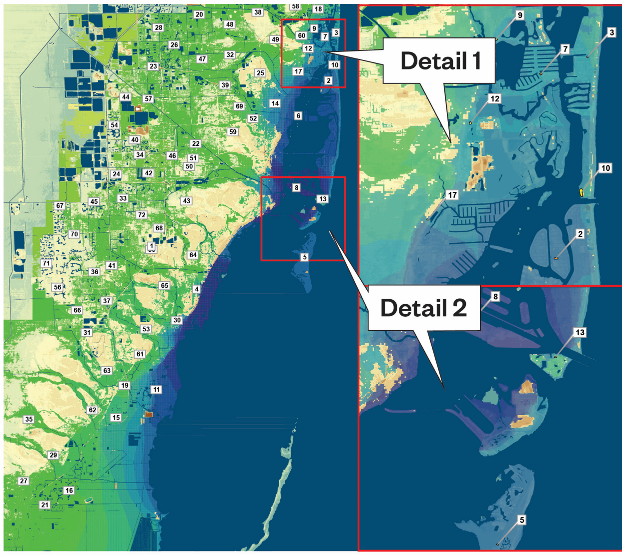
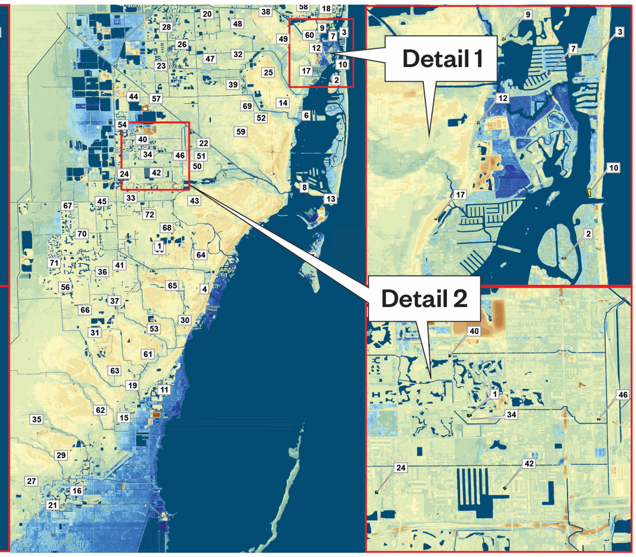
Hazen
Hazen and Sawyer
999 Ponce de Leon Blvd, Suite 1150
Coral Gables, FL, 33134



STORM SURGE INUNDATION



SEA LEVEL RISE INUNDATION

Sea Level Rise and Storm Surge Rapid Action Plan

FINAL REPORT

June 15, 2018

MIAMI-DADE COUNTY

Office of Resilience

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Executive Summary

Miami Dade County is one of the most vulnerable major metropolitan areas in the world with respect to sea level rise. As climate change impacts evolve, existing threats, such as storm surge, are also expected to become more severe. Several cities in the region are already seeing the impacts during King Tide events. This growing concern prompted the Miami-Dade County Board of County Commissioners to direct the Department of Regulatory and Economic Resources, Office of Resilience to commission this study of the vulnerability of key County infrastructure and projects. The purpose of this effort is to develop a capital planning approach that fully considers the impacts of climate change on County-owned facilities. Ultimately, this will help the County achieve its goal of ensuring that all facilities and projects are appropriately designed for sea level rise and storm surge. The adaptation measures presented in this report have the potential to protect projects worth more than $150 million.

The RAP plan has been developed to quickly determine the exposure of the county's current capital projects to the threats of sea level rise and storm surge. In order to do this, general criteria were established for which departments and assets would be evaluated. These included emergency response (Police, Fire Rescue), economic recovery (Aviation and Seaport), and operational recovery (Transit, Solid waste). Parks and Internal services were also considered given the wide range of locations and exposures they have. Public Housing was considered because of the number of assets under management with potential vulnerability to flooding, however, no projects were determined to be of such high criticality that they are included in the RAP. For a variety of reasons not all projects in the CIP were evaluated. For example, projects without a definitive address were not included in the final plan.

The first step in assessing how to protect County-owned infrastructure, was to determine what is vulnerable. The site conditions and locations of more than 1,000 county owned assets and properties were considered

during this project phase using Geographic Information System (GIS) information and Light Detection and Ranging (LiDAR) data. GIS information provided the location and attributes of assets (i.e., location, value, etc.). The LiDAR information provided very accurate elevation data, similar to a wide-area survey. Not all County-owned infrastructure was included in this initial study, but an effort was made to focus on the most essential assets. This study then examined the potential impact of permanent inundation from sea level rise and of the storm surges in the future, which will be amplified by sea level rise. Using these state-of-the-art tools, the project team determined that more than 45% of the County-owned properties included in this study are vulnerable to significant impacts by sea level rise and storm surge inundation. A further 30% are vulnerable to some degree of impact. According to this analysis more than 500 County-owned properties are vulnerable to one of these two hazards. This study provides departments with detailed information about the vulnerability of all their existing facilities which can inform their future planning efforts and future capital improvement plans.

The next step in the process was establishing the criticality of each asset. The project team met twice with each department's key individuals to confirm the need for each asset to execute their mission and continue departmental operations during and immediately after a significant storm event or emergency. Some departments are already identifying what they need to protect their facilities - though they do not always have adequate resources to take necessary measures. Most notably, the Miami-Dade Water and Sewer Department has done extensive work to model, project and evaluate climate change impacts and develop design standards to improve the resiliency and robustness of their critical assets. This effort is documented in "Design Guide for Hardening Wastewater Pump Station Facilities against Flooding from Surge, Sea Level Rise, and Extreme Rainfall" (CH2M/Hazen 2015). This work was used as the basis for examining the exposure of other departments' infrastructure.

The combination of vulnerability and criticality was used to determine the possibility of sea level rise and storm surge-related impacts to all projects in the current capital plan.

*This process was standardized so it can be applied to any number of projects in the future and provide a systematic justifiable framework for project prioritization and modification with respect to these two climate change components. Of the **171 projects** that were considered vulnerable, the **28 highest ranking projects** were selected as the projects to be included in the RAP. This amount was selected as a representative number (16%) of the projects identified in the CIP. These projects require various adaptations to increase their level of resilience.*

Many projects which are in the development stages of execution would need to be built higher. In several cases, this means increasing the elevation of the proposed asset. For existing assets that have already been built, the adaptations are more complicated, requiring mechanical or structural modifications to existing buildings and points of susceptibility. These remedial adaptations tend to be more expensive as a percentage of a given project. For example, some buildings would require the installation of watertight mechanical doors to reduce flooding in susceptible lower floors which hold key electrical equipment or servers that support the County's emergency management operations. However, many of these remedial adaptation measures are cost-effective when compared to the potential losses. As shown by recent tropical storms the costs to repair and rebuild an asset can be several orders of magnitude more expensive than preventing the damage with protective measures.

