

HILLSBOROUGH COUNTY COMMUNITY VULNERABILITY STUDY:

MATRIX OF COMMUNITY VULNERABILITIES

A CATEGORIZED LIST WITH REFERENCES
OF VULNERABILITIES ASSOCIATED WITH
SEA LEVEL RISE AND HURRICANE STORM SURGE

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MATRIX OF VULNERABILITIES

Mapped Vulnerabilities

Hurricane Case Studies

Ecological Information

BUILT ENVIRONMENT

CATEGORY	SUB-CATEGORY	SPECIFIC	COMPONENTS	DESCRIPTION/CASE STUDY	REFERENCES
Land Use Classifications	Residential Property	Single Family	Replacement housing	Rebuilding time may take 2-3 years. During this period housing is limited.	Comerio, M. C. (2002). Housing Issues After Disasters. Journal of Contingencies and Crisis Management, 5(3), 166-178. doi: 10.1111/1468-5973.00052 Comerio, M. C. (2002). Housing Issues After Disasters. Journal of Contingencies and Crisis Management, 5(3), 166-178. doi: 10.1111/1468-5973.00052 Comerio, M. C. (2002). Housing Issues After Disasters. Journal of Contingencies and Crisis Management, 5(3), 166-178. doi: 10.1111/1468-5973.00052
			Isolation		
	Multifamily	Renters / Owner Issues	Renters may leave the area and not return, creating dead areas within the city.	Naples Daily News Staff. (2018, September 7). Hurricane Irma: One Year Later. Retrieved from Naples Daily News: https://www.naplesnews.com/story/weather/hurricanes/2018/09/07/hurricane-irma-one-year-later-naples-marco-island-florida/1224427002/	
	Affordable Housing	Quicker recovery	The economics of investor-owned housing offers little incentive for owners to rebuild damaged buildings Government loan programs tend not to reach to multi-family owners as well as to single family properties Hurricane Andrew destroyed 25% and damaged 40% of units that were multi-family apartments. Many were shoddily built and did not conform to building code standards, as these standards were not rigidly enforced.	Fayazi, M., & Lizarralde, G. (2013). The role of low cost housing in the path from vulnerability to resilience. International Journal of Architectural Research 7(3), 146-167. Comerio, M. C. (2002). Housing Issues After Disasters. Journal of Contingencies and Crisis Management, 5(3), 166-178. doi: 10.1111/1468-5973.00052 Comerio, M. C. (2002). Housing Issues After Disasters. Journal of Contingencies and Crisis Management, 5(3), 166-178. doi: 10.1111/1468-5973.00052 Comerio, M. C. (2002). Housing Issues After Disasters. Journal of Contingencies and Crisis Management, 5(3), 166-178. doi: 10.1111/1468-5973.00052	
		Replacement housing	Post disaster, there is a need for alternative housing available at low rents.	Comerio, M. C. (2002). Housing Issues After Disasters. Journal of Contingencies and Crisis Management, 5(3), 166-178. doi: 10.1111/1468-5973.00052 Comerio, M. C. (2002). Housing Issues After Disasters. Journal of Contingencies and Crisis Management, 5(3), 166-178. doi: 10.1111/1468-5973.00052	

Mobile Homes	Evacuation	All mobile home residents are required to evacuate even in a Category 1 setting due to their vulnerability to heavy rain and flooding.	Cutter, S. L., Mitchell, J. T., & Scott, M. S. (2000). Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. <i>Annals of the Association of American Geographers</i> , 90(4), 713-737. doi: 10.1111/0004-5608.00219 Cutter, S. L., Mitchell, J. T., & Scott, M. S. (2000). Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. <i>Annals of the Association of American Geographers</i> , 90(4), 713-737. doi: 10.1111/0004-5608.00219 Cutter, S., Ash, K. D., & Emrich, C. T. (2014). The Geographies of Community Disaster Resilience. <i>Global Environmental Change</i> , 65-77. doi: /10.1016/j.gloenvcha.2014.08.005
	Lack of foundations	Populations living in mobile homes are more vulnerable due to the structures not being properly anchored to the ground. If structures are damaged or destroyed, there is a gap in providing a home post disaster.	
Homeownership	Absenteeism	Homes become vulnerable when owners are away, due to the inability to prepare the home for the disaster. May cause stress in homeowner, who cannot protect their property/belongings.	Comerio, M. C. (2002). Housing Issues After Disasters. <i>Journal of Contingencies and Crisis Management</i> , 5(3), 166-178. doi: 10.1111/1468-5973.00052 Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf
	Preparedness and Recovery	Rentals and apartment buildings may be owned by investors, creating issues of preparedness and recovery.	
Commercial Property		Commercial land uses "includes uses such as office, strip centers, restaurants, hotels, mini warehouses, boat slips, and other light and heavy commercial uses."	Tampa Bay Regional Planning Council. (2017). The Cost of Doing Nothing. Tampa: Tampa Bay Regional Planning. Retrieved from http://www.tbrpc.org/wp-content/uploads/2018/11/2017-The_Cost_of_Doing_Nothing_Final.pdf
Jobs and Economic Factors		Loss of commercial property can lead to increased job-loss, and loss of personal income and Gross Regional Product.	Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf
Industrial Sites		The Industrial category includes light and heavy manufacturing uses.	Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015
Toxicity		When in areas subject to storm surge, many large businesses might be affected and the release of materials that contain hazardous chemicals have risk of being released which has the potential for harming the environment and people's health.	Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf
Public/ Institutional		Public/institutional land uses "includes all federal, state, municipal, aviation and port authority properties"	Dash, N., Morrow, B. H., Mainster, J., & Cunningham, L. (2007). Lasting Effects of Hurricane Andrew on a Working-Class Community . <i>Natural Hazards Review</i> , 8(1), 13-21.
Community Infrastructure		"Hurricane Andrew had a devastating effect on the institutions of the community, as well as the larger region."	Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf
	Federally Owned		Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf
	County Owned		Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf
	Municipal		Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf

Churches Local religious buildings sustained major damage but services continued, sometimes outdoors for months after Hurricane Andrew

After Andrew, "Church officials reported a major drop in membership and attendance, usually lasting for several years."

Libraries Libraries are important as a place that archives media, but also as a community center and place for people to shelter.

Museums Collections, archives and facilities are all vulnerable.

Performing Arts Venues Physical facilities can be damaged but other considerations include loss of income. "Performing arts organizations are important community centers, places of business, and cultural anchors."

Right of Way

City or County Owned Road right of way is a main contributor to impervious surfaces and require maintenance.

Belonging to CSX

Schools

Impacts of Closure

Severe flooding can force schools to close, and buildings can be damaged limiting services.

Childcare

"All local public and private schools sustained major damage" from Hurricane Andrew, however, "most schools began classes within a couple of weeks in spite of damaged facilities and sometimes relying on donated supplies."

After hurricane Andrew, "school enrollments went down anywhere from 30 to 50% in these schools after the storm due to families being displaced by destroyed homes" or job locations being closed rather than repaired and re-opened and it was several years before enrollments reached 1992 levels.

Dash, N., Morrow, B. H., Mainster, J., & Cunningham, L. (2007). Lasting Effects of Hurricane Andrew on a Working-Class Community . Natural Hazards Review, 8(1), 13-21.

Dash, N., Morrow, B. H., Mainster, J., & Cunningham, L. (2007). Lasting Effects of Hurricane Andrew on a Working-Class Community . Natural Hazards Review, 8(1), 13-21.

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Dash, N., Morrow, B. H., Mainster, J., & Cunningham, L. (2007). Lasting Effects of Hurricane Andrew on a Working-Class Community . Natural Hazards Review, 8(1), 13-21.

Dash, N., Morrow, B. H., Mainster, J., & Cunningham, L. (2007). Lasting Effects of Hurricane Andrew on a Working-Class Community . Natural Hazards Review, 8(1), 13-21.

Dash, N., Morrow, B. H., Mainster, J., & Cunningham, L. (2007). Lasting Effects of Hurricane Andrew on a Working-Class Community . Natural Hazards Review, 8(1), 13-21.

	Public Schools	Year Built and Maintenance	"Damaged buildings resulted in more health-related absences by teachers and students." "The devastation that many public schools sustain due to floods is compounded by their age and condition."
	Private Schools		One report from one of the less damaged schools in South Miami Heights after Hurricane Andrew took two years to fully be repaired.
	Special Needs Schools		After Hurricane Ike, physical Damage to special needs classrooms forced those classes to relocate to other locations until they were repaired, or students left the school indefinitely and "double shifts were held in order to handle both student bodies."
	Universities		After Irma, flooding and damages to buildings caused difficulties accessing roads to campus and delays in reopening campus. After Harvey, large employers, universities, and transit services were among the earliest to reopen following the storm.
Hospitality		Transience	High vacancy rates may follow a major hurricane
	Hotels		Hurricane Katrina displaced persons living in hotels, costing American taxpayers \$11 million per day.
	Rentals		Due to rental properties often being lower income, their recovery time is often slow and it takes longer to rebuild. Renters do not have as many rights as the owner of the property. They often do not have enough insurance to cover their belongings, and often stay in damaged units or must go to temporary shelters. After Hurricane Andrew, in response to job loss, most renters simply left the area.
	Vacation Homes		The two most heavily impacted housing types from Hurricane Hugo were coastal vacation homes and condominiums.
Nursing Homes, Hospice and Assisted Living		Critical facility	Nursing homes and hospice facilities are considered critical facilities.
	Parks & Recreation		

Dash, N., Morrow, B. H., Mainster, J., & Cunningham, L. (2007). Lasting Effects of Hurricane Andrew on a Working-Class Community . *Natural Hazards Review*, 8(1), 13-21.
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<https://www.miamiherald.com/news/weather/hurricane/article172772611.html>
McWilliams, G., & Trotta, D. (2017, September 5). Houston quickens pace of Harvey recovery as new storm threatens U.S. Reuters. Retrieved from https://www.reuters.com/article/us-storm-harvey/houston-quickens-pace-of-harvey-recovery-as-new-storm-threatens-u-s-idUSKCN1BG21E?utm_source=apple-news

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Chen, E. (2005). Seeking a bridge to somewhere; Officials are trying to get hundreds of thousands of Katrina evacuees out of hotels into more stable housing. But the obstacles are many. *Los Angeles Times*; California: Los Angeles. pp. A-19. Retrieved from <https://www.latimes.com/archives/la-xpm-2005-oct-14-na-housing14-storv.html>
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	Public Fishing / Piers		The Louisiana Department of Wildlife and Fisheries estimates the 12-month retail value of lost sales resulting from the potential disruption of recreational fishing activities at almost \$200 million.	Buck, E. H. (2005). Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. Retrieved from Congress https://www.everycrsreport.com/files/20051013_RS22241_a64ef307cf5adbc9d49fc14457fd81797cee2395.pdf
	Trails			Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Tampa. https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015
	Beaches	Recreation	Beach recreation values are likely to drop due to a decrease in number and size from sea-level rise and erosion, limited access to fishing sites and open beaches for sunbathing and sports, and a destruction of both commercial and residential property along beaches.	Nelson, E. J., Kareiva, P., Ruckelshaus, M., Arkema, K., Geller, G., Girvetz, E., ... Tallis, H. (2013). Climate change's impact on key ecosystem services and the human well-being they support in the US. <i>Frontiers in Ecology and the Environment</i> , 11(9), 483-493. doi:10.1890/120312
				Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf
	Parks		Parks are often found near drainage or coastal buffer areas and are important for community recreation as well as ecosystem services.	Tampa Bay Regional Planning Council. (2006). Sea level rise in the Tampa Bay Region. Retrieved from https://studylib.net/doc/13572313/sea-level-rise-in-the-tampa-bay-region
	Agricultural Lands			
	Assets			
		Crops	A crops ability to tolerate an increase in salinity levels in the soil impacts the production of agricultural product and the relative crop yield. Fields can take up to two years to recover.	Williams, V. J. (2010). Identifying the Economic Effects of Salt Water Intrusion after Hurricane Katrina. <i>Journal of Sustainable Development</i> , 3(1), 29-37.
		Irrigation	After Hurricane Katrina, many plants were not planted because of soil contamination or contaminated waterways that would be used to irrigate the fields. A large industry that was affected by Hurricane Irma in Florida is agriculture. An informal evaluation by the Farm Bureau estimated losses just in Okeechobee County at \$16 million. While the citrus industry was also majorly impacted, causing over \$760 million in damages, the worst for Florida oranges since 1945. Floodwaters from Hurricane Florence damaged farmer's crops at harvest such as cotton,peanuts and tobacco.	Williams, V. J. (2010). Identifying the Economic Effects of Salt Water Intrusion after Hurricane Katrina. <i>Journal of Sustainable Development</i> , 3(1), 29-37. Campo-Flores, A., & Bauerlein, V. (2017). Hurricane Irma's major economic toll on Florida takes shape. <i>Wall Street Journal</i> . Retrieved from https://www.wsj.com/articles/hurricane-irmas-major-economic-toll-on-florida-takes-shape-1505381401
		Equipment	Hurricane Katrina damaged docks, electrical systems, and machinery from flooding. Repair time estimates ranged from a few weeks to a year.	CBS News. (2018, September 19). Florence gone but its flooding a crisis in parts of North Carolina- live updates. Retrieved from https://www.kktv.com/content/news/Florence-Tropical-Storm-besieges-North-and-South-Carolina-493376371.html
		Animals	An estimated 5,500 pigs and 3.4 million chickens were killed during Hurricane Florence.	Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress. Irfan, U. (September 21, 2018) Hog manure is spilling out of lagoons because of Hurricane Florence's floods. Retrieved from https://www.vox.com/energy-and-environment/2018/9/18/17873632/hurricane-florence-flooding-hog-lagoon-waste-coal-ash-north-carolina
		Soils	Hurricane Katrina increased soil moisture and caused some tree species to be more susceptible to falling down in areas of 50 km or further from the eye of the Hurricane Agriculture activity degrades the soil, and erosion exhausts it.	Kupfer, J. A., Myers, A. T., McLane, S. E., & Melton, G. N. (2008). Patterns of Forest Damage in a Southern Mississippi Landscape Caused by Hurricane Katrina. <i>Ecosystems</i> , 11, 45-60. World Wildlife Fund. (2019). Soil Erosion and Degradation. Retrieved from https://www.worldwildlife.org/threats/soil-erosion-and-degradation
	Agricultural Waste			Irfan, U. (September 21, 2018) Hog manure is spilling out of lagoons because of Hurricane Florence's floods. Retrieved from https://www.vox.com/energy-and-environment/2018/9/18/17873632/hurricane-florence-flooding-hog-lagoon-waste-coal-ash-north-carolina

Fisheries		Ecosystems that support robust wildlife and fisheries contribute to the seafood industry. This makes the livelihood of the populations dependent on the ecosystem service highly vulnerable to the financial burdens of relocating or depleted industries.	Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.
	Shrimping	Hurricane Katrina destroyed or severely damaged shrimp boats and shrimp processing and storage facilities during the peak harvesting season; other vessels are beached or trapped by debris blocking shipping channels. Shrimpers who survived Hurricane Katrina and Rita may find it difficult to resume fishing because of high fuel costs.	Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.
	Oysters	During Hurricane Katrina oyster beds and vessels were damaged or destroyed from siltation and contamination and may take several years to rebuild beds.	Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.
	Fishing	Hurricane Katrina damaged small boats at 12 month retail loss at \$200 million. A total of 15 major fishing ports, 177 seafood processing facilities, 1,816 federally permitted fishing vessels, and more than 13,000 state-permitted fishing vessels were located in the region initially affected by Katrina. Some fish and shellfish from the Gulf may disappear from the market, extensive domestic and imported seafood alternatives remain.	Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress. Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.
By-products	Agricultural Waste	During Hurricane Florence, Hog waste flooded into waterways after two storage tanks failed.	Irfan, U. (September 21, 2018) Hog manure is spilling out of lagoons because of Hurricane Florence's floods. Retrieved from https://www.vox.com/energy-and-environment/2018/9/18/17873632/hurricane-florence-flooding-hog-lagoon-waste-coal-ash-north-carolina
Supply Chain Management	Highways	Highways during emergency situations are essential to bring in supplies like food, water, and fuel.	Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.
Processing		In some areas, smaller dealers sell fresh product to larger local processors, delaying the reopening of the smaller dealers until the larger processors can resume work 178 seafood processing facilities were impacted by Hurricane Katrina.	Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress. Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.
	Equipment	Flooding destroyed docks, electrical systems, and costly machinery and processing equipment (e.g., compressors, motors, peelers, conveyors). Estimated repair times range from as little as a few weeks to as much as a year, depending on the availability of power, clean water, and functional sewer systems, as well as the response of insurers and the availability of replacement equipment.	Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.
	Distribution Hubs	A Distribution Center or Hub is a specialized building, designed to store products for relatively short periods of time. The main goal of this type of warehouse is to redistribute products to another location or directly to customers. Hurricane Katrina caused millions of pounds of unrefrigerated shrimp at damaged processing plants has to be disposed of; the Coast Guard reportedly has approved ocean disposal of this waste.	Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress. Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.
	Food Storage / Refrigeration		

	Food Pantries		Food pantries are organizations that provide meals, rations, or other food supplies to families based on the organization's criteria for need or assistance. Criteria for assistance often includes providing proof of residency in the pantry's area of influence in addition to showing evidence of low income or hardship. There are an estimated 151 food pantries located throughout Hillsborough County, which mainly include secular non-governmental and faith-based organizations. Due to the number of different food pantry resources, the exact reliance or utilization of food pantry assets is difficult to estimate. However, Feeding Tampa Bay, the local extension of Feeding America, estimates that over 52 million meals are delivered to at-need individuals annually by that organization alone. A 2014 study done by Feeding America states that approximately one out of every 6 people in Hillsborough County lives in some form of food insecurity. Therefore, potentially over 204 thousand people have need of continual operation by the local food pantries.	Feeding America. (2015). Hunger in America 2014 Report. Feeding America Tampa Bay. Retrieved from http://feedingtampabay.org/wp-content/uploads/2014/08/Hunger-In-America-2014.pdf
Historic	Historical Standing Structures	Loss or destruction	Potential loss of cultural value if damaged or destroyed from flooding or hurricane scenarios. There is also potential for environmental and health threat when these types of buildings are damaged.	Taboroff, J. (2000). Cultural Heritage and Natural Disasters: Incentives for Risk Management and Mitigation. In A. Kreimer, & M. Arnold, Managing Disaster Risk in Emerging Economies (pp. 71-79). Washington D.C: The International Bank for Reconstruction and Development/ THE WORLD BANK. --- no link and incorrect?
	National Registered Properties		The National Register of Historic Places is the official federal list of properties that are significant in American history, architecture, archaeology, or engineering.	National Park Service. (2018). National register of historic places. Retrieved from https://www.nps.gov/subjects/nationalregister/index.htm
	Historical Cemeteries		Flooded cemeteries can release chemicals into the soil such as arsenic, mercury, formaldehyde, varnishes, sealers, preservatives, lead, zinc, copper, and steel. There is also the concern that historical infectious bacterial and viral diseases could be spread, although not likely.	He, Z., Folsom, S., Henry, E., & Twaiite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf
Vacant			The Vacant category "includes undeveloped residential, commercial, and industrial parcels."	Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Tampa. Department of Emergency Management. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015
	Repetitive Loss Areas		A Repetitive Loss (RL) property is any insurable building for which two or more claims of more than \$1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978.	FEMA. (2005). National Flood Insurance Program: Frequently Asked Questions Repetitive Loss. Retrieved from https://www.fema.gov/txt/rebuild/repetitive_loss_faqs.txt
Critical Facilities				Tampa Bay Regional Planning Council. (2006). Sea level rise in the Tampa Bay Region. Retrieved from https://studylib.net/doc/13572313/sea-level-rise-in-the-tampa-bay-region
	Communications			Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Tampa. Assessing Vulnerability and Risk. Retrieved from https://www.hillsboroughcounty.org/library/hillsborough/media-center/documents/public-works/local-mitigation-strategy-2015/section-iv---assessing-vulnerability-and-risk---lms-2015.pdf
	Federal and State Facilities			Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Tampa. Department of Emergency Management. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015
	Fire Stations			Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Tampa. Department of Emergency Management. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015

Hospitals & Ambulatory Healthcare Services

Police Stations

Local Government

Nursing Homes, Hospice, Assisted Living

Schools

Southwest Florida Water Management District Facilities

Emergency Shelters

Schools

The hospital represents a critical asset in the event of a disaster, but it is also a vulnerable one. Hospitals can fall victim to the disaster event itself, as occurred in the cases of Katrina and other recent hurricanes. Hospitals are also vulnerable to an influx of disaster victims. Large numbers of victims descending on a hospital can be overwhelming and diminish its effectiveness in dealing with casualties.

