NE 13th Ave. Drianage

2021 Resilient Florida Grant Program

Application: SRP--569--

City of Oakland Park53706SRP--569--Statewide Flooding and Sea Level Rise Resilience PlanSRP

Started at: 10/23/2021 09:50 AM - Finalized at: 10/25/2021 04:11 PM

Page: Eligibility Questions

Applicant Name

City of Oakland Park

Entity Type

Local Florida Government or Municipality

Applicant County

Broward

Page: Grantee's General Info

Grant Type

Statewide Flooding and Sea Level Rise Resilience Plan

Provide the Applicant's FEID# that matches the registered listing in My Florida Market Place (MFM) (https://vendor.myfloridamarketplace.com (https://vendor.myfloridamarketplace.com))

1. Go to MFMP (https://vendor.myfloridamarketplace.com), and login to validate and obtain the correct sequence number for your entity's payment information.

2. Enter your User Name & Password. If unknown enter "publicuser" for the User Name & Password

3. Search through the listings under the detail section, that have the following fields that match your application information for where the applicant's funds are to be delivered to:

- Entity legal name
- Full address (physical)

4. Should you not find a listing that matches, please contact MFMP to get a correct entry listed for the Grantee at: https://www.dms.myflorida.com/business_operations/state_purchasing/myfloridamarketplace (https://www.dms.myflorida.com/business_operations/state_purchasing/myfloridamarketplace) operations.

5. If your question is not answered by the FAQ's link on MFMP's page, please contact the MFMP Vendor Customer Service Desk at vendorhelp@myfloridamarketplace.com (mailto:vendorhelp@myfloridamarketplace.com?subject=MFMP%20Assistance%20Needed) or by phone at 866-352-3776.

Federal Tax ID Number

F59-6000391

Sequence Number

2

DUNS Number

076043538

Provide current contact information for each contact. Some information may be duplicative. The grantee's grant manager is responsible for all correspondence with DEP after the grant is awarded and relaying any information necessary to partners and/or subcontractors.

Applicant's Physical Address

3650 NE 12th Avenue

Applicant's Physical City

Oakland Park

Applicant's Physical Zip Code

33334

Applicant's Grant Manager's Name

Sierra Marrero

Applicant's Grant Manager's Title

Asst. Dir. Eng. & Bldg. Svcs.

Applicant's Grant Manager's Physical Address

5399 N Dixie Highway, Suite #2

Applicant's Grant Manager's City

Oakland Park

Applicant's Grant Manager's Zip Code

33334

Applicant's Grant Manager's Phone Number

(954) 274-0581

Applicant's Grant Manager's Email Address

sierra.marrero@oaklandparkfl.gov

Applicant's Authorized Signer's Name

David Hebert

Applicant's Authorized Signer's Title

City Manager

Applicant's Authorized Signer's Physical Address

3650 NE 12th Avenue

Applicant's Authorized Signer's City

Oakland Park

Applicant's Authorized Signer's Zip Code

33334

Applicant's Authorized Signer's Phone Number

954-630-4596

Applicant's Authorized Signer's Email Address

DavidH@oaklandparkfl.gov

Applicant's Fiscal Agent's Name

Andrew Thompson

Applicant's Fiscal Agent's Title

Finance Director

Applicant's Fiscal Agent's Mailing Address

3650 NE 12th Avenue

Applicant's Fiscal Agent's City

Oakland Park

Applicant's Fiscal Agent's Zip

33334

Applicant's Fiscal Agent's Phone Number:

954-630-4250

Applicant's Fiscal Agent's Email Address

andrewt@oaklandparkfl.gov

Page: Project Information

Entity's Name

City of Oakland Park

Statewide Flooding and Sea Level Rise Resilience Plan Project Type

Project identified through a local vulnerability assessment that addresses risks of flooding and sea level rise to coastal and inland communities in the state

Project Title

NE 13th Avenue Stormwater

List the City(ies)/Town(s)/Village(s)

City of Oakland Park

Project Location

26.171359, -80.129615

Upload Map

Download File (https://vo-general.s3.amazonaws.com/d017b91f-429c-41d2-94c6-f764db3489dc/acbec7b3-e611-4125-a536-710b272abea3?AWSAccessKeyId=AKIAJ4PRWO26HAX3IOCA&Expires=1721662466&response-content-disposition=inline%3B%20filename%3D%221-Project%20Location%20Map%20with%20drawings.pdf%22&response-content-type=application%2Fpdf&Signature=1ipFJvliPsHhHdZGYY%2Fn07PFQ%2FM%3D)

State Lands being utilized?

No

PROJECT WORK PLAN

Please review the Statewide Plan parameters (http://laws.flrules.org/2021/28) under s. 380.093(5), F.S. If including any letters of support or other materials, they should specifically address the Work Plan components below.

Project Summary

Oakland Park is in coastal Broward County and is intersected by series of canals and lakes draining into Middle River Canal (C-13 Canal), flowing into the AICW. Nearly 90% of the City is in AH or AE zone Special Flood Hazard Area. Heavy rain events and rising sea levels make flooding throughout the community a growing threat. The project will develop a new stormwater system along NE 13th Avenue to protect commercial and residential properties.

Project Scope of Work

The proposed project will consist of the replacement of the existing drainage and potable water system along NE 13th Avenue stretching from the northern limit of NE 38th Street to Oakland Park Boulevard, which is the southern limit of the project site. The total length of the project is approximately 2,600 linear feet and will occur in the City-owned ROW. The City has worked with its consulting engineers to come up with a scope of work and opinion of cost. The cost estimate is included with this application. The scope of work will include the installation of the following facilities:

• FRENCH DRAIN, 18"
• PIPE CULV, OPT MATL, ROUND,18"SD
• INLETS, CURB, TYPE P-3, PARTIAL
• 72" COLLECTOR STRUCTURES
• 1" ASPHALT TYPE SP 9.5 OVERLAY
• DRAINAGE - TRENCH RESTORATION
• 8" WATER MAIN (INC. TRENCH RESTORATION)
• NEW WATER SERVICES
• SEWER LINING

The City will complete final design and permitting outside of the HMGP scope, and it will not be part of the grant request or matching funds. The requested financial assistance will be for construction and construction inspection services.

The estimated time to complete all the components of the project is 24 months with a total project cost of $3,786,953. The City will provide a 50% or $1,893,476 local cost share due to the significant size and cost of the project. The City will use its established purchasing/procurement guidelines in coordination with the grant requirements to competitively select a contractor/vendor to complete the project. This will include a public solicitation process and an evaluation of the respondents’ qualifications and experience.

PROJECT NEED AND BENEFIT

This section should continue to explain the need for the project in the context of flooding, sea level rise, and their effects while providing the information necessary for the Plan's evaluation criteria (https://frcp.secure-platform.com/a/page/PlanEvaluation_Criteria). See the Resilient Florida statute (http://laws.flrules.org/2021/28) for more information.

A. Explain the demonstrated need(s) and how the project will address those needs.

The City is of Oakland Park is situated in eastern coastal Broward County and is intersected by a series of canals and lakes draining into Middle River Canal (C-13 Canal) eventually flowing into the Intracoastal Waterway. Nearly 90% of the City is in an AH or AE zone Special Flood Hazard Area (SFHA). Inland flooding occurs when rain from hurricanes overflows rivers, streams, and canals such as the North Fork of the Middle River. Property owners in Oakland Park filed claims in 1979, 1986, and 1999 (with both Hurricanes Floyd and Irene) when heavy rainfall caused severe flooding, and again starting in 2003, with Jeanne, Francis, and Wilma. This has continued with the impacts of Hurricane Irma and Dorian as well as heavy rain events that occur throughout the year. Floods caused millions of dollars in damage and disrupted many of the normal functions of the community.

The increase in flooding during events such as Irma and Dorian forced the City to move towards identifying and planning for a more resilient infrastructure. During recent years, the City has begun shifting its focus to the potential impacts of tidal flooding through rising sea levels and the increase in severe weather due to changes in the climate. In 2018, the City completed a stormwater master plan and in 2020, completed both a Flood Vulnerability Assessment and an Adaptation Strategies Report. These comprehensive plans evaluated the current flooding vulnerabilities of the community and projected future impacts due to the changes in sea levels and climate conditions. These planning efforts identified projects such as the proposed drainage improvements as a priority to reduce potential flooding of homes and roadways and to protect public health.

B. Explain how the proposed project fits into the Project Type(s) chosen above.

The project will meet the project type of identification of vulnerabilities through a vulnerability assessment. The City recently completed an assessment, funded in part by FDEP, which identified the improvement of drainage facilities as a significant capital improvement that would serve as long-term protection against flooding from all sources.

Explain how the project is feasible and can be completed within a 3-year timeframe

The project is being designed and was determined to be feasible by the consulting engineers who are completing the specifications. Using data from the Vulnerability Assessment and proven drainage techniques, the project can be permitted and constructed in a timely manner. The anticipated time needed to complete the project is 24 months.

D. Is the project a follow-up or result of a previous state-funded project?

No

E. Explain the how the completed project will exceed the flood-resistant construction requirements of the Florida Building Code and applicable flood plain management regulations.

N/A

F. Explain how the project addresses risks to regionally significant assets.

The project will significantly reduce the risk to Oakland Park Boulevard, which is a regional transportation corridor. The roadway is used by thousands of drivers, transit, and public safety personnel on a daily basis. In addition, it provides a critical route for those wanting to evacuate or return to coastal areas as a result of a disaster such as a hurricane. If flooding from excessive rain and/or storm surge from the waterbody would overwhelm the existing drainage facilities along the corridor, the standing water would impact the roadway and disrupt the use of this critical asset.

G. Explain how the project reduces risks to areas with an overall higher percentage of vulnerable critical assets.

The proposed project will protect dozens of structures, including residences, businesses, churches, and the City public library, from the impacts of flooding. There are approximately 200 residents who will be directly impacted by the project. In addition, the replacement of the drainage system will protect the roadway, allowing for access for residents, first responders, and recovery personnel such as public works. While the protection of residences from water intrusion is the priority, maintaining the transportation system for the hundreds of people who live and work along the roadway is also critical. If the ability of first responders such as fire or medical personnel is delayed or disrupted due to flooded or damaged roadways, then public safety is at risk. Once complete, the project will significantly reduce the potential for flooding in the area.

Another critical facility protected by the project is the potable and wastewater systems that serve the area. The project will replace the potable water pipes that provide service to the structures and people. The existing sewer lines will be lined to provide added protection. This hardened infrastructure along with the reduction of flood impact will protect the potable and wastewater service to the community. Maintaining these critical services during and after a disaster is necessary to effectively recover from the impacts of a hurricane or major storm.

H. Does this project add to an existing flood mitigation project that will reduce upland damage costs by incorporating new or enhanced structures or restoration and revegetation projects?

No

I. Does the project enhance state or federal critical habitat areas for threatened or endangered species?

No

J. If the project will be done in a financially disadvantaged community, explain how the project will benefit that community.

No

K. Explain how the project addresses risks identified in a vulnerability assessment or other similar analysis of current and future flooding from rainfall and/or sea level rise.

In 2019, the City of Oakland Park (City) was awarded a grant from the Florida Department of Environmental Protection (FDEP), Agreement No. R1917, to perform a city-wide flood vulnerability assessment (FVA) and adaptation analysis. The City successfully completed the Flood Vulnerability Assessment and Adaptation Strategies reports in the summer of 2020. These reports served to identify the City's most vulnerable critical and important facilities affected by the current conditions and to develop adaptation strategies to lower exposure to their high risk of flooding. This year, the City has taken further initiative to update its stormwater master plan to include future conditions and develop a comprehensive hydrologic and hydraulic stormwater model, currently being finalized.

Using the data, modeling, and recommendations from the reports, the City has begun implementing projects that further the plans' overall goal of resiliency. The proposed project, which is a result of the reports, would represent the largest capital project undertaken since the completion of the plans.

L. Describe the current flooding and/or erosion conditions in the project area.

The project area experiences flooding from both rainfall and tidal events, much like the rest of the City. However, the stormwater conveyance along 13th Avenue drains directly into the Middle River and with little distance between the waterbody and the roadway corridor, backflow occurs during periods of high tide and even moderate rainfall. At this time, flooding is limited to the right of ways and roadways with little interaction with the residences. Yet, as climate conditions change, as predicted by the modeling and sea-level rises, this situation will only worsen if new and more effective drainage elements are not installed.

M. Describe the readiness of the project to proceed.

When the funding period begins in FY 2022-2023, the project will be well into final design and permitting. Based on the current schedule, construction could begin as early as January 2023 and be completed by December 2023. If funding is awarded and there is no delay between design and permitting to bidding and construction, the project will be completed well within the 36-month time period.

N. How is the project cost effective?

The City has obtained a Complete Streets and Local Initiative Grant from Broward County to assist with the cost of the above-ground improvements such as replacement of the sidewalks that will be needed as a result of the stormwater project. However, the grant will not assist with any of the underground stormwater work so badly needed. Funding in the amount of $1,104,747 from the grant will significantly reduce the funding needed to complete the project and lead to savings for the residents. Any additional grant funding for the flood prevention portion of the project will further maximize the community's resources.

The completion of the actual project will also represent long-term cost savings for the community. The other alternative to improve drainage in the area is to make minor repairs or improvements to the existing underground drainage and water systems. This could include slip lining and other methods to reduce further degradation of the facilities. While these actions would provide increased protection for the infrastructure, they would only provide a short-term solution and not provide the significant protection that the proposed replacement scope of work offers. The cost and impact of the alternative would be much less than the proposed project, but as stated, the mitigation of the problem would be considerably less. The proposed project was determined to be the best action to meet the objectives of the project, providing resilient and reliable infrastructure for the community.

O. Describe the availability of local, state, and federal matching funds, the status of such awards, and any federal authorization as applicable.

The City will use dedicated stormwater funding to provide a 50% local cost share. The City collects stormwater fees from all property owners. This funding is used for both maintenance and improvements to the community’s drainage system. The cash match of $1,893,476 will meet the intent of these funds in meeting the drainage needs of the community and protecting life and property.

P. Describe any innovative technologies that may be used to complete the project.

No

Design Plans

No File Uploaded

Permits

No File Uploaded

Vulnerability Assessment

Download File (https://vo-general.s3.amazonaws.com/d017b91f-429c-41d2-94c6-f764db3489dc/1b4efede-5511-4680-81ca-9c8207a647a8?AWSAccessKeyId=AKIAJ4PRWO26HAX3IOCA&Expires=1721662466&response-content-disposition=inline%3B%20filename%3D%22Oakland%20Park%20Taks%201%2020200528_TM_2-2_FloodVulnerabilityAssessment%202.pdf%22&response-content-type=application%2Fpdf&Signature=o5gSKb9GbOmQ5LeDfXyt74qqNI8%3D)

Page: Budget Information

Estimated total project cost

3786952

Grant funding amount requested

1893476

Cost-Share percentage available for the project

50

Cost-share source

Local Stormwater Funding

COST-SHARE FUNDING SOURCES

Other Funding Source Names

Cost-share document upload

Download File (https://vo-general.s3.amazonaws.com/d017b91f-429c-41d2-94c6-f764db3489dc/943d457f-4857-464d-bd83-0fb7e762ec55?AWSAccessKeyId=AKIAJ4PRWO26HAX3IOCA&Expires=1721662466&response-content-disposition=inline%3B%20filename%3D%22Local%20Funds%20Availability%20-%20NE%2013th%20Ave..pdf%22&response-content-type=application%2Fpdf&Signature=TiGCereP%2FeXOy8ym7lw6qVLYwiU%3D)

Multi-Year Funding Breakdown

Download File (https://vo-general.s3.amazonaws.com/d017b91f-429c-41d2-94c6-f764db3489dc/1a1d7216-f3b2-4545-8809-be511cda8877?AWSAccessKeyId=AKIAJ4PRWO26HAX3IOCA&Expires=1721662466&response-content-disposition=inline%3B%20filename%3D%22FY21-22%20RF%20Infrastructure%20Multi%20Year%20Breakdown.pdf%22&response-content-type=application%2Fpdf&Signature=wTPTb3CVkR3oaMzsrUHyyU4%2Bqm8%3D)

Budget Narrative Description

The estimated cost for the project was developed by the City's stormwater engineers and updated for this request for funding. The costs are based on the proposed scope of work including, design, permitting, bidding, construction, and inspection services. The costs are representative of the current construction climate in south Florida combined with accepted values and realized costs from similar projects completed in the area. The City will utilize consultants and vendors for all tasks.

Work Performed by:

Sub-Contractor Only

Sub-Contractor's Information.

All Sub-Contractors who will be performing work on this project, to be paid out using the requested funds from DEP, must be listed in the table below.

Sub-contractor 1 Company Name

Construction Firm-Contractor (TBD)

Sub-contractor 1 Contact Person Name

Sub-contractor 1 Title

Sub-contractor 1 Phone Number

Sub-contractor Email 1

Sub-contractor 1 Address

US

Sub-contractor 1 Amount Table

Tasks

Task #: 1
Amount: 3786952

additionalSub2only

No

Page: Tasks & Deliverables

PROJECT TIMELINE with

TASKS & DELIVERABLES DETAILS

This is where each task is listed with the title, due date for submission of all deliverables by task, and total of task funding amount requested. ***To avoid late submittals and financial consequences, be sure to allow enough time for submitting deliverables.***

Details for each task to include:

- Title,
- Goal,
- Description,
- Listing of deliverables,
- Total task amount, and
- Budget category (who will be performing the work, grantee and/or contractor)

Project Timeline Chart

Task #s

A. Task#: 1
B. Task Title: Stormwater System Construction
C. Task Goal: Replace an existing and deficient stormwater, sewer, and potable water infrastructure along NE 13th Avenue, adjacent to downtown Oakland Park. The new elements will provide a modern and hardened system that meets the overall goal of the project to ensure effective critical services both on a daily basis and during times of disaster.
D. Task Decription: The contractor will complete the construction activities identified below:

• Installation of new stormwater infrastructure
• Installation of new water main
• Installation of new water service connections
• Trench Restoration
• Asphalt Paving
• Sewer Lining
E. Task Deliverable(s) 1: Closed Permits, As-Builts, Pay Applications, Engineers Certification Other Closed Permits, As-Builts, Pay Applications, Engineers Certification
{5cf92fe3-b6f7-48c7-b193-1faf4b44e35e} {62d790af-954d-4953-a300-55b056db9101} {5648137f-4bbb-466c-9456-2066bc3a0ce1} {5307e474-2808-4d85-be59-5e9c0ee76c9f} {f5af7cc6-8e9f-40ee-9f21-f7d7ef9c3107} {4d304b61-4852-4691-bacd-99624f592b44} {45ab846d-413e-4840-afc1-6911f8e93d71} {ba41230b-ab12-41b8-b2f4-da80a22bb93f}
F. Task Due Date: 12/31/2024
G. Total Task Amount: 1893476
H. Task Budget Category: Sub-Contractor Only (CS)

Page: Certification Page

Grant Applicant's Certification Statement

"By signing this Statement page, the undersigned certifies that:

a. This application is in all respects fair and submitted in good faith without collusion or fraud;

b. If selected through this application process, the recipient will work in good faith and in partnership with the Resilient Florida Program (RF) to manage its subcontractors in a timely and accurate manner;

c. If federal funds are awarded as a result of this application process, said funds will not be used to supplant or replace any state or local funds;

d. Any funds awarded as a result of this application process will not be used as matching funds to apply for or recieve other state funds;

e. The undersigned has full authority to bind the applicant."

Please be advised that the selection of the checkboxes below are acting as a signature box on your behalf, as indicated in the field titles.

Grantee's Authorized Signer's Name

David Hebert

Do you Agree to the Certification Statement?

I agree

PROJECT LOCATION
NE 13th Avenue Driange
Improvements
Application

GARDENS
CENTRAL BUSINESS DISTRICT
CORAL HEIGHTS
CENTRAL CORALS
Oakland Park
SOUTH CORALS
RIVERS EDGE
CORAL SHORES
Wilton Manors
Lazy Lake
Prospect Rd
NW 45th Ct
NW 44th Ct
NW 45th St
NE 45th Ct
NE 45th St
NW 43rd St
NW 42nd St
NW 43rd Ct
NE 43rd Ct
NE 43rd St
NE 42nd Ct
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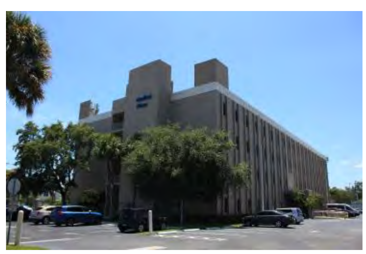
NW 9th Ave
NW 21st Ave
NE 6th Ave
NE 16th Ave
NE 15th Ave
NW 5th Ave
NE 2nd Ave
NE 3rd Ave
NE 5th Ave
NE 8th Ave
NE 13th Ave
NE 14th Ave
Lloyd Dr
Almar Dr
Park Dr
95
816
811
811A
845
1
Catfish Deweys
Royal Palm Park
Veteran's Park
Chamber Escapes
Easterlin Park
Oakland Park Festival Center
Parks & Leisure Services
The Home Depot
Lowe's Home Improvement
Taco Bell
Goodwill
Funky Buddha Brewery
LA Fitness
Mai-Kai Restaurant and Polynesian Show
AMC DINE-IN Coral Ridge 10
Pollo Tropical
Target
Culture Room
United States Postal Service
Lipton Toyota
Publix Super Market at Central Shopping Center
Paradise Island RV Resort
CSL Plasma
Publix Super Market at Five Points Plaza
Bed Bath & Beyond
Rosie's Bar & Grill
The Manor Complex
New York Grilled Cheese Wilton Manors
Georgie's Alibi Monkey Bar
Krispy Kreme
Whole Foods Market
Osswald Park
Mills Pond Park/Gold Coast Ski Club
Google

Hazen and Sawyer
4000 Hollywood Boulevard, Suite 750N
Hollywood, FL 33021 • 954.987.0066

-



City of Oakland Park
Flood Vulnerability Assessment Report

Final Report
Contract No. 200726-00
Hazen No. 47036-002
May 28, 2020

Table of Contents

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Executive Summary

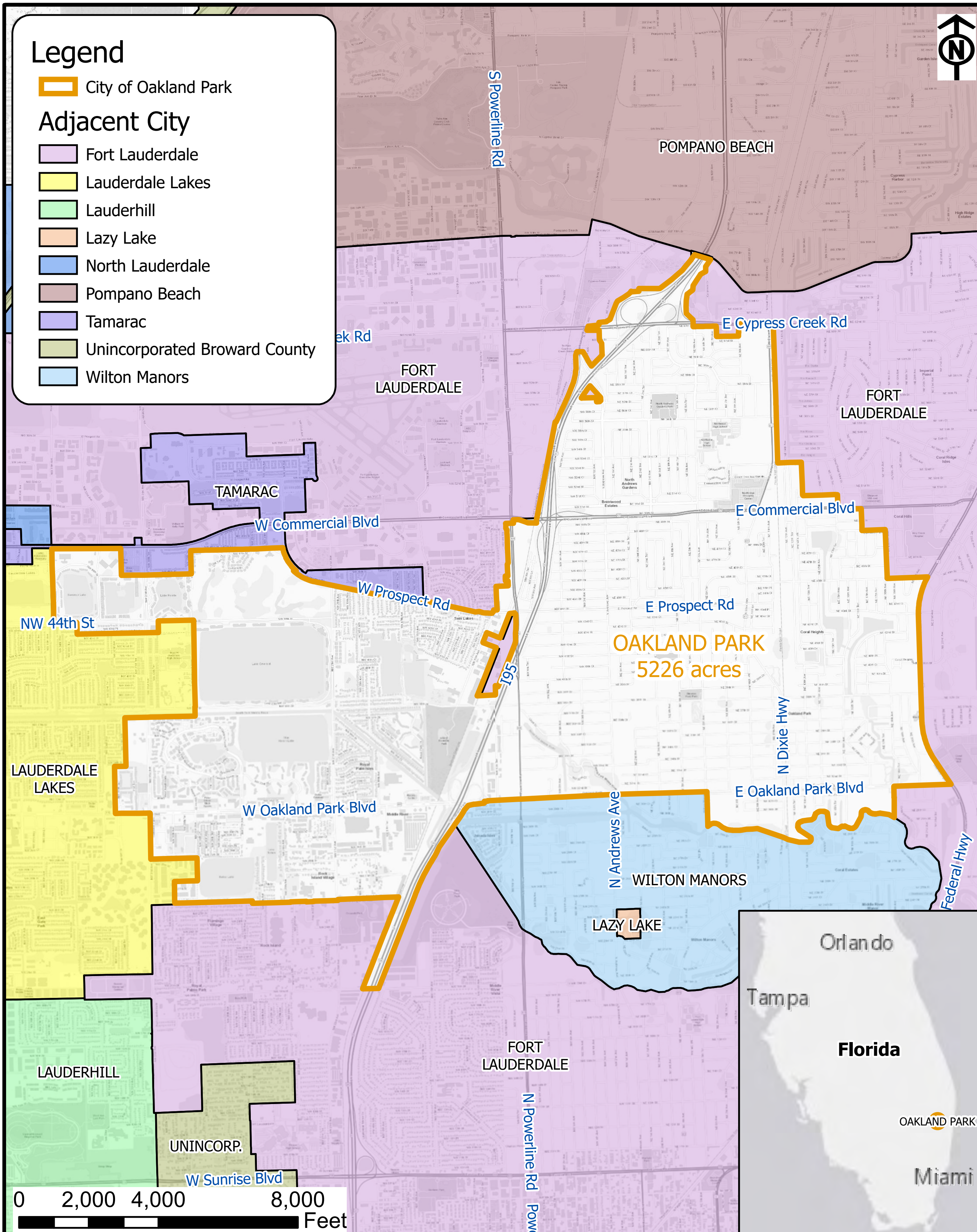
This report summarizes the Flood Vulnerability Assessment performed for the City of Oakland Park and satisfies the deliverable under Subtask 1.3 of Part 2 of City Contract 200726-00, Task Order No. 1, Stormwater Master Plan Update and Flood Vulnerability Assessment.

Hazen and Sawyer (Hazen), was tasked with developing a city-wide Flood Vulnerability Assessment for the City of Oakland Park (City). The assessment was based on a geospatial model comprised of various sources of data providing a comprehensive stormwater flooding analysis for both current and future projected climatological conditions. Hazen worked closely with the City to understand the City's composition and to identify critical and important facilities. Flood risk modeling results facilitated the identification and prioritization of specific vulnerabilities throughout the City.

1. Project Background and Purpose

The City received a grant from the Florida Department of Environmental Protection (FDEP) to perform a city-wide Flood Vulnerability Assessment. This Report shall be submitted to FDEP satisfying the grant's first task deliverable requirements.

This Report serves to summarize findings from the Flood Vulnerability Assessment, identifying the City's most critical and vulnerable areas in effort to direct the development of strategic improvements necessary to reduce flooding, mitigate for flooding and increase the City's resilience to climate change.



Hazen

Stormwater Master Plan Update & Flood Vulnerability Assessment

Print Date: 4/18/2020 5:07 PM

Printed By: E. Johnson

Review By: L. Medina

City of Oakland Park Location Map

Figure 2-1

Hazen Project Number: 47036-002
Plot date: 4/18/2020 5:07 PM By: ejohnson
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community, Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

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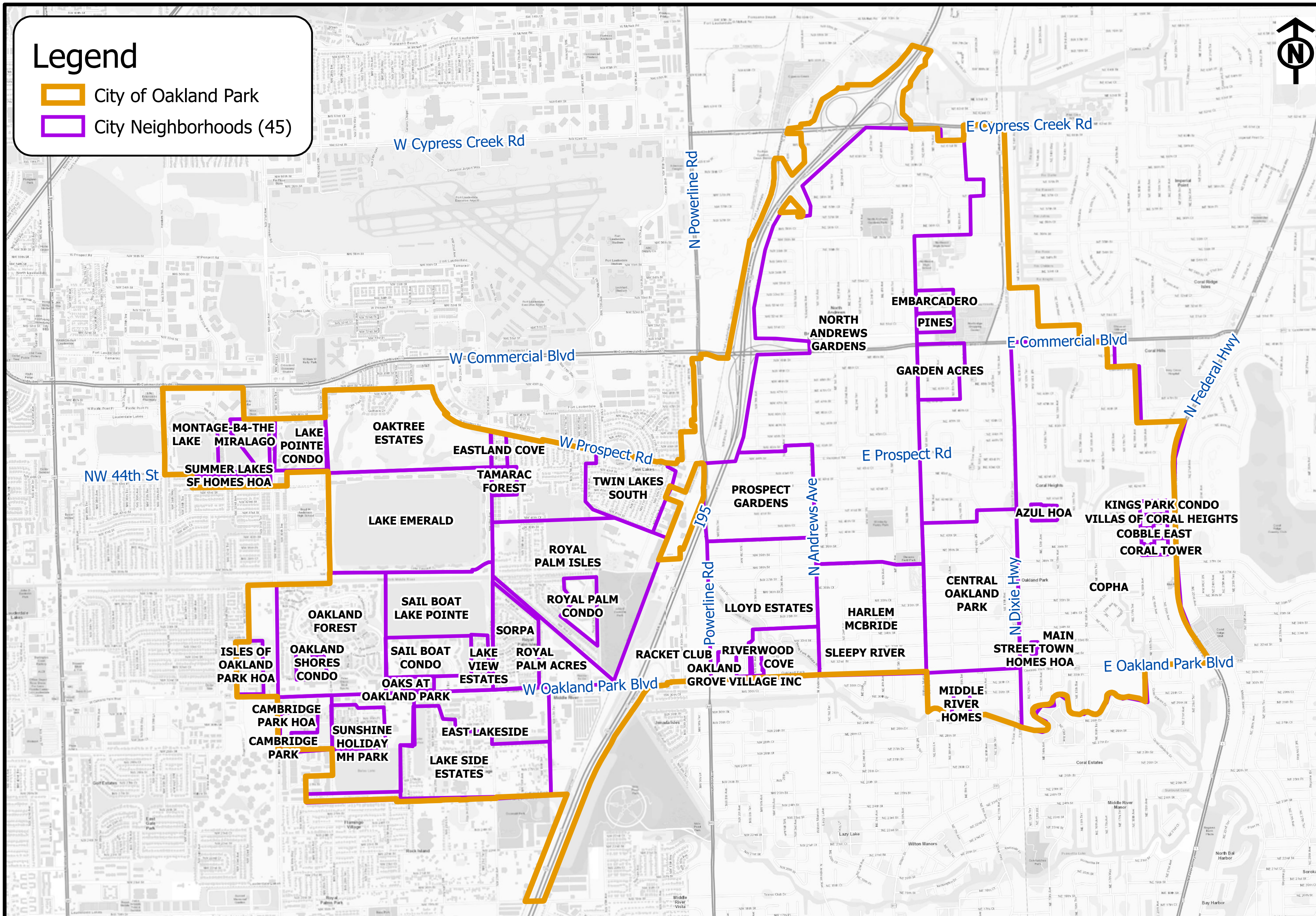

Hazen

Print Date: 5/27/2020 12:13 PM

Printed By: E. Johnson

Review By: L. Medina

Stormwater Master Plan Update & Flood Vulnerability Assessment

City of Oakland Park
Oakland Park Neighborhoods

Figure 2-2

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Hazen Project Number: 47036-002
Plot date: 5/27/2020 12:13 PM By: rloffing
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

2. Planning Horizon

Three planning horizons were identified for the Flood Vulnerability Assessment. Year 2020 was chosen to represent the current condition and years 2050 and 2060 the two future conditions. Year 2050 was selected to align modeling results with the end of a typical 30-year mortgage loan term in anticipation that adaptation strategies would benefit from analyzing this particular time-frame.

Broward County is currently undergoing a significant modeling effort that has already resulted in the release of the County's official, future groundwater map and that is expected to provide additional updates including the County's 100-year Flood Elevations map used to set finished floor elevations for purposes of construction guidance and permitting. The County has designated year 2060 as the planning horizon for the future condition of their modeling efforts. The City opted to mirror this future condition, leaving room for future collaboration and analysis with Broward County.

3. Data Collection and Sources

Data was collected from several sources to analyze both current and future flooding due to tidal variations, sea level rise, groundwater conditions, and storm surge through the next 40 years. Data collected was not only used as the technical basis to develop the flood risk model, but it also included the City's physical, social and economic characteristics which provided much valuable insight to this analysis. The following subsections detail the data collection effort.

3.1 City's Physical, Social, and Economic Composition

It is important to understand the City's underlining structure when calculating risk, identifying liabilities, and prioritizing solutions. The City's physical, social and economic composition provide insight and facilitate a translation of the modeling results into studied vulnerabilities.

Table 2-1, City Statistics, **Table 2-2**, Land Uses, and **Table 2-3**, Parks & Recreation Facilities, detail the physical characteristics of the City of Oakland Park.

Table 2-4, Census Quick Facts, **Table 2-5**, Population Characteristics, **Table 2-6**, Workforce Characteristics, **Table 2-7**, Housing Characteristics, and **Table 2-8**, Largest Taxpayers, detail the socio economic composition of the City of Oakland Park.