> *"We were designing the new Ocean Rescue Station when the RAP Team contacted us. While meeting with them, we realized that we could increase the resilience of the new station significantly by raising the elevation of the building an additional 2.5 to avoid sea level rise and reduce storm surge impacts."*
>
> *- Angel Lamela, Architect*
> *Fire Rescue Department*

*To assess potential losses the project team used a damage assessment method based on the Federal Emergency Management Agency's (FEMA) Hazus approach. Using this method, this study found the potential losses to the 28 selected exposed CIP projects exceeds **$24 million.***

To assess the potential costs to adapt these vulnerable CIP projects the project team estimated ***$6.3 million*** *in project revisions. These revisions are based on the estimated costs of reducing the exposure to inundation. Due to the variety of projects in the CIP and the high-level of analysis required within the defined timeline, this project was only able to establish very preliminary cost estimates. Where possible, these potential adaptation measures have been described in this report. Each Department will now need to evaluate in greater detail whether these project modifications make sense for their projects.*

This analysis was standardized so it can be applied future CIP projects and provide a systematic, justifiable framework for project prioritization and modification with respect to these two climate change components. However, because the CIP is funded by many different sources, funding these adaptation measures will require a variety of funding sources. Several projects are listed in the local mitigation strategy (LMS), which will have a onetime infusion of funds due to a recent storm event. However, Departments must include their projects in the LMS in order to be eligible for these federal funds. There are also Congressional funds, such as, the HUD Community Development Block Grant DR-Disaster Relief (CDBGDR). The state of Florida will be planning and working to allocate $1.4 billion of such funds, some of which may be eligible for Miami-Dade County projects. This is a new source of funds, that will be available to the County. The type of planning presented in the RAP will allow the County to better compete for and appropriate these resources.

This study considers what Miami-Dade can do ***today****, to address existing CIP projects and existing assets. In the future an Enhanced Capital Plan will be prepared which will look at the needs for future CIP investments. The Enhanced Capital Plan will determine actions for the future following the procedures presented here. Having a standardized, defendable approach will reliably illustrate both criticality and vulnerability to funding agencies as capital is planned and requested from all sources.*

1. Introduction

Miami Dade County is one of the most vulnerable geographic locations in the world with respect to sea level rise and storm surge. The frequency of severe weather further exacerbates that vulnerability and increases the need for well-informed planning and well-protected infrastructure. As part of that planning, the County has been very active in the Southeast Florida Climate Compact (Compact). The Compact has developed a Regional Climate Action Plan and developed regional sea level rise projections. The County also passed Resolution No. R-451-14 in 2014 requiring that all of the County's capital projects consider the impact of sea level rise based on these projections.

This Miami-Dade County Rapid Action Plan (RAP) is intended to develop a standardized process by which the County can assess the resilience of its existing assets and planned capital projects. This effort focused on quickly evaluating the vulnerability of County's own critical facilities and projects in the Capital Improvement Program (CIP). This project utilized Light Detection and Ranging (LiDAR) technology and Geospatial Information Systems (GIS) data to determine vulnerability. This project also relied upon input from Department staff to help determine the criticality rankings which were then used to prioritize projects.

Ultimately, the goal of this effort was to create a standard approach to evaluate future projects and ensure they are protected against the future flooding hazards.

2. Methods and Material

This RAP was developed using the following steps:

1. Establishment of Geospatial Information and Inundation Vulnerability
2. Establishment of the Project/Property Criticality
3. Estimation of Damage Costs
4. Estimation of Adaptation Costs

Establishment of Geospatial Information and Inundation Vulnerability

This portion of the project was developed using the following information and data sets from the identified sources:

1. County GIS Geodatabase: Miami-Dade County Department of Regulatory and Economic Resources
2. 2015, 5-foot Digital Elevation Model (DEM), developed from LIDAR data: Miami-Dade County Department of Regulatory and Economic Resources
3. 2016 Capital Plan: Miami-Dade County
4. Sea Level Rise Projections: South East Florida Regional Climate Change Compact Unified Sea Level Rise Projection (3 foot)
5. Storm Surge Predictions for Miami-Dade County, Category 5, Direct Hit: Based on modeling completed by consultants for MDWASD 2017 projections.

Other information was used from the South Florida Water Management District and the Florida Climate Institute. Several meetings were held with Miami-Dade County department-level staff to discuss their knowledge of their facilities' vulnerabilities to flooding and their projects criticality. Representatives from Emergency Management, Risk Management (ISD), the GIS team within ITD, and the Office of Resilience were also in each departmental meeting to identify ways to better collaborate.

This study did not include all County-owned assets. Some Departments were excluded because they are pursuing their own adaptation efforts, such as MDWASD. Others were excluded because their assets are less critical in the event of an emergency. The Departments included in this evaluation are:

1. Aviation (Miami International Airport)
2. Seaport
3. Internal Services
4. Parks, Recreation and Open Spaces
5. Fire Rescue
6. Solid Waste Management
7. Transportation & Public Works
8. Public Housing and Community Development
9. Police

The first step in the process was to use GIS to accurately identify the parcels owned by the County and overlay the elevation data. The County had an existing Digital Elevation Model from recent LiDAR which provides high-resolution ground topography information, similar to a survey. All elevations used in this project are in the NAVD88 Vertical Datum System. Existing GIS information contains detailed geo-spatial information about the County's assets including property value.

In the second step, GIS layers for groundwater/surface water levels representing sea level rise and storm surge amplified by sea level rise were overlaid to determine the areas that would be affected by each flooding hazard. As an example, **Figure 1** illustrates the location of all the Fire Rescue assets, with respect to countywide sea level rise and storm surge levels.

