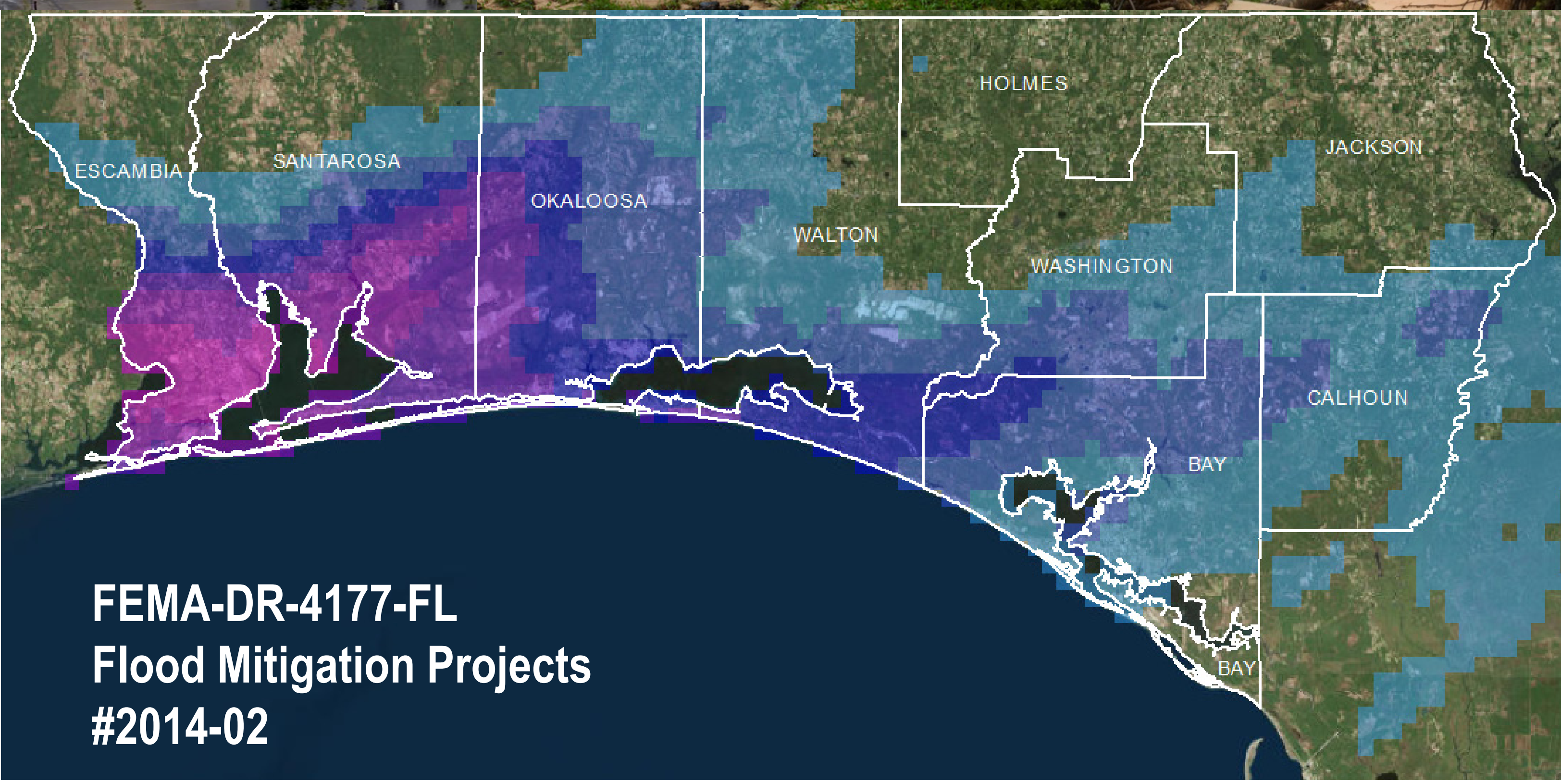
APPENDIX O:
Loss Avoidance Report Florida Severe Storms, Tornadoes, Straight-line Winds, and Flooding

Loss Avoidance Assessment

Florida Severe Storms, Tornadoes, Straight-line Winds, and Flooding

April 28th to May 6th, 2014



FEMA-DR-4177-FL
Flood Mitigation Projects
#2014-02

Florida Division of Emergency Management
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100
http://www.floridadisaster.org

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

Table of Contents

Table of Contents

Appendices

Executive Summary

Following the severe storms associated with DR-4177, the State of Florida conducted a loss avoidance assessment of flood mitigation projects funded through the Federal Emergency Management Agency (FEMA) Hazard Mitigation Assistance (HMA) grant programs. Analysts assessed mitigation projects completed by April 29, 2014[1] in the impacted area of DR-4177.

In total, 33 projects were evaluated by the State to determine their effectiveness during the flood event occurring throughout the Northwest Panhandle (DR-4177). The rain event impacted a total of seven counties including Bay, Calhoun, Escambia, Okaloosa, Santa Rosa, Walton, and Washington with rain totals reaching as high as 20 inches in portions of Escambia and Santa Rosa Counties. Due to the fact that many of these projects have been assessed in previous loss avoidance studies, the results have been integrated into the overall total of losses avoided to provide a net present value over the lifetime of the project.[2] Of the 33 projects evaluated in this report, 24 had been assessed in previous reports for other events.

The results produced from multiple Loss Avoidance Assessments validate the investment to spend resources mitigating the risk of natural hazards in Florida.

The 33 projects that were reviewed benefitted a total of 889 structures and 4 roadway projects within the impacted areas. Of the 33 projects, 10 were located within an area receiving over 12 inches of rain during the event. All projects were associated with at least one benefitting structure, while some projects, particularly drainage, benefitted multiple structures. In fact, the 10 projects receiving over 12 inches of rain benefitted a total of 697 structures based on the specific data that was analyzed for this assessment. Analysts only assessed projects completed at the time of the event and within the area of impact, as defined later in this report.

Losses avoided can be communicated in terms of Return on Investment (ROI), which is a function of costs avoided over project investment. Losses avoided are those losses which would have occurred without mitigation. Costs Avoided (CA) refers to the losses avoided minus project costs (in today's dollars). Project Investment (PI) is considered the project costs into today's dollars.

CA / PI = ROI

People survey the damage on Scenic Highway after part of the highway collapsed following heavy rains and flash flooding in Escambia County. Source: Reuters, Michael Spooneybarger

The 33 projects assessed for DR-4177 had a total capital cost of $18,422,686.64 (in 2015 dollars). Without mitigation, damages to the project sites affected by DR-4177 would have cost approximately $24,066,329.63. This is approximately 132% of the initial project investment.

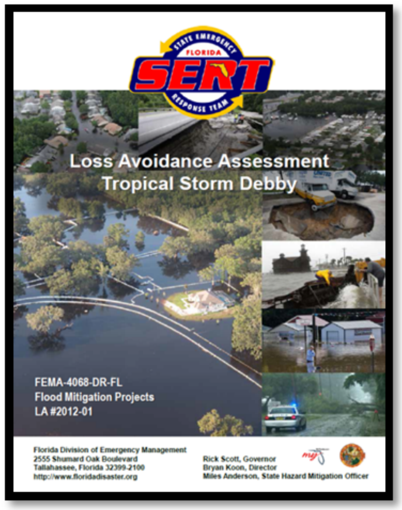
The total costs avoided (losses avoided minus project investment) for the FEMA DR-4177 event were calculated to be $5,643,642.79.

24 projects of the 33 projects analyzed during DR-4177 were impacted by events previously studied, and the ROI of over the lifetime of these projects is presented in this report.

[1] Due to the archival of earlier mitigation project files, only projects with open files after January 1, 2007 were available for review.

[2] Previous Loss Avoidance reports assessed damages from the following flood events: Tropical Storm Fay (2008), the North Florida Flood Event (spring 2009), the Unnamed June Flood Event (2012), Tropical Storm Debby (2012), Hurricane Isaac (2012), and Florida July Severe Storms and Flooding (2013).

The Tropical Storm Debby loss avoidance assessment evaluated 50 flood mitigation projects for their effectiveness during four events: Tropical Storm Fay (2008), the North Florida Flood Event (spring 2009), the Unnamed June Flood Event (2012), and Tropical Storm Debby (2012). Altogether the 50 projects cost $18.9 million dollars to implement, but the losses expected to have occurred without mitigation was approximately $21.9 million dollars. This is approximately 116% of the project costs, or a 16% ROI for this assessment.



The second loss avoidance assessment was conducted as a result of DR-4183 and DR-4084 and evaluated 37 flood mitigation projects for their effectiveness during two events: Hurricane Isaac (August 2012) and Severe Storms and Flooding (July 2013). Five projects were impacted by Hurricane Isaac and 842 structures benefitted. It cost $8.3 million to implement these projects and without mitigation the losses would have been over approximately $44 million dollars. This means the State avoided over $35 million dollars in costs related to Hurricane Isaac. The return on investment for Hurricane Isaac for the five projects analyzed is 435%. The ROI for Hurricane Isaac was successful due to the high proportion of drainage projects analyzed and the nature of the event. During Severe Storms and Flooding, 32 projects were analyzed for their effectiveness. It cost $4.2 million dollars to implement these projects, and the expected losses without mitigation would have been $5.4 million dollars. The State of Florida avoided over a million dollars in costs for this event. The ROI for this event was 29%.

The third loss avoidance assessment began after DR-4177 (Florida Severe Storms, Tornadoes, Straight-line Winds, and Flooding) and is a continuation of the State's effort to seek a better understanding of the fiscal benefits of implementing mitigation actions. Substantiating the money spent on hazard mitigation will help guide the decisions of policy makers, as well as provide a better understanding of how mitigation benefits local communities. This loss avoidance assessment presents policy makers with a quantitative assessment of the effectiveness of mitigation projects over the useful life of the project. This return on investment substantiates not only the value of a project for a certain event, but also across multiple events over the lifetime of the project.

The results of this assessment demonstrate that resource allocation for natural hazard risk mitigation in the State of Florida is a sound investment.

Of the 33 projects that were impacted by DR-4177, 24 were impacted by previously studied events, and the losses avoided represent 153% of the total project costs. These results provide a comprehensive snapshot of the value of mitigation in Florida, especially considering that the evaluations cover relatively few events over a short timeframe, compared to the average useful life of the projects (about 50 years).

Public funding is a scarce resource, and natural hazards impact infrastructure every time a disaster strikes. For this reason, it is pertinent that the State makes informed mitigation actions and gets the best value from the dollars it spends to avoid future losses. Loss avoidance assessments provide the opportunity not only to understand the fiscal benefits associated with hazard mitigation, but also analyze how mitigation can be applied most effectively. Continuing efforts to better understand where and which types of mitigation are most beneficial will increase the fiscal benefits of future mitigation projects in Florida.

When combined with previous loss avoidance results, the 33 mitigation projects analyzed for this event have avoided losses of approximately $33,236,520.50 from Presidentially Declared Disasters since Florida began regularly conducting loss avoidance assessments in 2008.

Report Contents

This report consists of two parts:

Part I contains an Introduction to Loss Avoidance Assessments, Event History, Detailed Results, Project Highlights, and Lessons Learned.

