

Village of North Palm Beach
Stormwater Master Plan

DRAFT
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Framework

Executive Summary 10
1. Introduction 1-1
1.1 Background and Orientation 1-1
1.2 Purpose and Scope of Study 1-1
1.3 Study Approach and Methodology 1-3
2. General Information and Data Sources 2-1
2.1 Village's Physical, Social and Economic Composition 2-1
2.2 Modeling Data Elements 2-5
2.2.1 Aerial Imagery 2-6
2.2.2 Digital Elevation Model 2-6
2.2.3 Watersheds Delineation 2-6
2.2.4 Rainfall 2-6
2.2.5 Soils 2-7
2.2.7 Land Cover, Land Use 2-11
2.2.8 Bathymetry 2-11
2.2.9 Hydraulics 2-11
2.2.10 Boundary Conditions 2-14
2.2.11 Insights 2-15
2.3 Regional Characteristics 2-17
2.3.1 Flood Zones 2-17
2.3.2 Contaminated Sites 2-17
2.3.3 Monitoring Wells 2-17
2.3.4 Wellfield Protection Zones 2-17
2.3.5 Saltwater Intrusion 2-17
2.3.6 SFWMD Drainage Basins and Ambient Monitoring Sites 2-17
3. Modeling Methodology, Parameterization and Assumptions 3-1
3.1 Modeling Approach and Software 3-1
3.2 Hydrology 3-1
3.2.1 Curve Numbers 3-1
3.2.2 Time of Concentration and Unit Hydrograph 3-2

3.2.3 Node Storage 3-2
3.3 Hydraulics 3-3
3.3.1 Links 3-3
3.3.2 Channels 3-4
3.3.3 Culverts 3-4
3.3.4 Overland Irregular Weirs 3-4
3.4 Modeling Schematic 3-5
3.5 Simulations 3-7
4. Identification of Flood Prone Areas 4-1
4.1 Consideration of Critical Assets 4-1
4.2 Flood Risk Modeling Results – Existing Scenario 4-1
4.2.1 2023 Current Sea Level, Existing Scenario 4-1
4.2.2 2040 NOAA Intermediate-Low Sea Level Rise, Existing Scenario 4-1
4.2.3 2040 NOAA Intermediate-High Sea Level Rise, Existing Scenario 4-2
4.2.4 2070 NOAA Intermediate-Low Sea Level Rise, Existing Scenario 4-4
4.2.5 2070 NOAA Intermediate-High Sea Level Rise, Existing Scenario 4-4
4.3 Level of Service Analysis 4-4
4.3.1 Roadways 4-5
4.3.2 Structures 4-8
4.3.3 Recommendations 4-10
5. Requirements for Proposed Surface Water Management Systems 5-1
5.1 Design Criteria 5-1
5.2 Water Quantity 5-1
5.3 Water Quality 5-1
5.3.1 Regulatory Authorities 5-2
5.3.2 Water Quality Criteria 5-2
5.3.3 Future Changes to Stormwater Permitting 5-3
5.3.4 Stormwater Best Management Practices 5-4
5.3.5 Floodplain Management 5-11
6. Proposed Projects for the Village's Capital Improvement Program and Additional Recommendations 6-1
6.1 CIP Proposed Improvements 6-1

6.1.1 CIP No. 1 - Project Specific Stormwater Management Improvements 6-4
6.1.2 CIP No. 2 - Tidal Valve Program 6-10
6.1.3 CIP No. 3 - Swale Rehabilitation Program 6-10
6.1.4 CIP No. 4 – Asset Cleaning, Inspection, Pipe Rehabilitation and Maintenance Program 6-11
6.1.5 CIP No. 5 - Water Quality and Environmental Protection Program 6-12
6.1.6 Summary of Capital Improvements 6-13
6.2 Flood Risk Modeling Results - Proposed Scenario 6-15
6.2.1 2023 Current Sea Level, Proposed Scenario 6-15
6.2.2 2040 Intermediate-High Sea Level Rise, Proposed Scenario 6-15
6.2.3 2070 Intermediate-High Sea Level Rise, Proposed Scenario 6-15
6.2.4 Comparison of Existing vs. Proposed Scenario 6-15
6.3 Recommended Programs, Practices, and Policies 6-16
6.3.1 Incentive Programs for Private Properties 6-16
6.3.2 Green Infrastructure and Materials 6-20
6.3.3 Community Outreach and Engagement 6-20
7. Stormwater Utility Fee and Rate Recommendations 7-1
7.1 Impacts of CIP on Stormwater Utility Rates 7-1
7.2 Stormwater Utility Rate Modifications 7-4
7.3 Grant Funding 7-4

List of Tables

Table 2-1: Village at a Glance 2-1
Table 2-2: Parks and Recreational Facilities 2-3
Table 2-3: Census Quick Facts 2-4
Table 2-4: Modeled Rainfall Depths 2-7
Table 2-5: Soil Types Listed by Percent Cover within the Village 2-7
Table 2-6: Percentage of Hydrologic Soil Groups within the Village 2-8
Table 2-7: SFWMD DBHYDRO Flow and Stage Data 2-14
Table 2-8: External Hydrograph Inflow Values 2-14
Table 2-9: Active NOAA Water Level Tidal Stations with Published Datums 2-15
Table 3-1: Curve Number Matrix 3-3
Table 3-2: Link Summary by Type 3-4
Table 3-3: Model Simulations 3-8
Table 3-4: Model Simulation Naming Structure Parts 3-8
Table 4-1: Performance Measure and Weight Factor for Flooded Roadways 4-5
Table 4-2: Performance Measure and Weight Factor for Flooded Structures 4-8
Table 5-1: Allowable Discharge by Drainage Basin 5-1
Table 5-2: Water Quality/Quantity Regulatory Agencies 5-2
Table 5-3: Common Stormwater Runoff Pollutants 5-6
Table 5-4: Examples of Nonstructural Best Management Practices 5-8
Table 5-5: Advantages and Disadvantages of Stormwater Treatment Systems 5-10
Table 5-6: Stormwater Treatment System Innovations 5-11
Table 6-1: Tidal Valve Program – Near-Term Recommended Locations 6-10
Table 6-2: CIP No. 4 – Annualized Expenses 6-11
Table 6-3: CIP No. 5 – Pollution Abatement Systems 6-13
Table 6-4: Summary of Proposed Capital Improvement Projects 6-14
Table 7-1: Proposed Capital Improvement Projects Implementation 7-2
Table 7-2: Projected Monthly Rate per ERU 7-4
Table 7-3: Grant Funding Sources 7-5

List of Figures

Figure 1-1: Location Map 1-2
Figure 2-1: Existing Land Use 2-2
Figure 2-2: Future Land Use 2-3
Figure 2-3: Soil Types 2-9
Figure 2-4: Hydrologic Soil Groups 2-10
Figure 2-5: Bathymetry 2-12
Figure 2-6: Existing Stormwater Infrastructure 2-13
Figure 2-7: NOAA Tidal Stations with Published Datums 2-16
Figure 2-8: FEMA Flood Zones 2-18
Figure 2-9: Contaminated Sites 2-19
Figure 2-10: Wellfield Protection Zones 2-20
Figure 2-11: Saltwater Intrusion 2-21
Figure 2-12: SFWMD Drainage Basins and Environmental Monitoring Stations 2-22
Figure 3-1: Modeling Schematic 3-6
Figure 4-1: Critical Asset Locations 4-3
Figure 4-2: Roadway Classification 4-6
Figure 4-3: Existing Roadway Flooding Depth, 10YR-24HR 4-7
Figure 4-4: Existing Structure Flooding, 100YR-72HR 4-9
Figure 4-5: Basin Prioritization Ranking 4-11
Figure 6-1: Capital Improvement Program, Recommended CIP 1 Stormwater Improvement Projects 6-3
Figure 6-2: Lakeside Park Seawall 6-8
Figure 6-3: Elevation Profile Along the Coast of Lakeside Park 6-9
Figure 6-4: Anchorage Park Seawall 6-10
Figure 6-5: 2023 Current Sea Level, Comparison of Existing vs. Proposed Scenarios, 25YR-24HR 6-17
Figure 6-6: 2040 Intermediate-High Sea Level Rise, Comparison of Existing vs. Proposed Scenarios, 25YR-24HR 6-18
Figure 6-7: 2070 Intermediate-High Sea Level Rise, Comparison of Existing vs. Proposed Scenarios, 25YR-24HR 6-19

List of Appendices

Appendix A-1: External Boundary Condition – S-44 External Hydrographs
Appendix A-2: External Boundary Condition – Observed NOAA Tidal Data at the Lake Worth Pier Station & Projected Sea Level Rise Scenarios
Appendix A-3: Excerpt from the 2022 “Global and Regional Sea Level Rise Scenarios for the United States” Technical Report
Appendix A-4: Excerpt from the National Resources Conservation Service Technical Release 55
Appendix A-5: Existing Scenario with 2023 Current Sea Level Flooding Depths
Appendix A-6: Existing Scenario with 2040 Intermediate-Low Sea Level Flooding Depths
Appendix A-7: Existing Scenario with 2040 Intermediate-High Sea Level Flooding Depths
Appendix A-8: Existing Scenario with 2070 Intermediate-Low Sea Level Flooding Depths
Appendix A-9: Existing Scenario with 2070 Intermediate-High Sea Level Flooding Depths
Appendix A-10: FEMA FIRM Panels for the Village (Effective Date 10/05/2017)
Appendix A-11: Proposed Scenario with 2023 Current Sea Level Flooding Depths
Appendix A-12: Proposed Scenario with 2040 Intermediate-High Sea Level Flooding Depths
Appendix A-13: Proposed Scenario with 2070 Intermediate-High Sea Level Flooding Depths

List of Acronyms

Abbreviation	Definition
ARPA	American Rescue Plan Act
ASCE	American Society of Civil Engineering
BMP	Best Management Practice
BRIC	Building Resilient Infrastructure and Communities
C-17	SWFMD Canal No. 17
CFS	Cubic Feet per Second
CIP	Capital Improvement Program/Capital Improvements Project
CWA	Clean Water Act
CRS	Community Rating System
CSM	cubic feet per second per square mile
DBHYDRO	South Florida Water Management District's corporate environmental database
DEM	Digital Elevation Model
DHS	Department of Homeland Security
DOD	Department of Defense
EPA	Environmental Protection Agency
EPGMD	Environmental Protection and Growth Management Department
ERP	Environmental Resource Permit
ERU	Equivalent Resident Unit
F.A.C.	Florida Administrative Code
FEMA	Federal Emergency Management Agency
FDEM	Florida Department of Emergency Management
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FIRM	Flood Insurance Rate Maps
FMA	Flood Mitigation Assistance
FSA	Florida Stormwater Association

Abbreviation	Definition
FY	Fiscal Year
GIS	Geographic Information System
GWIS	Geographic Watershed Information System
H&H	Hydrologic and Hydraulic
HAT	Highest Astronomical Tide
Hazen	Hazen and Sawyer
HHC	Human Health–Based Criteria
HMGP	Hazard Mitigation Grant Program
HSG	Hydrologic Soil Group
HVAC	Heating, Ventilation and Air Conditioning
ICPRv4	Streamline Technologies, Inc. Interconnected Pond and Routing model, version 4
LCLU	Land Cover Land Use
LF	Linear Feet
LiDAR	Light Detection and Ranging
LOS	Level of Service
NFIP	National Flood Insurance Program
MHHW	Mean Higher-High Water
MHW	Mean High Water
MS4	Municipal Separate Storm Sewer System
MSL	Mean Sea Level
NASA	National Aeronautics and Space Administration
NAVD88	1988 North American Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NPBCID	Northern Palm Beach County Improvement District
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS TR-55	National Resources Conservation Service Technical Release No. 55

Abbreviation	Definition
RIG	Resilience Implementation Grant
RLA	Repetitive Loss Areas
SFHA	Special Flood Hazard Area
SFWMD/WMD	South Florida Water Management District/Water Management District
SSURGO	Soil Survey in the Soil Survey Geographic
SWML	Surface Water Management License
TMDL	Total Maximum Daily Loads
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
Village	Village of North Palm Beach

Executive Summary

This report summarizes the Stormwater Master Plan analysis performed for the Village of North Palm Beach (Village) and satisfies the deliverable under Phase II of Village Contract 102022/102259, Stormwater Master Plan Modeling and Design Implementation Services.

Hazen and Sawyer (Hazen) was tasked with developing a Stormwater Master Plan for the Village. The assessment is 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 Village to understand the Village's composition, flooding insight, and water quality concerns and to identify facilities and areas with known vulnerabilities. Flood risk modeling results and condition assessments facilitated the identification and prioritization of specific proposed projects and broader programmatic improvements to address areas of concern throughout the Village.

The study's approach and methodology were based on developing a hydrologic and hydraulic model to simulate the Village's current and future stormwater infrastructure and operations under various conditions. The model's results, paired with knowledge regarding historical areas of flooding concern, including Village staff insights, were used to inform and direct the proposed CIP. The proposed projects were simulated to support final recommendations and an action plan for the Village to allocate and apply stormwater funds to prioritized neighborhoods or areas.

Several data elements were sourced, organized, and prepared with software tools and applications to dovetail raw data into modeling inputs and parameters. These data elements include aerial imagery, digital elevation model, watersheds delineation, rainfall, soils, land cover, land use, bathymetry, hydraulics, and boundary conditions. The model was run for a total of 34 simulations, 25 of which were for existing infrastructure conditions and nine for proposed infrastructure conditions, with varying planning horizons, sea level rise conditions, and design storms.

A level of service evaluation was conducted to determine the stormwater system's level of performance with respect to site-specific criteria. Flooding of roadways and (building) structures were used as the primary criteria for quantifying the Village's existing level of service under different storm events. The final scores determined from the level of service analysis of flooded roadways and structures were added together to determine the overall score for each basin. Basins with a higher score than their surrounding basins have a lower level of service and should be prioritized for further stormwater management projects. It should be noted that a variety of other logistical considerations also helped inform the prioritization and timing of projects.

