APPENDIX Q:

Loss Avoidance Report

Hurricane Hermine

Hurricane Hermine (DR-4280)

Loss Avoidance Assessment

Monday, 24 April 2017

Florida Division of Emergency Management
255 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
http://www.floridadisaster.org

Rick Scott, Governor
Bryan Koon, Director
Miles Anderson, State Hazard Mitigation Officer

[Page intentionally left blank.]

CONTENTS

TABLES

FIGURES

MAPS

APPENDICES

[1] County reports generated for counties with several flood mitigation projects impacted.

DEFINITIONS

The following definitions clarify the use and meanings of certain terms in this Loss Avoidance Assessment.

Area of Impact: Also known as the damage area or damage swath, within which damage is expected to have occurred as the result of a disaster event. The area of impact is dependent upon the type of hazard, and is defined differently for precipitation, storm surge, riverine flooding, and wind.

Building Modification Project: The term "building modification" has been adopted for this report to avoid conflicting terms used by other state and federal agencies. For example, the terms "non-structural" and "structural" are sometimes used to refer to the same projects, depending on the context. Therefore, for clarity, the term "building modification" is used in this report to refer to acquisitions, elevations, flood-proofing, mitigation reconstruction, and wind retrofits.

Current Dollars: Also known as "nominal dollars;" refers to dollars current to the year in which they were spent.

Depth-Damage Function (DDF): The mathematical relationship between the depth of flood water above or below the first floor of a building and the amount of damage that can be attributed due to the water. DDFs are also known as depth damage curves.

Direct Effect: Represents the initial impacts that occur as a result of an economic activity.

Drainage Project: Also referred to as "drainage improvement project;" any project that reduces minor localized flooding or improves the shedding of water from specified project areas. Examples include: installation of new retention areas; improvement or installation of culverts, drain pipes, or pumping stations; or slope stabilization or grading to direct water away from properties.

Employment: All full time equivalent jobs that are created or lost as a result of an economic activity.

Event: The incidence of a hazard that results in damaging impact to an area of the state. An event does not always have to result in a Presidential Disaster Declaration. For the purposes of this report, one event is assessed: Florida Hurricane Hermine (DR-4280).

Geographical Information Systems (GIS): A system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data.

IMPLAN: A private company that provides economic impact data and modeling for assessing economic impacts of project decisions in industry sectors.

Indirect Effects: The impact of direct economic effects on supporting industries, such as those that provide equipment and materials.

Induced Effects: The response to a direct effect that occurs through re-spending of income.

Labor Income: The expected combined income of employment in each industry sector generated by project implementation expenditures.

Losses Avoided: Those losses (total dollar value) that would have occurred without the mitigation measure being implemented. Also known as losses that would have occurred under the "Mitigation Absent" scenario.

Losses Avoided for Building Modification Projects: For the purposes of this assessment, the total of building, content, inventory, and displacement costs that would have occurred had the mitigation measure not been implemented.

Losses Avoided for Drainage / Special Projects: Can be calculated in two ways: 1) based on losses that have been recorded and documented in the project file for similar event return intervals in the past, normalized to present dollar amounts; and 2) the method used for this particular assessment, involves a modeling effort and is described in the *Loss Avoidance Methodology Appendix.*

Losses Avoided for Wind Projects: Similar to "Losses Avoided for Drainage / Special Projects," can be captured in two ways. The first is based on previous losses recorded and documented. The second method uses modeled outcomes based on information input into FEMA's HAZUS Multi-Hazard Loss Estimation software. The methodology used for this assessment can be found and described in the *Loss Avoidance Methodology Appendix.*

Net Present Value (NPV): The sum of losses avoided during all events assessed to date minus dollars spent in 2016 dollars.

Normalization: The process of converting dollar amounts from different years into a value that can be recognized and interpreted consistently. For this report, all dollar values have been normalized to 2016.

Occupancy Type: The use of a structure. Occupancy types used for this report include Agricultural, Commercial, Educational, Government, Hospital, Industrial, Religious, and Residential.

Project: An individual subrecipient award under which a mitigation measure has been implemented. A single project may have multiple project sites and locations. For example, one acquisition grant project may acquire multiple structures in different areas.

Project Cost: The total investment in project implementation; includes both federal and non-federal share at project completion. The project cost includes expected maintenance costs, when available.

Project Site: The location at which a mitigation measure is implemented. For building modification projects that involve multiple structures, project sites are analyzed individually for losses avoided because the same disaster event may have a different impact on different structures.

Real Dollars: Dollars normalized to present day values (2016). Real dollars are different from "current" or "nominal" dollars, which refer to the value of dollars current to the year in which they were spent.

Relative Share of Gross Domestic Product (GDP) Method of Cost Normalization: The cost normalization method used for this report; an appropriate method for normalizing dollars spent on public expenditures because it values public investment based on the size of the economy at the time of the investment. This method clarifies the value of the project at the time of investment as a share of the total amount of money available for investment in the country. It answers the question, "What was the public

investment's value?" with the question "How much of a share of GDP was spent on the public investment?"

Normalization through relative share of GDP can be described as follows:

$$\left(\frac{Cost_n}{Nominal\ GDP_n}\right) x\ Nominal\ GDP_y$$

Where:
n = Year of the cost incurred
y = Year prior to the present year
GDP = Gross domestic product

Recurrence Interval: Also referred to as return periods, defined as the inverse of the probability that the particular intensity of an event will be exceeded in any one year. For the purposes of this report, analysis was based on both flood and wind events. As an example, a 10-year event has a 10 percent chance of its intensity being exceeded in any given year and a 50-year event has a 2 percent chance of being exceeded in any given year. It is important This formula accounts for losses avoided lower than the project cost to avoid a negative ROI.

Special Project: Any project that does not fall within the context of drainage, building modification, or wind retrofit projects. These projects may be highly customized to the mitigation need and typically mitigate certain types of infrastructure. Examples include armoring coastal roadways or culvert retrofits.

to note that in any given 100-year period, a 100-year event may occur once, not at all, or multiple times as each outcome has a probability of occurring in every year.

Return on Investment (ROI): A factor of dollars saved (losses avoided) due to mitigation measures over the life of the investment. Losses avoided are considered an ROI because they represent money that is saved, as opposed to spent, due to the mitigation measure. ROI can help guide decision-making by identifying which investments have been cost-effective. For this report, this formula was used in calculating the ROI:

$$\frac{LA}{PC} = ROI$$

Where:
LA = Losses avoided in terms of any of the above normalization methods.
PC = Project cost
ROI = Return on Investment (%)

Wind Retrofit Project: Any project that that reduces the level of vulnerability of an existing structure to damage from wind and wind-driven rain intrusion during a high-wind event.

Wind Swath: A composite of wind ranges that represent the extent of hurricane, tropical storm, and strong winds.

EXECUTIVE SUMMARY

A loss avoidance assessment is a tool that analyzes the effectiveness of hazard mitigation projects, the results of which provide a return on investment (ROI) for public funds spent on these projects in the past. The ROI communicates the value of mitigation measures and informs future allocation of resources for their highest and best use. Assessing the performance of hazard mitigation is critical to substantiate the value of past mitigation efforts as well as assure prudent use of future resources.

The loss avoidance assessment demonstrates that mitigating the risk of natural hazards in Florida is a sound investment.

The Florida Division of Emergency Management (FDEM) conducts a loss avoidance assessment after each Presidential Disaster Declaration using real event data to assess the impacts that were prevented by past mitigation. Specifically, the assessment reports dollars saved due to mitigation measures (losses avoided), and calculates a ROI by comparing the cost of the project to actual losses avoided over time.

The Federal Emergency Management Agency Hazard Mitigation Assistance and the Hurricane Loss Mitigation Program, a state-funded program, provided funding for the flood and wind mitigation projects considered for this assessment. These were complete as of September 2016.

The State evaluated the effectiveness of 60 mitigation projects within the declared counties for DR-4280. Wind speeds reaching up to 70 miles per hour impacted wind retrofit projects in nine counties, and flooding from various sources impacted flood mitigation projects in eight counties. Impacted counties included Alachua, Dixie, Franklin, Gilchrist, Hillsborough, Jefferson, Lafayette, Leon, Levy, Madison, Manatee, Pasco, Pinellas, Sarasota, and Taylor. It is important to note that Hurricane Hermine may have impacted mitigation projects outside of the declared counties, which may be assessed for future events. Analysts only assessed projects within the declared counties for this assessment; therefore, savings likely exceeded those reported.

Hurricane Hermine impacted 31 of the 60 projects analyzed. The 31 projects had a combined capital cost of $9,776,270 in 2016 dollars. Without mitigation, damages to the project sites affected by DR-4280 would have cost approximately $20,694,240. The net present value for DR-4280 is $10,917,962, and the average ROI for the event is 82 percent.

The 60 projects evaluated in this assessment benefitted 110 structures, with all projects benefitting at least one structure and some projects, particularly drainage, benefitting multiple structures. Eight projects analyzed for Hurricane Hermine were also impacted by Tropical Storm Debby. The analysis integrates previous results into the

overall total of losses avoided to provide a net present value over the lifetime of this project, or a cumulative net present value and return on investment.

Loss avoidance assessments demonstrate the fiscal benefits associated with mitigation activities and support sound decision making related to public funding. Moreover, this assessment provides insight that FDEM and local communities can use to identify effective mitigation, improve mitigation strategies, and increase communities' resilience to natural hazards.