Part II provides an outline of Florida's System and Strategy and an explanation of how it was implemented for this report.

Appendices include:

A. **Individual Project Results**
B. **Project Call Sheets**
C. **Project Benefitting Structure Maps**
D. **Event Maps and High Water Mark Report**
E. **Blank Project Call Sheet**

Definitions are provided beginning on the next page in order to briefly familiarize readers with terms and concepts.

The road bed of Piedmont Street crumbles after it washed out due to heavy rains. Source: Getty Images, Marianna Massey

Detailed methodologies and technical details are provided in Florida's System and Strategy, available at www.floridadisaster.org/mitigation.

Definitions

Certain terms in this document may not be familiar to readers or may be familiar to readers within a different context. For this reason, the following provides clarification regarding the use and meaning of terms in this report. More detailed explanations of the terminology used in this report, as well as the methodology and calculations used to provide the results of this assessment are provided in the State of Florida's Loss Avoidance System and Strategy.

Area of Impact:	Also known as the damage swath. This is the area within which damage is expected to have occurred as the result of a hazard event. For the purposes of this report, the area of impact was determined to be areas that received cumulative precipitation amounts of six inches or greater over the duration of the event in counties that received a Presidential Disaster Declaration for the event being assessed. This low threshold for the area of impact resulted in the assessment of many project sites, within the defined area, without losses avoided, as explained later in this report.
Building Modification Project:	The term "building modification" has been adopted for this report in order to avoid confusion with conflicting terms used by other state and federal agencies. For instance, the United States Army Corps of Engineers uses the term "non-structural" to refer to projects which do not modify the environment. Use of this term may cause confusion as the same projects may also be referred to as "structural" by other agencies depending on context. Building modification projects here may refer to acquisitions, elevations, flood-proofing, or mitigation reconstruction.
Current Dollars:	Also known as "nominal". Refers to dollars current to the year in which they were spent.
Employment Impact Analysis:	An analytical assessment to estimate the employment-related benefits that certain activities provide. The Florida Division of Emergency Management conducted an Employment Impact Analysis in the fall of 2011 to determine the job-related benefits that mitigation activities, funded through the Hazard Mitigation Assistance Programs from August 2004 and February 2011, have provided to the state. Such a study is also called an Economic Impact Analysis.
Event:	The incidence of a hazard that results in damaging impact to an area of the state. An event does not have to result in a Presidential Disaster Declaration.
Losses Avoided:	Losses avoided, as reported in the results of this assessment, consist of those losses that would have occurred without the mitigation project, also known as losses that would have occurred in the "mitigation absent" scenario.
Losses Avoided for Building Modification Projects:	For the purposes of this assessment, losses avoided for building modification projects consist of the total of building, content, inventory, and displacement cost losses that would have occurred had the mitigation action never been implemented.
Losses Avoided for Drainage / Special Projects:	Losses avoided for drainage / special projects can be calculated in two ways: The first is 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. The second method, the method used for this particular assessment for DR-4177, involves modeling

and is described in Florida's Loss Avoidance Assessment System and Strategy.

Net Present Value: Net present value (NPV) of a mitigation project is the sum of losses avoided during all events assessed to date minus dollars spent, in 2015 dollars.

Normalization: Often, the year of project completion will occur prior to the event year (some events occur in the same year the project was completed). This means that $1 at the time of project completion likely does not have the same value as $1 at the date of event impact. As a result, past and present benefits and costs must be normalized in order to measure their true value. Normalization refers to the process of converting figures of differing origins, in this case different dollar amounts from different years, into a value that can be recognized and interpreted consistently.

Occupancy Type: Occupancy type refers to the use of the structure. Occupancy types used for the purposes of this report include Agricultural, Commercial, Educational, Government, Hospital, Industrial, Religious, and Residential.

Project: For the purposes of this assessment, a project refers to an individual subgrant award. A single project may have multiple project sites. For example, one acquisition grant project may acquire multiple structures in different areas.

Project Cost: Project cost consists of the total investment in project implementation and includes both federal and non-federal share at project completion.

Project Site: The project site is the location at which a project is implemented. For building modification projects that mitigate multiple structures, project sites are analyzed individually for losses avoided. This is due to the fact that the same event may have a different impact on different structures.

Real Dollars: Dollars normalized to present day values (2014). As opposed to "current" or "nominal" dollars, which refers to the value of dollars current to the year they were spent.

Relative Share of GDP Method of Cost Normalization: This is the method of cost normalization used to report results for this assessment. It is an appropriate method for normalizing dollars spent on public expenditures. This method to normalize costs values public investment based on the size of the economy at the time of the investment. It clarifies the value of the project at the time of the investment, in today's terms, as a share of the total amount of money available for investment in the country at the time. In other words, 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 calculated as follows:

$$\mathbf{(Cost_n / Nominal\ GDP_n)(Nominal\ GDP_x)}$$

Where, n is the year of the cost incurred and x refers to the year prior to the present year.

Full descriptions of the other two normalization methods used by the calculator are provided in the Loss Avoidance Assessment System and Strategy.

Recurrence Interval: Recurrence interval can also be referred to as return period. It is the inverse of the probability that a particular intensity event will be exceeded in any one year. In the case of this report, the event type is a flood. As an example, a 10-year flood has a 10-percent chance of its intensity being exceeded in any given year and a 50-year flood has a 0.02 or 2-percent chance of being exceeded in any one year. This does not mean that a 100-year flood will happen regularly every 100 years. In any given 100-year period, a 100-year event may occur once, not at all, or many times as each outcome has a probability of occurring in every year.

Return on Investment (ROI): ROI is a factor of the dollars saved (losses avoided) due to mitigation over the life of the investment. Losses avoided are considered a return because they represent money that is saved, as opposed to spent, due to the mitigation project. A return on investment is realized every time a disaster event impacts completed mitigation projects, because the intent of the project was successful and damages are avoided.

ROI can help guide decision-making by identifying which investments have been cost-effective. The formula below was used in calculating the ROI.

CA / PI = ROI

Where:

- **CA** = Actual costs avoided in terms of any of the above normalization methods (Losses Avoided minus PI);
- **PI** = Project Investment in terms of any of the above normalization methods (Mitigation Costs) ($); and
- **ROI** = Return on Investment (%).

Special Project: The term “special” project refers to all flood projects that are neither drainage nor building modification projects. These projects may be highly customized to the mitigation context and typically mitigate infrastructure. Examples might include armoring a coastal road or culvert opening.

Part I

- INTRODUCTION TO HAZARD MITIGATION AND LOSS AVOIDANCE ASSESSMENT
- EVENT HISTORY
- DETAILED RESULTS
- PROJECT HIGHLIGHTS
- CONCLUSIONS
- LESSONS LEARNED

Introduction to Hazard Mitigation and Loss Avoidance Assessment

Mitigation reduces risk to natural disasters.

Hazard mitigation or mitigation, is defined as any action taken to reduce or eliminate the long term risk to people and property from hazards and their impacts. Specifically, flooding remains the costliest natural hazard in the United States, causing on average $6 billion dollars in property damage and killing on average 140 people a year.[3] Investing in mitigation will help to reduce the impacts of natural hazards and loss avoidance assessments assist in quantifying the effectiveness of projects to improve the quality of future mitigation actions.

Effective mitigation measures reduce the loss of life and property, allow communities to recover from disasters more quickly, and lessen the financial impacts for individuals and local governments post disaster. Mitigation activities can be structural or non-structural and includes actions such as improved building codes, infrastructure and building hardening, acquisition and demolition, outreach and education, land use planning, legislation and more. Mitigation should take place across all stages of the emergency management life cycle, and is unique in that, *mitigation may reduce reaction based activities in the other stages of the cycle.* Mitigation achieves this by increasing the resiliency of a community against disaster related impacts. If there are lesser impacts, response and recovery will require fewer resources.

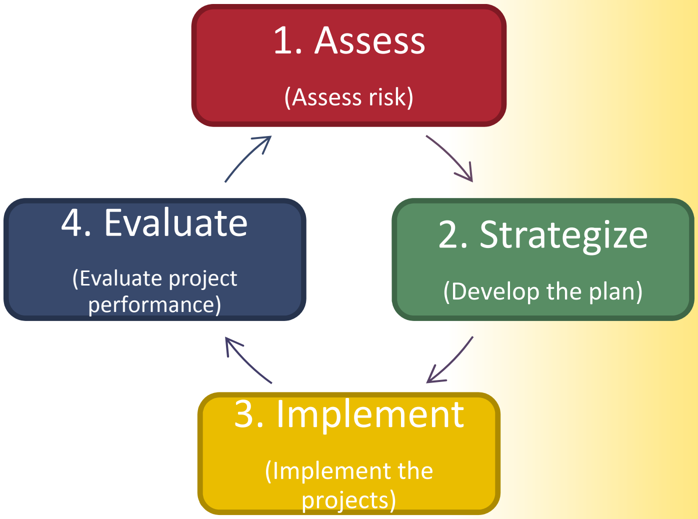
Loss avoidance assessments can be integrated into emergency management practices.

Mitigation planning takes place in a repeating cycle of four steps:

1) Assess risk and vulnerability,
2) Identify methods to reduce that risk,
3) Implement those methods, and
4) Evaluate the effectiveness of the methods implemented (Loss Avoidance Assessment).

A loss avoidance assessment completes the mitigation planning process. Its purpose is to evaluate the effectiveness of mitigation projects, and substantiate the actions that have been taken. This effectively helps to answer the question, "Is mitigation worth the cost?"

Loss Avoidance Assessment (Evaluate) is a natural part of the mitigation planning cycle and should be fully integrated into the process.



[3] U.S. Geologic Survey. U.S. Department of Interior.
USGS Science Helps Build Safer Communities.
Flood Hazards- A National Threat

Mitigation Provides Significant Value to Society.

Every year, through a variety of programs, the Federal Emergency Management Agency (FEMA) provides financial assistance for projects that will reduce or eliminate risks from natural hazards. To obtain assistance, local jurisdictions assess risk from natural hazards and identify mitigation projects to reduce vulnerability.

RETURN ON INVESTMENT

A study conducted by Multi-Hazard Mitigation Council (MMC), revealed that for every dollar spent on mitigation, society saves four dollars in prevented loss over the life of the project.

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

Due to the increased frequency and magnitude of natural disasters, along with the increased urbanization rate, costs associated with damages from natural disasters are on the rise. More than ever, it is important that completed mitigation projects are cost effective and sustainable for local jurisdictions. Conducting a loss avoidance assessment demonstrates the effectiveness of mitigation activities and can help aid decision making to appropriately allocate resources in the future.

Prevented losses include reduced direct property damage, direct and indirect reduced business interruption loss, reduced nonmarket damage, reduced environmental impacts, reduced human losses, and reduced cost of emergency response. There are many other potential benefits as a result of implementing mitigation measures, such as increased property values in mitigated communities, reduced economic impacts, and potential savings to the federal treasury in terms of avoided post-disaster relief costs, to name a few.

Loss avoidance assessment is one method to validate spending for hazard mitigation.

A loss avoidance assessment provides justification for existing and future mitigation actions. This assessment is an important tool that showcases the benefits of completed mitigation projects, while capturing the losses that were avoided from those projects.