Several design criteria are to be considered in the detailed development and evaluation of proposed improvements. The design frequency for structure improvements is the 100-year, 72-hour storm event, while for roadways it is the 10-year, 24-hour storm event. Additionally, Village-adopted requirements for seawall and barrier protection against rising sea levels and other tidal impacts were also used in proposing capital investments of that nature.

Water quality improvement is a particularly important consideration for the Village, especially because of the community's strong connection to adjacent water bodies. The Plan identifies criteria to be used in

association with new development and redevelopment to help protect local water quality. Also, the proposed slate of capital improvements includes a number of projects which serve to retrofit already developed areas with water quality best management practices (BMPs).

Lastly, as a coastal community with a significant waterfront interface, adaptation to a changing climate (both rainfall intensities and rising sea levels) is critical. As such, all proposed projects have been evaluated with consideration for these future conditions. Several of the CIP projects have elements to specifically address the impacts of climate change, such as the addition of pumping capability to overcome higher tailwater conditions. Also, a programmatic initiative to install tidal valves on systems serving low lying areas, combatting tidal (sunny day) flooding has been included.

Using the suite of projects and programs identified, a 5-year CIP was developed. Based upon the current base of ERU's in the Village's Stormwater Utility Assessment Program, an estimation of the resultant rate (needed to fund the 5-year CIP) was made.

In conclusion, this Stormwater Master Plan provides a comprehensive analysis of the Village's stormwater management systems and identifies areas in need of improvement. The proposed Capital Improvement Program, developed based on the modeling results and level of service analysis, offers a roadmap for the Village to allocate and apply stormwater funds to prioritized neighborhoods or areas. The recommendations and proposed improvements presented in this report will help the Village improve its stormwater management and prepare for future challenges.

1. Introduction

1.1 Background and Orientation

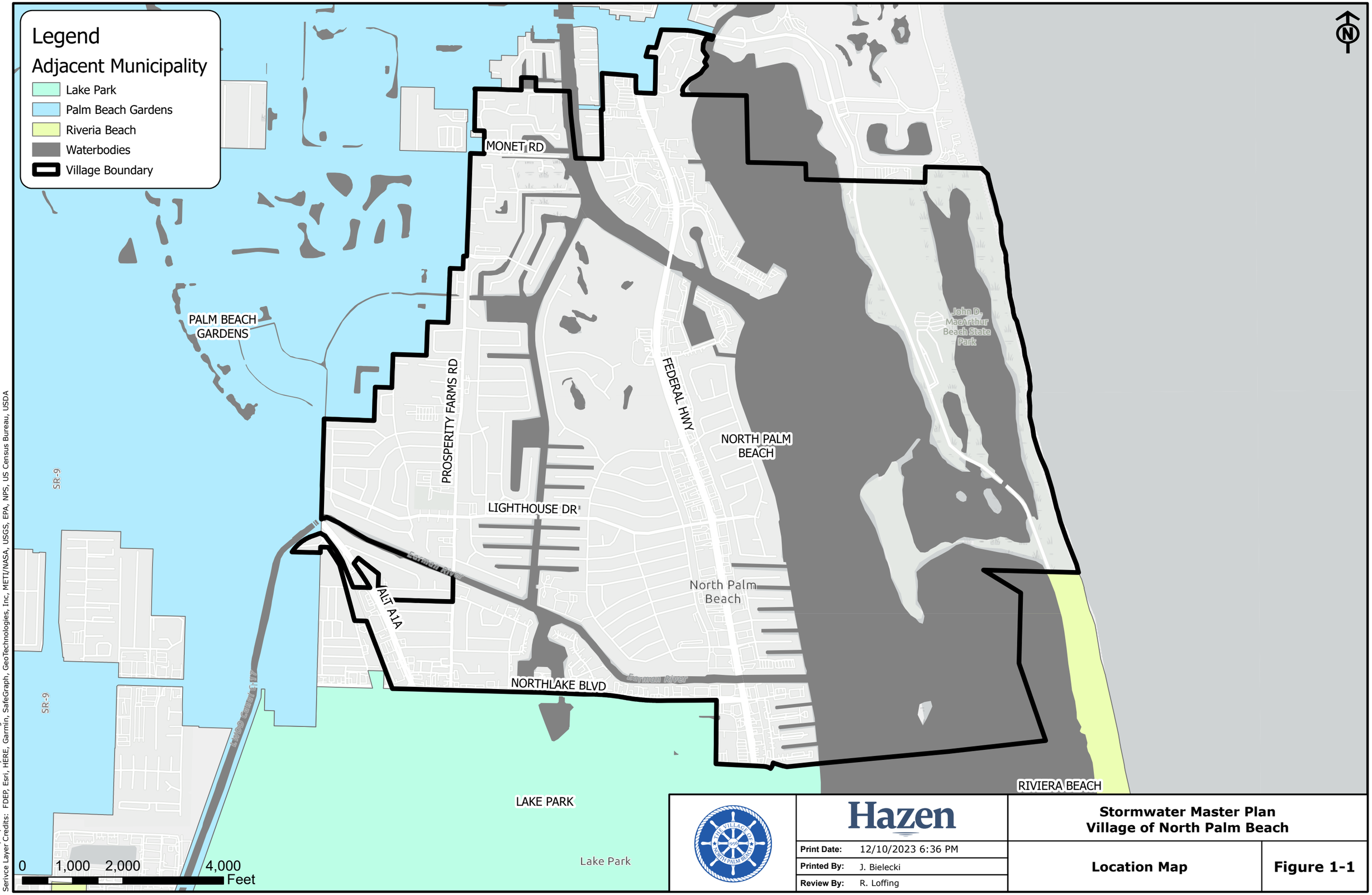
The Village of North Palm Beach (Village) is a southeast Florida community that became a municipality in 1956. The Village grew as more people moved to the area in the mid-20th century, and it is one of 39 municipal entities in Palm Beach County. The Village has the cities of Palm Beach Gardens, Lake Park, Riviera Beach, and unincorporated Palm Beach County as its neighbors. **Figure 1-1** shows where the Village is located compared to the surrounding municipalities.

1.2 Purpose and Scope of Study

Stormwater management is a fundamental concern for the Village, a coastal, urban region that is challenged by high groundwater levels, rising sea levels and increasingly frequent intense storms, as well as saltwater intrusion and water quality concerns. The Village strives to improve its stormwater management by supporting both physical assets as well as policies, procedures, and operations in preparation for flooding events and in protection of the Village's groundwater, surface waters, and natural resources.

The purpose of this Stormwater Master Plan is to analyze the Village's stormwater management systems, policies, and procedures to identify areas in need of improvement. This 2023 Master Plan report contains the approach, modeling methodology and results, as well as the proposed recommendations arising from the study.

The scope of this village-wide study includes taking inventory of the Village's existing stormwater assets and collecting data from various regional entities and organizations, identifying water quality and regulatory compliance requirements, developing a hydrologic and hydraulic (H&H) model representing current/existing conditions as well as two (2) future time scenarios (2040 and 2070), performing a level of service (LOS) analysis, developing a Capital Improvement Program (CIP) and evaluating the impacts of the CIP on the Village's stormwater utility rates.



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1.3 Study Approach and Methodology

The study's approach and methodology were based on developing an H&H model to simulate the Village's current stormwater infrastructure and operations under various conditions. The model results, paired with knowledge regarding historical areas of flooding concern, including Village staff insights, were used to inform and direct the proposed CIP. The proposed projects were simulated to support final recommendations and an action plan for the Village to allocate and apply stormwater funds to prioritized neighborhoods or areas.

The Stormwater Master Plan's development was comprised of the following tasks:

- Collection of existing hydrologic, hydrogeological, and hydraulic data for the purpose of developing a village-wide stormwater model to evaluate flood protection LOS.
- Identification of prudent water quality improvements and regulatory compliance requirements.
- Development of a hydrologic/hydraulic stormwater model. The model consists of the existing and proposed stormwater systems, and current and future boundary conditions, including future projected climatological conditions.
- Development of conceptual solutions for CIP, specifically in the areas found to be most susceptible to chronic flooding.
- Identification of funding sources and estimation of impacts of the proposed CIP on stormwater utility rates.
- Development of a permitting approach for the proposed infrastructure utilizing modeling methods and results to expedite permitting of resultant CIP projects.

2. General Information and Data Sources

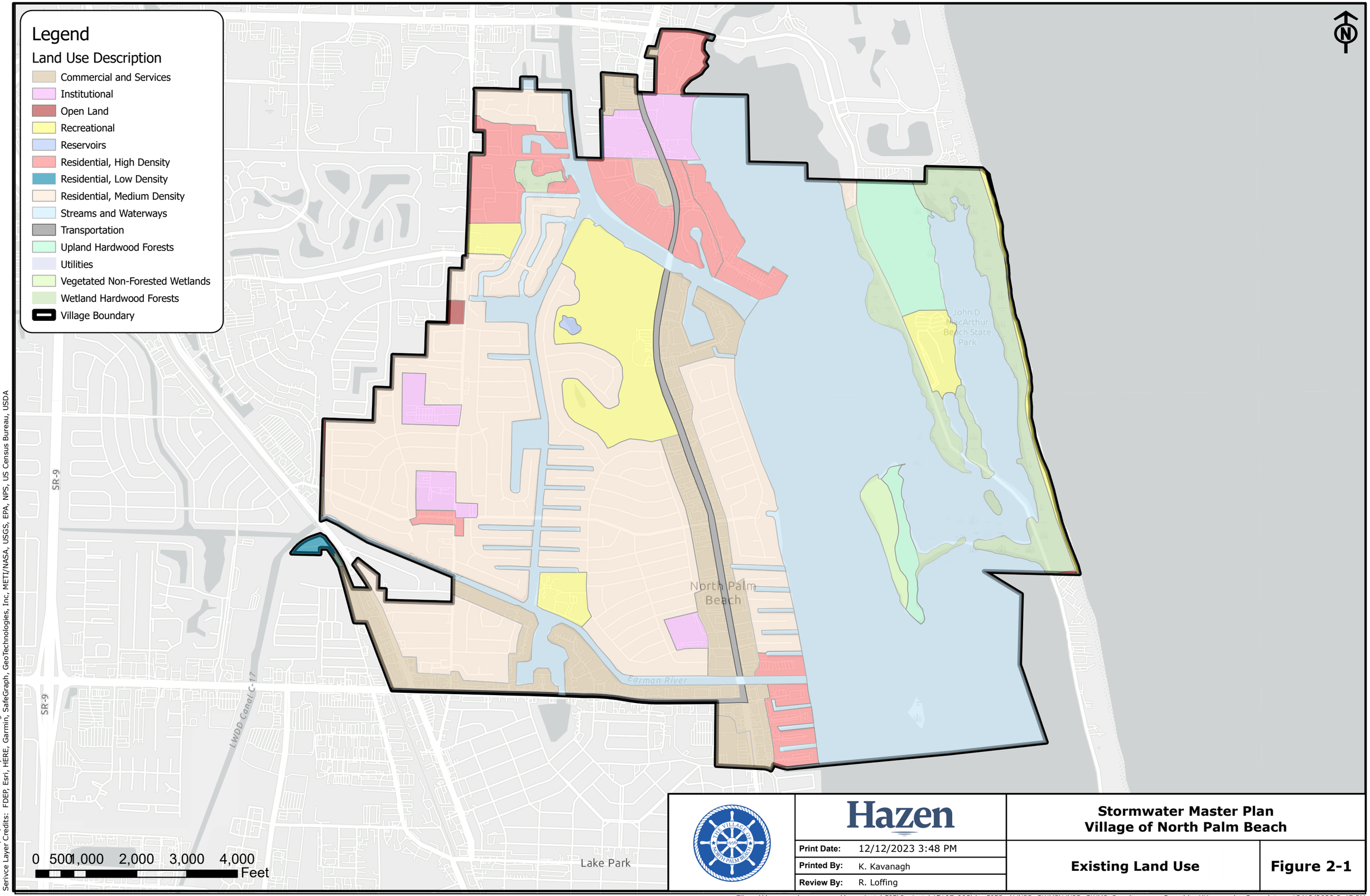
2.1 Village's Physical, Social and Economic Composition

The following series of tables detail the physical, social, and economic composition of the Village, with **Table 2-1** providing a brief overview. The Village is typical of a coastal community in Palm Beach County with predominantly residential and commercial property, open parks and green spaces with limited undeveloped areas. The Village's physical, social, and economic composition provides insight and facilitates a translation of the modeling results into stormwater planning.

Table 2-1: Village at a Glance

Description	Value	Unit
Date of Incorporation	August 13, 1956	-
Fiscal Year	October 1 - September 30	-
Form of Government	Council/Manager	-
Area of Village	5.8	square miles
Property Valuation	$2.96	billion dollars
Millage Rate	$6.9	rate (dollars)
Budgeted Positions		
Full-time	156	people
Part-time	108	people

Figure 2-1 presents the existing land use and **Figure 2-2** highlights the future land use provided by the Village as of 2021. The Village is largely comprised of low-density residential areas. Please note that there are two (2) types of wetlands that occur within the Village: Vegetated Non-Forested Wetlands and Wetland Hardwood Forests.