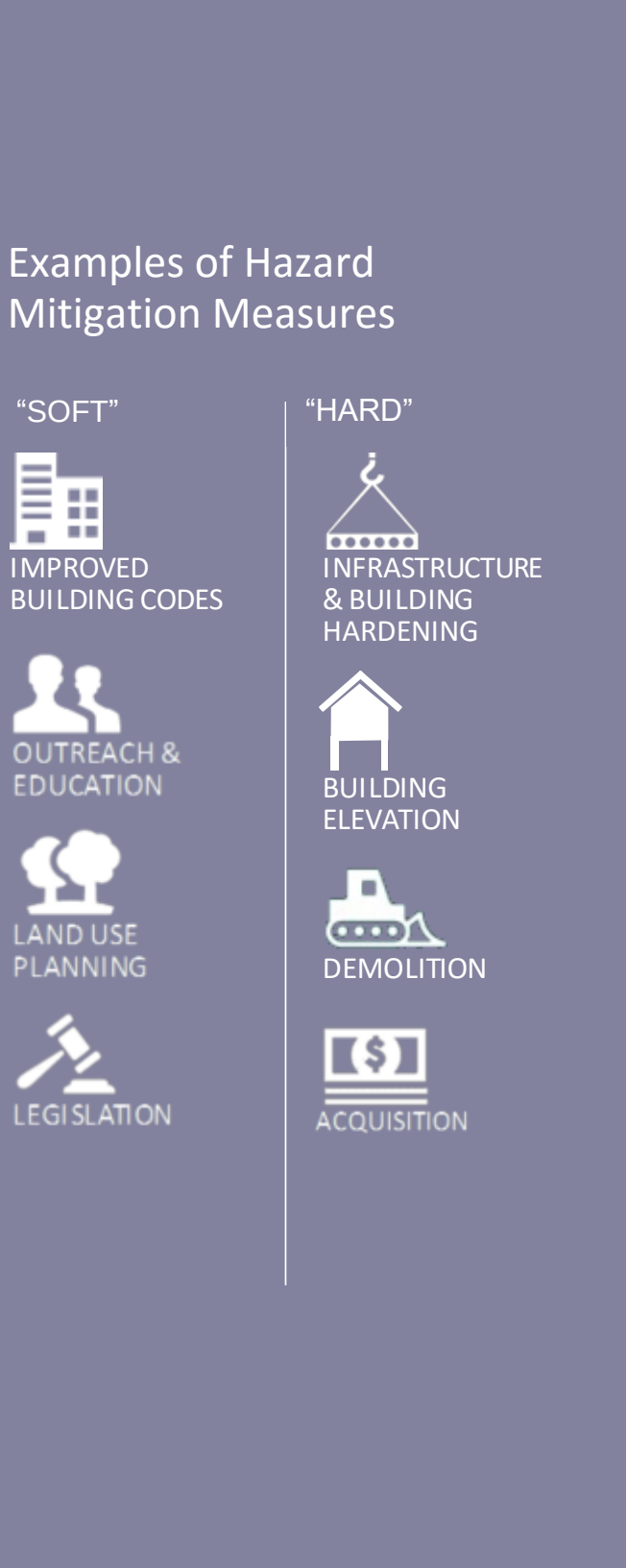
INTRODUCTION TO HAZARD MITIGATION & LOSS AVOIDANCE ASSESSMENTS

Natural hazards occur every day throughout the United States, with flooding being the costliest. Flooding causes the loss of more than 100 lives each year and annual losses of $6 billion in property damage in the United States.[2] We can reduce the numbers of lost lives and property damage by investing in hazard mitigation measures. Implementing mitigation measures also allow communities to recover more quickly and lessen the financial impacts of a natural disaster.

An Introduction to Hazard Mitigation

Hazard mitigation is any action, structural or nonstructural, taken to reduce or eliminate long-term risks to life and property from natural disasters. Mitigation projects may be one of a number of measures, examples of which include the following: improving building codes, hardening infrastructure and buildings, acquisition and demolition of structures, outreach and education, land use planning, and legislation (as shown in the panel to the right).

The frequency and magnitude of natural disasters are increasing, and coupled with growing urbanization, this has resulted in higher costs spent to recover from natural disasters. Communities can implement mitigation measures to prevent or reduce unnecessary losses and alleviate increasing damage costs. Mitigation measures can result in reduced direct property damage, reduced business interruption loss, fewer environmental impacts, reduced human losses, and lower cost of emergency response, among other benefits.



[2] U.S. Geological Survey and U.S. Department of Interior. Flood Hazards – A National Threat. Located at: https://pubs.usgs.gov/fs/2006/3026/2006-3026.pdf

Additionally, a study conducted by the Multihazard Mitigation Council (2005) found that mitigation measures result in significant potential savings to the federal treasury in terms of avoided post-disaster relief costs and future increased federal tax revenues. ***The report estimated that for every $1 spent on mitigation, almost $4 are saved.***[3] Loss avoidance assessments completed by the State of Florida to date are trending to corroborate a high return on investment for mitigation projects, considering damages avoided alone.

In addition to reducing long-term risk, a 2012 Federal Emergency Management Agency (FEMA) study shows that implementation of mitigation measures can also provide these benefits:

- Increased property values from reducing a structure's vulnerability and, hence, insurance premiums
- Increased property value leading to a strengthened tax base (which also then provides opportunity for continued investment in the local community)
- Increased resiliency and ability for local communities to recover more quickly from a natural disaster
- Improved safety of the neighborhood through building code improvements and reduction of the presence of damaged structures.
- Repetitive flood loss property conversion to additional green space for the community
- Opportunities to use acquired space for improved recreational services
- Added social benefits such as confidence for the future and ease of mind pending a disaster event

[3] Multihazard Mitigation Council. Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities. Located at: http://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/MMC/hms_vol1.pdf. The report evaluates the benefits of soft and hard mitigation activities by considering losses to society avoided: reduced direct property damage, reduced business interruption loss, reduced non-market damage, reduced human losses, reduced cost of emergency services. This loss avoidance assessment evaluates only direct physical damage and displacement benefits related to hard mitigation activities completed before Hurricane Hermine in the declared counties.

The Hazard Mitigation Process

The hazard mitigation process is a cycle (**Figure 1**). First, local jurisdictions must perform a risk and vulnerability assessment to identify potential risks to their communities from natural disasters. The risk and vulnerability assessment results in identified mitigation measures that can be implemented to reduce risk. Once mitigation projects are implemented and after a natural disaster occurs, the performance of mitigation efforts should be evaluated to inform future risk and vulnerability assessments and to assess whether public funds were spent wisely. This evaluation ensures mitigation measures effectively protect against hazards and are cost effective and sustainable for local jurisdictions. With substantial investments being made in mitigation, it is important for the State to demonstrate the cost-effectiveness of mitigation measures for continued support and funding.

It is important to continually assess whether public funds have been spent wisely.

The loss avoidance assessment fits within the evaluation step of the hazard mitigation process and provides justification for existing and future mitigation action. A loss avoidance assessment demonstrates the effectiveness of mitigation measures by showcasing the benefits of completed mitigation projects, capturing losses avoided, and producing a return on investment. Such an evaluation can aid decision making to appropriately allocate resources in the future. In other words, loss avoidance assessments help answer the question, “Is mitigation worth the cost?”

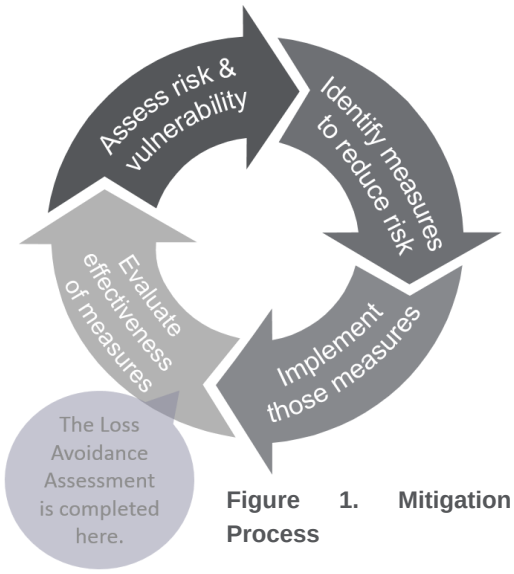


Figure 1. Mitigation Process

Loss avoidance assessment is one method to substantiate investment in hazard mitigation.

It is important to assess the economic performance of mitigation measures over time to encourage mitigation funding at the local level. The loss avoidance methodology evaluates the performance of implemented mitigation measures during a disaster and characterizes their value through a return on investment (ROI). This methodology uses an actual disaster to validate costs avoided by mitigation measures completed before the disaster event. The assessment compares loss scenarios with and without mitigation and reports money that was saved because of mitigation measures. The losses avoided because of the project are characterized as an ROI because they represent money saved as a percentage of the money invested in the mitigation project.

Loss avoidance assessments should be integrated into the hazard mitigation process to showcase return on investment.

The State can demonstrate a continued ROI if loss avoidance assessments are completed after every natural disaster event. This ROI can be used to improve community resiliency by justifying future investment in mitigation and providing leverage for continued support of mitigation actions. The State of Florida has committed to conducting a loss avoidance assessment after every Presidentially Declared Disaster as part of its Enhanced State status. This allows Florida to receive additional Hazard Mitigation Grant Program (HMGP) funding. This loss avoidance assessment evaluates the performance of mitigation projects that were within Hurricane Hermine's area of impact. Losses avoided during Hurricane Hermine are integrated with the results of previous loss avoidance assessments to demonstrate an overall ROI for those projects.

Since the state implemented a loss avoidance system and strategy in 2012, it has completed a loss avoidance analysis after every presidentially declared disaster.

Loss Avoidance Process Overview

As previously stated, the State of Florida maintains a FEMA-approved Enhanced State Hazard Mitigation Plan to receive additional HMGP funding. Part of maintaining the Enhanced State Hazard Mitigation Plan is performing loss avoidance analyses after every Presidentially Declared Disaster. The State of Florida, in accordance with 44 CFR 201.5(b)(2)(iv), developed a system and strategy by which it will assess and record the effectiveness of each completed mitigation project. Loss avoidance assessments analyze mitigation projects using funds from HMGP, Pre-Disaster Mitigation program, Repetitive Flood Claims (RFC) program, Severe Repetitive Loss program (SRL), Flood Mitigation Assistance program (FMA), and the State of Florida's Hurricane Loss Mitigation Program.[4] The aforementioned programs are not all active at once; for example, the RFC and SRL programs were recently combined into the FMA program. The Florida Division of Emergency Management (FDEM) administers these programs for the State of Florida and maintains project files with all information needed to conduct a loss avoidance assessment; thus, FDEM is the driving force behind loss avoidance assessments in Florida. Mitigation projects implemented with local or private dollars are not assessed in a loss avoidance assessment due to data and time constraints. As such, the results of this analysis can be considered a conservative estimate of mitigation efforts that avoided losses from Hurricane Hermine.