Nursing Homes and hospice facilities are more dependent than others on power/electricity and in some cases loss of power from a storm event can last for several weeks.

The buildings, even with some damage, served as the organizational hubs for the community to be rebuilt.

Schools played a major role in helping students get through this crisis, as well as rebuilding a sense of community.

Facilities are mapped in Local Mitigation Strategy update from 2015

Schools while used for their traditional purposes, are also used as evacuation centers in case of emergencies like floods and hurricanes.

Hospital-Based Emergency Care: At the Breaking Point. (2007) Chapter 7: Disaster Preparedness. 259-290. Retrieved from <https://www.nap.edu/read/11621/chapter/9#289>.

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Tampa. Department of Emergency Management. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Tampa. Department of Emergency Management. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Laditka, S. B., Laditka, J. N., Xirasagar, S., Cornman, C. B., Davis, C. B., & Richter, J. V. (2008). Providing Shelter to Nursing Home Evacuees in Disasters: Lessons From Hurricane Katrina. *American Journal of Public Health, 98*(7), 1288-1293.

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Tampa. Department of Emergency Management. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Dash, N., Morrow, B. H., Mainster, J., & Cunningham, L. (2007). Lasting Effects of Hurricane Andrew on a Working-Class Community . *Natural Hazards Review, 8*(1), 13-21.

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Tampa. Department of Emergency Management. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Nelson, E. J, Kareiva, P., Ruckelshaus, M., Arkema, K., Geller, G., Girvetz, E., ... Tallis, H. (2013). Climate change's impact on key ecosystem services and the human well-being they support in the US. *Frontiers in Ecology and the Environment, 11*(9), 483-493. doi:10.1890/120312

Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from <http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf>

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Tampa. Department of Emergency Management. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Pinellas County. (2018). Pinellas County, Florida Hurricane Irma After-Action Report. Retrieved from https://www.cna.org/CNA_files/centers/IPR/cia/HurricaneIrmaReport-013118-final.pdf

Coastal Armoring	Prisons	Jails, prisons, juvenile detention	Evacuating prisoners poses a vast amount of logistical issues in terms of security and protection. There have been many past mishaps in terms of not evacuating flooded prisons that created long-term negative health outcomes of those who were trapped in flooding jails.	Rannard, G. (2018, September 13). Hurricane Florence: Prisons in hurricane's path not evacuated. BBC News. Retrieved from https://www.bbc.com/news/world-us-canada-45509303
	Sea Walls		A large majority of the coast has been hardened by seawalls.	Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy
		Restricting coastal vegetation and habitat migration	Sea walls can act as a barrier to migrating habitats that are responding to SLR.	Enwright, N.M., Griffith, K.T., & Osland, M.J. (2016). Barriers to and opportunities for landward migration of coastal wetlands with sea-level rise. <i>Frontiers in Ecology and the Environment</i> , 14(6), 307-316.
		Special Needs	Following Hurricane Irma, Hillsborough County increased the number of pet friendly emergency shelters to eight, all of which exist outside of storm surge and sea level rise projections. The County provides special needs shelters for residents whose medical condition may require the use of electrical equipment, oxygen, dialysis, or individuals with physical, cognitive, or medical conditions that may require assistance from medical professionals.	Hillsborough County Emergency Management. (n.d.). Emergency Shelters. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/emergency-shelters
		Pet Friendly	According to a 2017-2018 survey conducted by the American Pet Product Association 68% of all U.S. households own pets. The majority of those households own at least one dog and/or cat.	Hillsborough County Emergency Management. (n.d.). Emergency Shelters. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/emergency-shelters
	Transit	Hillsborough Area Regional Transit (HART) provides free emergency evacuation bus services for people who need transportation to the emergency shelters. These pre-designated routes are identified for residents without transportation to know where the closest routes are before an emergency.	HART. (2019, August 05). Emergency Evacuation Maps. Retrieved from http://www.gohart.org/pages/maps-emergency-evac.aspx	

Use Zones

National Flood Insurance Program Flood zones		Flood zones are geographic areas that the Federal Emergency Management Agency (FEMA) has defined according to varying levels of flood risk. Zones provides federally supported (subsidized) flood insurance for properties with significant flood risk. In return, supported communities have to meet minimum floodplain management standards.	Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy
	A	"An area inundated by 1% annual chance flooding, for which no Base Flood Elevations (BFEs) have been determined." Are typically located near bodies of water, are the second most vulnerable properties. They are considered to have a high potential of flooding due to the rising of water and are required to have flood insurance. There are five types of A Zones: A, A#, AE, AO AH	FEMA. (2019). Flood Zones. Retrieved from https://www.fema.gov/flood-zones
	AE	"An area inundated by 1% annual chance flooding, for which BFEs have been determined."	
	AH	"An area inundated by 1% annual chance flooding (usually an area of ponding), for which BFEs have been determined."	
	AO	"An area inundated by 1% annual chance flooding, for which average depths and velocities have been determined."	
	V	The most hazardous flood zones and are typically beachfront coastal properties that are subject to additional hazards associated with the increase of wave velocity in storm-induced waves. There are three types of V Zones: V, V#, V.	
	VE	"An area inundated by 1% annual chance flooding with velocity hazard (wave action), BFEs have been determined."	
	X	"An area that is determined to be outside the 1% and 0.2% annual chance flood plains."	

X500

"An area inundated by 0.2% annual chance flooding; an area inundated by 1% annual chance flooding with average depths of less than 1 foot or with drainage areas of less than 1 square mile."

Coastal Construction Control Line Areas

These are areas connected to the Gulf (does not include Hillsborough, which is only connected to the bay) "The Coastal Construction Control Line is marked at the landward limit of coastal areas subject to the effects of a 100-year storm surge."

Tampa Bay Regional Planning Council. (2006). Sea level rise in the Tampa Bay Region. Retrieved from <https://studylib.net/doc/13572313/sea-level-rise-in-the-tampa-bay-region>

Riverine and Coastal Erosion

A riverine is a landscape formed by the natural movement of a water system such as a river. A riverine landscape includes the ecosystems (all living things including plants and animals) in and around the area of a river. A riverine may also be defined as a network of rivers and surrounding land.

Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy>

Flood Hazard Areas

Of the remaining vacant acres to be developed in Hillsborough County, approximately half are located in the Special Flood Hazard Area.

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Evacuation Zones

These are the areas that officials may order evacuated during a hurricane. These zones are mapped by the National Hurricane Center and indicate areas that will be affected by storm surge. Zones in Hillsborough County are identified from A - E, and there are parts of the county that are not in an evacuation zone.

Hillsborough County. Evacuation Zones vs. Flood Zones. Retrieved from <https://www.hillsboroughcounty.org/en/newsroom/2018/06/13/evacuation-zones-vs-flood-zones>

The Hurricane Evacuation Assessment Tool (HEAT) assists Hillsborough County residents in determining if they are in one of the five evacuation zones.

Hillsborough County Emergency Management. (n.d.). Emergency Shelters. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/emergency-shelters>

Shelter in Place

Shelter in place means finding a safe location indoors and staying there until you are able to leave safely.

Hillsborough County. (2019, August 5). Emergency Management, Shelter in Place. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/shelter-in-place>

Plan Areas, Overlay and Special Zoning Districts

Overlay zoning is a regulatory tool that creates a special zoning district, placed over an existing base zone(s), which identifies special provisions in addition to those in the underlying base zone. The overlay district can share common boundaries with the base zone or cut across base zone boundaries and is mapped in Local Mitigation Strategy update from 2015

University of Wisconsin. (2015). Planning Implementation Tools Overlay Zoning Retrieved from https://www.uwsp.edu/cnr-ap/clue/Documents/PlanImplementation/Overlay_Zoning.pdf

Municipalities and Community Areas

Municipalities are cities/towns that have corporate status and a local government. Hillsborough County's are mapped in the Local Mitigation Strategy update from 2015.

Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Existing Land Use Areas

Land use is one of the most controversial and central topics to address in a post-disaster redevelopment plan (PDRP). The composition of the community can affect the potentials for emergency management services, transportation, sheltering and community infrastructure.

Hillsborough County. (2019). Future Land Use - Hillsborough County. Retrieved from <https://www.arcgis.com/home/item.html?id=e285c9cc6248447da72c68ff40ca330>

Future Land Use

The Adopted Future Land Use map indicates how and where growth is intended to occur in unincorporated Hillsborough County. This data layer is updated quarterly based on adopted plan amendments.

Plan Hillsborough. (2019, August 5). Urban Service Area – An efficient growth management tool. Retrieved from <http://www.planhillsborough.org/urban-service-area/>

Urban Service Areas

Urban Service Areas allow local government to maximize infrastructure investments within a boundary where services are available and will be most needed as growth continues

Building Components

Soils

Damage may range from soiling basements and lower floors and their contents, and long term increase in residual moisture to destruction of structures and buildings from tremendous force of flood waters.

Taboroff, J. (2000). Cultural Heritage and Natural Disasters: Incentives for Risk Management and Mitigation. In A. Kreimer, & M. Arnold, Managing Disaster Risk in Emerging Economies (pp. 71-79). Washington D.C: The International Bank for Reconstruction and Development/ THE WORLD BANK.

		Soil erosion near buildings or foundations can cause damage to structures.		Taboroff, J. (2000). Cultural Heritage and Natural Disasters: Incentives for Risk Management and Mitigation. In A. Kreimer, & M. Arnold, Managing Disaster Risk in Emerging Economies (pp. 71-79). Washington D.C: The International Bank for Reconstruction and Development/ THE WORLD BANK.
Foundations	Failure			Florida Housing. (2017). Overview of the Florida building code. Retrieved from http://www.floridahousing.org/docs/default-source/aboutflorida/august2017/august2017/tab4.pdf
	Moisture	If the foundation is not properly sealed, moisture can enter through the walls and floor — and that can lead to problems like mildew, fungus, and mold.		Home Advisor. (2017). Should You Be Waterproofing Your Home?. Retrieved from https://patch.com/us/across-america/should-you-be-waterproofing-your-home
Waterproofing		In building construction, waterproofing is a fundamental aspect of creating a building envelope, which is a controlled environment. The roof covering materials, siding, foundations, and all of the various penetrations through these surfaces must be water-resistant and sometimes waterproof.		Home Advisor. (2017). Should You Be Waterproofing Your Home?. Retrieved from https://patch.com/us/across-america/should-you-be-waterproofing-your-home
Structure		During an event, wind or storm surge can damage the structure of a building and load bearing walls can collapse.		Blong, R. (2007). Residential building damage and natural perils: Australian examples and issues. Building Research & Information, 32(5), 379-390.
		The two most heavily impacted housing by Hurricane Hugo were homes built of light-wood frame construction and developed in the largely laissez-faire regulatory context of the 1980s and substandard housing of the rural poor, typically mobile homes placed on uncemented concrete blocks, without proper anchors and hold downs.		Blong, R. (2007). Residential building damage and natural perils: Australian examples and issues. Building Research & Information, 32(5), 379-390.
Building Materials		Different building materials react differently to being inundated such as: plaster board disintegration, wood swelling or warping, and shortage of electricals parts. Mold issues can also arise due to problems with humidity. Contaminants in flood waters can cause damage to the materials of the buildings as well as chemicals on building materials can be released into the flood water.		Comerio, M. C. (2002). Housing Issues After Disasters. Journal of Contingencies and Crisis Management, 5(3), 166-178. doi: 10.1111/1468-5973.00052
	Lead Paint	Buildings older than 1978 have the potential to contain lead-based paint and if inundated this can be released into the storm water.		Blong, R. (2007). Residential building damage and natural perils: Australian examples and issues. Building Research & Information, 32(5), 379-390.
	Asbestos	Many homes built before 1980 contain asbestos. Asbestos becomes a hazard when it is airborne. If asbestos in the home, and the home becomes damaged, asbestos fibers may be released.		Taboroff, J. (2000). Cultural Heritage and Natural Disasters: Incentives for Risk Management and Mitigation. In A. Kreimer, & M. Arnold, Managing Disaster Risk in Emerging Economies (pp. 71-79). Washington D.C: The International Bank for Reconstruction and Development/ THE WORLD BANK.
	Porous, Semi Porous and Nonporous Materials	Porous materials rapidly absorb liquid water and takes a long time to dry by evaporation. Semi Porous materials absorb liquid water slowly and dry slowly, while nonporous materials do not absorb water at all or absorb water at a negligible rate.		He, Z., Folsom, S., Henry, E., & Twaiite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from https://hsweng.com/wp-content/uploads/Artcile-Paaes-from-October-2018-Edition.pdf
Roofing		Roof or roofing materials can give way to the wind, allowing heavy rains to soak the interior of the home. A well-built roof protected with quality materials can save your home from destruction in severe weather. Very steep roof pitches act like a sail in high winds.		Brayton Purcell, LLP. (2019) Is There Asbestos in My Home?. Retrieved from https://www.asbestosnetwork.com/Worker-Safety/Asbestos-In-The-Home.shtml
		Lightweight shingles and shingles not installed using wind-zone techniques are easily lifted in high wind, and even if not torn off, this allows wind-driven rain under the shingles where it threatens damage to the roof deck		Brennan et al. (2018). Report to the U.S. Environmental Protection Agency on guidance documents to safely clean, decontaminate, and reoccupy flood-damaged houses. Retrieved from https://www.epa.gov/sites/production/files/2018-10/documents/flood-related_cleaning_contractor_report-final-508_8.31.18.pdf
				2019. Best Roof Types for Florida & Texas: Miami, Orlando, Houston. Retrieved from https://www.roofcostestimator.com/best-roof-types-florida-and-texas/
				2019. Best Roof Types for Florida & Texas: Miami, Orlando, Houston. Retrieved from https://www.roofcostestimator.com/best-roof-types-florida-and-texas/

Fences

After Hurricane Irma, roofing and fencing companies are still overwhelmed by repairs and roofing companies like Kelly Roofing in Naples had to more than double their staff from 100 employees to 250 to keep up with the overload of service calls after Irma.

Naples Daily News Staff. (2018, September 7). Hurricane Irma: One Year Later. Retrieved from Naples Daily News: <https://www.naplesnews.com/story/weather/hurricanes/2018/09/07/hurricane-irma-one-year-later-naples-marco-island-florida/1224427002/>

Building Services

Building services might include: control systems, energy distribution, energy supply, escalators and elevators, façade engineering, fire safety, HVAC, ICT networks, lighting, refrigeration, security and alarms, water, drainage, and plumbing, and carbon emission reduction. The basic requirements for a habitable condition are structural safety, operational toilets and sewage disposal, safe drinking water, bathing and cooking water, safe electric power, operational HVAC, and physical security.

2019. Designing Building - Building services. Retrieved from https://www.designingbuildings.co.uk/wiki/Building_services

Brennan et al. (2018). Report to the U.S. Environmental Protection Agency on guidance documents to safely clean, decontaminate, and reoccupy flood-damaged houses. Retrieved from https://www.epa.gov/sites/production/files/2018-10/documents/flood-related_cleaning_contractor_report-final-508_8.31.18.pdf

Elevation of Services Lower levels are most vulnerable

Flooding can destroy building services if located on lower levels.

Taboroff, J. (2000). Cultural Heritage and Natural Disasters: Incentives for Risk Management and Mitigation. In A. Kreimer, & M. Arnold, Managing Disaster Risk in Emerging Economies (pp. 71-79). Washington D.C: The International Bank for Reconstruction and Development/ THE WORLD BANK.

Safe Electricity Electric shock

A number of health hazards are present in homes that have been damaged during floods, hurricanes, or other extreme weather events such as electric shock. The ABC's of retiring to flooding buildings discuss the safe process and steps.

Brennan et al. (2018). Report to the U.S. Environmental Protection Agency on guidance documents to safely clean, decontaminate, and reoccupy flood-damaged houses. Retrieved from https://www.epa.gov/sites/production/files/2018-10/documents/flood-related_cleaning_contractor_report-final-508_8.31.18.pdf

Working Toilets and Sinks

This includes functioning potable water and sewer facilities.

Brennan et al. (2018). Report to the U.S. Environmental Protection Agency on guidance documents to safely clean, decontaminate, and reoccupy flood-damaged houses. Retrieved from https://www.epa.gov/sites/production/files/2018-10/documents/flood-related_cleaning_contractor_report-final-508_8.31.18.pdf

Drinkable Water

Potable water sources can be affected, water towers for instance. Drinking water sources that have been contaminated by flood waters are the major cause of outbreaks after flood events. Flood water often is contaminated with pathogens from sewage, farm animal wastes and wild animal populations, or those that occur naturally in water bodies.

Brennan et al. (2018). Report to the U.S. Environmental Protection Agency on guidance documents to safely clean, decontaminate, and reoccupy flood-damaged houses. Retrieved from https://www.epa.gov/sites/production/files/2018-10/documents/flood-related_cleaning_contractor_report-final-508_8.31.18.pdf

Heating and Cooling (HVAC)

HVAC characteristics make it likely that flood waters will render HVAC equipment inoperable, deposited contamination will be difficult to find and clean, and contamination may be distributed through a building.

Brennan et al. (2018). Report to the U.S. Environmental Protection Agency on guidance documents to safely clean, decontaminate, and reoccupy flood-damaged houses. Retrieved from https://www.epa.gov/sites/production/files/2018-10/documents/flood-related_cleaning_contractor_report-final-508_8.31.18.pdf

Year Built

After Hurricane Irma, the Florida Building Commission found no systemic failures of structural systems in single-family houses built in accordance to the 2001 Florida Building Code (i.e. houses built after March 2002). However, many structural failures in the pre- Florida building code houses were found.

Prevatt, D., Gurley, K., Roueche, D., & Wong-Parodi, G. (2018). Survey and investigation of buildings damaged by category II, III, IV and V hurricanes in FY 2017-18 – Hurricane Irma 2017. Retrieved from http://www.floridabuilding.org/fbc/publications/PrevattUF_FBC_2017_2018_FinalReport-Irma.pdf

Bracing and materials can be categorically different depending on the applicable code.

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Transportation

Transportation Network

Quantity of Options and Redundancies

The more tightly coupled and interconnected the infrastructure system, the less resilience it exhibits.