Table 2-1: City Statistics[1]

Category	Description	Value	Units
General			
	Year of Incorporation	1929	year
	Date of Adoption of City Charter	July 15, 1959	date
	Form of Government	Commission-Manager	--
	Recommended Budget (FY 20)	$92,632,802	dollars
	Recommended Budget-Number of Employees (FY 20)	251 Full-Time, 50 Part-Time (FY 20)	people
	Property Tax Millage Rate (FY 20)	6	mils
Population			
	Population	45,339	people
	Number of households	16,505	households
	Miles of water mains	197	miles
	Median Household Income	$48,390	dollars
	Per Capita Income	$25,769	dollars
	Number of Public Schools	5	schools
	Elementary	3	schools
	Middle School	1	schools
	High School	1	schools
Physical			
	Miles of streets	166	miles
	Miles of sidewalks	67	miles
	Miles of sewer lines	100	miles
	Size of City	8	sq-mi
	Public Park Facilities	199	acres
	Lakes	351	acres
	Canals and Waterways	9	miles
	Public Library	1	library
Fire Protection			
	Number of Stations	3	stations
	Fire Rescue – Certified	65.5	people
	Support Staff	3	people
Police Protection (By Contract through Broward County Sheriff's Office)			
	Sworn	88	people
	Support	11	people

1 Information shown within this table was provided by the City of Oakland Park. Values shown contain a margin of error.

Table 2-2: Land Uses[2]

Land Use	Area (sq ft)	Area (acres)	Percent Share
Low Density Residential (L)	61,935,899	1,422	27.20%
Low Medium Density Residential (LM)	11,945,585	274	5.20%
Medium Density Residential (M)	8,381,536	192	3.70%
Medium-High Density Residential (MH)	6,411,513	147	2.80%
Irregular Density	2,176,075	50	1.00%
Commercial (C)	22,480,900	516	9.90%
Local Activity Center (LAC)	3,635,745	83	1.60%
Industrial (I)	11,240,896	258	4.90%
Utilities (U)	747,554	17	0.30%
Community Facilities (CF)	9,300,673	214	4.10%
Parks/Recreation (P/R)	13,556,210	311	6.00%
Conservation (CON)	792,017	18	0.30%
Water (W)	15,274,859	351	6.70%
Roads	52,295,800	1,202	23.00%
Vacant	7,448,935	171	3.20%
TOTAL	**227,624,197**	**5,226**	**100.00%**

2 Information shown within this table was provided by the City of Oakland Park. Values shown contain a margin of error.

Table 2-3: Parks & Recreation Facilities[3]

Category	Description	Area (acres)
Neighborhood Parks		
	Wimberly Athletic Complex/Collins Community Center/ Tennis Center	14.00
	Spiher Recreation Center/Greenleaf Park/Ethel M. Gordon Oakland Park Library	2.00
	Dr. Carter G. Woodson Park	0.85
	Oakland Park Athletic Complex East/Stevens Field	3.00
	Cherry Creek Park (leased)	2.91
	Giusti Heart Parcours (leased)	5.00
	Jaco Pastorius Park & Community Center	6.99
	Lloyd Estates Park	0.42
	Mini-Park	0.12
	North Andrews Gardens Neighborhood Park	1.03
	North Andrews Gardens Community Center	1.10
	North Andrews Gardens Volunteer Park	0.25
	Schad Park	0.14
	Northeast High School (Reciprocal Use Agreement)	5.00
	James S. Rickards Middle School (Reciprocal Use Agreement)	3.50
	North Andrews Gardens Elementary School (Reciprocal Use Agreement)	2.00
	Oakland Park Elementary School (Reciprocal Use Agreement)	1.50
	Lloyd Estates Elementary School (Reciprocal Use Agreement)	1.00
Subtotal		**50.81**
Community Parks		
	Royal Palm Park	52.00
	City Boat Ramp	0.22
	Veterans Park	82.20
	39th Street Greenway	9.00
	Oakland Bark Park	2.25
	Lakeside Sand Pine Preserve	5.00
	Art Park	0.32
	Stunson Nature Trail	5.00
Subtotal		**155.99**
TOTAL		**206.80**
	Water Portion of Park System	118.00

3 Information shown within this table was provided by the City of Oakland Park. Values shown contain a margin of error.

Table 2-4: Census Quick Facts[4]

Category	Description	Value	Units
Population			
	Population estimates, July 1, 2019, (V2019)	45,339	people
	Population, Census, April 1, 2010	41,363	people
Age and Sex			
	Persons under 5 years, percent	6%	percent
	Persons under 18 years, percent	19%	percent
	Persons under 65 years and over, percent	12%	percent
	Female persons, percent	46%	percent
Race and Hispanic Origin			
	White alone, percent	58%	percent
	Black or African American alone, percent (a)	28%	percent
	American Indian and Alaska Native alone, percent (b)	1%	percent
	Asian alone, percent (a)	3%	percent
	Native Hawaiian and Other Pacific Islander alone, percent (a)	0%	percent
	Two or more Races, percent	7%	percent
	Hispanic or Latino, percent (b)	30%	percent
	White alone, not Hispanic or Latino, percent	37%	percent
Population Characteristics			
	Veterans, 2014-2018	1,933	people
	Foreign born persons, percent 2014-2018	33%	percent
Housing			
	Owner-occupied housing unit rate, 2014-2018	54%	percent
	Median value of owner-occupied housing units, 2014-2018	$195,300	dollars
	Median selected monthly owner costs - with mortgage, 2014-2018	$1,505	dollars
	Median selected monthly owner costs - without mortgage, 2014-2018	$526	dollars
	Median gross rent, 2014-2018	$1,167	dollars
Families and Living Arrangements			
	Households, 2014-2018	16,515	households
	Persons per household, 2014-2018	2.67	people
	Living in the same house 1 year ago, percent of person age year+, 2014-2018	81%	percent
	Language other than English spoken at home, percent of persons age 5 years+, 2014-2018	42%	percent
Computer and Internet Use			
	Households with a computer, percent, 2014-2018	84%	percent
	Household with broadband Internet subscription, percent, 2014-2018	26%	percent
Education			
	High school graduate or higher, percent of persons age 25 years+, 2014-2018	84%	percent

4 Information shown within this table was provided by the United States Census Bureau from the following website, https://www.census.gov/quickfacts/fact/table/oaklandparkcityflorida,US/PST045219

Table 2-4: Census Quick Facts (continued) [5]

	Bachelor's degree or higher, percent of persons age 25 years+, 2014-2018	26%	percent
Health			
	With a disability, under the age 65 years, percent, 2014-2018	8%	percent
	Persons without health insurance, under age 65 years, percent	23%	percent
Economy			
	In civilian labor force, total, percent of population age 16 years+, 2014-2018	72%	percent
	In civilian labor force, female, percent of population age 16 years+, 2014-2018	68%	percent
	Total accommodation and food service sales, 2012 ($1,000) (c)	$90,709	dollars
	Total health care and social assistance receipts/revenue, 2012 ($1,000) (c)	$168,977	dollars
	Total manufacturers' shipments, 2012 ($1,000) (c)	$457,543	dollars
	Total merchant wholesaler sales, 2012 ($1,000) (c)	$360,542	dollars
	Total retail sales, 2012 ($1,000) (c)	$654,560	dollars
	Total retail sales per capita, 2012 (c)	$15,282	dollars
Transportation			
	Mean travel time to work (minutes), workers age 16 years+, 2014-2018	25.6	minutes
Income & Poverty			
	Median household income (in 2018 dollars), 2014-2018	$50,380	dollars
	Per capita income in past 12 months (in 2018 dollars), 2014-2018	$26,611	dollars
	Persons in poverty, percent	17%	percent
Businesses			
	All firms, 2012	7,340	firms
	Men-owned firms, 2012	4,078	firms
	Women-owned firms, 2012	2,354	firms
	Minority-owned firms, 2012	3,187	firms
	Nonminority-owned firms, 2012	3,794	firms
	Veteran-owned firms, 2012	633	firms
	Nonveteran-owned firms, 2012	6,306	firms
Geography			
	Population per square mile, 2010	5,545.4	people
	Land area in square miles, 2010	7.46	sq mi
	FIPS Code	1250575	--

5 Information shown within this table was provided by the United States Census Bureau from the following website, https://www.census.gov/quickfacts/fact/table/oaklandparkcityflorida,US/PST045219

Table 2-5: Population Characteristics[6]

Category	Description	Oakland Park Value	Broward County Value	Units
Population				
	Total Population	45,339	45,339	people
	Persons per sq. mile	5,020	5,020	people
Sex				
	Male	55.00%	48.70%	percentage
	Female	45.00%	51.30%	percentage
Age				
	Median Age	41.5	40.1	years
	19 and Under	20.06%	23.72%	percentage
	20 to 44 years	35.32%	32.97%	percentage
	45 to 64 years	32.72%	27.71%	percentage
	65 years and over	11.90%	15.60%	percentage
Race and Ethnicity				
	White, Non-Hispanic	37.21%	38.15%	percentage
	Black, Non-Hispanic	27.12%	27.42%	percentage
	American Indian and Alaskan Native	0.05%	0.17%	percentage
	Asian	4.48%	3.51%	percentage
	Other	2.59%	2.40%	percentage
	Hispanic (Any Race)	28.54%	28.35%	percentage
Educational Attainment				
	High school, equivalency or less	46.75%	39.33%	percentage
	Some college, no degree	17.27%	17.85%	percentage
	Associate's degree	13.22%	13.66%	percentage
	Bachelor's degree or higher	22.76%	29.16%	percentage
Households				
	Total Households	16,505	675,828	households
	Average Household Size	2.56	2.77	people
Household Income				
	Median household income	$48,390	$54,895	dollars
Household Language				
	English language households	60.19%	56.97%	percentage
	Spanish language households	22.96%	27.72%	percentage
	Other language households	16.85%	15.31%	percentage

6 Information shown within this table was provided by the City of Oakland Park. Values shown contain a margin of error.

Table 2-6: Workforce Characteristics[7]

Category	Description	Oakland Park Value	Broward County Value	Units
Labor Force				
	Labor force population	26,139	1,008,709	people
	Labor force participation rate	71.5%	65.8%	percentage
Earnings				
	Median earnings for workers	$27,388	$31,118	dollars
	Median earnings for males	$40,843	$45,387	dollars
	Median earnings for females	$34,672	$39,288	dollars
Occupation Type				
	Management, business, science and arts occupations	29.9%	35.6%	percentage
	Service occupations	24.1%	19.9%	percentage
	Sales and office occupations	24.4%	27.5%	percentage
	Natural resources, construction, and maintenance occupations	11.1%	8.4%	percentage
	Production, transportation, and material moving occupations	10.5%	8.6%	percentage
Employment by Industry				
	Agriculture, forestry, fishing and hunting, and mining	0.1%	0.2%	percentage
	Construction	9.3%	6.6%	percentage
	Manufacturing	5.8%	4.8%	percentage
	Wholesale trade	2.8%	3.7%	percentage
	Retail trade	13.1%	13.3%	percentage
	Transportation and warehousing, and utilities	5.5%	5.6%	percentage
	Information	1.5%	2.4%	percentage
	Finance and insurance, and real estate and rental and leasing	6.1%	8.0%	percentage
	Professional, scientific, and management, and administrative	13.4%	13.9%	percentage
	Educational services, and health care and social assistance	16.8%	20.6%	percentage
	Arts, entertainment, and recreation, and accommodation and food services	14.3%	11.2%	percentage
	Other services, except public administration	7.6%	5.6%	percentage
	Public administration	3.7%	4.1%	percentage

7 Information shown within this table was provided by the City of Oakland Park. Values shown contain a margin of error.

Table 2-7: Housing Characteristics[8]

Category	Description	Oakland Park Value	Broward County Value	Units
Housing Units				
	Total Housing Units	18,856	818,382	--
Housing Type				
	Single-family, detached	43.4%	41.5%	percentage
	Single-family, attached	5.7%	8.3%	percentage
	Multi-family, 2-4 units	9.4%	7.0%	percentage
	Multi-family, 5+ units	39.9%	40.3%	percentage
	Manufactured home	1.6%	2.8%	percentage
	Other	0.0%	0.1%	percentage
Housing Age				
	Built since 1990	13.9%	29.0%	percentage
	Built 1989 and earlier	86.1%	71.1%	percentage
Occupancy Type				
	Owner-Occupied	53.8%	62.3%	percentage
	Renter-Occupied	46.2%	37.7%	percentage
Housing Costs				
	Median value owner-occupied homes	$174,900	$223,400	dollars
	Median monthly mortgage	$1,453	$1,753	dollars
	Median Rent	$1,124	$1,271	dollars

Table 2-8: Largest Taxpayers[8]

Largest Taxpayer	Business Type	Taxable Valuation	% of Total Valuation
WRI JT Northridge LP	Shopping Center	$40,704,660	1.20%
Alliance HTFL LP	Professional Services - Financial	$27,090,720	0.80%
Brookwood CP II LLC	Business Complex	$24,559,570	0.72%
Northland Greetree LLC	Apartments	$24,345,670	0.72%
Shores Behavioral Hospital LLC	Medical Center	$21,035,940	0.62%
SSC Property Holdings Inc	Warehouses	$17,960,210	0.53%
Jorken Crystal Lake LLC	Apartments	$16,675,560	0.49%
Set Point Associates LTD PRTNR	Apartments	$15,379,000	0.45%
NGP V Broward LLC	Condominiums	$13,558,700	0.40%
Cubesmart LP	Warehouses	$11,663,820	0.34%
TOTAL		**$212,973,850**	**6.29%**

8 Information shown within this table was provided by the City of Oakland Park. Values shown contain a margin of error.

3.2 Historical Flooding Areas

As of 2018, the City has had 393 flooding claims of which more than 30% have occurred within the last 10 years. Repetitive losses is a classification established by the National Flood Insurance Program (NFIP). A property is categorized as a repetitive loss if two or more flood insurance claims for more than $1,000 dollars have been paid within any 10-year period since 1978. In 2019, the City conducted a repetitive loss analysis and report, prepared by CRS Max Consultants, Inc., see **Appendix A**. The analysis established 29 Repetitive Loss Areas (RLAs), consisting of repetitive loss properties and the surrounding properties likely to experience similar flooding conditions. The City's historical flooding claims and RLAs are shown in **Figure 2-3.** This data was used to identify known areas of high flood risk.

3.3 Critical and Important Asset Identification

It is vital to assess the flooding vulnerabilities of the City's critical and important assets. Critical assets need to remain functional during a flooding event, whereas important assets are areas of interest that could become critical given a specific emergency. A total of 66 critical and important assets were identified. Since large parking areas may be useful during and following a storm event, nine (9) parking lots associated with these assets were included in the analysis. All assets were classified into the following eight categories:

- Assisted Living Facilities (5)
- Community Centers (2)
- Fire Stations (3)
- Hospitals (2)
- Municipal Facilities (9)
- Schools (6)
- Sanitary Sewer Lift Stations (34)
- Stormwater Pump Stations (5)

Table 2-9 and **Figure 2-4** indicate the location and information associated with each identified critical and important asset. All assets are not considered equal since some assets may be partially submersible or may contain only certain non-submersible components required to maintain system operation and integrity, such as electrical panels and generators for pump or lift stations. Each flooded asset will have a different effect on the overall system, operation or service it provides. In some cases, even partial loss of function could have severe impact.

Table 2-9: Critical and Important Assets

Name (Google Link)	Critical or Important	Large Parking Lot	Service Street Address	City	Zip	Parcel ID
Assisted Living Facilities						
TREEMONT ON THE PARK	Important	--	3881 NE 3rd Ave	Oakland Park	33334	494222000133
TROPICAL HAVEN, INC	Important	--	460 NW 40th Ct	Oakland Park	33309	494222082290
GOOD HOPE MANOR	Important	--	2251 NW 29th Ct	Oakland Park	33311	494229390010
PALMS VILLA RETIREMENT HOME	Important	--	2131 NW 28th St	Oakland Park	33311	494229020500
PARADISE MANOR	Important	--	365 NW 43rd Ct	Oakland Park	33309	494222080100
Community Centers						
Collins Community Center	Critical	X	3900 NE 3rd Ave	Oakland Park	33334	494222240010
JACO PASTORIUS PARK & COMMUNITY CENTER	Important	--	1098 NE 40th Ct	Oakland Park	33334	494223100030
Fire Stations						
FIRE STATION #9	Critical	X	301 NE 38th St	Oakland Park	33334	494222240010
FIRE STATION #20	Critical	--	4721 NW 9th Ave	Oakland Park	33309	494216070710
OAKLAND PARK FIRE ADMINISTRATION/FIRE STATION #87	Critical	--	2100 NW 39th St	Oakland Park	33309	494220050010
Hospitals						
FORT LAUDERDALE BEHAVIORAL HOSPITAL	Critical	X	5757 N Dixie Hwy	Oakland Park	33334	494211320010
HOLY CROSS MEDICAL GROUP FACILITY	Critical	X	5601 N Dixie Hwy	Oakland Park	33334	494211230010
Municipal Facilities						
Ethel M. Gordon Oakland Park Library	Important	--	1298 NE 37th St	Oakland Park	33334	494223250010
BROWARD SCHOOLS CENTRAL BUS DEPOT	Important	X	3831 NW 10th Ave	Oakland Park	33309	494221000090
CITY HALL	Critical	--	3650 NE 12th Ave	Oakland Park	33334	494223250010
CITY OF OAKLAND PARK MUNICIPAL BUILDING	Important	X	5399 N Dixie Hwy	Oakland Park	33334	494214280010
FDOT DIST IV	Important	X	3400 W Commercial Blvd	Oakland Park	33309	494218200511
Public Works Administration	Critical	X	3801 NE 5th Ave	Oakland Park	33334	494222240010
PUBLIC WORKS OPERATIONS COMPLEX	Critical	--	5100 NE 12th Terr	Oakland Park	33334	494214000010
PIONEER HOUSE & MUSEUM	Important	--	3860 NE 6th Ave	Oakland Park	33334	494223053270
Fiveash Water Treatment Plant	Critical	--	4321 NW 9th Ave	Fort Lauderdale	33309	494221000010
Schools						
LLOYD ESTATES ELEMENTARY	Important	X	750 NW 41st St	Oakland Park	33309	494222250010
NORTH ANDREWS GARDENS ELEMENTARY	Important	X	345 NE 56th St	Oakland Park	33334	494210430010
NORTHEAST HIGH	Important	X	700 NE 56th St	Oakland Park	33334	494214000041
OAKLAND PARK ELEMENTARY	Important	--	936 NE 33rd St	Oakland Park	33334	494223052940
RICKARDS MIDDLE	Important	--	6000 NE 9th Ave	Oakland Park	33334	494211000360
LIFE SKILLS CHARTER HIGH SCHOOL	Important	--	2360 W Oakland Park Blvd	Oakland Park	33311	494229220280

Table 2-9: Critical and Important Assets (continued)

Name (Google Link)	Critical or Important	Large Parking Lot	Service Street Address	City	Zip	Parcel ID
Sanitary Sewer Lift Stations						
LS 1	Critical	--	1604 NE 45th St	Oakland Park	33334	--
LS 2	Critical	--	4209 NE 15th Ave	Oakland Park	33334	--
LS 3	Critical	--	4850 NE 13th Terr	Oakland Park	33334	--
LS 4	Critical	--	1750 NE 42nd St	Oakland Park	33334	--
LS 7	Critical	--	1810 E Oakland Park Blvd	Oakland Park	33306	--
LS 8	Critical	--	1698 E Oakland Park Blvd	Oakland Park	33334	--
LS A2	Critical	--	3625 NE 17th Ave	Oakland Park	33334	--
LS B1	Critical	--	3581 NE 12th Ave	Oakland Park	33334	--
LS B2	Critical	--	928 NE 48th Ave	Oakland Park	33334	--
LS B3	Critical	--	4920 NE 12th Ave	Oakland Park	33334	--
LS C1	Critical	--	3590 N Andrews Ave	Oakland Park	33334	--
LS C2	Critical	--	840 NW 33rd St	Oakland Park	33309	--
LS C3	Critical	--	3271 NW 3rd Ave	Oakland Park	33309	--
LS C4	Critical	--	920 NW 38th St	Oakland Park	33309	--
LS D1	Critical	--	3301 NW 21st Ave	Oakland Park	33309	--
LS D10	Critical	--	2901 NW 44th St	Oakland Park	33309	--
LS D11	Critical	--	3500 N Oakland Forest Dr	Oakland Park	33309	--
LS D12	Critical	--	4900 NW 9th Ave	Oakland Park	33309	--
LS D13	Critical	--	2203 W Oakland Park Blvd	Oakland Park	33311	--
LS D14	Critical	--	3308 NW 31st Terr	Oakland Park	33309	--
LS D2	Critical	--	4400 NW 18th Terr	Oakland Park	33309	--
LS D3	Critical	--	3700 NW 18th Ave	Oakland Park	33309	--
LS D4	Critical	--	3098 NW 21st Ave	Oakland Park	33309	--
LS D4A	Critical	--	2360 NW 27th St	Oakland Park	33311	--
LS D5	Critical	--	3801 NW 10th Ave	Oakland Park	33309	--
LS D6	Critical	--	2901 W Oakland Park Blvd	Oakland Park	33311	--
LS D7	Critical	--	2700 NW 44th St	Oakland Park	33309	--
LS D8	Critical	--	4351 NW 21st Ave	Oakland Park	33309	--
LS D9	Critical	--	2751 NW 39th St	Oakland Park	33309	--
LS FARM STORE	Critical	--	155 E Prospect Rd	Oakland Park	33334	--
LS MILBRAN	Critical	--	899 W Prospect Rd	Oakland Park	33309	--
LS ROCK ISLAND	Critical	--	2681 NW 19th Ave	Oakland Park	33311	--
LS_B2-A	Critical	--	4750 NE 7th Ave	Oakland Park	33334	--
LS_S5	Critical	--	3340 NE 20th Ave	Oakland Park	33306	--

Table 2-9: Critical and Important Assets (continued)

Name (Google Link)	Critical or Important	Large Parking Lot	Service Street Address	City	Zip	Parcel ID
Stormwater Pump Stations						
STORM-PUMP-1	Critical	--	1090 NE 45th St	Oakland Park	33334	--
STORM-PUMP-2	Critical	--	4299 NE 11th Ave	Oakland Park	33334	--
STORM-PUMP-3	Critical	--	4404 NE 6th Terr	Oakland Park	33334	--
STORM-PUMP-4	Critical	--	1501 NW 38th St	Oakland Park	33309	--
STORM-PUMP-5	Critical	--	3121 N Andrews Ave	Oakland Park	33309	--

3.4 Topography and Hydrography

3.4.1 Imagery

The 2020 high-resolution aerial imagery used in this analysis was sourced from the Broward County Property Appraiser's office. This dataset was collected in December of 2019 and has a 6-inch per pixel resolution. High resolution images allow for better visualization, which is essential for the development of the flood risk model and flood vulnerability analysis. **Figure 2-5** shows the aerial map of the City.

3.4.2 Digital Elevation Model

The topographic data available for the City (and urban Broward County) is the 2007 Florida Department of Emergency Management (FDEM) Light Detection and Ranging (LiDAR) dataset, which is available from sites such as Florida International University's International Hurricane Research Center LiDAR Download Viewer, United States Geologic Survey's (USGS') National Elevation Dataset, or National Oceanic and Atmospheric Administration's (NOAA's) Data Access Viewer. 3001 Inc. collected the 2007 FDEM LiDAR dataset for FDEM between July 2007 and February 2008 as part of a state-wide LiDAR mapping effort. The dataset covers the entire City. FDEM acquired the dataset to develop a Digital Terrain Model that could be used for state-wide regional evacuation studies. 3001Inc. determined that the vertical accuracy of the ground points have a root-mean-square error (RMSE) of 0.15 foot (0.29 foot at the 95% confidence level) in unobscured areas. The accuracy assessment computed RMSE based on a comparison of ground control points and filtered LiDAR points. The horizontal accuracy was determined by 3001 to have a RMSE of 0.81 feet. Elevations represented by the Digital Elevation Model (DEM) are referenced to the North American Vertical Datum of 1988 (NAVD88) with units in feet.

Figure 2-6 shows the 2007 FDEM Bare-earth DEM within Broward County with a 5-foot cell size.

3.4.3 Bathymetry

Under normal conditions, water makes up approximately 11% of the City's surface. Bathymetry of submerged portions of waterbodies is obscured in the collection of LiDAR data used for the development of the 2007 FDEM DEM. For this reason, bathymetry for the City's waterbodies was burned into the DEM to reflect bottom elevations, improving the representation of water bodies.

Bathymetric data to define major canals within the City including C-13, Cypress Creek and the Middle River was sourced from the Federal Emergency Management Agency's (FEMA's) flood event model for Broward County, developed using MIKE SHE/ MIKE 11 software. A total of 32 unique cross sections were incorporated from the FEMA MIKE SHE/ MIKE 11 model.

Since the bathymetric data for ponds and lakes was limited, the modeling input contains assumed elevations for waterbodies without bathymetric data. Bottom elevations were assumed based on the size of the waterbody as shown in **Table 2-10,** Bathymetric Assumptions.

Final waterbodies and the location of bathymetric data is shown on **Figure 2-7,** Bathymetry. **Figure 2-8** shows the resulting DEM for the City of Oakland Park. The City's DEM shows an average ground elevation of 5.89 NAVD88.

Table 2-10: Bathymetric Assumptions

Waterbody Area (sqft)	Assumed Bottom Elevation (NAVD88)
< 19,000	-5
19,000 - 52,000	-10
52,000 - 107,000	-15
107,000 - 170,000	-20
170,000 - 275,000	-25
275,000 - 466,000	-30
466,000-700,000	-35
> 700,000	-40

3.5 Hydrogeology

3.5.1 Groundwater and Sea Level Rise

Since the 2007 FDEM DEM was not hydrographically corrected, meaning water bodies do not reflect a consistent (such as for ponds) or gently sloped water surface (such as for canals), groundwater elevations were used to estimate the typical standing water line within bodies of water.

Current groundwater conditions were determined using Broward County's most recent average wet season water table map shown in **Figure 2-9** and available from the Planning and Environmental Regulation Division, Environmental Protection and Growth Management Department.

Future groundwater conditions were estimated using a smoothed version of Broward County's future conditions average wet season groundwater elevation map shown in **Figure 2-10** sourced from the Planning and Environmental Regulation Division, Environmental Protection and Growth Management Department. As per the note shown on the County's map, "the map represents the expected future average wet season groundwater elevations for Broward County. The average is based on model outputs for the months of May through October over the period of 2060-2069. The models used are The Broward County Inundation Model and the Broward County Northern Variable Density model, both developed by the United States Geological Survey (USGS) and MODFLOW based. The future conditions that are modified in the models are both precipitation and sea level rise. The future precipitation pattern is based on the Center for Ocean-Atmospheric Prediction Studies (COAPS) downscaled Community Climate System Model (CCSM) and represents an increase of 9% rainfall from the base case of 1990-1999 (53.4 in/yr to 58.2 in/yr). Sea level rise was based on the United States Army Corps of Engineers (USACE) National Research Council Curve 3 (NRC3) curve which equates to an increase of 26.6 (2060) to 33.9 inches (2070) to the future period from 1992 levels. Final results are presented in 1988 North American Vertical Datum (NAVD 88)."

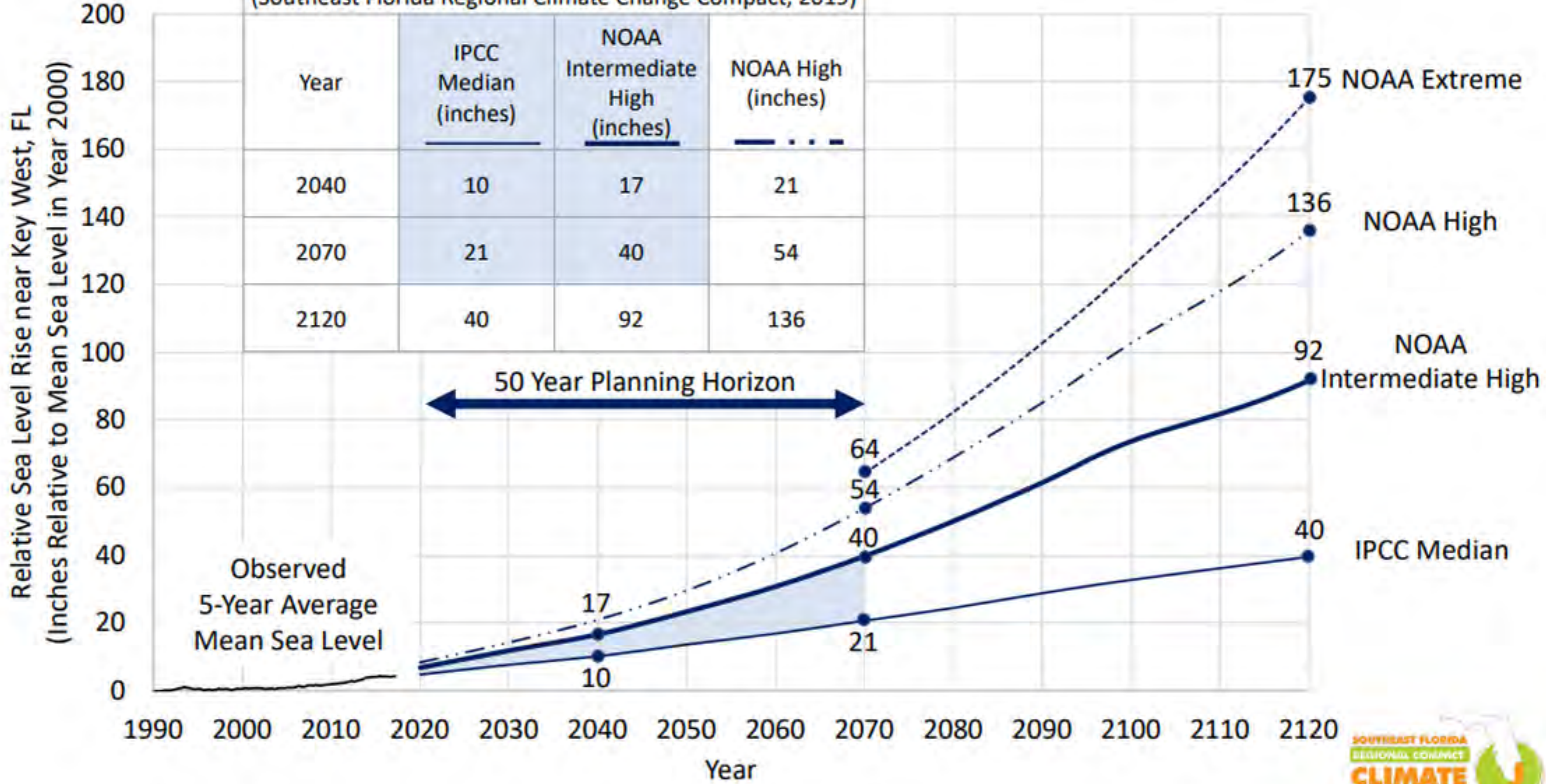
Future groundwater conditions for year 2060 were estimated by adding 3.4 inches to the County's future conditions average wet season groundwater elevations to in order to incorporate the updated sea level rise projection as per the National Oceanic and Atmospheric Administration (NOAA) Intermediate High curve (equivalent to the USACE curve) shown on the Unified Sea Level Rise Projection as presented at the Southeast Florida Regional Climate Change Compact in 2019. Future groundwater conditions for year 2050 were then estimated by subtracting 7 inches from the calculated 2060 groundwater elevations to incorporate 10 years less of sea level rise also using the NOAA Intermediate High curve.

Final groundwater conditions for each planning horizon were determined for the City of Oakland Park and shown on **Figure 2-11, Figure 2-12** and **Figure 2-13.** The groundwater elevation for the current 2020 condition has a minimum of 0.5 NAVD88, a maximum of 2.56 NAVD88 and a mean of 1.28 NAVD88. The ground water elevation for the future 2050 condition has a minimum of 1.29 NAVD88, a maximum of 2.84 NAVD88 and a mean of 2.08 NAVD88. The ground water elevation for the future 2060 condition has a minimum of 1.88 NAVD88, a maximum of 3.43 NAVD88 and a mean of 2.67 NAVD88. There is nearly 1.4 feet of difference in average groundwater elevation between current and future (2060) conditions.

Future conditions simulations reflect the Unified Sea Level Rise Projections first presented by the Southeast Regional Climate Change Compact in December 2019. The updated United Sea Level Rise Projection for Southeast Florida (2019) is included in **Appendix B** of this report. The projection, as presented in the 2019 compact and shown on **Figure 2-14**, was applied for the years 2050 and 2060, reflecting sea level rise per the NOAA Intermediate-High (considered equivalent to the USACE High shown in the previous compact projections). A total of 23 inches and 30 inches of sea level rise is incorporated into the 2050 and 2060 future conditions scenarios, respectively.

Unified Sea Level Rise Projection
(Southeast Florida Regional Climate Change Compact, 2019)

Year	IPCC Median (inches)	NOAA Intermediate High (inches)	NOAA High (inches)
2040	10	17	21
2070	21	40	54
2120	40	92	136



Hazen		Stormwater Master Plan Update & Flood Vulnerability Assessment
Print Date: 5/6/2020 7:41 PM	City of Oakland Park	Figure 2-14
Printed By: E. Johnson	Unified Sea Level Rise Projections (Southeast Florida Regional Climate Change Compact, 2019)	
Review By: L. Medina		

Hazen Project Number: 47036-002
Plot date: 5/6/2020 7:41 PM By: rloffing
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3.6 Oceanography

3.6.1 King Tidal Conditions

Flood events are always influenced by tidal conditions. Flooding impact gets compounded by whether the storm occurs during high or low tide. Tidal rage greatly varies around the world and tidal conditions at any given time may be classified by intensity or amplitude. Although the frequency of tides is highly predicable since high tide occurs about every 12 hours and 25 minutes, the intensity or amplitude is variable. Observed water levels have been known to significantly differ from predicted values. It is critical to account for the highest probable tide conditions when assessing flood vulnerabilities.

3.6.1.1.1 Definition and Colloquial Meaning

For purposes of flood risk modeling, the perigean spring tide, more commonly known as the King Tide(s) (KT), is of greatest concern. KT typically occur three or four times a year. This phenomenon is observed when the moon is a new moon or a full moon and is simultaneously nearest the earth, as the word *perigean* implies. Refer to **Figure 2-15** adapted from NOAA's National Ocean Service for a visual explanation of the celestial cause of KT. Annual tidal elevations tend to be the highest from September through November. With the continuation of sea level rise, it is anticipated that a larger portion of the City will be impacted by increasing KT elevations in years to come. Despite the technical differentiation between KTs and typical spring tides, both are colloquially referred to as KTs. Throughout this assessment, the colloquial definition of KT is implied unless otherwise stated.

3.6.1.1.2 Data Source

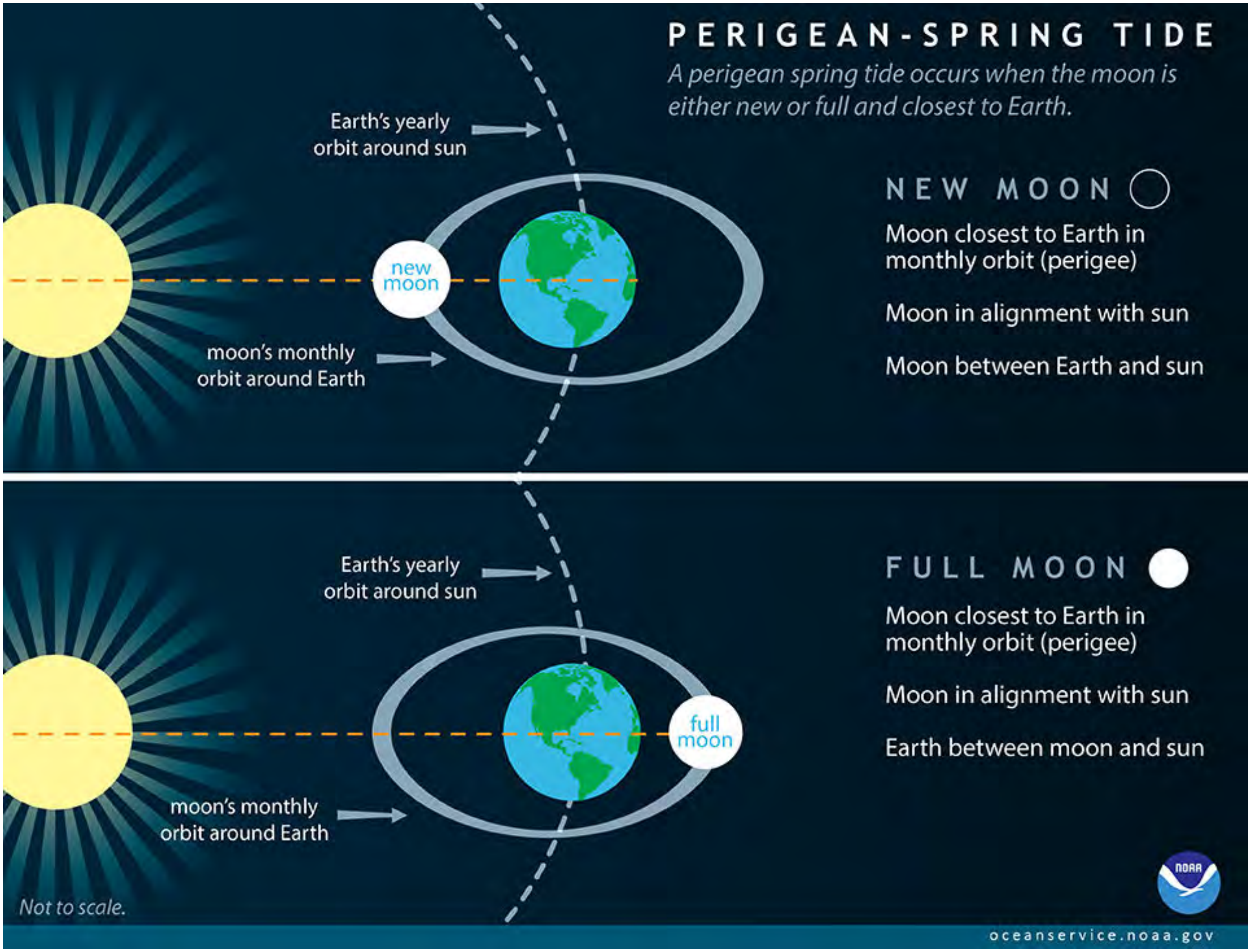
Tidal water level measurements and mean values of tidal datum are available from NOAA for numerous stations in southeastern Florida. Datum are based on the latest NOAA National Tidal Datum Epoch (1983 through 2001). National Tidal Datum Epochs are 19-year periods adopted by the National Ocean Service and used to define mean values of tidal datum, such as mean sea level. **Table 2-11** summarizes the active NOAA tidal water level stations and data record characteristics that are located in proximity to Oakland Park. Although South Port Everglades is the closest active water level tidal station to the City as illustrated in **Figure 2-16,** the available data set only goes back to January of 2018. For this reason, KT values and projections for this assessment were based on the Virginia Key Tidal Gauge (VKTG).

