community safe in the future.

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