[4] Mitigation programs are often dynamic; not all programs are currently active. In 2014, FEMA combined the RFC and SRL program requirements and funding into the FMA program.

Limitations of the Loss Avoidance Analysis

Limitations apply to the DR-4280 loss avoidance assessment that likely underestimate both the number of mitigation projects assessed and the ROI of projects that are included. Limitations include:

- The loss avoidance assessments for Hurricane Hermine and Hurricane Matthew (DR-4283) are the first, other than pilot assessments, to evaluate wind mitigation projects.
- This assessment is limited to evaluating losses avoided in terms of direct physical damages and displacement costs. It does not include other important benefits (or losses avoided) such as loss of critical services, roadway closures, and human impacts (mental stress and anxiety, lost productivity, and loss of life or injury).
- This loss avoidance assessment is limited to evaluating mitigation projects that protect structures and does not include projects which solely protect critical infrastructure or essential services.

The loss avoidance analysis process can be organized into four broad categories, as summarized below. Refer to the *Loss Avoidance Methodology Appendix* for greater detail.

1 – Project and Event Data Collection: Project Analysts collect project data needed to conduct a loss avoidance assessment throughout the grant life-cycle. They obtain files for completed mitigation projects from FDEM and review them to extract appropriate

information. They use event data to identify the DR-4280 area of impact, and may include event precipitation, wind swath, high water marks, gauge height, and event photographs (**Table 1**).

Table 1 Event Data and Data Sources

Data Source	Data
National Oceanic and Atmospheric Administration / National Weather Service	Precipitation Data Tide Gauge Data
United States Geologic Survey Flood Event Viewer	High Water Marks Storm Tide Sensor Data (Peak Stage Data)
United States Geologic Survey	Gauge Height
United States Fish and Wildlife Commission	Aerial Imagery
HURREVAC	Wind Swath

2 – Data Review: Analysts review project and event data to ensure accuracy of project file information. Project location, structure information, and elevation are the most critical pieces of information for loss avoidance assessments

3 – Data Processing and Quality Assurance/Quality Control: Analysts overlay mitigation project and disaster event data in GIS to determine which projects lie within the DR-4280 area of impact for inclusion in the loss avoidance assessment. Analysts estimate impacts to the projects using event data, then confirm them through phone calls, emails, and meetings with local representatives familiar with particular mitigation measures. Florida's Loss Avoidance Calculators quantify the effectiveness of the impacted mitigation projects. Analysts adjust the results to reflect the impacts conveyed by local representatives, as appropriate.

4 – Reporting: Analysts report loss avoidance results and ROI specific to DR-4280. Projects that were included in previous loss avoidance assessments receive an overall ROI, which integrates the DR-4280 results with those of previous disaster events.

This loss avoidance assessment additionally builds upon a 2012 economic impact analysis performed by FDEM, which reveals that hazard mitigation activities provide a positive economic benefit to Floridians in terms of employment and added economic activity, in addition to losses avoided. To further demonstrate the economic benefit of hazard mitigation activities, this loss avoidance assessment includes an update of FDEM's 2012 economic impact analysis. The update evaluates economic output and job creation benefits associated with the implementation of mitigation projects impacted by Hurricane Hermine using the IMPLAN economic impact assessment software system. IMPLAN uses an input-output methodology, in combination with social accounting matrices and economic multipliers, to estimate the result of changes or activities in a study area. To conduct the analysis, analysts allocate project funds to a range of appropriate IMPLAN economic sectors and enter funds per sector into the IMPLAN software as an industry change. IMPLAN reports countywide economic effects of implementing mitigation measures in terms of sales and revenues, value added to GDP, labor income, and employment. Refer to the *Loss Avoidance Methodology Appendix* for greater detail on the economic impact analysis approach.

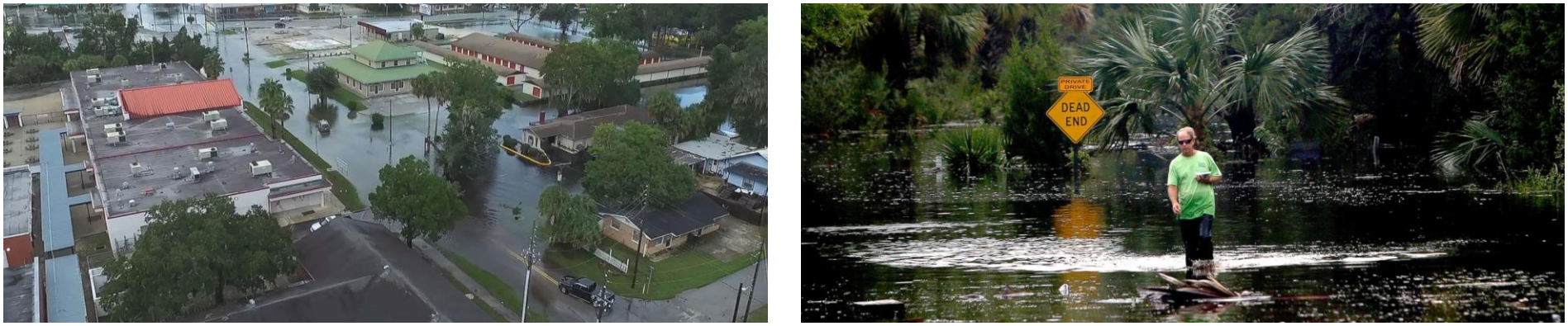


Figure 2. Left: Crystal River, FL. Right: Taylor County, FL. Source: ABC News.

Previous Loss Avoidance Assessments

Florida's previous loss avoidance assessments are summarized in **Table 2**. Tropical Storm Debby is the only disaster assessed to date with projects that were also impacted by Hurricane Hermine. The results of the Tropical Storm Debby loss avoidance assessment are integrated with the results of this assessment to demonstrate a cumulative ROI for the projects listed in **Table 3.**

Table 2. Previous Loss Avoidance Assessment Results

Disaster Assessed	Project Cost	Losses Avoided	ROI
Tropical Storm Fay (2008), North Florida Flood Event (2009), Unnamed June Flood Event (2012), Tropical Storm Debby (2012)	50 projects cost $18.9 million	Approximately $21.9 million in expected losses	16%
Hurricane Isaac (2012)	5 projects cost $8.3 million to protect 842 structures	Approximately $44 million in expected losses, with over $35 million avoided	435% return on project capital investment, due to the high proportion of drainage projects analyzed and the nature of the event
Severe Storms and Flooding (2013)	32 projects cost $4.2 million	Approximately $5.4 million in expected losses, with over $1 million avoided	29%
Florida Severe Storms, Tornadoes, Straight-Line Winds, and Flooding (2014)	33 projects cost $18.4 million	Approximately $24.1 million in expected losses, with $5.6 million in losses avoided	54%

Table 3. Projects Impacted by Hurricane Hermine and Tropical Storm Debby (reported as 2012 dollars)

Project Number	Project Type	Project Location	Project Cost	Losses Avoided (Previous Assessments)	Return on Investment (Previous Assessments)
FMA-PJ-04-FL-2007-003	Elevation	Pinellas	$363,730	$76,226	21%
FMA-PJ-04-FL-2008-008	Elevation	Pinellas	$232,440	$52,197	22%
FMA-PJ-04-FL-2008-009	Elevation	Pinellas	$218,400	$42,535	19%
RFC-PJ-04-FL-2008-001	Acquisition	Pinellas	$448,207	$121,330	27%
SRL-PJ-04-FL-2008-016	Mitigation Reconstruction	Hillsborough	$175,585	$74,937	43%
SRL-PJ-04-FL-2008-020	Elevation	Pinellas	$286,517	$48,201	17%
SRL-PJ-04-FL-2008-01	Acquisition	Pinellas	$448,207	$121,330	27%
1561-100-R	Drainage	Sarasota	$996,131	$189,033	19%

EVENT DETAILS

On September 1, 2016, Hurricane Hermine made landfall in the panhandle of Florida, east of St. Mark's on the Jefferson and Wakulla County line, causing severe damage and disruption in its path and surrounding areas. The President of the United States signed a Major Presidential Disaster Declaration, FEMA DR-4280, on September 28, 2016. The following 26 counties were declared for disaster assistance: Alachua, Baker, Citrus, Columbia, Dixie, Franklin, Gadsden, Gilchrist, Hernando, Hillsborough, Jefferson, Lafayette, Leon, Levy, Liberty, Madison, Manatee, Marion, Pasco, Pinellas, Sarasota, Sumter, Suwannee, Taylor, Union, and Wakulla (**See Map 1**).

Figure 3. Hurricane Hermine Making Landfall. Sources: Baltimore Sun and CNBC

Hurricane Hermine developed from a long-tracked tropical wave in the Atlantic Ocean that crossed into the Gulf of Mexico and moved westward after affecting the Caribbean islands. A trough slowly fell into place over the southeastern United States and resulted Hermine moving toward the northeast. Hermine became a Category 1 Hurricane before making landfall. It was the first hurricane to make landfall in the state of Florida since Hurricane Wilma in 2005, and developed 80 miles per hour (mph)

Details of Hurricane Hermine

September 1, 2016
Panhandle of Florida

80 mph
sustained winds at peak intensity

983 mb
pressure at peak intensity

22 inches
of total rainfall

325,000
people without power

sustained winds at its peak intensity with an atmospheric pressure of 983 millibars (mb). Wind speed dropped to tropical storm force shortly after landfall; nevertheless, gusts were measured up to almost 80 mph in parts of Franklin County. Rainfall exceeded 22 inches and storm surge heights reached six feet in some areas. Record storm surge was measured in Cedar Key, Levy County, with a peak of 6.1 feet early September 2nd. An estimated 325,000 people reported power outages throughout Florida because of sustained hurricane and tropical storm force winds.

Table 4 provides the counties that reported the greatest impacts.