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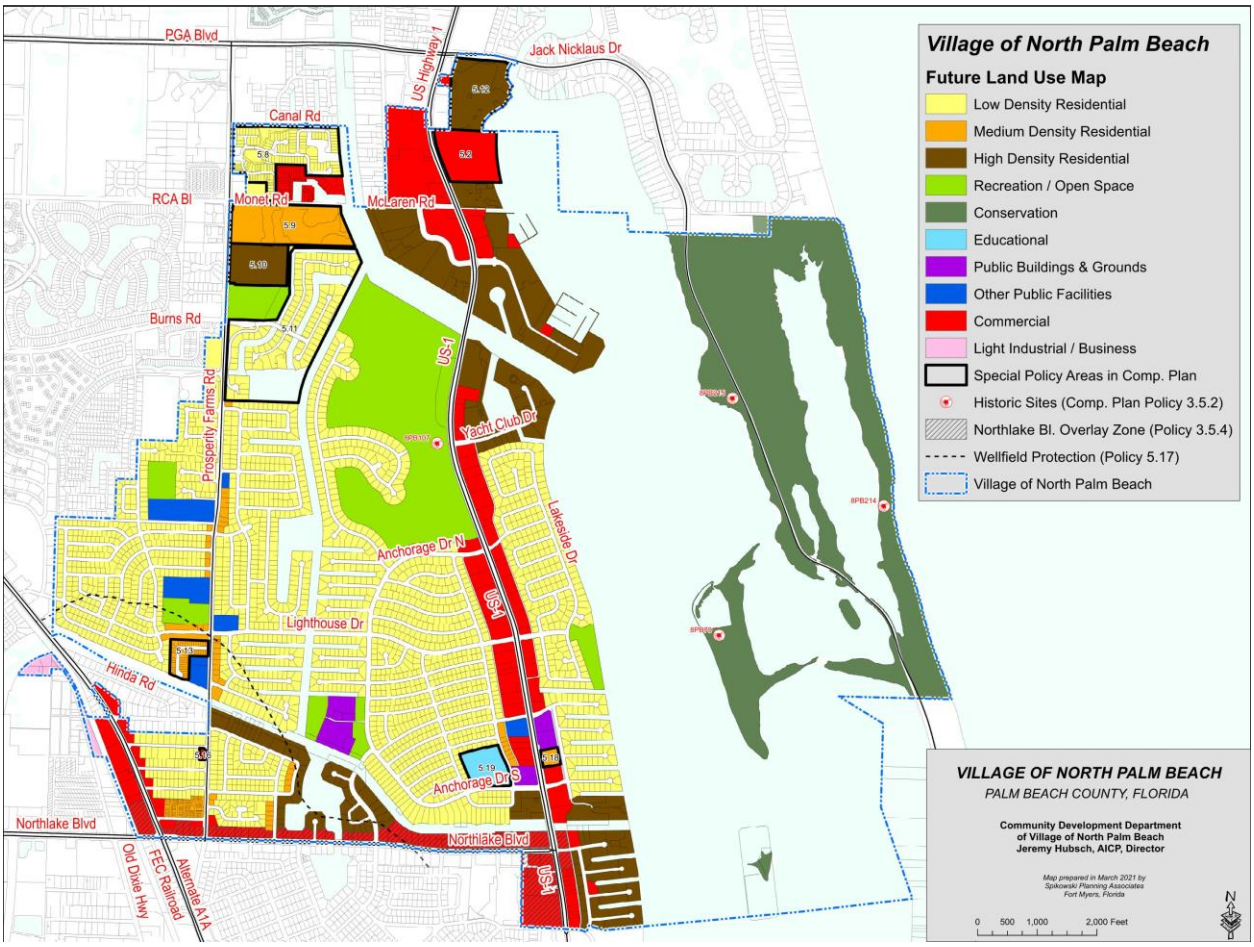


Figure 2-2: Future Land Use

The Village contains four (4) parks and one community center as highlighted in **Table 2-2**.

Table 2-2: Parks and Recreational Facilities[1]

Facility Name	Area (acres)
Anchorage Park	21.5
Community Center	12.5
Lakeside Park	5.7
Osborne Park	7.1
Veterans Park	0.5
Total Area	**47.3**

The Census Quick Facts provided by the United States Census Bureau are shown in **Table 2-3.**

[1] Information shown within this table was sourced from the Village website (https://www.village-npb.org/191/Parks-Recreation).

Table 2-3: Census Quick Facts

Fact	Village Value	Palm Beach County Value
Population		
Population Estimates, July 1, 2022, (V2022)	13,083	1,518,477
Population estimates base, April 1, 2020, (V2022)	13,160	1,492,198
Age and Sex		
Persons under 5 years, percent	3%	5%
Persons under 18 years, percent	13%	19%
Persons 65 years and over, percent	33%	25%
Female persons, percent	51%	51%
Race and Hispanic Origin		
White alone, percent	90%	74%
Black or African American alone, percent	1%	20%
American Indian and Alaska Native alone, percent	0%	1%
Asian alone, percent	3%	3%
Native Hawaiian and Other Pacific Islander alone, percent	0%	0%
Two or More Races, percent	5%	2%
Hispanic or Latino, percent	10%	24%
White alone, not Hispanic or Latino, percent	84%	52%
Population Characteristics		
Veterans, 2017-2021	1,545	72,340
Foreign born persons, percent, 2017-2021	12%	26%
Housing		
Owner-occupied housing unit rate, 2017-2021	78%	69%
Median value of owner-occupied housing units, 2017-2021	$366,400	$316,600
Median selected monthly owner costs -with a mortgage, 2017-2021	$2,222	$1,945
Median selected monthly owner costs -without a mortgage, 2017-2021	$862	$733
Median gross rent, 2017-2021	$1,594	$1,534
Families and Living Arrangements		
Households, 2017-2021	6,316	581,119
Persons per household, 2017-2021	2.07	2.51
Living in same house 1 year ago, percent of persons age 1 year+, 2017-2021	87%	86%
Language other than English spoken at home, percent of persons age 5 years+, 2017-2021	14%	33%
Computer and Internet Use		
Households with a computer, percent, 2017-2021	96%	95%
Households with a broadband Internet subscription, percent, 2017-2021	93%	88%
Education		
High school graduate or higher, percent of persons age 25 years+, 2017-2021	97%	89%
Bachelor's degree or higher, percent of persons age 25 years+, 2017-2021	48%	38%

Fact	Village Value	Palm Beach County Value
Health		
With a disability, under age 65 years, percent, 2017-2021	7%	7%
Persons without health insurance, under age 65 years, percent	10%	17%
Economy		
In civilian labor force, total, percent of population age 16 years+, 2017-2021	54%	60%
In civilian labor force, female, percent of population age 16 years+, 2017-2021	52%	55%
Total health care and social assistance receipts/revenue, 2017 ($1,000)	90,695	12,287,254
Total transportation and warehousing receipts/revenue, 2017 ($1,000)	1,693	2,228,937
Total retail sales, 2017 ($1,000)	113,306	24,445,666
Total retail sales per capita, 2017	$8,667	$16,623
Transportation		
Mean travel time to work (minutes), workers age 16 years+, 2017-2021	19.5	26.3
Income and Poverty		
Median household income (in 2021 dollars), 2017-2021	$81,135	$68,874
Per capita income in past 12 months (in 2021 dollars), 2017-2021	$59,568	$43,733
Persons in poverty, percent	5%	12%
Businesses		
All employer firms, Reference year 2017	463	42,022
Men-owned employer firms, Reference year 2017	224	24,659
Minority-owned employer firms, Reference year 2017	44	6,934
Nonminority-owned employer firms, Reference year 2017	379	31,960
Nonveteran-owned employer firms, Reference year 2017	407	36,206
Geography		
Population per square mile, 2020	4,031	760
Population per square mile, 2010	3,348	670
Land area in square miles, 2020	3.3	1,964
Land area in square miles, 2010	3.6	1,970
FIPS Code	1249600	-

2.2 Modeling Data Elements

Several data elements have been sourced, organized, and prepared with software tools and applications to dovetail raw data into modeling inputs and parameters. This report describes each portion of data leveraged to develop the Village's Streamline Technologies, Inc. Interconnected Pond and Routing model, version 4 (ICPRv4) model. As new, modified, or better data becomes available, the Village may update portions of their stormwater geodatabase and H&H model, continuously improving future analyses. Additionally, the Village's H&H model may be cropped into smaller areas of interest to vet local benefits associated with future proposed alternatives while utilizing boundary conditions of the master simulations, allowing for faster modeling runs. Additionally, this village-wide model may be used

to expedite the permitting effort for the proposed improvements by seeking conceptual approval from the South Florida Water Management District (SFWMD).

2.2.1 Aerial Imagery

The 2022 high-resolution aerial imagery used in this analysis was sourced from the Palm Beach County's Appraiser's office. This dataset was collected in 2022 and has a 0.5-ft by 0.5-ft resolution. High-resolution images allow for better visualization, which is essential for the development of the H&H model and master drainage plan analysis.

2.2.2 Digital Elevation Model

The Digital Elevation Model (DEM) data was derived from 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 Administrations (NOAA's) Data Access Viewer. The DEM was updated by the SFWMD and sourced in 2022. The spatial resolution of the data was 2.5 feet, with horizontal and vertical datum, respectively, were North American Datum 1983 and North American Vertical Datum 1988 (NAVD88).

2.2.3 Watersheds Delineation

Hazen used ArcHydro tools designed by Esri and the DEM data to delineate preliminary sub-basin boundaries. The preliminary subbasin boundary delineation solely relied on land surface elevation, and sinks in elevation data were filled or retained to guide the process. Subsequently, the preliminary subbasin boundaries were modified using Spatial Analyst tools in ArcGIS based on aerial photography, ridgelines, significant drainage areas, and stormwater infrastructure data obtained from the VNPB. The watershed areas outside the VNPB boundary were delineated at a coarser level of detail to achieve reasonable model runtime. The watershed area within VNPB boundaries was delineated with a higher level of detail to include all details pertinent to this project.

2.2.4 Rainfall

Five design storms were simulated based on the SFWMD rainfall frequency distributions. Isohyetal maps from SFWMD's Environmental Resource Permit (ERP) Information Applicant's Handbook Volume II, effective May 22, 2016, were utilized to establish rainfall depths for each modeled simulation. SFWMD published this data in 1990 in a Technical Memorandum titled "Frequency Analysis of One and Three-day Rainfall Maxima for Central and Southern Florida."

In April 2022 the SFWMD adopted future extreme rainfall change factors for flood resiliency planning in South Florida. The SFWMD rainfall contours were georeferenced to create a rainfall surface and the extreme rainfall factors were utilized to interpolate an additional change factor for each storm event. **Table 2-4** shows modeled rainfall depths for each design storm as used for each modeling scenario and time.

Table 2-4: Modeled Rainfall Depths

	Modeled Rainfall Depth (in)			Rainfall Change Factor Percentage		
Design Storm	Current	2040	2070	Current	2040	2070
5-Year, 24-Hour	7	7.25	7.67	0%	3.6%	6.6%
10-Year, 24-Hour	9	9.42	10.13	0%	4.7%	12.5%
25-Year, 24-Hour	10	10.61	11.63	0%	6.1%	16.3%
25-Year, 72-Hour	13	13.7	14.87	0%	5.4%	14.4%
100-Year, 72-Hour	16	17.15	19.07	0%	7.2%	19.2%

2.2.5 Soils

Soil characteristics for the modeling domain were derived from the Natural Resources Conservation Service (NRCS) Soil Survey in the Soil Survey Geographic (SSURGO) database.

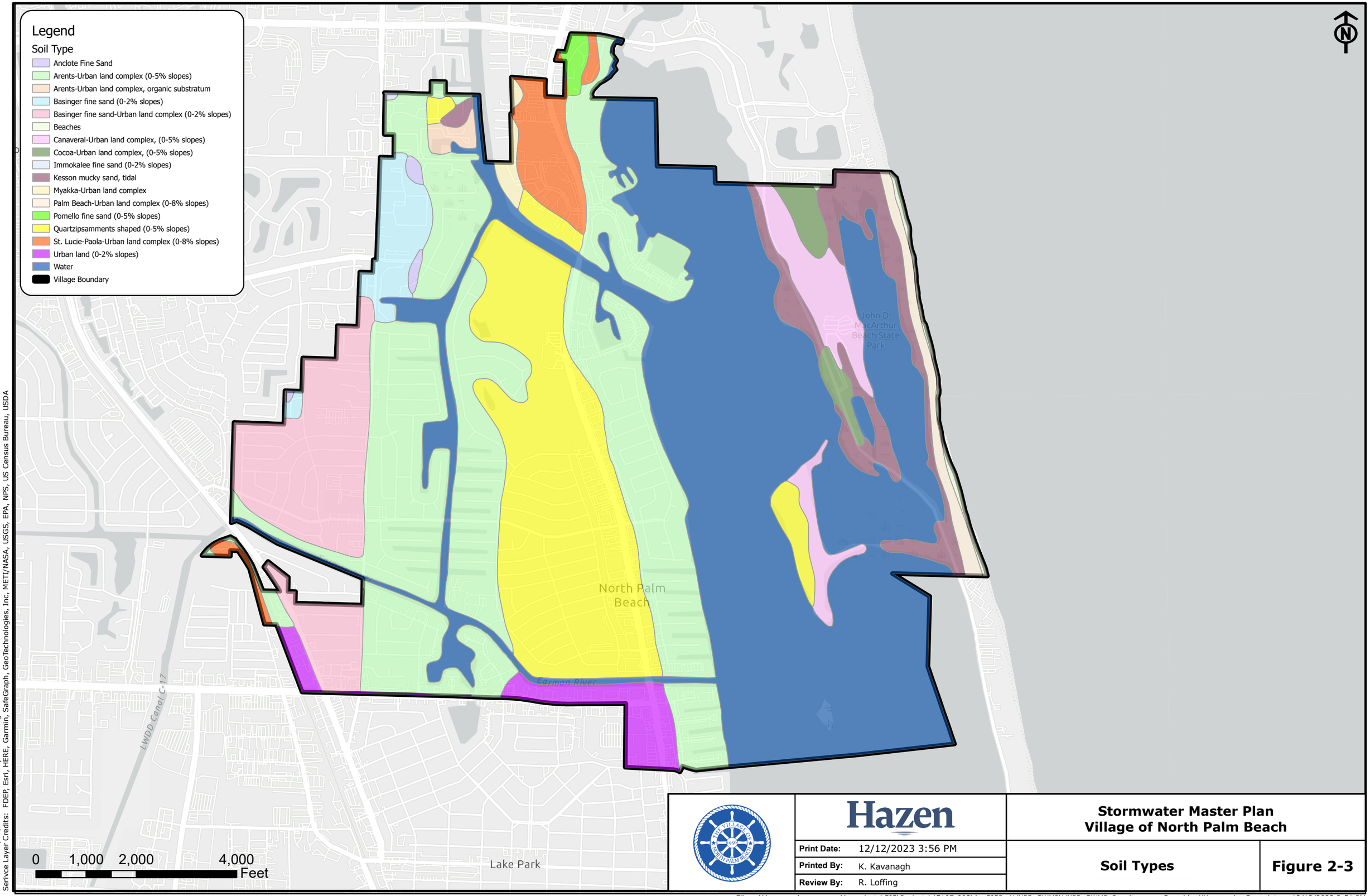
Table 2-5 summarizes the percent cover for each soil type within the Village. **Table 2-6** summarizes the percentage of coverage by area for hydrological soil groups within the Village. The spatial distribution of soil types and hydrologic soil groups (HSGs) can be seen in **Figure 2-3** and **Figure 2-4**, respectively.