Assessing the economic performance of mitigation projects over time is critical to support mitigation activities and encourage additional funding opportunities. Losses avoided are the damages that would have occurred if mitigation measures were not implemented. By quantifying the losses avoided in DR-4177 as a result of implementing mitigation projects, we can characterize the benefits of mitigation actions taken in Florida from one perspective.

To assess the effectiveness of mitigation projects and quantify the value of mitigation, the loss avoidance methodology can be applied. This methodology is simply evaluating the performance of a completed mitigation project during an actual hazard event and validating the costs that were avoided through the mitigation activity. It is performed by assessing, post-disaster, how much money was actually saved through the mitigation project.

A loss avoidance assessment provides the justification for existing and future mitigation projects and measures. The ability to assess the economic performance of mitigation projects over a period of time is important to encourage additional funding and continued support of mitigation activities. The assessment also requires the mitigation project be completed prior to the event being analyzed. Losses avoided by the mitigation measure are determined by comparing damage that *would have been caused* by the same event, had the project not been in place. The message of loss avoidance may be communicated and applied consistently if the assessment is completed on a regular basis immediately following an event.

PROCESS OVERVIEW

The State of Florida, in accordance with 44 CFR 201.5(b)(2)(iv), developed a system and strategy by which it will conduct an assessment of completed mitigation projects and to record the effectiveness of each mitigation project. The State adopted Florida's Loss Avoidance System and Strategy in 2011 and has committed to completing a loss avoidance assessment after every presidentially declared disaster.

Project data needed to conduct loss avoidance assessment is collected as part of the regular project grant application process, and is readily available for loss avoidance assessments. The benefits of capturing and retaining project information for future use at the time of application vastly outweigh the minimal cost in staff time and data storage.

Event data required to conduct loss avoidance assessment may be gathered as a regular part of post-disaster preliminary damage assessments. This can be accomplished through the gathering of high water marks, evidence of projects within the area of impact, through interviews with local officials or through further in-depth analysis.

Due to the severity of the DR-4177 event, severe erosion and structural failures were observed at several drainage structures, roadways, and private residences throughout the declared counties within the state. In order to determine the magnitude of the impacts to these facilities, a preliminary post disaster survey was performed in select areas where ongoing flood mitigation projects are located, as well as areas of known flooding. The locations of sites surveyed and an estimated flood depth based on observed high water marks (HWM) can be found in the High Water Mark Assessment Report found in Appendix D.

A two person field team was assembled and equipped with portable tablet devices to provide a preliminary survey. Using the database software program AssetHound; the GPS field location, height of the HWM, general observations, and photographs were recorded and documented at each site. All measurements were taken in US customary units (i.e., inches and feet) and GPS locations were referenced to the WGS84 datum. It should be noted that several areas displayed signs of flooding; however, no HWM was visible. In lieu of a visible HWM, when available, homeowners identified the peak of flooding observed. For some locations, analysts used modeling and methods using aerial photographs, as described in Part II of this report.

In general, HWMs were observed along wooden, privacy and chain-link fences, exterior brick walls, doorways, windows, and automobile tires. HWMs were measured from existing ground level below the feature, and if possible, a benchmark, or set point of known elevation (e.g., valves, manholes, fire hydrants, inlets, and roadway centerlines, etc.) was identified. Where applicable, the HWM was photographed with orientation to a benchmark to give a visual reference of flood depths. Data reports were filled out for each site, noting location, date and time, HWM ID, field representatives, and estimated flood depth.

In 2009, the State of Florida adopted a FEMA approved Enhanced State Hazard Mitigation Plan. States with enhanced status at the time of a declared disaster receive an additional five percent mitigation funding. This has meant millions of dollars in additional funding for the State of Florida

Event History

A series of severe storms in late April and early May, 2014 in northwestern Florida caused flooding of rivers and streams within several counties in the Florida Panhandle. The President of the United States signed a Major Presidential Disaster Declaration, FEMA DR-4177; on May 6, 2014 and as result of the severe storms, the following nine counties were declared for disaster assistance under DR-4177 (FEMA, 2014):

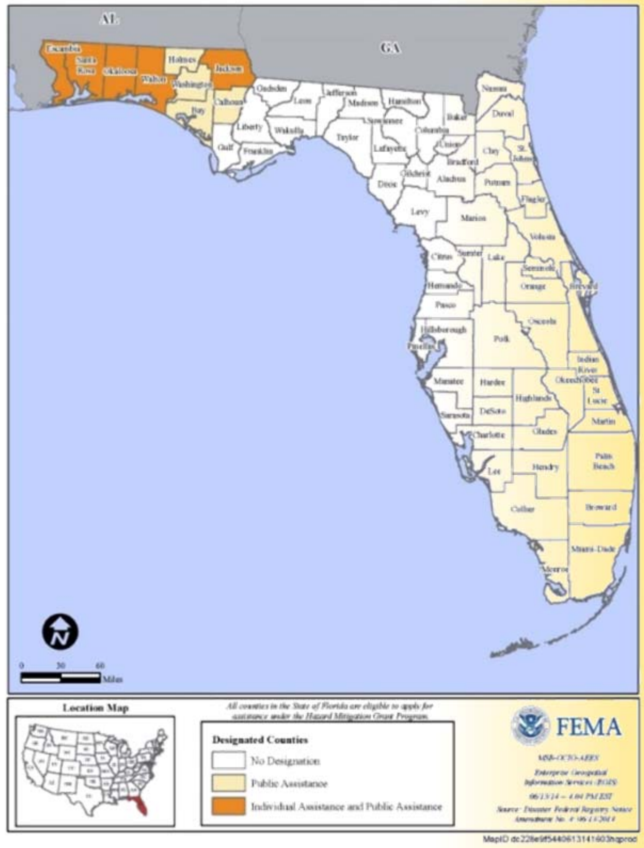
Bay County	*Calhoun County*
Escambia County	*Jackson County*
Santa Rosa County	*Okaloosa County*
Washington County	*Walton County*
Holmes County[4]	

Rainfall on April 29th-30th, 2014. Source: The Weather Channel

CAUSE AND BACKGROUND

With a slow moving cold front and a powerful low pressure system from the Plains, came heavy rainfall on the evening of Tuesday, April 29, 2014 to part of coastal Alabama and the western Florida Panhandle. This historic rainfall caused severe and record flooding, which subsequently resulted in sinkholes, the destruction of several roads, and severe damage to drainage systems in the affected counties.[5]

FEMA-4177-DR, Florida Disaster Declaration as of 06/13/2014

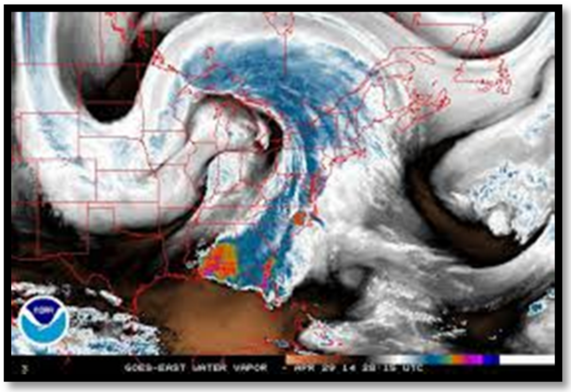


The total rainfall was caused largely by two separate storms; the first late Monday, April 28, 2014 and the second early Tuesday, April 29, 2014. Between 3-8" of precipitation fell in the affected areas during the first storm, and an estimated 10-15" of precipitation fell in the affected areas during the second storm.

The second storm was more severe, causing increased flooding largely because the rainfall fell within a very short period of time (estimated at 9 hours). According to National Oceanic and Atmospheric Administration (NOAA), this high intensity rainfall overwhelmed local roadways, canals, and drainage systems and resulted in severe flash flooding. Record rainfall was recorded at numerous locations throughout the Florida panhandle, including the Pensacola Regional Airport (PNS), and estimates of the two-day total of 20.47" for the event in Pensacola, Florida registered between a 100- to 200-year event per NOAA.

[4] Although declared under DR-4177, complete mitigation projects within Jackson and Holmes Counties are not analyzed in this report because they are not located within the area of impact.

[5] National Oceanic Atmospheric Administration (NOAA)



Radar image of storm event April 29-30th, 2014 Source: National Oceanic Atmospheric Administration

In addition to the torrential downpour, saturated soils from previous events may have also contributed to the intense flooding in some areas, with rainfall totals from the prior weeks at 200-600% of the 30 year normal from PRISM Data (NOAA)[6].

According to the National Climatic Data Center, damages descriptions from the 7 impacted, declared counties included the following as a result of FEMA DR-4177:

Bay County: Many roads in the county sustained damage with losses estimated at $1,591,122[7]. In addition, some businesses suffered flood damage with estimates at approximately $250,000. Heavy rain breached the levee in the Intracoastal Waterway at the Bay-Walton county line, shutting down barge traffic. This resulted in a local gas shortage for Panama City as none of the barges could deliver gasoline to the local market. The Army Corps of Engineers estimated that permanent work will cost up to $5 million.

Calhoun County: Major flooding occurred across the county due to a combination of very heavy rainfall and already saturated conditions. Many roads in the county sustained damage with damage estimated at $3,234,208.

Escambia County: This was the heaviest hit area of the panhandle, with central and southern parts of the county experiencing historic flooding the night of April 29th into the early morning of April 30th. Nearly 2 feet of rain fell across portions of southern Escambia County. Pensacola International Airport recorded a storm total of 20.47 inches. 1,687 residential homes suffered major flooding with 12 inches of water or more. 1,518 residential homes suffered minor flooding with less than 12 inches of water. 13 homes were destroyed. 117 commercial businesses experienced major damage. Widespread infrastructure damage, totaling $27.5 million, occurred with numerous roads, bridges, and drainage systems heavily damaged. Numerous water rescues took place during the height of the event due to the rapid rise of water. A 67 year old Pensacola woman drowned when her vehicle was submerged by flood waters on U.S. 29 near Cantonment, FL.

Home flooded in Escambia County. Source: ARCADIS-US

Holmes County: According to State Officials, major flooding occurred across Holmes County during the event due to a combination of very heavy rainfall and already saturated conditions. Many roads in the county sustained damages with losses estimated at $945,255.

Jackson County: According to the NWS Storm Survey, several tornados touched down about a half mile east of Highway 77 south of Graceville and along Highway 231 southeast of Campbellton. Damage was mostly to trees, but several homes were also damaged. Reports from the Emergency Manager estimated that 64 roads were closed or underwater across Jackson County due to heavy rain and flash flooding. State Officials reported that major flooding occurred across Jackson County due to a combination of very heavy rainfall and already saturated conditions. Many roads in the county sustained damage with damage estimated at $6,691,424.

[6] PRISM is a technique that uses point data in conjunction with a digital elevation model to create gridded datasets of precipitation and temperature for the U.S.

[7] All losses reported in this section are preliminary damage assessments to be updated upon the quantification of all true damages. As of January 2015, most counties are still developing damage and cost documentation.