NOAA has observed that tide elevations are steadily increasing, possibly due to climate change and sea level rise. **Figure 2-17** shows the mean sea level trend at the VKTG since 1931. As per NOAA's website, the plot shows the monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. These trends are reflected in the assessment of future KT.

Table 2-11: Active NOAA Water Level Tidal Stations with Published Datum near Oakland Park, FL

Name	Station Number	Period of Record	Elevations on Station Datum Relative to NAVD88, feet (Relative to NAVD29, feet)				
			MHHW	MHW	MSL	HAT	Max
Lake Worth Pier	8722670	4/14/1970 - present	0.55 (2.12)	0.37 (1.94)	-0.97 (0.60)	1.81 (3.38)	2.56 (4.13)
South Port Everglades	8722956	1/2/2018 - present	0.53 (2.10)	0.38 (1.95)	-0.85 (0.72)	1.63 (3.20)	2.06 (3.63)
Virginia Key	8723214	1/26/1994 - present	0.21 (1.78)	0.15 (1.72)	-0.90 (0.67)	1.13 (2.70)	3.79 (5.36)
Vaca Key	8723970	12/4/1970 - present	-0.36 (1.21)	-0.47 (1.1)	-0.83 (0.74)	0.27 (1.84)	5.43 (7.00)
Key West	8724580	1/18/1913 - present	0.05 (1.62)	-0.24 (1.33)	-0.87 (0.70)	0.89 (2.46)	3.18 (4.75)

Note: Mean Higher-High Water (MHHW), Mean High Water (MHW), Mean Sea Level (MSL), Highest Astronomical Tide (HAT), and Maximum Tide (Max) presented, 1983-2001 Epoch.



Source: National Ocean Service. 2017. What is a perigean tide? National Oceanic and Atmospheric Administration.

Available at URL: http://oceanservice.noaa.gov/facts/perigean-spring-tide.html

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City of Oakland Park
Celestial Cause of King Tides

Figure 2-15

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Service Layer Credits: N/A

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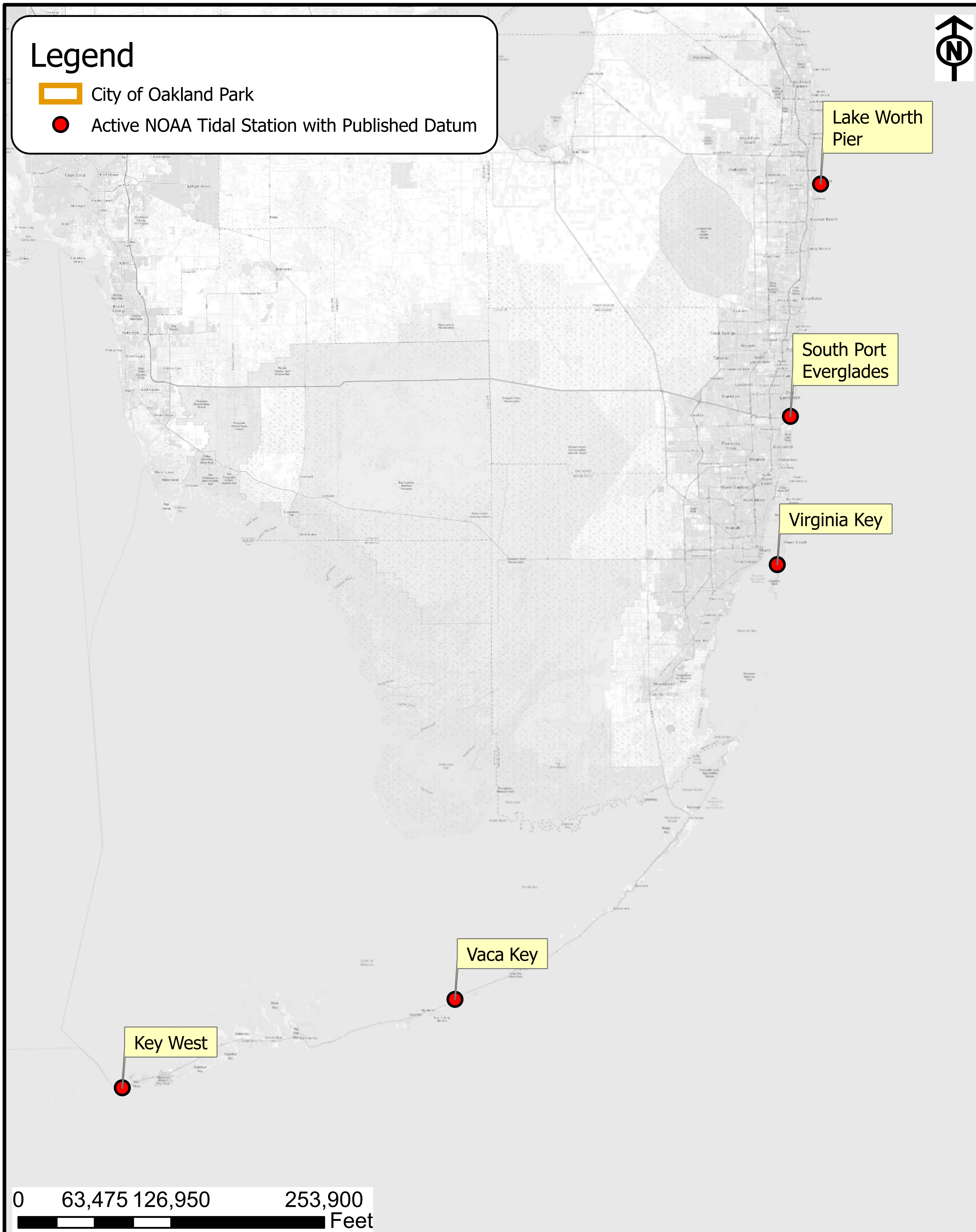

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Stormwater Master Plan Update & Flood Vulnerability Assessment

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City of Oakland Park

Active NOAA Water Level Stations near Oakland Park, FL

Figure 2-16

Hazen Project Number: 47036-002
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Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

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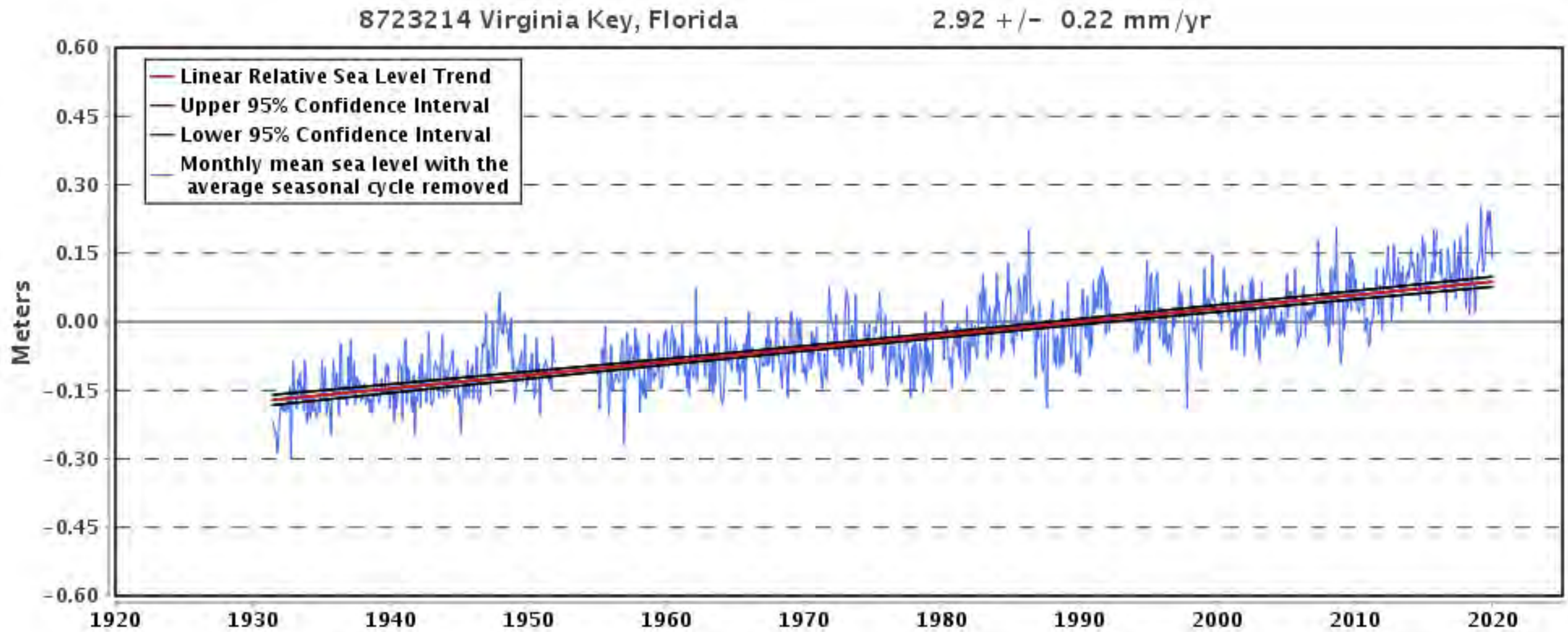

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Service Layer Credits: N/A

Source: Tides & Currents. 2019. Mean Sea Level Trend 8723214 Virginia Key, Florida. National Oceanic and Atmospheric Administration.

Available at URL: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8723214

City of Oakland Park Florida

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Stormwater Master Plan Update & Flood Vulnerability Assessment

City of Oakland Park

Mean Sea Level Trend at the NOAA Virginia Key Tide Gauge

Figure 2-17

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3.6.1.1.3 Current King Tide (KT) Conditions

The highest tides observed at the VKTG was sourced from NOAA's Tides & Currents site in the datum of NAVD88. Tidal data was gathered and analyzed for the highest tides observed in September, October, or November from 1999 to 2019. The sourced high tides were plotted by elevation and year as shown in **Figure 2-18**. The KT observed for the current modeling condition was determined based on October 2019 elevation value of 2.19 NAVD88.

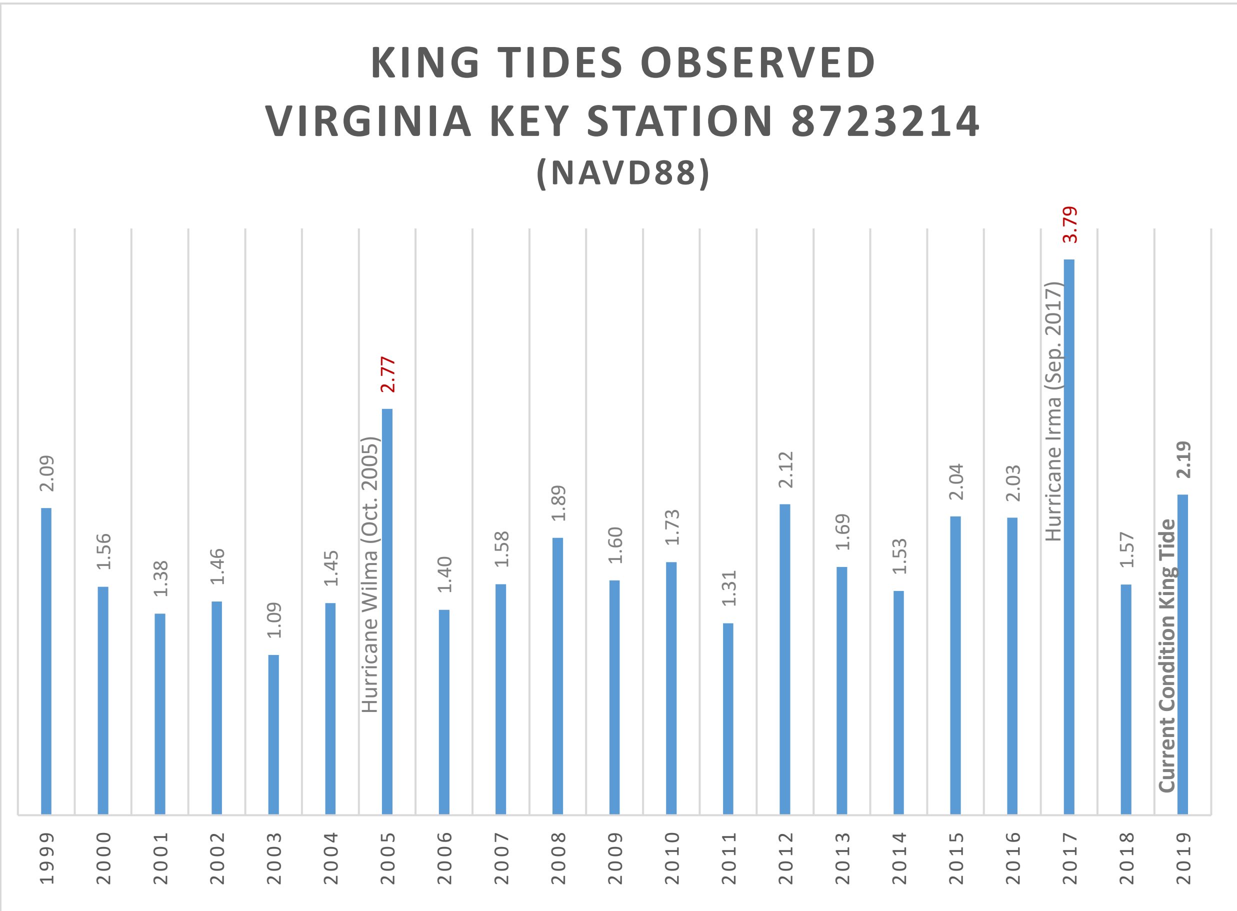


Figure 2-18: King Tide Elevations Observed at VKTG Since 1999 (September – November)

3.6.1.1.4 Future King Tide Conditions

Future KT were projected by fitting the observed KT since 1999 with an exponential trend. To ensure that the data analysis represented "typical" KT, the following occurrences with known significant storm surge contribution to tidal elevations were disregarded and replaced with the second highest tidal value observed for that year:

- October 2005 - Hurricane Wilma (2.77 NAVD88), replaced with September 2005 value of 2.15 NAVD88.
- September 2017 - Hurricane Irma (3.79 NAVD88) replaced with October 2017 value of 2.24 NAVD88.

Figure 2-19 shows an exponential trendline fitted to the king tide elevations observed at VKTG since 1999 (September – November). King tide elevations for years 2050 and 2060 were projected using the trendline equation and determined to be 2.92 NAVD88 and 3.34 NAVD88, respectively.

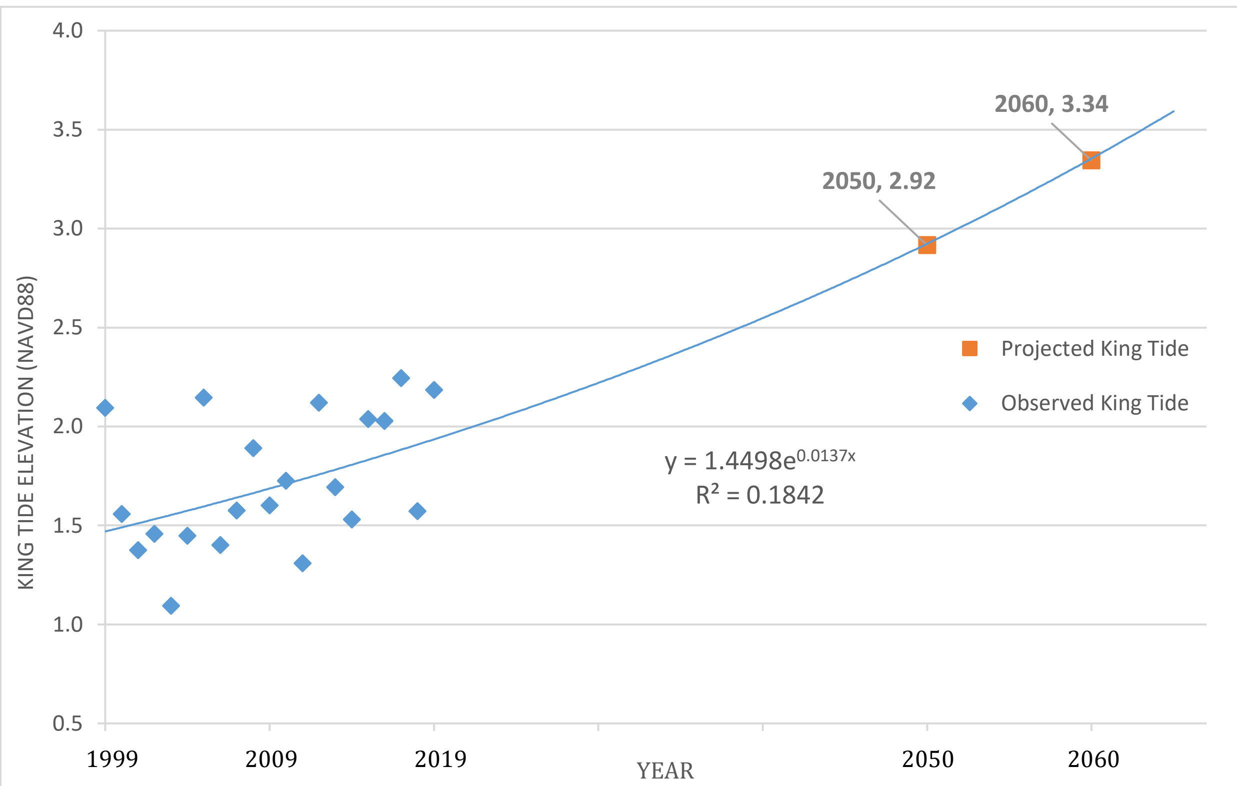


Figure 2-19: Projected King Tide Elevations

3.6.2 Storm Surge & Storm Tide

NOAA defines storm surge as "the abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide. The surge is caused primarily by a storm's winds pushing water onshore. The amplitude of the storm surge at any given location depends on the orientation of the coast line with the storm track; the intensity, size, and speed of the storm; and the local bathymetry." NOAA defines storm tide as "the total observed seawater level during a storm, resulting from the combination of storm surge and the astronomical tide. Astronomical tides are caused by the gravitational pull of the sun and the moon and have their greatest effects on seawater level during new and full moons—when the sun, the moon, and the Earth are in alignment. As a result, the highest storm tides are often observed during storms that coincide with a new or full moon." **Figure 2-20** shows a graphic NOAA uses to highlight the technical difference between storm surge and storm tide.

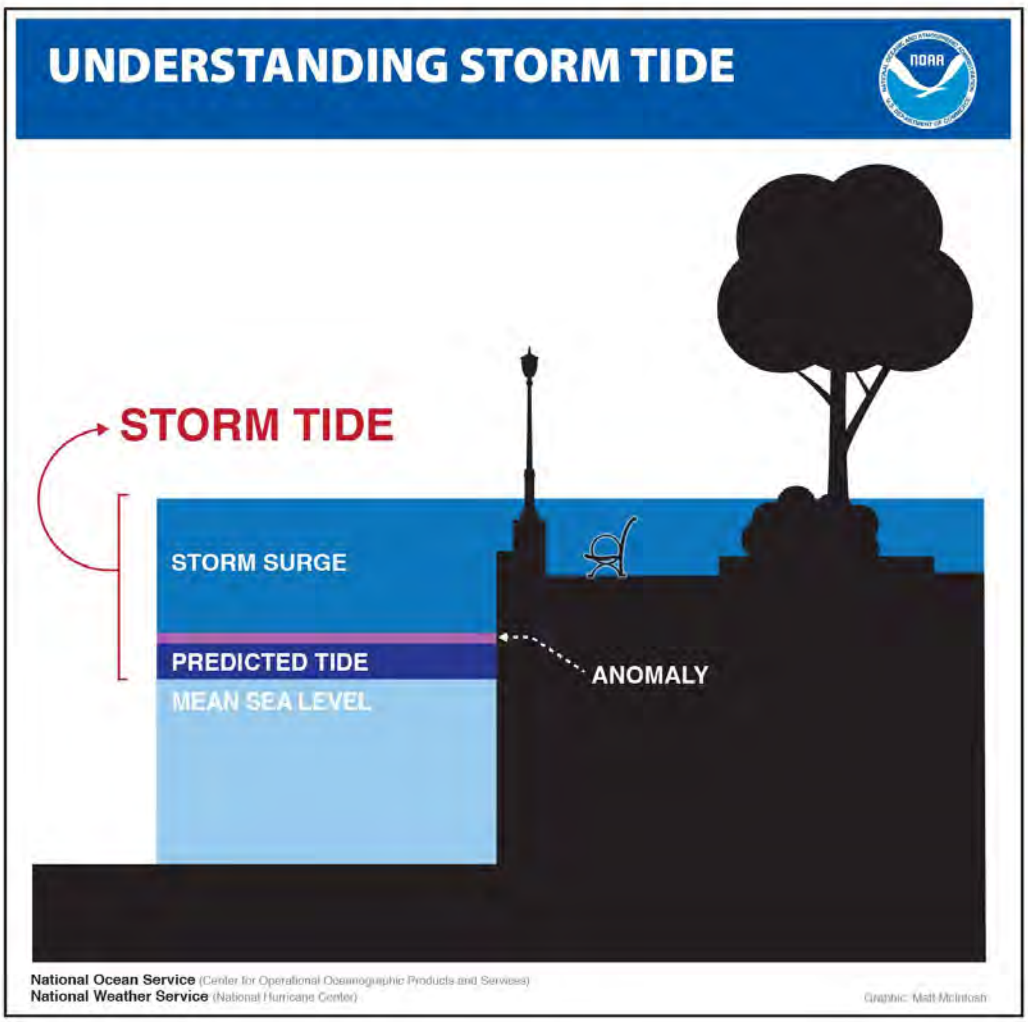
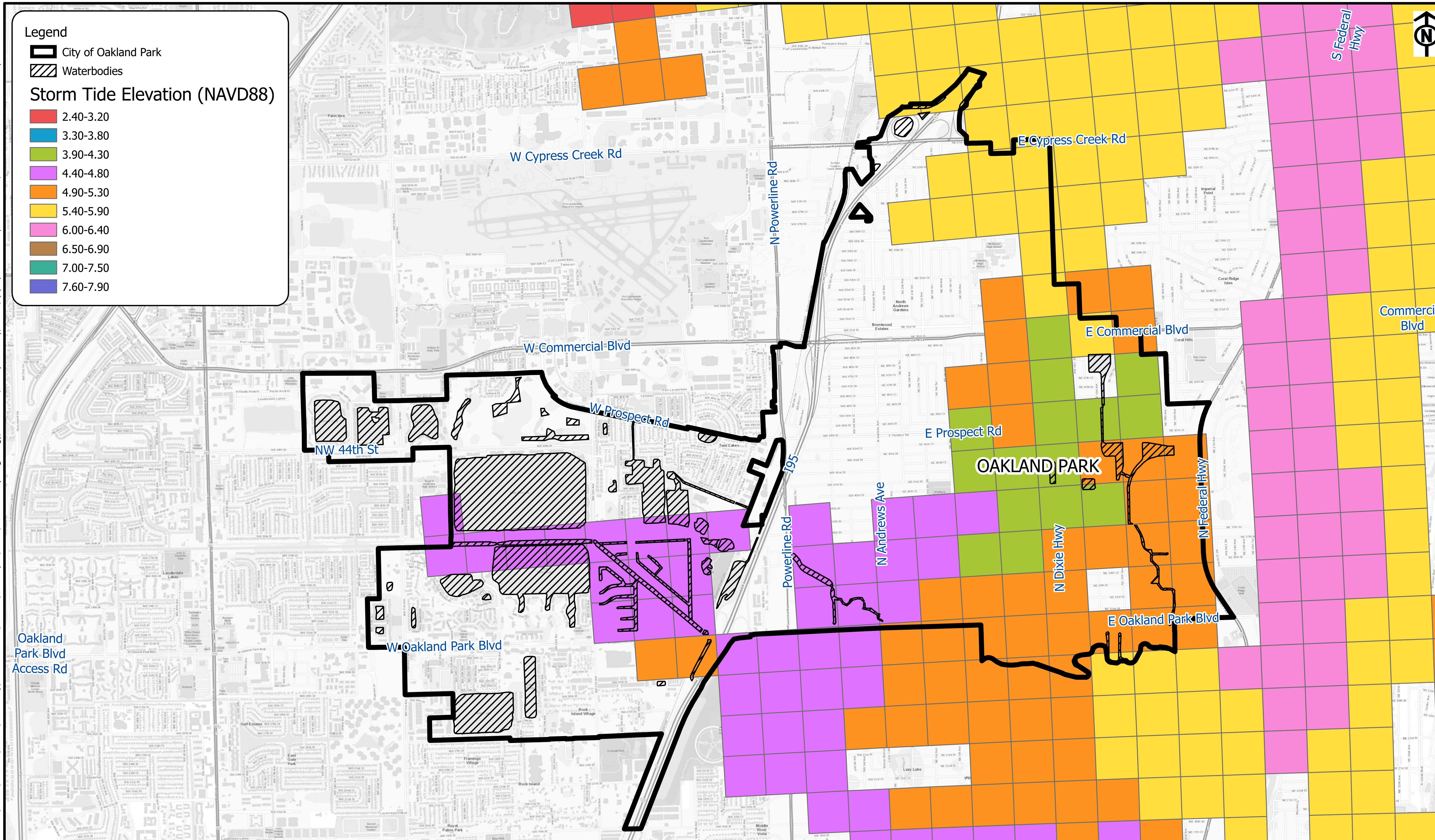


Figure 2-20: Storm Surge and Storm Tide

3.6.2.1 Sea, Lake and Overland Surges from Hurricanes

The National Weather Service developed a computerized numerical model for Sea, Lake and Overland Surges from Hurricanes (SLOSH). The SLOSH model simulates a vast quantity of historical, hypothetical and predicted hurricane events. For any given location, the SLOSH model presents the maximum storm tide level (or depth from dry ground) from all hypothetical simulations for a specific category of hurricane. Hazen and Sawyer coordinated with NOAA and the National Hurricane Center (NHC) to determine the best SLOSH data set to be used for analyzing surge impacts on the City of Oakland Park. The SLOSH model data was used to visually and quantifiably represent the predicted maximum storm tide levels for the City under Category I, III and V hurricanes.

Figure 2-21 shows a typical raw data set sourced from the SLOSH model with a cell size of 500 by 500 feet. The data included an initial high tide level of 1.0-foot NAVD88. This high tide offset was accounted for and the raw data was digested and tailored to represent more detailed analysis for the City's use.



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Stormwater Master Plan Update & Flood Vulnerability Assessment

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City of Oakland Park

Typical Raw SLOSH Data Category V, High Tide

Figure 2-21

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Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Table 2-12: Flood Vulnerability Assessment Scenarios and Statistics

Scenario ID	Figure ID	Planning Horizon & Groundwater Condition	Storm Surge Category	Imposed Flood Elevation [NAVD 88]	Elevation Raster [NAVD88]	Depth Raster [ft above Dry Condition]	Percent of Ground Surface Impacted	Average Surface Flooding Depth [ft]	Maximum Surface Flooding Depth [ft]
Dry Condition									
1	Figure 2-22	2020 Current	--	--	DEM_GW_20	--	--	--	--
2	Figure 2-23	2050 Future	--	--	DEM_GW_50	--	--	--	--
3	Figure 2-24	2060 Future	--	--	DEM_GW_60	--	--	--	--
King Tide Condition									
4	Figure 2-26	2020 Current	--	2.19	K20_219	K20_219D	1%	0.01	1.69
5	Figure 2-27	2050 Future	--	2.92	K50_292	K50_292D	2%	0.01	1.63
6	Figure 2-28	2060 Future	--	3.34	K60_334	K60_334D	3%	0.02	1.46
Storm Surge Condition									
7	Figure 2-29	2020 Current	Category 1	2.5	SS20_C1_250	SS20_C1_250D	1%	0.01	2.00
8	Figure 2-30	2020 Current	Category 3	3.72	SS20_C3_372	SS20_C3_372D	5%	0.05	3.22
9	Figure 2-31	2020 Current	Category 5	4.92	SS20_C5_492	SS20_C5_492D	26%	0.25	4.42
See Note		2050 Future	Category 1	2.5	SS50_C1_250	SS50_C1_250D	See Scenario 7		
See Note		2050 Future	Category 3	3.72	SS50_C3_372	SS50_C3_372D	See Scenario 8		
See Note		2050 Future	Category 5	4.92	SS50_C5_492	SS50_C5_492D	See Scenario 9		
See Note		2060 Future	Category 1	2.5	SS60_C1_250	SS60_C1_250D	See Scenario 7		
See Note		2060 Future	Category 3	3.72	SS60_C3_372	SS60_C3_372D	See Scenario 8		
See Note		2060 Future	Category 5	4.92	SS60_C5_492	SS60_C5_492D	See Scenario 9		
King Tide and Storm Surge Compounding Condition									
See Note		2020 Current	Category 1	3.69	KT20_C1_369	KT20_C1_369D	See Scenario 8		
See Note		2020 Current	Category 3	4.91	KT20_C3_491	KT20_C3_491D	See Scenario 9		
See Note		2020 Current	Category 5	6.11	KT20_C5_611	KT20_C5_611D	See Scenario 13		
10	Figure 2-32	2050 Future	Category 1	4.42	KT50_C1_442	K5_C1_442D	15%	0.13	3.13
11	Figure 2-33	2050 Future	Category 3	5.64	KT50_C3_564	K5_C3_564D	49%	0.58	4.35
12	Figure 2-34	2050 Future	Category 5	6.84	KT50_C5_684	K5_C5_684D	77%	1.39	5.55
	See Note	2060 Future	Category 1	4.84	KT60_C1_484	KT60_C1_484D	See Scenario 9	See Note	2060 Future
13	Figure 2-35	2060 Future	Category 3	6.06	KT60_C3_606	K6_C3_606D	60%	0.82	4.18
14	Figure 2-36	2060 Future	Category 5	7.26	KT60_C5_726	K6_C5_726D	83%	1.72	5.38

Note: This scenario was calculated but not mapped due to the similarities to one of the other 14 mapped scenarios.

5. Flood Vulnerabilities

5.1 Stormwater Infrastructure

Figure 2-22 shows the City's stormwater infrastructure, including existing solid pipe as well as exfiltration trenches. The stormwater management system serves the City under typical storms as well as more extreme, less frequent events as analyzed within this report. The City is in the process of updating its stormwater master plan. This update includes a comprehensive hydraulic and hydrologic analysis used to identify improvements needed to increase the functionality and/or capacity of the City's stormwater infrastructure.

For this analysis, the intersection of the existing stormwater assets and flooding rasters was used to identify assets that are most relied upon under each flooding event. This comparison also identifies impacted areas that may be currently underserved by the existing system. Of particular note is that the neighborhoods of Embarcadero, Pines, and North Andrews Gardens experience flooding during future compounding events of category III or higher (scenarios 11-14), however they show to have no existing stormwater infrastructure and may benefit from traditional storm water management practices. The stormwater master plan update will address these potential vulnerabilities in greater detail in order to identify opportunities to improve the City's stormwater management system.

5.2 Dry Condition Scenarios

A dry condition scenarios is a composite of the bare-earth DEM and the groundwater condition of the corresponding planning horizon. Dry conditions are those in absence of any storm event and serve as the baseline to determining depth for each flooding scenario. **Figures 2-23, 2-24 and 2-25** show the elevations in NAVD88 of dry condition scenarios for 2020, 2050 and 2060.

5.3 Critical and Important Asset Flood Vulnerabilities

Each of the City's critical and important assets, as identified in **Table 2-9** and discussed in section 3.3 of this report, was evaluated (relative to vulnerability) under the final 14 "flooding" scenarios. For each asset, an analysis area was determined using a buffer around the critical or important asset (and large parking lot if applicable as noted in **Table 2-9**). The use of an analysis area ensures that the flooding observed is uniform across and around the asset. It also helps identify how much of the asset of interest is experiencing flooding, particularly useful for large assets or those with multiple parts.

Table 2-13 shows maximum flooding depths of each critical and important asset for each scenario studied. This table summarizes the results shown in the ground surface flooding depth maps, **Figures 2-26 through 2-36**. Each flooding depth map shows the distance in feet from the flooded surface to the corresponding dry condition surface, for the given scenario. Each map also shows the critical and important assets that are impacted under the scenario depicted.

A wide range of comparisons can be made across all assets or all assets of the same type; however, consideration and final selection of adaptations are subject to many factors. The development of adaptation strategies, as discussed in section 6 of this report, will not only introduce potential solutions geared towards lessening the identified vulnerabilities for each critical and important asset, but also it will consider the impacts of critical systems as a whole and the requirements of implementation.

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A wide range of comparisons can be made across all assets or all assets of the same type; however, consideration and final selection of adaptations are subject to many factors. The development of adaptation strategies, as discussed in section 6 of this report, will not only introduce potential solutions geared towards lessening the identified vulnerabilities for each critical and important asset, but also it will consider the impacts of critical systems as a whole and the requirements of implementation.