Table 2-5: Soil Types Listed by Percent Cover within the Village

Soil Type	Percent by Area
Anclote Fine Sand	0.8%
Arents-Urban land complex, 0 to 5 percent slopes	22.5%
Arents-Urban land complex, organic substratum	0.2%
Basinger and Myakka sands, depressional	2.3%
Basinger fine sand, 0 to 2 percent slopes	7.3%
Basinger fine sand-Urban land complex, 0 to 2 percent slopes	7.9%
Canaveral-Urban land complex, 0 to 5 percent slopes	0.4%
Immokalee fine sand, 0 to 2 percent slopes	11.2%
Kesson mucky sand, tidal	0.1%
Myakka fine sand, 0 to 2 percent slopes	0.8%
Myakka-Urban land complex	2.7%
Kelantan muck, drained, frequently ponded, 0 to 1 percent slopes	0.1%
Pomello fine sand, 0 to 5 percent slopes	0.6%
Quartzipsamments, shaped, 0 to 5 percent slopes	10.8%
Sanibel muck	0.1%
St. Lucie-Paola-Urban land complex, 0 to 8 percent slopes	25.3%
Urban land, 0 to 2 percent slopes	7.1%

Table 2-6: Percentage of Hydrologic Soil Groups within the Village

Soil Group	Percent by Area
B	10.8%
C	0.6%
D	22.5%
NA - Arents-Urban land complex, 0 to 5 percent slopes (No HSG listed)	22.5%
NA - Arents-Urban land complex, organic substratum (No HSG listed)	0.2%
NA - Basinger fine sand-Urban land complex, 0 to 2 percent slopes (No HSG listed)	7.9%
NA - Canaveral-Urban land complex, 0 to 5 percent slopes (No HSG listed)	0.4%
NA - Myakka-Urban land complex (No HSG listed)	2.7%
NA - St. Lucie-Paola-Urban land complex, 0 to 8 percent slopes (No HSG listed)	25.3%
NA - Urban land, 0 to 2 percent slopes (No HSG listed)	7.1%



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Soil Types

Figure 2-3

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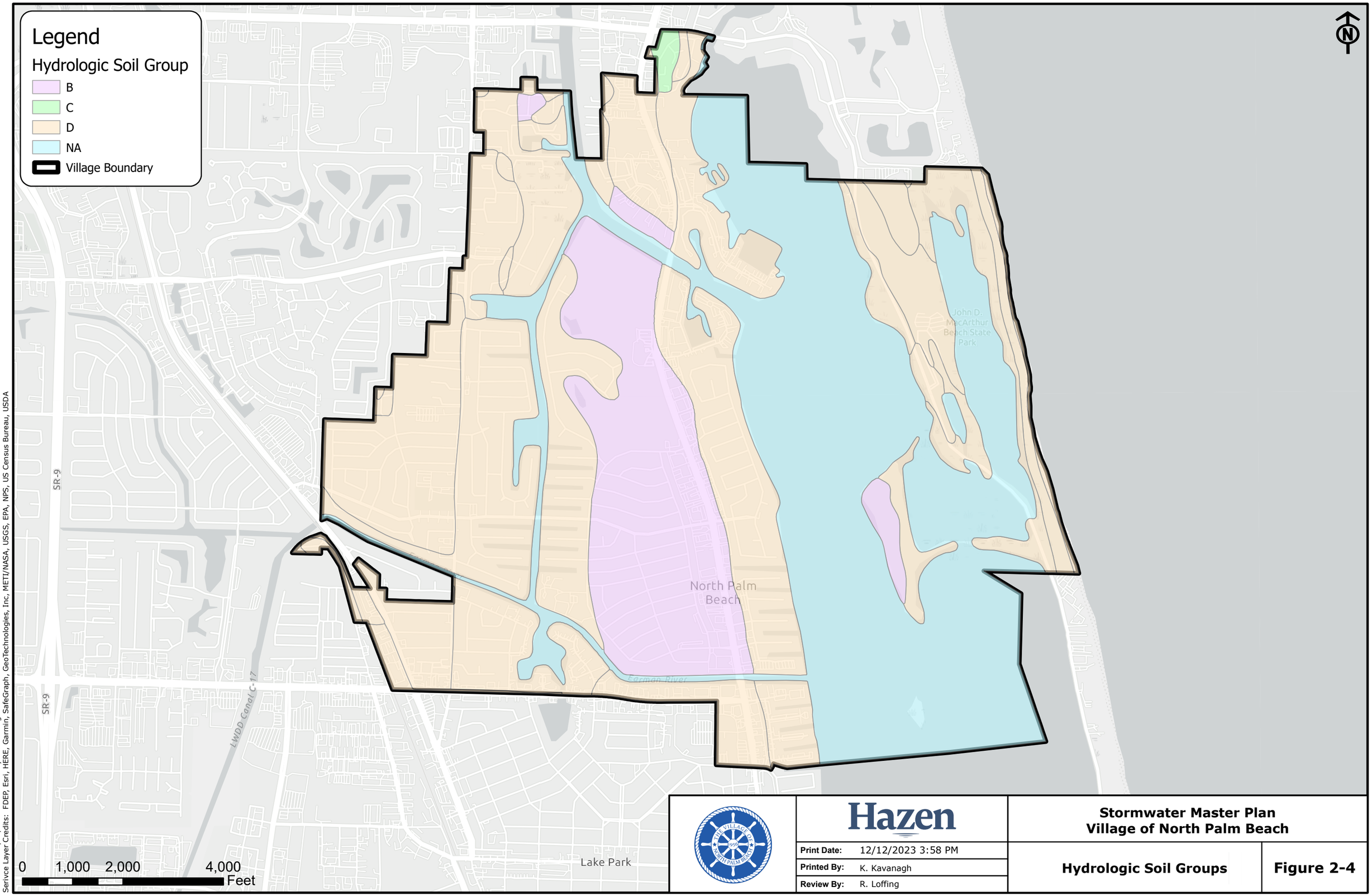

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2.2.7 Land Cover, Land Use

Current Land Cover, Land Use (LCLU) data was derived from the SFWMD LCLU dataset from 2017-2019 and was used as a proxy for defining impervious area as well as overland roughness under current condition modeling scenarios (i.e. 2023 scenarios). The future LCLU data was derived from the current LCLU data in conjunction with the future land use map provided by the Village. The future LCLU data was applied to the future conditions modeling scenarios (i.e. 2040 and 2070). The current and future spatial distributions of LCLU are shown previously in **Figure 2-1** and **Figure 2-2**.

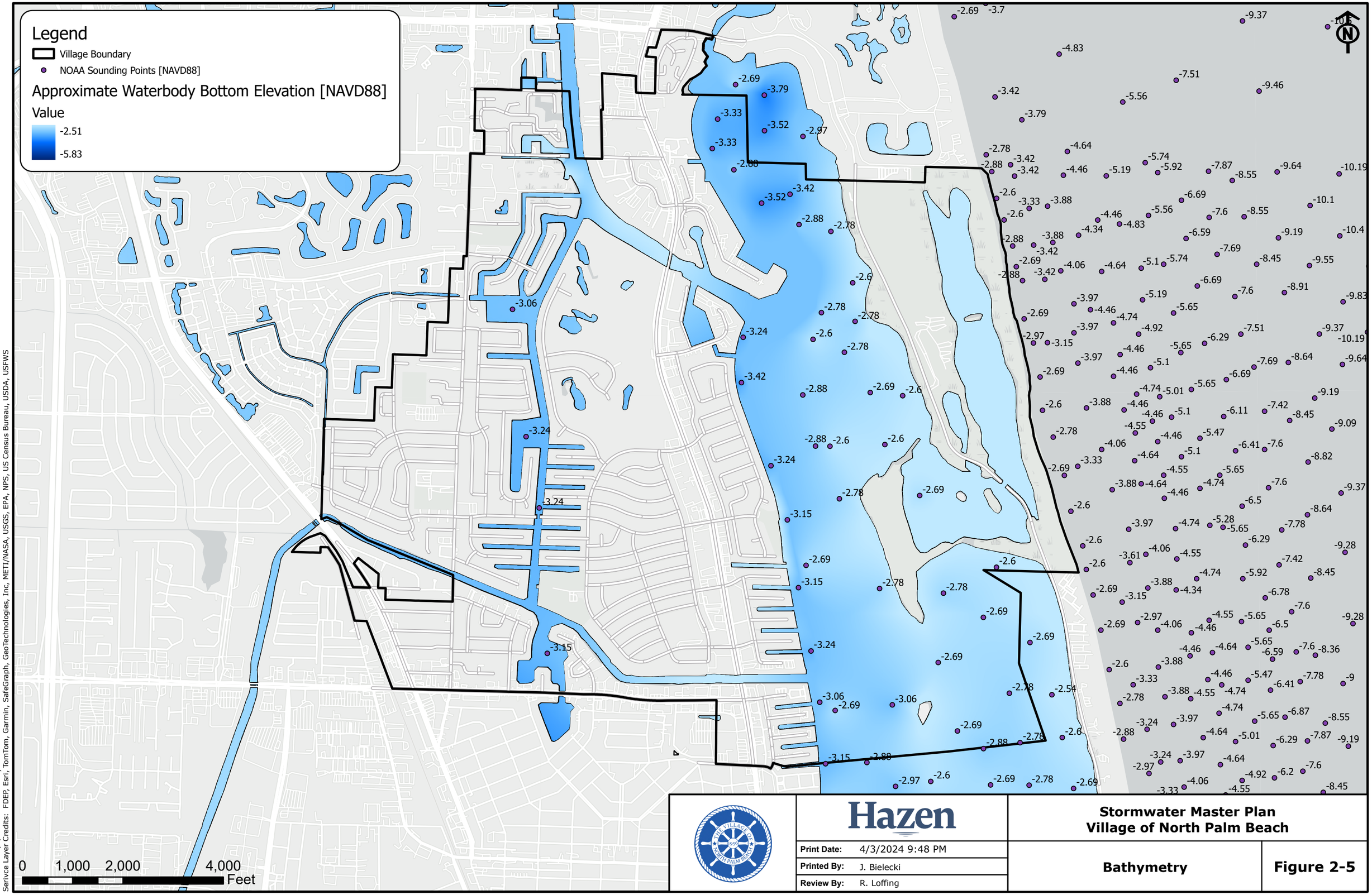
2.2.8 Bathymetry

Under normal conditions, water makes up approximately 38% of the Village's surface. The bathymetry of waterbodies is obscured in the collection of LiDAR data used for the development of the DEM. For this reason, bathymetry data representing the Village's waterbodies, both in sounding depth points and contours, were sourced from National Oceanic and Atmospheric Administration (NOAA), converted to the NAVD88 vertical datum, developed into a triangular irregular network (TIN) surface, converted into raster, and burned into the Village's DEM. This dataset reflects approximate bottom elevations within waterbodies, as are shown in **Figure 2-5**, and directed assumptions associated with modeling the channel cross sections.

2.2.9 Hydraulics

The hydraulic portion of the model was based on existing stormwater infrastructure as reflected in the Village's stormwater geodatabase shown in **Figure 2-6**. Additional information critical to the analysis was provided by the Village and integrated into the model. The stormwater geodatabase includes a physical representation of the Village's storm lines and drainage structures as well as attributes for each feature detailing specific information, such as size and material based on Geographic Information System (GIS) survey data obtained by the Village. This dataset was organized and leveraged to develop the final modeling schematic, as discussed in **Section 1** of this report.

It is recommended that the Village keep its stormwater geodatabase up to date to facilitate future stormwater analyses and for purposes of asset management. The H&H model could be updated regularly with geodatabase additions/modifications for it to continue to be a useful tool for the Village when exploring additional future improvements.