Okaloosa County: Eight to fourteen inches of rain fell across Okaloosa County during the evening of April 29th and the early morning of April 30th. The rain resulted in widespread flash flooding across the county. 737 homes were damaged by flood waters. Numerous roads were impassable during the event, with several damaged or $6,691,424.compromised by the fast moving flood waters.

Santa Rosa County: Major to historic flash flooding took place on the evening of April 29th through the early morning of April 30th as 12 to 22 inches of rain fell across the southern half of Santa Rosa County. The highest measured rainfall was 20.39 inches 10 miles south of Milton by a local observer. Hundreds of homes and businesses experienced significant flooding with property damage estimated at almost $10 million. The hardest hit areas included Milton, Gulf Breeze, and Navarre. In addition, widespread infrastructure damage to roads, bridges, and drainage systems was caused by the rapid rising flood waters. Infrastructure damage is estimated to have cost around $6 million.

Walton County: Road damage in the county was estimated at $1,464,696. At least 10 businesses were impacted with damage estimated at approximately $300,000. Significant flash flooding occurred for an unusually long period of time as very heavy rain moved repeatedly over the area. At least three cars were flooded in the Miramar Beach area.

Washington County: Several trees were blown down and multiple roadways were impassible and closed off throughout the County Monetary damage was estimated. Major flooding occurred across Washington County at the end of the month due to a combination of very heavy rainfall and already saturated conditions. Many roads in the county sustained damage with damage estimated at $2,155,731.

Roadway crumbles along CR3280 at Magnolia Lodge Road in Freeport. Photo courtesy of Walton County Sheriff's Office

Road washed out due to flooding In Okaloosa County. Source: Crestview Bulletin, Matthew Brown

Detailed Results

This section provides the results of the loss avoidance assessment in terms of projects analyzed and losses avoided during DR-4177, and also provides a consolidated analysis of the first Loss Avoidance Assessment (DR-1785, DR-1831, DR-4068 and June 2012 Floods), the second Loss Avoidance Assessment (DR-4084 and DR-4138), and DR-4177 results.

Detailed methodology for loss avoidance calculations are provided in Florida's Loss Avoidance System and Strategy posted on the Bureau's website (www.floridadisaster.org/mitigation). A description of how the methodology was implemented for this assessment is provided in Part II and Appendix E of this report.

RESULTS FOR DR-4177

Projects analyzed in this report are completed flood mitigation projects that are located in the area of impact[8] for DR-4177.

Staff gathered data and supporting documentation from 33 Projects which had mitigated a total of 893 structures in the declared counties.

Table 1 provides a snapshot of mitigated projects assessed for DR-4177, by project type, and Table 2 provides a summary of projects assessed by occupancy. These tables include the total cost of the projects in current dollars (2015), the average cost per mitigated structure, or in the case of the drainage and roadway projects, structures benefitting from the project itself. Table 3 provides a summary of losses avoided during this event. Seven of the 9 declared counties had completed projects within the area of impact.

Figure 1 and Figure 2 is a visual representation of the information provided in Table 1and Table 2 respectively.

Results are reported as losses avoided and return on investment in 2015 dollars using the GDP Deflator method of cost normalization (see Definitions).[9]

[8] See Appendix A: Definitions for an explanation of the area of impact.

The total cost of the 33 evaluated flood mitigation projects for DR-4177 was $18,422,686.64 in real 2015 dollars. The average share of project cost per benefitting structure was $331,892.08. Of the mitigation projects analyzed for DR-4177, drainage projects benefitted far more, on average, than any other flood mitigation project type. This is to be expected, as building modification projects typically focus on fewer structures. In addition, drainage projects are uniquely suited to tackle issues of excessive rainfall and sheet flow in urbanized areas. For detailed results of losses avoided by project, please refer to Appendix A: Individual Project Results.

The results show that the projects assessed have demonstrated a positive return on investment during this event. Losses avoided have exceeded the project costs invested and provided additional benefit to Floridians valued at approximately $5.6 million dollars. As additional events impact these project sites, losses avoided and the return on investment should increase.

Summary of aggregate values for the 33 DR-4177 projects assessed for losses avoided (in 2015 dollars)

- $18,422,686.64 in flood mitigation project costs
- $24,066,329.63 in **losses** that are **expected** to have occurred **without the mitigation projects** in place (losses avoided).
- $5,643,642.79 in **actual costs avoided** (losses avoided minus project costs).

[9] The Loss Avoidance Calculator provides results using three different methods of cost normalization. These methods are detailed in the Loss Avoidance System and Strategy.

Table 1 Summary of Projects Reviewed by Type (Current Dollars)

Project Type	# of Projects	# of Structures Benefitting	Total Cost	Avg. Cost Per Benefitting Structure
Acquisition	11	22	$3,614,544.87	$164,297.49
Drainage	14	862	$9,419,506.49	$10,927.50
Elevation	4	4	$636,779.51	$159,194.88
Floodproofing	1	1	$182,768.81	$182,768.81
Roadway/Infrastructure	4	4	$4,569,086.96	$1,142,271.74*
Total	***33***	***893***	***$18,422,686.64***	***$331,892.08***

*Roadway projects are intended to protect service rather than structures.

Table 2 Summary of Structures (by Occupancy) Benefitting from Flood Mitigation Projects Reviewed (Current Dollars)

Occupancy	# of Structures	Total Cost	Avg. Cost Per Structure
Residential	29	$13,537,080.28	$15,814.35
Religious	4	$4,569,086.96	$1,142,271.74
Government	4	$151,701.85	$37,925.46
Commercial	856	$164,817.55	$7,491.71
Total	***893***	***$18,422,686.64***	***$300,875.81***

Figure 1 Number of Projects Impacted by DR-4177

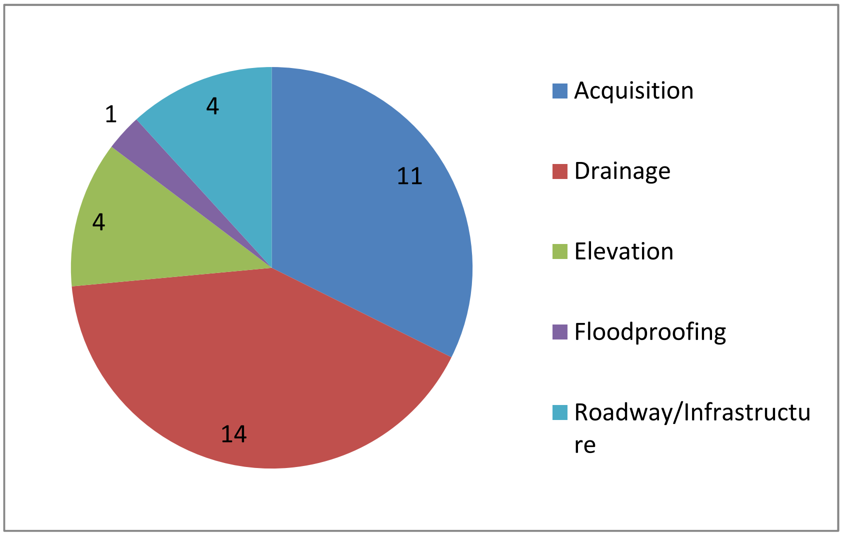


Figure 2 Summary of Structure Benefitting by Occupancy Type for DR-4177

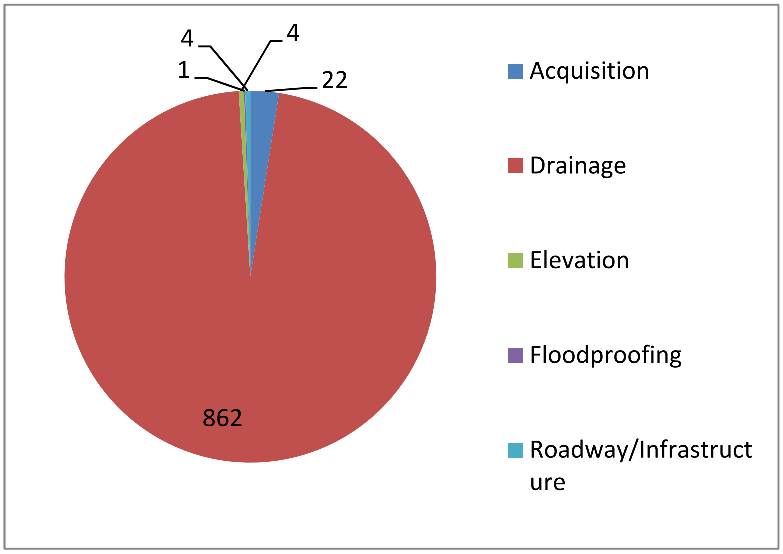


Table 3 Summary of Losses Avoided by County

County	# of Projects Impacted	Total Project Cost	Total Losses Avoided	Net Present Value (Actual Costs Avoided)
Bay	8	$ 2,269,512.67	$1,376,601.68	($892,910.98)*
Calhoun	4	$ 4,569,086.96	$278,980.80	($4,290,106.56)*
Escambia	3	$ 3,000,177.68	$334,518.04	($2,665,659.64)*
Okaloosa	5	$ 1,395,308.41	$6,807,963.13	$5,412,654.73
Santa Rosa	9	$ 5,717,877.62	$15,083,280.77	$9,365,403.14
Walton	1	$ 479,134.89	$55,309.84	($423,824.85)*
Washington	3	$ 991,588.41	$129,675.37	($861,913.05)*
Total	***33***	***$18,422,686.64***	***$24,066,329.63***	***$5,643,642.79***

* Indicates a negative value

**Due to the nature of this event drainage projects were very successful.

Integrated Results

- **LOSS AVOIDANCE ASSESSMENT #1: DR-1785/DR-8131/DR-4068/JUNE 2012 FLOODS**
- **LOSS AVOIDANCE ASSESSMENT #2: DR-4084/DR-4138**
- **LOSS AVOIDANCE ASSESSMENT #3: DR-4177**

Table 4 summarizes the losses avoided and actual costs avoided for the 33 mitigation projects analyzed in this report by county. The tables incorporate results from the previous loss avoidance studies to provide actual costs avoided over the lifetime of the project across multiple events.

Results are reported as losses avoided and actual costs avoided in 2015 dollars using the GDP Deflator method of cost normalization (see Definitions).[10]

Of the 33 projects analyzed, $33 million dollars in losses were avoided over the seven different disaster events that have been assessed. Of the 33 projects impacted by DR-4177, 24 were impacted by previously studied events, although; no project was identified as having been impacted by more than two events. Eight projects were impacted by one of the four events studied in the first loss avoidance report, and nine projects were impacted by one of the two events in the second loss avoidance report. Table 5 summarizes the events which have impacted the projects analyzed in this report. The losses avoided have exceeded the project costs invested and provided additional benefit to Floridians valued at over $10.8 million dollars. Counties with significant impacts from multiple events have the highest losses avoided because the completed projects have mitigated the risk of flooding on multiple occasions.

The integrated results showcase that the completed mitigation projects assessed in this report have demonstrated a substantial positive return on investment. As additional events impact these projects in the future, losses avoided and the return on investment will continue to increase.