Cutter, S., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A Place-Based Model for Understanding Community Resilience to Natural Disasters. *Global Environmental Change*, 18, 598-606. doi: /10.1016/i.aloenvcha.2008.07.013

Air Transportation

Land Transportation	Airports	<p>Airports are considered a critical facility. Airports are vital pieces of infrastructure that play key roles in the preparation and recovery of an area affected by flooding. Without airports, the logistics and distribution of aid becomes nearly impossible. In areas such as Hillsborough County, the majority of larger, more capable airfields are within the risk area for flooding events related to tropical storms and hurricanes. These facilities not only are vital for emergency response, but they are also large revenue generators for the Tampa Bay and Hillsborough County area. There are two major airports, seven minor airports, and thirteen helipads in the county.</p> <p>Air transit was among the five industries economically impacted the most by Hurricane Harvey.</p>	<p>Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015</p> <p>Cambridge Systematics, Inc; Jacobs Engineering Group, Inc; Florida Atlantic University. (2014). Retrieved from PlanHillsborough website: http://www.planhillsborough.org/wp-content/uploads/2013/10/NoAppendix_Hillsborough-MPO_FHWA-Pilot-Final-Report1.pdf(Frosch, Ailworth, & Gold, 2017)</p> <p>Dow Jones. (2017). Hurricane Impacted Industries. Retrieved from https://www.dowjones.com/insight/hurricane-impacted-industries/</p>
	Runways	These are at the ground level and are critical to airport functionality.	Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf
	Helicopter Pads		Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015
	Roads	Highways during emergency situations are essential to bring in supplies like food, water, and fuel.	Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015
	Base material	Damage to roads and bridges occurs when the gravel underneath the concrete or asphalt is washed away. Without this foundational support, these elements of infrastructure are vulnerable to collapse, washout, or being crushed by high winds.	Alexander, A., & Cope, C. (2018, September 21). Florence damaged hundreds of NC roads and bridges. When will there be repairs? The Charlotte Observer. Retrieved from https://www.charlotteobserver.com/news/weather/article218671150.html
	Drainage	In many low lying communities, roads are lower than the surrounding lands, so that land can drain into the streets. As a result, the streets are the first to flood.	Titus, J. (2002). Does Sea Level Rise Matter to Transportation Along the Atlantic Coast? U.S. Department of Transportation. Retrieved from https://www.transportation.gov/sites/dot.gov/files/docs/titus_Sea_Level_Rise_Matter_Transportation_Atlantic_Coast.pdf
	On/Off Ramps	Travelers may not be able to access the regional roadway network at all if, for example, a key surface street or entrance ramp were flooded.	Plan Hillsborough. (2014). Hillsborough MPO transportation vulnerability assessment pilot project. Retrieved from http://www.planhillsborough.org/hillsborough-transportation-vulnerability-assessment-pilot-project/
	Interchanges		DesRoches, R. (2006). Hurricane Katrina : Performance of Transportation Systems. Technical Council of Lifeline Earthquake Engineering. https://doi.org/10.1061/9780784408797
	Bridges & Overpasses	Roadways and bridges could be damaged or blocked due to flooding or debris.	Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015
	Historical Bridges		
Critical Bridges for Islands	Residents of barrier islands depend heavily on a small number of bridges and roads that connect islands to one another and to the mainland. If bridges or sections of the road are destroyed, damaged, or congested, there may not be any, alternative routes for evacuation.	Frazier, T., Thompson, C. M., Dezzani, R., & Butsick, D. (2013). Spatial and temporal quantification of resilience at the community scale. <i>Applied Geography</i> , 42, 95-107.	
	Hurricane Harvey: Moving floodwaters erode supports for bridges, causing them to collapse; gravel foundation washed away undermines pavement or concrete on roads;	Jansen, B. (2017, August 30). Texas has 53,488 bridges. Here's the toll Harvey is expected to take on those. Retrieved from USA Today: https://www.usatoday.com/story/news/2017/08/30/harvey-floodwaters-topple-bridges-gnaw-roads/616930001/	

Traffic Lights	During Hurricane Irma, of the more than 300 traffic signals maintained by Hillsborough County, 125 lost power, making it difficult for motorists to navigate.	Graham, N. (2019). Hurricane Irma Outages Prompt Solar Powered Light Signals in Hillsborough. Retrieved from https://wusfnews.wusf.usf.edu/post/hurricane-irma-outages-prompt-solar-powered-light-signals-hillsborough
Evacuation Routes	During a disaster flooding, debris and manpower are the major factors affecting access to evacuation routes and fuel.	Frazier, T., Thompson, C. M., Dezzani, R., & Butsick, D. (2013). Spatial and temporal quantification of resilience at the community scale. <i>Applied Geography</i> , 42, 95-107.
Truck Routes		Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015
Railroads	Rail lines are crucial to county infrastructure in transporting bulk products.	DesRoches, R. (2006). Hurricane Katrina : Performance of Transportation Systems. Technical Council of Lifeline Earthquake Engineering. <i>American Society of Civil Engineers</i> https://doi.org/10.1061/9780784408797
Tracks	Tracks can be blocked by debris or experience damage caused by washouts/collapse. Railroads often cut across marsh areas in the coastal zone. In the case of some smaller short line railroads, tracks are so low that they are often flooded, and the beds may be vulnerable to sinking from compaction of marsh peat.	DesRoches, R. (2006). Hurricane Katrina : Performance of Transportation Systems. Technical Council of Lifeline Earthquake Engineering. <i>American Society of Civil Engineers</i> https://doi.org/10.1061/9780784408797 Titus, J. (2002). Does Sea Level Rise Matter to Transportation Along the Atlantic Coast? U.S. Department of Transportation. Retrieved from https://www.transportation.gov/sites/dot.gov/files/docs/titus_Sea_Level_Rise_Matter_Transportation_Atlantic_Coast.pdf
Transit	80,000 people in Hillsborough County rely on Public Transit.	Hillsborough County. (2010). Hillsborough county post-disaster redevelopment plan. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/post-disaster-redevelopment-plan Tampa Bay Regional Planning Council. (2011). Tampa Bay Disaster Resiliency Study. Retrieved from http://www.tbrpc.org/eap/pdfs/eap_projects/2011/TB_DisasterResiliencyStudy2011.pdf Hillsborough County. (2008). Comprehensive plan for unincorporated Hillsborough County Florida - Coastal management element. Retrieved from Plan Hillsborough website at http://www.planhillsborough.org/wp-content/uploads/2013/01/COASTAL-MANAGEMENT-with-3rd-cycle-2012-amendments.pdf
Transit Facilities		He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from https://hsweng.com/wp-content/uploads/Article-Pages-from-October-2018-Edition.pdf
Fixed Systems	Fixed-route transportation systems use buses, vans, light rail, and other vehicles to operate on a predetermined route according to a predetermined schedule.	Hillsborough County. (2010). Hillsborough county post-disaster redevelopment plan. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/post-disaster-redevelopment-plan Tampa Bay Regional Planning Council. (2011). Tampa Bay Disaster Resiliency Study. Retrieved from http://www.tbrpc.org/eap/pdfs/eap_projects/2011/TB_DisasterResiliencyStudy2011.pdf
Flexible Systems	Flex route transportation systems, also called deviated fixed-route systems, use a hybrid fixed-route and demand-response model. Flex route systems also use pre scheduled timetables, but may deviate from the predetermined route in order to go to a specific location such as major employment site, a child care center, or a house.	Hillsborough County. (2010). Hillsborough county post-disaster redevelopment plan. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/post-disaster-redevelopment-plan

Sea Transportation

Navigable Waters

Shipping Channel and 2 Mile Buffer

Ports

During disasters like flooding, debris and manpower are the major factors affecting access to evacuation routes and fuel. Location of facilities is not the only concern, the Tampa port is one of the main storage and distribution hubs for the county and surrounding areas.

[Hurricane Katrina: Port closures cost \\$260 million after a week of being closed](#)

Ships

Small Boats

Hurricane Katrina caused extensive damage to small boats and charter crafts.

Boat Slips

A boat slip is the portion of a pier, main pier, finger pier, or float where a boat is berthed or moored, or used for embarking or disembarking.

Marinas

A marina is a dock or basin with moorings and supplies for yachts and small boats. A marina differs from a port in that a marina does not handle large passenger ships or cargo from freighters.

Docks and Piers

Projected property impacts through 2040 in the City of Tampa are mostly limited to open spaces and docks.

Tanker storage tanks

Associated hazardous materials

Port Vessel Collision

Hillsborough County. (2010). Hillsborough county post-disaster redevelopment plan. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/post-disaster-redevelopment-plan>

Tampa Bay Regional Planning Council. (2006). Sea level rise in the Tampa Bay Region. Retrieved from <https://studylib.net/doc/13572313/sea-level-rise-in-the-tampa-bay-region>

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Amadeo, K. (2018). Hurricane Katrina facts, damage, and costs. Retrieved from <https://www.thebalance.com/hurricane-katrina-facts-damage-and-economic-effects-3306023>

Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.

Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from <http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf>

Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from <http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf>

Tampa Bay Regional Planning Council. (2006). Sea level rise in the Tampa Bay Region. Retrieved from <https://studylib.net/doc/13572313/sea-level-rise-in-the-tampa-bay-region>

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Santella, N., Steinberg, L., & Sengul, H. (2010). Petroleum and Hazardous Material Releases from Industrial Facilities Associated with Hurricane Katrina. Risk Analysis, 30(4), 635-649.

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Potable Water

Dam and Levee Locations and Inundation Area

A dam is a water control structure that can be used for flood protection. If a dam breaks, additional flooding will occur throughout the county.

Copeland, C. (2005). Hurricane-Damaged Drinking Water and Wastewater Facilities: Impacts, Needs, and Response. Congressional Research Service. Retrieved from https://www.everycrsreport.com/files/20060322_RS22285_b075e0c650cb9d4868f20478641ebe9835c3f299.pdf

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Wells

Physical damage

Coarse sediment in flood waters could erode pump components. If the well is not tightly capped, sediment, debris, and flood water could enter the well and contaminate it. Wells that are more than ten years old or less than 50 feet deep are likely to be contaminated, even if there is no apparent damage. Floods or heavy debris may cause some wells to collapse.

Water Systems Council. (2018). Emergencies and disasters and wells. Retrieved from https://www.watersystemscouncil.org/download/wellcare_information_sheets/maintaining_your_well_information_sheets/EmergenciesDisasters_FINAL-update-9.2018.pdf

Groundwater / Aquifer (water source)

Saltwater Intrusion

As sea levels rise, coastal communities could lose up to 50 percent of their fresh water supplies due to salt water intrusion.

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Waterlines

[Hurricane Katrina cost \\$20 million in replacing broken water lines.](#)

Lee, L. J., & Hall, B. (2011, July). Louisiana's Recovery. Retrieved from Federal Highway Administration: <https://www.fhwa.dot.gov/publications/publicroads/11julaug/05.cfm>

Baker, I., Peterson, A., Brown, G., & McAlpine, C. (2012). Local government response to the impacts of climate change: An evaluation of local climate adaptation plans. *Landscape and Urban Planning Journal*, 107(2), 127-136. doi: 10.1016/j.landurbplan.2012.05.009

Pumps
Desalination plants

Closed basin systems require pumps to remove water. Seawater desalination is the removal of salt and impurities from seawater to produce fresh water. Our desalination plants use a reverse osmosis process. Seawater is pumped into the desalination plant from the ocean and passes through pretreatment filtration to remove majority most of the large and small particles.

Tampa Bay Water. (2019). Tampa Bay Seawater Desalination. Retrieved from <https://www.tampabaywater.org/tampa-bay-seawater-desalination>

The Tampa Bay Seawater Desalination facility is a drought-proof, alternative water supply that provides up to 25 million gallons per day of drinking water to the region. This makes up 10% of the regions water needs.

Tampa Bay Water. (2019). Tampa Bay Seawater Desalination. Retrieved from <https://www.tampabaywater.org/tampa-bay-seawater-desalination>

Water Treatment

Tampa's demand for water averages about 80 million gallons a day. Most of the demand, pumped from the Hillsborough River reservoir is treated with a six-step process prior to being stored in large underground tanks called clear wells.

City of Tampa. (2019, August 5). Water Treatment Process. Retrieved from <https://www.tampagov.net/water/water-treatment-process-slideshow>

Sewage Water

Pipes and Components

Water main breakage or failure

[Heavy rainfall from the remnants of Hurricane Florence sent tens of thousands of gallons of untreated wastewater into a tributary of North Carolina's Cape Fear River basin over the weekend.](#)

CBS News. (2018, September 19). Florence gone but its flooding a crisis in parts of North Carolina- live updates. Retrieved from <https://www.kktv.com/content/news/Florence-Tropical-Storm-besieges-North-and-South-Carolina-493376371.html>

Corrosion
Pumps

Loss of electricity will prevent water and sewage pumping.

Naples Daily News Staff. (2018, September 7). Hurricane Irma: One Year Later. Retrieved from Naples Daily News: <https://www.naplesnews.com/story/weather/hurricanes/2018/09/07/hurricane-irma-one-year-later-collier-lee-utilities-add-backup-power-avoid-sewage-overflow-repeat/1085505002/>

Sewage Treatment Plants

Floods cause wastewater treatment plants to back up. Other issues in the basin include elevated levels of fecal coliform bacteria from agricultural and urban stormwater runoff, sewage treatment plants, septic systems, and sewer overflows.

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Copeland, C. (2005). Hurricane-Damaged Drinking Water and Wastewater Facilities: Impacts, Needs, and Response. Congressional Research Service. Retrieved from https://www.everycrsreport.com/files/20060322_RS22285_b075e0c650cb9d4868f20478641ebe9835c3f299.pdf

Underwood, E. (2018). Sea level rise threatens hundreds of wastewater treatment plants, Eos, 99. DOI: 10.1029/2018EO097351.

Underwood, E. (2018). Sea level rise threatens hundreds of wastewater treatment plants, Eos, 99. DOI: 10.1029/2018EO097351.

Underwood, E. (2018). Sea level rise threatens hundreds of wastewater treatment plants, Eos, 99. DOI: 10.1029/2018EO097351.

Hillsborough County. (2010). Hillsborough county post-disaster redevelopment plan. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/post-disaster-redevelopment-plan>

Tampa Bay Regional Planning Council. (2011). Tampa Bay Disaster Resiliency Study. Retrieved from http://www.tbrpc.org/eap/pdfs/eap_projects/2011/TB_DisasterResiliencyStudy2011.pdf

EPA. (2006, August 17). Summary Results of Sediment Sampling Conducted by the Environmental Protection Agency in response to Hurricanes Katrina and Rita. Retrieved from <https://archive.epa.gov/katrina/web/html/summary.html>

Hillsborough County City-County Planning Commission. (2017). Sea level rise vulnerability assessment for the City of Tampa. Retrieved from <http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf>

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from <http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf>

Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from <http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf>

Watt, E., & Marsalek, J. (2013). Critical review of the evolution of the design storm event concept. Canadian Journal of Civil Engineering, 40(2), 105-113.

Bacterial contamination in floodwater

[During Hurricane Harvey, at least 40 wastewater treatment plants in Texas were damaged by the floodwaters, and some leaked raw sewage for weeks](#)

Untreated sewage could affect 5 times more people than direct flooding.

[During Hurricane Katrina, sewage was so bad on streets that reports on the ground had to be decontaminated by the National Guard](#)

Septic Tanks

During flood events and with sea level rise, septic tanks can become backed up and may contaminate the aquifer and well water.

Storm Water

Several stormwater basins and some stormwater facilities are within the at-risk areas based on NOAA 2040 SLR projections.

Drainage System

"Both sea level rise and climate changes that produce more rainfall are expected to strain drainage systems."

Man Made Water Reservoirs

A detention pond collects and slows the flow of water before entering into the stormwater systems. They are helpful during a heavy rain event because it helps prevent flooding and sewer issues.

Culverts

Inlets

Inlets can be blocked by debris which causes flooding.

Electricity	Network Structures			Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf
	Open Drains			Hillsborough County Planning Commission. (2017). Sea Level Rise Vulnerability Assessment for the City of Tampa. Tampa: Hillsborough County. Retrieved from http://www.planhillsborough.org/wp-content/uploads/2017/01/Sea-Level-Rise-Vulnerability-Assessment-for-the-City-of-Tampa-rev5.pdf
	Pumps	Failure	Loss of electricity will prevent water and sewage pumping.	Ouroussoff, N. (2005, Oct 09). How the city sank. New York Times. Retrieved from https://www.nytimes.com/2005/10/09/arts/design/how-the-city-sank.html
			"This may have an impact to operations associated with utilities, alternative sources of water, and natural habitats and environmental lands. "	Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015
	Canals	Back Up at Canals		Schwartz, J. (2005, Dec 21). New orleans wonders what to do with open wounds, its canals. New York Times. Retrieved from https://www.nytimes.com/2005/12/21/us/nationalspecial/new-orleans-wonders-what-to-do-with-open-wounds-its.html
			After Hurricane Katrina, New Orleans experienced significant infrastructure damage from corrosion of underground utility lines (electric, cable, and phone) due to saltwater inundation	Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy
			Hurricane Irma: Manatee County, 26 schools lost power, including some used for emergency shelter	White, D. (2017, September 12). In Manatee, Irma-related costs will be substantial. Herald Tribune. Retrieved from https://www.heraldtribune.com/news/20170912/in-manatee-irma-related-costs-will-be-substantial
	Power Plants	Power generating capability may not meet total demand during extreme weather conditions or after a severe storm.	Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy	
	Coal Ash ponds		Purdy, J. (2018, September 18). The Unequal Distribution of Catastrophe in North Carolina. Retrieved from The New Yorker: https://www.newyorker.com/news/our-columnists/the-unequal-distribution-of-catastrophe-in-north-carolina	
			Pierre-Louis, K., Popovich, N., & Tabuchi, H. (2018, September 24). Florence's Floodwaters Breach Coal Ash Pond and Imperil Other Toxic Sites. Retrieved from https://www.nytimes.com/interactive/2018/09/13/climate/hurricane-florence-environmental-hazards.html?mtref=www.google.com&gwh=8E9C2E4F608C1B24BF25CC3CF265BD7D&gwt=pay&assetType=REGIWALL	
	Above Ground Power Lines	Hurricane Katrina: Power-lines down in streets after the storm	Baranger, W. (2015, August 26). Katrina: A turning point at The Times. The New York Times. Retrieved from https://www.nytimes.com/2015/08/25/insider/how-we-covered-hurricane-katrina.html	
		Tree damage can impact loss of power and recovery time.	Baranger, W. (2015, August 26). Katrina: A turning point at The Times. The New York Times. Retrieved from https://www.nytimes.com/2015/08/25/insider/how-we-covered-hurricane-katrina.html	

Gas	Underground power lines	Underground power lines are not invulnerable to power loss, exhibited by loss of power in New York following Hurricane Sandy; underground networks can still experience power loss due to flooding.	Hillsborough County. (2010). Hillsborough county post-disaster redevelopment plan. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/post-disaster-redevelopment-plan
	Transmission Stations		Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy
	Gasoline	Gas stations usually rely on electricity to power their pumps.	Luis A. Godoy, P. D. (2006). Damage of Canopies in Gas Stations due to Hurricanes Katrina and Rita . Puerto Rico. Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy
	Propane and Fuel Storage Facilities	Damage to propane storage facilities can cause fires. Reports indicated that the fires originated from a warehouse containing propane tanks that exploded and spread the flames.	Tampa Bay Regional Planning Council. (2011). Tampa Bay Disaster Resiliency Study. Retrieved from http://www.tbrpc.org/eap/pdfs/eap_projects/2011/TB_DisasterResiliencyStudy2011.pdf
	Gas Lines	"Due to saltwater inundation, the valves on gas lines were corroded and had to be replaced before gas service could be resumed"	Santella, N., Steinberg, L., & Sengul, H. (2010). Petroleum and Hazardous Material Releases from Industrial Facilities Associated with Hurricane Katrina. Risk Analysis, 30(4), 635-649.
	Pipelines	On and offshore leaks causing contamination of stormwater and release of nitrogen oxide into the air.	He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from https://hsweng.com/wp-content/uploads/Article-Pages-from-October-2018-Edition.pdf Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy
Communications			Hillsborough County. (2010). Hillsborough county post-disaster redevelopment plan. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/post-disaster-redevelopment-plan
	Radio and Tv Transmitters	Damage to communication transmitters, due to storm surge can impeded communication to the public.	Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy
	Cable		Kwasinski, A., Weaver, W. W., Chapman, P. L., & Krein, P. T. (2006). Telecommunications Power Plant Damage Assessment Caused by Hurricane Katrina - Site Survey and Follow-Up Results . INTELEC 06 - Twenty-Eighth International Telecommunications Energy Conference . Kwasinski, A., Weaver, W. W., Chapman, P. L., & Krein, P. T. (2006). Telecommunications Power Plant Damage Assessment Caused by Hurricane Katrina - Site Survey and Follow-Up Results . INTELEC 06 - Twenty-Eighth International Telecommunications Energy Conference .
Waste	Garbage	After Hurricane Irma, in Marion County there was a delay in garbage collection.	White, D. (2017, Sep 13). Irma-related costs will be substantial. Retrieved from the Sarasota Herald-Tribune at https://www.heraldtribune.com/news/20170912/in-manatee-irma-related-costs-will-be-substantial
	Yard and Wood Waste	Organic debris is a major factor in disaster cleanup	White, D. (2017, Sep 13). Irma-related costs will be substantial. Retrieved from the Sarasota Herald-Tribune at https://www.heraldtribune.com/news/20170912/in-manatee-irma-related-costs-will-be-substantial

Solid Waste Landfill Facilities

Facilities include transfer stations, landfill disposal, chemical collection centers, and those for managing yard waste

Hillsborough County. (2010). Hillsborough county post-disaster redevelopment plan. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/post-disaster-redevelopment-plan>

Hazardous Materials

Chemical Storage

Contaminants of major concern include: heavy metals, pesticides, volatile and semi volatile organic pollutants, and microorganism.