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Bathymetry

Figure 2-5

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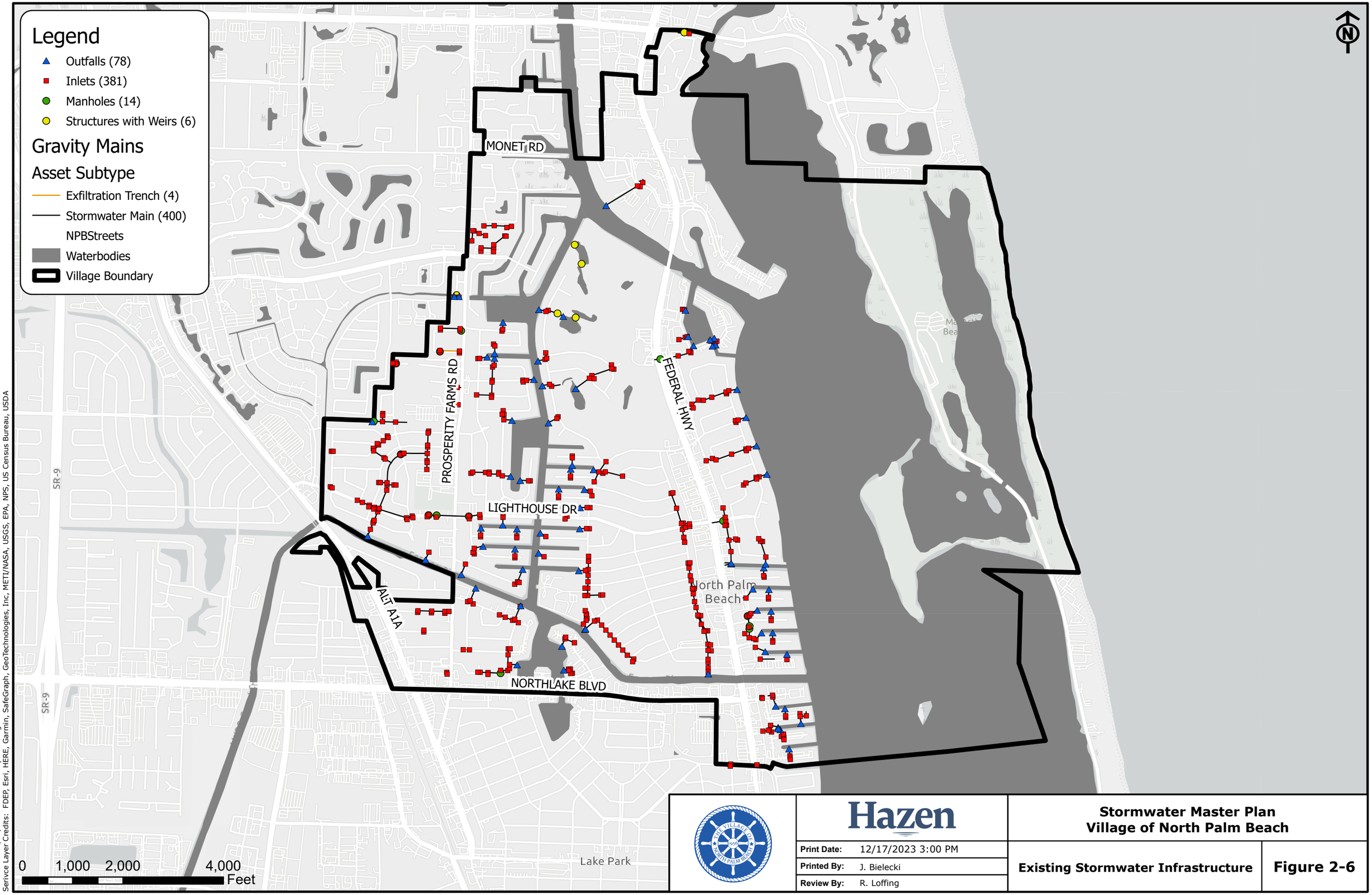

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Village of North Palm Beach

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Existing Stormwater Infrastructure

Figure 2-6

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2.2.10 Boundary Conditions

2.2.10.1 External Inflows

Figure 3-1 shows the location of the SFWMD structure S-44, located on the west side of the Village. S-44 regulates flow and stage for the Earman River (i.e. the Canal No. 17 (C-17)). S-44 is a critical control structure since its operations have a direct impact on surface water elevations for C-17, the downstream boundary condition for a major portion of the Village's stormwater systems.

Flow and stage data for S-44 was sourced from SFWMD's corporate environmental database (DBHYDRO), an environmental database that stores hydrologic, meteorological, and water quality data from SFWMD and from USGS, NOAA, and the Everglades National Park. The flow and stage data and associated frequency and period of record are listed in **Table 2-7**. The peak inflow values, used to develop an external hydrograph in cubic feet per second (CFS), derived from the S-44 data are listed in **Table 2-8**; refer to Appendix A-1 for tables presenting the external hydrographs by 15-minute time steps derived from the S-44 data. The external hydrographs were applied to each design storm scenario in the model at the node representing the S-44.

Table 2-7: SFWMD DBHYDRO Flow and Stage Data

Station	Data Type	Frequency	Statistic Type	Agency	Start Date	End Date
S44_S	Flow	Continuous	Instantaneous	WMD	01/01/1978	present

Table 2-8: External Hydrograph Inflow Values

Design Storm	Modeled Peak Inflow for S-44 (CFS)
5-year, 24-hour	1,924
10-year, 24-hour	2,263
25-year, 24-hour	2,776
25-year, 72-hour	2,776
100-year, 72-hour	3,729

2.2.10.2 Tidal and Sea Level Rise

Being located on the Lake Worth Lagoon and various tidal waterways, tidal conditions have a significant impact on the Village's drainage. Tidal water level measurements and mean values of tidal datums are available from NOAA for numerous stations in southeastern Florida. Datums 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 datums, such as mean sea level. The Lake Worth Pier (station no. 8722670) is the station closest to the Village as illustrated in **Figure 2-7**. **Table 2-9** summarizes the active NOAA tidal water level and data record characteristics for the Lake Worth Pier.

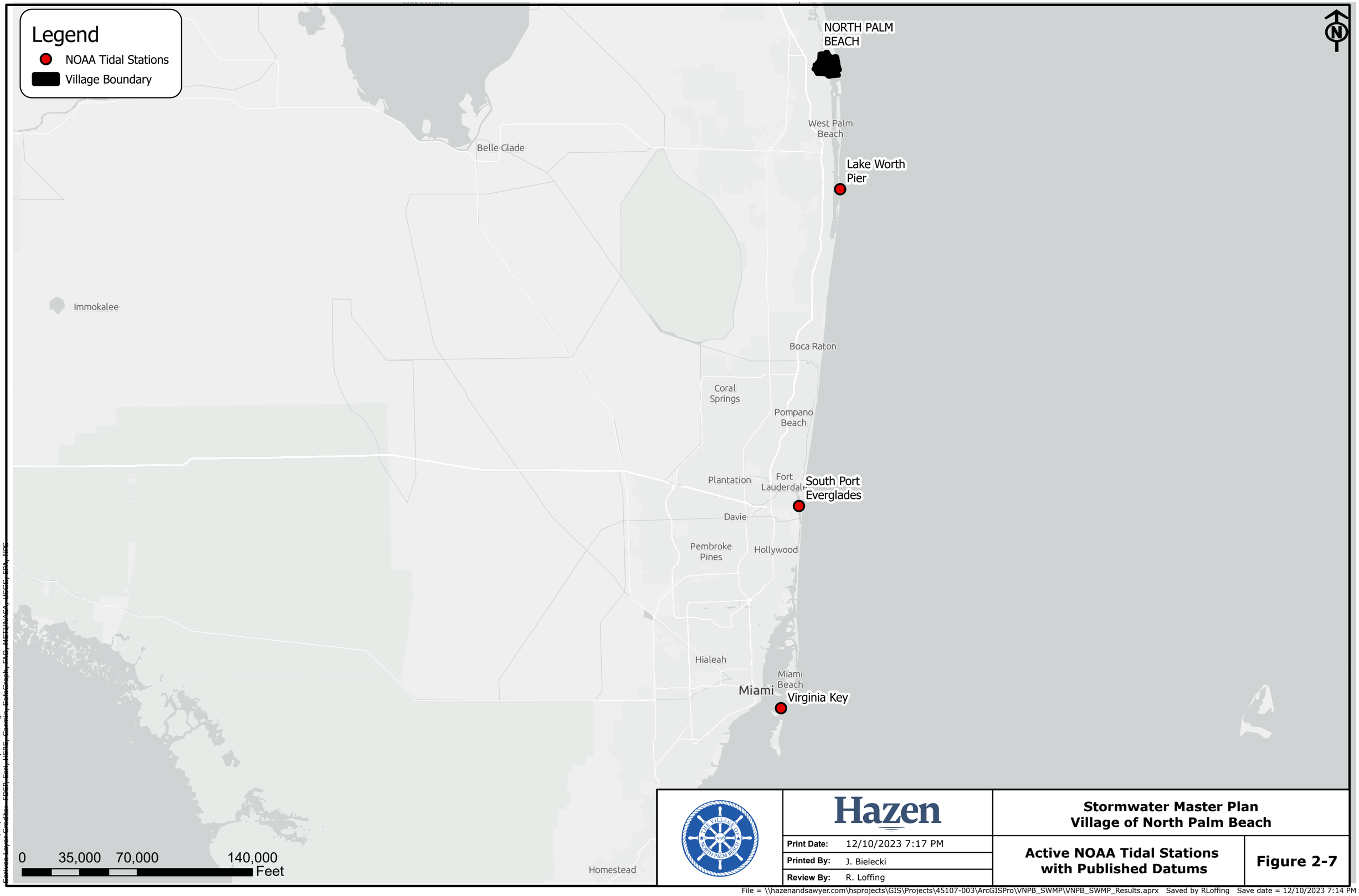

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Table 2-9: Active NOAA Water Level Tidal Stations with Published Datums

Name	Station Number	Period of Record	Elevations on Station Datums Relative to NAVD88, feet (Relative to NGVD29, feet)				
			MHHW	MHW	MSL	HAT	Max
Lake Worth Pier	8722670	4/14/1970 - present	0.55 (*2.12*)	0.37 (*1.94*)	-0.95 (*0.60*)	1.73 (*3.30*)	2.83 (*4.40*)

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

The past two years of tidal data were reviewed for the NOAA Lake Worth Pier station, with the highest tide occurring on November 25, 2022. As such, the tidal data for the four-day period beginning with November 25, 2022 was selected to represent the "existing" tidal conditions; this data is presented in **Appendix A-2**.

The various design storm scenarios are *not* anticipated to affect the tidal water level, however provisions were taken to account for the effects of sea level rise. Regionalized sea level rise projections are provided in the 2022 "Global and Regional Sea Level Rise Scenarios for the United States" technical report prepared by NOAA, the National Aeronautics and Space Administration (NASA), EPA, USGS, US Department of Homeland Security (DHS), US Federal Emergency Management Agency (FEMA), the US Army Corps of Engineers (USACE) and the US Department of Defense (DOD); a relevant excerpt from this report is included in **Appendix A-3**. The sea level rise projection for the Southeast, shown in the excerpt, was used in this analysis. The observed peak tidal data was adjusted upwards for the 2040 and 2070 scenarios as warranted by the intermediate-low and intermediate-high sea level rise projects. The projected tidal conditions that account for sea level rise are presented in **Appendix A-2**. Except for the S-44 node, all nodes located within tidal waterways are time-stage nodes; refer to **Figure 3-1** for a map showing the location of these nodes. Sea level rise is simulated at the time-stage nodes based on the projected tidal conditions as shown in **Appendix A-2**.

2.2.11 Insights

Over the years, the Village has gathered valuable information pertaining to the identification of known vulnerabilities by regional studies, the public's informal knowledge, as well as internal, operational knowledge. This information was communicated and integrated into the final analyses and prioritization of recommendations for the proposed CIP.

2.3 Regional Characteristics

The following series of figures show regional characteristics with potential influence over proposed stormwater recommendations that have been considered in the development of the proposed CIP projects.

2.3.1 Flood Zones

FEMA flood zones based on percent chance of flooding are shown in **Figure 2-8**. A large portion of the Village is impacted by flood zone 'AE' which represents a 1% annual chance of flooding. This flood zone aided in identifying areas within the Village at a high risk of flooding and is used to determine minimum design criteria for proposed improvements. The Village is also impacted by flood zone 'VE'. This flood zone represents areas that have a 1% or greater chance of flooding with additional hazard associated with storm waves. These areas are primarily along the coast and Lake Worth Lagoon.

2.3.2 Contaminated Sites

There are a number of contaminated sites within the Village, as shown in **Figure 2-9**.

2.3.3 Monitoring Wells

The SFWMD's DBHYDRO database showed the Village has no active monitoring wells.

2.3.4 Wellfield Protection Zones

Figure 2-10 shows the wellfield protection zones within and near the Village.

2.3.5 Saltwater Intrusion

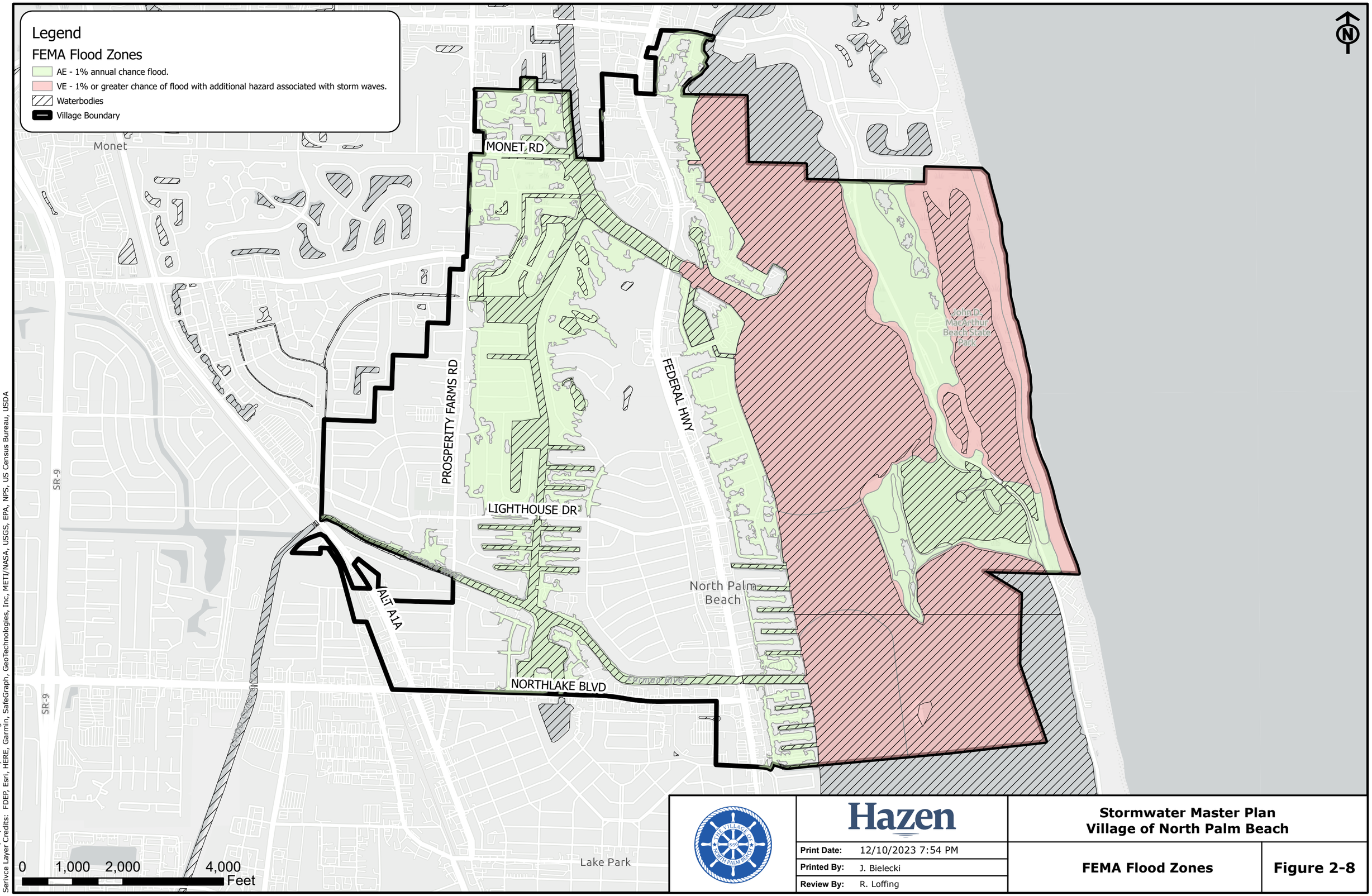
Approximately 87% of the Village is located east of the saltwater intrusion line as shown in **Figure 2-11**. The influence of saltwater intrusion would affect the efficacy of drainage wells and exfiltration trenches. The Village may propose the use of alternate materials, made to withstand harsher groundwater conditions for the proposed improvements.