Summary of Integrated Results (in 2015 dollars)

- $18,422,686.64 in flood mitigation project costs
- $33,236,520.56 in **losses** that are **expected** to have occurred **without the mitigation projects** in place (losses avoided).
- $10,834,517.34 in **actual costs avoided** (losses avoided minus project costs).
- The **return on investment (ROI)** for the assessed Florida DR-4177 projects is currently 53.81% or 153.81% of project capital investment.

Flood damage in Pensacola, FL.
Source: Pensacola News Journal

[10] The Loss Avoidance Calculator provides results using three different methods of cost normalization. These methods are detailed in the Loss Avoidance System and Strategy.

Table 4 Consolidated Losses Avoided by County

County	# of Projects Impacted	Total Project Cost	Total Losses Avoided	Net Present Value (Actual Costs Avoided)
Bay	8	$ 2,269,512.67	$5,404,257.45	$3,134,744.78
Calhoun	4	$ 4,569,086.96	$278,980.80	($4,290,106.16)*
Escambia	3	$ 3,000,177.68	$378,562.06	($2,621,615.62)*
Okaloosa	5	$ 1,395,308.41	$6,870,647.01	$5,475,338.60
Santa Rosa	9	$ 5,717,877.62	$19,885,322.04	$14,167,444.42
Walton	1	$ 479,134.89	$141,450.39	($337,684.50)*
Washington	3	$ 991,588.41	$277,300.81	($714,287.60)*
Total	***33***	***$18,422,686.64***	***$33,236,520.56***	***$14,813,833.92***

* Indicates a negative value

Table 5 Summary of Previous Events

FEMA Project Number	DR-1785,DR-1831, June Floods 2012, DR-4068	DR-4084, DR 4138	DR-4177
1069-0003		X	X
1069-0006		X	
1069-0091		X	X
1806-0002		X	X
FMA-PJ-04-FL-2008-011			X
RFC-PJ-04-FL-2007-201			X
RFC-PJ-04-FL-2008-002			X
RFC-PJ-04-FL-2008-003			X
1595-32			X
1831-25			X
1831-6			X
1831-7-R			X
1195-0104			
1595-27-R			X
SRL-PJ-04-FL-2008-021	X		

FEMA Project Number	DR-1785,DR-1831, June Floods 2012, DR-4068	DR-4084, DR 4138	DR-4177
1062-0015		X	X
1195-0100			X
1551-20-R			X
1551-21-R			X
PDMC-2003-080			X
1551-027-R	X		X
1551-028-R	X		X
1551-033-R	X		X
1551-038-R	X		X
1551-26-R	X		X
1831-9-R	X		X
4087-04			X
FMA-PJ-04-FL-2009-001	X		X
SRL-PJ-04-FL-2009-019			X
1249-0066		X	x
1249-0066			
1249-0066			X
1035-0005		X	X
1035-0005		X	X
1195-0067			X
DR-1035-0005		X	
DR-1035-0005		X	
DR-1035-0005		X	X
DR-1035-0005		X	
DR-1035-0005			X
DR-1035-0005			X
DR-1035-0005		X	
DR-1035-0005		X	
DR-1035-0005		X	X

Project Highlights

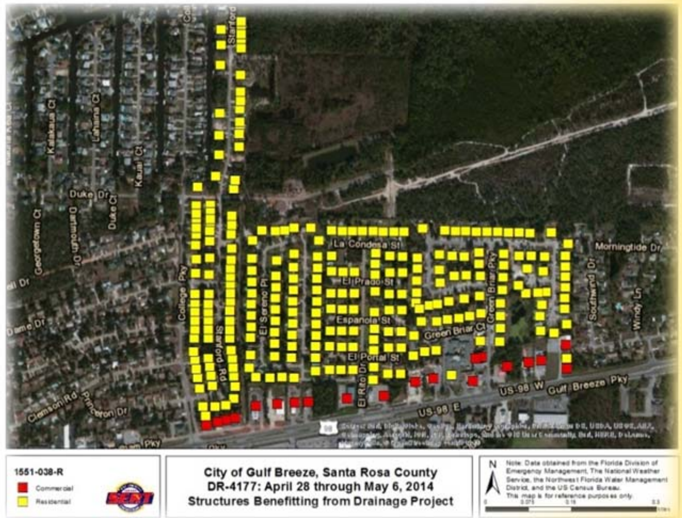
During this loss avoidance assessment, analysts identified mitigation projects that were most successful, and they are highlighted below. Analyzed drainage projects proved to have the most positive outcomes during DR-4177, due to the fact that this was largely a storm water event and because these projects often benefit so many structures. The projects below are meant to serve as examples of best practices, and it is hoped they provide practical guidance to jurisdictions for hazard mitigation efforts.

SANTA ROSA COUNTY - GREENBRIAR DRAINAGE PROJECT

Santa Rosa County used mitigation funding to implement a comprehensive drainage project which has subsequently benefitted over 282 structures. This project was impacted by the Unnamed June Event in 2012 and also by DR-4177 in 2014. Altogether throughout the duration of this mitigation project, $11.87 million dollars in damages have been avoided, while the project costs were only $1 million dollars. $8.8 million dollars in damages were avoided for DR-4177 alone. The project mitigated possible damages to 22 commercial structures and 260 residential structures, including a nursing home, multi-family housing and single family homes.

The project was implemented to improve drainage in the Greenbriar subdivision located in Gulf Breeze by removing inadequate drainage facilities and replaced them with a comprehensive and coordinated drainage network capable of handling excepted runoff from the area. Final design plans determined that the improved flood protection is realized and the project eliminates structural flooding for up to a 100 year storm event.

Not only are there fiscal benefits associated with avoiding direct damages to the benefitting structures, but social losses were avoided as well. Expected impacts to the nursing home could have caused the facility to close temporarily and would have caused the residents be relocated to alternate facilities. Homes for the aged are equipped with specialized technology to serve their specific needs, and relocation efforts would have been expensive, time consuming and difficult to implement.



SANTA ROSA COUNTY– ORION LAKE STORMWATER DRAINAGE IMPROVEMENT

The county used mitigation funds to improve storm water drainage in the Orion Lake subdivision located in Navarre. The project was impacted by two events, the Unnamed June Event in 2012 and DR-4177 in 2014. The project cost was approximately $682,000, but throughout the duration of the project over $1.62 million dollars in losses have been avoided. $1.4 million in losses was avoided for DR-4177 alone. 216 residential properties have benefitted from this project, and local officials reported the project has performed as designed with no structural flooding.

Improvements included upgrading inadequate drainage facilities to a comprehensive drainage network capable of handling expected runoff from the area. The project is designed to provide protection up to a 100-year storm event.

SANTA ROSA COUNTY – VILLA VENYCE STORMWATER DRAINAGE IMPROVEMENT

Mitigation funding improved the stormwater drainage system in the Villa Venyce neighborhood in Gulf Breeze. Again, this project was impacted by two events, Unnamed June Event in 2012 and DR-4177. Over the two events assessed, $3.5 million dollars in losses were avoided, and it cost $500,000 to implement the project. 40 residential structures have benefitted from this project.

Improvements included updating the Villa Venyce storm water drainage facilities to a comprehensive drainage network capable of handling expected runoff from the area. Pipes, inlets, swales and under drain were used to accomplish these objectives. The completed construction minimized recurring flooding, reduces repetitive flood loss to properties, and provides protection against a 100-year storm event. Local Officials attested to the success of this project and report the project has performed as designed in storm events.

BAY COUNTY – DRAINAGE PROJECT

The drainage project in Lynn Haven benefitted 24 residential structures. The project was impacted by two disaster events, Florida Severe Storms and Flooding in 2013 and DR-4177 in 2014. Throughout the duration of the project approximately $3.4 million dollars in losses have been avoided and it only cost $200,000 to implement the project. The drainage improvements have proved to be successful and the project area was not affected during the severe flooding of DR-4177 because the project performed as intended and effectively removed water from the site.

> *"All stormwater hazard mitigation projects (15+ projects) completed to date performed as designed, with no damages to date. These project range from projects completed in 1997 to as recent as 2013, and they have great success in mitigating damages. We are very appreciative for the FDEM program that funded these projects. –Bay County Engineering Division*

CALHOUN COUNTY- ROAD PROJECTS

Four road mitigation projects were completed in the county before DR-4177. Mitigation of the roads included elevating and paving the roads, as well as adding culverts underneath. Three of the four road projects performed as designed during DR-4177 protecting the infrastructure itself and use of the road during and after the storm event. One of the roads experienced minimal damage because the mitigation project was not successful. The designed to level of protection was not great enough to withstand the impacts of DR-4177.

> *"We embrace the opportunity to pursue HMGP funding and perform hazard mitigation to become more resilient to natural hazards in our community. Had we not performed mitigation in our community, the damages from DR-4177 would have been much greater." –EM Director Calhoun County*

Conclusions

Mitigation works.

All projects analyzed in this loss avoidance assessment, as well as the prior two assessments, produced positive results and showcased the return on investment. There were no losses recorded for the flood hazard mitigation projects funded through the HMA programs and identified for this report.

The results analyzed in the loss avoidance assessment showcase a return on investment from mitigation funding, and reveals the successful implementation of mitigation projects. The projects analyzed create more resilient communities and validate the money spent on mitigation projects. This assessment gives an in-depth look on how mitigation benefits the community and also how the return on investment is captured.

The projects analyzed in this report represent a small fraction of the mitigation that is occurring throughout the State, and therefore represent only a fraction of the benefits of mitigation. There are many types of mitigation not reviewed in this report including mitigation efforts addressed through local codes and ordinances, planning, outreach. Such activities are arguably more effective as they may help prevent construction in harm's way or promote development of mitigated communities. The results of this report are only a cross-section of the most easily quantified benefits of mitigation, and the true value of mitigation is much greater than the benefits highlighted in this report, which may include physical damages, displacement, and loss of function, where appropriate, and only evaluate potential impacts to structures.

The results of this loss avoidance assessment support investment in hazard mitigation projects in Florida.

The results of this assessment demonstrate the effectiveness of assessed mitigation projects in the State of Florida for projects completed within a relatively short period of time (January 2007 through April 2014).

The return on investment for all 33 mitigation projects that sustained repeated impacts within the 9 declared counties, completed before DR-4177 is **31.57%** (over 131% of the project costs) and the consolidated return on investment from all three (3) loss avoidance assessments for the 24 repeatedly impacted projects is **53.81%** (over 153% of the project costs). These results validate that mitigation projects funded by federal dollars in Florida are cost effective in practice.

Standing water remains around homes in Gulf Breeze six days following the flooding. Source: Pensacola News Journal, Katie King

Some project types provide more comprehensive mitigation than others.

Elevations may mitigate flooding to structures, but do not mitigate ingress/egress issues from flooding. During the events assessed, some elevated structures still encountered access issues but did not sustain any damages from the assessed disasters. Drainage projects reduced the overall flooding hazard to impacted areas and acquisition projects eliminated vulnerability to the hazard entirely. Improved drainage projects may be the most cost-effective way to mitigate flooding in urban setting. Aside from preventative actions, such as planning and codes and standards, communities are able to mitigate multiple structures through one mitigation project.

A whole neighborhood approach to mitigation is recommended.