Table 2-13: Critical and Important Assets Maximum Flooding Depth

		King Tide			Storm Surge			Storm Surge & King Tide					Flooding Depth Range	
		Current	Future		Current			Future						
		2020	2050	2060	CAT I	CAT III	CAT V	2050 & CAT I	2050 & CAT III	2060 & CAT III	2050 & CAT V	2060 & CAT V		
Flooded Critical and Important Assets	TYPE	K20_219D [FT]	K50_292D [FT]	K60_334D [FT]	S2_C1_250D [FT]	S2_C3_372D [FT]	S2_C5_492D [FT]	K5_C1_442D [FT]	K5_C3_564D [FT]	K6_C3_606D [FT]	K5_C5_684D [FT]	K6_C5_726D [FT]	Minimum	Maximum
Assisted Living Facilities														
Treemont on the Park	ALF	--	--	--	--	--	1.6049	1.10	2.32	2.74	3.52	3.94	1.10	3.94
Tropical Haven, INC	ALF	--	--	--	--	--	--	--	--	0.55	1.33	1.75	0.55	1.75
Good Hope Manor	ALF	--	--	--	--	--	--	--	--	--	--	0.00 (0.83)	0.00 (0.83)	0.00 (0.83)
Palms Villa Retirement Home	ALF	--	--	--	--	--	--	--	--	--	1.97	2.39	1.97	2.39
Paradise Manor	ALF	--	--	--	--	--	--	--	--	--	1.16	1.58	1.16	1.58
Community Centers														
Collins Community Center	CC	--	--	--	--	--	--	--	--	0.85	1.63	2.05	0.85	2.05
Jaco Pastorius Park & Community Center	CC	--	--	--	--	--	--	--	1.51	1.93	2.71	3.13	1.51	3.13
Fire Stations														
Fire Station #9	FIRE	--	--	--	--	--	--	--	--	0.54	1.32	1.74	0.54	1.74
Fire Station #20	FIRE	--	--	--	--	--	--	--	--	--	--	--	--	--
Oakland Park Fire Administration/Fire Station #87	FIRE	--	--	--	--	--	--	--	--	--	0.00 (0.52)	0.00 (0.94)	0.00 (0.52)	0.00 (0.94)
Hospitals														
Fort Lauderdale Behavioral Hospital	HOSP	--	--	--	--	--	--	--	--	1.24	2.02	2.44	1.24	2.44
Fort Lauderdale Behavioral Hospital Parking Lot	PRK	--	--	--	--	--	--	--	0.62	1.22	2	2.42	0.62	2.42
Holy Cross Medical Group Facility	HOSP	--	--	--	--	--	--	--	--	--	0.74	1.16	0.74	1.16
Holy Cross Medical Group Facility Parking Lot	PRK	--	--	--	--	--	--	--	--	0.81	1.59	2.01	0.81	2.01

Note: After further analysis, values in red have been modified to show no flooding for these assets and replaced with value in black.

Table 2-13: Critical and Important Assets Maximum Flooding Depth (continued)

		King Tide			Storm Surge			Storm Surge & King Tide					Flooding Depth Range	
		Current	Future		Current			Future						
		2020	2050	2060	CAT I	CAT III	CAT V	2050 & CAT I	2050 & CAT III	2060 & CAT III	2050 & CAT V	2060 & CAT V		
Flooded Critical and Important Assets	**TYPE**	**K20_219D [FT]**	**K50_292D [FT]**	**K60_334D [FT]**	**S2_C1_250D [FT]**	**S2_C3_372D [FT]**	**S2_C5_492D [FT]**	**K5_C1_442D [FT]**	**K5_C3_564D [FT]**	**K6_C3_606D [FT]**	**K5_C5_684D [FT]**	**K6_C5_726D [FT]**	**Minimum**	**Maximum**
Municipal Facilities														
Ethel M. Gordon Oakland Park Library	MUN	--	--	--	--	--	--	--	0.83	1.25	2.03	2.45	0.83	2.45
Broward Schools Central Bus Depot	MUN	--	--	--	--	--	1.03	0.53	1.75	2.17	2.95	3.37	0.53	3.37
Broward Schools Central Bus Depot Parking Lot	PRK	--	--	--	--	2.23	3.43	2.32	3.54	3.37	4.74	4.57	2.23	4.74
City Hall	MUN	--	--	--	--	--	1.58	--	2.30	2.72	3.50	3.92	1.58	3.92
City of Oakland Park Municipal Building	MUN	--	--	--	--	--	--	--	--	--	1.21	1.63	1.21	1.63
City of Oakland Park Municipal Building Parking Lot	PRK	--	--	--	--	--	--	--	0.65	1.07	1.85	2.27	0.65	2.27
FDOT District IV	MUN	--	--	--	--	--	--	--	--	--	--	0.00 (2.93)	0.00 (2.93)	0.00 (2.93)
FDOT District IV Parking Lot	PRK	1.69	0.97	0.80	2.00	3.22	4.42	2.47	3.69	3.52	4.89	4.72	0.80	4.89
Public Works Administration	MUN	--	--	--	--	--	0.70	--	1.42	1.84	2.62	3.04	0.70	3.04
FS#9 Public Works Administration Collins Parking Lot	PRK		--	--	--	--	1.65	1.15	2.37	2.79	3.57	3.99	1.15	3.99
Public Works Complex	MUN	--	--	--	--	--	1.30	--	2.02	2.44	3.22	3.64	1.30	3.64
Pioneer House & Museum	MUN	--	--	--	--	--	1.06	0.51	1.78	2.20	2.98	3.40	0.51	3.40
Fiveash Water Treatment Plant	WTP	--	--	--	--	--	3.61	2.26	3.48	3.31	4.68	4.51	2.26	4.68
Schools														
Lloyd Estates Elementary	SCH	--	--	--	--	--	1.30	0.80	2.02	2.44	3.22	3.64	0.80	3.64
Lloyd Estates Elementary Parking Lot	PRK	--	--	--	--	--	1.63	--	2.35	2.77	3.55	3.97	1.63	3.97
North Andrews Gardens Elementary	SCH	--	--	--	--	--	--	--	--	0.88	1.66	2.08	0.88	2.08
North Andrews Gardens Elementary Parking Lot	PRK	--	--	--	--	--	--	--	--	0.82	1.60	2.02	0.82	2.02
Northeast High	SCH	--	--	--	--	--	--	--	0.79	1.36	2.14	2.56	0.79	2.56
Northeast High Parking Lot	PRK	--	--	--	--	--	--	--	0.94	1.99	2.77	3.19	0.94	3.19
Oakland Park Elementary	SCH	--	--	--	--	--	--	--	1.62	2.04	2.82	3.24	1.62	3.24
Rickards Middle School	SCH	--	--	--	--	--	--	--	1.23	1.65	2.43	2.85	1.23	2.85
Life Skills Charter High School	SCH	--	--	--	--	--	--	--	0.80	1.22	2.00	2.42	0.80	2.42

Note: After further analysis, values in red have been modified to show no flooding for these assets.

Table 2-13: Critical and Important Assets Maximum Flooding Depth (continued)

		King Tide			Storm Surge			Storm Surge & King Tide					Flooding Depth Range	
		Current	Future		Current			Future						
		2020	2050	2060	CAT I	CAT III	CAT V	2050 & CAT I	2050 & CAT III	2060 & CAT III	2050 & CAT V	2060 & CAT V		
Flooded Critical and Important Assets	**TYPE**	K20_219D [FT]	K50_292D [FT]	K60_334D [FT]	S2_C1_250D [FT]	S2_C3_372D [FT]	S2_C5_492D [FT]	K5_C1_442D [FT]	K5_C3_564D [FT]	K6_C3_606D [FT]	K5_C5_684D [FT]	K6_C5_726D [FT]	Minimum	Maximum
Sanitary Sewer Lift Stations														
LS_1	SSLS	--	--	--	--	--	--	--	0.85	1.27	2.05	2.47	0.85	2.47
LS_2	SSLS	--	--	--	--	--	1.40	0.90	2.12	2.54	3.32	3.74	0.90	3.74
LS_3	SSLS	--	--	--	--	--	--	--	0.71	1.13	1.91	2.33	0.71	2.33
LS_4	SSLS	--	--	--	--	--	1.10	0.60	1.82	2.24	3.02	3.44	0.60	3.44
LS_7	SSLS	1.67	1.63	1.46	1.98	3.20	4.40	3.13	4.35	4.18	5.55	5.38	1.46	5.55
LS_8	SSLS	--	1.43	1.46	1.01	2.23	3.43	2.93	4.15	4.18	5.35	5.38	1.01	5.38
LS_A2	SSLS	1.09	1.46	1.29	1.40	2.62	3.82	2.96	4.18	4.01	5.38	5.21	1.09	5.38
LS_B1	SSLS	--	--	--	--	--	--	--	--	0.71	1.49	1.91	0.71	1.91
LS_B2	SSLS	--	--	--	--	--	--	--	1.72	2.14	2.92	3.34	1.72	3.34
LS_B3	SSLS	--	--	--	--	--	1.11	--	1.83	2.25	3.03	3.45	1.11	3.45
LS_C1	SSLS	--	--	0.75	--	1.42	2.62	2.12	3.34	3.47	4.54	4.67	0.75	4.67
LS_C2	SSLS	--	--	--	--	--	1.81	1.31	2.53	2.95	3.73	4.15	1.31	4.15
LS_C3	SSLS	1.53	1.55	1.38	1.84	3.06	4.26	3.05	4.27	4.10	5.47	5.30	1.38	5.47
LS_C4	SSLS	--	--	--	--	--	1.21	0.71	1.93	2.35	3.13	3.55	0.71	3.55
LS_D1	SSLS	--	--	--	--	--	--	--	0.98	1.40	2.18	2.60	0.98	2.60
LS_D10	SSLS	--	--	--	--	--	--	--	--	0.61	1.39	1.81	0.61	1.81
LS_D11	SSLS	--	--	--	--	--	--	--	--	--	1.57	1.99	1.57	1.99
LS_D12	SSLS	--	--	--	--	--	--	--	--	--	--	--	--	--
LS_D13	SSLS	--	--	--	--	--	--	--	--	0.53	1.31	1.73	0.53	1.73
LS_D14	SSLS	--	--	--	--	--	--	--	--	--	--	0.00 (0.56)	0.00 (0.56)	0.00 (0.56)
LS_D2	SSLS	--	--	--	--	--	--	--	1.04	1.46	2.24	2.66	1.04	2.66
LS_D3	SSLS	--	--	--	--	--	1.49	0.99	2.21	2.63	3.41	3.83	0.99	3.83
LS_D4	SSLS	--	--	--	--	--	--	--	0.53	0.95	1.73	2.15	0.53	2.15
LS_D4A	SSLS	--	--	--	--	--	--	--	--	--	--	--	--	--
LS_D5	SSLS	--	--	--	--	--	1.43	0.93	2.15	2.57	3.35	3.77	0.93	3.77
LS_D6	SSLS	--	--	--	--	--	--	--	--	0.66	1.44	1.86	0.66	1.86
LS_D7	SSLS	--	--	--	--	--	--	--	--	--	0.50	0.92	0.50	0.92
LS_D8	SSLS	--	--	--	--	--	--	--	--	0.72	1.50	1.92	0.72	1.92
LS_D9	SSLS	--	--	--	--	--	--	--	--	0.53	1.31	1.73	0.53	1.73
LS_FARMSTORE	SSLS	--	--	--	--	--	--	--	--	--	0.81	1.23	0.81	1.23
LS MILBRAN	SSLS	--	--	--	--	--	--	--	--	--	--	--	--	--
LS_RockIsland	SSLS	--	--	--	--	--	--	--	1.01	1.43	2.21	2.63	1.01	2.63
LS B2-A	SSLS	--	--	--	--	--	--	--	0.89	1.31	2.09	2.51	0.89	2.51
LS_S5	SSLS	--	--	--	--	--	--	--	--	--	0.83	1.25	0.83	1.25

Note: After further analysis, values in red have been modified to show no flooding for these assets.

Table 2-13: Critical and Important Assets Maximum Flooding Depth (continued)

Flooded Critical and Important Assets	TYPE	King Tide			Storm Surge			Storm Surge & King Tide					Flooding Depth Range	
		Current	Future		Current			Future						
		2020	2050	2060	CAT I	CAT III	CAT V	2050 & CAT I	2050 & CAT III	2060 & CAT III	2050 & CAT V	2060 & CAT V		
		K20_219D [FT]	K50_292D [FT]	K60_334D [FT]	S2_C1_250D [FT]	S2_C3_372D [FT]	S2_C5_492D [FT]	K5_C1_442D [FT]	K5_C3_564D [FT]	K6_C3_606D [FT]	K5_C5_684D [FT]	K6_C5_726D [FT]	Minimum	Maximum
Stormwater Pump Stations														
STORM-PUMP-1	PS	--	--	--	--	--	--	--	1.16	1.58	2.36	2.78	1.16	2.78
STORM-PUMP-2	PS	--	--	--	--	--	--	--	2.56	2.98	3.76	4.18	2.56	4.18
STORM-PUMP-3	PS	--	--	--	--	--	--	--	1.54	1.96	2.74	3.16	1.54	3.16
STORM-PUMP-4	PS	--	--	--	--	--	1.07	0.57	1.79	2.21	2.99	3.41	0.57	3.41
STORM-PUMP-5	PS	0.97	1.55	1.38	1.28	2.50	3.70	3.05	4.27	4.10	5.47	5.30	0.97	5.47

Note: After further analysis, values in red have been modified to show no flooding for these assets.

6. Next Steps – Adaptation Strategies Analysis and Report

This report shall be utilized in the development of adaptation strategies to address the identified vulnerabilities to improve the City's resiliency to sea level rise and climate change. The recommended adaptations will be detailed in a report following the conclusion of the analysis of potential strategies and the City's prioritization of addressing the known vulnerabilities. Those recommended adaptations will be part of the second draft deliverable due at the end of June 2020.

7. Contact Information

Should you require any further detail or have any questions or comments, please do not hesitate to contact Lucia Z. Medina, with Hazen and Sawyer, at (954) 987-0066.

8. References

1. AECOM, July 2011. Broward County, Florida MIKE SHE / MIKE 11 Models.

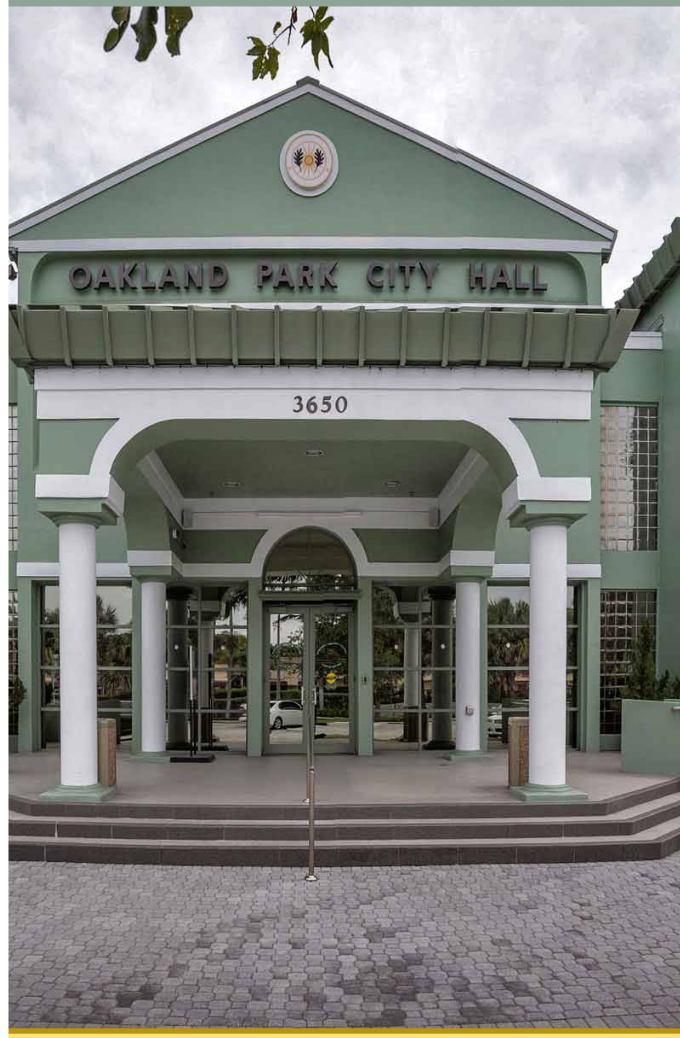
2. Broward County Environmental Protection & Growth Management Department, Environmental Planning & Community Resilience Division. 2020. Broward County Water Resources Fact Book. Oakland Park, Florida.

3. Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group. 2019. Unified Sea Level Rise Projection for Southeast Florida. Florida

Appendix A: Oakland Park Repetitive Loss Area Analysis

Oakland Park

Repetitive Loss Area Analysis



December 2019

Report Prepared by:
CRS Max Consultants, Inc.

Mapping by:
Florida Technical Consultants, Inc.

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Repetitive Loss Area Analysis

November 2019

Executive Summary

The National Flood Insurance Program has established the "repetitive loss property" as a classification for properties that continue to be impacted by flooding and its resulting claims. These properties, together with surrounding properties that may experience similar problems, are classified as "repetitive loss areas" and become the focus of attention. The Repetitive Loss Area Analysis is a tool that a community can use to address its most costly flooding issues. It is comprised of an analysis of the repetitive loss areas, including a description of every building, a statement of the problem in each area, and recommendations to mitigate the problem. The City of Oakland Park, in order to be proactive in its efforts to mitigate flooding in the community, has produced a Repetitive Loss Area Analysis covering all the repetitive loss areas in the City.

The Analysis includes considering a broad spectrum of activity types, including:

- Preventive
- Property protection
- Natural resource protection
- Emergency services
- Structural projects
- Public information

The specific recommendations given in this report represent concrete steps the City, the affected communities, and the property owners can take to mitigate flooding in each of the repetitive loss areas in the City.

1 Overview

No natural hazard is more common in the United States than flooding. Floods have been the cause of more than 70 percent of all Presidential Disaster Declarations, occurring in over 20,000 American communities. More than 8 million residential and commercial structures are currently built in areas at risk of flooding, and floods are costly to local, state and federal governments, as well as to flood victims, who must shoulder the cost of recovery.

The City of Oakland Park has not been immune to the flooding hazard. Intense or prolonged, concentrated rain is the primary cause of localized flooding. Major rainfall events often accompany hurricanes, tropical storms, and thunderstorms. The overabundance of rainfall creates saturated soil conditions, after which additional rain causes surface ponding or an overflow of catchment canals and ponds. This can result in street and yard flooding, which is regarded as nuisance flooding. It can also result in flooding of buildings, a consequence that is of particular importance to the City because of its impact to the community's residents and businesses.

In response to the challenge of the flood hazard, the City has established a proactive approach, which includes stormwater planning, floodplain management planning, establishment of higher regulatory standards, implementation of an aggressive stormwater capital improvement program and implementation of sustainable development standards

1.1 National Flood Insurance Program (NFIP)

Historically the private insurance industry was reluctant to insure properties against flood losses due to the financial risk that would be required. Beginning in 1968 the federal government made flood insurance available through the National Flood Insurance Program (NFIP). The NFIP is based on a cooperative agreement between the Federal Emergency Management Agency (FEMA) and local units of government. FEMA now underwrites flood insurance policies within communities. Local governments are tasked to regulate development in the floodplain. Participation in the NFIP is voluntary. Communities have incentive to join because federally backed flood insurance is not available in non-participating communities and a non-participating community will not receive Federal aid for damage to insurable buildings in the flood hazard areas.

1.2 Community Rating System (CRS)

The Community Rating System (CRS) is a voluntary program recognized by NFIP and designed to reward a community for doing more than simply meeting the NFIP minimum requirements to reduce flood damages. Once a community has been accepted into the CRS, the community's floodplain management activities are rated according to the scoring system described in the *CRS Coordinator's Manual*. CRS communities are rated on a scale of 1-10; Class 10 is the lowest and Class 1 is the highest. A Class 10 community receives no reduction in flood insurance premiums; each class above Class 10 receives an additional 5% premium cost reduction over the previous class for properties located within special flood hazard areas. Class 1 requires the most credit points and provides the highest premium reduction of 45%.

Communities can improve their CRS ratings by performing activities such as: reducing flood damage to existing buildings, managing development in areas not shown in the floodplain on the FIRMs, protecting new buildings from floods greater than the 100-year flood, maintaining and improving stormwater drainage infrastructure, helping insurance agents obtain flood data, and encouraging people to obtain flood insurance. The reward for these activities comes in the form of reduced premiums for flood insurance policy holders.

In October 1994, the City of Oakland Park qualified for the CRS Program. There are currently 3,591 flood insurance policies in place in the City, with approximately $1.6 million paid in premiums annually. The average policy cost is $444. To keep the CRS discounts, the City must continue to implement its CRS program and provide status reports to the NFIP each year. The City of Oakland Park is currently rated as Class 7 in the CRS program, earning its residents and businesses within its special flood hazard areas a 15% premium reduction. Each year participation in the CRS program earns an average discount of $51 per policy and a total community discount of $182,911.

1.3 Repetitive Loss Properties

The NFIP considers a property a Repetitive Loss Property if two or more flood insurance claims of more than $1,000 have been paid within any 10-year period since 1978. Currently, repetitive loss properties nationwide account for 15-20 percent of all flood losses, however, they comprise only 1.3 percent of all flood insurance policies. The NFIP has paid over $9 billion in claims to properties classified as repetitive loss properties. By focusing specifically on mitigation of flooding in areas where there are repetitive loss properties, a community can make strides to significantly reduce the detrimental impacts of flooding.

According to FEMA's records, dated May 31, 2018, there are 39 Repetitive Loss Properties within the City of Oakland Park.

1.4 Repetitive Loss Categories

CRS identifies the following three categories of repetitive loss communities based on the number of properties on the updated FEMA Repetitive Loss list:

(1) **Category A:** A community that has no repetitive loss properties, or whose repetitive loss properties all have been mitigated. A Category A community has no special requirements except to submit information needed to update its repetitive loss list.

(2) **Category B:** A community with at least one, but fewer than 50, repetitive loss properties that have not been mitigated. At each verification visit, a Category B community must complete the following activities:

(a) Prepare a map of the repetitive loss area(s),

(b) Review and describe the causes of the repetitive loss,

(c) Prepare a list of the addresses of all improved properties in the identified repetitive loss areas, and

(d) Undertake an annual outreach project to those addresses. A copy of the outreach project is submitted with each year's recertification.

(3) Category C: A community with 50 or more repetitive loss properties that have not been mitigated. A Category C community must

(a) Complete Category B Activities AND

(b) Prepare a floodplain management plan or area analyses for its repetitive loss area(s). The plan and area analysis requirements are explained in Activity 510 (Floodplain Management Planning) in the *CRS Coordinator's Manual*.

The total of 39 repetitive loss properties categorizes the City of Oakland Park as a Category B community. The City utilizes the Broward County Local Mitigation Strategy as its floodplain management plan. In an effort to further address the City's flood hazard, the City determined the benefit of specific focus upon those areas of the community that have been most impacted by flooding, as shown by their historical flood insurance claims. These areas are known as Repetitive Loss Areas (RLAs).

1.5 Repetitive Loss Area (RLA)

A Repetitive Loss Area (RLA) consists of Repetitive Loss Properties and the surrounding properties that experience the same or similar flooding conditions, whether or not the buildings on those surrounding properties have been damaged by flooding.

Based on the 5/31/2018 AW-501 worksheets, there are 39 unmitigated repetitive loss properties. A total of 29 Repetitive Loss Areas (RLAs) have been identified. The areas were based on the following:

(1) Identified properties within a reasonable radius of the repetitive loss properties. This identification was based on an analysis using parcel data and building footprints;

(2) Evaluation of topographical lows and other factors that may have contributed to the flooding of the repetitive loss properties;

(3) Neighboring historical loss properties;

(4) Connectivity of adjacent properties with associated repetitive loss properties, e.g. not separated by a topographic ridge.

From this analysis conducted in July 2019, 251 properties were included in the 29 RLAs. Following the initial determination, site visits were conducted to investigate each of these areas and examine the surrounding land and building characteristics. The individuals conducting the site visits included a stormwater supervisor and a CRS consultant.

Following the first site visit, the CRS consultant revisited all the areas, gathered data for each building within the areas, interviewed homeowners and determined a more precise and appropriate delineation of the RLA boundaries. During the site visits and in response to the letter sent to RLA properties, some of the property owners, managers, and renters were interviewed concerning their experience with flooding. This exercise proved informative and beneficial.

The site visits resulted in a net decrease of 23 RLA properties. The final number of properties in the these RLAs was 228. The limits of the 29 RLAs was based upon an evaluation of the historic claims data and the determinations made from the onsite visits.

Figure 1 shows the 29 RLAs in Oakland Park. For reporting purposes, the 29 Repetitive Loss Areas were grouped into two General Areas based on such characteristics as topography, geography and flooding source. The two General Areas are:

Area 1: Western
Area 2: Eastern

Detailed maps of each area are included in this analysis. Figure 1 provides an overview map of the two General Areas and the Repetitive Loss Areas included in each General Area.

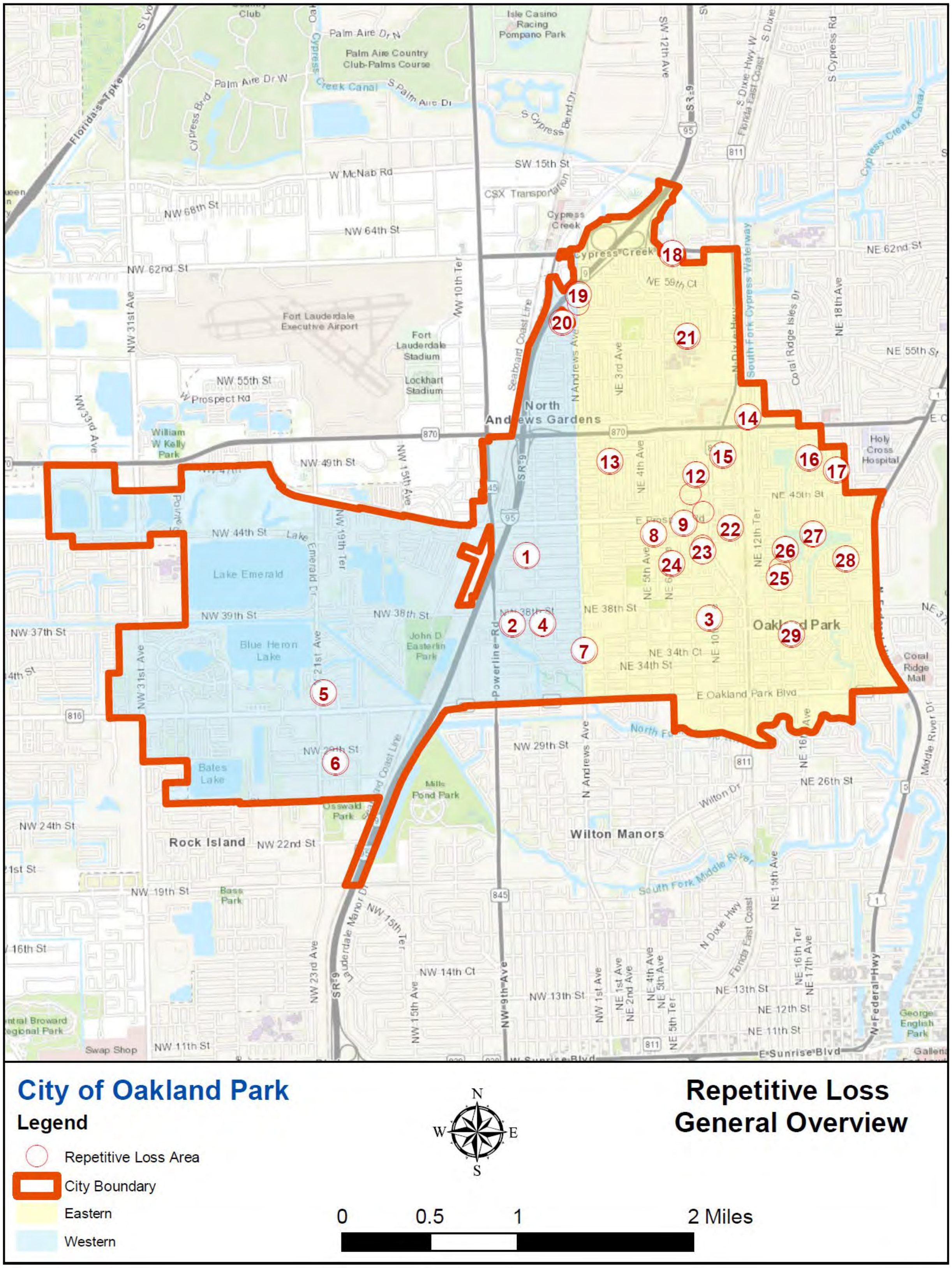


Figure 1: General Repetitive Loss Areas

1.6 Repetitive Loss Area Analysis (RLAA)

Having made an initial determination of the repetitive loss areas, the next required activity is to develop a detailed analysis of these repetitive loss areas to gain a comprehensive understanding of the specific flood conditions. This repetitive loss area analysis is also intended to identify alternative remedies and to provide specific recommendations for flood mitigation.

The following repetitive loss area analysis is a detailed mitigation plan for repetitive loss areas. It provides more specific guidance on how to reduce damage from repetitive flooding.

1.7 Repetitive Loss Area Analysis (RLAA) Process

CRS credit is dependent upon the community's following an appropriate process. The process of developing a RLAA consists of the following five steps outlined in the *2017 CRS Coordinator's Manual*:

Step 1 – Advise all the properties in each Repetitive Loss Area (RLA) that the analysis will be conducted and request their input on the hazard and recommended actions.

Step 2 – Contact agencies or organization that may have plans or studies that could affect the cause or impacts of the flooding.

Step 3 – Visit each building in the RLA and collect basic data.

Step 4 – Review alternative approaches and determine whether any property protection measures or drainage improvements are feasible. The review must look at all of the property protection measures that are appropriate for the types of buildings affected, including: preventative activities, property protection activities, natural resource protection activities, emergency services measures, structural projects, and public information activities.

Step 5 – Document the findings in a report. The report should include: a summary of the process that was followed and how property owners were involved in the process; a problem statement with a map of the affected area; a list or table showing basic information for each building in the affected area; the alternative approaches that were reviewed; and a list of action items identifying the responsible party, when the action should be completed, and how it will be funded.

Following the completion of the five steps of the RLAA process the report must be submitted to the community's governing body for adoption. Thereafter the community must prepare an annual progress report for its area analysis by May 1 and update its repetitive loss area analyses in time for each CRS cycle verification visit.

2. City of Oakland Park RLAA Process

STEP 1: Advise All Property Owners

The City of Oakland Park undertook its Repetitive Loss Area Analysis in 2019. A letter of advisement was sent to all residents and businesses within the identified repetitive loss areas on November 1, 2019. A copy of this letter and the properties to which it was sent is included in Exhibit 1. Following the completion of the RLAA a second letter was sent to the same residents and businesses on December 3, 2019, advising of the draft completion, making the document available and soliciting input. A copy of this letter is also included in Exhibit 1.

Several property owners responded to the letter; their comments were recorded and their concerns were taken under consideration. Additionally, while visiting the RLAs, the City team was able to speak with several property owners and renters concerning their particular flood experiences.

STEP 2: Contact Agencies and Organizations

The City sent letters to pertinent agencies and organizations on November 21, 2019. Copies of the letters sent to 26 agencies and organizations are included as Exhibit 2.

In addition to contacting other agencies, extensive review with City Public Works staff provided valuable and pertinent information.

The following resources proved particularly beneficial:

- City of Oakland Park Public Works Department
- Federal Emergency Management Agency/ISO, City of Oakland Park, FL, Repetitive Loss Data, May 31, 2018
- Federal Emergency Management Agency, National Flood Insurance Program, *Community Rating System CRS Coordinator's Manual*. FIA-15/2017. Section 510.
- The Federal Emergency Management Agency's *Flood Insurance Study for Broward County*, 2014.

STEP 3: Building Data Collection

One of the City's Stormwater Division staff member and the City's CRS consultant visited all 29 repetitive loss areas on October 31, 2019. On this site visit, the City described the known history of flooding in each area and mitigation projects either previously completed or planned. A second meeting with staff to obtain additional information was held on November 14, 2019. During these meetings, the flooding causes were analyzed and solutions were discussed. Additionally, the CRS consultant returned, took photographs of each building and gathered additional building data, including the following information:

- Address
- Structure type
- Structure condition
- Existing mitigation
- Foundation type
- Foundation condition
- Number of stories
- Height above street grade
- Height above site grade
- HVAC unit or other electrical equipment
- Drainage patterns around building
- Additional structures
- Roadside drainage/swale
- Additional notes as deemed appropriate

The building data collected is available as Appendix A. In order to comply with the Privacy Act of 1974 (5 U.S.C. 522a), however, this information will not be shared with the general public. Photos of some of the typical buildings in each RLA are included in this report. Additional photos are available upon request.

STEP 4: Review Alternative Mitigation Approaches

Many types of flood hazard mitigation strategies exist. There is not one mitigation measure that fits every case. Nor is there even one strategy that fits most cases. Successful mitigation often requires multiple strategies. The *2017 CRS Coordinator's Manual* lists the following primary types of mitigation as follows under Categories of Floodplain Management Activities (FEMA FIA-15, 2017):

1. **Preventive** activities keep flood problems from getting worse. The use and development of flood-prone areas is limited through planning, land acquisition, or regulation. They are usually administered by building, zoning, planning, and/or code enforcement offices.

2. **Property Protection** activities are usually undertaken by property owners on a building-by- building or parcel basis.

3. **Natural Resource Protection** activities preserve or restore natural areas or the natural functions of floodplain and watershed areas. They are implemented by a variety of agencies, primarily parks, recreation, or conservation agencies or organizations.

4. **Emergency Services** measures are taken during an emergency to minimize its impact. These measures are usually the responsibility of city or county emergency management staff and the owners or operators of major or critical facilities.

5. **Structural Projects** keep flood waters away from an area with a levee, reservoir, or other flood control measure. They are usually designed by engineers and managed or maintained by public works staff.

6. **Public Information** activities advise property owners, potential property owners, and visitors about the hazards, ways to protect people and property from the hazards, and the natural and beneficial functions of local floodplains. They are usually implemented by a public information office.

The City took all six of these categories of floodplain management activities into consideration for both of its General Repetitive Loss Areas.

Property protection by homeowners can be undertaken in a variety of ways. Different measures are appropriate for different flood hazards, building types and building conditions. The *2013 CRS Coordinator's Manual* lists the following typical property protection measures.

- Demolish the building or relocate it out of harm's way.
- Elevate the building above the flood level.
- Elevate damage-prone components, such as the furnace or air conditioning unit.
- Dry flood proof portions of the building so water won't cause damage.
- Construct a berm or redirect drainage away for the building.
- Maintain nearby streams, ditches, and storm drains so debris does not obstruct them.
- Correct sewer backup problems.

Grant funding for property protection and flood mitigation is available for both communities and property owners. Following is a partial listing of available grants:

FEMA Grants

- Flood Mitigation Assistance Grant
- Hazard Mitigation Grant
- Pre-Disaster Mitigation Grant
- Repetitive Flood Claims Grant

Other Grants

- US Economic Development Administration (EDA) Public Works/ Infrastructure Grant (Infrastructure/ Stormwater Improvements)
- Five Star/ Urban Waters Restoration (Stormwater Improvement/ Flood Reduction)
- Community Budget Issue Request (Florida Legislature direct application for water-related projects)

While the first three steps of the RLAA process are basically identical for all repetitive loss areas, the review of alternative mitigation approaches varies somewhat in accordance with the specific conditions that are encountered in each RLA. Accordingly, the implementation of this step begins with a problem statement for each general area, followed by a discussion of alternative mitigation approaches and a recommendation of action items to be implemented.