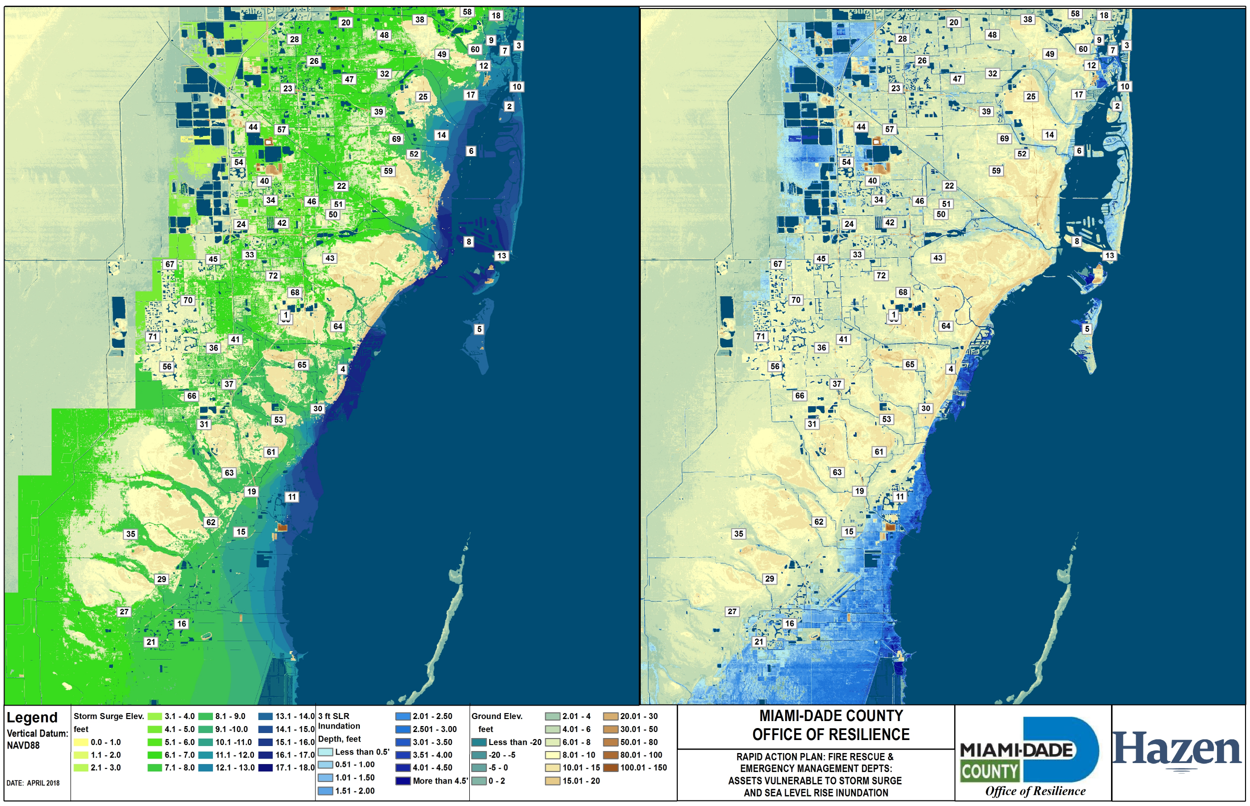


Figure 1: Fire Rescue/Emergency Operations Assets Vulnerability

Storm surge (**Figure 1, Left**) vulnerability, as expected, occurs primarily at properties along or near to the coast. Sea level rise (**Figure 1, Right**) vulnerability analysis indicates coastal effects as well, but also shows the susceptibility of inland areas where ground elevations are low with respect to sea level. This is also expected given the high transmissivity/porosity of the ground in South Florida and the interconnected water management network. While this study did not include the risk of flooding due to high groundwater levels or heavy rainfall, detailed information about these hazards exists and should be included in any subsequent study.

The next step was to look more specifically at properties with planned capital improvement projects. **Figures 2 and 3** provide examples of the vulnerability of specific Fire Rescue projects**.** As these figures show, in some cases only a small part of the property may be exposed to flooding, but it is important to look at how each building (or project) within that property will be impacted and determine the expected water levels. These figures include an Internal Services Department project for Fire Rescue at the centralized Information Technology Department building which is part of a dispatcher backup system for Fire Rescue/Emergency Management. Planners should note that the localized conditions on each property are very important to understand inundation issues. The high resolution of the LiDAR data allows for detailed analysis of potential project inundation and project access during and after events.