Projects which addressed entire neighborhoods provided greater benefit and per structure cost of mitigation was considerably lower. The whole neighborhood approach to local resilience offers potential for long-term loss risk reduction. With the cost of natural disasters increasing, communities need to shift their focus towards resiliency and understanding the importance of mitigation. These efforts are achievable and essential for a public commitment to a sustainable neighborhood approach.

Lessons Learned

IMPORTANCE OF DATA COLLECTION

Data collection is by far the most resource-intensive step in the loss avoidance assessment process. It is important to collect data rapidly to document the event for a loss avoidance study. The State's project database helps to assist in this effort, but data regarding historical losses and impacted structures are not captured within this database. No two disaster events are ever the same, thus capturing historical loss data will likely be different after each event. Local officials are often the best resource to determine impacts to structures and infrastructure within the area of impact for a particular disaster event. Nevertheless, in a post-disaster scenario local officials may be occupied with disaster response activities and other methods of data collection will have to be performed. Historical losses should be recorded pre-mitigation and post-mitigation. Each loss avoidance assessment provides an opportunity to improve data available for *future assessments.*

Collecting high water marks after each disaster event will also aid in updating historical data, as well as serving the purpose of collecting event data. See Appendix D Event Maps and High Water Mark Report.

PERFORMANCE CALL SHEETS

It is important to maintain a point of contact in each county impacted by the disaster so that current project and data information may be easily collected. During each loss avoidance assessment, contact information is updated to keep current when reaching out to counties to gather data. As a method to assist with collecting information on historical losses, performance call sheets are used in combination with collecting high water marks. Performance call sheets are comprised of a series of questions that assist in data gathering and recording local expert knowledge of hazard impacts for mitigation projects in the community. Performance call sheets serve a dual purpose, not only are they recording impacts for that specific event, but they also assist in maintaining a record of previous disaster events, as well as identifying specific hazard concerns within the community.

GIS AND PROJECT LOCATIONS

The heart of a loss avoidance assessment is to understand the benefits of mitigation actions, and understanding the location of areas where natural hazards have repeated impacts is one of the key benefits of a loss avoidance assessment. Resources such as ArcGIS allow the State to visualize the area of impact and structures benefitting from a project. This is useful tool when assessing potential locations for future mitigation initiatives. Analysts can visually depict areas of repetitive impact with "heat maps" that may identify what type of projects are successfully mitigating disaster losses in those areas. In addition, the State may identify those areas where mitigation measures have assisted in achieving goals set in the Florida Enhanced State Hazard Mitigation Plan.

Visualizing where the successful projects are located and use this information to guide the location and implementation of new mitigation opportunities where they can be most successful. Furthermore, knowing where mitigation projects are in relation to know hazard areas, coupled with an understanding of project effectiveness will aid in identifying where mitigation opportunities can be most successful and cost effective in the future.

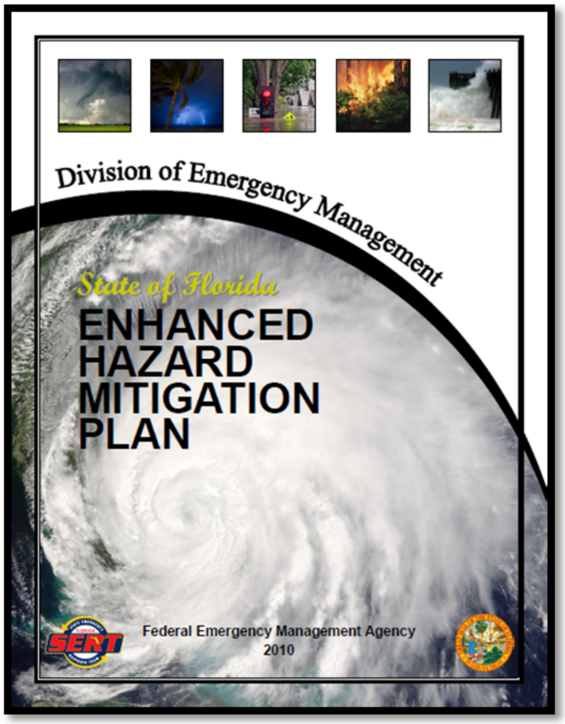
Part II

- FLORIDA'S LOSS AVOIDANCE ASSESSMENT SYSTEM AND STRATEGY
- SYSTEM AND STRATEGY IMPLEMENTATION FOR DR-4177

Florida's Loss Avoidance Assessment System and Strategy

The Florida Loss Avoidance System and Strategy was developed as a guide to conduct an assessment of completed mitigation actions and record the effectiveness of each mitigation action. The federal government incentivizes loss avoidance analysis by requiring such analyses to maintain a FEMA approved Enhanced State Hazard Mitigation Plan (SHMP). States with enhanced status at the time of a presidentially declared disaster are eligible to receive additional mitigation funding. The State of Florida has developed a loss avoidance system and strategy in accordance with 44 CFR 201.5(b)(2)(iv) to assess the value of mitigation projects funded by FEMA to date.

Loss avoidance analysis is incentivized by the Federal Government.



Enhanced status has meant millions of dollars in additional funding for the State of Florida.

Florida has developed a system and strategy to conduct loss avoidance analyses.

As a disaster prone state, Florida desires to better understand the fiscal benefits of implementing mitigation actions, as well as receive additional 5% in Hazard Mitigation Grant Program (HMGP) funding. To meet this goal Florida has developed its own loss avoidance methodology and loss avoidance calculators for projects that mitigation flood or wind hazards. The State developed its methodologies with the motivation to distill the best components of various approaches to achieve a streamlined and defensible process that does not significantly add to the cost of mitigation.

The United States Federal Government contributes significant funding to reduce the potential impact of natural disasters by implementing mitigation projects. These projects must adhere to specific criteria identified by the programs that administer them, as well as the OMB Circulars and Codes of Federal Regulation (CFR). A key criterion is cost-effectiveness.

The majority of mitigation projects are subject to a benefit cost analysis (BCA) prior to funding, but policy makers are also interested in mitigation project performance during an actual hazard event. By understanding the performance of mitigation projects, we can understand their effectiveness, which is often characterized as the losses avoided. FEMA has developed methodologies using a quantitative approach to assess the performance of mitigation projects based upon actual post-construction hazard events. Policy now incentives states to do the same.

The loss avoidance calculators use a broad range of data to calculate losses avoided for one event or multiple events over the lifetime of a project. Hence, in addition to understanding the losses avoided for a single project for a single event, Florida can provide the net present value of a mitigation project or potentially the net present value, in investment terms, of all mitigation projects in the State of Florida available for analysis.

In this way, loss avoidance assessments are completing the mitigation cycle by evaluating the effectiveness of mitigation projects. Such analyses will help guide decision making and identify best practices, as well as identify those projects that are most cost beneficial.

Guidance to use this system and strategy is provided by project type on the Florida Division of Emergency Management's website. This guidance consists of the following sections:

Section A System and Strategy Overview: Provides a basic outline of the process and an introduction to the guide.

Section B Project Record Keeping and Data Needs: This section provides recommendations for preparing for loss avoidance assessment and outlines project record-keeping and data needs.

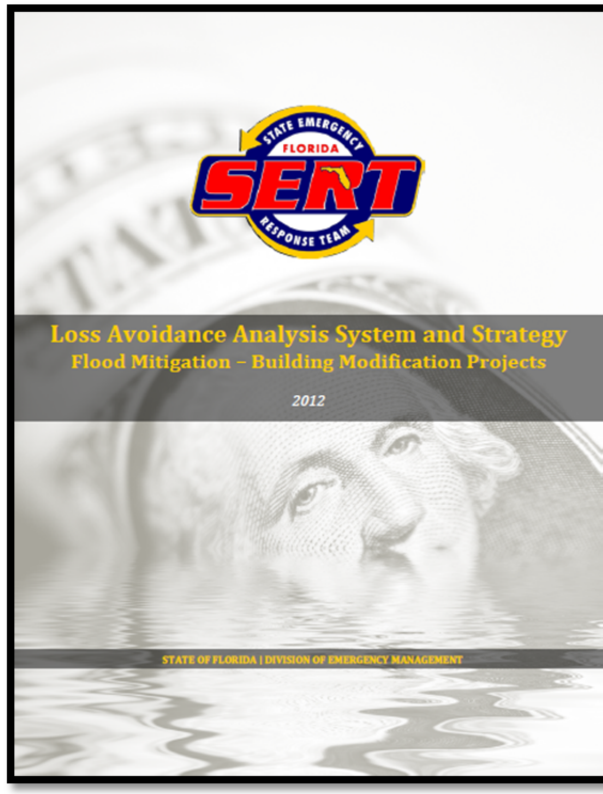
Section C Event Data Collection and Processing: This section identifies event data needs and recommended methods for obtaining that data.

Section D Loss Avoidance Calculator User Guide: This section contains the user guide for the Loss Avoidance Calculator version 1.0 for the appropriate project type. The calculator is what provides losses avoided based on the analyst's inputs.

Section E Technical Details: This section includes technical details regarding computation of quantitative impacts, losses avoided, return on investment, and sources used to develop the system and strategy.

Loss Avoidance Calculator: The current LACs (Version 1.0) operate within Microsoft Excel 2007 and 2010. This platform was chosen because it can be quickly and easily adapted, stored, and transferred to other users. The State of Florida is making the calculator publically available, so that others may substantiate the value of mitigation in their communities.

Florida has developed calculators to help conduct loss avoidance assessments.



The System and Strategy is available on the Florida Division of Emergency Management website at www.floridadisaster.org.

System and Strategy Implementation for DR-4177

This section will discuss how Florida's System and Strategy was implemented for DR-4177. The basic steps of loss avoidance assessment include collecting event data, entering the data into the loss avoidance calculators to calculate the nominal costs avoided, normalized losses avoided, and calculating return on investment. For this report, previous loss avoidance assessment results were integrated to provide a comprehensive assessment over the project useful life. Florida considers collecting project data as the preparatory process for a loss avoidance assessment. This is because once data is already collected for a project it need not be collected again. As such, for this loss avoidance assessment, project data was readily available for all projects analyzed in this report.

Projects analyzed met the following criteria:

- Projects that mitigated a flood hazard
- Projects completed prior to the designated incident period for FEMA DR-4147
- Projects that have not been archived to date
- Projects within the impacted areas that were declared by FEMA

The following sections outline the step taken to collect project and event data, utilize the loss avoidance calculators and integrate previous loss avoidance results.

Project Selection and Data Needs

When conducting loss avoidance assessments there are two types of data sets necessary: (1) event data and (2) project data (See Section B Project Record Keeping and Data Needs of Florida's System and Strategy). Project information is collected in preparation for the loss avoidance assessment from the FDEM project database. Event data is available post event, and it paints a picture of the impacts to the project area and the projects performance during the event. Data needs and the various methods to gather this data are outlined in Section C Event Data Collection and Processing of Florida's System and Strategy.

In preparation for the loss avoidance assessment, analyst compiled project information for completed mitigation projects in the counties declared under DR-4177. All completed projects within the impacted area were already recorded, and all the necessary project information for the loss avoidance assessment was available.

The first step in the loss avoidance assessment was to identify completed mitigation projects within the area of impact. Precipitation data from the National Oceanic Atmospheric Association (NOAA) was utilized to define the area of impact. The area of impact is demarcated as any area within the nine affected counties that received more than six inches of rain. Any completed mitigation projects within the impacted area are analyzed in this report.