STEP 5: Documentation of Findings

Step 5 entails a description of the Repetitive Loss Areas, an analysis of the alternative mitigation measures considered for each area, and a determination of the actions recommended for each area. This analysis for both General Repetitive Loss Areas is included in the remainder of this report.

2.1 City of Oakland Park RLAA – General Area 1: Western

Problem Statement

General Area 1 (Western) includes the area in the City ***west*** of North Andrews Avenue, which effectively divides the City into two geographically distinct areas. Interstate 95 is included in this area, as are most of the City's lakes and storage basins. Lloyd's Lake and the Sleepy River are contained in General Area 1 on the west. Though this area is further inland than the Eastern Area, tidal flow and tidal flooding especially impacts the Western Area. A multimillion-dollar stormwater pumping system was recently installed immediately west of North Andrews Avenue to mitigate flooding in the southern portion of the Western Area, which contains most of the area's repetitive loss properties. Though there are fewer RLAs in the Western Area than there are in the Eastern Area, some of the RLAs include the greatest density of Repetitive Loss Properties. Because of the strong tidal influence of the aforementioned water bodies, the growing concern of sea level rise poses an increasing problem for this general area. All RLAs in General Area 1 are in residential communities.

An exceptionally high number of intense rainfall events over the past two decades, compared with previous decades, increased the number of flood insurance claims.

General Area 1 (Western) is composed of 6 Repetitive Loss Areas with 12 Repetitive Loss Properties and 55 total properties within the RLAs.

Repetitive Loss Area	Community Characteristics	Number of RL Properties	Number of Additional Properties*	Total Number of Properties in RL Area	Road Names
1	Residential community	2	6	8	NW 42 Street
2	Residential community	6	27	33	Lloyd Drive NW 36 Street NW 37 Street
4	Residential community	1	2	3	NW 37 Street

Repetitive Loss Area	Community Characteristics	Number of RL Properties	Number of Additional Properties*	Total Number of Properties in RL Area	Road Names
5	Residential community	1	3	4	NW 32 Court
6	Residential community	1	2	3	NW 38 Street
20	Residential community	1	3	4	NW 57 Street

*Potential properties due to proximity

Table 1: General Repetitive Loss Area 1 – Western

Figure 2: Repetitive Loss Area 1 – Residential community

RLA 1 Typical buildings

Figure 3: Repetitive Loss Area 2 – Residential community

RLA 2 Typical buildings

Figure 4: Repetitive Loss Area 4 – Residential community

RLA 4 Typical buildings

Figure 5: Repetitive Loss Area 5 – Residential community

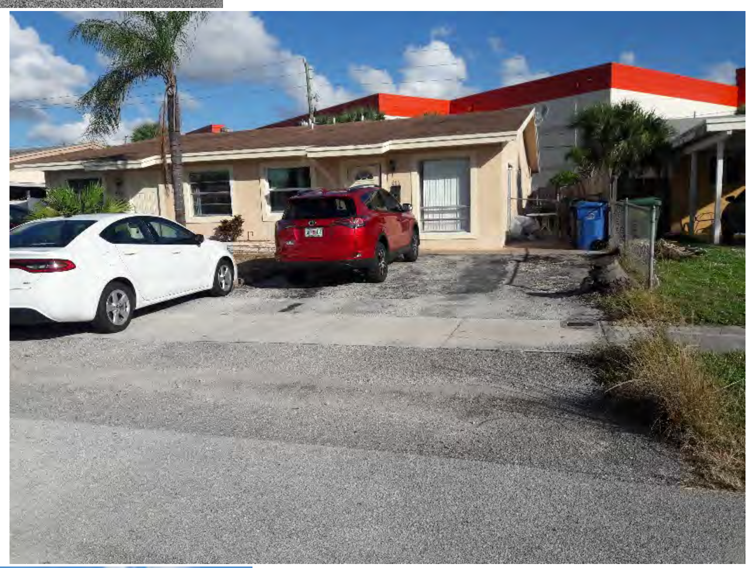
RLA 5 Typical buildings

Figure 6: Repetitive Loss Area 6 – Residential community

RLA 6 Typical buildings

Figure 7: Repetitive Loss Area 20 – Residential community

RLA 20 Typical buildings



Potential Mitigation Measures for General Area 1: Western

Mitigation measures under consideration for General Area 1 should include both structural and nonstructural solutions.

Structural Alternatives:

Following is a listing and brief description of the primary methods of structural property protection:

1. Demolition/Relocation.

The only way to absolutely ensure a structure will not accumulate additional losses from future flood events is to demolish the structure completely. A second effective option could be to relocate the structure to an area that is not flood prone.

2. Elevation

Whenever the floor of a home is below FEMA's 100-year flood elevation, physically elevating the structure is often recommended as it is one of the most effective means to prevent flood damage. On a smaller scale, elevating crucial items such as furnaces, water heaters, air conditioning units and other electrical components can also be effective means of flood mitigation.

3. Dry flood-proofing

Dry flood-proofing consists of completely sealing around the exterior of the building so that water cannot enter the building

4. Wet flood-proofing

Wet floodproofing consists of modifying uninhabited portions of a home, such as a crawl space, garage, or unfinished basement with flood-damage resistant materials, to allow floodwaters to enter the structure without causing damage.

5. Direct drainage away from the building

In some cases, there are improvements the property owner can make on-site such as directing shallow floodwater away from a flood-prone structure. Building strategically located berms or retention ponds are examples or such mitigation measures.

6. Drainage maintenance.

Removing leaves and other debris from the top of a stormwater catch basin is a simple yet effective means of mitigating flooding.

7. Drainage improvements.

Implementation of drainage improvements, such as installing larger pipes or additional catch basins to receive more stormwater, can effectively reduce flooding.

The homeowner is encouraged to consider each of the structural alternatives listed above and pursue them as deemed appropriate. FEMA grants may be available for some of these alternatives. In addition to homeowner-initiated structural solutions, there are possible structural solutions the City could undertake within City rights-of-way that may provide additional flood mitigation, such as local drainage improvement projects.

Nonstructural Alternatives:

Nonstructural alternatives often provide flood mitigation indirectly. Their impact may be as significant as structural alternatives, but that impact may not be as immediately realized or as dramatic as structural solutions. Following are examples of effective nonstructural mitigation alternatives.

1. Promote the purchase of flood insurance.
2. Improve the City's floodplain and zoning ordinances.
3. Improve the City's floodplain mapping, and stormwater master planning.
4. Provide enhanced public education concerning the flood hazard and flood mitigation alternatives. This can take place through such means as distributing flyers, utilization of social media and City websites, and neighborhood meetings.
5. Elevate damage-prone components, such as the furnace or air conditioning unit.
6. Coordinate with the Broward County Division of Emergency Management and the National Weather Service (NWS) to enhance flood warning system.
7. Increase open space designation.

General Area 1 is especially impacted by the growing heights of seasonal and King Tides. Several alternatives can continue to be implemented to mitigate the effects of King Tides and high tides, including the following:

- Assuring the protocol for operation of the stormwater pump station optimizes the minimization of tidal effects.
- Maintenance of public outfalls
- Coastal Resilience programming

The City of Oakland Park has been very proactive in its efforts to address flooding in the community. In addition to the multimillion-dollar Expanded Lloyd Estates Residential and Industrial Improvements (LERIX) project, which was completed in 2017, there have been numerous bid packages in recent years that have prioritized flood mitigation and have resulted in improved conditions. At the same time, the City is not content to rest on the improvements that have already been achieved but is ever seeking to make additional structural drainage improvements.

A brief listing of potential mitigation activities specific to the RLAs in General Area 1 follows:

RLA 1: Because this area has been subject to City drainage improvements within the past 10 years and because its drainage system has recently been recertified, there is no urgent need for additional structural improvements at this time.

RLA 2: Of all the RLAs in the City, RLA 2 has both the most buildings (33) and the most Repetitive Loss Properties (6). This RLA is profoundly impacted by the aforementioned LERIX project, completed within the past three years. The City may consider additional local drainage installations, considering the area's proximity to Lloyd's Lake, which has historically been subject to flooding.

RLA 4: Considering a claim in this RLA has been filed as recently as 2017, additional drainage improvements in this RLA may prove beneficial.

RLA 5: New drainage improvements have been made in this area within the past five years. There is currently no significant flooding issue in this RLA.

RLA 6: New drainage improvements have been made in this area within the past five years. There is currently no significant flooding issue in this RLA.

RLA 20: This RLA was annexed into the City subsequent to the last flood insurance claim for its Repetitive Loss Property in 2003. There is currently no significant flooding issue in this RLA.

General Area 1 Recommendations

In light to the risk that is encountered by properties located in General Area 1, flood mitigation efforts on the part of property owners is encouraged. The prospect of sea level rise will make flooding in the riverine area of this region particularly concerning in the future. The following mitigation action items are recommended:

1. Capital Stormwater Projects Implementation Specific to General Area 1

Of the six RLAs in General Area 1, there are two RLAs that the City may consider for additional capital stormwater projects: RLA 2 and RLA 4.

Responsibility: The Public Works Department is responsible for considering what specific capital stormwater projects would be appropriate in these RLAs and to follow through with bid packages and construction.

Funding: The City's Stormwater Fund would be the primary funding means for these projects.

Timing: It is anticipated that both projects could be implemented within five years.

2. Low Impact Development

For purposes of both flood mitigation and water quality improvement, it is recommended that low-impact development be promoted and encouraged in General Area 1. Low Impact Development is a sustainable stormwater management strategy that distributes stormwater across a project site in order to replenish groundwater supplies, rather than sending it into a system of storm drain pipes and channelized networks.

Responsibility: The City's Department of Engineering and Community Development will be responsible for this action item.

Funding: No additional City funding needed; funds are available in City's operations budget.

Timing: This will be done consistently as a matter of the development review process.

3. Flood Insurance Promotion

In 2019, the City began implementation of Activity 370, Flood Insurance Promotion, as outlined in the *2017 CRS Coordinator's Manual.* The intent is to prioritize encouragement of property owners and renters to purchase both content and building flood insurance. This effort will continue, including an annual letter from the to all properties in the General Area 1 RLAs.

Responsibility: The City's CRS Coordinator is responsible for this action item.

Funding: No additional funding needed; funds are available in City's operations budget.

Timing: Annually.

4. Enhanced Floodplain Standards

The City is championing the implementation of higher regulatory standards as it works together with other communities in the Southeast Florida Regional Climate Change Compact. Currently the City enforces a one-foot freeboard above the FEMA Flood Insurance Rate Map's 100-year flood elevation for finish floor elevation of buildings, in accordance with the Florida Building Code. The City approved sustainable development standards.

Responsibility: The City Commission is responsible for increasing regulatory standards.

Funding: No additional funding needed; funds are available in City's operations budget.

Timing: Ongoing.

5. Public Information Outreach

The City established a Program for Public Information in 2019 that is intended to strengthen the City's public information outreach to the community. The PPI Report was adopted by the Commission on December 4, 2019. This activity should continue and grow. No less than one outreach each year is focused exclusively on the Repetitive Loss Areas, following the guidelines required by the CRS program.

Responsibility: The CRS Coordinator is responsible for this activity.

Funding: No additional funding needed; funds are available in City's operations budget.

Timing: Annually.

6. Property Protection Measures

Property owners are encouraged to take actions that will protect themselves and their properties from flood damage. This includes such actions as elevating equipment above published flood levels and implementing various measures. The City's Engineering and Community Development Department provides consultation to homeowners, as may be requested.

Responsibility: The City's CRS Coordinator is responsible for distributing public information pertaining to property protection. The City Engineering and Community Development Department will provide the consultation.

Funding: No additional funding needed; funds are available in City's operations budget.

Timing: Ongoing.

2.2 City of Oakland Park RLAA – General Area 2: Eastern

Problem Statement

General Area 2, comprising the reminder of the City, is located on the east side of North Andrews Avenue, transecting the City in a north-south orientation. There are several distinctive features which characterize this area and join to impact its particular flooding features. Unlike the Western General Area, the Eastern General Area is comprised of both residential RLAs as well as commercial/industrial RLAs. Commercial and industrial properties with extensive impervious areas for buildings and parking can be particularly vulnerable to flooding. Properties that do not provide adequate slope for stormwater conveyance away from buildings can also be vulnerable. Much of the stormwater infrastructure is old and undersized. Additionally, in General Area 2 there are not as many bodies of water to which stormwater can be readily conveyed. The typical challenge in this area is finding a means to convey stormwater from properties and streets to the lakes and waterways that are within reasonable proximity. The fact that Broward County owns some of the stormwater conveyance systems in this General Area adds a further layer of complexity in forging effective flood mitigation solutions. The Eastern Area encompasses by far the most RL properties and RL areas.

General Area 2 (Eastern) is composed of 23 RLAs, with a total of 27 Repetitive Loss Properties and 175 total properties.

Repetitive Loss Area	Community Characteristics	Number of RL Properties	Number of Additional Properties*	Total Number of Properties in RL Area	Road Names
3	Residential community	1	7	8	NE 37 Street
7	Commercial mall	1	3	4	North Andrews Avenue
8	Commercial/ industrial area	1	7	8	NE 43 Street NE 5 Terrace NE 5 Avenue

Repetitive Loss Area	Community Characteristics	Number of RL Properties	Number of Additional Properties*	Total Number of Properties in RL Area	Road Names
9	Commercial/ industrial area	1	3	4	NE 44 Street
10	Commercial/ industrial area	1	3	4	NE 44 Street N Dixie Highway
11	Commercial/ industrial area	2	5	7	NE 45 Street NE 6 Terrace
12	Residential community	1	2	3	NE 8 Terrace NE 47 Street
13	Residential community	1	3	4	NE 2 Avenue
14	Commercial/ industrial area	1	7	8	NE 12 Avenue E Commercial Boulevard
15	Commercial/ industrial area	1	10	11	NE 10 Avenue NE 11 Avenue N Dixie Highway
16	Residential community	1	5	6	NE 48 Street NE 15 Way

					NE 16 Avenue
Repetitive Loss Area	**Community Characteristics**	**Number of RL Properties**	**Number of Additional Properties***	**Total Number of Properties in RL Area**	**Road Names**
17	Residential community	1	3	4	NE 17 Terrace NE 47 Court NE 47 Street
18	Residential community	1	3	4	NE 7 Avenue NE 61 Court
19	Commercial/ industrial area	1	2	3	N Andrews Avenue
21	Residential community	1	3	4	NE 56 Street
22	Commercial/ industrial area	1	11	12	NE 43 Court NE 43 Place NE 43 Street NE 11 Avenue
23	Commercial/ industrial area and residential area	1	5	6	N Dixie Highway NE 8 Avenue NE 43 Street

Repetitive Loss Area	Community Characteristics	Number of RL Properties	Number of Additional Properties*	Total Number of Properties in RL Area	Road Names
24	Commercial/ Industrial area	4	23	27	NE 5 Terrace NE 6 Avenue NE 7 Avenue NE 7 Terrace NE 40 Court NE 42 Street
25	Single-family and multifamily residential communities	1	21	22	NE 14 Avenue NE 15 Avenue NE 40 Drive NE 40 Place
26	Residential community	1	4	5	Ne 15 Avenue NE 41 Street NE 42 Street
27	Residential community	1	7	8	NE 16 Avenue NE 16 Terrace

Repetitive Loss Area	Community Characteristics	Number of RL Properties	Number of Additional Properties*	Total Number of Properties in RL Area	Road Names
28	Residential community	1	3	4	NE 8 Avenue
29	Residential community	1	8	9	SW 12 Street

*Potential properties due to proximity

Table 2: General Repetitive Loss Area 2 – Eastern

Figure 8: Repetitive Loss Area 3 – Residential community

RLA 3 Typical buildings

Figure 9: Repetitive Loss Area 7 – Commercial/industrial area

RLA 7 Typical buildings

Figure 10: Repetitive Loss Area 8 – Commercial/industrial area

RLA 8 Typical buildings

Figure 11: Repetitive Loss Area 9– Commercial/industrial area

RLA 9 Typical buildings

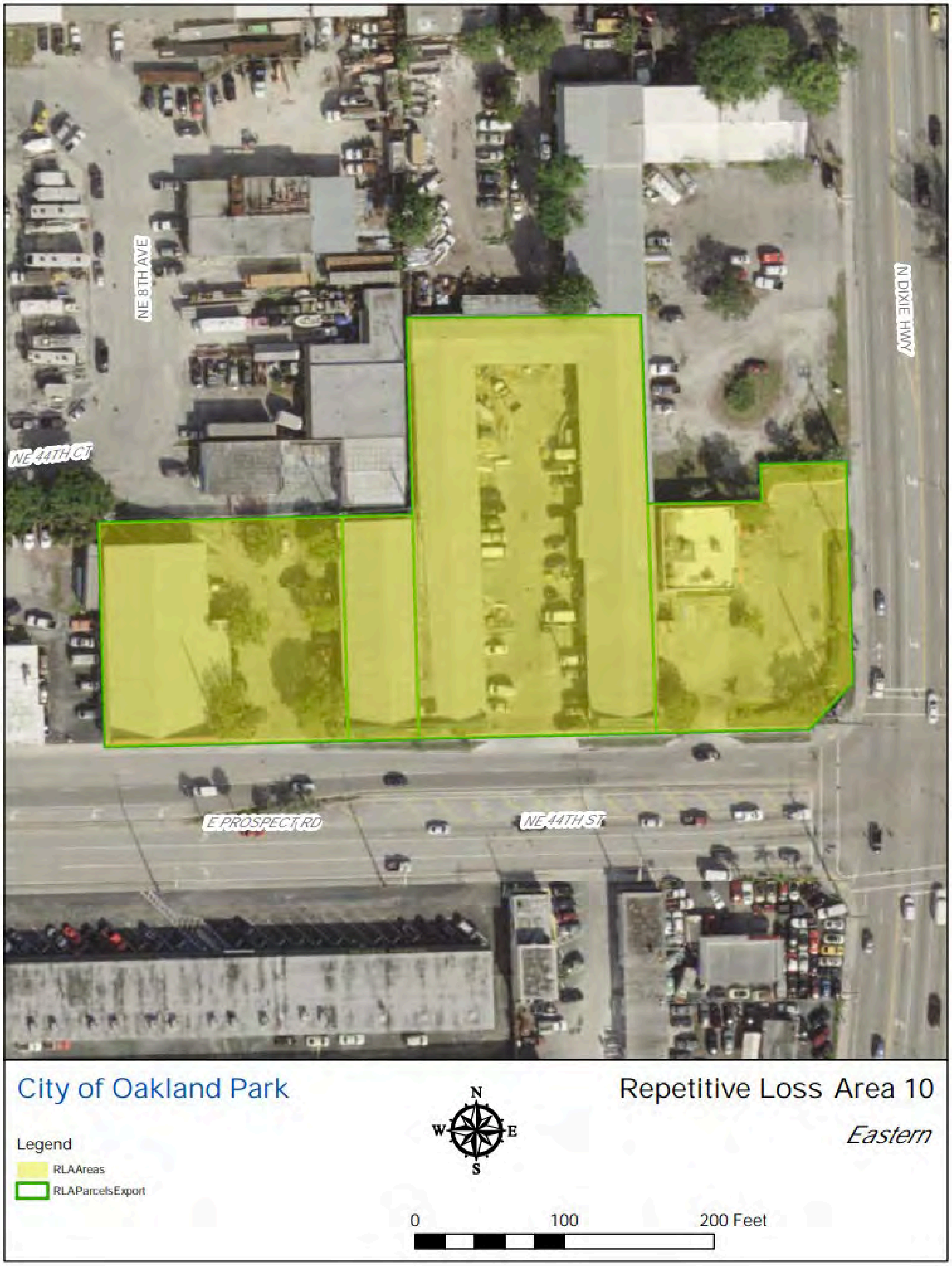


Figure 12: Repetitive Loss Area 10– Commercial/industrial area

RLA 10 Typical buildings

Figure 13: Repetitive Loss Area 11– Commercial/industrial area

RLA 11 Typical buildings

Figure 14: Repetitive Loss Area 12 – Residential community

RLA 12 Typical buildings

Figure 15: Repetitive Loss Area 13 – Residential community

RLA 13 Typical buildings

Figure 16: Repetitive Loss Area 14 – Commercial/industrial area

RLA 14 Typical buildings

Figure 17: Repetitive Loss Area 15 – Commercial/industrial area

RLA 15 Typical buildings

Figure 18: Repetitive Loss Area 16 – Residential community

RLA 16 Typical buildings

Figure 19: Repetitive Loss Area 17 – Residential community

RLA 17 Typical buildings

Figure 20: Repetitive Loss Area 18 – Residential community

RLA 18 Typical buildings

Figure 21: Repetitive Loss Area 19 – Commercial/industrial area

RLA 19 Typical buildings

Figure 22: Repetitive Loss Area 21 – Residential community

RLA 21 Typical buildings

Figure 23: Repetitive Loss Area 22 – Commercial/industrial area

RLA 22 Typical buildings

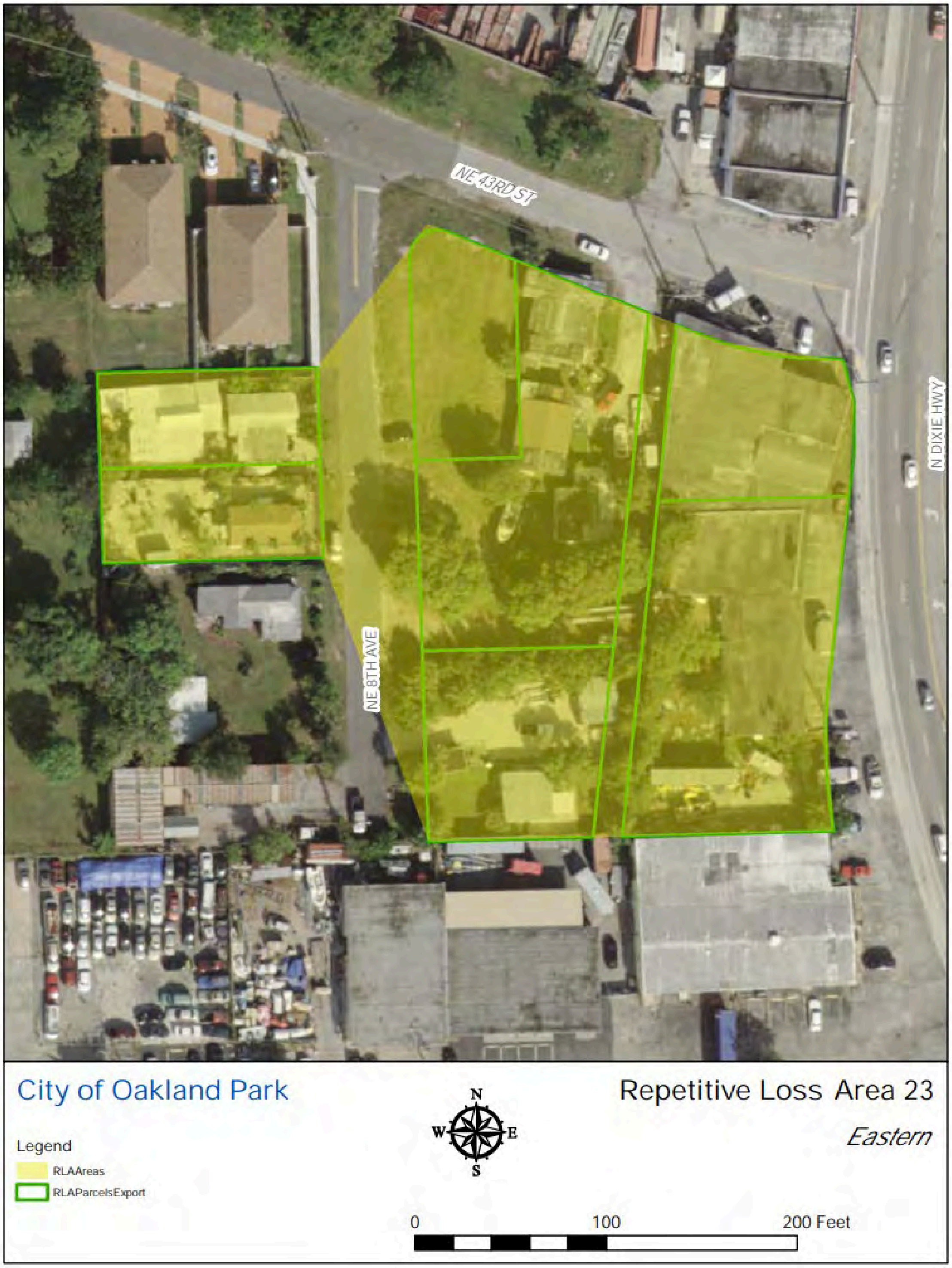


Figure 24: Repetitive Loss Area 23 – Commercial/industrial and residential area

RLA 23 Typical buildings

Figure 25: Repetitive Loss Area 24 – Commercial/industrial area

RLA 24 Typical buildings

Figure 26: Repetitive Loss Area 25 – Residential community

RLA 25 Typical buildings

Figure 27: Repetitive Loss Area 26 – Residential community

RLA 26 Typical buildings

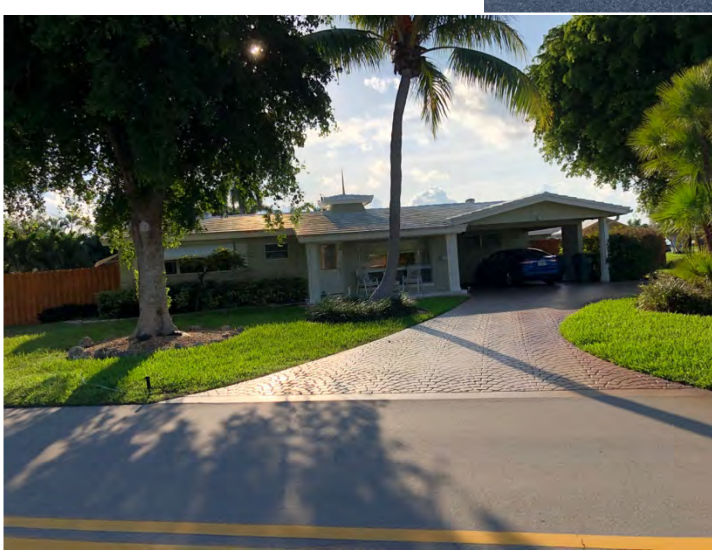


Figure 28: Repetitive Loss Area 27 – Residential community

RLA 27 Typical buildings

Figure 29: Repetitive Loss Area 28 – Residential community

RLA 28 Typical buildings

Figure 30: Repetitive Loss Area 29 – Residential community

RLA 29 Typical buildings

Potential Mitigation Measures for General Area 2

Mitigation measures under consideration for General Area 2 should include both structural and nonstructural solutions.

Structural Alternatives:

Following is a listing and brief description of the primary methods of structural property protection:

1. Demolition/Relocation.

The only way to absolutely ensure a structure will not accumulate additional losses from future flood events is to demolish the structure completely. A second effective option could be to relocate the structure to an area that is not flood prone.

2. Elevation

Whenever the floor of a home is below FEMA's 100-year flood elevation, physically elevating the structure is often recommended as it is one of the most effective means to prevent flood damage. On a smaller scale, elevating crucial items such as furnaces, water heaters, air conditioning units and other electrical components can also be effective means of flood mitigation.

3. Dry flood-proofing

Dry flood-proofing consists of completely sealing around the exterior of the building so that water cannot enter the building

4. Wet flood-proofing

Wet floodproofing consists of modifying uninhabited portions of a home, such as a crawl space, garage, or unfinished basement with flood-damage resistant materials, to allow floodwaters to enter the structure without causing damage.

5. Direct drainage away from the building

In some cases, there are improvements the property owner can make on-site such as directing shallow floodwater away from a flood-prone structure. Building strategically located berms or retention ponds are examples or such mitigation measures.

6. Drainage maintenance.

Removing leaves and other debris from the top of a stormwater catch basin is a simple yet effective means of mitigating flooding.

7. Drainage improvements.

Implementation of drainage improvements, such as installing larger pipes or additional catch basins to receive more stormwater, can effectively reduce flooding.

The homeowner is encouraged to consider each of the structural alternatives listed above and pursue them as deemed appropriate. FEMA grants may be available for some of these alternatives. In addition to homeowner-initiated structural solutions, there are possible structural solutions the City could undertake within City rights-of-way that may provide additional flood mitigation, such as local drainage improvement projects.

Nonstructural Alternatives:

Nonstructural alternatives often provide flood mitigation indirectly. Their impact may be as significant as structural alternatives, but that impact may not be as immediately realized or as dramatic as structural solutions. Following are examples of effective nonstructural mitigation alternatives.

1. Promote the purchase of flood insurance.
2. Improve the City's floodplain and zoning ordinances.
3. Improve the City's floodplain mapping, and stormwater master planning.
4. Provide enhanced public education concerning the flood hazard and flood mitigation alternatives. This can take place through such means as distributing flyers, utilization of social media and City websites, and neighborhood meetings.
5. Elevate damage-prone components, such as the furnace or air conditioning unit.
6. Coordinate with the Broward County Division of Emergency Management and the National Weather Service (NWS) to enhance flood warning system.
7. Increase open space designation.

Following is a brief listing of potential mitigation activities specific to the RLAs in General Area 2 (Eastern):

RLA 3: This area, comprised of single-family residences, has been subject to flooding several times within the past decade, the most recent occurrence taking place in 2017. Some of the home elevations are very low; consideration on the part of the homeowners could be given to elevation. Additionally, the City may consider making this RLA a beneficiary of a local drainage system improvement.

RLA 7: This area is unique among the City's RLAs; it is comprised of a single strip mall. Because it is privately owned, there is no flood mitigation improvement the City could implement in this RLA. Property owners may consider drainage improvements within the parking lot area or in connection with downstream conveyance.

RLA 8: In 2019, the City installed a new structure to collect stormwater and completed drainage improvements that are favorably impacting this commercial/industrial RLA. No additional improvement in this area is recommended at this time.

RLA 9: According to the available records from FEMA, there is only one building in this commercial/industrial RLA that has been subject to flooding. This building is extremely low. Considering no City improvement could favorably impact this property, the property owner will need to address the situation. Because there has not been a claim since 2005, it is possible that the situation has already been addressed.

RLA 10: The properties in this commercial/industrial RLA that have had flood insurance claims have private drainage systems on their properties. Owners are advised to assure that the drains and lines are kept clean.

RLA 11: This commercial/industrial RLA is low with minimal capacity to convey stormwater through positive drainage. Accordingly, the City has installed injection wells in the area. As recently as November 2019, there was a significant rain event that resulted in extensive street flooding. One issue was the failure of the injection wells to start as programed. Attention given to this issue could significantly improve flood mitigation in this RLA.

RLA 12: The repetitive loss property in this area is low in relation to other properties. There is a stormwater structure in the vicinity, but it is insufficient. One option the owner may consider is elevating the building.

RLA 13: The City has made drainage improvements in this vicinity which appear to have been effective; there have not been any flood insurance claims since 2003.

RLA 14: Within the past four years, the City has implemented drainage improvements in the vicinity of this commercial/industrial area. While these improvements have proven somewhat effective in flood mitigation, the street continues to flood and threaten buildings. One option for additional drainage improvement is a private/public partnership project between the City and the owner of most of the properties in the area.

RLA 15: The drainage infrastructure in this RLA, which includes both public and private components, is old. Installation of additional drainage in the area may prove beneficial.

RLA 16: The City recently completed stormwater drainage improvements (Bid Pack 9) in the area which appear to have been effective in flood mitigation.

RLA 17: The City recently completed stormwater drainage improvements (Bid Pack 9) in the area which appear to have been effective in flood mitigation.

RLA 18: In response to significant flooding many years ago in this RLA, the City installed extensive stormwater drainage infrastructure. There has been no significant flooding recorded in this RLA since 2009.

RLA 19: Repetitive flooding in this RLA has been observed for many years. A project within the last decade entailed installation of a wall that relieved the flooding somewhat.

Key drainage structures are located on private property; property owner may consider additional mitigation.

RLA 21: This area has had significant street flooding issues for years. Within the past year, additional drainage infrastructure has been installed, further reducing the threat of flooding.

RLA 22: The drainage pipes tend to hold water in this RLA. This indicates a high water level in the drainage system. Coordination of the City with Broward County to address this issue may prove helpful.

RLA 23: The repetitive loss property in this RLA is very low in relation to the surrounding properties and street. The property owner may consider installation of a pumping system.

RLA 24: The stormwater drainage infrastructure of this commercial/industrial area, which includes a total of six repetitive loss properties, is old and belongs to Broward County. Coordination of the City with Broward County may prove helpful for flood mitigation.

RLA 25: The pipes and drainage components of this residential single-family and multifamily RLA are very old. Installation of new and larger pipes may be warranted.

RLA 26: The drainage in this RLA has benefitted from Bid Pack 8 in November 2019.

RLA 27: Within the last five years, the drainage infrastructure of this RLA has been enhanced. Currently additional drainage improvements are underway.

RLA 28: This RLA has been impacted by drainage from neighboring properties. Stormwater drainage improvements from Bid Pack 9 within the last few years has benefitted this RLA.

RLA 29: A large drainage pipe was installed in the vicinity approximately 10 years ago. This improvement, together with the installation of swales this year, has served to mitigate the flooding in this RLA.

General Area 2 Recommendations

General Area 2, which is characterized by older infrastructure and large areas of impervious surfaces, has unique challenges pertaining to flooding. The effects of King Tides in this area, which is closer to the Intracoastal Waterway, are becoming increasingly evident. Flood mitigation efforts on the part of property owners is encouraged. The following mitigation action items are recommended for General Area 2:

1. Capital Stormwater Projects Implementation Specific to General Area 2

The City has been especially diligent to implement drainage improvements in this general area in recent years. Additional improvements may be especially appropriate in the following RLAs:

- RLA 3
- RLA 14
- RLA 15
- RLA 25

Responsibility: The City Public Works Department can analyze these areas, prioritize them and move forward with implementing capital improvements.

Funding: Stormwater Fund.

Timing: While some projects could be implemented before others, it may be advisable to complete all the projects within five years.

2. Coordination Specific to General Area 2

Because the drainage system in RLA 24 is owned by Broward County, coordination with the County to mitigate flooding in this area could prove beneficial.

Responsibility: The City's Public Works Department, together with the City's Engineering and Community Development Department can begin dialogue with Broward County to encourage mitigation efforts.

Funding: No additional City funding needed; funds are available in City's operations budget.

Timing: Dialogue with Broward County could begin within the next year. Subsequent activity would depend upon the cooperation of Broward County.

3. Low Impact Development

For purposes of both flood mitigation and water quality improvement, it is recommended that low-impact development be promoted and encouraged in General Area 2. Low Impact Development is a sustainable stormwater management strategy that distributes stormwater across a project site in order to replenish groundwater supplies, rather than sending it into a system of storm drain pipes and channelized networks.

Responsibility: The City's Department of Engineering and Community Development will be responsible for this action item.

Funding: No additional City funding needed; funds are available in City's operations budget.

Timing: This will be done consistently as a matter of the development review process.

4. Flood Insurance Promotion

The City has inaugurated implementation of Activity 370, Flood Insurance Promotion, as outlined in the *2017 CRS Coordinator's Manual,* in its efforts to encourage property owners to purchase both content and building flood insurance. This effort will be continued on an annual basis to all properties in the General Area 2 RLAs.