Figure 4. Flooding in Pasco County During Hurricane Hermine. Source: http://wfla.com/2016/08/31/tracking-tropical-depression-9-pasco-county/

Table 4. Summary of Hurricane Hermine Impacts by County

County	Impact
Alachua	The City of Gainesville experienced widespread wind damage including: 37 fallen trees, 29,000 people without power, and flooded roadways leading to road closures on highways and local streets.
Baker	Voluntary evacuations took place in anticipation of flooding on the St. Mary's River along the border of Georgia and Florida. Downed trees and power lines resulted from Hermine's winds, with one injury reported after a tree collapsed onto a residence.[5]
Citrus	Portions of the Crystal River experienced flooding of up to two feet during Hermine, closing off portions of US Highway 19, roads near Kings Bay, and portions of downtown. Multiple businesses and restaurants in this area were affected and rescue efforts were necessary in some residential areas. Citrus County overall experienced $102 million in damage, with more than 2,600 homes and properties affected.[6]
Columbia	Areas surrounding Lake City were some of the harder hit locations, with wind gusts measuring up to 80 mph. Upwards of 7,000 people lost power due to downed power lines and trees. Roads were closed from wind debris including tree limbs, trees, and power lines.
Dixie	Primary impacts were related to flooding and storm surge, particularly in Horseshoe Beach. The town experienced devastating impacts from the storm, with 50 mph sustained winds and more than five inches of rain. Some residential areas experienced flooding of up to three feet of water. Sustained damages in Dixie County totalled more than $3.2 million.[7]
Franklin	Apalachicola experienced sustained winds of 55 mph, with gusts of up to 73 mph. Rising water over Highway 98 prompted road closures throughout the area, including the St. George Island Bridge.[8]
Hernando	Hernando County reported almost $7.8 million worth of damage after Hurricane Hermine, much of which was caused by storm surge. Evacuations took place throughout the County, and rescue operations went into effect for those who did not leave the coastal areas. Businesses

[5] The Weather Channel, Hurricane Hermine Tracking and Updates
[6] Mesmer, A. "Crystal River overtaken by floodwaters Friday." Fox 13. September 2, 2016. http://www.fox13news.com/news/local-news/200392709-story; http://wfla.com/2016/09/02/crews-assess-storm-damage-in-citrus-county/
[7] Brittingham, S. "Governor Scott asks FEMA to help with hurricane damages." September 21, 2016. http://www.wuft.org/news/2016/09/21/governor-scott-asks-fema-to-help-with-hurricane-damages/
[8] Weather.com. "One Dead after Hermine Causes 'Severe' Coastal Damage, Flooding in Florida, Thousands Without Power." September 2, 2016 https://weather.com/storms/hurricane/news/hurricane-hermine-preps-impacts-florida-georgia-carolinas

County	Impact
	and residents in Hernando County coastal areas experienced flooding, causing major damage to 18 buildings and minor damage to 179 buildings.
Hillsborough	Power outages, downed trees and power lines, and road closures took place in the Tampa area, including the closure of Bayshore Boulevard. Tampa's wastewater treatment plant and two pump stations lost power in the aftermath of the storm, resulting in millions of gallons of the partially treated wastewater dumped into Tampa and Hillsborough Bay to prevent flow into streets and residential properties.
Leon	In Tallahassee, an estimated 100,000 people lost power due to downed trees and power lines. Roads were closed due to power lines and debris, including US 319, US 90, and Capital Circle NE (State 261). Leon County claimed more than $10 million in damages, with $4 million being for utilities including debris removal.
Levy	Residents of Cedar Key and Yankeetown were issued mandatory evacuations in advance of landfall. Numerous roads were inundated with floodwaters, including County Road 40 and State Road 24. Cedar Key alone suffered close to $10 million in damages resulting from a 7-foot storm surge.
Marion	Heavy winds affected the area resulting in the state of Florida's one fatality occurring in Ocala due to a downed tree from the high winds.[9]
Pasco	Evacuations were called for close to 2,500 homes in anticipation of residential flooding from the Anclote River. Flooding caused road closures throughout the County, and 30 people had to be evacuated by boat. Overall the County reported approximately $111 million of damage.[10]
Pinellas	Heavy rain caused extreme flooding and damaging winds shut down area bridges, including the Sunshine Skyway Bridge of Tampa Bay. Multiple rescues took place because of flooding and high water, including areas along the rising Lake Maggiore. Numerous roadways were shut down due to flooding, including 5th Avenue and 64th Street in St. Petersburg, as well as areas in Holiday.[11]
Sarasota	Upwards of nine inches of rain caused flooding issues throughout the County. The wastewater treatment plant in Siesta Key overflowed releasing millions of gallons of partially treated wastewater into the Grand Canal. Gallop Avenue near McIntosh and Wilkinson Roads reported specific wind damage from Hurricane Hermine.[12]
Taylor	Keaton Beach was one of the harder hit areas to suffer severe coastal damage from landfall. The National Weather Service reported storm surge heights upwards of six feet. Wind gusts were measured up to 70 mph with sustained winds over 50 mph, resulting in power loss throughout the majority of the County. Rescue efforts took place in areas where residents chose not to evacuate. Upwards of 1,200 homes and businesses were damaged.[13]
Wakulla	High winds and heavy rainfall caused of several reported injuries. Storm surge heights reached eight to 10 feet in some parts of the County, also causing damage to docks and flooding of coastal roads. Heavy rainfall and storm surge caused flooding on local highways including State 363 and State 267, as well as closures on Sopchoppy and Crawfordville Highways due to downed trees and power lines. Almost 20% of the County was without power.[14]

[9] Miller, A. "One death in Marion blamed on Hermine." September 2, 2016 http://www.ocala.com/news/20160902/one-death-in-marion-blamed-on-hurricane-hermine

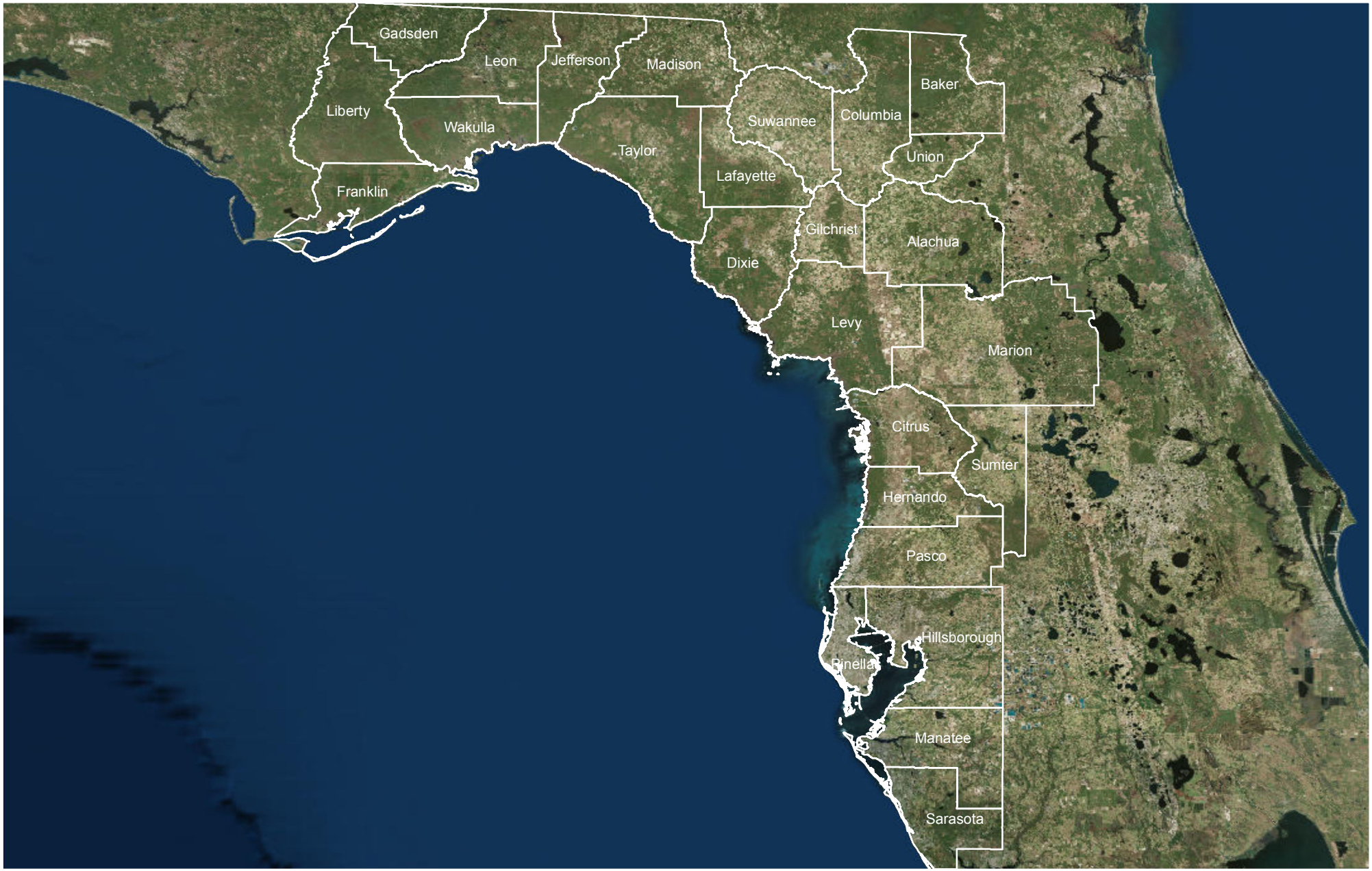
[10] McGuire, M. "Hermine damage estimates rise to $111 million in Pasco." September 2, 2016. http://wfla.com/2016/09/07/hurricane-hermine-caused-nearly-90-million-damage-in-pasco/ , http://wfla.com/2016/09/11/fema-officials-tour-pasco-county-as-damage-estimates-rise-to-111-million/

[11] WFLA Web Staff. "Hermine Aftermath: Pinellas County." August 31, 2016. http://wfla.com/2016/08/31/tracking-tropical-depression-9-pinellas-county/

[12] My Suncoast News. "Sarasota Co neighborhood left with damage from Hurricane Hermine." September 2, 2016. http://www.mysuncoast.com/news/local/sarasota-co-neighborhood-left-with-damage-from-hurricane-hermine/article_bdc23572-70c0-11e6-9367-b7b6ec52aa41.html; http://www.heraldtribune.com/news/20160901/surfers-rescue-woman-knocked-off-nokomis-jetty-by-waves

[13] Lisch, E. "Hurricane Hermine causes devastation to local beach community." September 6, 2016. http://www.wctv.tv/content/news/Hurricane-Hermine-Causes-Devastation-to-Local-Beach-Community-392513021.html