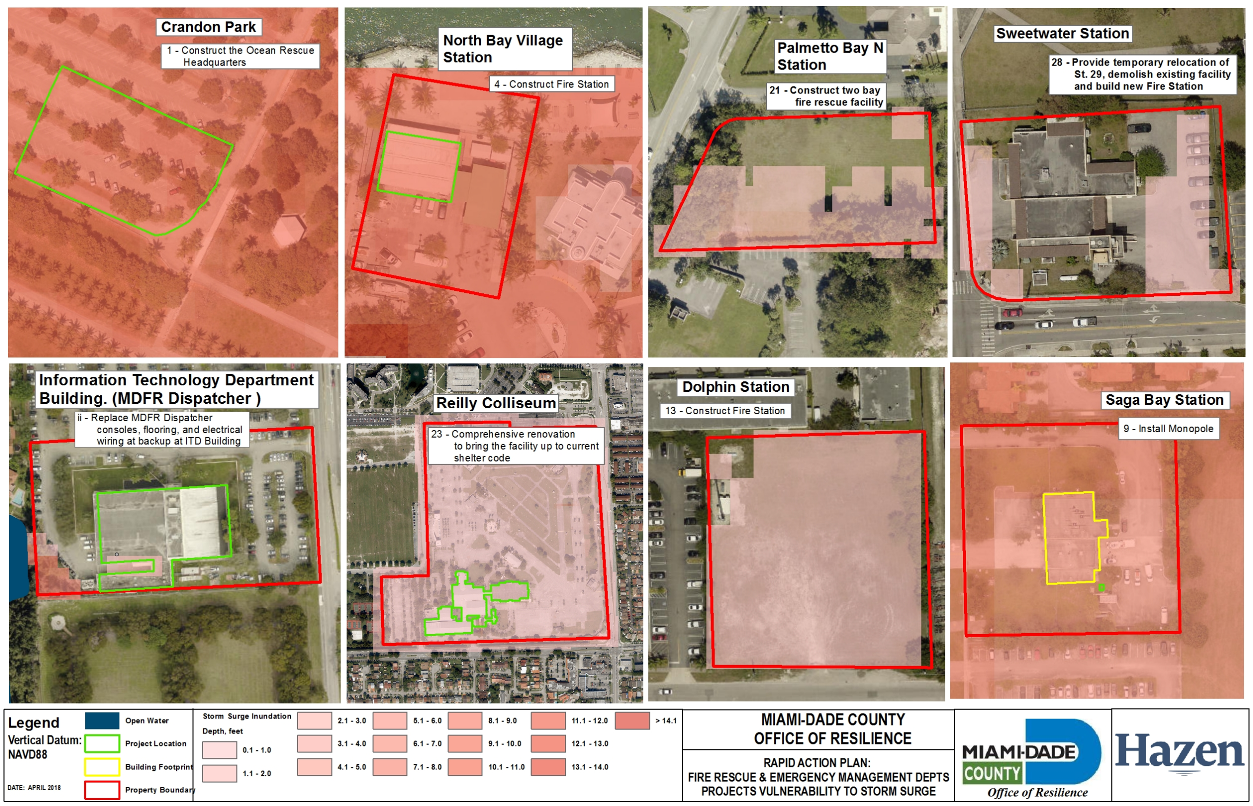


Figure 2: Storm Surge Vulnerability of Fire Rescue/Emergency Operations Projects

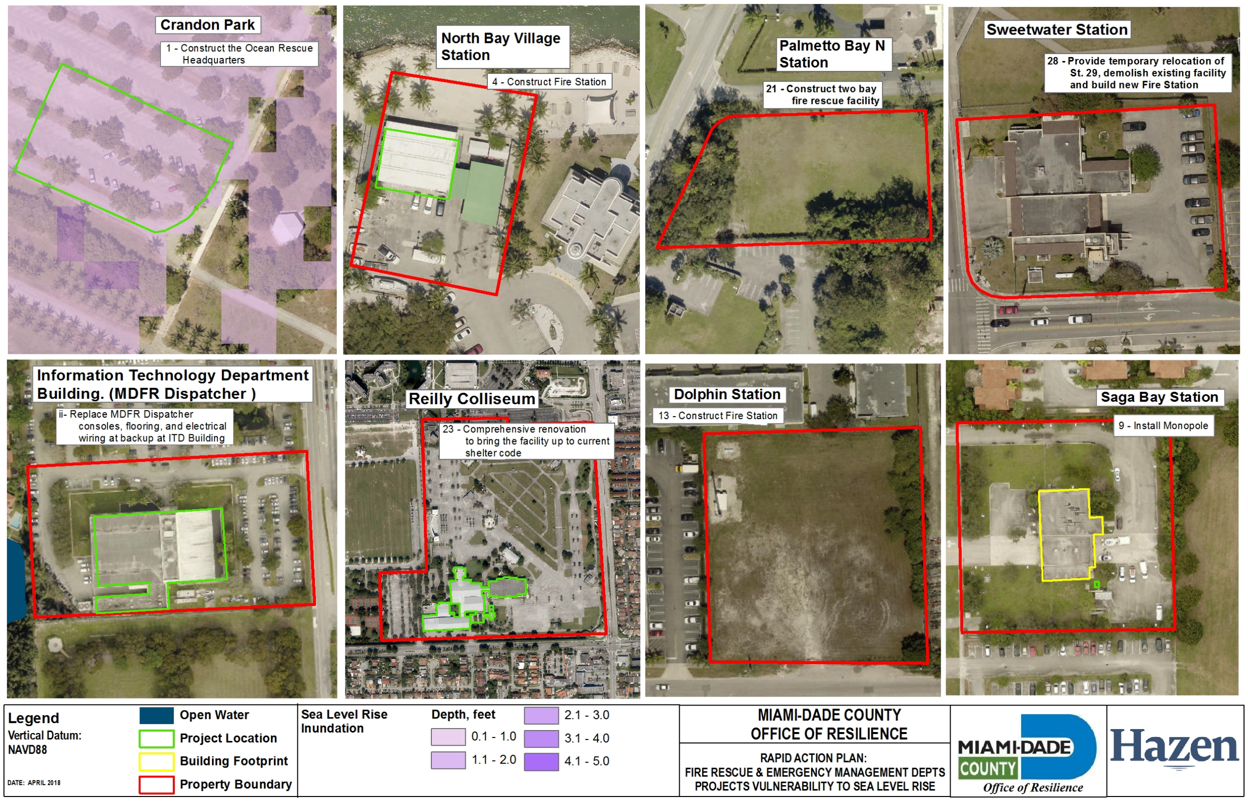


Figure 3: Sea Level Rise Vulnerability of Fire Rescue/Emergency Operations Projects

Figures 2 and 3 illustrate the approach used to further identify vulnerability within a property. The red outline delineates are the property boundaries for each location while the yellow and green lines delineate the building and project locations on those properties. The shading in the figures indicate the depth of storm surge and sea level rise flooding. For example, North Bay Station is expected to experience storm surge across the entire property whereas other stations are only partially affected.

The next step was to determine a vulnerability score for each property, which was assessed by combining its exposure to sea level rise (SLR) and storm surge (SS). To account for the spatial variation of the SLR and SS coverages used in the evaluation, each property was divided in 25-foot by 25-foot grid cells. The SLR exposure for each cell was determined directly from the SLR depth file provided by the County. Each cell was classified in three groups: 1) not exposed, 2) between 0.01 to 2-foot exposure and 3) more than 2-foot exposure.

A similar procedure was applied to the SS evaluation. In this case the SS exposure included a calculation of the SS depth at each cell based on SS elevations and the DEM provided by the County. The SS exposure was classified as follows: 1) not exposed, 2) between 0.01 to 2-foot exposure, 3) between 2.01 and 5-foot exposure and 4) more than 5-foot exposure.

These classifications, made at a grid level, were summarized for each property to identify the total area within the property that fell within each class. Water bodies such as canals and lakes were excluded from the summary and were not used to calculate the percent of the property exposed to each hazard. These percentages were then used to calculate a "Vulnerability Score". This score, which is a number from zero to five, indicates the level of exposure of the property. A score of 5 indicates that the 100% of the property is exposed to more than 2 feet of SLR and more than 5 feet of SS inundation. A score of zero indicates the property is not exposed to SLR or SS inundation. The resulting values were combined to develop a vulnerability score and ranking for each location, by department property/asset. These values are shown in the attached examples in **Appendix D**, which contains the complete set of values produced for all the Departments included in the evaluation.

Establishment of Project/Property Criticality

While the criticality of each facility depends on the particular emergency, this project created a generic criticality score for all assets and projects across departments. Initial scores were developed by Hazen and Sawyer and subsequent meetings with several staff members from each department were used to refine these estimates and more accurately determine their projects' criticality. After the projects were ranked, additional meetings were held with Departments to obtain project details such as project location, elevation and construction materials.