Responsibility: The CRS Coordinator is responsible for this activity.

Funding: No additional City funding needed; funds are available in City's operations budget.

Timing: This will be done annually.

5. Enhanced floodplain standards

The City should consider implementation of higher regulatory standards.

Responsibility: The City's Engineering & Community Development Department may propose higher regulatory standards. The Commission is ultimately responsible for adoption of higher regulatory standards.

Funding: No additional City funding needed; funds are available in City's operations budget.

Timing: The timing of this item is dependent upon staff recommendation and City Commission approval.

6. Public Information Outreach

The City has established a Program for Public Information intended to strengthen the City's public information outreach to the community. This activity should continue and grow, in accordance with the specific guidelines specified in the Program for Public Information Report. At least one mailed outreach a year is focused exclusively on the Repetitive Loss Areas with specific guidelines required by the CRS program.

Responsibility: The City's CRS Coordinator is responsible for this activity.

Funding: No additional City funding needed; funds are available in City's operations budget.

Timing: Annually.

7. Property Protection Measures

Property owners are encouraged to take actions that will protect themselves from flood damage. This will include such actions as elevating equipment above possible flood levels, and implementing various measures, such as those specified on page 15. Furthermore, the City's Engineering & Community Development Department will provide consultation to homeowners, as may be requested.

Responsibility: The City's CRS Coordinator is responsible for distributing public information pertaining to property protection. The City's Engineering & Community Development Department will provide the consultation.

Funding: No additional City funding needed; funds are available in City's operations budget.

Timing: This activity is ongoing.

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Repetitive Loss Area Analysis, City of Savannah, GA, 2015.

Repetitive Loss Area Analysis, City of West Palm Beach, FL, 2016.

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Exhibit 1

Letters to Repetitive Loss Area Properties

November 1, 2019

RE: ***City of Oakland Park Repetitive Loss Area Analysis***

Dear Owner or Occupant:

The City of Oakland Park is reviewing ways to reduce repetitive flooding in our neighborhoods. Your property is located in one of the areas that the city is targeting for a Repetitive Loss Area Analysis. The purpose of this analysis is to get a better understanding of flooding issues in the vicinity and to offer ideas for reducing flood losses. Results will provide the city with technical information that can be used to develop mitigation recommendations for drainage improvements.

Within the next three weeks, personnel from the City and CRS Max Consultants will visit your neighborhood to collect general information about each building, such as the type of foundation and approximate elevation of the house above the street. This information is needed to develop flood mitigation strategies to protect buildings and residents in the area. The team will observe buildings from the street and take photographs. They will not enter your property and there is no need for you to be present.

As part of the analysis, we welcome residents to share information and experiences with flooding. You may tell us about the flood hazard in your neighborhood, any efforts you have made to reduce flood damage, recommendations to the city to alleviate flooding, or other related input. Your participation in this Repetitive Loss Area Analysis is completely voluntary and none of your personal information will be made public. If you have information to share, you may contact Earl King by phone at (954) 421-7794 or by email at crsmaxinc@bellsouth.net.

After the analysis is completed, you will be invited to review the findings and preliminary recommendations.

If you have any questions about this project, please feel free to contact Earl King at the aforementioned phone number or email address.

Thank you in advance for your cooperation.

Sincerely,

Richard G. Buckeye

Rick Buckeye, AICP
Senior Planner, City of Oakland Park

December 3, 2019

RE: ***City of Oakland Park Repetitive Loss Area Analysis***

Dear Owner or Occupant:

Please be advised that the Repetitive Loss Area Analysis (RLAA) process about which I wrote you in November is nearing completion. The draft RLAA has been completed and we would like to invite you to review the findings and preliminary recommendations. We welcome your comments.

If you would like to review the draft Repetitive Loss Area Analysis, we would be pleased to send you an electronic copy of it. Please contact me at (954) 630-4345 or by email at rickb@oaklandparkfl.gov.

Thank you for your cooperation throughout this process.

Sincerely,

Richard G. Buckeye

Rick Buckeye, AICP
Senior Planner, City of Oakland Park

RLA #1	
501 NW 42 St	
634 NW 42 St	
607 NW 42 St	33309
633 NW 42 St	33309
590 NW 42 St	33309
649 NW 42 St	33309
665 NW 42 St	33309
697 NW 42 St	33309
666 NW 42 St	33309
536 NW 42 St	33309
518 NW 42 St	33309
4151 NW 5 Ave	33309
RLA # 2	
3576 Lloyd Dr	
3700 Lloyd Dr	
3620 Lloyd Dr	
3606 Lloyd Dr	
3600 Lloyd Dr	
3610 Lloyd Dr	
3630 Lloyd Dr	
3640 Lloyd Dr	
3650 Lloyd Dr	
3670 Lloyd Dr	
3565 Lloyd Dr	
711 NW 37 St	
721 NW 37 St	

740 NW 38 St	
710 NW 38 St	
720 NW 38 St	
750 NW 38 St	
741 NW 37 St	
750 NW 37 St	
730 NW 38 St	
751 NW 37 St	
757 NW 36 St	
761 NW 37 St	
770 NW 37 St	
811 NW 37 St	
821 NW 37 St	
841 NW 37 St	
731 NW 37 St	
641 NW 37 St	
621 NW 37 St	
760 NW 37 St	
740 NW 37 St	
730 NW 37 St	
720 NW 37 St	
710 NW 37 St	
640 NW 37 St	
620 NW 37 St	
757 NW 36 St	
749 NW 36 St	
760 NW 36 St	
3691 NW 5 Ave	33309

RLA # 3	
953 NE 37 St	
999 NE 37 St	
935 NE 37 St	
919 NE 37 St	
901 NE 37 St	
920 NE 37 Street	
902 NE 37 St	
1016 NE 37 St	33334
RLA# 4	
420 NW 37 St	
380 NW 37 St	
440 NW 37 St	33309
RLA # 5	
2000 NW 32 Ct	
2030 NW 32 Ct	
2020 NW 32 Ct	
1990 NW 32 Ct	33309
RLA # 6	
2006 NW 28 St	
2018 NW 28 St	
2030 NW 28 St	33311

RLA # 7	
3436 N Andrews Ave	
3436 N Andrews Ave	
3424 N Andrews Ave	
3420 N Andrews Ave	
RLA # 8	
508 NE 43 St	
502 NE 43 St	
508 NE 43 St	
512 NE 43 St	
514 NE 43 St	
520 NE 43 St	
4300 NE 5 Terr	
4310 NE 5 Ave	33334
RLA # 9	
668 NE 44 St	
700 E Prospect Rd	33334
730 NE 44 St	
750 NE 44 St	
RLA # 10	
859 NE 44 St	

831 NE 44 St	
841 NE 44 St	
4401 N Dixie Hwy	33334
RLA # 11	
698 NE 45 St	
792 NE 45 ST	
696 NE 45 St	
700 NE 45 St	
740 NE 45 St	
750 NE 45 St	
4490 NE 6 Terr	33334
RLA # 12	
4700 NE 8 Terrace	
840 NE 47 St	33334
4710 NE 8 Terr	33334
RLA # 13	
4780 NE 2 Ave	
4790 NE 2 Ave	
4770 NE 2 Ave	
4760 NE 2 Ave	
RLA # 14	

5045 NE 12 Ave	
5042 NE 12 Ave	
5056 NE 12 Ave	
5055 NE 12 Ave	
5041 NE 12 Ave	
1139 E Commercial Blvd	
1199 E Commercial Blvd	
1201 E Commercial Blvd	
RLA # 15	
4800 NE 10 Ave	
4816 NE 10 Ave	
4830 NE 10 Ave	
4850 NE 10 Ave	
4849 NE 11 Ave	
4831 NE 11 Ave	
4807 NE 11 Ave	
4801 NE 11 Ave	
4805 NE 10 Ave	33334
4800 N Dixie Hwy	33334
4892 N Dixie Hwy	33334
RLA # 16	
1574 NE 48 St	
4780 NE 15 Way	
4764 NE 15 Way	
4801 NE 16 Ave	

4811 NE 15 Way	
4800 NE 15 Way	
RLA # 17	
4710 NE 17 Terr	
4732 NE 17 Terr	33334
1761 NE 47 Ct	33334
1780 NE 47 St	
RLA # 18	
640 NE 61 Ct	
630 NE 61 Ct	
640 NE 61 Ct	
6161 NE 7 Ave	33334
RLA # 19	
5800 N Andrews Ave	
5851 N Andrews Ave	
5890 N Andrews Ave	
5750 N Andrews Ave	
5740 N Andrews Ave	
RLA # 20	
215 NW 57 St	
211 NW 57 St	

131 NW 57 St	
221 NW 57 St	
231 NW 57 St	
RLA # 21	
701 NE 56 ST	
691 NE 56 St	
711 NE 56 St	
721 NE 56 St	
RLA # 22	
1081 NE 43 Ct	
1091 NE 43 Ct	
1024 NE 43 St	
1045 NE 43 Place	
1051 NE 43 Ct	
1030 NE 43 Ct	
1036 NE 43 Ct	
1042 NE 43 Ct	
1048 NE 43 Ct	
1054 NE 43 Ct	
4355 NE 11 Ave	
1058 NE 43 Ct	
RLA # 23	
4281 N Dixie Hwy	

4231 N Dixie Hwy	
4210 NE 8 Ave	
810 NE 43 St	
4241 NE 8 Ave	
4240 NE 8 Ave	
RLA # 24	
4068, 4074 NE 5 Terrace	
4032 NE 5 Terrace	
4062. 4068, 4074 NE 7 Terr	
4201 NE 6 Ave	
601 NE 42 St	
721 NE 42 St	
700 NE 42 St	
4050 NE 7 Ave	
4044 NE 7 Ave	
715 NE 40 Ct	
739 NE 40 Ct	
4033 NE 7 Ave	
4041 NE 7 Ave	
4057 NE 7 Ave	
4140 NE 6 Ave	
4130 NE 6 Ave	33334
4050 NE 6 Ave	
4032 NE 6 Ave	
4028 NE 40 Ct	
4019 NE 6 Ave	
4031 NE 6 Ave	

4029 NE 6 Ave	
4051 NE 6 Ave	
4057 NE 6 Ave	
4097 NE 6 Ave	
560 NE 42 St	
4160 NE 5 Terr	
4060 NE 5 Terr	
4056 NE 5 Terr	
4050 NE 5 Terr	
4044 NE 5 Terr	
4038 NE 5 Terr	
4020 NE 5 Terr	33 props
RLA # 25	
1540 NE 40 Pl	
1550 NE 40 Pl	
1530 NE 40 Pl	
1520 NE 40 Pl	
1510 NE 40 Pl	
1500 NE 40 Pl	
1340 NE 40 Dr	
1341 NE 40 Pl	
1350 NE 40 Dr	
1351 NE 40 Pl	
1360 NE 40 Dr	
1361 NE 40 Pl	
1371 NE 40 Pl	
1380 NE 40 Dr	

1381 NE 40 Pl	
1370 NE 40 Dr	
4061 NE 14 Ave	
4081 NE 14 Ave	40 Dr?
4041 NE 14 Ave	
4021 NE 14 Ave	
4001 NE 14 Ave	
4041 NE 15 Ave	33334
RLP # 26	
4120 NE 15 Ave	
1441 NE 41 St	
4110 NE 15 Ave	
4100 NE 15 Ave	
1430 NE 42 St	
RLA # 27	
4240 NE 16 Ave	
4230 NE 16 Ave	
4250 NE 16 Ave	
4210 NE 16 Ave	
4220 NE 16 Ave	

4261 NE 16 Terr	
4251 NE 16 Terr	
4241 NE 16 Terr	
RLA # 28	
4060 NE 18 Ave	
4050 NE 18 Ave	
4040 NE 18 Ave	
4070 NE 18 Ave	
RLA # 29	
1531 NE 35 St	
1547 NE 35 St	
1533 NE 35 ST	
1567 NE 35 St	
1501 NE 35 St	
1555 NE 35 St	
1573 NE 35 St	
1509 NE 35 St	
1579 NE 35 St	

Exhibit 2

Letters to Agencies and Organizations Soliciting Input

A CITY ON THE MOVE

November 21, 2019

Gerry O'Reilly, District 4 Secretary
Florida Department of Transportation
3400 West Commercial Blvd.
Oakland Park, FL 33309

RE: *City of Oakland Park Repetitive Loss Area Analysis*

Dear Mr. O'Reilly:

The City of Oakland Park is in the process of performing a *Repetitive Loss Area Analysis* for its community. The intent of this effort is to investigate flooding issues in areas within the city that have been especially prone to flooding, as demonstrated by repetitive flood insurance claims. In addition to gleaning information from the City's staff, residents, and businesses, we are also seeking input from other groups or agencies whose plans, studies, programs, initiatives and activities may affect the flood mitigation planning effort in the City of Oakland Park.

If your agency is doing anything that will affect this community's flood hazard mitigation efforts, we would be interested in knowing about it within the next two weeks. In addition, if there is any way you would like to support our efforts, we welcome your participation.

The City has retained CRS Max Consultants to assist with this effort. Earl King, Vice President, is managing the City's efforts in this regard. He can be reached at (954) 421-7794 or via email at crsmaxinc@bellsouth.net. Please feel free to contact me at (954) 630-4339 or rickb@oaklandparkfl.gov if you have any questions.

We look forward to hearing from you and thank you for your support.

Sincerely,

Rick Buckeye, AICP
City of Oakland Park

Name	Organization	Address	Address2	City	State	Zip
Broward Metropolitan Planning Organization	Trade Center South	6th Floor, Suite 650	100 West Cypress Creek Road	Fort Lauderdale	FL	33309-2181
Earl King	CRS Max Consultants, Inc.	3331 NW 71st Street		Coconut Creek	FL	33073-0000
To Whom it May Concern	U.S. Army Corps of Engineers, South Florida Area Office	4400 PGA Blvd, Suite 203		Palm Beach Gardens	FL	33410-6555
Mayor Dean J. Trantalis	Commission Office	City Hall, 8th Floor	100 North Andrews Ave	Fort Lauderdale	FL	33301
Leigh Ann Henderson, City Manager	City of Wilton Manors	2020 Wilton Drive		Wilton Manors	FL	33305
Representative Theodore E. Deutch	Congressional District 22	2447 Rayburn House Office Building		Washington	DC	20515-0922
Jennifer Smith, Director Southeast District	Florida Department of Environmental Protection	3301 Gun Club Rd	MSC 7210-1	West Palm Beach	FL	33406
To Whom it May Concern	Association of State Floodplain Managers	2809 Fish Hatchery Rd	Suite 204	Madison	WI	53713-0000
Senator Rubio	United States Senate	284 Russell Senate Office Building		Washington	DC	20510
Gerry O'Reilly, District Four Secretary	Florida Department of Transportation	3400 West Commercial Blvd		Fort Lauderdale	FL	33309
Phil Alleyne, City Manager	City of Lauderdale Lakes	4300 NW 36 Street		Lauderdale Lakes	FL	33319
Steve Martin, Floodplain Management Officer	State of Florida Department of Community Affairs	Florida Division of Emergency Management	2555 Shumard Oak Blvd	Tallahassee	FL	32399-2100
Laura Waterman, Mitigate FL Group	Florida State Hazard Mitigation Office	Florida Division of Emergency Management	2555 Shumard Oak Blvd	Tallahassee	FL	32399-2100
James J. Moran, Governing Board Member	South Florida Water Management District	PO Box 24680		West Palm Beach	FL	33416-4680
Gracia Szcech, Regional Administrator	Federal Emergency Management Agency	FEMA Region IV	3003 Chamblee Tucker Rd	Atlanta	GA	30341
Miles Anderson, Mitigation Bureau Chief	Florida Division of Emergency Management	Florida State Bureau of Mitigation	2555 Shumard Oak Blvd	Tallahassee	FL	32399-2100
Necole Holton Jacobs, MEP	Broward County Migiation Program Manager	Emergency Management Division	201 NW 84 Ave	Plantation	FL	33324
Mayor Dale Holness	Broward County	Broward County Government Center	115 S. Andrews Ave, Room 417	Fort Lauderdale	FL	33301
Eddy Bouza	Florida Division of Emergency Management	Florida State Bureau of Mitigation	2555 Shumard Oak Blvd	Tallahassee	FL	32399-2100
National Weather Service	Miami Office	7500 NW 58th Street		Miami	FL	33166
Broward County Building Officials	BOIEA	1126 South Federal Highway	Suite 394	Fort Lauderdale	FL	33316
Kevin Brice, Southeast Director	Land Trust Alliance	Southeast Programs Office	PO Box 12212	Research Triangle Park	NC	27709
To Whom it May Concern	National Oceanic and Atmospheric Administration	1401 Constitution Ave, NW	Room 5128	Washington	DC	20230
Environmental Protection Agency	Atlanta Federal Center	61 Forsyth Street, SW		Atlanta	GA	30303-3104

Appendix B: Unifed Sea Level Rise Projection Southeast Florida, 2019

Unified Sea Level Rise Projection Southeast Florida

2019 UPDATE

Prepared by the

Southeast Florida Regional Climate Change Compact's
Sea Level Rise Ad Hoc Work Group

Table of Contents

Recommended Citation

Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact). February 2020. A document prepared for the Southeast Florida Regional Climate Change Compact Climate Leadership Committee. 36p.

Sea Level Rise Ad Hoc Work Group

The Southeast Florida Regional Climate Change Compact wishes to acknowledge the Work Group participants for contributing to the development of the projection and guidance document:

- Ricardo Domingues, University of Miami/National Oceanic and Atmospheric Administration*
- David Enfield, Ph.D., National Oceanic and Atmospheric Administration (retired)
- Nancy J. Gassman, Ph.D., City of Ft. Lauderdale
- Laura Geselbracht, The Nature Conservancy
- Katherine Hagemann, C.F.M., Miami-Dade County
- Jake Leech, Ph.D., Palm Beach County
- Jayantha Obeysekera, Ph.D., P.E., Florida International University (Chair)
- Akintunde Owosina, P.E., South Florida Water Management District
- Joseph Park, Ph.D., P.E., U.S. Department of Interior*
- Michael Sukop, Ph.D., PG, CHg, Florida International University
- Tiffany Troxler, Ph.D., Florida International University
- John Van Leer, Sc.D., University of Miami
- Shimon Wdowinski, Ph.D., Florida International University
- Staff Liaison: Samantha Danchuk, Ph.D., P.E., Broward County
- Compact Staff Support: Lauren Ordway, Institute for Sustainable Communities

** Staff participation from federal agencies does not necessarily imply official review or opinions of their agencies.*

The Compact also wishes to express its appreciation to those whom provided technical guidance in the early phase of the process to support the recommendations of the Work Group:

- Andrea Dutton, Ph.D., University of Wisconsin
- John Hall, Ph.D., Bureau of Land Management
- Robert E. Kopp, Ph.D., Rutgers University
- Glenn Landers, P.E., U.S. Army Corps of Engineers*
- Mark Merrifield, Ph.D., Scripps Institution of Oceanography at the University of California San Diego
- Gary Mitchum, Ph.D., University of South Florida
- William Sweet, Ph.D., National Oceanic and Atmospheric Administration
- Philip R. Thompson, Ph.D., University of Hawaii
- Chris Weaver, Ph.D., Environmental Protection Agency

**Participants contributed information, engaged in group meetings and/or online discussions, and helped develop or review portions of the group report. Participation by these individuals does not necessarily imply personal or agency agreement with the complete findings and recommendations of this report.*

Executive Summary

Early in the Southeast Florida Regional Climate Change Compact's ("the Compact") work together, Broward, Miami-Dade, Monroe, and Palm Beach counties recognized the need to unify a diversity of local sea level rise projections to create a single, regionally unified projection, ensuring consistency in adaptation planning and policy, and infrastructure siting and design in the Southeast Florida four-county region. The Compact published the first Regionally Unified Sea Level Rise Projection for Southeast Florida in 2011, and updated the projection in 2015. This document, the Compact's third Regionally Unified Sea Level Rise Projection, provides an update to the amount of anticipated sea level rise in Southeast Florida through 2120. These projections represent a consensus from a technical Work Group consisting of members from the academic community and federal agencies, with support from local government staff, and incorporates the most up-to-date, peer-reviewed literature, and climate modeling data. The Projection supports local government, regional entities, and other partners in understanding vulnerabilities associated with sea level rise and informs the development of science-based adaptation strategies, policies, and infrastructure design.

The 2019 Projection is based on projections of sea level rise developed by the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2014), as well as projections from the National Oceanic and Atmospheric Administration (NOAA) (Sweet et al., 2017), and accounts for regional effects, such as gravitational effects of ice melt, changes in ocean dynamics, vertical land movement, and thermal expansion from warming of the Florida Current that produce regional differences in Southeast Florida's rate of sea level rise compared to global projections.

Based on past and current emissions, all projection curves assume a growing greenhouse gas emission concentration scenario, in which emissions continue to increase until the end of the century, consistent with the IPCC Fifth Assessment Report's (AR5) Representative Concentration Pathways (RCP 8.5). Estimates of sea level rise are provided from a baseline year of 2000, and the planning horizon has been extended to 2120, in response to the release of climate scenarios extending beyond the year 2100 by federal agencies (NOAA and the U.S. Army Corps of Engineers) and the need for planning for infrastructure with design lives greater than 50 years.

In the short term, sea level rise is projected to be 10 to 17 inches by 2040 and 21 to 54 inches by 2070 (above the 2000 mean sea level in Key West, Florida). In the long term, sea level rise is projected to be 40 to 136 inches by 2120. Projected sea level rise, especially beyond 2070, has a significant range of variation as a result of uncertainty in future greenhouse gas emissions reduction efforts and resulting geophysical effects.

The 2019 Unified Sea Level Rise Projection includes three curves for application, in descending order, the NOAA High Curve, the NOAA Intermediate High Curve, and the curve corresponding to the median of the Intergovernmental Panel on Climate Change (IPCC) AR5 RCP 8.5 scenario. A fourth curve, the NOAA Extreme curve, is included for informational purposes, not for application, illustrating the possible upper limit of sea level rise in response to potential massive ice sheet collapse in the latter part of the century. This curve underscores that without imminent and substantial reductions in greenhouse gas emissions, much greater sea level rise is possible more than 100 years from now.

This guidance document describes the recommended application of the projection as it relates to both high- and low-risk projects and short- and long-term planning efforts. The Work Group recommends that this guidance be updated, at a minimum every five years to reflect the ongoing advances in scientific knowledge related to global climate change and potential impacts.

Introduction

IMPACTS ASSOCIATED WITH SEA LEVEL RISE FOR SOUTHEAST FLORIDA

The climate is changing, manifesting in significant impacts for the Southeast Florida region, including increasing average temperatures, more intense storm events, and rising sea levels. Sea level rise, caused by the thermal expansion of warming ocean water and melting land ice as the earth warms, is one of the most evident impacts in our region given Southeast Florida's low-lying elevation and porous geology.

The consequences associated with sea level rise are already apparent in Southeast Florida and pose an immediate and real threat to lives, livelihoods, economies, and the environment. Consequences include physical impacts such as coastal inundation and erosion, increased frequency of flooding in vulnerable coastal areas as well as inland areas due to impairment of the region's largely gravity-driven stormwater infrastructure system, reduced soil infiltration capacity, and saltwater intrusion of drinking-water supply. Moreover, the impacts of surge from tropical storms or hurricanes are exacerbated as a result of sea level rise. Increased pollution and contamination as a result of flooding degrades natural resources critical to the region's economy. Consequences also include cascading socio-economic impacts such as displacement, decrease in property values and tax base, increases in insurance costs, loss of services and impairment of infrastructure such as roads and septic systems. ***Appendix A: State of the Science***, describes the interconnected processes and resulting impacts of sea level rise in additional detail.

The extent of these impacts into the future is dependent upon the factors influencing the rate of sea level rise such as thermal expansion of oceans and increased rate of melting of land-based ice sheets due to global warming, the degree to which society limits greenhouse gas emissions in the near-term, and the decisions and investments made by communities to increase their climate resilience. One of the values of the Unified Sea Level Rise Projection is its application for scenario testing to better understand the potential impacts and timeline of sea level rise within the Southeast Florida community.

OBSERVED SEA LEVEL RISE IN SOUTHEAST FLORIDA

Global mean sea level (GMSL) during 2018 was the highest annual average in the satellite altimetry record (1993–2018), rising approximately 3 inches above the 1993 average (Thompson et al., 2019). Projections anticipate an increase in the acceleration of sea level rise regionally based on recent observations in response to changes in the speed and thermodynamics of the Florida Currents and Gulf Stream (Domingues et al., 2018; Sweet et al., 2017; Volkov et al., 2019). Based on the 5-year moving average, the observed sea level rise at the Key West tide gauge from 2000 to 2017 is 3.9 inches. Whether this rapid rise will be persistent into the future is unclear at this time.

HOW ARE GREENHOUSE GAS EMISSIONS AND SEA LEVEL RISE RELATED?

Since the beginning of the Industrial Revolution, human activities have caused significant increases in emissions of greenhouse gases in the atmosphere, such as carbon dioxide, methane, and nitrous oxides in addition to natural emissions of these gases due to the biome carbon and nitrogen cycles. Major sources of carbon dioxide are the burning of fossil fuels such as coal, petroleum-based liquid fuels, and natural gas for electric power generation, transportation, and industrial processes. These greenhouse gases trap heat from the sun in a natural process called the “greenhouse effect,” which would otherwise be radiated back to space. Problematically, as the concentrations of these gases accumulate in the earth’s atmosphere as a result of human activities, the earth’s average temperature continues to rise. This process is called “global warming.”

More than 90% of the warming that has happened on Earth over the past 50 years has been transferred to the ocean. Sea level rise is a result of both the expansion of seawater as the ocean temperature increases, as well as the melting of glaciers and ice sheets. As a result of continuing global warming, the rate of sea level rise accelerates with passing time.

FUTURE PROJECTIONS IF EMISSIONS ARE REDUCED

The rate of sea level rise projected, particularly in the latter half of the century, is dependent upon the amount of greenhouse gas emissions generated in the next decade and sustained in the coming decades. Rapid and immediate global, federal, state, local, and individual action will be necessary to limit the amount of sea level rise adaptation required. The four greenhouse gas concentration scenarios, known as the Representative Concentration Pathways (RCPs) are sets of scenarios for greenhouse gas emissions dependent upon reduction commitments, economic activity, energy sources, population, and land use trajectories, and other socio-economic factors. RCPs are input into climate models which yield sea level rise scenarios. The lowest concentration scenario, RCP 2.6, is viewed as the scenario necessary to keep global temperature increases below 2°C and slow the rate of sea level rise (van Vuuren et al 2011a). This scenario would require that greenhouse gas emissions peak around 2020 and decrease at 4% annually (van Vuuren et al., 2011a). Future global mean sea level would be significantly lower for RCP 2.6 compared to that of RCP 8.5 (IPCC, 2019). The types of reduction strategies necessary to reduce regional emissions can be found in the Compact’s Regional Climate Action Plan (www.rcap2.org).

WHAT ARE RCPS?

The future impacts of climate depend not only on the response of our Earth system, but also on how global society responds through changes in technology, economy, policy, and lifestyle. These responses are uncertain, so future scenarios are used to explore the consequences of different options. Representative Concentration Pathways (RCPs) are possible future scenarios for greenhouse gas emissions, or concentration pathways, used within the IPCC AR5 and other complex climate modeling activities that simulate how the climate might change in the future. There are generally four of these scenarios used in climate modeling: RCP 8.5, RCP 6, RCP 4.5, and RCP 2.6. The numbers in each RCP refers to the amount of radiative forcing produced by greenhouse gases in 2100, which is a measure of the energy absorbed and retained by the lower atmosphere. For example, in RCP 8.5 the radiative forcing is 8.5 watts per meter squared (W/m^2) in 2100.

RCPs start with atmospheric concentrations of greenhouse gases rather than socioeconomic processes (van Vuuren et al., 2011b). This is important because every modelling step from a socioeconomic scenario to climate change impacts adds uncertainty. That said, these concentration pathways are dependent upon reduction commitments, economic activity, energy sources, population, land use trajectories, and other socio-economic factors that could lead to a particular concentration pathway and magnitude of climate change.

SCENARIO COMPONENT	RCP 2.6	RCP 4.5	RCP 6	RCP 8.5
Greenhouse gas emissions	Very low	Medium-low mitigation Very low baseline	Medium baseline; high mitigation	High baseline
Agricultural area	Medium for cropland and pasture	Very low for both cropland and pasture	Medium for cropland but very low for pasture (total low)	Medium for both cropland and pasture
Air pollution	Medium-Low	Medium	Medium	Medium-high

Main characteristics of each Representative Concentration Pathway (RCP). *Vuuren et.al., 2011*

RCP PRIMARY CHARACTERISTICS

>> **RCP 2.6** is representative of scenarios in the literature that lead to very low greenhouse gas concentration levels. It is a “peak-and-decline” scenario; its radiative forcing level first reaches a value of around 3.1 W/m^2 by mid-century, and returns to 2.6 W/m^2 by 2100. In order to reach such radiative forcing levels, greenhouse gas emissions (and indirectly emissions of air pollutants) are reduced substantially, over time (Van Vuuren et al. 2007a).

>> **RCP 4.5** is a stabilization scenario in which total radiative forcing is stabilized shortly after 2100, without overshooting the long-run radiative forcing target level (Clarke et al. 2007; Smith and Wigley 2006; Wise et al. 2009).

>> **RCP 6** is a stabilization scenario in which total radiative forcing is stabilized shortly after 2100, without overshoot, by the application of a range of technologies and strategies for reducing greenhouse gas emissions (Fujino et al. 2006; Hijioka et al. 2008).

>> **RCP 8.5** is characterized by increasing greenhouse gas emissions over time, representative of scenarios in the literature that lead to high greenhouse gas concentration levels (Riahi et al. 2007).

(Characteristics quoted from van Vuuren et.al., 2011)

Purpose and Intended Use

WHO SHOULD USE THIS PROJECTION AND GUIDANCE DOCUMENT?

The Unified Sea Level Rise Projection for Southeast Florida and this guidance document are intended to assist decision-makers at both the local and regional levels in Southeast Florida to plan for and make decisions about sea level rise and associated vulnerabilities based on best-available science. The projection (Unified Sea Level Rise Projection for Southeast Florida) contains a graph and table describing the anticipated rise in sea level from 2000 through 2120. The projection can be used to estimate future potential sea level elevations in Southeast Florida and the relative change in sea level from today to a point in the future. The section, *Guidance for Application*, contains directions and specific examples of how the projection can be used by local governments, planners, designers, engineers, and developers. This regional projection is offered to ensure that all major infrastructure projects throughout the Southeast Florida region have the same basis for design and construction relative to future sea level.

WHO DEVELOPED THE UNIFIED SEA LEVEL RISE PROJECTION FOR SOUTHEAST FLORIDA?

In 2010, the Southeast Florida Regional Climate Change Compact first convened the Sea Level Rise Ad Hoc Work Group (Work Group) for the purpose of developing a Unified Sea Level Rise Projection for the region. The Work Group reviewed existing projections and scientific literature and developed a unified regional projection for the period from 2010 to 2060 (Compact, 2012), and recommended a review of the projection four years after its release in 2011.

In September 2014, the Sea Level Rise Work Group was reconvened to develop the second update of the Unified Sea Level Rise Projection, based on projections and scientific literature released since 2011, which was published by the Compact in October 2015 (Compact, 2015).

Based on guidance from the Work Group, and in response to emergent research since the publication of the 2015 report, the Compact reconvened the Work Group in 2019 to produce the third update. In particular, new research has indicated the potential for faster rates of melting of the Antarctic Ice Sheet, triggering the likelihood of higher rates of rise in the future. In addition, the Work Group opted to include the regional sea level rise rates as reported in the Fourth National Climate Assessment (Sweet et al., 2017).

The Ad Hoc Sea Level Rise Work Group consists of experts within the academic community and federal agencies, and is supported by individuals from local government and staff support to the Compact. Most of the 2019 Work Group members contributed to the previous Compact projections.

FREQUENCY OF FUTURE UPDATES

The Southeast Florida Regional Climate Change Compact is committed to updating the Unified Sea Level Rise Projection periodically, and at a minimum every five years, to incorporate the latest scientific understanding of climate change and sea level rise for Southeast Florida. Scientific understanding of sea level rise is rapidly advancing, generating new, peer-reviewed literature and modeling from a variety of key sources, including the Intergovernmental Panel on Climate Change (IPCC), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Army Corps of Engineers (USACE), among other recognized sources. By updating this document and the Unified Sea Level Rise Projection at least every five years, the Compact seeks to provide ongoing and current guidance for regionally consistent sea level rise planning and decision-making.

Unified Sea Level Rise Projection for Southeast Florida

2019 PROJECTION AND SUMMARY

This Unified Sea Level Rise Projection for Southeast Florida updated in 2019 projects the anticipated range of sea level rise for the region from 2000 to 2120 (Figure 1). The projection highlights three planning horizons:

1. **short term:** by 2040, sea level is projected to rise 10 to 17 inches above 2000 mean sea level.
2. **medium term:** by 2070, sea level is projected to rise 21 to 54 inches above 2000 mean sea level.
3. **long term:** by 2120, sea level is projected to rise 40 to 136 inches above 2000 mean sea level.

Details of the projection development methodology appear in the next section.