[14] Replogle, J. "Hermine hits Florida coast as 1st hurricane in decade." September 2, 2016. http://www.gadsdentimes.com/news/20160902/hermine-hits-florida-coast-as-1st-hurricane-in-decade

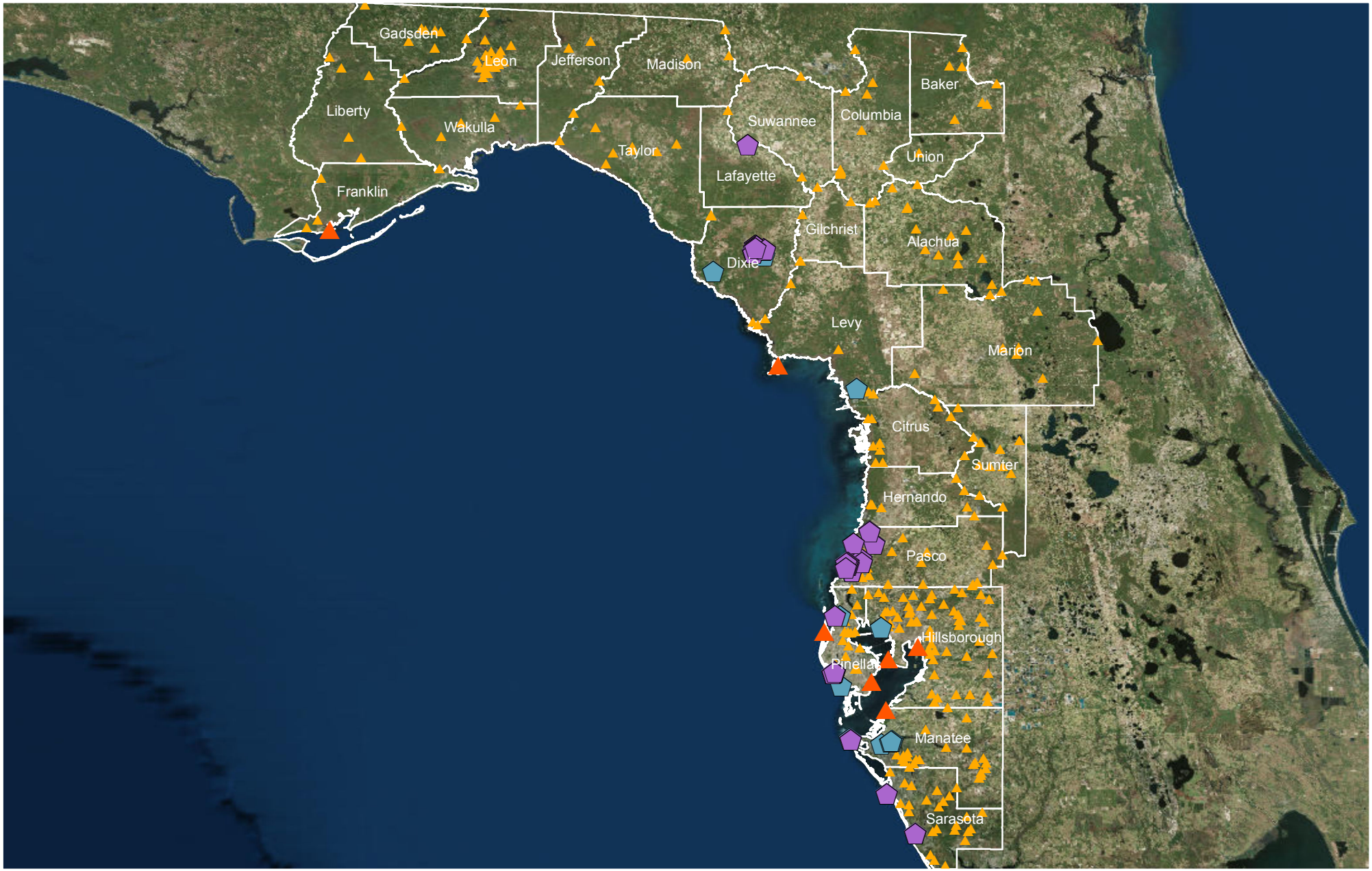


2016 Loss Avoidance Assessment

DR-4280: August 31 to September 3, 2016

Declared Counties

0 25 50 100 Miles



2016 Loss Avoidance Assessment
DR-4280: August 31 to September 3, 2016

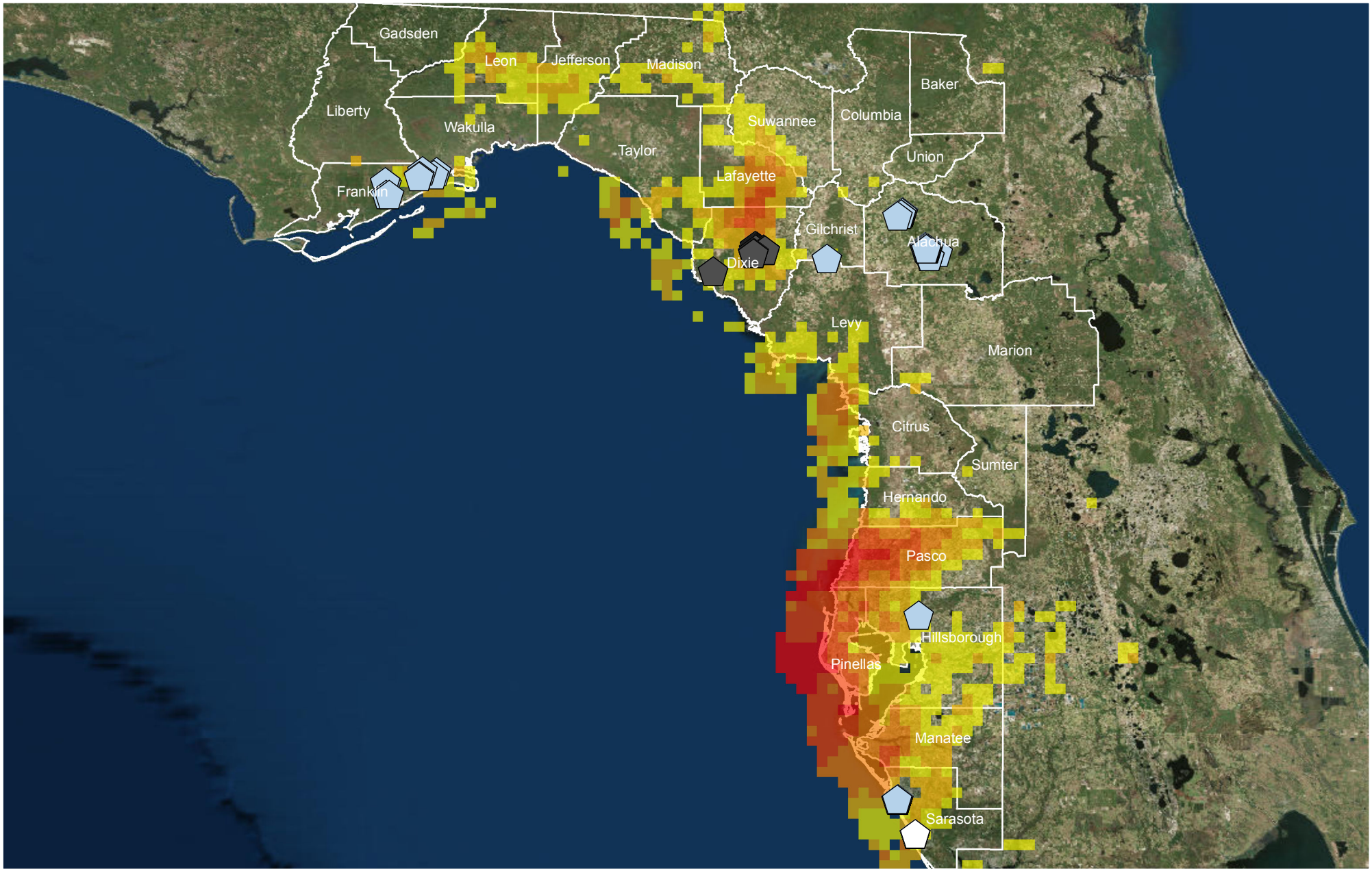
Flood Projects with Results

All Flood Projects

Coastal Gauges

River Gauges

0 25 50 100 Miles



2016 Loss Avoidance Assessment

DR-4280: August 31 to September 3, 2016

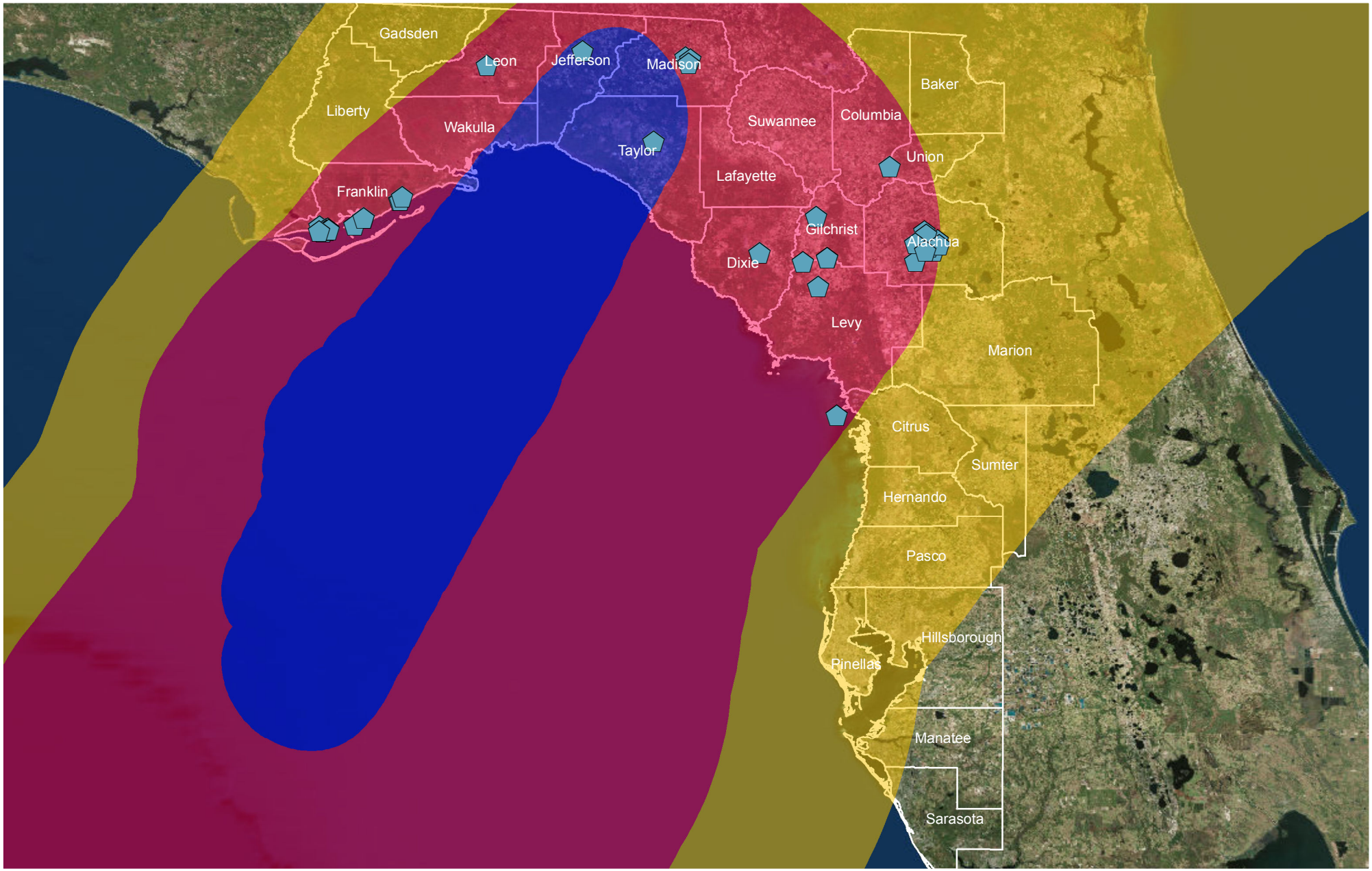
Precipititation **Inches**

- 6 - 7
- 7 - 9
- 9 - 11
- 11 - 14
- 14 - 20

Project Type

- Drainage - In Impact Area
- Drainage - No Results
- All Drainage

0 25 50 100 Miles



2016 Loss Avoidance Assessment
DR-4280: August 31 to September 3, 2016

HermineSwath Wind Speed Heavy Wind | Tropical Storm | Hurricane | Wind Projects

0 25 50 100 Miles

PROJECT HIGHLIGHTS

There are 60 mitigation projects within Hurricane Hermine's area of impact, which were analyzed for potential avoided losses. Of these projects, 45 mitigate damages from flood impacts, while 15 protect structures from hurricane-force winds. Hermine impacted 31 of the 45 flood mitigation projects, meaning the storm was large enough to cause damage had the community not implemented the project. Analysis results revealed wind speeds during Hermine were not great enough to cause significant impacts to wind retrofit projects, and as such, the expected results of various wind scenarios are included in the ***DR-4280 Results*** section. **Maps 2** through **4** display data used to determine Hurricane Hermine's area of impact for wind and flood hazards, and the location of mitigation projects within the context of these hazards.

According to analysis results, Pasco County mitigation projects received the brunt of Hurricane Hermine.[15] Storm surge from Hurricane Hermine, coupled with high tides, caused severe coastal flooding in the County, with storm surge reaching six feet in some areas along the coast.

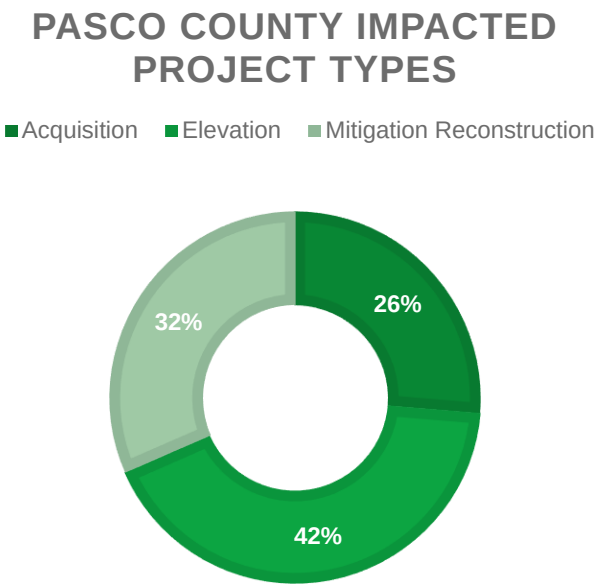


Figure 5. Distribution of Pasco County Impacted Flood Mitigation Projects

110 structures
protected by mitigation projects within the Hurricane Hermine impact area

45 projects
mitigated flood damages

15 projects
mitigated wind damages

15 counties
contain a mitigation project within Hurricane Hermine's area of impact

[15] This analysis considers the impacts of Hurricane Hermine on mitigation projects. Counties and other locations without mitigation projects also experienced significant damage from the event.