The final step in developing the RAP project prioritization list was to combine the vulnerability of the property with the criticality of the asset.

The combined score was the result of multiplying the **project criticality score** by the **vulnerability score of the property** hosting each project. Planners should note that **projects** and their importance (criticality) are independent of the **property** and its intrinsic exposure to sea level rise and storm surge (vulnerability). The full project list is shown in **Appendix B** which presents assets sorted both alphabetically and by their Criticality/Vulnerability Score.

Estimate of Damage Costs

Once the key CIP projects were identified the potential damage from not protecting them was calculated. Estimated damage costs were prepared for the 28 projects that were shown to be the most vulnerable and critical. These projects are presented in **Appendix A.** Select projects are also discussed in the following section**.**

The loss estimates were based upon the overall estimate of project costs which was determined by the owner-agency (Department). The project component losses were derived as a percentage of those overall project costs. Due to the diverse nature of the costs, the first step in the definition of those costs was to clearly define the scope of each project. Planners should note that the RAP includes the loss of the value of the project component, or portion of the proposed project, in question. In larger scale efforts, such as the Enhanced Capital Plan, the project itself may be a component of the asset. For example, an information technology project loss may only be a portion of a vulnerable building loss. These differences should be understood to accurately estimate the asset level, building level and facility level of a given "Capital Project". In the example the CIP would include the adaptation for the project loss not the building loss which should be considered in broader analyses like insurance surveys and the LMS. This was done in the RAP through meetings with each Department and follow up discussions. A coding system was used to determine the type of project evaluated (i.e., New Building (NB), Building Upgrade (BU), Building Component (BC), and Miscellaneous (MC)).

The Federal Emergency Management Agency (FEMA) utilizes a Multi-Hazard Loss Estimation Methodology (HAZUS) model to calculate the losses of several different types of assets. This approach was reviewed to develop an estimated loss for the 28 priority projects in the RAP. To estimate damage the HAZUS methodology was used. This method utilizes standardized and unitized costs and assigns unitized costs based on categories. For example, a government emergency response facility (i.e., a police building), is first categorized as a "GOV 2" and then the unitized costs of construction corresponding to "GOV 2" (i.e., $166.59/ square foot) is applied. The unitized costs are based on square footage costs from a widely used source for building cost (RSMeans, 2006).

Due to locally higher construction costs (caused by the need to build to protect against potential severe weather events that impact South Florida), these values significantly underestimate the building cost of governmental facilities in Miami-Dade County. Therefore, unitized prices for new buildings include hardening costs and construction methods (i.e., concrete block, impact windows, and roofing) typical of the region. Thus, the estimate for building costs was adjusted to $300/square foot. This value is based on Engineer's local experience for municipal buildings in compliance with Florida Building Code. The primary loss estimating mechanism employed under the HAZUS approach is Depth-Damage curves. These curves established percent loss (i.e., 50%) based on the depth of flooding (i.e., 8 feet) at a given facility. **Figure 4** presents the original HAZUS inundation/loss estimation curves. However, the curves developed for the HAZUS methodology do not match the type of structures seen in South Florida. For example, they included calculations for damages in basements, which explains damages for negative inundation depths. Therefore, a modified curve was developed for this study. This modified curve is shown with a green line in **Figure 4**.

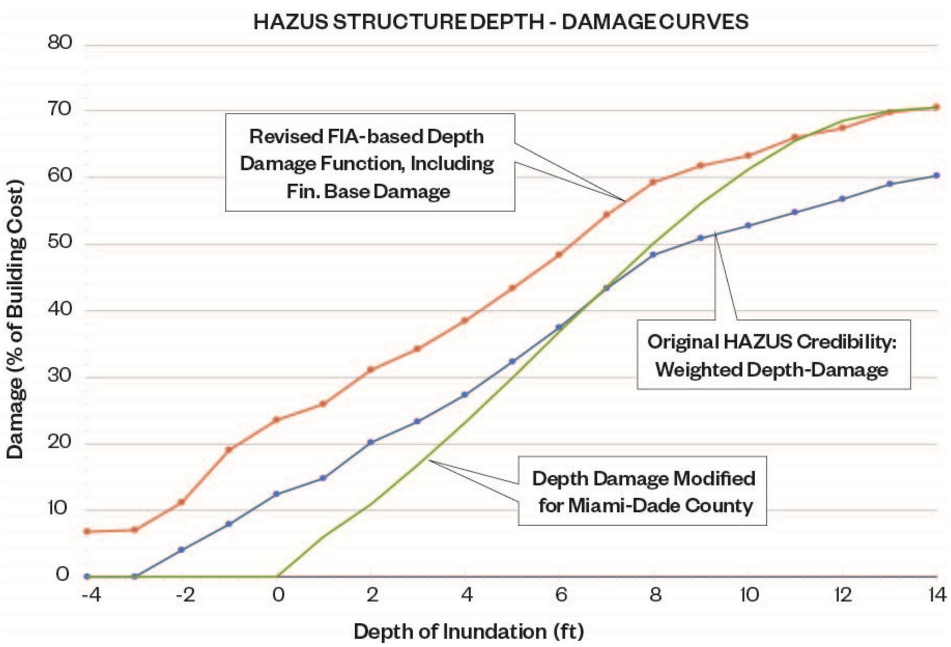


Figure 4: HAZUS Structure "Depth-Damage" Curves

The values in the modified curve were used to estimate the RAP losses. In many cases, a standard unitized approach like this could not simply be applied without specific understanding of the particular project. Case by case estimates for damage were developed for those projects based on engineering judgment. **Appendix**

A presents these data in full and **Table 1** on page 9 presents an excerpt from that table for Fire Department projects.

Estimate of Adaptation Costs

Adaptation costs were established based on unitized "percent of construction" costs for given resiliency hardening approaches. This approach may include asset, building and/or facility level adaptations. An adaptation at the asset level may include the addition of water tight doors, elevated electrical panels, and other improvements based around a given piece of equipment or project element. These costs are between 1.0 and 5.0 percent of construction per foot of elevation change. This range is estimated based on a review of estimated cost changes to similar facilities in South Florida (i.e., Broward County). Adaptations at the building or facility level may include raising the building finished floor elevations. Such larger improvements typically incur costs related to more than one discipline (i.e., civil site work, structural, electrical, plumbing, IT and telecom, etc.). These costs are between 0.5 and 1.0 percent of construction per foot of elevation change. These ranges are also based on changes to facility design in South Florida. The use of each approach is determined by the nature of the construction (i.e., New Building (NB), Building Upgrade (BU), Building Component (BC), and Miscellaneous (MC)). Adaptations for the current group of projects were primarily done on a case by case basis based on the nature of the construction activity. Select projects and adaptations are presented in the following section. **Appendix A** presents these data for all RAP projects and **Table 1** on page 9 presents an excerpt from that table for Fire Department projects.