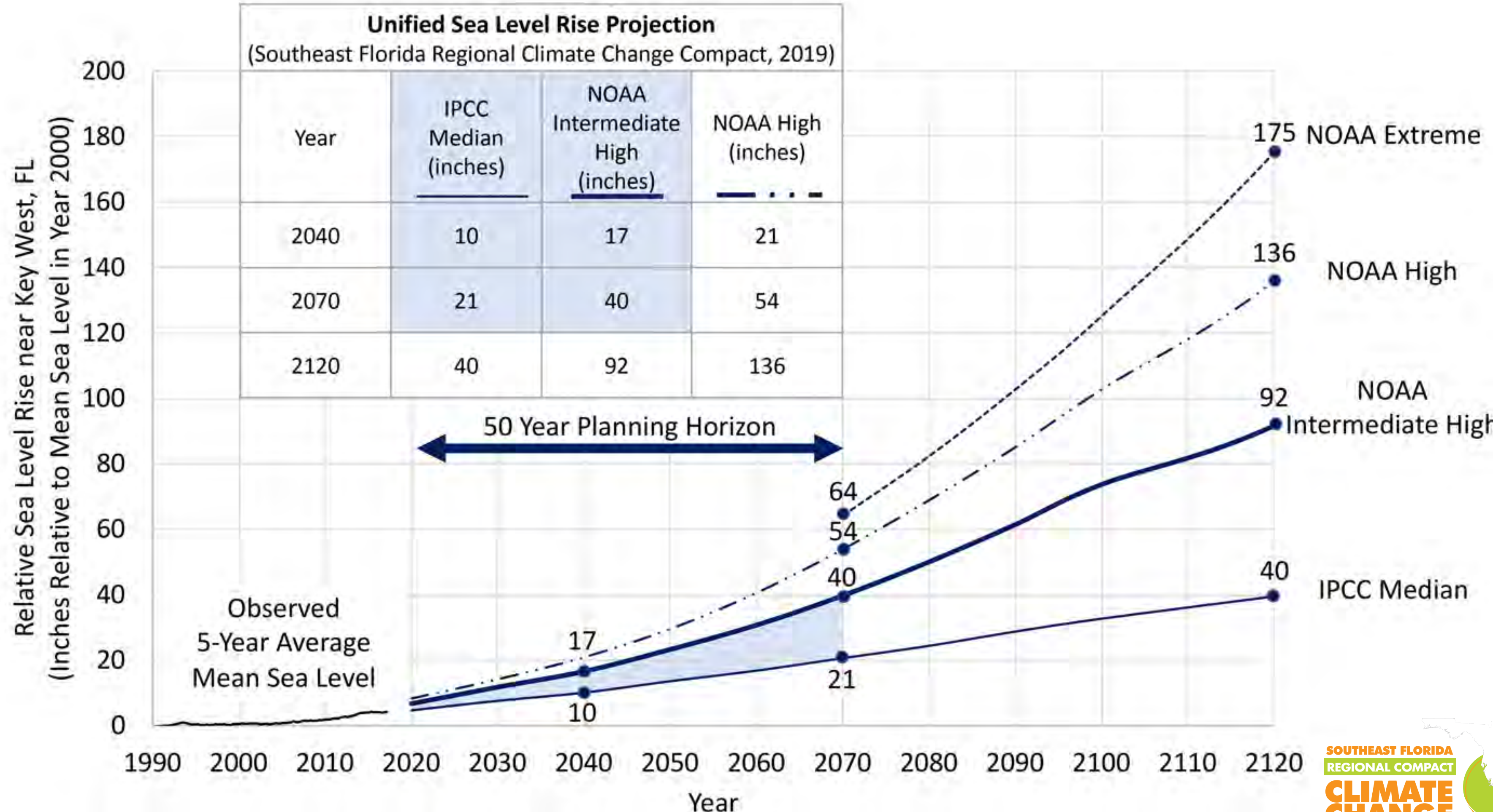
The Projection is recommended to be applied in the following manner:

- The blue shaded zone between the IPCC median curve and the NOAA Intermediate-High curve is recommended to be generally applied to most projects within a short-term planning horizon (up to 2070). The IPCC median curve represents the most likely average sea level before 2070, but is not representative of the realistic interannual and interdecadal variations that will occur with sea level rise values within the blue shaded zone. The IPCC median curve can be used for non-critical, low risk projects with short design lives (<50 years) that are adaptable, and have limited interdependencies with other infrastructure or services. All other projects with design lives that end before 2070 should consider values within the blue zone or along the NOAA Intermediate-High curve based on risk tolerance.
- For non-critical infrastructure in service during or after 2070, the NOAA Intermediate-High Curve is recommended. Sea level rise is unlikely to exceed the NOAA Intermediate-High Curve by 2100.
- The NOAA High curve of the projection, above the shaded zone, should be utilized for planning of critical, high risk projects in service after 2070 or for projects which are not easily replaceable or removable or are critically interdependent with other infrastructure or services. Examples are: major roads and bridges, water and wastewater utilities, power plants including nuclear, major urban developments, etc. Sea level rise is very unlikely to be higher than the NOAA High curve before 2100.
- The NOAA Extreme curve is displayed on the Unified Sea Level Rise Projection for informational purposes but is not recommended for design.

TABLE 1: Sea Level Rise Projection data by decadal intervals

DATUM: FEET 2000 MSL			
YEAR	IPCC MED 50%	NOAA2017 INT-HIGH	NOAA2017 HIGH
2000	0.00	0	0
2010	0.19	0.3	0.33
2020	0.39	0.56	0.69
2030	0.63	0.98	1.18
2040	0.84	1.38	1.74
2050	1.13	1.94	2.46
2060	1.40	2.56	3.38
2070	1.72	3.31	4.49
2080	2.03	4.17	5.74
2090	2.40	5.12	7.09
2100	2.72	6.14	8.56
2120	3.29	7.64	11.32

DATUM: FEET NAVD			
YEAR	IPCC MED 50%	NOAA2017 INT-HIGH	NOAA2017 HIGH
2000	-0.80	-0.78	-0.78
2010	-0.61	-0.49	-0.45
2020	-0.42	-0.22	-0.09
2030	-0.17	0.2	0.4
2040	0.04	0.6	0.96
2050	0.33	1.15	1.68
2060	0.60	1.78	2.6
2070	0.91	2.53	3.71
2080	1.23	3.38	4.96
2090	1.59	4.34	6.3
2100	1.92	5.35	7.78
2120	2.49	6.86	10.54



Year	IPCC Median (inches)	NOAA Intermediate High (inches)	NOAA High (inches)
2040	10	17	21
2070	21	40	54
2120	40	92	136

FIGURE 1: Unified Sea Level Rise Projection

These projections start from zero in year 2000 and are referenced to mean sea level at the Key West tide gauge. Based on the 5-year average of mean sea level, approximately 3.9 inches of sea level rise has occurred from 2000 to 2017 (see historic sea level section of guidance document). The projection includes global curves adapted for regional application: the median of the IPCC AR5 RCP 8.5 scenario (Growing Emissions Scenario) as the lowest boundary (solid thin curve), the NOAA Intermediate High curve as the upper boundary for short-term use until 2070 (solid thick line), the NOAA High curve as the upper boundary for medium and long-term use (dash dot curve). The shaded zone between the IPCC AR5 RCP 8.5 median curve and the NOAA Intermediate High is recommended to be generally applied to most projects within a short-term planning horizon. Beyond 2070, the adaptability, interdependencies, and costs of the infrastructure should be weighed to select a projection value between the IPCC Median and the NOAA High curves. The NOAA Extreme curve (dash curve) brackets the published upper range of possible sea level rise under an accelerated ice melt scenario. Emissions reductions could reduce the rate of sea level rise significantly.

Projection Development Methodology

PROJECTION UPDATE

The key components of the methodology used to develop the Unified Sea Level Rise Projection are as follows:

Starting in 2000: The year 2000 has been selected as the initial year of the projection because of its use as the reference year for the latest regional sea level projections published by NOAA (Sweet et al., 2017), which is the primary source of the data used in this report. The previous projection started in 1992, based on the midpoint of the tidal epoch from 1983 to 2001 which defined the previous elevation of mean sea level. Defining mean sea level by a timeframe is necessary because sea level is constantly changing. A fixed elevation is necessary to serve as a baseline for which to add sea level rise projections and to convert to elevations in other datums. NOAA has determined a new mean sea level for 2000, the midpoint of the tidal epoch from 1991 to 2009. A comparison of the 2015 and 2019 Unified Sea Level Rise Projection is presented in the next section.

Updated Planning Horizons: To align with a 20-year planning horizon for land use and a 50-year planning horizon for infrastructure, the sea level rise values displayed were moved to 2040 and 2070, respectively.

Planning Horizon of 2120: In response to the release of climate scenarios extending beyond 2100 by federal agencies including the US Army Corps of Engineers (USACE) and the National Oceanographic and Atmospheric Administration (NOAA) and the need for planning for infrastructure with design lives greater than 50 years, the Unified Sea Level Rise Projection time scale has been extended to 2120.

Tide Gauge Selection: The Key West gauge (NOAA Station ID 8724580) was maintained as the reference gauge for calculation of the regional projection, consistent with all previous projections. In addition, appropriate conversion calculations are provided in Section 4: Guidance for Application, in order to reference the projection to the Miami Beach gauge (NOAA Station ID 8723170), the South Port Everglades gauge (NOAA Station ID 8722956) or the Lake Worth Pier gauge (NOAA Station ID 8722670). The Key West gauge has recorded tidal elevations since 1913. Tidal records from Miami Beach, South Port Everglades and Lake Worth Pier are available since 2003, 2018 and 1996, respectively.

Updated Historic Data: Observed data from the Key West tide gauge was plotted from 1992 to 2017 based on the mean sea level, averaged over 5-year intervals. These data were obtained from the USACE Sea Level Tracker, https://climate.sec.usace.army.mil/slr_app/.

Selection of NOAA (2017) Regional Projections and Update of IPCC Median Curve: The regional sea level projections available from NOAA (Sweet et al., 2017) replaced two of the three previously used curves. The selected curves are regional projections rather than previously used global projections. The NOAA Intermediate High regional projection was selected as the upper short term boundary for typical infrastructure because of its IPCC determination to be very likely under the RCP 8.5 emissions pathway, which aligns with current global emissions trends. The NOAA Intermediate High regional projection also approximates the previously used USACE High curve. The NOAA High curve was updated with its regional projection. The third curve, the IPCC Median, was reprojected for the region (Key West) rather than global scale, using the NOAA (Sweet et al., 2017) methodology.

Reference to NOAA Extreme Curve: The NOAA Extreme curve is displayed on the Unified Sea Level Rise Projection for informational purposes but is not recommended for design.

COMPARISON WITH PREVIOUS PROJECTIONS

Table 2 compares values from the 2015 and 2019 Unified Sea Level Rise Projections at the planning horizons referenced in the 2015 projection. The numeric values have been rounded for simplicity. The difference in the reference elevation for the two projections is less than 1 inch (1992 mean sea level compared to 2000 mean sea level) and was considered to be included in the rounding error to allow this comparison. The lowest curve, the IPCC median, increased by 2 to 3 inches in the 2019 projection. The upper boundary of the short term projection increased by 2 to 5 inches (for planning horizons before 2060). The NOAA High curve used for critical infrastructure or planning horizons after 2060 increased 7 to 22 inches, the most significant change between projections.

TABLE 2: Comparison of Unified Projection in 2015 and 2019 at Key West

UNIFIED SEA LEVEL RISE PROJECTION COMPARISON						
Year	High Adaptability ⟷					Low Adaptability
	2015	2019	2015	2019	2015	2019
	IPCC Median Global (inches)	IPCC Median Regional (inches)	USACE High (inches)	NOAA Inermediate High (inches)	NOAA High (inches)	NOAA High (inches)
2030	6	8	10	12	12	14
2060	14	17	26	31	34	41
2100	31	33	61	74	81	103

Note: The NOAA Extreme curve values are not included in the table because there was not a comparable curve in the 2015 projection.

Guidance for Application

GUIDANCE IN APPLYING THE PROJECTIONS

Audiences

The Unified Sea Level Rise Projection for Southeast Florida is intended to be used for planning purposes by a variety of audiences and disciplines when considering sea level rise in reference to both short- and long-term planning horizons as well as infrastructure siting and design in the Southeast Florida area. Potential audiences for the projections include, but are not limited to, elected officials, urban planners, architects, engineers, developers, resource managers, and public works professionals.

One of the key values of the projection is the ability to associate specific sea level rise scenarios with timelines. When used in conjunction with vulnerability assessments, these projections inform the user of the potential magnitude and extent of sea level rise impact at a general timeframe in the future. The blue shaded portion of the projection provides a likely range for sea level rise values at specific planning horizons. Providing a range instead of a single value may present a challenge to users such as engineers who are looking to provide a design with precise specifications. Public works professionals and urban planners need to work with the engineers and with policymakers to apply the projection to each project based on the nature, value, interconnectedness, and life cycle of the infrastructure proposed.

Finally, elected officials should use the projections to inform decision-making regarding adaptation policies, budget impacts associated with design features that address future sea level rise, capital improvement projects associated with drainage and shoreline protection, and land use decisions.

Applying Projection Curves to Infrastructure Siting And Design

When determining how to apply the projection curves, the user needs to consider the nature, value, interconnectedness, and lifespan of the existing or proposed infrastructure. An understanding of the risks that critical infrastructure will be exposed to throughout its life cycle such as sea level rise inundation, storm surge, and nuisance flooding and a plan for adaptation must be established early in the conceptual phase. A determination must be made on whether or not threats can be addressed mid-life cycle via incremental adaptation measures, such as raising the height of a sluice gate on a drainage canal. If incremental adaptation is not possible for the infrastructure proposed and inundation is likely, designing to accommodate the projected sea level rise at conception or selection of an alternate site should be considered. Forward thinking risk management is critical to avoiding loss of service, loss of asset value, and most importantly loss of life or irrecoverable resources. The guidance in the following paragraphs can be considered for selection of curves from the projection for project applications.

>> Application of the IPCC Median Curve

The IPCC Median or lower blue shaded portion of the projection can be applied to most infrastructure projects before 2070 or projects whose failure would result in limited consequences to others. An example low risk projects may be a small culvert in an isolated area. The designer of a type of infrastructure that is easily replaced, has a short lifespan, is adaptable, and has limited interdependencies with other infrastructure or services must weigh the potential benefit of designing for higher sea level rise with the additional costs. Should the designer opt for specifying the lower curve, she/he must consider the consequences of under-designing for the potential likely sea level condition. Such consequences may include premature infrastructure failure.

>> Application of the NOAA Intermediate High Curve

Projects in need of a greater factor of safety related to potential inundation should consider designing for the NOAA Intermediate High Curve. Examples of such projects may include evacuation routes planned for reconstruction, communications and energy infrastructure, and critical government and financial facilities or infrastructure that may stay in place beyond a design life of 50 years.

>> Application of the NOAA High Curve

Due to the community's fundamental reliance on major infrastructure, existing and proposed critical infrastructure should be evaluated using the NOAA High curve. Critical projects include those projects which are not easily replaceable or removable, have a long design life (more than 50 years), and are interdependent with other infrastructure or services. If failure of the critical infrastructure would have catastrophic impacts, it is considered to be high risk. Due to the community's critical reliance on major infrastructure, existing and proposed high risk infrastructure should be evaluated using the NOAA High curve. Examples of high risk critical infrastructure include nuclear power plants, wastewater treatment facilities, levees or impoundments, bridges along major evacuation routes, airports, seaports, railroads, and major highways.

Projection Referenced to the North American Vertical Datum

The Unified Sea Level Rise Projection referenced to the North American Vertical Datum (NAVD) is shown in Figure 2 and summarized in Table 3. Each NOAA tide gauge in the region has published datums that can be used for conversions between elevations (https://tidesandcurrents.noaa.gov/datums.html?id=8724580).

FIGURE 2: Unified Sea Level Rise Referenced to NAVD

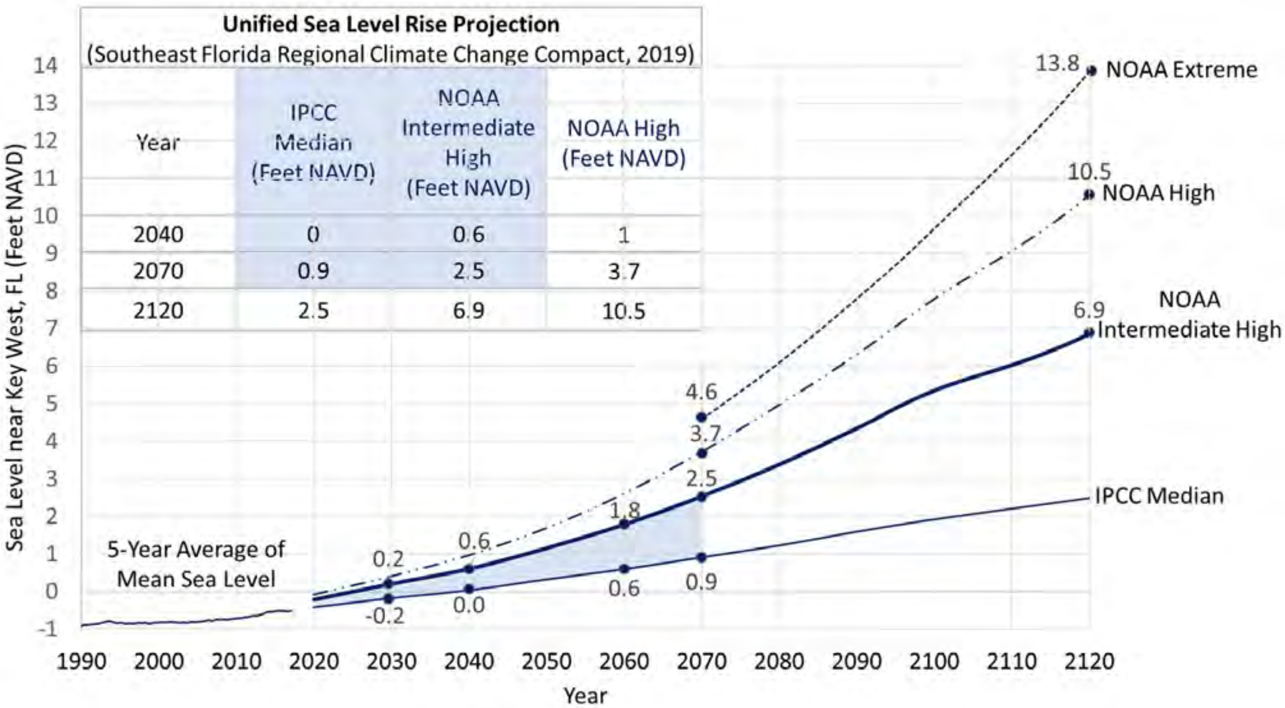


TABLE 3: Unified Sea Level Rise Projection Referenced to NAVD

UNIFIED SEA LEVEL RISE PROJECTION (Southeast Florida Regional Climate Change Compact, 2019)			
Year	IPCC Median (Feet NAVD)	NOAA Intermediate High (Feet NAVD)	NOAA High (Feet NAVD)
2040	0	0.6	1
2070	0.9	2.5	3.7
2120	2.5	6.9	10.5

Referencing to Today's Sea Levels

Based on the 5-year average of mean sea level at Key West, sea level rose approximately 3.9 inches from 2000 to 2017 (NOAA, 2020). This value of 3.9 inches can be subtracted from the rise projected in Table 1 to obtain an estimate of how much sea level will rise from the 2017 mean sea level. Note the availability of computed values for the 5-year average of mean sea level will always be delayed as a function of needing to have 2.5 years data past the date in order to compute the average.

To compute the rise expected from any future date relative to the existing sea level, the linear trend should be computed and its slope should be multiplied by the number of years that have passed since 2000. Based on a linear trend analysis of the historic record at Key West, sea level has risen at a rate of approximately 0.1 inches per year. Note this linear trend will change as more data are collected by the tide gauge. Also, when the slope of the linear trendline changes, the computed amount of rise will change. Care should be taken to consider the computation methodology before comparing statements of relative sea level rise for a distinct time period.

TOOLS AVAILABLE TO VISUALIZE SEA LEVEL RISE

The observed data and NOAA curves included in the projection can be reproduced using the USACE Sea Level Rise calculator http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html and USACE Sea Level Tracker https://climate.sec.usace.army.mil/slr_app/. Inundation from sea level rise can be visualized by using the Florida Sea Level Sketch Planning Tool https://sls.geoplan.ufl.edu/beta/viewer/.

Summary

The Work Group recommends the use of the NOAA High curve, the NOAA Intermediate High curve, and the median of the IPCC AR5 RCP 8.5 scenario (IPCC, 2013) as the basis for a Southeast Florida sea level rise projection for the 2040, 2070 and 2120 planning horizons. In the short term, mean sea level rise is projected to be 10 to 17 inches by 2040, and 21 to 54 inches by 2070 (above the 2000 mean sea level).

Both mean and annual average of sea level exhibit significant variability over time and that should be considered when using the projections. Annual average of sea level at the Key West gauge has risen approximately 3.9 inches from 2000 to 2017 (which is much larger than the linear trend-derived rate of rise reported by NOAA). Whether this rapid rise will be persistent into the future is unclear at this time.

In the long term, sea level rise is projected to be 40 to 136 inches by 2120. The IPCC Median or lower blue shaded portion of the projection can be applied to most infrastructure projects before 2070 or projects whose failure would result in limited consequences to others. Projects in need of a greater factor of safety related to potential inundation should consider designing for the NOAA Intermediate High Curve. For critical infrastructure projects with design lives in excess of 50 years, use of the NOAA High curve is recommended with planning values of 54 inches in 2070 and 136 inches in 2120. Sea level will continue to rise even if global mitigation efforts to reduce greenhouse gas emissions are successful at stabilizing or reducing atmospheric CO_2 concentrations; however, emissions mitigation is essential to moderate the severity of potential impacts in the future. A substantial increase in sea level rise within this century is likely and may occur in rapid pulses rather than gradually.

The recommended projection provides guidance for the Compact Counties and their partners to initiate planning to address the potential impacts of sea level rise in the region. The shorter-term planning horizons (through 2070) are critical to implementation of the Southeast Florida Regional Climate Change Action Plan, to optimize the remaining economic life of existing infrastructure, and to begin to consider adaptation strategies. As scientists develop a better understanding of the factors and reinforcing feedback mechanisms impacting sea level rise, the Southeast Florida community will need to adjust the projections accordingly and adapt to the changing conditions. To ensure public safety and economic viability in the long run, strategic policy decisions will be needed to develop guidelines to direct future public and private investments to areas less vulnerable to future sea level rise impacts.

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Appendix A: State of Science Update

REGIONAL AND GLOBAL SEA LEVEL RISE OBSERVATIONS

Historic Sea Level Rise in Southeast Florida

Based on the 5-year average of mean sea level, approximately 3.9 inches of sea level rise has occurred from 2000 to 2017. Figure A-1 shows the rise of sea level as observed in Key West for the time period from 1913 to 2020 and includes the monthly mean sea level data, the 5-year average of mean sea level and a linear trendline through the monthly mean sea level. The linear trend does not match the monthly mean sea level data well. The linear trend suggests sea level rose only 2 inches from 2000 to 2019, which is less than the 5-year average trend analysis from 2000 to 2017 shown (NOAA, 2020). The 5-year average of the monthly mean sea level illustrates the variability in sea level throughout the time period and highlights the continued increase in sea level above the linear trend in the last decade.

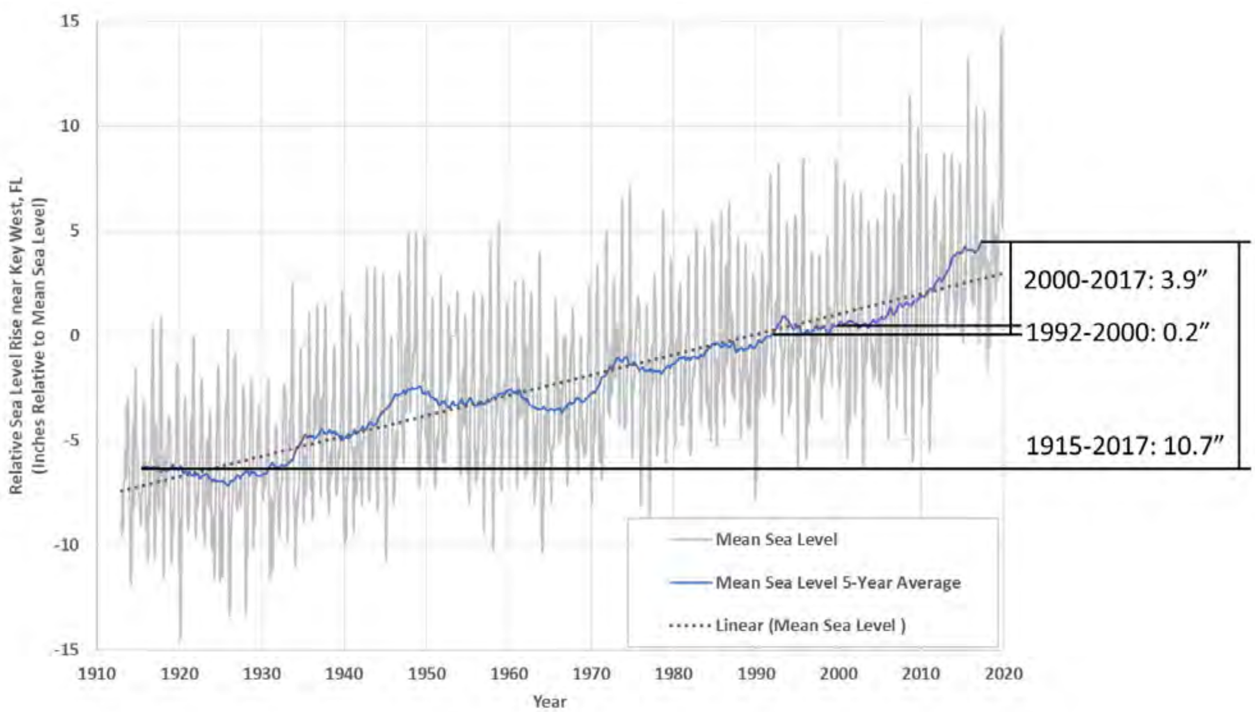

FIGURE A-1. Relative Sea Level Rise in Key West, Florida (NOAA Station ID 8724580) presented as monthly mean sea level, 5-year average of monthly mean sea level and linear trend of monthly mean sea level. Annotated measurements on right of figure are computed by subtracting the 5-year average mean sea levels for the years listed. Sea level rise computed based on the linear trend will differ from the 5-year mean sea level trend shown.

As discussed in the following sections describing the factors influencing sea level rise, the changing climate will drive new nonlinear trends in sea level that deviate from historic trends, hence the need for the Unified Projection. Although significant changes in sea level trends are anticipated over the coming decades, a preliminary comparison of the Unified Projection and the available measured data is presented in Figure A-2. The 5-year average mean sea level was observed to track between the IPCC Median and NOAA Intermediate High curves from 2013 to 2017 (2017 was the last year of computable 5-year average at the time of publication).

Monthly mean sea level was observed to exceed the NOAA Intermediate High curve in almost every tidal cycle since 2000. For additional context, the linear trend based on historic data included in Figure A-1 remains below the IPCC Median curve from 2007 onward and below the 5-year average of mean sea level from 2010 onward.

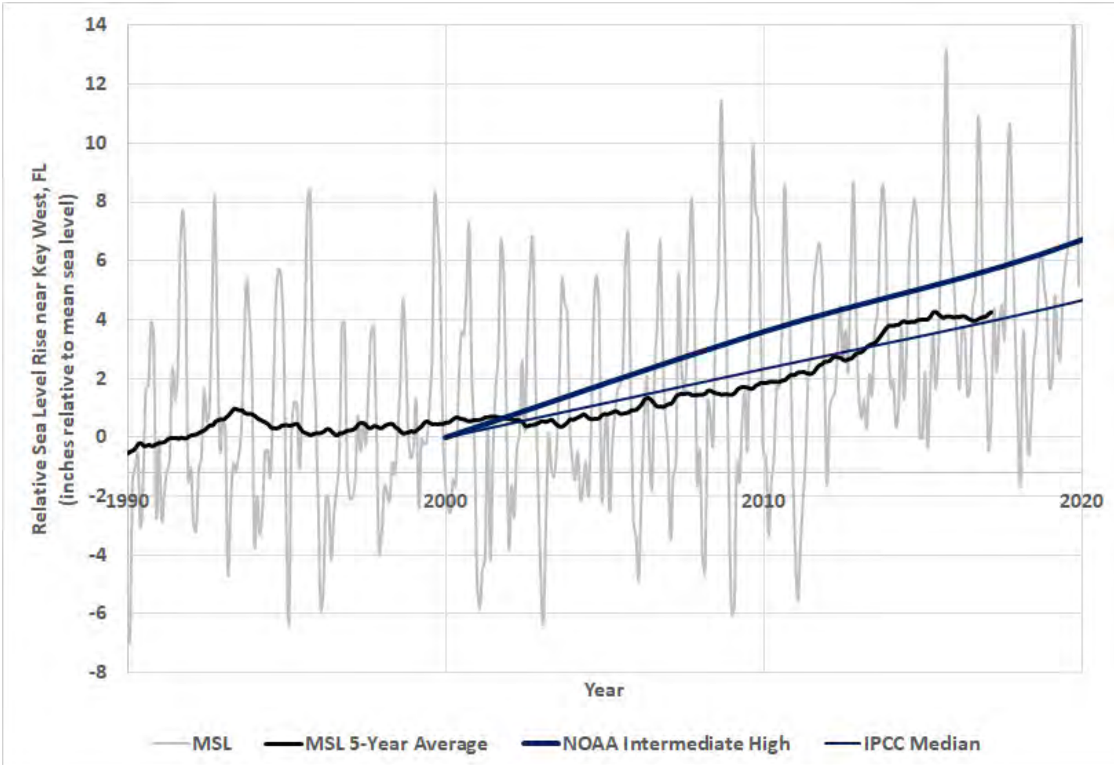

FIGURE A-2. Comparison of the Unified Sea Level Rise Projection from 2000 to 2020 and Relative Sea Level Rise in Key West, Florida from 1990 to 2020. Monthly mean sea level and the 5-year average of monthly mean sea level are based on measurements from NOAA Station ID 8724580.

ACCELERATION OF SEA LEVEL RISE

Dangendorf et al., (2017) produced a global mean sea level reconstruction for the 21st century incorporating up-to-date observations of vertical land motion and corrections for local gravitational changes resulting from ice melting and terrestrial freshwater storage. Their results provided a global sea level rise rate of 1.1 ± 0.3 millimeter per year before 1990 that is below previous estimates, and a rate of 3.1 ± 1.4 millimeter per year from 1993 to 2012 that is consistent with independent estimates from satellite altimetry.

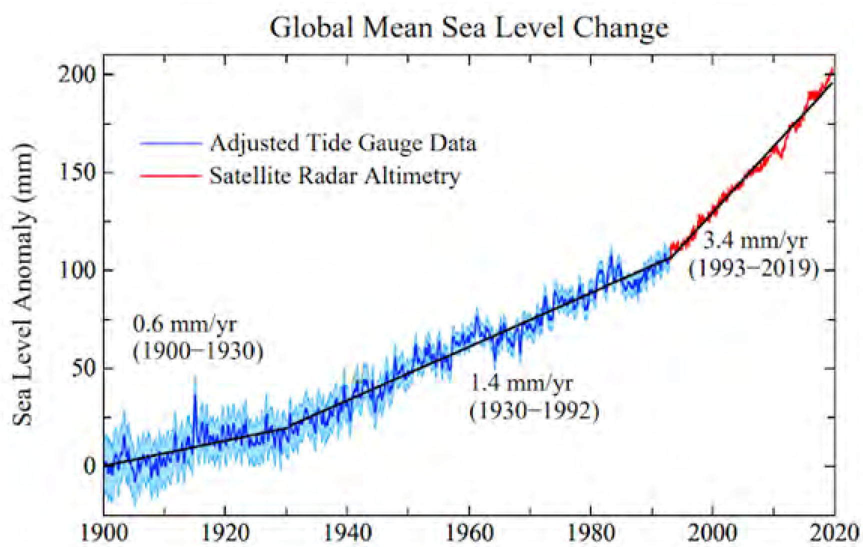

FIGURE A-3. Global mean sea level change from 1900 to 2019 and increasing acceleration rates (modified by Hansen et al., (2015) from Church and White (2011) and Hay et al., (2014). 1993 to 2019 data distributed by AVISO+ (https://www.aviso.altimetry.fr) with support from CNES.

Recent analyses of tide gauge records acquired along the United States Atlantic coast indicate year-to-year acceleration in the rate of sea level rise (Sweet et al., 2017). During 2010-2015, accelerated sea level rise at rates five times the global average was observed between Key West and Cape Hatteras (Valle-Levinson, 2017), and is attributed to the warming of the Florida Current (Domingues et al., 2018). Locally, Wdowinski et al. (2016) analyzed the Virginia Key tide gauge record (near Miami) and found a significant acceleration in the rate of sea level rise since 2006. The average rate of regional sea level rise since 2006 was 9±4 millimeters per year, significantly higher than the global average rate, which has been estimated to be in the range of 4-5 millimeters per year for the post-2006 period (WMO, 2019). The global and regional processes driving sea level rise and its acceleration are discussed in the following sections.

NOAA Sea Level Rise Scenarios

For the Compact 2019 projections, the workgroup referenced the technical information provided in the NOAA report (Sweet et al., 2017) which was also used as input to the sea level rise chapter of the National Climate Assessment (NCA) (https://science2017.globalchange.gov/chapter/12/). The sea level projections in the NOAA report were developed by a Federal Interagency Sea Level Rise Task Force and they included six scenarios (Table A-1 below) using a risk-based framing approach to deal with uncertainties. The scenario approach is similar to the regional sea level rise scenarios produced by Hall et al. (2016) and they are linked to the greenhouse gas emission scenarios, RCP 2.6, 4.5, and 8.5 as shown in Table A-1. The NOAA 2017 report includes the best available research since the production of the Compact 2015 report and is considered to be a reliable source of data from the national effort on sea level rise projections. More importantly, the projections are available regionally and that allowed the work group to customize 2019 projections using the Key West gauge as was done for the 2015 projections.

TABLE A-1: Interpretations of the Interagency Global Mean Sea Level (GMSL) rise scenarios (National Climate Assessment (NCA), Chapter 12)

SCENARIO	INTERPRETATION
Low	Continuing current rate of GMSL rise, as calculated since 1993 Low end of *very likely* range under RCP 2.6
Intermediate-Low	Modest increase in rate Middle of *likely* range under RCP 2.6 Low end of *likely* range under RCP 4.5 Low end of *very likely* range under RCP 8.5
Intermediate	High end of *very likely* range under RCP 4.5 High end of *likely* range under RCP 8.5 Middle of *likely* range under RCP 4.5 when accounting for possible ice cliff instabilities
Intermediate-High	Slightly above high end of *very likely* range under RCP 8.5 Middle of *likely* range under RCP 8.5 when accounting for possible ice cliff instabilities
High	High end of *very likely* range under RCP 8.5 when accounting for possible ice cliff instabilities
Extreme	Consistent with estimates of physically possible “worst case”

In general, the global sea level rise pathways for different emission scenarios are not very different until about the mid-century after which they deviate significantly (e.g. Figure 4.2, IPCC 2019). The broad range of sea level rise projection during the latter part of the century reflects the significant uncertainty in predicting the contributions of individual sea level rise components, attributable primarily to ice cliff instability. Driven by the desire to capture the potential for larger sea level rise resulting from rapid melting from the ice sheets towards the latter part of the century, the work group made a decision to select higher scenarios that are also consistent with the growing emission scenario, RCP 8.5. Recent sea level rise guidance from the Tampa Bay Region recommended the use of RCP 8.5 “*...until the private and public sectors make meaningful efforts to reduce greenhouse gas emissions.*” Consequently, the Intermediate High, and High scenarios (Table A-1) were included in the 2019 scenarios set. Consistent with the 2015 projections, IPCC Median scenario for RCP 8.5 was added to define the lower boundary of the range. The IPCC Median (with a Global Mean Sea Level, GMSL, rise of 0.73 meters) lies between Intermediate Low (0.5 meter of GMSL) and Intermediate (1 meter GMSL) scenarios in the NOAA 2017 set (Table A-1). The Work Group also included the NOAA 2017 Extreme Scenario as an estimate of the upper bound of what could happen as a result of a catastrophic ice sheet collapse and the primary intent of this inclusion was to emphasize what could happen to GMSL if the emissions were allowed to continue without mitigation.Inclusion of such an extreme scenario is not unprecedented. For instance, New York City (Gornitz et al., 2019) included a new, physically plausible, upper-end scenario dubbed ARIM (Antarctic Rapid Ice Melt) scenario for this purpose. The California guidance also includes a similar scenario, called H++ which reflects extreme sea level but with unknown probability.

FACTORS INFLUENCING FUTURE SEA LEVEL RISE

Global Processes

Thermal expansion

Warming of oceans leads to a lower density and as a consequence volume per unit mass increases. The ocean has absorbed more than 90% of the heat that is generated by heat trapping greenhouse gasses making the thermal expansion a significant component of the observed sea level rise. Thermal expansion is expected to increase, but its contribution to the global sea level rise may be exceeded by the increased contributions from melting land-based ice sheets.