Of the County's 20 flood mitigation projects, Hermine impacted 18 building modification projects (**Figure 5**). The 18 mitigation projects cost **$4.9 million** to implement in 2016 dollars and prevented **$1.5 million** in losses. The average ROI in Pasco County for Hermine is **36 percent** (**Figure 6**).

Results indicate elevation projects were the most effective flood mitigation project type in the County when considering flood depth, losses avoided, and project costs, with an average ROI of 50 percent compared to an average ROI of 24 percent for acquisition projects and 29 percent for mitigation reconstruction projects (

Table 5). An elevation project funded by the Flood Mitigation Assistance (FMA) program in 2004 had a 100 percent ROI for DR-4280 alone. Had the project not been implemented, flood impacts would have caused substantial damage to or destroyed the structure.

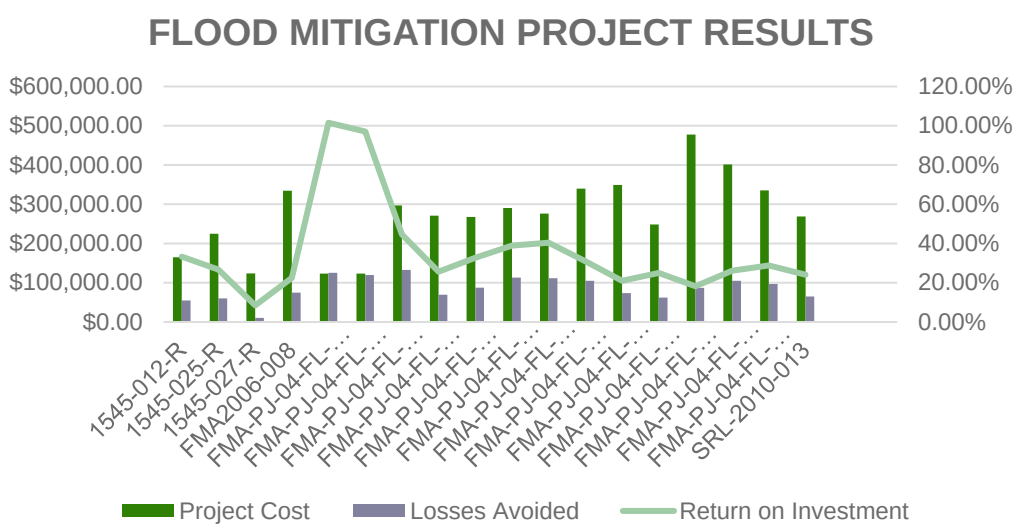


Figure 6. Pasco County Flood Mitigation Project Results

Table 5. Pasco County Flood Mitigation Project Results

Project Type	Count	Project Cost	Losses Avoided	Net Present Value	Return on Investment
	Calculation	*A*	*B*	*C=B-A*	*D=B/A*
Acquisition	5	$1,030,600	$252,400	-$778,220	24%
Elevation	7	$1,766,550	$704,680	-$1,061,870	50%
Mitigation Reconstruction	6	$2,119,440	$596,390	-$1,523,050	29%
Total	**18**	**$4,916,600**	**$1,553,470**	**-$3,363,140**	**36%**

DETAILED RESULTS

This assessment reports the number and type of projects analyzed, losses avoided, and ROI realized during DR-4280. This report also integrates DR-4280-specific results with previous Florida loss avoidance assessments to demonstrate a cumulative ROI for projects that have been impacted multiple times. Seven projects within Hurricane Hermine's area of impact were also impacted by Tropical Storm Debby; however, only four of the projects experienced impacts during Hermine.

DR-4280 Results

Forty-five flood mitigation projects comprise 75 percent of the projects analyzed for Hurricane Hermine; fifteen wind projects make up 25 percent of the projects analyzed (**Figure 7**). Thirty-one of the 45 flood mitigation projects (68 percent of flood mitigation projects and 51 percent of total projects analyzed) sustained impacts at the project site that were great enough to calculate losses avoided. The assessment reveals Hurricane Hermine wind speeds were not great enough to cause impacts to wind retrofit projects; however, had the storm's wind speeds been greater, much more damage would have occurred. The ***Wind Mitigation Project Results*** section provides information and expected impacts for various wind scenarios.

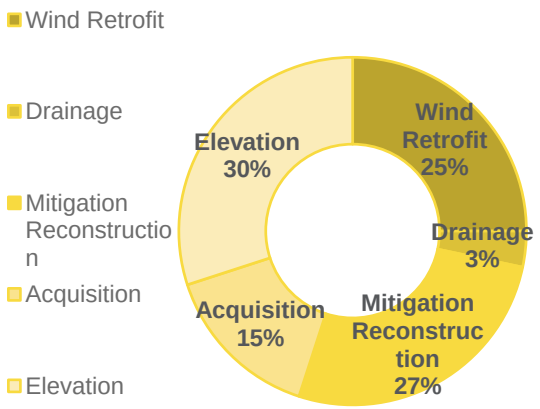


Figure 7. Distribution of Project Types Evaluated within Impact Area

$9,776,270

in mitigation project costs for those impacted by DR-4280.