Analysts identified 33 projects as existing within the DR-4177 area of impact and complete at the time of the event. The 33 projects benefitted a total of 889 structures and four roads. These projects are identified in the map below. The table below provides an example of the information collected from the FDEM database.

Project information data includes

- Project Code
- Project Type
- Project Location
- Building Type
- Structure Latitude and Longitude
- Structure Square Footage
- Ground Elevation
- Pre-Mitigation First Floor Elevation (FFE)
- Post-Mitigation First Floor Elevation (FFE)
- Federal Share of Project Cost
- State/Local Share of Project Cost
- Total Cost to Perform Project

Event data includes

- Precipitation data
- Stream gauge data
- Aerial imagery
- Digital elevation models
- High water marks

Table 6 Sample of Project Information for Impacted Projects

Project Code	1551-038-R	SRL-PJ-04-FL-2008-021	1249-0066
Project Type	Drainage	Elevation	Acquisition
Project Location	30.390836, -87.082587	30.34052, -87.11723	30.454004, -85.899097
Federal Share	$1,940.47	$149,292	$98,766
Non-federal Share	$646.82	$16,588	$32,922
Total Project Cost	$2,587.29	$165,880	$131,688
Building Type	Residential	Residential	Residential
Number of Stories	1 to 2	1 story	1 to 2
Structure Square Footage	1,530 sq. ft.	1,292 sq. ft.	1,800 sq. ft.
Ground Elevation	14.64 ft.	3.5 ft.	15 ft.
Pre-mitigation First Floor Elevation	15.14 ft.	4.17 ft.	15.5 ft.
Post-mitigation First Floor Elevation	-	16.79 ft.	0 ft.

Event Analysis

The next step in a loss avoidance assessment is to determine flood depths. There multiple ways to determine flood depth using a fairly broad range of skills. FEMA suggests a hierarchy of event data that can be used to determine flood depths including high water marks, stream gauge discharge data, stream gauge gate stage data, as well as preliminary damage assessments and local interviews.

For the purposes of this loss avoidance assessment, analysts collected high water marks, stream gauge data, digital elevation models, and aerial imagery taken immediately after the event to aid in the event analysis.

Analysts collected high water marks for the event, and this data was utilized wherever applicable as it is the most accurate data for calculating flood depths. The aerial imagery was provided by the Northwest Florida Water Management District (NWFWMD), and it was utilized to calculate flood depths, as well as to corroborate flooding at project sites when other data sources were used. For the projects where high water marks and aerial imagery were not available, stream gauge data collected from the United States Geologic Survey was used where ever applicable.

If there were still data gaps, emergency management directors or other local officials were contacted with questions, in order to collect event data and estimate the flood depths and durations, as well as any damages, experienced as a result of the event. A systematic approach is necessary to efficiently gather event information through interviews with local partners. Information was logged in Performance Call Sheets, available in Appendix B. There are unique benefits associated with working through local partners to obtain event information. Besides providing quantitative information in the form of estimated flood depths, local partners know what works best in their community, where key vulnerabilities reside, and they have frontline knowledge of project performance. Additionally, local partners provide qualitative data in the form of local testimonials, photographs, and other content rich information.

Finally, digital elevation models (DEM) for each county were provided by the NWFWMD. Digital elevation models were used for a number of reasons; to validate flood elevations at high water marks, to confirm first floor elevations of structures, and to estimate flood elevations using aerial imagery.

MODELING FLOOD DEPTHS

Methodology

This section provides an overview of the methodology employed by analysts to assess (1) potential flood impact in the mitigation absent scenario, (2) flood depth for projects that experienced stormwater runoff / urban flooding, and (3) the QA/QC process for the set of storm events.

Assessment of Potential Flood Impact

Precipitation data from NOAA was obtained for the period of interest to determine the sites that were impacted by the storms. The accumulated precipitation within the periods for each of these events was calculated. All project sites with cumulative precipitation values of greater than six inches over the period of the event were flagged as having a higher likelihood of being impacted by flooding.

To determine whether a given site location was impacted by flooding; the following water balance equation was used:

$P - L_i - E - R - I - S_D = 0$ (Gupta, 2001)

Where:

- P = precipitation
- L_i = interception
- E = evapotranspiration
- R = runoff
- I = infiltration
- S_D = storage depression

Since analysts looked at flooding for a short period of time, they were able to assume that evaporation was negligible. Both storage and interception were also negligible because quantities would be small relative to precipitation. This reduced the equation to:

$P = R + I$ (Gupta, 2001)

Analysts also assumed infiltration to be zero because significant precipitation occurred prior to the flooding reported from April 29th to May 6th, most likely saturating the soil to the infiltration capacity and preventing further infiltration during the flooding period. Given the water balance equation and these assumptions, P would be equivalent to R in the long-term.

Flood Depth Estimation

Analysts estimated flood depth for a given site as the difference between the flood elevation and the ground elevation at a given location. Ground elevations are determined using the digital elevation map (DEM). Analysts identified the flood source for each project location based on a review of the flood plain for each of the 33 projects associate with DR-4177.

While flood elevations are typically estimated through hydrologic and hydraulic analysis and modeling, time and budget constraints did not allow for the extensive work required to set up, calibrate, and simulate models for each of the project locations. Analyst did, however, use a method founded on valid assumptions and based upon best available data to obtain the best possible estimates of flood elevation.

Stormwater Runoff/Urban Flooding

Drainage projects classified with the stormwater runoff/urban flooding mechanism frequently have many benefitting structures, and, due to time and budget constraints, ultimately required a customized methodology to determine flood elevations. Rather than simply gathering flood elevation data for one location and applying the results to all structures within a project, the results from a sample of structures strategically located based on elevation in the project site were obtained and averaged in order to provide a more accurate representation of the flooding and associated impacts. Flood depth analysis was performed for the randomly dispersed sample of structures associated with a given project location, and the results were averaged together and taken as a representative depth for the entire group of structures within the single drainage project. This methodology is considered sound because the array of benefitting structures within the area of the project locations experience only slight variations in ground elevations.

For the stormwater flooding locations, the flood depth estimation was divided into two steps:

A. Runoff Prediction: The rational method considers the entire drainage area as a single unit and estimates the peak discharge at the most downstream point of that area (Gupta, 2001). This method was used to estimate the peak rate of runoff based on the drainage area, runoff coefficient, and rainfall intensity. While this method is efficient, it does assume uniform distribution of rainfall within the drainage area, the predicted peak discharge has the same probability of occurrence as rainfall intensity, and the runoff coefficient is constant during the storm event.

B. Flood Depth Estimation: The estimated peak rate of runoff was used to calculate the water depth at the curb, using the Federal Highway Administration (FHWA) hydraulic toolbox.

The rational method is a frequently used method for the design of storm sewers without modeling. The rational formula is expressed as follows:

$$Q = C\ i\ A$$

Where Q is the peak discharge in cubic feet per second (cfs), i is the rainfall intensity in inches per hour, C is the dimensionless runoff coefficient ($0 \le C \le 1$), and A is the drainage area in acres. The dimensionless runoff coefficient, C, is defined as the ratio of peak runoff rate to rainfall rate for a drainage basin. It depends on the percent imperviousness, slope, soil conditions, and ponding characteristics of the surface. The values used in our methodology are shown in ***Table 1*** below:

Table 1: Values of Runoff Coefficient (*C*) for Rational Formula

Land Use	**C**	**Land Use**	**C**
Business: Downtown areas Neighborhood areas	 0.70 - 0.95 0.50 - 0.70	***Lawns:*** Sandy soil, flat, 2% Sandy soil, avg., 2-7% Sandy soil, steep, 7% Heavy soil, flat, 2% Heavy soil, avg., 2-7% Heavy soil, steep, 7%	 0.05 - 0.10 0.10 - 0.15 0.15 - 0.20 0.13 - 0.17 0.18 - 0.22 0.25 - 0.35

Residential:
Single-family areas
Multi units, detached
Multi units, attached
Suburban
	
	0.30 - 0.50
	0.40 - 0.60
	0.60 - 0.75
	0.25 - 0.40
		Agricultural land:
		Bare packed soil
		*Smooth
		*Rough
		Cultivated rows
		*Heavy soil, no crop
		*Heavy soil, with crop
		*Sandy soil, no crop
		*Sandy soil, with crop
		Pasture
		*Heavy soil
		*Sandy soil
		Woodlands
			
			0.30 - 0.60
			0.20 - 0.50
			
			0.30 - 0.60
			0.20 - 0.50
			0.20 - 0.40
			0.10 - 0.25
			
			0.15 - 0.45
			0.05 - 0.25
			0.05 - 0.25

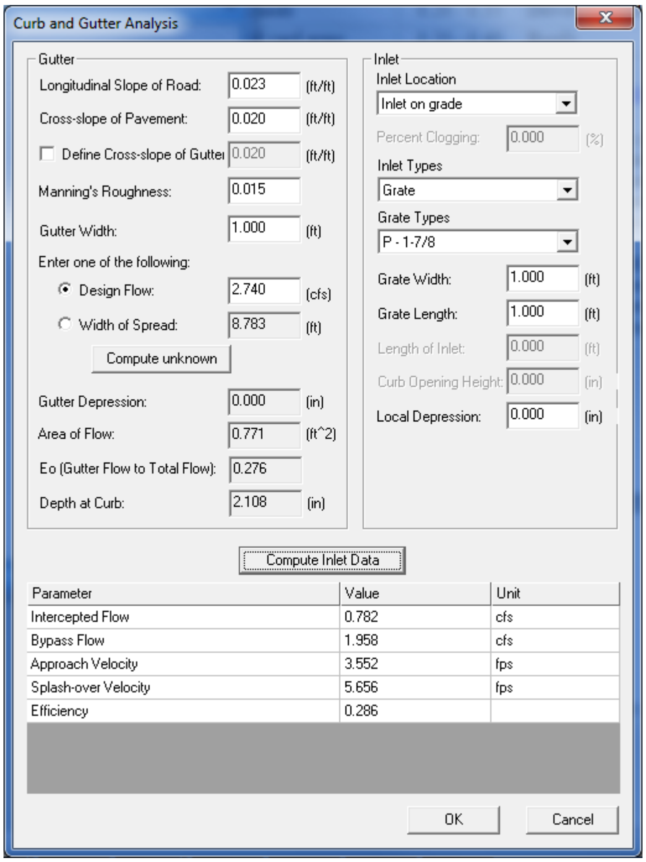
Industrial: Light areas Heavy areas	 0.50 - 0.80 0.60 - 0.90	*Streets:* Asphaltic Concrete Brick	 0.70 - 0.95 0.80 - 0.95 0.70 - 0.85
Parks, cemeteries	0.10 - 0.25	Unimproved areas	0.10 - 0.30
Playgrounds	0.20 - 0.35	Drives and walks	0.75 - 0.85
Railroad yard areas	0.20 - 0.40	Roofs	0.75 - 0.95

Source: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/cwt/guidance/513.pdf

The rainfall intensity is typically selected based on the design rainfall duration (or time of concentration) and return period. For this report, the rainfall intensity was chosen based on the rainfall events between April 29th and May 6th, as well as the precipitation frequency (PF) analysis published by NOAA for the declaration period. These periods were chosen to account for potential rain impact before and after the designated declaration dates.