Acceleration of Ice Melt

Accelerated melting of glaciers and ice sheets of Greenland and Antarctica has become the predominant factor affecting sea level rise acceleration (Oppenheimer et al., 2019). Melting is caused by anthropogenic forcing leading to increasing temperatures and warming of the atmosphere, warm currents moving along the coast of Greenland, and warm ocean water moving under and up into ice sheets through deep outlet glacial fjords in Greenland and Antarctica in response to meteorologic changes. The rate of melt of the Greenland Ice Sheet was relatively stable in the 1990s and has increased since then to a rate seven times greater than in 1992 (IMBIE, 2019; Chen et al., 2017). The rate of acceleration peaked in 2011, slowed in response to cooler conditions until 2016, but has begun increasing again. Although all of the ice melt processes are not fully represented in the climate projection models, studies suggest contributions from ice melt are likely to match the estimates of melt from the IPCC AR5 RCP 8.5 scenario (Oppenheimer et al., 2019).

Based on geologic records from the last two pre-historical periods that the Greenland and Antarctica ice sheets melted, global mean sea level likely rose 18 to 27 feet in response, but potentially as much as 75 feet. Models and analyses cannot yet confirm if similar rates of pre-historic rise will occur in response to melt in the future (Oppenheimer et al., 2019). The possibility of such extreme rise in response to ice melt prompted the inclusion of the NOAA Extreme curve for reference in the Unified Sea Level Rise Projection and to highlight the importance of greenhouse gas mitigation. Although unlikely and not appropriate for infrastructure planning, the Work Group wanted to acknowledge the evolving science in projecting accelerating ice melt and bracket the uncertainty in rise at the end of the century based on the most recent observations and models.

Thawing Permafrost

Frozen soils are both a major source of emissions today, and a major sink for carbon during past ice ages. Permafrost is permanently frozen soil, which holds vast amounts of organic material in a suspended state of decay. It is found in vast, remote and inaccessible places: under tundra's covered active layer (seasonally melted mud), underwater, and under sea ice and/or snow. It is the least understood, but potentially one of the most important climate change drivers. Satellite remote sensing is less useful in its direct observation of permafrost, compared to other phenomena important to sea level rise. But the high atmospheric methane concentration in the atmosphere above the northern polar region stands out above other regions on earth. Russian, Alaskan and other scientists from around the world are actively investigating the potential for significant additional emissions of carbon dioxide and methane from thawing permafrost (Shakova et al., 2019). Prior to the last three decades, heavy multi-year sea ice protected solid frozen permafrost, and the methane sequestered within it as massive subaqueous methane hydrate deposits. Release of this methane could constitute a powerful tipping point for atmospheric warming, and the glacial melting to follow. It is unknown when such a tipping point is likely to occur, but the continued acceleration of global warming with business as usual, RCP 8.5, puts us on a dangerous trajectory.

Regional/ Local Processes

Distinct rates of sea level rise recorded along the U.S. East Coast are currently largely modulated by the effect of various regional and local processes (Piecuch et al., 2018). The long-term regional sea level rise projections employed in this report are primarily based on the recent scenarios convened by the Sea Level Rise and Coastal Flood Hazard Interagency Task Force (Sweet et al., 2017), which explicitly consider these effects from regional drivers. As an example, regional drivers may account for an additional 37 centimeters of sea level rise by 2100 in Key West under the assumptions linked with the NOAA Intermediate-High scenario, totaling 1.87 meters of sea level rise compared with 1.5 meters globally. The following section describes the most important regional drivers that can affect rates of sea level rise in Southeast Florida.

Vertical Land Movement

Vertical earth movements (subsidence or uplift), which regionally and locally modify the averaged rate of sea level change, result in a relative rate of change that varies from one location to another. These land movements are inferred from historical tide data and geodesic measurements. When added to projected rates of mean sea level rise, the vertical land movement results in a perceived rates of sea level rise change ranging from increased rise in regions of subsidence (e.g., New Orleans) to falling sea levels where the land is being uplifted (e.g., along the northern border of the Gulf of Alaska). Sea level rise in geologically stable regions have only small differences with respect to the global rate of rise. Some of the processes leading to vertical land movement include the post-glacial rebound (known as Glacial Isostatic Adjustment — GIA), sediment compaction, dam retention, and groundwater and oil withdrawal.

A robust method for estimating vertical land movements is based on continuous GPS measurements conducted at selected locations. Over the past two decades, more than 60 continuous GPS stations were constructed and operated in Florida by federal and state institutes, including the Continuously Operating Reference (COR) network, US Coast Guard, Florida Department of Transportation, and others. The length of record in these stations vary from one to fourteen years, reflecting the difficulties in maintaining smooth operation of a continuous GPS station. The continuous GPS measurements indicate that vertical land movements in Florida are fairly small; they vary in the range of ±4 millimeters/year. In South Florida, in general, coastal land elevations are considered relatively stable—meaning that the land is not experiencing significant uplift or subsidence. Therefore, the processes listed above are likely not playing a major role on the current sea level rise rates observed in Southeast Florida. It is important to note, however, that the vertical land movement that is occurring is non-uniform across South Florida, and movement measured at specific monitoring stations sites may not reflect vertical land movement in adjacent areas.

Ocean Dynamics, Gulfstream/ Circulation

Regional patterns of sea level change are partly due to trends in ocean currents, redistribution of temperature and salinity, and atmospheric pressure. The reasons for changes in “Ocean Dynamics” are well known (Hall et al., 2016). Thermal expansion changes the elevation of the sea surface non-uniformly and to balance the resulting pressure gradient, ocean mass will flow from areas of large water depths into shallower continental shelf areas (Hall et al. 2016; Yin et al. 2009). Long-term changes in ocean dynamics still represent one of the largest sources of uncertainty for long-term projections of sea level rise (Kopp et al., 2014; Chen et al., 2019), and current observations show only a modest decline in the strength of the Florida Current flow.

Ocean circulation has changed little during the current period of scientific observation, but in the future it may considerably alter the relative rate of sea level rise in some regions, including Southeast Florida. The potential slowing of the Florida Current and Gulf Stream could result in a more rapid sea level rise along the east coast of North America. By 2100, these circulation changes could contribute an extra eight inches of sea level rise in

New York and three inches in Miami according to Yin et al. (2009). Most of the global climate models used by the IPCC (IPCC, 1913 project a 20-30% weakening of the Atlantic Meridional Overturning Circulation (AMOC), of which the Gulf Stream and Florida Current are a part, a response to warming caused by increasing greenhouse gases. Measurements of the AMOC have yet to conclusively detect the beginning of this change, however there has been a report of a recent decline in AMOC strength by Smeed et al. (2014) that coincides with the mid-Atlantic hotspot of sea level rise reported by Ezer et al. (2013) and Rahmstorf et al. (2015). Recent analysis of the Florida Current transport has detected only a slight decrease in circulation over the last decades. Assuming the long-term slowdown of the AMOC does occur, sea level rise along the Florida east coast could conceivably be as much as twenty centimeters (eight inches) greater than the global value by 2100. Given that changes in ocean dynamics, such as these changes projected for the AMOC, are still one of the main sources of uncertainty for long-term regional sea level rise scenarios (e.g. Kopp et al., 2014; Piecuch et al., 2018), longer records of the Florida Current and Gulf Stream transport are required to confirm if the long-term decline in the strength of the flow persists, or if it is associated with interannual/decadal natural variations. Recent regional sea level rise scenarios for the U.S. coasts have been made available by the Sea Level Rise and Coastal Flood Hazard Interagency Task Force (Sweet et al., 2017), and explicitly consider regional effects of changes in ocean dynamics and other local contributors, as described above.

Regional Ocean Heat Content Changes

Recent studies revealed accelerated rates of year-to-year changes in regional sea level variability along the U.S. East Coast (Valle-Levinson et al., 2017). Even though these variations are not necessarily linked with long-term sea level rise trends, these accelerated changes currently contribute to flooding conditions often observed at Southeast Florida communities. Analysis showed that accelerated sea level rise recently observed for Southeast Florida from 2010 to 2015 were in fact associated with thermal expansion from warming of the Florida Current during the same time period, as reported in Domingues et al., (2018). Further analysis (Volkov et al., 2019) revealed that such warming was linked to large-scale heat convergence within the North Atlantic subtropical gyre caused by changes in the Atlantic Meridional Overturning Circulation (AMOC). While current findings indicate that these effects occur mostly on year-to-year timescales, under a long-term scenario that includes the decline in the AMOC circulation (as suggested by IPCC 2013), it is likely that amplified sea level rise rates may be observed along Southeast Florida through similar mechanisms.

Sea level fingerprinting (Gravitational Effects)

Melting ice sheets in polar regions is one of the main processes contributing to sea level rise, but not in a spatially uniform manner, because of gravitational forces. Melting ice sheets reduces the mass of water stored in polar regions and, consequently, reduce the gravitational attraction of continental ice sheets. As a result, the volume of ocean water near the melting ice sheet decreases, leading to reduction in sea level height near the polar regions, and an increase in sea level further away. This process is termed sea level fingerprinting (Mitrovica et al., 2011, 2009). It suggests a counterintuitive change in regional patterns of sea level changes, in which sea level height decreases near the source of fresh water supply to the ocean.

A sea level fingerprinting study by Hay et al. (2014) suggest that melting of the Greenland Ice Sheet results in a slightly lower rate of sea level rise along the Florida shorelines with respect to the global mean rate. The calculated change is 20% of the total contribution of the Greenland Ice Sheet to the global mean rate, which is currently estimated as 1-1.5 millimeters/year. According to Hay et al. (2014), melting of the West Antarctic Ice Sheet increases the rate of sea level rise along the Florida coast by 20% with respect to the total contribution of the West Antarctic Ice Sheet to the global mean rate, which is so far about 0.75-1 millimeters/year. Thus far, the contribution of sea level fingerprinting in southeast Florida had been fairly small, about 0.2-0.3 millimeters/year.

However, in the future with increasing rate of polar ice melt, the effect of sea level fingerprinting can increase, especially if the Antarctic Ice Sheet will melt significantly faster than the Greenland Ice Sheet. It should be noted that the NOAA (2017) scenarios used for the current projections explicitly account for regional fingerprinting.

EFFECTS OF GREENHOUSE GAS EMISSIONS

The Intergovernmental Panel on Climate Change based the climate projections of their Fifth Assessment Report on four greenhouse gas concentration scenarios, known as the Representative Concentration Pathways (RCPs) (IPCC, 2014). These RCPs are sets of scenarios for greenhouse gas emission, greenhouse gas concentration, and land use trajectories; their primary product is greenhouse gas concentration scenarios for use as inputs into climate models (van Vuuren et al., 2011a). The number in the name of each RCP is the end-of-century radiative forcing in W/m^{-2} caused by the greenhouse gas concentrations in 2100.

The lowest concentration scenario, RCP 2.6, is viewed as the scenario necessary to keep global temperature increases below 2°C (van Vuuren et al 2011a). This scenario would require that greenhouse gas emissions peak around 2020 and decrease at 4% annually (van Vuuren et al. 2011a). The highest concentration scenario, RCP 8.5, assumes a greatly increased population with low economic and efficiency gains by 2100, along with a strong dependence on fossil fuels, including a ten-fold increase in coal use by the end of the century (Riahi et al., 2011).

RCP 4.5 and RCP 6.0 are concentration scenarios sitting between these two extremes. In the RCP 4.5 scenario, emissions valuation policies, reaching $85 per ton of carbon dioxide by 2100, drive alternatives in energy production and land use changes to reduce emissions. It assumes use of bioenergy production coupled with carbon capture and storage to produce energy with net-negative carbon emissions. RCP 6.0 assumes cost-effective reduction of emissions through a global emissions permit market, and includes a shift from coal-fired to gas-fired energy production and more than 30% non-fossil fuel energy production by 2100 (Masui et al., 2011).

Beyond these four concentration pathways, the IPCC recently released a report outlining the emissions scenarios required to limit global warming to 1.5°C (IPCC, 2018). In this model pathway, global net anthropogenic carbon dioxide emissions decline by about 45% from 2010 levels by 2030, reaching net zero around 2050. The report also contains an emissions projection to limit global warming to 2.0°C; in this scenario, carbon dioxide emissions decline by about 25% by 2030, and reach net zero around 2070.

Prior to 2050, different emission scenarios produce minor differences in sea level rise projections, however, they diverge significantly past mid century. After 2050, the sea level rise projections increasingly depend on the trajectory of greenhouse gas emissions, underscoring the critical need for urgent and ambitious decarbonization policies and efforts.

Seasonal Cycle of Sea Level and Interannual Variability

There is a strong seasonality to average sea level variation with any given year. This is primarily driven by seasonal oceanographic and atmospheric processes such as fluctuations in coastal ocean temperature, salinity, winds, atmospheric pressure, and ocean currents. In Southeast Florida, the sea level driven by astronomical tides exhibits a strong seasonality with higher than average values during the months of September to November with a peak during the month of October (Figure A-4). The seasonal high in October may be as much as 5-6 inches above the average. The high values during September to November, superimposed on the mean sea level curve and diurnal and semidiurnal tides further exacerbates the recurrent flooding that has been increasing in recent years.

In addition to the seasonal fluctuations, sea level may also exhibit interannual variability due to fluctuations in oceanographic and atmospheric processes (Figure A-4). Such fluctuations may further increase the mean annual sea level above the average seasonal cycle shown in Figure A-4 and they may persist at a higher or lower level for several years. For example, Figure A-5 shows that the annual fluctuation since about 2012 has been largely positive until 2019, a pattern that is not characteristic of annual variability since 1990. It is possible that such a persistence may be due to a systematic trend in ocean currents and/or other atmospheric-oceanographic process but it is too early to make such an attribution.

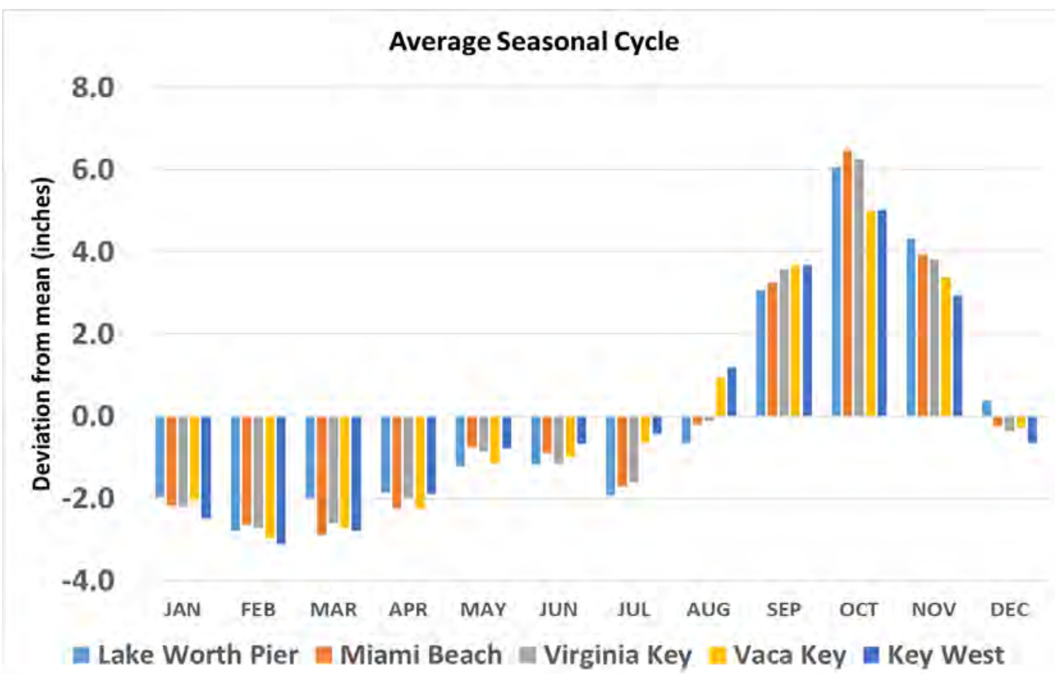

FIGURE A-4: Tidal water elevations in the Southeast Florida area average 5 to 6 inches higher at the end of the summer (NOAA, 2020b). This increases the risk of recurrent high tide street flooding and more severe storm surge impacts, particularly during periods of astronomical high tides (i.e. king tides). Ongoing and accelerating local sea level rise will just make this problem worse.

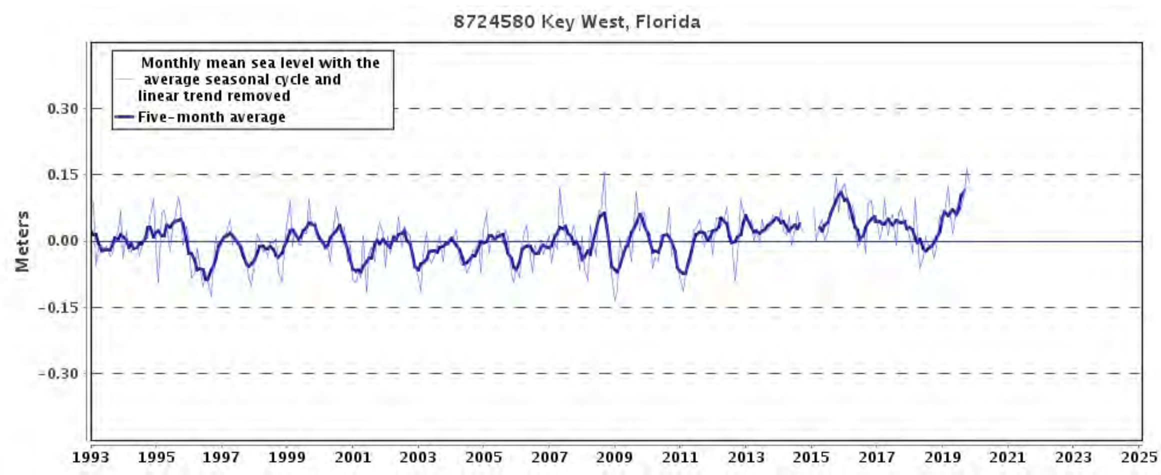

FIGURE A-5: The plot shows the interannual variation of monthly mean sea level and the 5-month running average. The average seasonal cycle and linear sea level trend have been removed (Retrieved from NOAA Tides and Currents website (https://tidesandcurrents.noaa.gov/)

Increase in Recurrent Tidal Flooding

Accelerating rates of sea level rise, due to both global and regional processes, have resulted in increased flooding frequency in several coastal communities along the US Atlantic coast, including the Southeast Florida region (Ezer et al., 2013; Ezer and Atkinson, 2014; Kirshen et al., 2008; Kleinosky et al., 2006; Sweet et al., 2018; Wdowinski et al., 2016; 2019; Valle-Levinson et al., 2017). These recurrent flood events, often termed "nuisance flooding," occur during high tide conditions, with or without heavy inland rainfall. When flooding events occur due to high tide flooding alone, they are also termed "king tides", or "sunny-day flooding." Recurrent tidal flooding results in inundation, impedes access, impairs stormwater drainage infrastructure, and damages vulnerable systems. With sea level rise, the frequency of tidal flooding will increase, leading to chronic flooding approaching permanent inundation.

An analysis of flooding frequency from 1998 to 2013 in Miami Beach revealed that recurrent tidal flooding events quadrupled, from two events during the eight years from 1998-2005, to 8 to 16 total events in the following eight years from 2006-2013 (Wdowinski et al., 2016). In 2005, 2015, 2016, and 2017, compound flooding induced by hurricanes led to the highest observed numbers of annual flood days on record (Ezer and Atkinson, 2017; Ezer et al., 2017; Wdowinski, 2019). From 2006 to 2012, recurrent tidal flooding occurred approximately every other year, typically during the fall (September through November). Since 2010, higher than normal tides have also been observed in the winter and spring seasons (Figure A-6, Wdowinski et al., 2019). In 2019, unprecedented flooding occurred in Key Largo, where a neighborhood was flooded continuously for more than four months.

How will flooding frequency evolve over time?

On the national scale, NOAA (2014) published an assessment of nuisance flooding finding that the duration and frequency of these events are intensifying around the United States. Subsequently, Park and Sweet (2015) demonstrated that coastal areas are experiencing an increased frequency of flood events (an acceleration) over the last few decades, and that this acceleration in flood occurrence will continue regardless of the specific rate of sea level rise. The recent assessment published by NOAA (Sweet et al., 2018) in fact shows that the number of high-tide flooding days has been increasing at a nonlinear rate for locations along the U.S. East Coast, including Southeast Florida. Results from this assessment indicate that under the NOAA Intermediate scenario, Miami will likely experience approximately 60 days of high-tide flooding per year by 2050, while under the NOAA Intermediate-High scenario this number may exceed 150 days per year (Figure A-7, personal communication, Sweet et al., 2018).

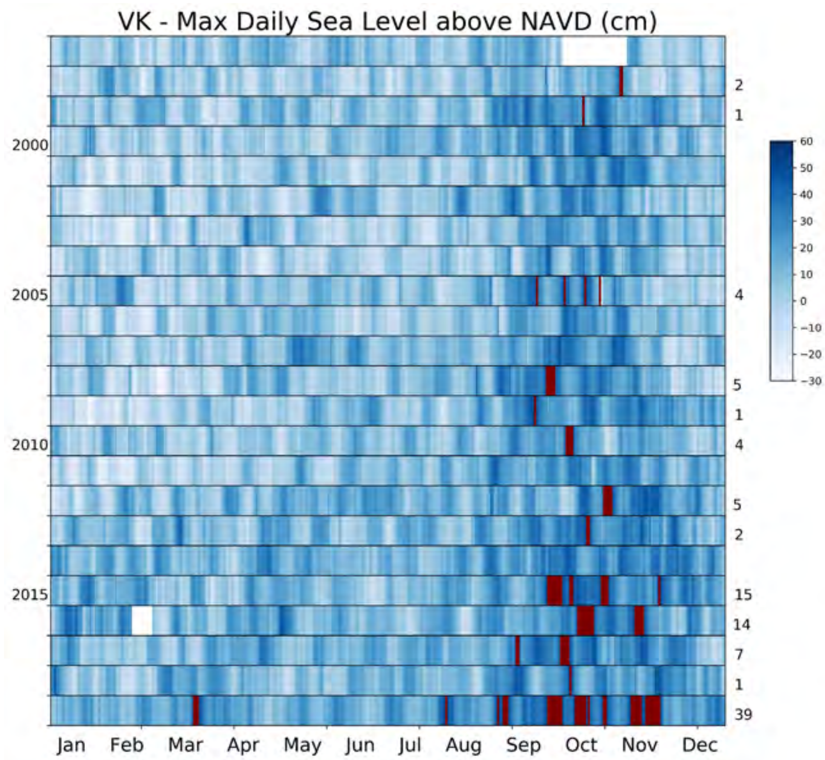

FIGURE A-6. Frequency of tidal flooding in Miami Beach, based on Virginia Key tide gauge. Higher than normal tides shown as red bars in figure. Number of events in a given year listed in right margin of graphic (Wdowinski, 2019).

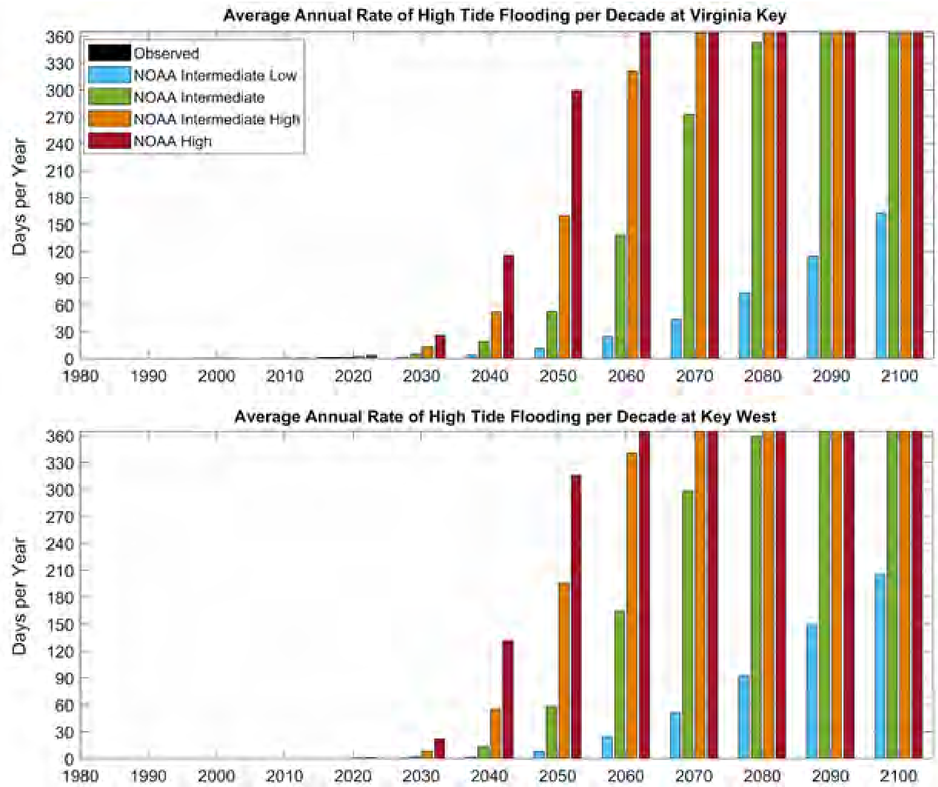

FIGURE A-7: Projected annual frequencies of high tide flooding associated with the NOAA sea level rise (Sweet et al., 2017) estimated at NOAA tide gauges in Virginia Key and Key West. High tide flooding threshold values levels above MHHW are 0.52 meters for Virginia Key, and 0.53 meter for Key West (Courtesy of William Sweet - NOAA National Ocean Service).

Groundwater Rise and Reduced Drainage Capacity

Sea level rise may also affect flooding by raising the water table and reducing the ability of rainfall to infiltrate and be stored in the soil. In coastal areas of Southeast Florida, groundwater levels were observed to rise at the same rate as sea level rise over the long term (Decker et al., 2019; Sukop et al., 2018). Flooding as a consequence of groundwater rise and reduced soil storage is anticipated to double or triple in flood frequency over the next 40 years (Sukop et al., 2018; Obeysekera et al., 2019). By 2070, certain coastal areas of South Florida are projected to lose all wet season storage capacity (Obeysekera et al., 2019).

In one example, Sukop et al. (2018) examined the long-term record of water levels in a well (G-852, in the North Miami/Arch Creek area) approximately one mile from tide water at Biscayne Bay. The water levels in the well have been increasing at approximately 2.8 millimeters/year since at least 1974. This rate is consistent with the rate of sea level rise at Key West of 2.42 millimeters/year over the same time period. (https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8724580).

As part of an assessment for the Florida Building Commission, Obeysekera et al. (2019) used projections of sea level rise from previous versions of this report in groundwater models to estimate the change in water table elevation in Miami-Dade County by 2069. Between 2010 and 2069, drainage capacity is estimated to decrease by four to ten inches of water in most of the county (Figure A-8) under the high sea level rise scenario.

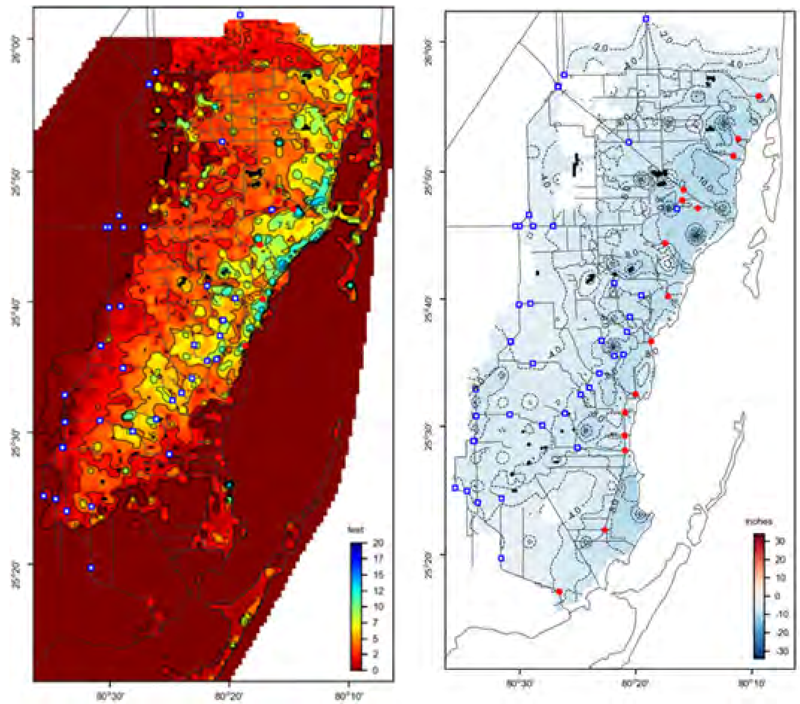

FIGURE A-8: Miami-Dade County depth to water in 2069 (left) and loss of wet season soil storage capacity from 2015 through 2069 (right) (Obeysekera et al., 2019).

Increasing sea levels also have the potential to compromise the capacity of coastal water control structures (also known as salinity barriers). As the ocean-side water levels increase, the water control gates of these gravity structures cannot be opened due to the threat of saltwater entering into the canals they serve and potentially contributing to saltwater intrusion (Obeysekera et al. 2011).

Storm Surge, Waves, and Sea Level Rise

Storm surge and sea level rise are independent coastal processes that, when occurring simultaneously, lead to compounded impacts. Sea level rise has the potential to increase the inland areal extent inundated by surges, the depth of flooding, power of the surge, and the extent and intensity of damage associated with storm surge and waves. As a result, severe storms of the future may cause significantly more damage than storms of equal intensity occurring at today's sea level. The frequency of extreme sea levels that cause severe flooding will also increase as a consequence of sea level rise (Rasmussen, 2018). To avoid impacts from surge, coastal infrastructure design elevations and reinforcement will need to consider the relationship between future sea level rise and surge.

The effects of sea level rise on storm tides or surge is nonlinear and location specific. Analyses that superimpose sea level rise projections on top of surge depths are likely not capturing the nonlinearity of the processes, and may possibly underestimate depths and forces. Reduction of sea bottom stress and tidal wave energy dissipation in waters deepened by sea level rise can result in higher surge heights in shallow nearshore waters (Arns et al., 2015). Similarly, changes in deep water wave heights and wave periods can increase wave setup and swash zone activity (Melet et al., 2018). Location- specific projections of future waves and the interactions between sea level, tides and surges are not yet available (Oppenheimer et al., 2019), but site-specific modeling of the impacts of future severe storms on infrastructure has occurred for projects across the Compact four-county region by increasing water levels to represent future conditions.

Rare, extreme water levels that typically occured once every 100 years in the past are projected to occur annually or more frequently by 2065 in response to sea level rise (Oppenheimer et al., 2019). The Intergovernmental Panel on Climate Change has concluded high confidence in this projected frequency and suggested adaptation planning occur before extreme events become regular in the latter half of the 21st century. Moreover, the duration, precipitation, landfalls, and intensity of future hurricanes is predicted to increase with global warming (IPCC, 2014; Knutson et al., 2015; Scoccimarro et al., 2017; Yamada et al., 2017).

Natural Resource Degradation

As sea level rise increasingly inundates coastal areas, natural resources in the ecologically diverse and important transition zone—including mangrove forests, tidal flats, and beaches—will be degraded unless focused effort is devoted to: 1) accommodating the inland migration of coastal habitats, and 2) implementing coastal management practices that maintain coastal elevation at pace with sea level rise rates (Glick 2006, Florida Oceans and Coastal Council 2010). In Southeast Florida, existing urban development in the form of seawalls, roads, and other infrastructure currently blocks much of the ability of coastal habitats to migrate as sea level rises. Reduced freshwater delivery and conversion of coastal areas to non-vegetated lands limit or eliminate plant growth, diminish the capacity for coastal areas to maintain natural system functions, and result in natural system decline. Intrusion of saltwater inland, into inland water bodies, and within the aquifer is already negatively impacting freshwater resources. With further sea level rise, these impacts will worsen or accelerate without adaptation that includes coastal management. Inundation of shorelines will also increase the extent and severity of beach erosion in previously stable coastal areas. In combination, these impacts will cascade throughout the region's ecosystems even if they are not immediately adjacent to open water areas.

These ecosystems (natural infrastructure) and the natural resources they support, are critical to the resilience of people and the urban environment. Natural systems provide many important benefits. These include providing nesting, spawning, and feeding habitat for numerous species including sea turtles, shorebirds, fish, and invertebrates; contributing to climate change mitigation via sequestration of carbon dioxide from the atmosphere; enhancing storm protection, water and air purification; moderating urban heat effects; and supporting livelihoods and economic activity throughout South Florida that depend on tourism and recreational and commercial fisheries. The region can manage for natural resource benefits by providing space for habitat transitions, implementing practices that help adapt coastlines to sea level rise, and reducing anthropogenic pressures (e.g., nutrient and solid waste pollution, recreational activities that can damage natural resources, development practices) that would compound the degrading effects of sea level rise.

For more information, visit:
www.climatecompact.org

CITY OF OAKLAND PARK, FLORIDA

Recommended Budget - Fiscal Year 2022
Stormwater (Fund 405) Summary of Revenues and Expenditures

	FY 2018 Actual	FY 2019 Actual	FY 2020 Actual	FY 2021 Amended Budget	FY 2021 Forecast	FY 2022 Recommended Budget
Funding:						
Permits Fees & Special Assessments	3,634,621	3,475,698	3,472,884	3,459,366	3,444,515	3,457,502
Intergovernmental Revenue	-	100,000	70,000	-	-	-
Miscellaneous Revenues	68,123	103,286	41,943	6,250	1,200	6,250
Other Sources	-	-	-	2,326,171	2,211,413	679,569
Total Funding	**3,702,744**	**3,678,983**	**3,584,826**	**5,791,787**	**5,657,128**	**4,143,321**
Expenditures:						
Departmental						
Stormwater	3,570,048	3,771,114	3,827,287	5,791,787	5,657,128	4,143,321
Total Departmental	**3,570,048**	**3,771,114**	**3,827,287**	**5,791,787**	**5,657,128**	**4,143,321**
Total Expenditures	**3,570,048**	**3,771,114**	**3,827,287**	**5,791,787**	**5,657,128**	**4,143,321**

Resilient Florida Infrastructure Funding

Year	Fiscal Year (July 1 – June 30)	Project Phase	DEP Grant Request Amount	Federal-sourced Match Amount	Other-sourced Match Amount	Cumulative Total
1	FY 22-23					
2	FY 23-24					
3	FY 24-25					
4	FY 25-26					
5	FY26-27					
Total Cost	N/A	Total for all phases				

Instructions

- Please fill out the table indicating what phase of the project will be worked on in each fiscal year and the associated costs for each year.

- The phases should include design, permitting, construction, feasibility studies, pre and post construction monitoring, etc.

- If a phase will overlap between fiscal years, please include each phase in each fiscal year row.

- Please note that state fiscal years are July 1 through June 30 and that is the basis on which we are requesting the breakdown.

- Please verify that this aligns with your tasks and deliverable due dates, and that the total amounts are correct.