Tampa Bay Regional Planning Council. (2011). Tampa Bay Disaster Resiliency Study. Retrieved from http://www.tbrpc.org/eap/pdfs/eap_projects/2011/TB_DisasterResiliencyStudy2011.pdf

Fuel Storage

Most common mechanism of release is failure of storage tanks. "Flooding caused tanks to dislodge from their foundations and move"

Santella, N., Steinberg, L., & Sengul, H. (2010). Petroleum and Hazardous Material Releases from Industrial Facilities Associated with Hurricane Katrina. Risk Analysis 30(4) 635-649
He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from <https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf>

Diesel

Heavier fuels may cause tar ball formation while lighter oils are more likely to undergo evaporation

He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from <https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf>

Gas Stations

[During Hurricane Katrina, failure of storage tanks was the "most common mechanism of release" of petroleum. Most of these failures were caused by storm surge.](#)

He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from <https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf>

"Studies have shown that during Hurricanes Katrina and Rita, storm surge was responsible for the majority of petroleum releases, and the failure of storage tanks was the most common mechanism of release. Potential sources of contaminants following storm surge and flooding include: chemicals leaching from industrial facilities; sewage leaking from the wastewater collection system; septic tanks and wastewater treatment plants; gasoline leaking from submerged vehicles and fuel stations; businesses and submerged homes; and decaying vegetation and other organic debris. Inundation of historically contaminated soils and redistribution of historically contaminated aquatic sediments also raised concerns for potential adverse effects on human health and the ecosystem."

He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from <https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf>

Mining & Extractive Sites

Mining Sites

Hillsborough County. (2015). Hillsborough County local mitigation strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy>

He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from <https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf>

Excavation Areas
Ammonia

Ammonia floats on the water surface, then rapidly dissolves within the water body into ammonium (NH4OH) or evaporates into the atmosphere as gaseous ammonia (NH3).

He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from <https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf>

Toxic Organic
Compounds and
Heavy Materials

He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from <https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf>

Processing

He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from <https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf>

		Earthen Dikes		He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf
		Gypsum Stacks and Leaching	Phosphate ore is dissolved in sulfuric acid to release phosphogypsum. Phosphogypsum, a mildly radioactive waste product, is stored in environmentally unstable 'gypsum' stacks. The stacks contain uranium and its decay product, radium sulfate.	He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf
		Railcar Containers	Inundation of hazardous materials can release Volatile Organic Compounds.	Pierre-Louis, K., Popovich, N., & Tabuchi, H. (2018, September 24). Florence's Floodwaters Breach Coal Ash Pond and Imperil Other Toxic Sites. Retrieved from https://www.nytimes.com/interactive/2018/09/13/climate/hurricane-florence-environmental-hazards.html?mtrref=www.google.com&gwh=8E9C2E4F608C1B24BF25CC3CF265BD7D&gwt=pay&assetType=REGIWALL
Energy Production	Byproducts	Coal Ash ponds	Coal combustion residuals (CCR), more commonly referred to as coal ash, are created when coal is burned in coal-fired power plants. Coal ash includes a number of by-products such as Fly Ash, Bottom Ash, Boiler Slag, and Flue Gas Desulfurization Material. Coal sludge impoundments, or "ponds," store liquid coal waste known as sludge or slurry. This sludge contains coal and an assortment of heavy metals. Surge water inundation can weaken impoundment walls, triggering the release of billions of gallons of liquid coal waste potentially contaminated with heavy metals and other toxic chemicals. The contaminants foul groundwater, surface water, sediment and soil long after surge water recedes. Remediation is a complex and imperfect process that cannot fully restore the damaged ecosystem.	Tampa Electric Company. (2018). Big Bend Power Station North and South Economizer Ash Ponds Closure Plan. Retrieved from https://www.tampaelectric.com/files/environment/teco-big-bend-economizer-ash-closure-plan.pdf
		Soils	Hazardous materials stored onsite can cause potential human health and environmental concern through either surface water or soil contamination. Such materials include acids, ammonia, chlorine, petroleum fuels/oils, metals, phosphorus, organic pesticides and insecticides, and other toxic chemicals. Prolonged inundation can erode safeguards keeping chemicals contained.	He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from https://hsweng.com/wp-content/uploads/Artcile-Pages-from-October-2018-Edition.pdf
	Components	Cement Caps	Contaminants are released into stormwater. Hurricane Harvey prolonged flood exposure due to cracked cement caps.	Pierre-Louis, K., Popovich, N., & Tabuchi, H. (2018, September 24). Florence's Floodwaters Breach Coal Ash Pond and Imperil Other Toxic Sites. Retrieved from https://www.nytimes.com/interactive/2018/09/13/climate/hurricane-florence-environmental-hazards.html?mtrref=www.google.com&gwh=8E9C2E4F608C1B24BF25CC3CF265BD7D&awt=pav&assetType=REGIWALL Tampa Bay Estuary Program, (2020). DRAFT 2020 Habitat Master Plan Update. Retrieved from https://tbep.tech.org/attachments/article/285/Draft_Final_2020_Habitat_Master_Plan_Optimized.pdf
		Superfund Sites		Linton, C. (2012, November 3). Hurricane Sandy's Fallout: What About Rikers Island? The Daily Beast. Retrieved from https://www.thedailybeast.com/hurricane-sandys-fallout-what-about-rikers-island
				Linton, C. (2012, November 3). Hurricane Sandy's Fallout: What About Rikers Island? The Daily Beast. Retrieved from https://www.thedailybeast.com/hurricane-sandys-fallout-what-about-rikers-island

POPULATIONS AND PUBLIC HEALTH

CATEGORY	SUB-CATEGORIES	SPECIFIC	DESCRIPTION/CASE STUDY	REFERENCES
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Socio-Economic Status (SES)

Below Poverty	Poverty perpetuated by a disaster	Poverty plays a big role in keeping people vulnerable to disasters. Disasters serve as a powerful downward trigger to poverty by continually destroying the few assets of the poor and wiping out investments in infrastructures and services that serve the poor.	Alcira Kreimer, Margaret Arnold. (2000). Managing Disaster Risk in -Emerging Economies. Retrieved from http://documents.worldbank.org/curated/en/372441468740717582/pdf/multi-page.pdf
	Recovery	From a community standpoint, the poor are likely to require substantial government assistance. They more commonly become the inhabitants of refugee camps, mass shelters and temporary housing and tend to remain there longer. Low-income households may lack the resources to secure alternative housing during or after a disaster.	Morrow, B. H. (2002). Identifying and Mapping Community Vulnerability. <i>Disasters</i> , 23(1), 1-18. doi: 10.1111/1467-7717.00102
	Low Income Households	Financial strain	Morrow, B. H. (2002). Identifying and Mapping Community Vulnerability. <i>Disasters</i> , 23(1), 1-18. doi: 10.1111/1467-7717.00102
	Unemployed		Frankenberg, E., Sikoki, B., Sumantri, C., Suriastini, W., & Thomas, D. (2013). Education, Vulnerability, and Resilience after a Natural Disaster. <i>Ecology and Society</i> , 18(2), 16.
No High School Diploma	Mental health	Research shows that "the better educated were in better psychosocial health than those with less education" and concluded that education is associated with higher levels of resilience over the longer term.	Frankenberg, E., Sikoki, B., Sumantri, C., Suriastini, W., & Thomas, D. (2013). Education, Vulnerability, and Resilience after a Natural Disaster. <i>Ecology and Society</i> , 18(2), 16.
		Coping and adapting	Education plays a role in respect to coping with the disaster over the longer term. The better educated were far less likely than others to live in a camps or other temporary housing, and instead, moved to private homes, stayed with family or friends, or rented a new home.
	Homeless	Sheltering	Sheltering homelessness populations increase the chances of disease transmission due to the close-quarter sheltering and post disaster environment.
Homeless	Exposure to flood waters		Compton, J. (2017, September 6). Deadly Hurricane Exposes Dangers of Being LGBTQ and Homeless. Retrieved from NBC News: https://www.nbcnews.com/feature/nbc-out/hurricane-harvey-exposes-dangers-being-lgbtq-homeless-n799126
	Children	Unaccompanied youth post disaster will need care and protection after being found.	Government Accountability Office [GAO]. (2006). Lessons Learned for Protecting and Educating Children after the Gulf Coast Hurricanes (Report No. 06-680R). Retrieved from https://www.gao.gov/new.items/d06680r.pdf
	Exploitation	Homeless youth are at higher risk to be sexually exploited for shelter.	Compton, J. (2017, September 6). Deadly Hurricane Exposes Dangers of Being LGBTQ and Homeless. Retrieved from NBC News: https://www.nbcnews.com/feature/nbc-out/hurricane-harvey-exposes-dangers-being-lgbtq-homeless-n799126

Household Composition and Disabilities

Gender	Women are most likely to recognize and respond to risk; men are more likely to respond and recover	Gender differences appear to affect risk assessment and response, household preparation and evacuation.	Enarson, E. (2006). SWS Fact Sheet: Women and Disaster. Retrieved from https://socwomen.org/wp-content/uploads/2018/03/fact_10-2006-disaster.pdf
		Men and women have different perception of risks. While woman express higher levels of concern about the environment and presented hazards, woman try to avoid risk while men are more willing to take risks. This has implications on their preparedness and safety in disasters.	Enarson, E. (2006). SWS Fact Sheet: Women and Disaster. Retrieved from https://socwomen.org/wp-content/uploads/2018/03/fact_10-2006-disaster.pdf

Men	Experience stress and depression in regards to the ability to protect the family	Husbands and fathers were more likely to be upset by their perceived failure to protect and take care of their families. They felt responsible for dealing with adjusters and contractors, and for getting their homes repaired. When things went wrong, there was a tendency to feel they had failed their families.	Enarson, E., & Fordham, A. (2001). Lines that divide, ties that bind: Race, class, and gender in women's flood recovery. Australian Journal of Emergency Management, 15(4), 43- 52. Retrieved from https://www.diversitypreparedness.org/browse-resources/resources/AJEM%20Flood%20women/
	Failure to evacuate	Men typically disregard evacuation orders, while woman evacuate early.	
Leadership/first responder responsibilities	Men more often than women hold leadership roles in established economic and political organizations responding to disaster and are highly visible in male "first responder" roles		
Women	Caregiver responsibilities	Typically, woman are tasked with the responsibility of caring for children, seniors, and ill/disabled relatives. Domestic responsibilities become more difficult in partially destroyed homes or temporary shelters and expand to include contacts with outside agencies.	
	Tendencies to evacuate	Emergency warnings from local disaster managers are more likely to be found credible by women than by men, and women are more likely to act upon them.	
	Access to resources	Women tend to suffer disproportionately in every stage of disaster response, and their mortality rates have been found to be higher in many disasters.	
		Women often have less access to what disaster managers consider to be key assets for survival and eventual recovery, e.g. diverse income, health and safety, time, information, transportation, language skills, citizenship status and social support.	
	Economic inequality	Women tend to be poorer relative to men and may not have the necessary resources to respond to and recover from disasters. This problem is particularly evident among single mothers, whose poverty rates exceed that of single or married women, and who must not only protect themselves but must also safeguard the lives of their children when threats emerge.	
	Pregnant women	Women who are pregnant face serious risks during a hurricane or flood event such as an increased risk of preterm birth and not having postnatal formula for newborn babies.	
		Increased stress from these events can cause infants to have intrauterine growth restriction, low birth weight, a small head circumference, and even increase the risk of fetal death	
	Employment disruption	Women's employment is more likely to be in low-status jobs or in the informal economy, work subject to fluctuation in the best of times and likely to disappear completely after an event.	
Larger dependence of temporary housing	The last families remaining in the temporary trailers nearly two years after Andrew were large, three-generation households headed by women		
Increase in sexual assault	Woman have a higher risk of experiencing sexual assault and domestic violence during disaster.		
		Enarson, E., & Fordham, A. (2001). Lines that divide, ties that bind: Race, class, and gender in women's flood recovery. Australian Journal of Emergency Management, 15(4), 43- 52. Retrieved from https://www.diversitypreparedness.org/browse-resources/resources/AJEM%20Flood%20women/	
		Morrow, B. H. (2002). Identifying and Mapping Community Vulnerability. Disasters, 23(1), 1-18. doi: 10.1111/1467-7717.00102	
		Enarson, E., & Fordham, A. (2001). Lines that divide, ties that bind: Race, class, and gender in women's flood recovery. Australian Journal of Emergency Management, 15(4), 43- 52. Retrieved from https://www.diversitypreparedness.org/browse-resources/resources/AJEM%20Flood%20women/	
		Enarson, E., & Fordham, A. (2001). Lines that divide, ties that bind: Race, class, and gender in women's flood recovery. Australian Journal of Emergency Management, 15(4), 43- 52. Retrieved from https://www.diversitypreparedness.org/browse-resources/resources/AJEM%20Flood%20women/	
		Donner, W., & Rodríguez, H. (2008). Population composition, migration, and inequality: The influence of demographic changes on disaster risk and vulnerability. Social Forces 87(2), 1089-1114. https://doi.org/10.1353/sof.0.0141	
		Donner, W., & Rodríguez, H. (2008). Population composition, migration, and inequality: The influence of demographic changes on disaster risk and vulnerability. Social Forces 87(2), 1089-1114. https://doi.org/10.1353/sof.0.0141	
		Donner, W., & Rodríguez, H. (2008). Population composition, migration, and inequality: The influence of demographic changes on disaster risk and vulnerability. Social Forces 87(2), 1089-1114. https://doi.org/10.1353/sof.0.0141	
		Enarson, E., & Fordham, A. (2001). Lines that divide, ties that bind: Race, class, and gender in women's flood recovery. Australian Journal of Emergency Management, 15(4), 43- 52. Retrieved from https://www.diversitypreparedness.org/browse-resources/resources/AJEM%20Flood%20women/	
		Peek, L., & Fothergill, A. (2008). Displacement, Gender, and the Challenges of Parenting after Hurricane Katrina. NWSA Journal, 69-105. Retrieved from https://www.uvm.edu/~afotherg/NWSAarticle.pdf	
		Committee on Health Care for Underserved Women. (2010). Preparing for Disasters: Perspectives on Women. Retrieved from https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2010/06/preparing-for-disasters-perspectives-on-women	

	Increase in sex-trafficking	Sex-trafficking increases during natural disasters due to numerous factors, such as disruption of governmental organizations, and difficulty enforcing border patrols. Traffickers can pose as aide workers or offer jobs in order to deceive and entrap their next victims.	Bowersox, Z. (2017). Natural disasters and human trafficking: Do disasters affect state anti-trafficking performance. <i>International Migration</i> , 56(1), 196-212. doi:10.1111/imig.12374 Bowersox, Z. (2017). Natural disasters and human trafficking: Do disasters affect state anti-trafficking performance. <i>International Migration</i> , 56(1), 196-212. doi:10.1111/imig.12375
LGBTQ+	Afraid to seek shelter	LGBTQ+ populations may not seek shelter because of fears of discrimination and being mistreated.	National Center for Transgender Equality. (2013). Hurricane preparedness: Info for trans people. Retrieved from https://transequality.org/issues/resources/hurricane-preparedness-info-trans-people
	Difficulty in communicating with isolated/homeless population	LGBTQ+ seniors are more likely to be isolated, and are less likely to have children or other family compared to other seniors; therefore they may need additional assistance in receiving emergency messages and accessing resources.	Compton, J. (2017, September 6). Deadly Hurricane Exposes Dangers of Being LGBTQ and Homeless. Retrieved from NBC News: https://www.nbcnews.com/feature/nbc-out/hurricane-harvey-exposes-dangers-being-lgbtq-homeless-n799126 National LGBT Health Education Center. (n.d.). Emergency Preparedness and Lesbian, Gay, Bisexual & Transgender (LGBT) People: What Health Centers Need to Know. Retrieved from https://www.lgbthealtheducation.org/wp-content/uploads/Emergency-Preparedness-for-LGBT-People-Final.pdf
	Relationships may not be legally recognized	Because many LGBTQ+ couples and families are not able to have legally recognized relationships, first responders may not recognize these relationships.	National LGBT Health Education Center. (n.d.). Emergency Preparedness and Lesbian, Gay, Bisexual & Transgender (LGBT) People: What Health Centers Need to Know. Retrieved from https://www.lgbthealtheducation.org/wp-content/uploads/Emergency-Preparedness-for-LGBT-People-Final.pdf
	Stigmas	Stigmas exist around the LGBTQ+ populations and are sometimes blamed for natural disasters by religious groups.	Pasha-Robinson, L. (2017, September 6). Gay people to blame for Hurricane Harvey, say evangelical Christian leaders. Retrieved from The Independent: https://www.independent.co.uk/news/world/americas/gay-people-hurricane-harvey-blame-christian-leaders-texas-flooding-homosexuals-lgbt-a7933026.html
	Access to medications	Many of the LGBTQ+ population are using hormone therapy, and access to medication may become difficult during storms.	National LGBT Health Education Center. (n.d.). Emergency Preparedness and Lesbian, Gay, Bisexual & Transgender (LGBT) People: What Health Centers Need to Know. Retrieved from https://www.lgbthealtheducation.org/wp-content/uploads/Emergency-Preparedness-for-LGBT-People-Final.pdf
Single-Parent	Mental and financial stress	As a single-parent there is additional mental and financially stress due to typically only having one income as well as being the primary caregiver for children whose dependencies increases. Preparation, response and recovery all becomes more difficult. Children may require additional resources including diapers, formula, and baby food. It now takes at least two wage earners to provide a middle-class standard of living. Single-parent families, particularly when headed by women, are likely to live on the economic margins. Similarly, the rising cost of raising children has put extra burdens on large families. Families with many dependents — children, elderly or disabled members — are likely to encounter greater obstacles when responding to an emergency. Veterans already experience comorbidities with mental health and disability from the nature of their jobs as soldiers (Trivedi et al., 2015). During an emergency like a hurricane or flood, this is only exacerbated, and researchers have observed higher rates of PTSD after these events.	Expert Opinion, Elizabeth Dunn, MPH, CPH Tobin-Gurley, J., & Enarson, E. (2013). Gender. In D. S. Thomas, B. D. Phillips, W. E. Lovekamp, & A. Fothergill, <i>Social Vulnerability to Disasters</i> (pp. 139-166). Boca Raton: Taylor & Francis. Morrow, B. H. (2002). Identifying and Mapping Community Vulnerability. <i>Disasters</i> , 23(1), 1-18. doi: 10.1111/1467-7717.00102
Veterans			Constans, J. I., Vasterling, J. J., Deitch, E., Han, X., Teten Tharp, A. L., & Davis, T. D. (2012). Pre-Katrina Mental Illness, Postdisaster Negative Cognitions, and PTSD Symptoms in Male Veterans Following Hurricane Katrina. <i>Psychological Trauma: Theory, Research, Practice, Policy</i> , 4(6), 568-577.