$20,694,240

in losses expected for DR-4280 without mitigation projects in place (losses avoided).

82 percent

Aggregate ROI for DR-4280 alone.

Results by County

Dixie, Pasco, and Pinellas Counties experienced the most flood impacts from Hurricane Hermine, as demonstrated in **Table 6**. Pasco had the most impacted projects, followed by Pinellas County. Dixie County reaped the greatest benefits because over thirty-five structures benefitted from one drainage project.

Table 6. Summary of Results by County

County	Number of Projects	Total Project Costs	Total Loses Avoided	Total Net Present Value	Average Hermine ROI
Dixie	1	$1,184,640	$18,433,310	$17,248,670	1556%
Lafayette	1	$132,080	$215,540	$83,460	163%
Pasco	18	$4,916,600	$1,553,470	-$3,363,140	36%
Pinellas	10	$3,248,450	$437,030	-$2,811,420	15%
Sarasota	1	$294,510	$54,890	-$239,610	19%
Total	**31**	**$9,776,270**	**$20,694,240**	**$10,917,960**	**82%**

Results by Occupancy

The results by occupancy type are summarized in **Table 7**. Residential structures comprise the vast majority of structures benefitting from mitigation. The loss avoidance assessment evaluates direct physical damages and displacement costs, but does not capture avoided human impacts (mental stress and anxiety, lost productivity, and loss of life or injury) for mitigated residential structures. As such, results for residential structures are likely conservative. Similarly, the assessment does not account for avoided business interruption impacts for commercial structures, so those results may also be conservative.

Table 7. Summary of Results by Occupancy

Occupancy	Number of Structures	Total Project Cost	Total Losses Avoided	Total Net Present Value	Average Hermine ROI
Commercial	1	$294,500	$54,890	-$239,610	19%
Religious	1	$132,080	$215,540	$83,460	163%
Residential	63	$9,349,690	$20,423,810	$11,074,120	81%
Total	**65**	$9,776,270	$20,694,240	$10,917,960	82%

Results by Project Type

Overall, drainage projects reap the greatest return on investment (over 1,000 percent) for any project type, followed by acquisition projects, with an average ROI of 47 percent (**Figure 9**). Drainage projects have a greater ROI because many structures benefit from a single project. Drainage projects cost the most to implement, averaging $1 million in costs per project for Hurricane Hermine, but produced the highest benefits at more than $18 million in losses avoided. Mitigation reconstruction were also costly to implement, costing on average $361,040 per project, compared to $265,970 per elevation project and $193,780 per acquisition project. Due to the higher costs of mitigation reconstruction projects, these produced the lowest ROI (22 percent) and losses avoided ($801,320) for Hurricane Hermine (**Table 8**). Nevertheless, mitigation reconstruction projects require that the building is rebuilt to all current Florida Building Code requirements and may also provide additional protection against wind hazards.

Table 8. Summary of DR-4280 Results by Project Type

Project Type	Number of Projects	Total Project Cost	Average Cost Per Project
Acquisition	6	$1,162,690	$193,780
Drainage	1	$1,184,640	$1,184,640
Elevation	13	$3,457,540	$265,970
Mitigation Reconstruction	11	$3,971,390	$361,040
Total	**31**	**$9,776,270**	-

Flood Mitigation Project Results: Building Modification Projects

Building modification projects refer to projects that reduce flood risk by way of acquisition and demolition, elevation, second-story conversion, or reconstruction. Building modification represent **$8.5 million** in mitigation investment made between the early 2000s and 2016. These specific projects avoided a total of **$2.3 million** in damages from Hurricane Hermine, with an average ROI of **35 percent (Figure 8).**

Results for the DR-4280 loss avoidance assessment show that 31 building modification projects in the declared counties would have been exposed to flooding during hurricane Hermine had mitigation not occurred.

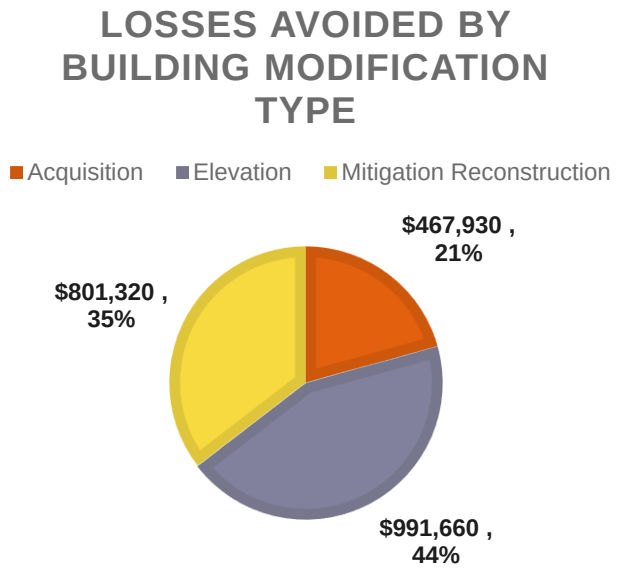


Figure 8. Distribution of Building Modification Losses Avoided

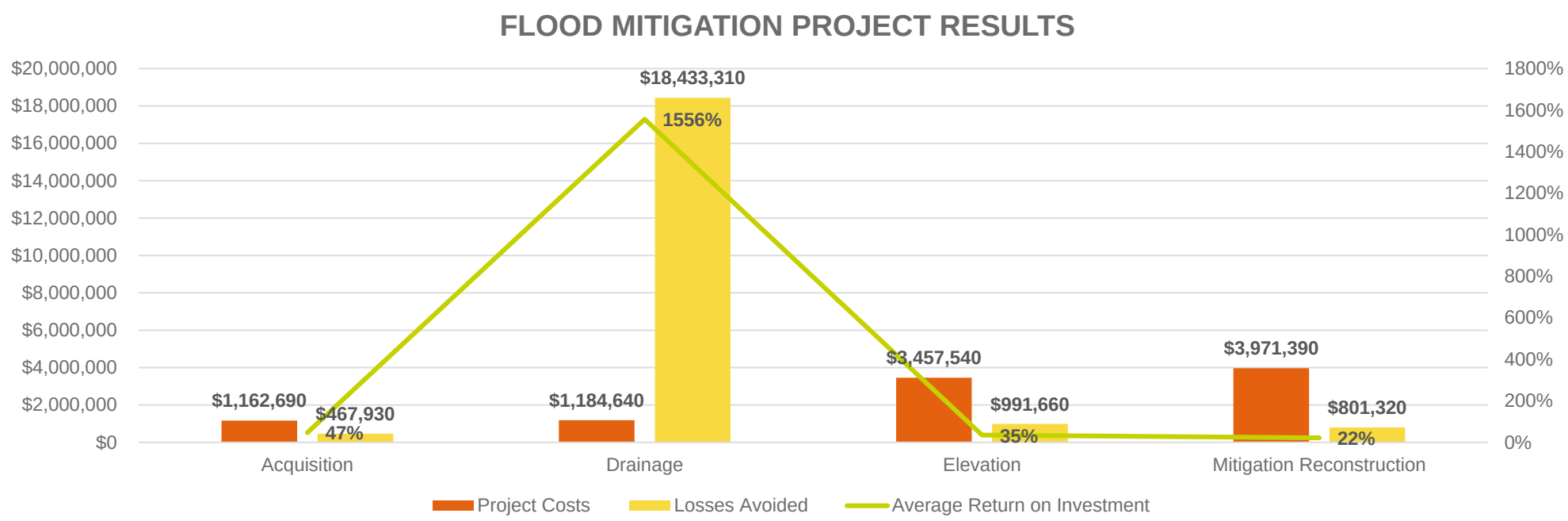


Figure 9. Hurricane Hermine Flood Mitigation Project Results

Flood Mitigation Project Results: Drainage Projects

Drainage mitigation projects refer to projects that help reduce the frequency and severity of stormwater flooding, as well as the long-term risk to the community. The drainage project cost **$1 million**, returning a benefit of **$18 million** after Hurricane Hermine alone. The drainage project protected 35 structures, and the ROI for the structural drainage project assessed is over 1,550 percent. Drainage projects may be very beneficial to a community, where implementation is appropriate; cost is often relatively low when compared to the large number of benefitting structures and aggregate losses avoided.

Results for the DR-4280 loss avoidance assessment show that one of the two drainage project sites within the impact area would have experienced flooding from Hurricane Hermine had the community not implemented the drainage project.

Analysts evaluated the performance of 15 wind retrofit projects, protecting 30 wind retrofitted structures, that fell within Hurricane Hermine's wind swath. Hermine's low wind speeds did not show significant losses avoided; the maximum wind speed at a project site was 72 miles per hour, according to the HURREVAC wind swath. Analysts adjusted the maximum wind speed during Hurricane Hermine to better understand impacts that might have been avoided had the storm strengthened.

Results of the wind probability analysis indicate a Category 3 storm intensity produces the greatest losses avoided.

Storms of greater intensity cause catastrophic impacts unrelated to wind mitigation, such a wall collapse, that make wind mitigation activities inconsequential. As such, losses avoided decrease for categories 4 and 5 storm intensities because some structures would be expected to be total losses due to structural failure, regardless of wind mitigation activities (**Table 9**). these results indicate a mitigation 'sweet spot' for wind hazards; protecting structures to category 4 and 5 hurricanes may not be cost-effective in the long run.

Table 9. Hurricane Hermine and Probabilistic Scenario Results

Scenario	Structures Impacted	Losses Avoided	Aggregate ROI	Maximum Wind Speed
Hermine	5	< $1,200	-	72
Category 1	19	$150,000	4.6%	95
Category 2	19	$1,200,000	46.0%	110
Category 3	30	$6,900,000	265.5%	129
Category 4	30	$5,600,000	217.2%	156
Category 5	30	$2,900,000	114.0%	200

Integrated Results

Thirty-one of 60 mitigation projects implemented prior to Hurricane Hermine in declared counties prevented **$20 million** in estimated losses. Tropical Storm Debby also impacted seven of the 60 projects analyzed, and only four of the 31 projects with losses avoided**.** Analysts integrated losses avoided over the two events to calculate a cumulative ROI.