Analysts used the nearest PF stations within these counties, Panama City and Niceville, to determine rainfall intensity for this report. Although these counties are not exactly where the declarations were, they provided the best available data.

The drainage area for each location was calculated by HEC-GeoHMS based on the digital elevation model (DEM). The Arc Hydro tools were used for terrain reconditioning, sink filling to generate the grids of flow direction, flow accumulation, stream linking, and catchment delineation. The drainage area for each location was calculated from the nearest flow accumulated cell drained to that location. The depth at the curb was calculated by the Curb and Gutter Analysis tool from FHWA, shown in the figure below.

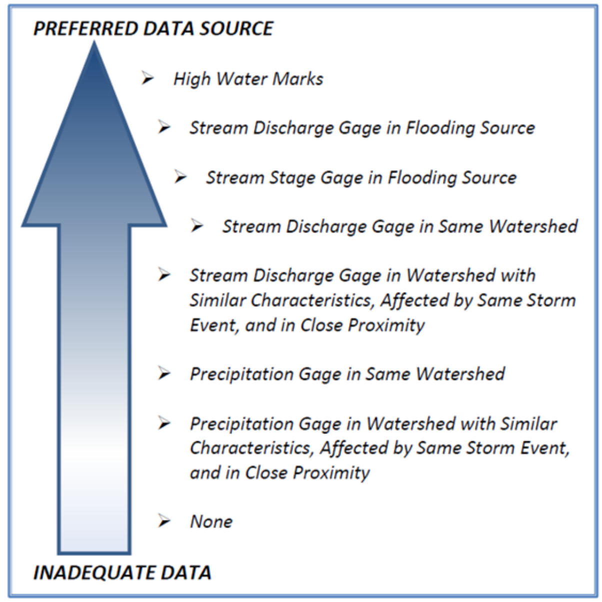


The inputs included the following:

- Road slope,
- Cross-slope of the pavement
- Manning's roughness coefficient, and
- Design flow.

The road slope was calculated by ArcGIS tool from the FDEM slope analysis. The cross-slope of the pavement was set at the default value of 0.02, which is the typical value for straight road based on the Florida Department of Transportation (FDOT). The Manning's roughness coefficient was set at the default value of 0.015, which is the typical value for roads and pipelines.

Determination of Flood Elevation and Flood Depth



Flood depths for each project were determined based upon four different sources of information; high water marks, aerial imagery, stream gauge data or local experts. High water marks are the most accurate source of information, followed by aerial imagery then stream gauge data. When none of those options were available, local officials were contacted.

It is practice to use the most accurate source of information available. Before flood depths can be calculated two pieces of information are needed, (1) flood elevation and (2) the first floor elevation of the impacted structure.

Digital elevation models utilized in ArcGIS were the primary source for determining the flood elevation and the first floor elevation of impacted structures. Flood elevation is determined by measuring the elevation at either a high water mark, the location of visible flooding in aerial imagery, or the elevation at a stream gauge. The first floor elevation is measured by determining the ground elevation of a structure and then adding half a foot. First floor elevations were confirmed with previously recorded project information, when available.

This section provides a discussion of the methodology used to determine flood depths based upon the data source and more detailed methodology is available in Florida's System and Strategy, Section C Event Data

Collection. The succeeding sections provide a summary of the analysis conducted for each project in this report.

For any source of data, calculating flood depth can be summarized as:

Flood Elevation – First Floor Elevation = Flood Depth

HIGH WATER MARKS

High water marks were utilized when an impacted project was within 0.25 miles of a recorded high water mark. The first floor elevation of each structure of the impacted project was recorded by utilizing digital elevation models, and the elevation values were confirmed with previously recorded project information. The closest high water mark, no further than 0.25 mi, was utilized to determine the flood elevation. Analysts recorded flood elevations at high water marks. The flood depth is determined by finding the difference between the elevation of the high water mark and the elevation of the structure.

Flood Elevation at the High Water Mark – First Floor Elevation of structure = Flood depth at structure

AERIAL IMAGERY

Where aerial imagery from the dates of the event was available, it was used in similar fashion as high water marks. The first floor elevation of the structures of the impacted project was recorded using a digital elevation model and confirmed with project data. Next the flood elevation was measured by recording the highest elevation of the nearest visible location of flooding. The flood depth is calculated by finding the difference between the highest elevation of the visible flooding and the elevation of the structure.

Highest Elevation of visible flooding – First Floor Elevation of structure = Flood depth at structure

STREAM GAUGE DATA

The next most accurate type of data used to calculate flood elevation is stream gauge data. Flood elevation is calculated by measuring the height of the stream gauge during the days of the event. The elevation of each structure of the impacted projects is determined by utilizing digital elevation models and previous project information. The difference between the elevation at the stream and the elevation of the structure is the flood depth.

Elevation at stream gauge –First Floor Elevation of structure = Flood depth at structure

LOCAL EXPERTS

If no other data was available, local officials were contacted to collect event information. If the local officials stated there was no flooding at the project site, the flood depth was recorded as zero.

Calculating Losses Avoided

Once flood depths are calculated, they are entered into the calculators along with building characterization information to estimate or calculate losses avoided for two scenarios; 1) mitigation has not occurred and 2) mitigation has occurred.

In both scenarios, three pieces of information are needed to calculate losses:

- First floor elevation
- Flood depth
- Building characterization

First floor elevation and flood depth values will vary between pre- and post-mitigation values based upon the scenario and project type. Pre-mitigation values apply to the scenario in which no mitigation has occurred, and post-mitigation values apply to the scenario in which mitigation has occurred.

Acquisitions and Elevations Projects- Pre-mitigation first floor elevations are used in the scenario in which no mitigation has occurred. Post-mitigation first floor elevations are used in the scenario in which mitigation has occurred for elevation projects. For acquisition projects, the hazard has been mitigated and therefore there is no need to calculate losses for a scenario in which mitigation has occurred. Flood depths are held constant.

Drainage Projects- The first floor elevations are held constant, while the flood depths vary. Pre-mitigation flood depths are used in the scenario in which no mitigation has occurred, and post-mitigation flood depths are used in the scenario in which mitigation has occurred. The pre-mitigation flood depth provides a basis to estimate damages before mitigation would have taken place. Pre-mitigation flood depths are always modeled.

Once the appropriate information is entered into the LAC's, the calculators rely upon depth damage curves to calculate losses. There is depth damage curve associated with each type of building. Depth damage curves relate depth of flooding in feet to damage expressed as a percent of replacement costs.

Once the appropriate information is entered into the LAC's, the calculators rely upon depth damage curves to calculate losses. There is depth damage curve associated with each type of building. Depth damage curves relate depth of flooding in feet to damage expressed as a percent of replacement costs.

For a discussion of the specific methodology used for each type of data available see Florida's System and Strategy.

LOSS AVOIDANCE CALCULATION

To execute loss avoidance calculations Florida's LACs perform three significant functions:

1. Compute **costs avoided** in the hazard event
2. **Normalize** project capital and maintenance costs to present day dollars
3. Calculate losses avoided and return on investment

Costs avoided are simply the difference between two project scenarios and the associated impacts during a hazard event: 1) structure has been mitigated and 2) structure has not been mitigated. To determine costs avoided, damages associated with these two scenarios must be estimated and calculated.[11] Cost avoidance is presented in nominal terms: in terms of the year in which the impacting event occurred. In order to calculate losses avoided, the project cost and maintenance costs must be subtracted from the costs avoided, but only after they have been normalized to today's dollars. This is because one dollar at the time of project completion is not the same as one dollar today. This loss avoidance assessment utilizes the GDP Deflator normalization method. The Net Present Value of a project is the costs avoided minus project investment, therefore the NPV are the losses avoided.

[11] To understand how damages are estimated see Florida's System and Strategy, Section E Flood Technical Details, Chapter 2: Calculating Losses.

For a thorough discussion of the methodology concerning the calculators, see Section E Technical Details of the System and Strategy.

Analysts entered project and event data into the calculators according to the instructions provided in the Loss Avoidance System and Strategy. Two types of calculators were utilized for this assessment; the building modification calculator, which assesses elevation, acquisition, floodproofing and road projects, and the drainage calculator, which assesses drainage projects. During this loss avoidance assessment the calculator were updated and are available of the Divisions website: (http://www.floridadisaster.org/Mitigation)

Analysts noted any assumption in the comments section. Detailed reports are generated by the calculator for each project, and they are available in Appendix A Individual Project Results. A summary of the results in discussed in the section below.

Caveats

This loss avoidance assessment reviews only flood mitigation projects.

This loss avoidance assessment captures direct losses that would have occurred without the projects, such as, building, content, inventory and displacement losses. Losses avoided in the form of loss of function, casualties, shelter needs, emergency response measures, debris clean up, employment loss and other related losses are not captured. In addition, there are many qualitative benefits not captured in this assessment, such as life disruption avoided or emotional or social losses.

Results are presented in terms of net present value (actual costs avoided).

CONSOLIDATING PREVIOUS RESULTS

This report integrates the results of the previous loss avoidance assessments to provide actual costs avoided to date the mitigation projects impacted by DR-4177 and previously studied events.

The previous losses avoided have been normalized to present day dollars so that they may be consolidated to present a net present value, or actual costs avoided, for the project over events assessed. Table 7 provides example results for a project assessed only for a single event. Table 8 below provides a snapshot of ROI of a project over multiple events.

Quantifying the fiscal benefits of mitigation in Florida provides decision makers with the tools necessary to make informed decisions in regards to creating more resilient communities in Florida. Natural hazard events will continue to occur, and it is imperative the State of Florida continues to mitigate the risks associated with natural hazards, so that the future impacts to local communities may be reduced.

Any subsequent loss avoidance assessments will include the results from this assessment and all results must be normalized to present day dollar amounts.

Table 7 Example Table of DR-4177 ROI's

					DR-4177			
FEMA Project Number	County	Project Type	Project Cost	Real Costs Through 2015	Real Costs Avoided	Net Present Value	Percent of Project Costs	ROI
1069-0003	Bay	Drainage	233,527.00	324,110.41	902,414.24	578,303.84	278.43%	178.43%
1069-0006	Bay	Drainage	155,415.00	213,381.65	-	-	-	
1069-0091	Bay	Drainage	171,850.00	235,946.58	69,588.45	(166,358.12)	29.49%	-

Table 8 Example of Consolidated ROI's

					Consolidated		
FEMA Project Number	County	Project Type	Project Cost	Real Costs Through 2015	Real Costs Avoided	Net Present Value	Percent of Project Costs
1069-0003	Bay	Drainage	233,527.00	324,110.41	$3,365,751.64	$3,041,641.23	938.46%
1069-0006	Bay	Drainage	155,415.00	213,381.65	$684,651.27	$471,269.62	220.86%
1069-0091	Bay	Drainage	171,850.00	235,946.58	$638,162.28	$402,215.70	170.47%

STATE EMERGENCY
FLORIDA
SERT
RESPONSE TEAM