2.3.6 SFWMD Drainage Basins and Ambient Monitoring Sites

SFWMD drainage basins and ambient monitoring sites are shown in **Figure 2-12**. The Village is divided into the following drainage basins:

- Earman River (C-17)
- Lake Worth Lagoon Drainage Basin

The SFWMD drainage basins were considered in calculating allowable discharges for the drainage systems affected by proposed improvements based on tributary drainage area, as further detailed in **Section 5.2** of this report.



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Village of North Palm Beach

FEMA Flood Zones

Figure 2-8

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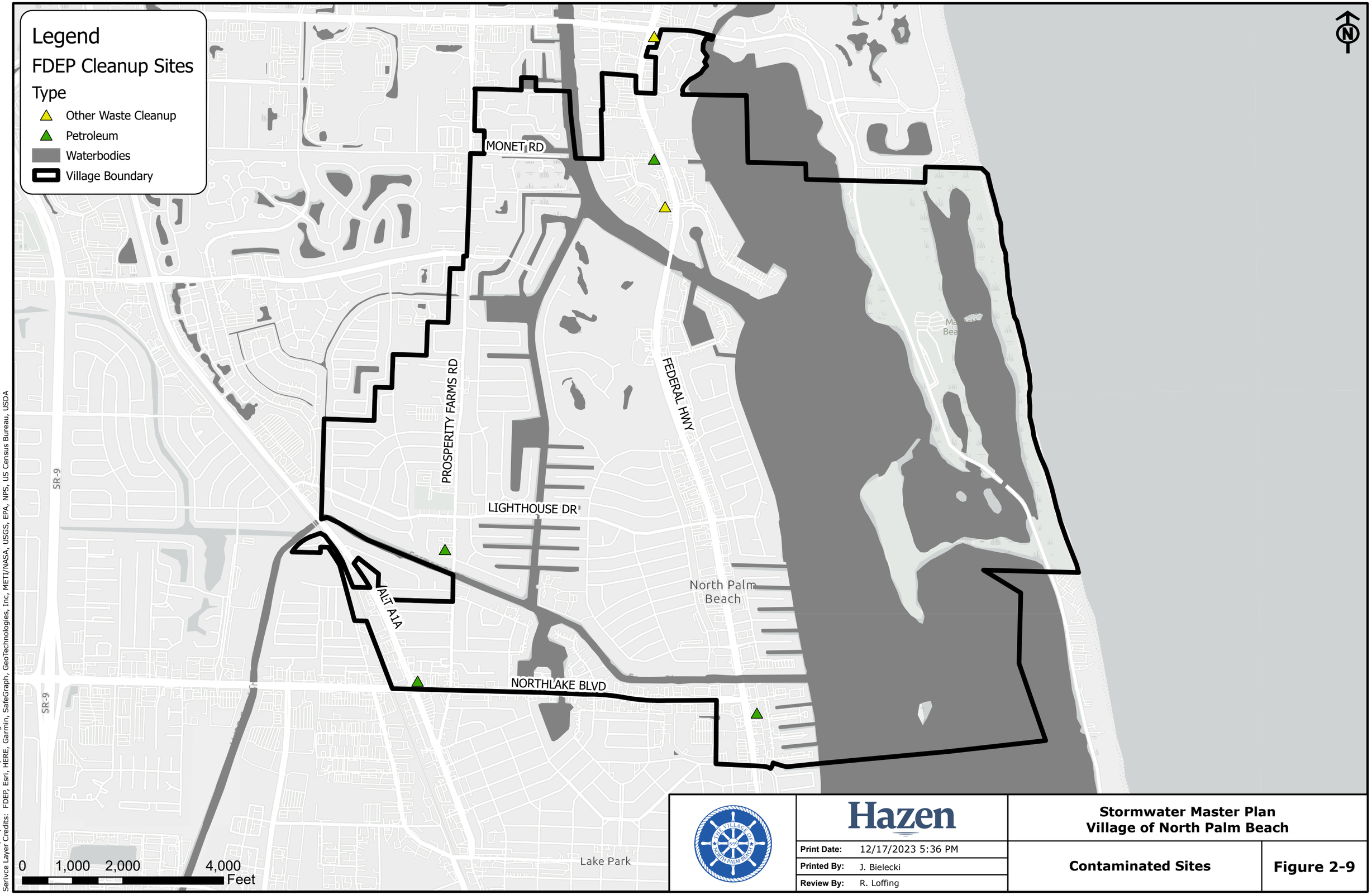

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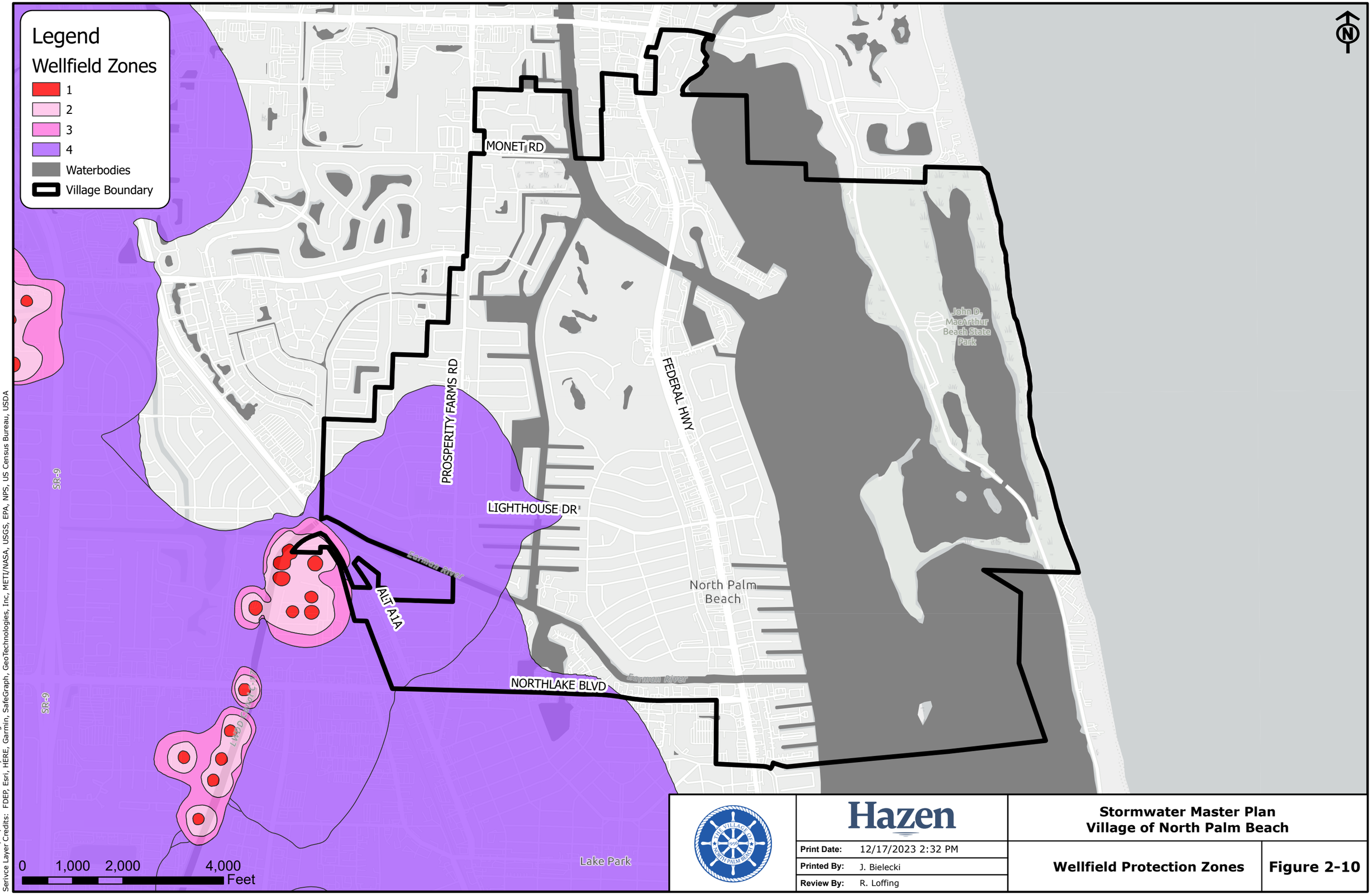

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Village of North Palm Beach

Wellfield Protection Zones

Figure 2-10

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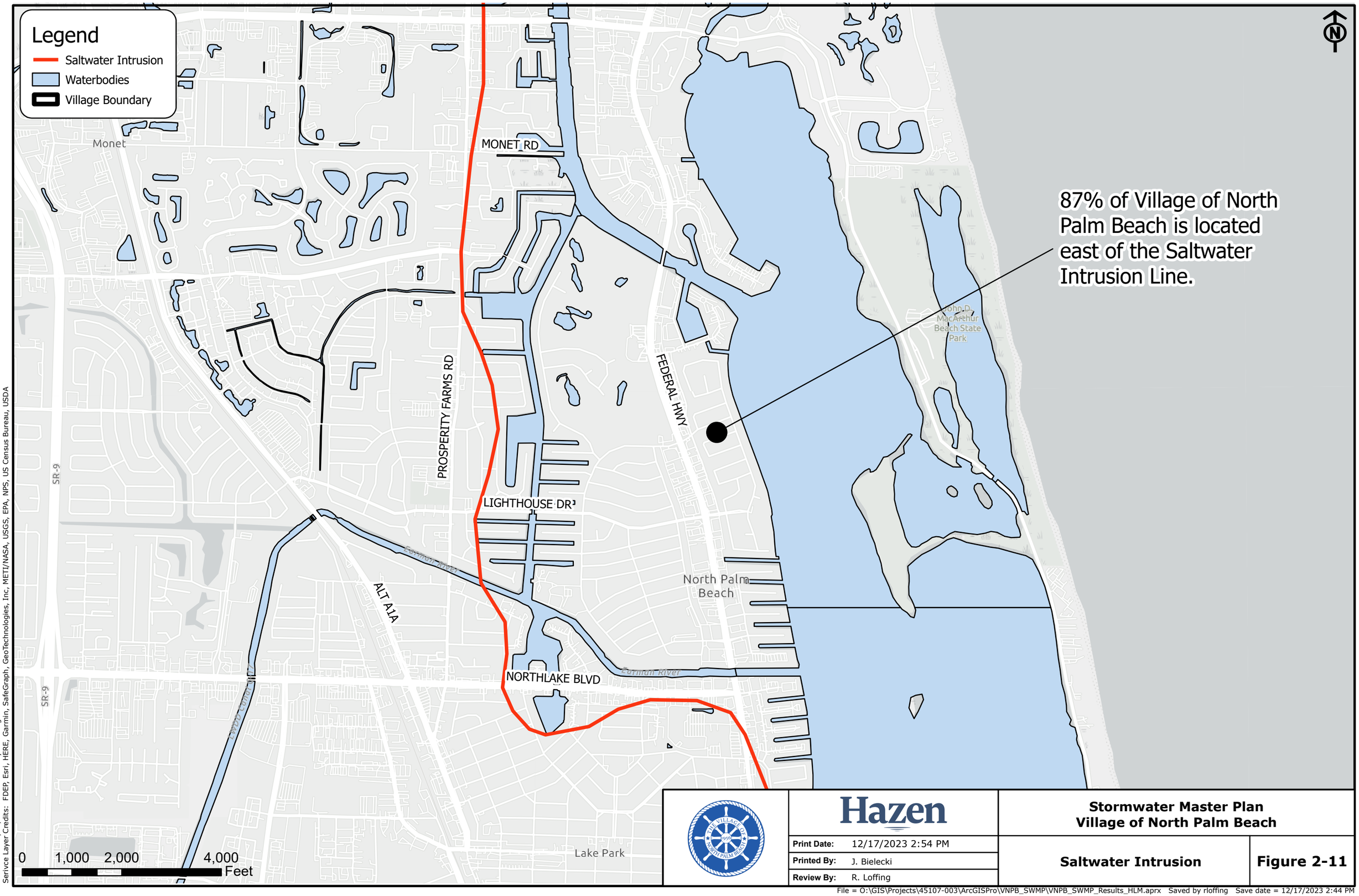