Table 1: Fire Department Projects - Evaluation, Damage and Adaptation Costs Estimation

No.	Facility Project Title (Fire Rescue and Emergency Management)	Sea Level Rise Inundation Depth (ft.)			Storm Surge Inundation Depth (ft.)[1]			Exposure to Sea Level Rise		Exposure to Storm Surge[1]			Vulnerability Score	Criticality Facility / Project[3]	Vulnerability x Criticality	County-wide Ranking Based on Vulnerability x Criticality Score	Source	Host Property Value 2016 (As Per Folio) (Dollars in thousands)	Project Cost (Dollars in thousands)[4]	Project Cost (Dollars in thousands)[4]	Project #[4]	Nature of Construction	Estimated Loss (Dollars in thousands)[7]	Estimated Adaptation Cost (Dollars in thousands)
		Min	Max	Mean	Min	Max	Mean	% Exposed between 0.01 ft. and 2 ft.	% Exposed >= 2 ft.	% Exposed between 0.01 ft. and 2 ft.	% Exposed between 2 ft. and 5 ft.	% Exposed >= 5 ft.												
1	Key Biscayne: Construct Ocean Rescue facility at Crandon Park	0.24	0.88	0.49	7.78	11.74	9.63	100.0%				100.0%	4.00	5	20.00	1	CIP	38,746	$2,900	$2,900	376760	NB	$422	$114.3
4	St. 27 North Bay Village*: Replace temporary station at Pelican Harbor	0.00	0.44	0.03	9.97	10.49	10.18					100.0%	3.00	4	12.00	8	CIP	3,475	$2,900	N/A	377840	NB	$1,740	$114.4
9	St. 55 Saga Bay: Install monopole at Station 55 Saga Bay6	0.00	0.00	0.00	4.89	4.89	4.89				100.0%		2.00	4	8.00	15	CIP	884	$100	$100	2000000705	BC	$29	$7.3
13	St. 68 Dolphin: Construct three bay fire rescue facility	0.00	0.00	0.00	0.00	0.67	0.33			94.4%			0.94	5	4.72	20	CIP	1,526	$4,000	$4,000	10420	NB	$129	$19.5
21	St. 62 Palmetto Bay: Construct two bay fire rescue facility	0.00	0.00	0.00	0.00	2.17	0.45			46.5%	4.7%		0.56	5	2.79	31	CIP	496	$4,776	$4,776	375681	NB	$177	$32.4
23	Reilly Coliseum: Comprehensive renovation to bring the facility up to current shelter code	0.00	4.46	0.01	0.00	5.55	0.22	0.1%	0.2%	52.9%	0.1%	0.0%	0.54	5	2.68	33	LMS	8,787	$1,175	$1,175		BU	$33	$3.9
28	St. 29 Sweetwater: Provide temporary relocation of Station 29, demolish existing facility and build new Miami-Dade County fire station due to FDOT widening of SW 107 Ave	0.00	0.00	0.00	0.00	0.63	0.07			29.4%			0.29	5	1.47	51	CIP	568	$5,500	$5,500	5410	NB	$127	$5.6

No.	Improvements to the Data Processing Center[2]																							
i.1	ITD: Collaboration Room Interior: Expand Vault Room within a portion of an existing 1st Floor space approximately 912 sq. ft. in size ITD NOC: Command Center Interior Refurbishment within a portion of an existing 1st Floor space approximately 2,000 sq. ft. in size	0.00	0.00	0.00	0.00	0.00	0.00						0.00	5	0.00	1	CIP	$10,328.89	$0	$466 $164	115820	BC	$0	N/A
i.2	**UPS Replacement**	0.00	0.00	0.00	0.00	0.00	0.00						0.00	5	0.00	1	CIP			$302		BU	$0	N/A
ii	**ITD Building 2: Replace MDFR Dispatcher consoles, flooring, and electrical wiring at backup**	0.00	0.00	0.00	0.00	0.00	0.00						0.00	5	0.00	1	CIP			$500	2000000587	BU	$0	N/A

1 Storm Surge projected for a Cat. 5 Hurricane in the future accounting for sea level rise
2 These assets/projects were ranked based on their criticality and were not assessed in the same manner as the other projects
3 Criticality based on input received from MD County Departments
4 Cost and Project # obtained from database listed in Source Column
5 Adaption Cost includes sealing gates for grade level assets
6 Project costs assumed by HS
7 Cost of Damages estimated based on depth of flooding according to HAZUS methodology
**Fire Rescue will lease the property, values assumed from Ocean Rescue Headquarters project*

NB: New Building
BU: Building Upgrade
BC: Building Component
MC: Miscellaneous

Resilient Project
Sea Level Rise Inundation depth exceeding 3 FT indicates the site or portion thereof is currently below sea level.
Most Vulnerable/Critical to Least (Left to Right)

3. Discussion and Results

The goal of this project was more than simply producing the RAP for the immediate-term capital improvement plan. This project developed an approach to analyzing large data sets and GIS/DEM information to effectively prioritize capital improvement projects. The combination and indexing of vulnerability scoring from both sea level rise and storm surge perspectives was valuable in determining the potential impacts to properties. The use of the DEM, built from LIDAR data, in addition to the indexed value allowed the analysis to include specific project locations on vulnerable properties. Although this was not an adaptation strategy used for the RAP, it would allow site specific, relocation of projects to less vulnerable portions of a given property to be employed or to relocate projects to other, less exposed parcels.

Additional meetings were held with Departments to obtain project details after ranking projects by property vulnerability-criticality. The information provided was location, elevation and construction materials among other data.

Some examples of projects reviewed with the Departments are described below.

3.1 Fire Rescue

Project 1: **Construct Ocean Rescue Facility at Crandon Park**
Location: Crandon Park

- This project is currently under design phase. The facility will be the lifeguard's headquarters holding life boats and will be located close to the shore line. The Department provided elevation information from design drawings showing an average grade elevation of 4.5 ft. NGVD29 (2.96 ft. NAVD88), and first floor elevation of 11.5 ft. NGVD29 (19.96 ft. NAVD88).
- The vulnerability analysis exhibits an average inundation depth of 9.63 ft. under storm surge conditions (**Appendix C, Figures C1 and C-2**).
- The Fire Rescue Architects raised the original design by 2.5 ft, which is the maximum allowed as per the handicap ramp design constrains. This will avoid the sea level rise risk of inundation and minimized the storm surge impact to the facility.
- **Appendix F.1** presents project survey and drawings.