	PTSD	PTSD is post-traumatic stress disorder that causes anxiety and flashbacks triggered by a traumatic event. The condition may last months or years, with triggers that can bring back memories of the trauma accompanied by intense emotional and physical reactions.	Constans, J. I., Vasterling, J. J., Deitch, E., Han, X., Teten Tharp, A. L., & Davis, T. D. (2012). Pre-Katrina Mental Illness, Postdisaster Negative Cognitions, and PTSD Symptoms in Male Veterans Following Hurricane Katrina. <i>Psychological Trauma: Theory, Research, Practice, Policy</i> , 4(6), 568-577.
Pet Owners	Evacuation failure	The most significant risk factor for evacuation failure is pet ownership, particularly in people who do not have children. Also, the more pets someone owns, the higher the risk of evacuation failure.	Chadwin, R. (2017). Evacuation of pets during disasters: A public health intervention to increase resilience. <i>American Journal of Public Health</i> , 107, 1413-1317. Retrieved from https://doi.org/10.2105/ajph.2017.303877
	Re-entry into unsafe zones to rescue pet	Pet owners may attempt to re-enter evacuation sites illegally to rescue their animals.	Glasse, S. (2018). Did Harvey Learn from Katrina? Initial Observations of the Response to Companion Animals during Hurricane Harvey. <i>Animals</i> , 8(4), 1-9.
	Understaffed medical facilities	Health care workers may refuse to work if their animals are in danger, leaving medical facilities understaffed during crises	Chadwin, R. (2017). Evacuation of pets during disasters: A public health intervention to increase resilience. <i>American Journal of Public Health</i> , 107, 1413-1317. Retrieved from https://doi.org/10.2105/ajph.2017.303877
	Ability to find shelters that take pets	According to a 2017-2018 survey conducted by the American Pet Product Association 68% of all U.S. households own pets. The majority of those households own at least one dog and/or cat. Using these estimates paired along with the U.S. Census 2010-2017 data, there are potentially over 340,000 households in Hillsborough County that own one or more pets. In addition to that population, local animal shelters, such as the Pet Resource Center and Humane Society of Tampa Bay report thousands to tens of thousand more animals living in local animal shelters.	Chadwin, R. (2017). Evacuation of pets during disasters: A public health intervention to increase resilience. <i>American Journal of Public Health</i> , 107, 1413-1317. Retrieved from https://doi.org/10.2105/ajph.2017.303877
	Companion pets being displaced or left behind	Losing a pet can significantly alter mental wellbeing, leading to stress, grief, and depression. This may be especially true when owners are forced to abandon their pets in an emergency and are later overcome with guilt and grief.	Centers for Disease Control and Prevention [CDC]. (2018). Pet safety in emergencies. Retrieved from https://www.cdc.gov/healthypets/emergencies/index.html
Tourists	Unfamiliar with the regional issues	Tourist populations may not have the local knowledge of preparedness and of evacuation procedures. Population stability and being 'of a place' are shown to create resiliency.	Hillsborough County. Emergency Management. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/emergency-shelters
	No mitigation or preparedness for flooding		Chadwin, R. (2017). Evacuation of pets during disasters: A public health intervention to increase resilience. <i>American Journal of Public Health</i> , 107, 1413-1317. Retrieved from https://doi.org/10.2105/ajph.2017.303877
	Lack of support systems	Tourists are unlikely to have family and relatives within the travel destination leaving them without a support system and tourists are also likely unaware of formal support system services.	Cutter, S., Ash, K. D., & Emrich, C. T. (2014). The Geographies of Community Disaster Resilience. <i>Global Environmental Change</i> , 65-77. doi: /10.1016/j.gloenvcha.2014.08.005
New Residents	Unfamiliar with the regional issues	New residents may not have the local knowledge of preparedness and of evacuation procedures. Population stability and being 'of a place' are shown to create resiliency.	Cahyanto, I., & Pennington-Gray, L. (2015). Communicating Hurricane Evacuation to Tourists: Gender, Past Experience with Hurricanes, and Place of Residence. <i>Journal of Travel Research</i> 54(3), 329-343. doi: 10.1177/0047287513517418
	Lack of support systems	New residents may not have family and relatives within the area, leaving them without a support system and may be unaware of formal support system services.	Cahyanto, I., & Pennington-Gray, L. (2015). Communicating Hurricane Evacuation to Tourists: Gender, Past Experience with Hurricanes, and Place of Residence. <i>Journal of Travel Research</i> 54(3), 329-343. doi: 10.1177/0047287513517418
Flood Related Occupations	Increased exposure to risks	Working in specific fields may increase risk to hazards and vectors (i.e., snake bites, rabid animals, rodents)	Cutter, S., Ash, K. D., & Emrich, C. T. (2014). The Geographies of Community Disaster Resilience. <i>Global Environmental Change</i> , 65-77. doi: /10.1016/j.gloenvcha.2014.08.005
People whose Livelihoods Depend on the Coast		People who rely on the coast for their living; people who work on the coast, have restaurant and businesses that act as community centers. population in urban areas, resulting in increasing population concentration in coastal communities and flood prone areas. Urban sprawl is affecting escape routes, dense infrastructure, congestion, and poverty.	National Institute for Occupational Safety and Health. (n.d.). Hazards of flood clean up work. Retrieved from http://www.ct.gov/agingservices/lib/agingservices/pdf/hazardsoffloodcleanupwork.pdf
			Colburn, L., & Jepson, M. (2012). Social indicators of gentrification pressure in fishing communities: a context for social impact assessment. <i>Coastal Management</i> . Retrieved from https://doi.org/10.1080/08920753.2012.677635
			Donner, W., & Rodríguez, H. (2008). Population composition, migration, and inequality: The influence of demographic changes on disaster risk and vulnerability. <i>Social Forces</i> 87(2), 1089-1114. https://doi.org/10.1353/sof.0.0141

Age 17 or Younger

Coastal population are the most at-risk

School disruption

Failing to stabilize the systems of care in people's lives will likely have long-term consequences. Parents' mental health issues, such as untreated depression, have been shown to increase the risk of mental health disability among children, many of whom are traumatized and already psychologically vulnerable; the lack of sufficient school-based services and capacity, as well as students own lack of attendance, will likely lead to diminished academic performance and advancement, further limiting their economic opportunities; and social isolation may lead to increased risk behaviors such as drug use, which in turn increases the hazards of communicable disease, crime, and incarceration. School disruption is a huge issue for children. After a flood or hurricane, schools can be damaged and/or experience delays in re-opening because they were used as evacuation shelters. [6 months after Hurricane Katrina the majority of public schools in the New Orleans area were still closed \(20/118 reopened; 9,500/60,000 students\).](#)

[After hurricane Andrew, "school enrollments went down anywhere from 30 to 50% in these schools after the storm due to families being displaced by destroyed homes" or job locations being closed rather than repaired and re-opened and it was several years before enrollments reached 1992 levels.](#)

Lower Academic Performance

Schools with even small damages can take up to 3 or 4 years to stabilize education due to students may not attend school as frequently and/or may perform more poorly in school.

Damaged Schools

"double shifts were held in order to handle both student bodies" due to the overcrowding of schools. This gives less attention to each child compared to prior to the event. Physical Damage to Schools forced students to be relocated to other locations until they were repaired, or students left the school indefinitely.

Delay in reopening schools can cause economic stress

If there is no alternative child care, the child's parents may be prevented from returning to work, thereby creating economic stress.

Separation from caregiver

Children may be more vulnerable after a disaster. They rely on caregivers, who may be unprepared or overwhelmed. Very young children may not be able to communicate necessary information if they become separated from their caregivers.

Damaged Health Facilities

Disaster and non disaster related injuries or illnesses become unable to be treated.

Greater health impacts

Children breathe more air per pound of body weight than adults do, and their bodies contain less fluid, making them more susceptible to dehydration.

Children can be at a point in their development where health problems today can have long-term consequences. Children may have greater trouble processing emotional trauma.

Increased risk of childhood injury and parental violence against children during flooding events

Injuries are the leading cause of death in post-infancy children.

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from

<https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

Abramson, D. P., & Garfield, R. R. (2006). On the Edge: Children and Families Displaced by Hurricanes Katrina and Rita Face a Looming Medical and Mental Health Crisis. New York: Columbia University Mailman School of Public Health. Retrieved from file:///P:/CDR-Files/PROJECTS/6100%20FLOOD/RESOURCES/RESEARCH_PUBLICATIONS/VULNERABILITIES/PUBLIC%20HEALTH/Abramson_Louisiana%20on%20the%20Edge.pdf

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Edny, H. T., & Prince, Z. (March 30, 2006). New Orleans residents ponder their future, Katrina series- Part 8 [periodical]. New York Beacon; New York: NY. pp.6, 33. Retrieved from <http://www.districtchronicles.com/news/view.php/424833/New-Orleans-residents-ponder-their-future>

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Kousky, C. (2016). Impacts of Natural Disasters on Children. *Future of Children*, 26(1), 73-92. doi: 10.1353/foc.2016.0004

Peek, L., & Fothergill, A. (2008). Displacement, Gender, and the Challenges of Parenting after Hurricane Katrina. *NWSA Journal*, 20(3), 69-105.

Dash, N., Morrow, B. H., Mainster, J., & Cunningham, L. (2007). Lasting Effects of Hurricane Andrew on a Working-Class Community . *Natural Hazards Review*, 8(1), 13-21.

Kousky, C. (2016). Impacts of Natural Disasters on Children. *Future of Children*, 26(1), 73-92. doi: 10.1353/foc.2016.0004

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Younger children require additional resources
 Younger children require additional resources such as formula, diapers, and baby food.

Reduced intake of nutrients
 Reduction of calorie intake, essential vitamins and nutrients, and clean drinking water. Loss of school time; some children dependent on school for healthy, hot meals now unable to get access to that food.
 Schools sometimes are a child's source of healthy options and hot meals, so when schools are lost or disrupted, this further reduces children's access to nutrients.

Heightened stress, fear, anxiety, inability to cope, and exaggerated response
 PTSD
 All of these responses can manifest as developmental regression, withdrawal, clinginess, tantrums, enuresis, or somatic complaints, among other symptoms.

PTSD is post-traumatic stress disorder that causes anxiety and flashbacks triggered by a traumatic event. The condition may last months or years, with triggers that can bring back memories of the trauma accompanied by intense emotional and physical reactions.
 Girls are more likely to experience prolonged PTSD.

Over 65

Higher mortality rates
 75 year olds and higher were significantly more likely of being a disaster victim with disproportionate deaths among blacks.

71% deaths were 61 years and higher which included deaths in nursing homes.

More susceptible to foodborne illness and infectious disease
 Older persons are more susceptible to foodborne illness because they typically have lowered immune systems, which can sometimes be caused by medications that need to be taken.

Compromised medications
 Some medications go bad without refrigeration, or can be compromised when exposed to unclean floodwaters. It is recommended to have a supply of 7 days worth of needed medications.

More susceptible to heat stress/stroke

Peek, L., & Fothergill, A. (2008). Displacement, Gender, and the Challenges of Parenting after Hurricane Katrina. *NWSA Journal*, 20(3), 69-105.

Stough, L. M., Villarreal, E., & Castillo, L. G. (2010). Disaster and social vulnerability: The case of undocumented Mexican migrant workers. In J. D. Rivera and D. S. Miller (Eds.), *Minority resiliency and the legacy of disaster* (pp. 297-315). New York: Edwin Mellen. Retrieved from <https://oaktrust.library.tamu.edu/bitstream/handle/1969.1/153543/Disaster%20and%20social%20vulnerability-The%20case%20of%20undocumented%20Mexican%20migrant%20workers.pdf?sequence=1>

Kousky, C. (2016). Impacts of Natural Disasters on Children. *Future of Children*, 26(1), 73-92. doi: 10.1353/foc.2016.0004

Kousky, C. (2016). Impacts of Natural Disasters on Children. *Future of Children*, 26(1), 73-92. doi: 10.1353/foc.2016.0004

Kousky, C. (2016). Impacts of Natural Disasters on Children. *Future of Children*, 26(1), 73-92. doi: 10.1353/foc.2016.0004

Needle, S., & Wright, J. (2015, November 01). Ensuring the Health of Children in Disasters. Retrieved from <http://pediatrics.aappublications.org/content/136/5/e1407>

Weems, C., Taylor, L., Cannon, M., Marino, R., Romano, D., Scott, B., Perry, A., & Triplett, V. (2010). Post-Traumatic Stress, Context, and the Lingering Effects of the Hurricane Katrina Disaster among Ethnic Minority Youth. *J Abnorm Child Psychology*, 38, 49-56.

Weems, C., Taylor, L., Cannon, M., Marino, R., Romano, D., Scott, B., Perry, A., & Triplett, V. (2010). Post-Traumatic Stress, Context, and the Lingering Effects of the Hurricane Katrina Disaster among Ethnic Minority Youth. *J Abnorm Child Psychology*, 38, 49-56.

Brunkard, J., Namulanda, G., & Ratard, R. (2013). Hurricane Katrina Deaths, Louisiana, 2005. *Disaster Medicine and Public Health Preparedness*, 2(4), 215-223.

Brunkard, J., Namulanda, G., & Ratard, R. (2013). Hurricane Katrina Deaths, Louisiana, 2005. *Disaster Medicine and Public Health Preparedness*, 2(4), 215-223.

United States Federal Drug Administration. (2011). Food safety for older adults. Retrieved from <https://www.fda.gov/Food/FoodbornellnessContaminants/PeopleAtRisk/ucm312705.htm>

United States Federal Drug Administration. (2017). Emergency preparedness: Safe drug use after a natural disaster. Retrieved from <https://www.fda.gov/Drugs/EmergencyPreparedness/ucm085200.htm>

American Red Cross. (2019). Disaster preparedness: For seniors by seniors. Retrieved from https://www.redcross.org/content/dam/redcross/atg/PDF_s/Preparedness__Disaster_Recovery/Disaster_Preparedness/Disaster_Preparedness_for_Srs-English.revised_7-09.pdf

CDC. (2017, June 19). Natural Disasters and Severe Weather. Retrieved from <https://www.cdc.gov/disasters/extremeheat/medical.html>

More susceptible to infectious disease			Rhoades, J., Gruber, J. & Horton, B. (2013). Developing an In-Depth Understanding of Elderly Adult's Vulnerability to Climate Change. <i>The Gerontologist</i> , 58(3), 567-577.
Difficult outreach and communication	Advertising and outreach campaigns occur more over social media, and older populations are not able to navigate as easily as others		Expert opinion- Elizabeth Dunn's mother who runs several assisted living facilities.
Lack of support system/social exclusion/isolation	Less likely to receive warnings, react to threats, and recover from disaster without a support system or caregiver.		Rhoades, J., Gruber, J. & Horton, B. (2013). Developing an In-Depth Understanding of Elderly Adult's Vulnerability to Climate Change. <i>The Gerontologist</i> , 58(3), 567-577.
Mobility issues	Populations over the age of 65 typically have mobility issues due to decreased physical ability and the dependency on walkers and wheelchairs. Mobility problems compounded with other barriers, make the elderly particularly at risk for death or injury from disasters.		Peek, L., & Fothergill, A. (2008). Displacement, Gender, and the Challenges of Parenting after Hurricane Katrina. <i>NWSA Journal</i> , 20(3), 69-105.
Potential cognitive decline	Alzheimer's and other cognitive impairments can present challenges throughout the hazard life cycle, making it difficult for elders to receive and comprehend warnings, take needed steps to protect themselves, and navigate potentially complex recovery processes.		Rhoades, J., Gruber, J. & Horton, B. (2013). Developing an In-Depth Understanding of Elderly Adult's Vulnerability to Climate Change. <i>The Gerontologist</i> , 58(3), 567-577.
Hearing Impairments	Poor hearing can make it difficult to hear and comprehend warnings making elderly individuals dependent on the support of caregivers, leaving them at heightened risk during events.		Rhoades, J., Gruber, J. & Horton, B. (2013). Developing an In-Depth Understanding of Elderly Adult's Vulnerability to Climate Change. <i>The Gerontologist</i> , 58(3), 567-577.
Fixed/low Income	Lack of employment and living on a low or fixed income can reduce adaptive capacity. As a result, elders may lack the money needed to gather emergency supplies and make preparations to be able to safely take shelter at home in a storm or other emergency. They may also be unable to pay for alternative shelter in an emergency or conduct repairs or clean up after a storm or flood.		Rhoades, J., Gruber, J. & Horton, B. (2013). Developing an In-Depth Understanding of Elderly Adult's Vulnerability to Climate Change. <i>The Gerontologist</i> , 58(3), 567-577.
Limited Understanding of language / lack of formal education	Individuals with a limited command of the English language can face difficulties receiving warnings of impending severe weather, taking steps to protect themselves, and receiving needed support as part of the recovery process.		Rhoades, J., Gruber, J. & Horton, B. (2013). Developing an In-Depth Understanding of Elderly Adult's Vulnerability to Climate Change. <i>The Gerontologist</i> , 58(3), 567-577.
Dependency on public transit	Adequate transportation resources are vital for elderly individuals to gather resources to prepare for climate-related stressors, seek safe shelter away from home, and access resources and services to aid in their recovery. Many of the personal characteristics described previously, including certain disabilities, diminished sensory awareness, and financial limitations, can make it difficult for elderly individuals to drive or own a car. As a result, many elderly adults are dependent on public transportation for meeting these needs.		Rhoades, J., Gruber, J. & Horton, B. (2013). Developing an In-Depth Understanding of Elderly Adult's Vulnerability to Climate Change. <i>The Gerontologist</i> , 58(3), 567-577. Rhoades, J., Gruber, J. & Horton, B. (2013). Developing an In-Depth Understanding of Elderly Adult's Vulnerability to Climate Change. <i>The Gerontologist</i> , 58(3), 567-577.