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Saltwater Intrusion

Figure 2-11

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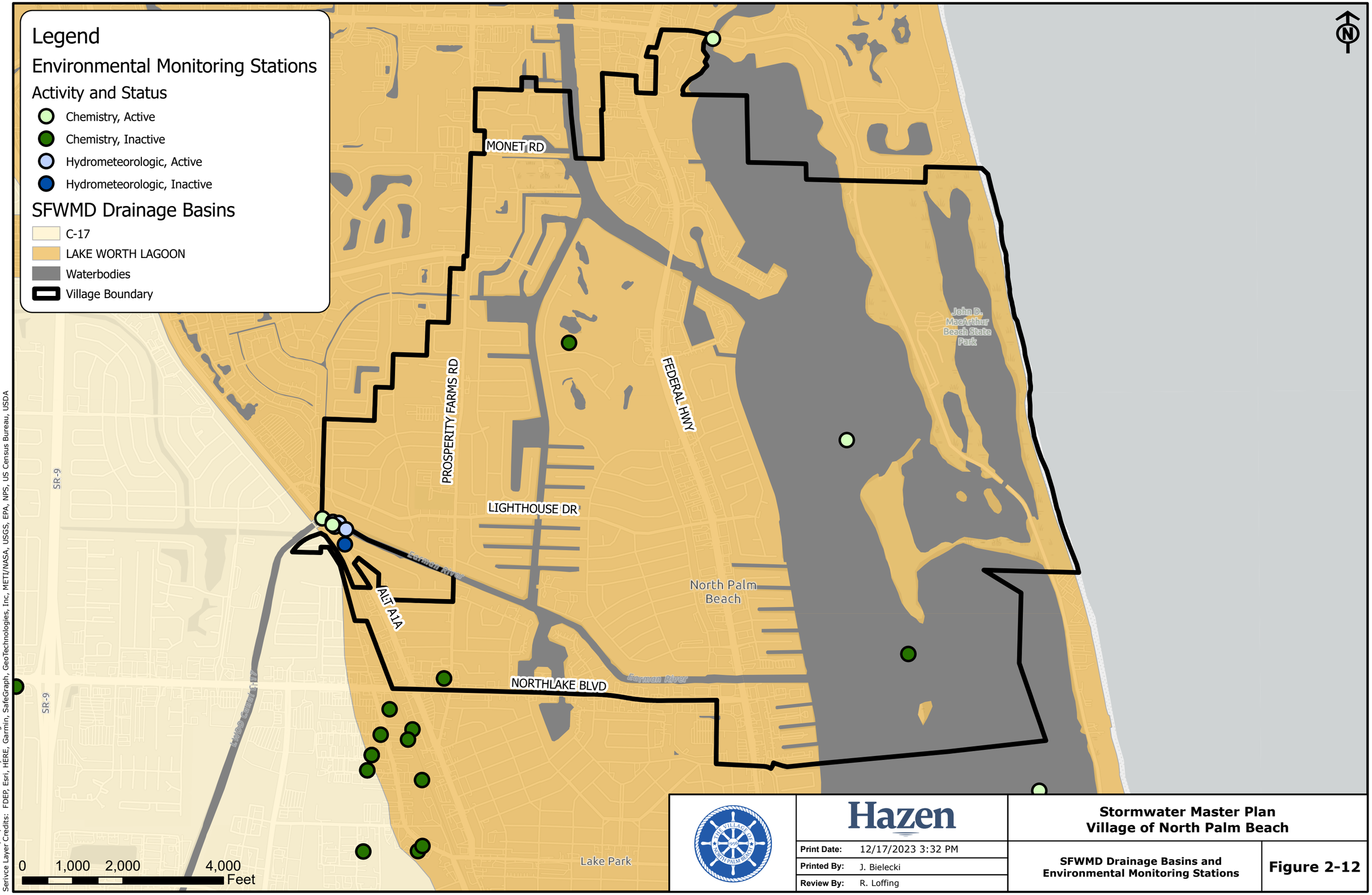

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Village of North Palm Beach

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SFWMD Drainage Basins and Environmental Monitoring Stations

Figure 2-12

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3. Modeling Methodology, Parameterization and Assumptions

3.1 Modeling Approach and Software

The ICPRv4 model (Streamline Technologies Inc., 2018) was selected to simulate the hydrologic and hydraulic (H&H) conditions throughout the Village area. ICPR4 is a well-established model in the State of Florida used to simulate surface water flow, floodplain delineation and analysis, and Best Management Practices (BMPs) analysis. ICPRv4 is a link-node model with basins (catchment areas), nodes, and links as building blocks. The model calculates storm-induced surface runoff for each subbasin, which is assigned to the subbasin storage node. Subsequently, the stage at each sub-basin node is used to calculate flow, which is routed between sub-basins using links. The ICPR4 model can be driven using observed rainfall data or inbuilt design storm hydrographs.

The model elements and relevant data were organized in a Geographic Watershed Information System (GWIS) geodatabase. The data sources described in Sections 2.2 and 2.3 were used to construct the model schematic, along with reasonable and conservative assumptions that are described throughout Section 3. All the feature classes in the GWIS database were completed and reviewed for completeness. The GWIS 2.1 to ICPR4 conversion tool within ArcGIS was used to create the ICPR4 model input .csv files from the GWIS database. The .csv files were imported into the ICPR4 model following the methodology outlined in the ICPR4 help menu. The ICPR4 model was evaluated for completeness, and if there were any issues in the ICPR4 model or missing data, the GWIS database was corrected, and the GWIS to ICPR4 conversion process was repeated to ensure that both the GWIS and ICPR4 model were in sync. Once it was verified that all the GWIS parameters were successfully converted into the ICPR4 model, the model was executed and tested for stability, errors, and warnings.

3.2 Hydrology

3.2.1 Curve Numbers

The direct surface runoff volume generated in response to the rainfall depth applied uniformly over the model domain was estimated in the ICPR model using the Curve Number (CN) Method. The Soil Conservation Services originally developed the CN method, which is applied to simulate runoff volume in response to design storms. The input data required for the CN method includes the area's soil hydrologic group, land use, management practices, and hydrologic conditions. The details and assumptions of CN methodology are described in detail in the National Engineering Handbook - 4 (NEH4) and in the National Resources Conservation Services Technical Release No. 55 (NRCS TR-55). Refer to **Appendix A-4** for applicable excerpts from this document. The ICPR model calculates the curve number for each unique combination of soil type and land use combinations in each subbasin.

Two sets of curve numbers were developed; one for the 2023 model scenarios based on current LCLU, and one for the 2040 and 2070 model scenarios based on the future LCLU.

3.2.2 Time of Concentration and Unit Hydrograph

Time of Concentration (TC) is defined by the total time water takes while traveling from the most distant point in each sub-basin to the outlet. TC was calculated for each sub-basin using the methodology outlined in TR-55 (USDA, 1986; USDA, 2003). The longest flow path for each sub-basin was drawn using DEM data and ArcHydro tools. The longest flow path was split into two segments using the "split" tool in ArcGIS. The first 100 feet of the longest flow path was considered sheet flow, after which the flow was classified as shallow concentrated flow (USDA, 2003). The travel time for each of these flow components was estimated using equations defined in TR-55. Finally, TC for each sub-basin was equal to the sum of travel time for both components. A minimum value of ten (10) minutes was used for sub-basins with extremely short TC, as recommended in the TR-55 document. A unit hydrograph with a peak rate factor of 256 was applied in all subbasins. The peak factor was considered a constant characteristic of the entire watershed.

3.2.3 Node Storage

One stage-area node was assigned to each delineated sub-basin. These nodes served as the loading nodes and were generally in the cell with the lowest elevation in the sub-basin. Additional "dummy/junction" nodes were added to facilitate water routing using pipes, and channels throughout the watershed. Inflows and outflows at the model boundaries were simulated using boundary nodes, which were all Time-Stage type.

The "Drainage area characterization" tool in ArcHydro and DEM data was used to estimate floodplain storage volumes corresponding to varying water surface elevations in each sub-basin. The cumulative storage volume was estimated to correspond to a uniform increment of 0.1 feet in stage for each subbasin node. The output from the Arc Hydro tool was used to define the stage-storage relationship at sub-basin nodes in the ICPR4 model. In subbasins with channels, channel storage was removed from the stage-storage calculations to avoid double accounting of available storage in the subbasins. Channel cross-section information was used to draw exclusion polygons, and the subbasin area covered by the exclusion polygon was removed from the subbasin area before determining the stage-storage relationship using Arc Hydro tools. Finally, the stage-storage relationship for a randomly selected group of nodes were checked to ensure the adequacy of the nodal stage-storage relationships used in the model.

Table 3-1: Curve Number Matrix

LCLU	Soil Group			
	B	C	D	NA
Commercial and Services; Commercial and Services	92	94	95	95
Commercial and Services; Shopping Centers	-	94	95	95
Institutional; Educational Facilities	92	-	95	95
Institutional; Institutional	92	-	95	95
Open Land; Inactive Land with Street Pattern	-	-	-	84
Open Land; Poor Condition	-	-	-	89
Recreational; Community Recreation Facilities	69	-	84	84
Recreational; Golf Course	69	-	-	84
Recreational; Parks and Zoos	-	-	84	84
Reservoirs; Reservoirs	100	-	100	100
Residential, High Density; Mobile Home Units	-	90	92	92
Residential, High Density; Multiple Dwelling Units, High Rise	85	-	92	92
Residential, High Density; Multiple Dwelling Units, Low Rise	-	90	92	92
Residential, Low Density; Fixed Single-Family Units	-	-	-	85
Residential, Medium Density; Fixed Single-Family Units	75	83	87	87
Residential, Medium Density; Mixed Units, Fixed and Mobile Home Units	-	-	-	87
Streams and Waterways; Channelized Waterways, Canals	100	-	100	100
Streams and Waterways; Natural River, Stream, Waterway	-	-	-	100
Transportation; Roads and Highways	98	98	98	98
Upland Coniferous Forests; Pine Flatwoods	-	-	77	77
Upland Hardwood Forests; Upland Hardwood Forests	-	-	77	77
Upland Mixed Forests; Upland Mixed Coniferous / Hardwood	-	-	77	77
Utilities; Sewage Treatment	88	-	-	93
Wetland Hardwood Forests; Mixed Shrubs	-	-	77	-
Wetland Hardwood Forests; Mixed Wetland Hardwoods	-	-	-	77

3.3 Hydraulics

3.3.1 Links

Hydraulic links used in the model route surface water flow between subbasin storage nodes. Three types of hydraulic links, namely culverts, channels, and overland weirs, were used in the Village's ICPR model. These links were placed and parameterized based on the surface water infrastructure data provided by the Village and desktop review of the study area and associated aerial photos. Model parameters pertinent to each of the hydraulic links were obtained from reliable sources such as textbooks, the ICPR4 technical document, and existing ICPR models developed by Hazen for other watersheds in the region. **Table 3-2** summarizes the number of links, by type, within the modeling extent.

Table 3-2: Link Summary by Type

Hydraulic Link Type	Number of Links (count)
Channel	123
Pipe	385
Weir	144

3.3.2 Channels

A total of 123 irregular cross-section channels were included in the Village ICPR model. The channel cross-section and length data were extracted from the land surface elevation data. The DEM data used to extract the cross-section data was corrected for channel bathymetry. Exclusion polygons around all the channels were digitized to include storage volume up to the top of the bank on both sides of the channels. The exclusion polygon was used to ensure that the available storage volume in any sub-basin was not unrealistically high due to the double accounting of channel volume. Manning's roughness coefficient of the channels was obtained from the literature (e.g., Chow, 1959; USGS, 1967; and Gillen 1996). The bridges in the model domain were represented as irregular channels with varying length cross sections. The "ICPR3" conveyance method was set for all channel links.

3.3.3 Culverts

Hydraulic connections between sub-basins using culverts were based on the culvert locations and pertinent information provided by the Village. The culvert-related information included upstream and downstream inverts, lengths, and roughness coefficients. Including all pipe sizes in the model will help identify potential local flooding issues caused by an under-sized pipe.

3.3.4 Overland Irregular Weirs

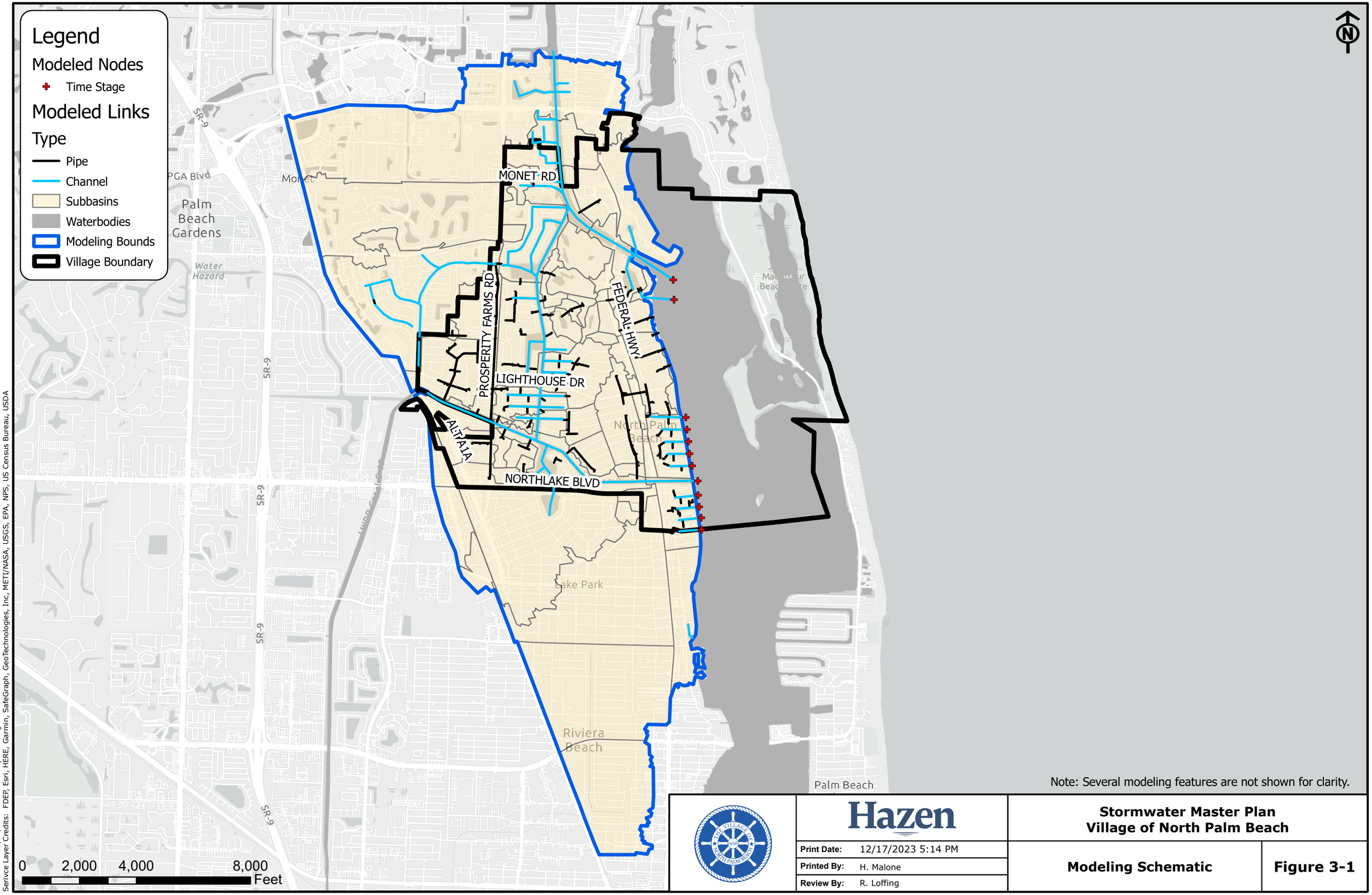
All the weirs included in the model were natural overland flow weirs. An overland weir was used to route overland flow between subbasins from depression areas over topographic saddles. The cross-section for the overland weirs was extracted using the land surface elevation data along the sub-basin boundaries. The weir discharge coefficients used in the model were consistent with other ICPR models Hazen has built in the region.