> *"We were designing the new Ocean Rescue Station when the RAP Team contacted us. While meeting with them, we realized that we could increase the resilience of the new station significantly by raising the elevation of the building an additional 2.5 to avoid sea level rise and reduce storm surge impacts."*
>
> *- Angel Lamela, Architect*
> *Fire Rescue Department*

Project 2: **Replace Temporary Station at Pelican Harbor**
Location: Station 27 North Bay Village

- This facility is currently under preliminary design and the Fire Rescue Department will lease the building.
- The vulnerability analysis exhibits an average inundation depth of 10.18 ft. under storm surge conditions with average storm surge elevation of 14.64 ft. NAVD88 (16.18 ft. NGVD29). This information provides grounds for the department to request a design with the adequate elevation for these conditions **(Appendix C, Figures C1 and C-2**).

Project 3: **Construct Three Bay Fire Rescue Facility**
Location: New Dolphin Station

- This project is under design phase. The lot average grade elevation is approximately 6 ft. NGVD29 (4.46 ft NAVD88), and the street elevation is at 7.5 ft. NGVD29 (5.96 ft NAVD).
- The storm surge scenario exhibits an inundation depth of 0.33 ft. (**Appendix C, Figures C1 and C-2**)
- Since the current base flood criteria requires that the facility be raised 3 ft. above street level, the design already exceeds the elevation required to avoid inundation. This is an example of a resilient project.
- **Appendix F.2** presents project survey and drawings.

Project 4: **Replace MDFR Dispatcher Consoles, Flooring, and Electrical Wiring at Back-Up Location (ITD Building)**
Location: ITD Building

- This facility's loading dock has experienced storm flooding in the past. However, the sea level rise inundation scenario does not show any risk of flooding to the facility. The storm surge scenario exhibits an average inundation depth estimated at 0.89 ft. at the loading dock area, and the first floor elevation is at 11.0 ft NGVD29 (9.46 ft NAVD88) (**Appendix C, Figures C-1 and C-2**). This building is not at risk of sea level rise or storm surge inundation.
- Appendix F.4 presents the building elevations.

3.2 Internal Services

Project: **Refurbish Existing Emergency System and Replace Generator at the Miami Dade County Court House**
Location: Miami-Dade-County Court House

- The project is in an area susceptible to an average storm surge inundation depth of 8 ft. (**Appendix C, Figures C6 and C-7**).
- The generator and the automatic transfer switch may have been installed at an elevation lower than 8 ft. from grade. The Department should confirm these elevations and then raise generators and other key electrical components as needed. Mechanical adaptation may also be needed.

3.3 Solid Waste Management

Project: **Design and Construct an Active Gas Extraction System to the East Cell**
Location: North Dade Landfill

- This project is required by the Florida Department of Environmental Protection and is located at the south east corner of the property near the confluence of the Snake Creek Canal and the Oleta River.
- The storm surge scenario exhibits an average inundation depth of 0.43 ft. above ground, or a storm surge of 6.43 ft NAVD88 (7.97 ft NGVD29).
- The design should raise the elevation one foot to reach a resilience level for the project.

3.4 Parks, Recreation and Open Spaces

Project: **Replace Bear Cut and West Bridges on the Rickenbacker Causeway**
Location: Rickenbacker Causeway

- The Department has allocated $143 million. The project includes widening and elevating the bridge.
- The design already includes storm surge elevation scenarios and adequate materials that make this project resilient.

3.5 Aviation

Project: **Build New MIA Fuel Tank**
Location: Miami International Airport

- This project is located at the most vulnerable part of the Airport, where the storm surge scenario exhibits an average inundation depth of 1.6 ft. This is equivalent to an average storm surge inundation elevation of 6.29 ft NAVD88 (7.83 ft NGVD29).
- The tank's elevation is a sensitive matter because the fuel system works by gravity.
- The Fuel System has operation elevation constrains. However, the Aviation Department is committed to addressing the inundation risk. They will elevate the tank up to 2 ft above grade and will build protection walls around the tanks if necessary. This additional 2 ft in elevation will provide protection to the facilities and will avoid sea level rise and storm surge impact.

> *"When we met with the RAP Team it appeared the new Fuel Tank project would need some adaption. However, while reviewing the project we realized that the new design elevation eliminates the risk of sea level rise and storm surge impact."*
>
> *- Pedro Hernandez, PE., Assistant Director, Facilities, Development Division - Aviation Department*

The RAP loss and adaptation cost estimating approach allows for high level, order of magnitude budget impacts to be included in decision-making. The unitized loss pricing based on the HAZUS methodology is based on generally accepted principles and can be further developed through subsequent projects for specific Miami-Dade conditions. The current "percent of construction" approach to adaptation estimates can also be refined to suit the varying types of projects (i.e., New Building (NB), Building Upgrade (BU), Building Component (BC), Miscellaneous (MC)) undertaken by the county.

This project also brought-out the factors that make this type of county-wide analysis difficult but informative. Some county departments have limitations to adaptation by the very nature of their core mission and primary customers/constituents. The Port and Aviation departments are two such cases. Several of the improvements and projects being executed at the Port are directly related to the requirements and needs of their customers (i.e., cruise and cargo companies). The ships and their operations create specific conditions that must exist for continued operation. Access to portion of the vessels creates the need for certain elevations at those facilities. The Aviation Department has similar constraints from concourse levels to plane doors and the jetway capabilities. In reviewing these departments and their projects, the need for resiliency became obvious. However, developing an approach to addressing viable alternatives and estimating the costs would require detailed review of the constraints and the design of the facilities. For this reason, the RAP does include these facilities, but not the cost factors.