Minority Status and Language

Limited English Proficiency (LEP)

Communication	Those with language barriers may have less access to warning information or experience more difficulties navigating recovery programs. Current preparedness training for health care workers does not include medical interpreters.	Blazer, J., & Murphy, B. (2008). Addressing the needs of immigrants and limited English communities in disaster planning and relief. <i>National Immigration Law Center</i> , 22(8), 1-11. Shiu-Thornton, S. P. (2008). A Culturally Competent Preparedness Model for Researching Limited English Proficient (LEP) Communities. University of Washington School of Public Health and Community Medicine. Retrieved from http://www.presentica.com/ppt-presentation/a-culturally-competent-preparedness-model-for-researching-limited-english-proficient-lep-communities
	Barriers in communication between LEP groups and first responders/care providers	Shiu-Thornton, S. P. (2008). A Culturally Competent Preparedness Model for Researching Limited English Proficient (LEP) Communities. University of Washington School of Public Health and Community Medicine. Retrieved from http://www.presentica.com/ppt-presentation/a-culturally-competent-preparedness-model-for-researching-limited-english-proficient-lep-communities

Undocumented Residents

	Due to their social and economic status, undocumented immigrants are particularly at risk not only for being affected by a disaster, but also for encountering difficulties during the response and relief phases of a disaster. As a result, they experience disproportionately adverse consequences.	Stough, L. M., Villarreal, E., & Castillo, L. G. (2010). Disaster and social vulnerability: The case of undocumented Mexican migrant workers. In J. D. Rivera and D. S. Miller (Eds.), <i>Minority resiliency and the legacy of disaster</i> (pp. 297-315). New York: Edwin Mellen. Retrieved from https://oaktrust.library.tamu.edu/bitstream/handle/1969.1/153543/Disaster%20and%20social%20vulnerability-The%20case%20of%20undocumented%20Mexican%20migrant%20workers.pdf?sequence=1
Low income	As of 2007, undocumented workers between the ages 18-39 constitute more than 12.4% of the nations workforce and typically work in areas along the coast and prone to natural disasters, Arizona, California, Texas, and Florida. There jobs are typically low-wage services, manufacturing, and agriculture based.	Stough, L. M., Villarreal, E., & Castillo, L. G. (2010). Disaster and social vulnerability: The case of undocumented Mexican migrant workers. In J. D. Rivera and D. S. Miller (Eds.), <i>Minority resiliency and the legacy of disaster</i> (pp. 297-315). New York: Edwin Mellen. Retrieved from https://oaktrust.library.tamu.edu/bitstream/handle/1969.1/153543/Disaster%20and%20social%20vulnerability-The%20case%20of%20undocumented%20Mexican%20migrant%20workers.pdf?sequence=1
Exploitative labor practices	Following Katrina, massive reconstruction efforts took place throughout the affected regions of Louisiana, thus increasing the demand for low-cost labor. Many construction workers that came to assist were undocumented immigrants, which are highly vulnerable to exploitative labor practices.	Stough, L. M., Villarreal, E., & Castillo, L. G. (2010). Disaster and social vulnerability: The case of undocumented Mexican migrant workers. In J. D. Rivera and D. S. Miller (Eds.), <i>Minority resiliency and the legacy of disaster</i> (pp. 297-315). New York: Edwin Mellen. Retrieved from https://oaktrust.library.tamu.edu/bitstream/handle/1969.1/153543/Disaster%20and%20social%20vulnerability-The%20case%20of%20undocumented%20Mexican%20migrant%20workers.pdf?sequence=1
Misconceptions/communication	Mixed messages from government officials, language and cultural barriers, complicated rules about immigrant eligibility for public benefits, and a generalized climate of fear due to harsh enforcement policies at the federal and state levels all combine to make it very difficult for low- income immigrant hurricane survivors to obtain relief assistance from private and government relief agencies.	Grantmakers Concerned with Immigrants and Refugees. (2017). The impact of natural disasters on immigrants and refugees in the United States: What funders need to know in the immediate term. Retrieved from https://www.gcir.org/sites/default/files/resources/GCIR-Impact-Natural-Disasters-on-Immigrants-Brief.pdf
Fear of seeking help/stigmas	Undocumented residents may not seek assistance or shelter because of stigmas and fear of being mistreated by documented residents/citizens.	Stough, L. M., Villarreal, E., & Castillo, L. G. (2010). Disaster and social vulnerability: The case of undocumented Mexican migrant workers. In J. D. Rivera and D. S. Miller (Eds.), <i>Minority resiliency and the legacy of disaster</i> (pp. 297-315). New York: Edwin Mellen. Retrieved from https://oaktrust.library.tamu.edu/bitstream/handle/1969.1/153543/Disaster%20and%20social%20vulnerability-The%20case%20of%20undocumented%20Mexican%20migrant%20workers.pdf?sequence=1
Access to financial assistance		FEMA. (2004, June 17). Questions and Answers for Undocumented Immigrants Regarding FEMA Assistance. Retrieved from https://www.fema.gov/news-release/2004/06/17/questions-and-answers-undocumented-immigrants-regarding-fema-assistance
U.S. citizen child	Fear and confusion around seeking assistance for U.S. citizen children of undocumented residents.	FEMA. (2004, June 17). Questions and Answers for Undocumented Immigrants Regarding FEMA Assistance. Retrieved from https://www.fema.gov/news-release/2004/06/17/questions-and-answers-undocumented-immigrants-regarding-fema-assistance
Connection to community leaders in cultural pockets	Community-based organizations are often in the best position to meet the specific needs of immigrants and refugees. Some may have experienced damage to their infrastructure, and/or their staff may have been directly affected by the hurricane	Grantmakers Concerned with Immigrants and Refugees. (2017). The impact of natural disasters on immigrants and refugees in the United States: What funders need to know in the immediate term. Retrieved from https://www.gcir.org/sites/default/files/resources/GCIR-Impact-Natural-Disasters-on-Immigrants-Brief.pdf

Minorities	Preparedness	There was a significant association between race/ethnicity and self-reported preparedness level with white respondents reporting the highest percentage of being "very prepared."	Stough, L. M., Villarreal, E., & Castillo, L. G. (2010). Disaster and social vulnerability: The case of undocumented Mexican migrant workers. In J. D. Rivera and D. S. Miller (Eds.), <i>Minority resiliency and the legacy of disaster</i> (pp. 297-315). New York: Edwin Mellen. Retrieved from https://oaktrust.library.tamu.edu/bitstream/handle/1969.1/153543/Disaster%20and%20social%20vulnerability-The%20case%20of%20undocumented%20Mexican%20migrant%20workers.pdf?sequence=1
	Higher mortality rates	Mortality rates tend to be higher among minorities.	Bethel, J. W., Burke, S. C., & Britt, A. F. (2013). Disparity in disaster preparedness between racial/ethnic groups. <i>Disaster Health</i> , 1(2), 110-116. doi: 10.4161/dish.27085.
	Dependency on friends and family as sources of disaster preparation information Distrust in authorities	Latino homeowners prefer to utilize friends and family as sources of disaster preparation information. There is a long history of minority groups in the United States distrusting the medical and public health leadership. The level of a community's distrust will be partially buffered based on the extent to which authorities display competency, fairness, empathy, honesty, and openness prior to a disaster. Racial/ethnic minority groups are less likely to have medication supplies but only Spanish-speaking Hispanics were less likely to have an emergency evacuation plan than white respondents. Voting precincts were unavailable after a disaster in heavily in black neighborhoods, due to hurricane damage.	Peguero, A. A. (2006). Latino Disaster Vulnerability: The Dissemination of Hurricane Mitigation Information Among Florida's Homeowners. <i>Hispanic Journal of Behavioral Sciences</i> 28(1), 5-22. Cordasco, K. M., Eisenman, D. C., Golden, J. F., & Asch, S. M. (2007). They Blew the Levee: Distrust of Authorities Among Hurricane Katrina Evacuees. <i>Journal of Health Care for the Poor and Underserved</i> , 18(2), 277-282.
Refugees/Immigrants	Mental Health and re-traumatization		Bethel, J. W., Burke, S. C., & Britt, A. F. (2013). Disparity in disaster preparedness between racial/ethnic groups. <i>Disaster Health</i> , 1(2), 110-116. doi: 10.4161/dish.27085. Edny, H. T., & Prince, Z. (March 30, 2006). New Orleans residents ponder their future, Katrina series- Part 8 [periodical]. New York Beacon; New York: NY. pp.6, 33. Grantmakers Concerned with Immigrants and Refugees. (2017). The impact of natural disasters on immigrants and refugees in the United States: What funders need to know in the immediate term. Retrieved from https://www.gcir.org/sites/default/files/resources/GCIR-Impact-Natural-Disasters-on-Immigrants-Brief.pdf
	Unfamiliar with the regional issues	In some refugees/immigrant populations, it may be their first hurricane or flood event and they may not have the local knowledge of preparedness and of evacuation procedures.	Lutheran Immigration and Refugee Service. (n.d.). Disaster Preparedness in Migrant Communities: A manual for First Responders. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&cad=rja&uact=8&ved=2ahUKEwj-kq3i6ufdAhWB1IMKHY0HBJQQFjACegQIBxAC&url=https%3A%2F%2Fwww.lcms.org%2Fdocument.fdoc%3Fsrc%3Dlcm%26id%3D4789&usg=AOvVaw3ul5lpY_ZXSx3mQKCuATZT Elizabeth Dunn, Expert opinion
	Lack of communication occurring to refugee community leaders Misconceptions/communication Higher risk of exploitation		Grantmakers Concerned with Immigrants and Refugees. (2017). The impact of natural disasters on immigrants and refugees in the United States: What funders need to know in the immediate term. Retrieved from https://www.gcir.org/sites/default/files/resources/GCIR-Impact-Natural-Disasters-on-Immigrants-Brief.pdf
People with Low Literacy Levels		People with low literacy levels face increased barriers in filling out and reading forms related to warnings and government issues. The lack of plain language in published information about evacuation and preparation exacerbates this disparity.	Rowel, R. P., Sheikhattari, P. M., Barber, T. M., & Evans-Holland, M. D. (2010). A Guide to Enhance Grassroots Risk Communication Among Low-Income Populations. Maryland Department of Health and Mental Hygiene. Retrieved from http://diversitypreparedness.org/~media/Files/diversitypreparedness/GUIDE%20TO%20Enhance%20GRC%20Updated%20Feb%2018%202010.ashx?la=en

More than 20% of the U.S. population struggles with literacy, and the Organization for Economic Cooperation and Development [OECD] found that 50 percent of U.S. adults cannot read a book written at an eighth-grade level

Rowel, R. P., Sheikhattari, P. M., Barber, T. M., & Evans-Holland, M. D. (2010). A Guide to Enhance Grassroots Risk Communication Among Low-Income Populations. Maryland Department of Health and Mental Hygiene. Retrieved from <http://diversitypreparedness.org/~media/Files/diversitypreparedness/GUIDE%20TO%20Enhance%20GRC%20Updated%20Feb%2018%202010.ashx?la=en>

Organization for Economic Cooperation and Development. (2012). Survey of adult skills first results. Retrieved from <https://www.oecd.org/skills/piaac/Country%20note%20-%20United%20States.pdf>

Housing and Transportation

People in Mobile Homes

Populations living in mobile homes are more vulnerable due to the structures not being properly anchored to the ground. If structures are damaged or destroyed, there is a gap in providing a home post disaster.

Cutter, S. L., Mitchell, J. T., & Scott, M. S. (2000). Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. *Annals of the Association of American Geographers*, 90(4), 713-737. doi: 10.1111/0004-5608.00219

People in Nursing Homes

Nursing Homes and hospice facilities are more dependent than others on power/electricity and in some cases loss of power from a storm event can last for several weeks.

Laditka, S. B., Laditka, J. N., Xirasagar, S., Cornman, C. B., Davis, C. B., & Richter, J. V. (2008). Providing Shelter to Nursing Home Evacuees in Disasters: Lessons From Hurricane Katrina. *American Journal of Public Health*, 98(7), 1288-1293.

Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from <https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015>

4,403 nursing homes, or 10.8% were within a flood hazard zone, which represents 162,114 beds at greater risk to flooding.

Florida Health Finder. (n.d.). Facility/Provider Locator. Retrieved from Florida Health Finder:

<http://www.floridahealthfinder.gov/facilitylocator/FacilitySearch.aspx>

Children in Foster Care

In Hillsborough County, there are 2,491 children in foster care as of August 2018.

Florida Department of Children and Families. (2018, November 14). Children in Out-of-Home Care - Statewide. Retrieved from

<http://www.dcf.state.fl.us/programs/childwelfare/dashboard/c-in-ooh.shtml>

Living Near Hazardous Sites Health issues

Flooding can spread toxic chemicals that may affect one's health. The disposal of wastes in landfill sites has increasingly caused concern about possible adverse health effects for populations living nearby, particularly in relation to those sites where hazardous waste is dumped.

Vrijheid, M. (2000). Health effects of residence near hazardous waste landfill sites: A review of epidemiologic literature. *Environmental Health Perspectives*, 108, 101-112. Retrieved from <https://doi.org/10.2307/3454635>

Lack of Vehicle Access

Vehicle ownership

Transportation out of an evacuation zone is problematic for people who do not have access to a vehicle.

Bullard, R. D. (2008). Differential vulnerabilities: Environmental and economic inequality and government response to unnatural disasters. *Social Research*, 75(3), 753-784.

Bullard, R. D. (2008). Differential vulnerabilities: Environmental and economic inequality and government response to unnatural disasters. *Social Research*, 75(3), 753-784. Expert Opinion, Elizabeth Dunn, MPH, CPH

Populations are more reliant on public transit, which may be disrupted or not in service before, during and after an event.

Expert Opinion, Elizabeth Dunn, MPH, CPH

More dependence of shelters

Significant coordination is required in reaching this population during an event. Without a vehicle, this population relies on public transit to gather supplies and will depend more on shelters due to the inability/difficulty to evacuate.

Paratransit

"The Sunshine Line provides door-to-door transportation and bus passes for elderly, low-income, and disabled persons in need of transportation."

Hillsborough County. (2019, August 5). Sunshine Line. Retrieved from <https://www.hillsboroughcounty.org/government/departments/sunshine-line>

People with Well Systems	Physical damage	Coarse sediment in flood waters could erode pump components. If the well is not tightly capped, sediment, debris, and flood water could enter the well and contaminate it. Wells that are more than ten years old or less than 50 feet deep are likely to be contaminated, even if there is no apparent damage. Floods or heavy debris may cause some wells to collapse.	Water Systems Council. (2018). Emergencies and disasters and wells. Retrieved from https://www.watersystemscouncil.org/download/wellcare_information_sheets/maintaining_your_well_information_sheets/EmergenciesDisasters_FINAL-update-9.2018.pdf
Incarcerated		Prisoners face more obstacles to recovery as well, as their survival depends entirely on the institution they are incarcerated in. Prisoners add another complex layer to an already vulnerable population as they need to have constant monitoring as prisoners	Prisoners were blown over during hurricane harvey and hurricane irma. (2017, Sep 18). University Wire Retrieved from https://search.proquest.com/docview/1942383657?accountid=14745
	Access to personal needs	After Hurricane Harvey, water was shut-off and inmates began preserving the toilet water as drinking water and instead relieved themselves into containers.	Prisoners were blown over during hurricane harvey and hurricane irma. (2017, Sep 18). University Wire Retrieved from https://search.proquest.com/docview/1942383657?accountid=14746
	Difficult to evacuate and/or transfer	Evacuating prisoners poses a vast amount of logistical issues in terms of security and protection. There have been many past mishaps in terms of not evacuating flooded prisons that created long-term negative health outcomes of those who were trapped in flooding jails.	Bohatch, E. (2018, September 11). SC officials won't evacuate medium-security prison despite mandatory order. The State. Retrieved from https://www.thestate.com/news/state/south-carolina/article218179005.html
		During Hurricane Irma, 4,500 people were left in correctional institutions in Miami-Dade County. Cells were covered in mold, feces, and urine. During Hurricane Harvey, 4 county jails evacuated and suffered structural damage despite being built to resist most severe hurricanes.	Dolnick, S. (2012, November 11). As storm raged, 15 fled New Jersey halfway house. The New York Times. Retrieved from https://www.nytimes.com/2012/11/12/nyregion/15-inmates-escaped-from-new-jersey-halfway-house-during-hurricane-sandy.html
Renters	Emergency housing needs	According to Escambia County's (Florida) Long Term Recovery plan from Hurricane Ivan, renters comprised the majority of applicants for emergency housing assistance from FEMA.	Rannard, G. (2018, September 13). Hurricane Florence: Prisons in hurricane's path not evacuated. BBC News. Retrieved from https://www.bbc.com/news/world-us-canada-45509303
	More likely a part of SES populations	The occupants of rental housing are more likely than homeowners to have characteristics such as low income, minority status, and lack of attachment to their community that previous research has associated with limited preparedness for disasters.	Rannard, G. (2018, September 13). Hurricane Florence: Prisons in hurricane's path not evacuated. BBC News. Retrieved from https://www.bbc.com/news/world-us-canada-45509303
	Lack of mitigation measures	Renters are likely to lack the resources and motivation to invest in mitigation because their dwellings are owned by others and the owners of rental housing are likely to have little motivation to invest in mitigation measures because their cost can be difficult to recover through higher rents.	Burby, R. J., Steinberg, L. J., & Basolo, V. (2003). The Tenure Trap: The Vulnerability of Renters to Joint Natural and Technological Disasters. <i>Urban Affairs Review</i> , 39(1), 32-58. doi: 10.1177/1078087403253053
	Less knowledge on disaster preparedness	Shorter tenure in a location by renters likely means less exposure to public information on preparedness and mitigation, maybe less familiarity with local risks and a smaller social network in the area.	Burby, R. J., Steinberg, L. J., & Basolo, V. (2003). The Tenure Trap: The Vulnerability of Renters to Joint Natural and Technological Disasters. <i>Urban Affairs Review</i> , 39(1), 32-58. doi: 10.1177/1078087403253053
Homes without Flood Insurance		Those who live in homes without flood insurance experience anxiety from a lack of a safety net in case there is a disaster.	Leavenworth, S., & Bland, D. (2018, September 13). Got flood insurance? Thousands of homeowners in Hurricane Florence's path do not. Retrieved from https://pittnews.com/article/135252/uncategorized/florence-threatens-households-without-flood-insurance/
	Financial barriers	Households without flood insurance depend on personal/additional funds for all repairs which can be a significant burden to families that depend on one income or are considered low-income households.	Leavenworth, S., & Bland, D. (2018, September 13). Got flood insurance? Thousands of homeowners in Hurricane Florence's path do not. Retrieved from https://pittnews.com/article/135252/uncategorized/florence-threatens-households-without-flood-insurance/

Pregnant Women	Increased stress and health risks	Women who are pregnant face serious risks during a hurricane or flood event such as an increased risk of preterm birth and not having postnatal formula for newborn babies. Postnatal- formula for babies requires clean water.	Committee on Health Care for Underserved Women. (2010). Preparing for Disasters: Perspectives on Women. Retrieved from https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2010/06/preparing-for-disasters-perspectives-on-women Badakhsh, R., Harville, E., & Banerjee, B. (2010). The childbearing experience during a natural disaster. <i>J. Obstet Gynecol Neonatal Nurs</i> , 39(4), 489-497.
	Birth defects/growth restrictions	Exposure and having to walk through floodwaters increases stress in pregnant woman. Prenatal maternal stress has also been associated with an increased risk for preterm birth and adverse mental health outcomes in child development. Increased stress from these events can cause infants to have intrauterine growth restriction, low birth weight, a small head circumference, and even increase the risk of fetal death	
	Increased risk of complications	The impact of a flood disaster on 47 pregnant women in Poland showed that 55.3% of study participants experienced miscarriage, fetal death, or other adverse outcomes, along with other physical and mental complications that were associated with stress.	
	Distractions from pregnancy	Prior to Hurricane Katrina all the women thought they would be focusing on their pregnancies and manage normal daily stressors. After the storm the women expressed other issues required immediate attention so their pregnancies took the backseat	
	Evacuation	Evacuating from a disaster area meant the women had to establish relationships with new doctors without having access to their medical records: Formula requires clean water source.	
Breastfeeding Women	Access to clean water	Formula requires clean water source.	United States Breastfeeding Committee. (n.d.). Breastfeeding and Emergencies. Retrieved from United States Breastfeeding Committee: http://www.usbreastfeeding.org/emergencies U.S. Department of Health and Human Services. (n.d.). Responding to the needs of people with serious and persistent mental illness in times of major disaster. Retrieved from http://cretscmhd.psych.ucla.edu/nola/Video/MHR/Governmenreports/1-Responding_to_Needs_Serious_Mental_Illness.pdf
Mental Health	Increased risk of being triggered	Anyone's mental health can be hampered by a flood or hurricane, but those with mental illness immediately face increased risks of being triggered, as any change in environment can trigger negative responses of mental illness	Waite, T. D., Chaintarli, K., Beck, C. R., Bone, A., Amlot, R., Kovats, S., Reacher, M., Armstrong, B., Leonardi, G., Rubin, G.J., & Oliver, I. (2016). The English national cohort study of flooding and health: cross-sectional analysis of mental health outcomes at year one. <i>BMC Public Health</i> , 17(1291), 1-9 American Red Cross. (2019). Disaster preparedness: For seniors by seniors. Retrieved from https://www.redcross.org/content/dam/redcross/atg/PDF_s/Preparedness___Disaster_Recovery/Disaster_Preparedness/Disaster_Preparedness_for_Srs-Enalish.revised_7-09.pdf
HIV/AIDS	Compromised/lack of medications	Some medications go bad without refrigeration, or can be compromised when exposed to unclean floodwaters. It is recommended to have a supply of 7 days worth of needed medications.	Anthony, C., Nkongolo, O. T., Schmitz, P., Hango, J. N., & Kistemann, T. (2015). The impact of flooding on people living with HIV: a case study from the Ohangwena Region, Namibia. <i>Global Health Action</i> , 8(1), 26441.
	Nutrition must be maintained	People with HIV/AIDS have immune systems that are suppressed, and therefore, proper nutrition must be maintained even during times of disaster or consequences could be fatal.	Anthony, C., Nkongolo, O. T., Schmitz, P., Hango, J. N., & Kistemann, T. (2015). The impact of flooding on people living with HIV: a case study from the Ohangwena Region, Namibia. <i>Global Health Action</i> , 8(1), 26441.
	Compromised/lack of medications	Some medications go bad without refrigeration, or can be compromised when exposed to unclean floodwaters. It is recommended to have a supply of 7 days worth of needed medications.	Anthony, C., Nkongolo, O. T., Schmitz, P., Hango, J. N., & Kistemann, T. (2015). The impact of flooding on people living with HIV: a case study from the Ohangwena Region, Namibia. <i>Global Health Action</i> , 8(1), 26441.
	Spreading the virus	Lacerations from debris/broken structures create the ability to spread the virus.	Anthony, C., Nkongolo, O. T., Schmitz, P., Hango, J. N., & Kistemann, T. (2015). The impact of flooding on people living with HIV: a case study from the Ohangwena Region, Namibia. <i>Global Health Action</i> , 8(1), 26441.
	More susceptible to infections in worsened air and water quality	Because of their compromised immune systems, they are more susceptible to infections in worsened air and water quality conditions.	Gomez, M. (2012, September 5). Natural Disasters and People Living with HIV and AIDS. Retrieved from HIV.gov: https://www.hiv.gov/blog/natural-disasters-and-people-living-with-hiv-and-aids-2