Results show the average cumulative ROI is 33 percent, meaning a third of the initial investment has been realized as loss avoided in four years, between 2012 and 2016 (Table 10).[16]

Table 10. Results for Projects Impacted by Hurricane Hermine and Tropical Storm Debby

Project Number	Project Type	Project Location	Project Cost	Hermine Losses Avoided	Integrated Losses Avoided	Hermine ROI	Cumulative ROI
FMA-PJ-04-FL-2007-003	Elevation	Pinellas	$376,250	$42,200	$121,880	11%	32%
FMA-PJ-04-FL-2008-008	Elevation	Pinellas	$245,640	$23,980	$78,540	10%	32%
FMA-PJ-04-FL-2008-009	Elevation	Pinellas	$230,800	$28,470	$72,940	12%	32%
SRL-PJ-04-FL-2008-020	Elevation	Pinellas	$301,730	$60,410	$110,800	20%	37%

[16] Tropical Storm Debby caused flooding in Florida during late June 2012.

Economic Impact Analysis

Mitigation measures have additional economic benefits beyond losses avoided that are advantageous for communities. Implementing mitigation activities requires engagement with various economic industries such as technical services, construction, State employment, and office administration services. Mitigation projects boost sales and revenues (economic output) in these industries, increasing GDP contributions from Florida and generating jobs. As an addition to the DR-4280 loss avoidance assessment, FDEM evaluated all mitigation measures impacted by Hurricane Hermine to identify economic output and job creation benefits based on project expenditures only. Analysts completed this evaluation using IMPLAN input-output economic modeling software.

The 108 jobs equate to 99 full-time equivalent jobs.[17] The IMPLAN analysis software evaluates the relationships between employment, labor income, economic output, and value added to GDP three ways: 1) direct impacts, which include industries that are directly related to mitigation activities; 2) indirect impacts for industries which support those that are directly impacted; and 3) induced impacts, or benefits created through employee spending.

Direct employment within these industries made up over 61% of total jobs created due to mitigation activities impacted by DR-4280. The construction sectors reap the most benefit because most projects impacted by Hurricane Hermine are building modification projects. Top industries with indirect employment benefit from implementation of mitigation measures impacted by Hurricane Hermine included retail, wholesale trade, and real estate while industries with the most induced employment impacts include hospitals, retail, and building services. The majority of these industries operate locally, meaning the money is infused into the very communities benefitting from the losses avoided.

The economic impact analysis reveals mitigation activities mainly benefit the real estate, construction, and architectural/engineering and related services industries.

Two of Florida's top industries – Real Estate and Tourism – are supported by FDEM mitigation activities. In addition, industries that benefit most from implementing mitigation measures are those which tend to suffer in times of economic stress.

[17] IMPLAN presents jobs created as full-time, part-time, and temporary employment; IMPLAN jobs are not Full Time Equivalent (FTE) equivalents. FTE is a method to standardize workload in order to make comparisons across various contexts or fields of study. Analysts used IMPLAN's methodology to convert full-time, part-time, and temporary employment to FTE jobs. Analysts use a simple ratio for each IMPLAN industry to covert between IMPLAN jobs and FTE jobs.

Economic impact analysis evaluates more factors than job growth alone. Economic output, labor income, and value added[18] are also important indicators of economic health.

Table **11** shows the ten top-performing industries for these benefits, which follow trends similar to that of employment: real estate, construction, and architectural/engineering benefit most from mitigation investment.

Considering these factors, ***mitigation is a sound investment in Florida's economy in both comfortable and demanding economic times.*** Benefits of mitigation are historically limited to post-disaster losses avoided, but FDEM considers implementation of mitigation measures an important economic contribution to Florida when considering job growth and economic output generated.

Table 11. Top Ten Performing Industries

Sector	Description	Total Labor Income	Total Value Added	Total Output
63	Maintenance and repair construction of residential structures	$875,250	$1,371,090	$3,742,540
59	Construction of new single-family residential structures	$934,080	$1,732,650	$3,532,010
440	Real estate	$141,420	$916,990	$1,544,270
449	Architectural, engineering, and related services	$404,180	$410,440	$958,340
441	Owner-occupied dwellings	$0	$219,130	$327,320
395	Wholesale trade	$95,600	$189,660	$301,590
401	Retail - Health and personal care stores	$64,060	$84,780	$129,620
482	Hospitals	$55,900	$63,690	$115,340
399	Retail - Building material and garden equipment and supplies stores	$32,580	$52,380	$83,620
49	Electric power transmission and distribution	$5,250	$29,100	$70,380

[18] Output is sales and revenues for industries; Labor income considers all forms of employment income, including wages and benefits for employees and proprietor income; Value added is a measure of the contribution to GDP.

LESSONS LEARNED

The State of Florida identified the important lessons learned while conducting phone calls and meetings with communities to validate the analysis results. Communities may use these experiences to enhance mitigation initiatives and strategically focus future investments to create a comprehensive approach to resilience. As extreme weather continues to stress and shock the physical and social fabric of our communities, it is imperative we learn from past experiences and adapt to achieve a more resilient future.

Understanding Local Risk

Understanding local risk is critical to developing a mitigation strategy that includes palatable, effective mitigation measures. Communities must balance the risk and cost of protecting themselves against chronic stresses – frequent events that weaken a community, such as heavy rainfall – with acute shocks – sudden threatening events, such as a hurricane. This balance affects the type of mitigation projects a community invests in. This is demonstrated by the results of the Hermine wind analysis probabilistic scenarios, which identifies a Category 3 hurricane as the 'sweet spot' for wind mitigation projects.

A best management practice shared by an impacted community suggests that an implementation plan for mitigation measures should incorporate a public education component to ensure that residents understand the risk projects intend to mitigate. This can help residents make better decisions to protect health and safety in the event of acute shocks.

- Balance costs and mitigation measures to mitigate chronic stresses and protect against acute shocks for a mitigation 'sweet spot'.
- Pick the low-hanging fruit available in your community: those easiest to mitigate.
- Consider mitigation measures that provide co-benefits: those that protect the environment, provide economic benefit, and improve quality of life.

Strategic Mitigation Planning

Addressing local risk is accomplished through strategic mitigation planning: prioritizing mitigation projects based on impact and benefit. Local officials from several impacted communities recommend a combined approach to target mitigation: address site-specific issues on a regular basis, and plan for large-scale projects that benefit a wide audience on a longer time frame. Low-hanging fruit, or easily implementable projects, are different for every community: some actively implement building modification projects to address site-specific issues as they are most effective in reducing risk to structures, while some communities take a passive approach to mitigation and use upcoming capital improvements as an opportunity to incorporate resiliency measures on a larger scale. The local risk context, available mitigation options, and community vision are all factors communities may consider when developing strategic mitigation plans.

Comprehensive Resilience through Mitigation

Mitigation projects are known to provide benefits in the form of losses avoided: physical damages, displacement and relocation of residents and businesses, economic interruptions, and casualties as well as other benefits that increase the resiliency of the built environment, its' residents, and the economy. Mitigation projects may also contribute to a community's overall resilience by providing co-benefits: those that protect the environment, improve residents' quality of life, and spur economic investment and diversity. One may refer to these benefits as value-added, as opposed to losses avoided. Co-benefits can contribute to ecological, social, and economic resilience[19], altogether improving a community's overall resilience.

One impacted community provided an example of co-benefits for a drainage project. Not only did the drainage project resolve nuisance flooding to structures and evacuation routes, but it also helped improve the water quality of a local creek. The community reported that the creek's water quality was not negatively impacted during Hurricane Hermine because flow volumes were moderated to discharge past the peak of the storm. This co-benefit, improved water quality, supports the local ecosystem's ability to return to normal after a hazard event.

[19] Ecological resilience is an ecosystem's ability to absorb disturbances and still persist; likewise, social resilience is the ability of different social entities to respond, adapt, and transform in the face of shocks or stressors. Many factors contribute to social resilience, but social capital and social networks play a critical role in building and maintaining social resilience. Social capital is the networks and relationships between people in a certain society that enable the society to function effectively. Economic resilience is the economy's ability to be flexible and cope with external shocks.

CONCLUSIONS

Assessing the performance of hazard mitigation measures is critical to substantiate the value of mitigation efforts, and loss avoidance assessment results help assure prudent use of limited public resources. FDEM conducts a loss avoidance assessment after each Presidential Disaster Declaration using actual event data to validate avoided hazard impacts due to completed mitigation projects. These avoided hazard impacts are presented in terms of dollars saved (losses avoided) due to mitigation action, and project ROI.

The Hurricane Hermine loss avoidance analysis results reveal that out of 60 projects within the storm's area of impact, 31 experienced impacts that would have caused damage had the community not implemented the mitigation project. Overall, the 31 projects cost **$9.7 million** to implement and avoided **$20 million** in potential damage. The average ROI for DR-4280 is **82 percent**. Drainage projects show the greatest ROI because multiple structures benefit from one mitigation action. Flood mitigation building modifications averaged a 35 percent ROI; revealing, on average, a third of the initial mitigation investment was returned during Hurricane Hermine alone. Analysts combined DR-4280 results with the results of previous loss avoidance assessments to generate a cumulative ROI. Both Tropical Storm Debby and Hurricane Hermine impacted four of the 60 projects; integrated results reveal the cumulative ROI is **33 percent**.

In addition to evaluating losses avoided and ROI, FDEM analysts evaluated additional economic benefits of mitigation actions. Implementing mitigation activities engages various economic industries; in turn, boosting sales and revenues, increasing GDP contributions from Florida, and generating jobs. Results show that a $20 million-dollar investment in mitigation actions has created **99 jobs**, generated **$19.7 million** in sales and revenue, and contributed **$11 million** to the national GDP.

Loss avoidance assessments demonstrate the fiscal benefits of mitigation projects, and LAA results support sound decision making related to public funding. Chronic stresses and acute shocks related to natural hazards are drastically altering the physical and social fabric of our cities. Increasingly frequent and more intense coastal storms will affect social, economic, and environmental systems and infrastructure that communities rely on every day. Loss avoidance analysis provides insight that FDEM and local communities can use to explore strategies for a resilient future.

82 percent

of the initial mitigation investment was realized during Hurricane Hermine alone.

99 jobs created,

$19.7 million in sales and revenue generated,

$11 million

contributed to the national GDP because

Florida

implemented mitigation actions.