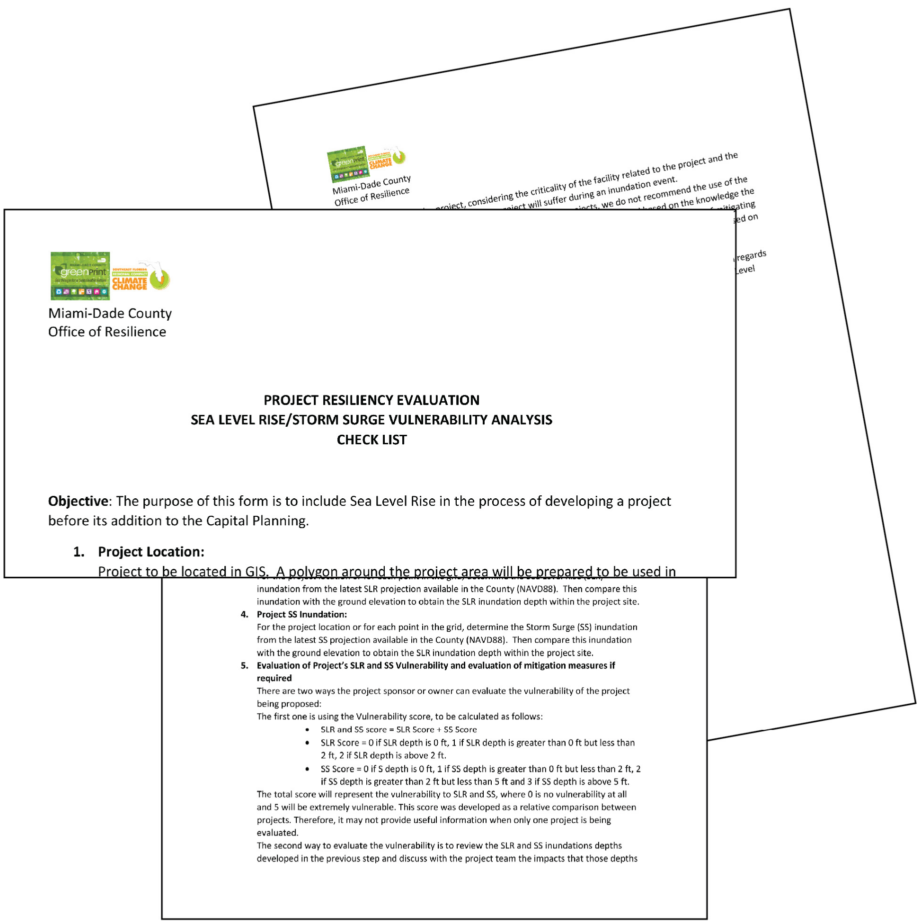
The projects that were well developed, and could readily be scoped, were reviewed and cost estimated using the procedures identified earlier in this plan. One comprehensive example is the Department of Fire Rescue/Emergency Operations, Ocean Rescue Facility on Key Biscayne, in Crandon Park. This facility, as designed, would have had an inundation depth of 5.13 feet (storm surge). This inundation depth would have resulted in a HAZUS loss percentage of 30.83% with a total loss of $894,000. Based on the RAP Team meeting with the Department, a design change was made to increase the elevation of the facility to reduce the inundation depth to 2.63 feet. Additional adaptations were included, such as flood vents, to reduce surge impacts. The change in elevation alone reduces the potential losses to $422,000 and the adaptation costs to $114,000. The reason the complete change in elevation was not designed into the revised facility is that the requirements for handicapped access necessitate control elevations below the storm surge levels. Those requirements may be overcome by additional adaptations; therefore, this project was still included in the RAP and costs were associated with those improvements.

The overall RAP marginal cost increase, recommended to the current CIP, for the projects where all the data is available and applicable, is $6,305,000. This amount will protect $158,860,000 in projects with loss estimates of $24,078,000 for the prioritized projects. It is important to note these costs and avoided losses are related to the capital project proposed. The cost to the economy may be much higher, especially when interrupted activity occurs at certain economic engines such as the Seaport and Aviation departments.

4. Conclusion

The RAP projects are a cross-section of the types of projects the County performs with varying degrees of both vulnerability and criticality. The largest challenge to evaluating the projects is attempting to develop detailed descriptions of the projects at differing levels of development. For this reason, a checklist was prepared and presented in **Appendix E - Project Resiliency Evaluation**. This checklist should be followed and submitted with all capital projects. Estimated resiliency cost increases should be recorded to form a database of estimated and actual bid prices for project components.

Using the state-of-the-art tools available, the RAP Team determined that more than 45% of the assets in the county were vulnerable to significant impacts by sea level rise and storm surge inundation. Based on the values presented herein vulnerable capital projects are exposed to losses of approximately 15%. These losses can be mitigated with 4% increases to those budgets. Planners should note many of the adaptations considered would protect future projects, as well as, the original modification. For example, raising a building to eliminate sea level rise impacts for one project will prevent loss/damage for all future projects from this threat.


Miami-Dade County
Office of Resilience

PROJECT RESILIENCY EVALUATION
SEA LEVEL RISE/STORM SURGE VULNERABILITY ANALYSIS
CHECK LIST

Objective: The purpose of this form is to include Sea Level Rise in the process of developing a project before its addition to the Capital Planning.

1. **Project Location:**
   Project to be located in GIS. A polygon around the project area will be prepared to be used in

inundation from the latest SLR projection available in the County (NAVD88). Then compare this inundation with the ground elevation to obtain the SLR inundation depth within the project site.

4. **Project SS Inundation:**
   For the project location or for each point in the grid, determine the Storm Surge (SS) inundation from the latest SS projection available in the County (NAVD88). Then compare this inundation with the ground elevation to obtain the SLR inundation depth within the project site.
5. **Evaluation of Project's SLR and SS Vulnerability and evaluation of mitigation measures if required**
   There are two ways the project sponsor or owner can evaluate the vulnerability of the project being proposed:
   The first one is using the Vulnerability score, to be calculated as follows:
   - SLR and SS score = SLR Score + SS Score
   - SLR Score = 0 if SLR depth is 0 ft, 1 if SLR depth is greater than 0 ft but less than 2 ft, 2 if SLR depth is above 2 ft.
   - SS Score = 0 if S depth is 0 ft, 1 if SS depth is greater than 0 ft but less than 2 ft, 2 if SS depth is greater than 2 ft but less than 5 ft and 3 if SS depth is above 5 ft.

   The total score will represent the vulnerability to SLR and SS, where 0 is no vulnerability at all and 5 will be extremely vulnerable. This score was developed as a relative comparison between projects. Therefore, it may not provide useful information when only one project is being evaluated.
   The second way to evaluate the vulnerability is to review the SLR and SS inundations depths developed in the previous step and discuss with the project team the impacts that those depths

Figure 5: Project Resiliency Evaluation – Sea Level Rise/Storm Surge Vulnerability Analysis – Checklist