Chronic Health Issues	Limited access to care/medications	Access to care can decrease with closure of pharmacies or ruined medications from flood, which leads to HIV in the blood making the patient more resistant to treatment.	Gomez, M. (2012, September 5). Natural Disasters and People Living with HIV and AIDS. Retrieved from HIV.gov: https://www.hiv.gov/blog/natural-disasters-and-people-living-with-hiv-and-aids-3
		A chronic condition is a human health condition or disease that is persistent or otherwise long-lasting in its effects or a disease that comes with time.	Davis, J. M., Wilson, S. P., Brock-Martin, A. D., Glover, S. P., & Svendsen, E. R. (2010). The Impact of Disasters on Populations With Health and Health Care Disparities. <i>HHS Public Health</i> , 4(1), 30-38.
		Those with chronic health issues also face increased risk of disaster in a disaster. Confusion before and after natural disasters increases the danger for those with known cardiovascular issues, like diabetes, high blood pressure and smoking.	Davis, J. M., Wilson, S. P., Brock-Martin, A. D., Glover, S. P., & Svendsen, E. R. (2010). The Impact of Disasters on Populations With Health and Health Care Disparities. <i>HHS Public Health</i> , 4(1), 30-38.
	Higher chance of death	Leading causes of death among chronic health populations during an emergency, is difficulties accessing health care facilities during recovery phase and the higher dependence on caregivers.	Davis, J. M., Wilson, S. P., Brock-Martin, A. D., Glover, S. P., & Svendsen, E. R. (2010). The Impact of Disasters on Populations With Health and Health Care Disparities. <i>HHS Public Health</i> , 4(1), 30-38.
Diabetes	Increased risk of heart attack during and after hurricane	"There's pretty good data that, after a natural disaster, whether it be a hurricane, an earthquake or a flood, that there's a higher risk of patients having heart attacks and stroke, there was a 30 percent increase in the rates of heart attack immediately after Hurricane Katrina as compared to before." confusion before and after natural disasters increases the danger for those with known cardiovascular issues, like diabetes, high blood pressure and smoking. Risks are also related to a lack of medications, the stress of being in a natural catastrophe and a lack of access to medical care.	Mask, A. (2018). How a hurricane could lead to a heart attack. University of North Carolina Health Team. Retrieved from https://www.wral.com/how-a-hurricane-could-lead-to-a-heart-attack/17874725/
	Dependency on routines, regulated diets, and routine schedules	People with chronic conditions may as a matter of course depend on health care specialists and on complex treatment regimens, diets, and other interventions. Not having shelter or usual routines can create more disruptions than arise for people without such conditions.	Mask, A. (2018). How a hurricane could lead to a heart attack. University of North Carolina Health Team. Retrieved from https://www.wral.com/how-a-hurricane-could-lead-to-a-heart-attack/17874725/
	Asthma and Allergies	For those with chronic conditions like asthma, damp buildings and furnishings promote the growth of bacteria, dust mites, cockroaches and mold, which can aggravate asthma and allergies and may cause the development of wheezing, coughs, and other allergic diseases	Rath, B., Donato, J., Duggan, A., Perrin, K., Bronfin, D. R., Ratard, R., VanDyke, R., & Magnus, M. (2007). Adverse Health Outcomes after Hurricane Katrina among Children and Adolescents with Chronic Conditions. <i>Journal of Health Care for the Poor and Underserved</i> , 18(2). 405-417.
		Individuals with diabetes were very seriously affected owing to the lack of medical care, appropriate food, and medications. Disruption of health care provisions and medications is likely to have both a short-term and long-term impact on this condition.	American Lung Association. (2019). Floods and water damage. Retrieved from https://www.lung.org/our-initiatives/healthy-air/outdoor/emergencies-and-natural-disasters/floods-and-water-damage.html
Hospice/ Life threatening illness	Food options	Food options need to consider special needs.	Fonseca, V. M. (2009). Impact of a Natural Disaster on Diabetes: Exacerbation of Disparities and Long-term Consequences. <i>Diabetes Care</i> , 32(9), 1632-1638.
	Prolonged stress	Prolonged stress can further impact individuals with type 2 diabetes by raising blood sugar levels.	Fonseca, V. M. (2009). Impact of a Natural Disaster on Diabetes: Exacerbation of Disparities and Long-term Consequences. <i>Diabetes Care</i> , 32(9), 1632-1638.
	Space for hospice within shelters	Hospice is specialized type of care for those facing a life-limiting illness, their families and their caregivers. ... Hospice care concentrates on managing a patient's pain and other symptoms so that the patient may live as comfortable as possible and make the most of the time that remains. Space for hospice to needs to be pre-determined within shelters to continue operation.	Sanford, C., Jui, J., Miller, H. C., & Jobe, K. A. (2007). Medical treatment at Louis Armstrong New Orleans International Airport after hurricane Katrina: The experience of disaster medical assistance teams WA-1 and OR-2. <i>Travel Medicine and Infectious Disease</i> , 5(4), 230-235.
	Increased risk of death		Sanford, C., Jui, J., Miller, H. C., & Jobe, K. A. (2007). Medical treatment at Louis Armstrong New Orleans International Airport after hurricane Katrina: The experience of disaster medical assistance teams WA-1 and OR-2. <i>Travel Medicine and Infectious Disease</i> , 5(4), 230-235.
	Preparing loved ones in case client dies during evacuation	Make sure hospice has the name and address of the location you are evacuating to.	TrustBridge. (n.d.). Hurricane: Hospice FAQ and guide. Retrieved from https://www.trustbridge.com/news-media/hurricane-hospice-faq-and-guide

Dialysis	Equipment needed, electricity required	Dialysis is used to treat people with kidney problems and if there is loss of electricity, treatment can be disrupted/delayed.	Dosa, D. M., Grossman, N. B., Wetle, T. P., & Mor, V. P. (2007). To Evacuate or Not to Evacuate: Lessons Learned From Louisiana Nursing Home Administrators Following Hurricanes Katrina and Rita. <i>Journal of the American Medical Directors Association</i> , 8(3), 142-149.
Oxygen dependent	Special need shelter	Need to be in a special needs shelter because of need for constant electricity. The County provides special needs shelters for residents whose medical condition may require the use of electrical equipment, oxygen, dialysis, or individuals with physical, cognitive, or medical conditions that may require assistance from medical professionals.	Dosa, D. M., Grossman, N. B., Wetle, T. P., & Mor, V. P. (2007). To Evacuate or Not to Evacuate: Lessons Learned From Louisiana Nursing Home Administrators Following Hurricanes Katrina and Rita. <i>Journal of the American Medical Directors Association</i> , 8(3), 142-149. Hillsborough County. (2019, August 5). Register for Special Needs Disaster Assistance. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/action-folder/register-for-special-needs-disaster-assistance
Dementia	Disruption can worsen dementia	Dementia is a general term for a decline in mental ability severe enough to interfere with daily life. Memory loss is an example. Alzheimer's is the most common type of dementia. Having a consistent schedule helps symptoms.	Hikichi, H., Aida, J., Kondo, K., Tsuboya, T., Matsuyama, Y., Subramanian, S. V., & Kawachi, I. (2016). Increased risk of dementia in the aftermath of the 2011 Great East Japan Earthquake and Tsunami. <i>PNAS</i> , 113(45), E6911-6918.
Food Insecure	Need games/puzzles to keep patients occupied Disrupt distribution	Systems that provide food to food insecure families may become compromised in disaster, disrupting food sources for families	Hikichi, H., Aida, J., Kondo, K., Tsuboya, T., Matsuyama, Y., Subramanian, S. V., & Kawachi, I. (2016). Increased risk of dementia in the aftermath of the 2011 Great East Japan Earthquake and Tsunami. <i>PNAS</i> , 113(45), E6911-6918. Expert opinion- Sheri Dunn, MPH-BC, BSN, RN-BC
People who are Hospitalized		If hospitals are not prepared for sudden surges in demand for acute and emergency care, then compromises not only to the incoming disaster patients but also to existing emergency department and hospitalized patients will occur.	Pyles, L. P., Kulkarni, S. P., & Lein, L. P. (2007). Economic Survival Strategies and Food Insecurity. <i>Journal of Social Service Research</i> , 34(3), 43-53.
	Medication shortage		University of Michigan Institute of Health Care Policy and Innovation. (n.d.) Ripple effect: How hurricanes and other disasters affect hospital care. Retrieved from https://ihpi.umich.edu/news/ripple-effect-how-hurricanes-other-disasters-affect-hospital-care
	Non-functioning medical equipment		University of Michigan Institute of Health Care Policy and Innovation. (n.d.) Ripple effect: How hurricanes and other disasters affect hospital care. Retrieved from https://ihpi.umich.edu/news/ripple-effect-how-hurricanes-other-disasters-affect-hospital-care
	Transfer of medical records	In cases where evacuation of patients is necessary and they are transferred to another facility, it is important to use electronic records, however if power is lost, access to records will be limited if not cut off.	University of Michigan Institute of Health Care Policy and Innovation. (n.d.) Ripple effect: How hurricanes and other disasters affect hospital care. Retrieved from https://ihpi.umich.edu/news/ripple-effect-how-hurricanes-other-disasters-affect-hospital-care
	Physical Disability	Individuals with physical disabilities during times of emergencies face more difficult means to prepare and respond to the event and even face long-term health impacts.	Connecticut Developmental Disabilities Network. (2002). A Guide for Including People with Disabilities in Disaster Preparedness Planning. Retrieved from https://www.ct.gov/ctcdd/lib/ctcdd/guide_final.pdf Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015

	Dependent of electronic mobility	Unable to use electric scooters in floodwaters.	Connecticut Developmental Disabilities Network. (2002). A Guide for Including People with Disabilities in Disaster Preparedness Planning. Retrieved from https://www.ct.gov/ctcdd/lib/ctcdd/guide_final.pdf
			Hillsborough County. (2015). Hillsborough County Local Mitigation Strategy. Retrieved from https://www.hillsboroughcounty.org/en/residents/public-safety/emergency-management/local-mitigation-strategy-documents-2015
	Accessible entrance/routes	Not all private properties have ramps or the ability to evacuate the property without assistance and in some case, ramps may be damaged, blocked, or flooded.	U.S. Department of Justice. (2012). ADA Checklist for Emergency Shelters. Washington, D.C: U.S. Department of Justice. Retrieved from https://www.ada.gov/pca toolkit/chap7shelterchk.htm
	Obesity issues	Individuals over 300 pounds cannot stay in shelters because of cot limitations. Other bariatric concerns may exist.	Expert Opinion, Angela Baird, Medical Reserve Corps Manager
	Short Term Housing	The two most common forms of short-term housing for disaster survivors were apartments and trailers. People with mobility disabilities often had difficulties securing accessible apartments and even trailers provided by FEMA were not accessible. Even trailers that were purportedly "accessible" because they had ramps at the entrances often were located in gravel fields; inside, there was insufficient space to turn a wheelchair; bathrooms were inaccessible; and people in wheelchairs could not enter the kitchens to prepare food.	National Council on Disability. (2006). The Impact of Hurricanes Katrina and Rita on People with Disabilities: A Look Back and Remaining Challenges. Retrieved from https://ncd.gov/rawmedia_repository/e89f084e_e132_496c_a5b8_56351dfb3f10.pdf
Mental Disability	Exacerbates illnesses after disaster	Persons with severe mental illness (SMI) can experience post-traumatic stress disorder (PTSD), depression, anxiety, and illness exacerbation after disaster. There is evidence that persons with SMI can be resilient in the short term when they are enrolled in an assertive community treatment program prior to the disaster; however, the outcomes for people with severe mental illness in other treatment modalities are unclear.	Person, C., & Fuller, E. (2007). Disaster care for persons with psychiatric disabilities: Recommendations for policy change. <i>Journal of Disability Policy Studies</i> , 17 (4), 238-248. doi:10.1177/10442073070170040701
Deaf/ Blind	Communication	Need multiple modes of communication through visual information and auditory information, for those who cannot see or hear.	National Council on Disability. (2006). The Impact of Hurricanes Katrina and Rita on People with Disabilities: A Look Back and Remaining Challenges. Retrieved from https://ncd.gov/rawmedia_repository/e89f084e_e132_496c_a5b8_56351dfb3f10.pdf
		Dependent on cell phone service, closed caption television and description maps.	National Council on Disability. (2006). The Impact of Hurricanes Katrina and Rita on People with Disabilities: A Look Back and Remaining Challenges. Retrieved from https://ncd.gov/rawmedia_repository/e89f084e_e132_496c_a5b8_56351dfb3f10.pdf
	Trained volunteers and interpreters	Shelters need to have sign Language interpreters and trained volunteers to assist/work with the deaf and blind.	National Council on Disability. (2006). The Impact of Hurricanes Katrina and Rita on People with Disabilities: A Look Back and Remaining Challenges. Retrieved from https://ncd.gov/rawmedia_repository/e89f084e_e132_496c_a5b8_56351dfb3f10.pdf
	Evacuation difficulties	Deaf/blind populations must rely on friends and family or their access to public transit to evacuate.	National Council on Disability. (2006). The Impact of Hurricanes Katrina and Rita on People with Disabilities: A Look Back and Remaining Challenges. Retrieved from https://ncd.gov/rawmedia_repository/e89f084e_e132_496c_a5b8_56351dfb3f10.pdf

ECOLOGY

CATEGORIES	SUB-CATEGORIES	SPECIFIC	DESCRIPTION	REFERENCES
The Watershed				
			<p>The Tampa Bay watershed is 1,693,866 acres, which encompasses the continuum of natural plant communities that extend from the headwaters to the estuary. It (the coastal stratum, river floodplain stratum, and upland stratum) provides critical wildlife habitat and important nutrients, flood mitigation, stabilizes shorelines, minimizes erosion, and assimilates pollutants from urban runoff.</p> <p>Future stressors include urban development, sea level rise, and climate change. These create a level of uncertainty for ecosystems that will suffer without action that is flexible and responsive.</p>	<p>Tampa Bay Estuary Program, (2020). DRAFT 2020 Habitat Master Plan Update. Retrieved from https://tbep.tech.org/attachments/article/285/Draft_Final_2020_Habitat_Master_Plan_Optimized.pdf</p> <p>Tampa Bay Estuary Program, (2020). DRAFT 2020 Habitat Master Plan Update. Retrieved from https://tbep.tech.org/attachments/article/285/Draft_Final_2020_Habitat_Master_Plan_Optimized.pdf</p>
Upland (Supratidal) Habitats				
	Development Pressure	Upland native habitats, such as pine flatwoods, are largely unprotected and disappearing quickly. Since 1990, 39% of native upland habitats have been lost to development and the region's population continues to grow.		Tampa Bay Estuary Program, (2020). DRAFT 2020 Habitat Master Plan Update. Retrieved from https://tbep.tech.org/attachments/article/285/Draft_Final_2020_Habitat_Master_Plan_Optimized.pdf
	Salinity	Upland landscapes will be imperiled by increased salinity from sea level rise and storm surge. The salinity can damage or kill trees, plants, cultural landscape plants such as turf, and agricultural fields.		Williams, V. J. (2010). Identifying the Economic Effects of Salt Water Intrusion after Hurricane Katrina. <i>Journal of Sustainable Development</i> , 3(1), 29-37.
	Erosion	Upland landscape health and resilience can be compromised by the erosive effects of flooding. Stressors are compounded by development and compromised/vulnerable ecosystems. The erosion of upland habitats negatively impacts communities downstream and in the estuary.		Jackson, C. (2006). Ecological effects of gulf coast hurricanes: short-term and long-term consequences. <i>Bulletin of the Ecological Society of America</i> . Retrieved from https://doi.org/10.1890/0012-9623(2006)87[374:eeogch]2.0.co;2
	Tree Fall	Hurricanes may cause trees to fall, substrate disturbance, and seed dispersal. Upland habitats can benefit from renewal by cycles of growth and disruption, but the effects of urbanism with changes to habitat regime can cause problems to the ecosystem structure and resiliency.		U.S. Fish and Wildlife Service. (1999). Hydric Pine Flatwoods, from the Multi-Species Recovery Plan for South Florida. Retrieved from https://www.fws.gov/verobeach/MSRPPDFs/HydricPineFlat.pdf
			1,125 trees were planted along road corridors to restore tree canopy after Hurricane Katrina.	Audubon Society. (Accessed on Sept. 24, 2019) Hurricane Michael: Effects and Recovery in a Time of Changing Climate. Retrieved from Lee, L. J., & Hall, B. (2011, July). Louisiana's Recovery. Retrieved from Federal Highway Administration: https://www.fhwa.dot.gov/publications/publicroads/11julaug/05.cfm
	Nutrients and Organic Load	Hurricanes can damage the ecosystem and nutrient cycle by overloading it with live foliage litter, which is slower to decompose and overloads the system with high organic content.		Jackson, C. (2006). Ecological effects of gulf coast hurricanes: short-term and long-term consequences. <i>Bulletin of the Ecological Society of America</i> . Retrieved from https://doi.org/10.1890/0012-9623(2006)87[374:eeoach]2.0.co;2
	Ecosystem Integrity	Changes occur to biotic communities when affected by a severe event. Naturally, these would induce rejuvenation and adaptation cycles of ecological systems. However, human impacts can effect this process.		U.S. Fish and Wildlife Service. (1999). Hydric Pine Flatwoods, from the Multi-Species Recovery Plan for South Florida. Retrieved from https://www.fws.gov/verobeach/MSRPPDFs/HydricPineFlat.pdf
	Exotic Plants	Exotics, also known as invasive species, often outcompete native communities when large areas are cleared either by a storm event or human development. The ecosystem services of exotics typically perform lower than natives.		Jackson, C. (2006). Ecological effects of gulf coast hurricanes: short-term and long-term consequences. <i>Bulletin of the Ecological Society of America</i> . Retrieved from https://doi.org/10.1890/0012-9623(2006)87[374:eeoach]2.0.co;2
	Flatwood	Flatwoods are noted for flat topography with less flow than percolation and water saturated soil. Slow runoff occasionally creates very poorly defined first-order streams and sheet flow patterns during storms and high water events. Flatwoods are vegetated with a carpet of grasses, herbs, and scattered trees.		Whitney, E.W, Means B.M, Rudloe A.R. (2004). <i>Priceless Florida</i> . Sarasota, Florida. Pineapple Press, Inc.
	Hydric Pine Flatwood	Hydric soils are wet and low in oxygen content. They are typically composed of more clay in the soil and are closer to the water table, anywhere from three feet to water above grade.		Whitney, E.W, Means B.M, Rudloe A.R. (2004). <i>Priceless Florida</i> . Sarasota, Florida. Pineapple Press, Inc.

Pine Flatwood/Dry
Prairie
Hydric Hammock

Pine flatwoods and dry prairies typically occupy dry areas with sandier well-drained soils. Hydric hammocks are one of the most biodiverse landscapes and are typically associated with riverine conditions as a spillover space that absorbs infrequent flood. They help to maintain the atmosphere, regulate climate, disperse and slow the flow of rainfall, keep the soil soft and healthy, and to hold its integrity while inundated.

Whitney, E.W, Means B.M, Rudloe A.R. (2004). Priceless Florida. Sarasota, Florida. Pineapple Press, Inc.
Whitney, E.W, Means B.M, Rudloe A.R. (2004). Priceless Florida. Sarasota, Florida. Pineapple Press, Inc.

Interior and Coastal
Scrub

Interior Florida scrub occurs on well-drained sandy ridges. The sandy soil in these areas allows for rapid aquifer recharge, and the dryer upper layer supports plants that are adapted to well-drained soils.

Whitney, E.W, Means B.M, Rudloe A.R. (2004). Priceless Florida. Sarasota, Florida. Pineapple Press, Inc.

Interior Water Habitats

Rivers, Springs, Streams

Headwaters and fresh water conveyances are critical to provide the region with clean water and to maintain the salinity balance that estuarine communities require.

Tampa Bay Estuary Program, (2020). DRAFT 2020 Habitat Master Plan Update. Retrieved from https://tbep.tech.org/attachments/article/285/Draft_Final_2020_Habitat_Master_Plan_Optimized.pdf
Tampa Bay Estuary Program, (2020). DRAFT 2020 Habitat Master Plan Update. Retrieved from https://tbep.tech.org/attachments/article/285/Draft_Final_2020_Habitat_Master_Plan_Optimized.pdf
Guccione, M. J. (1995). Indirect Response of the Peace River, Florida to Episodic Sea-Level Change. *Journal of Coastal Research*, 11(3), 637-650.

Reduction in Water

There is a substantial loss of headwater stream, largely due to impoundment for municipal drinking water. Clean water supply is additionally impacted by phosphorus mining activities at the headwaters of sources like the Alafia.

Erosion

Changes in the water-table elevation, which is affected by sea level rise and climate change, influence the amount of soil that is cut and moved from the littoral edges of a body of water. This destabilizes the edges and potentially overburdens water bodies downstream from increased sediment loading.

Reduction in Water
Quality and Habitat

Sudden peak inflows or runoff can "flush" out juvenile nekton and sediments, deepen and channelize the systems, and introduce unsuitable water quality conditions within the tributaries, thereby reducing or eliminating benthic microalgae production and altering biotic communities.

PBS&J (2010). Tampa Bay Estuary Program Habitat Master Plan Update. Retrieved from the Tampa Bay Estuary Program at https://www.tbep.tech.org/TBEP_TECH_PUBS/2009/TBEP_06_09_Habitat_Master_Plan_Update_Report_July_2010.pdf

Nutrient Load

Issues in the basin include elevated levels of fecal coliform bacteria from agricultural and urban stormwater runoff, sewage treatment plants, septic systems, and sewer overflows; and decreased levels of dissolved oxygen from the breakdown of organic matter.

He, Z., Folsom, S., Henry, E., & Twaite, W. (2018). A Storm Surge-Induced Chemical Contamination Study for the Tampa Bay Area. Retrieved from <https://hsweng.com/wp-content/uploads/Article-Pages-from-October-2018-Edition.pdf>

Soil Pollution

Oil and diesel runoff can contaminate the soil and settle in the sediment.

EPA. (2006, August 17). Summary Results of Sediment Sampling Conducted by the Environmental Protection Agency in response to Hurricanes Katrina and Rita. Retrieved from <https://archive.epa.gov/katrina/web/html/summary.html>
Tampa Bay Estuary Program, (2020). DRAFT 2020 Habitat Master Plan Update. Retrieved from https://tbep.tech.org/attachments/article/285/Draft_Final_2020_Habitat_Master_Plan_Optimized.pdf

Canals

Flood control canals, like the Tampa Bypass Canal and the Lake Tarpon Outfall Canal represent extremes in terms of hydrologic alterations. The two canals respectively either reduce or overwhelm the freshwater outflow to the extent that salinity balances at their termination compromise estuarine communities.

Saltwater Inundation

Canals that connect the city to the coast can allow storm surges to travel inland, bringing salt water that damages the land.

Williams, V. J. (2010). Identifying the Economic Effects of Salt Water Intrusion after Hurricane Katrina. *Journal of Sustainable Development*, 3(1), 29-37.

Lakes

In Florida's flat terrain, lakes and ponds are essential to recharging the aquifer. A lake has multiple underwater zones with a rich biodiverse aquaculture.

Whitney, E.W, Means B.M, Rudloe A.R. (2004). Priceless Florida. Sarasota, Florida. Pineapple Press, Inc.

Eutrophication

Combined stressors like warming, salinization, development, nutrient loading, exploitation of fish, and extreme water level fluctuation jointly lead to eutrophication.

Zohary, T., & Ostrovsky, I. (2011). Ecological Impacts on Excessive Water Level Fluctuations in Stratified Freshwater Lakes. *Inland Waters*, 1(1), 47-59.

Diminished Littoral
Zones

Abnormal water-level fluctuations diminish littoral zones, associatively decreasing the food resources and nursery/shelters. This will decrease the reproduction and survival rates of both terrestrial and aquatic organisms and have cascading effects on species diversity, richness and abundance and the water quality of the ecosystem. These cascading effects make littoral communities more vulnerable to invasive species.

Zohary, T., & Ostrovsky, I. (2011). Ecological Impacts on Excessive Water Level Fluctuations in Stratified Freshwater Lakes. *Inland Waters*, 1(1), 47-59.

Wetlands

"Man-made hydrologic reservoirs tend to experience greater water level fluctuations than natural lakes," and are typically lacking the littoral zones making them less diverse and more susceptible to cyanobacterial blooms.

In one study, a flooding event increased water levels by 1m above the normal maximum and caused a decrease in 24% of reed beds, which diminished the effectiveness of ecosystem health and function.

Wetlands are areas with relatively wet soils, either permanently or at intervals for significant periods. They are saturated or inundated by surface water or groundwater frequently enough to support a predominance of plants that are adapted for life in water-saturated soils that are low in oxygen.

Wetlands absorb and store water, which mitigates flooding. Within urban areas, their value is in reducing surface-water runoff from pavement and buildings into a potentially overloaded stormwater management system. They also help to filter out pollutants and improve water quality.

Wetland Loss from Development
Altered hydrologic regimes diminish the mitigative potential for both flooding and drought. Permits are required for wetland alteration.

Displacement of Habitats
Under high sea level rise scenario emergent tidal wetlands could be replaced by subtidal seagrass and mangroves.

Cypress Swamps

A cypress swamp is a natural wetland that balances the oscillations between flood and drought, which supports numerous native species.

Loss of Trees
Increased flooding can have serious consequences even for the most flood tolerant trees. In one study where water remained over 120 cm deep, 50% of cypress died after four years.

Change of Habitat
Cypress swamps will degenerate into marsh or open water due to saltwater intrusion (and human extraction).

Wet Prairie

A wet prairie is a habitat found in flat or gently sloping areas with wet, but not inundated, soils. The length of time that soils are flooded ranges from 3-7 months each year. Often a wet prairie is found between lower lying depression marshes or swamps and slightly higher pine flatwoods.

Wet Meadow/Marsh

A marsh is a wetland dominated by herbs that are rooted in saturated soil on which water stands for much of the year.

Loss of Carbon Storage
Previously sequestered carbon is released when marshlands are degraded or eroded. Wetland loss (from development pressure, natural disaster, or sea level rise) equals the loss of a highly productive carbon sink.
Hurricanes can trigger large carbon losses of sequestered soil carbon through the destruction of large areas of marsh.

Habitat Change / Loss
Vegetation root networks provide structure to marsh soil. When wetland vegetation is lost, the marsh soil elevation decreases rapidly resulting in the conversion to ponds or open water. The conversion of a marsh to open water "releases a considerable amount of carbon into the adjacent estuary or coastal shelf."

Zohary, T., & Ostrovsky, I. (2011). Ecological Impacts on Excessive Water Level Fluctuations in Stratified Freshwater Lakes. *Inland Waters*, 1(1), 47-59.

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Williams, V. J. (2010). Identifying the Economic Effects of Salt Water Intrusion after Hurricane Katrina. *Journal of Sustainable Development*, 3(1), 29-37.

Jackson, C. (2006). Ecological effects of gulf coast hurricanes: short-term and long-term consequences. *Bulletin of the Ecological Society of America*. Retrieved at [https://doi.org/10.1890/0012-9623\(2006\)87\[374:eeogch\]2.0.co;2](https://doi.org/10.1890/0012-9623(2006)87[374:eeogch]2.0.co;2)

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Delaune, R.D., & White, J.R. (2012). Will Coastal Wetlands Continue to Sequester Carbon in Response to an Increase in Global Sea Level? : a case study of the rapidly subsiding Mississippi river deltaic plain. *Climatic Change* 110, 297-314.

Delaune, R.D., & White, J.R. (2012). Will Coastal Wetlands Continue to Sequester Carbon in Response to an Increase in Global Sea Level? : a case study of the rapidly subsiding Mississippi river deltaic plain. *Climatic Change* 110, 297-314.

Delaune, R.D., & White, J.R. (2012). Will Coastal Wetlands Continue to Sequester Carbon in Response to an Increase in Global Sea Level? : a case study of the rapidly subsiding Mississippi river deltaic plain. *Climatic Change* 110, 297-314.

Constructed canals reduce freshwater sheet flow, causing freshwater depletion in wetlands and extreme changes in salinity levels. Saltwater intrusion and higher salinity levels encourage salt-tolerant vegetation, such as mangroves, to migrate inward and colonize in the freshwater wetlands; which further decays the salt marshes.

Radabaugh, K.R., Powell, C.E., & Moyer, R.P. (2017). Coastal Habitat Integrated Mapping and Monitoring Program. Fish and Wildlife Research Institute. Retrieved from https://ocean.floridamarine.org/CHIMMP/Resources/CHIMMP_Report_061317.pdf

Coastal (Subtidal) Habitats

Bay Waters

The waters of Tampa Bay support a vast diversity of species and communities that thrive in the bay's specific balance of salinity, clarity, nutrient composition, and depth. The Bay averages 10 feet in depth and is fed by numerous streams, rivers, springs, and rain.

Whitney, E.W, Means B.M, Rudloe A.R. (2004). Priceless Florida. Sarasota, Florida. Pineapple Press, Inc.

Habitat Loss

Rising seas and increasingly dangerous storm surges threaten to submerge and erode habitat, and make the groundwater more saline — destroying coastal plant communities and drinking water.

Baker, I., Peterson, A., Brown, G., & McAlpine, C. (2012). Local government response to the impacts of climate change: An evaluation of local climate adaptation plans. *Landscape and Urban Planning Journal*, 107(2), 127-136. doi: 10.1016/j.landurbplan.2012.05.009

Oysters likely suffered significant mortality due to Hurricane Katrina. Fish and crustacean populations may have suffered minimal increased mortality due to the same event.

Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.

Nutrient and pH Changes

Runoff from upland flooding changes the pH level and causes more turbid waters, which limits solar access to subtidal communities.

Dolan, A. H., & Walker, I. J. (2004). Understanding Vulnerability of Coastal Communities to Climate Change Related Risks. *Journal of Coastal Research*, 1(39), 1316-1323.

"Increased nutrients in storm runoff have the potential to stimulate harmful algal blooms in offshore waters."

Bennett, A. (2018, September 24). NASA can see dark, polluted Carolina Rivers Spilling into the Ocean from Space. Retrieved from *The Herald Sun*: <https://www.heraldsun.com/news/local/article218934685.html>

Buck, E. H. (2005). Resources, Science, and Industry Division of Congress. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries — Damage and Recovery. RS22241. Library of Congress.

Coastal (Intertidal) Habitats

Coastal Wetlands

The tidal saline wetlands of the Gulf of Mexico are one of the most sea-level rise sensitive and wetland-rich regions of the world.

Whitney, E.W, Means B.M, Rudloe A.R. (2004). Priceless Florida. Sarasota, Florida. Pineapple Press, Inc.

Urban Development Barriers to Habitat Migration

Gulf of Mexico coastlines have a substantial amount of area available for tidal saline wetland migration except for the Tampa to Ft. Myers coastline. Tampa's current and future urban development is the primary barrier to horizontal habitat migration necessary for plant communities to adapt to Sea Level Rise.

Enwright, N.M., Griffith, K.T., & Osland, M.J. (2016). Barriers to and opportunities for landward migration of coastal wetlands with sea-level rise. *Frontiers in Ecology and the Environment*, 14(6), 307-316.

Sea level rise is happening too fast to allow for landward migration of tidal wetlands.

Tampa Bay Estuary Program, (2020). DRAFT 2020 Habitat Master Plan Update. Retrieved from https://tbep.tech.org/attachments/article/285/Draft_Final_2020_Habitat_Master_Plan_Optimized.pdf

Subsurface Hydrology

Saltwater intrusion

The aquifer

Saltwater intrusion into Florida's underground aquifers will worsen with sea level rise and as cities overdraw freshwater supplies.

Fleury, P., Bakalowicz, M. & de Marsily, G. (2007). Submarine springs and coastal karst aquifers: A review. *Journal of Hydrology*, 339(1), 79-92.

Seagrass Meadows

Habitat Loss

Seagrass meadows blanket estuarine seafloors like the Tampa Bay, providing invaluable habitat for diverse species. Additionally, they provide some level of storm surge mitigation as a source of friction as big ocean waves roll in.

Whitney, E.W, Means B.M, Rudloe A.R. (2004). Priceless Florida. Sarasota, Florida. Pineapple Press, Inc.

Seagrasses are sensitive to environmental stressors. Significant seagrass losses, directly from dredging propeller scars from boats, and light shading from degraded water quality caused algal blooms, have occurred in Tampa Bay.

Sheehan, L., Crooks, S., Tomasko, D., Robinson, D., Connell, H., & Quinton, B. (2016). Tampa Bay Blue Carbon Assessment: Summary of Findings. Tampa Bay: Tampa Bay Environmental Restoration Fund. Retrieved from https://estuaries.org/wp-content/uploads/2019/02/FINAL_Tampa-Bay-Blue-Carbon-Assessment-Report-updated-compressed.pdf

Oyster Beds

Oysters live in salty or brackish waters on all U.S. coasts, clustering on older shells, rock, piers, or any hard, submerged surface. They fuse together as they grow, forming rock-like reefs that provide habitat for other marine animals and plants. Oyster reefs protect underwater vegetation and waterfront communities from waves, floods, and tides.

Oysters feed by sifting algae from the water, they function as a natural filter and improve water that is overloaded with nutrients. A single oyster filters up to 50 gallons of water per day. The clearer, cleaner water supports plentiful underwater grasses, which—like the oyster reef—create a stable bay bottom and a safe, nurturing habitat for juvenile crabs, scallops, and fish.

The term mangrove can refer to any of 50 species of trees and shrubs that grow in saline soils. In Florida, the most common are red, black, and white mangroves. A mangrove swamp is a tidal wetland dominated by saline-tolerant trees and shrubs. They are essential to the overall health of the coastal ecosystem as they trap and cycle various chemicals, organic materials, and nutrients. They act as a defense to wave damage, large storms, and flooding, but can be damaged by long-term flooding and sea level rise.

Office of Habitat Conservation. (2019, March, 11). Oyster Reef Habitat. Retrieved from <https://www.fisheries.noaa.gov/national/habitat-conservation/oyster-reef-habitat>

Office of Habitat Conservation. (2019, March, 11). Oyster Reef Habitat. Retrieved from <https://www.fisheries.noaa.gov/national/habitat-conservation/oyster-reef-habitat>

Whitney, E.W, Means B.M, Rudloe A.R. (2004). Priceless Florida. Sarasota, Florida. Pineapple Press, Inc.

Mangroves

Habitat Change / Loss Mangrove coverage is estimated to increase to 85-89% coverage of the estuary ecosystem as a result of habitat migration.

Accretion (SLR) Mangroves can respond to SLR either through vertical building (soil accretion) or lateral retreat. However, some mangroves have restricted flexibility and mobility due to natural or human barriers, preventing the system from adapting to SLR.

Storm Damage Tall mangrove forests along the coast and on barrier islands were greatly damaged by intense storm surge, but inland mangroves saw little damage due to the protection from coastal mangroves.

During Hurricane Irma, 40% of South Florida mangroves were damaged/ flattened.

Sherwood, E.T., & Greening, H. S. (2013). Potential Impacts and Management Implications of Climate Change on Tampa Bay Estuary Critical Coastal Habitats. Environmental Management, 53(2), 401-412.

McKee, K., Cahoon, D., & Feller, I.. (2007). Caribbean mangroves adjust to rising sea level through biotic controls on change in soil elevation. Global Ecology and Biogeography, 16, 545-556. Retrieved from <https://doi.org/10.1111/j.1466-8238.2007.00317.x>

Radabaugh, K.R., Powell, C.E., & Moyer, R.P. (2017). Coastal Habitat Integrated Mapping and Monitoring Program. Fish and Wildlife Research Institute. Retrieved from https://ocean.floridamarine.org/CHIMMP/Resources/CHIMMP_Report_061317.pdf

Staletovich, J. (2018, April 18). NASA team finds massive Everglades mangrove damage from Irma. Can it recover? Retrieved from Miami Herald: <https://www.miamiherald.com/news/local/environment/article209148999.html>

Whitney, E.W, Means B.M, Rudloe A.R. (2004). Priceless Florida. Sarasota, Florida. Pineapple Press, Inc.

Saltwater Marshes

A salt marsh is a ribbon of grassland between the forest and the sea. Increasing stress from changes in salinity, oxygen levels, wave energy, and temperature will diminish salt marsh robustness.

Habitat Change / Loss Marshes help to recruit and retain mangrove seedlings in order to revegetate and restore intertidal sites to climax mangrove forest condition.

Salt marsh coverage is estimated to reduce to 10-14% of the estuary ecosystem and salt barren habitats are estimated to diminish to less than 1%.

Sheehan, L., Crooks, S., Tomasko, D., Robinson, D., Connell, H., & Quinton, B. (2016). Tampa Bay Blue Carbon Assessment: Summary of Findings. Tampa Bay: Tampa Bay Environmental Restoration Fund. Retrieved from https://estuaries.org/wp-content/uploads/2019/02/FINAL_Tampa-Bay-Blue-Carbon-Assessment-Report-updated-compressed.pdf

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Salt Barrens

Tampa Bay salt barren habitats are found at the extreme, upper intertidal flat which is inundated typically only by spring tides once or twice a month.

Habitat Loss With the decrease and deterioration of other habitats around it, salt barrens are vulnerable. Salt marsh coverage is estimated to reduce to 10-14% of the estuary ecosystem and salt barren habitats are estimated to diminish to less than 1%.

Sheehan, L., Crooks, S., Tomasko, D., Robinson, D., Connell, H., & Quinton, B. (2016). Tampa Bay Blue Carbon Assessment: Summary of Findings. Tampa Bay: Tampa Bay Environmental Restoration Fund. Retrieved from https://estuaries.org/wp-content/uploads/2019/02/FINAL_Tampa-Bay-Blue-Carbon-Assessment-Report-updated-compressed.pdf

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Tidal Flats

Tidal flats are coastal wetlands that form in intertidal areas where sediments have been deposited by tides or rivers.

Beach, Dunes, and
Barrier Islands

Barrier islands and beaches are made of sandy, erodible soil and subject to high-energy wave action. They are dynamic systems that constantly form and reform. In areas without establish plant communities, they fluxuate in size depending on accretion and erosive forces. Barrier islands serve many valuable ecological functions, such as reducing coastal erosion, purifying water and providing habitat for fish and birds.

"Katrina's towering storm surge completely washed over most of the barrier islands along the Mississippi coast, scattering hefty amounts of debris."

Loss of Sand

High rates of water movement remove sediment and in absence of nourishment there is a loss of sand.

Coastal Forest

Coastal forests are defined as wooded communities that develop within 100 km of the coast and usually occur on barrier islands, ridges, delta splays, and along river and bayou drainages. Coastal forests around the gulf encompass a wide range of habitat types that vary from estuarine systems like the mangroves in south Florida and Mexico to arid communities like the Tamaulipan thorn scrub of south Texas and northern Mexico.

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