3.4 Modeling Schematic

The model schematic presented here includes a realistic representation of the area's surface flow hydrology and hydraulics. The hydraulic features included in the existing conditions model schematic are listed below. An overview of the modeling schematic is shown in **Figure 3-1.** Not all modeled features are shown in the figure for clarity.

- Sub-basins – a total of 60 sub-basins were included in the initial schematic ranging from 2.43 to 708 acres.
- Node – a total of 508 nodes were included in the schematic of the model. Out of these nodes, 60 were subbasin storage nodes, and 430 were junction nodes simulated as Stage-Area type nodes. There were 12 boundary nodes that were simulated as Time-Stage type nodes.
- Culvert – a total of 385 links representing flow between basins through pipes were included in the model schematic.
- Weir – a total of 144 weir links proposed in the model.
- Open Channel – a total of 123 open channels were included in the model schematic.

Channel and overland flow weir cross-sections were extracted from the land surface elevation data used in this project.



Note: Several modeling features are not shown for clarity.

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Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Modeling Schematic

Figure 3-1

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3.5 Simulations

The ICPR model developed in this project was meant to assist the Village in floodplain level of service analysis and management. Therefore, at total of 34 model simulations were performed, five (5) of which were for existing H&H conditions (year 2023) and twenty (20) for future H&H conditions (year 2040 and 2070) with varying planning horizons, sea level rise conditions and design storms as shown in **Table 3-3**. The remaining nine (9) model simulations were proposed existing and future conditions models that address flooding issues in the Village and serve as the basis for proposed Capital Improvement Projects recommended to the Village. The naming structure for all the 34 simulations is within **Table 3-4**; while most of the simulations discussed in the reports are described in full, these abbreviated names are used throughout various figures and electronic documents. Additionally, extensions may be added to the end of these simulation names to denote specific characteristics of a simulation, such as "_FD" indicating "flood depth." Such extensions will be explained at their first occurrence.

The existing infrastructure without sea level rise (VE_X23) scenarios were performed to:

1. Confirm that the model results show flood patterns that are expected based on historical observed flooding, known stormwater system conditions and DEM elevations.
2. Identify if there are any locations that are prone to flooding where upgrades may be required to bring the area within the Village's LOS standards.

The existing infrastructure sea level rise scenarios (VE_L40, VE_H40, VE_L70 and VE_H70) were performed to:

1. Estimate under what conditions (sea level rise and design storm conditions) certain areas within the Village may flood, and if upgrades may be required to bring the areas within the Village's LOS standards.
2. Prioritize upgrades based on the planning horizons.

The proposed infrastructure (VP) scenarios were performed to:

3. Compare the flood reduction achieved by the proposed infrastructure compared to the existing infrastructure (VE) scenarios.
4. Demonstrate whether the proposed upgrades are sufficient to achieve the Village's LOS standards.

Table 3-3: Model Simulations

Infrastructure	Planning Horizon		Sea Level Rise	Design Storm				
				5YR-24HR	10YR-24HR	25YR-24HR	25YR-72HR	100YR-72HR
Existing	Current	2023	None	VE_X23_5	VE_X23_10	VE_X23_25A	VE_X23_25B	VE_X23_100
	Future	2040	Intermediate-Low	VE_L40_5	VE_L40_10	VE_L40_25A	VE_L40_25B	VE_L40_100
			Intermediate-High	VE_H40_5	VE_H40_10	VE_H40_25A	VE_H40_25B	VE_H40_100
		2070	Intermediate-Low	VE_L70_5	VE_L70_10	VE_L70_25A	VE_L70_25B	VE_L70_100
			Intermediate-High	VE_H70_5	VE_H70_10	VE_H70_25A	VE_H70_25B	VE_H70_100
Proposed	Future	2023	None	-	VP_ X23_10	VP_ X23_25A	-	VP_ X23_100
		2040	Intermediate-High		VP_ H40_10	VP_ H40_25A		VP_ H40_100
		2070	Intermediate-High		VP_H70_10	VP_H70_25A		VP_H70_100

Table 3-4: Model Simulation Naming Structure Parts

Infrastructure	Sea Level Rise	Year	Design Storm
VE = Existing	_X = None	23 = 2023	_5 = 5-Year, 24-Hour
VP = Proposed	_L = Intermediate-Low	40 = 2040	_10 = 10-Year, 24-Hour
	_H = Intermediate-High	70 = 2070	_25A = 25-Year, 24-Hour
			_25B = 25-Year, 72-Hour
			_100 = 100-Year, 72-Hour

4. Identification of Flood Prone Areas

4.1 Consideration of Critical Assets

Flooding vulnerabilities of the Village's critical assets were considered for the LOS analysis, prioritizing areas of the Village to benefit from the proposed CIP projects. Critical assets need to remain functional during a flooding event. A total of 21 critical assets were identified. All assets were classified into the following eight categories:

- Community Centers (1)
- Electrical Production and Supply Facilities (1)
- Emergency Operation Centers (2)
- Fire Stations (1)
- Health Care Facilities (5)
- Law Enforcement Facilities (1)
- Local Government Facilities (1)
- Marinas (4)
- Schools (5)

Figure 4-1 shows the location of each identified critical assets.

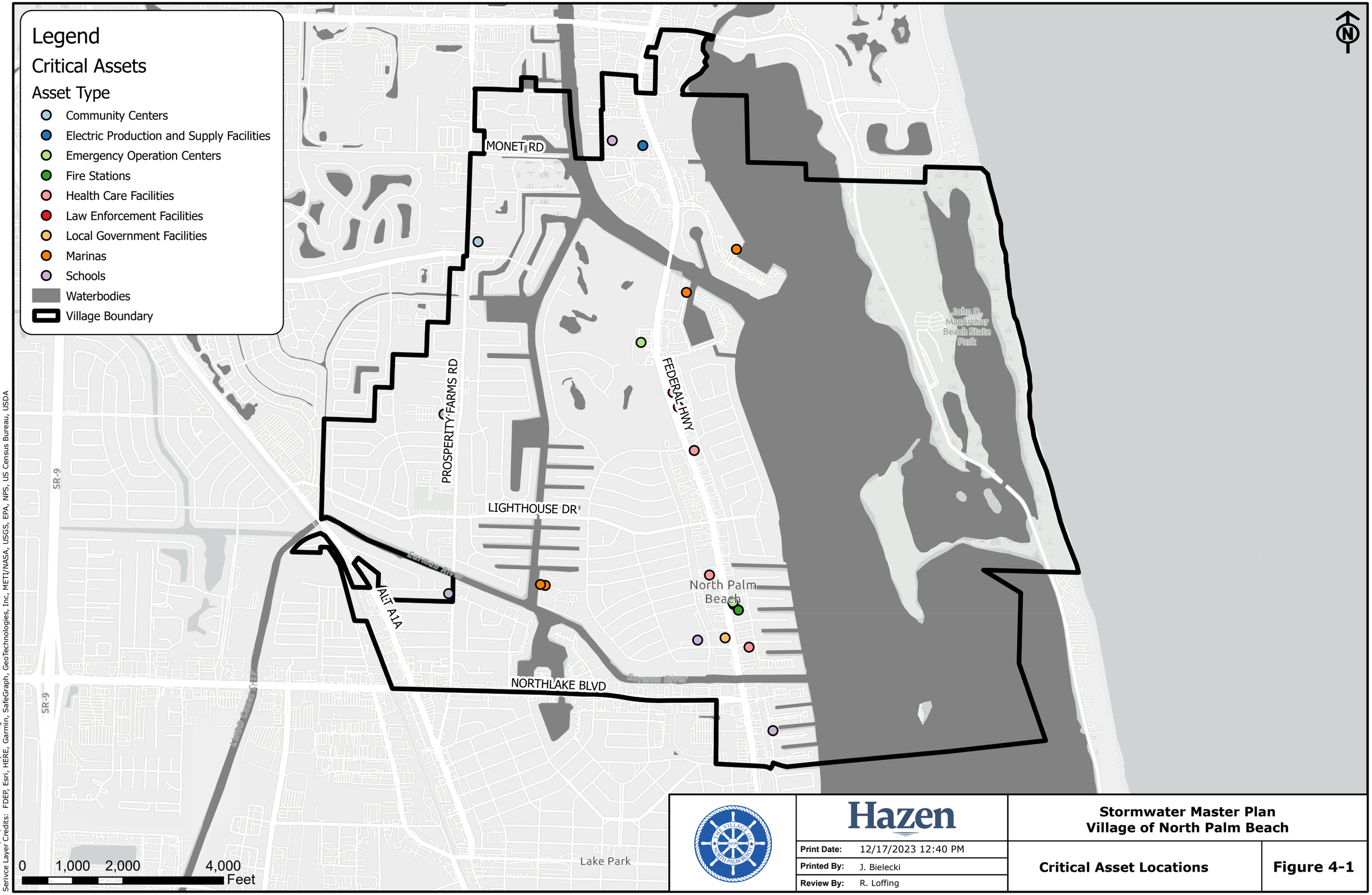
4.2 Flood Risk Modeling Results – Existing Scenario

The model was run for the 25 existing infrastructure simulations shown in **Table 3-3**. The model results were exported and the maximum stages within each basin, in conjunction with the DEM, were used to develop the flood depth rasters. These flood depths rasters provide a visualization of the maximum flood depths throughout the Village and allow for a quick visual comparison between scenarios.

4.2.1 2023 Current Sea Level, Existing Scenario

Appendix A-5 shows the flooding depth modeling results of the Existing Scenario with 2023 Current Sea Level for the 5YR-24HR, 10YR-24HR, 25YR-24HR, 25YR-72HR and 100YR-72 storms, respectively.

4.2.2 2040 NOAA Intermediate-Low Sea Level Rise, Existing Scenario



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Appendix A-6 shows the flooding depth modeling results of the Existing Scenario with 2040 NOAA Intermediate-Low Sea Level Rise for the 5YR-24HR, 10YR-24HR, 25YR-24HR, 25YR-72HR and 100YR-72 storms, respectively.

4.2.3 2040 NOAA Intermediate-High Sea Level Rise, Existing Scenario

Appendix A-7 shows the flooding depth modeling results of the Existing Scenario with 2040 NOAA Intermediate-High Sea Level Rise for the 5YR-24HR, 10YR-24HR, 25YR-24HR, 25YR-72HR and 100YR-72 storms, respectively.

4.2.4 2070 NOAA Intermediate-Low Sea Level Rise, Existing Scenario

Appendix A-8 shows the flooding depth modeling results of the Existing Scenario with 2070 NOAA Intermediate-Low Sea Level Rise for the 5YR-24HR, 10YR-24HR, 25YR-24HR, 25YR-72HR and 100YR-72 storms, respectively.

4.2.5 2070 NOAA Intermediate-High Sea Level Rise, Existing Scenario

Appendix A-9 shows the flooding depth modeling results of the Existing Scenario with 2070 NOAA Intermediate-High Sea Level Rise for the 5YR-24HR, 10YR-24HR, 25YR-24HR, 25YR-72HR and 100YR-72 storms, respectively.

4.3 Level of Service Analysis

A LOS evaluation is a condition assessment to determine the stormwater system's level of performance with respect to site-specific criteria. These LOS criteria can be used as benchmarks to gage the performance of existing systems and facilitate proper management decisions concerning the administration, operation, maintenance, and capitalization of stormwater assets.

For the purposes of this LOS analysis, flooding of roadways and structures were used as the primary criteria for quantifying the Village's existing LOS under different storm events. Using the ICPRv4 model simulations for the 10-year 24-hour, and the 100-year 72-hour storm events, water stage elevations were determined for each of the modeled basins. These stage elevations were measured against the primary criteria to determine the length of roadways and number of structures that were estimated to be flooded for each storm event. Based on the type and length of roadway, and type and number of structures inundated, a scoring system was utilized to determine the relative LOS for each of the basins; basins with more structures and roads inundated would have a higher score and, thus a lower LOS. Such basins with a high score and low LOS should be prioritized for further stormwater management projects.

4.3.1 Roadways

Street centerline data for the Village was sourced from the Palm Beach County GIS and all of the publicly owned right of ways within the Village were classified based on their functionality into three main categories: local, collector, and major roads, as shown in **Figure 4-2.** Note, all major roads within the Village are evacuation routes.

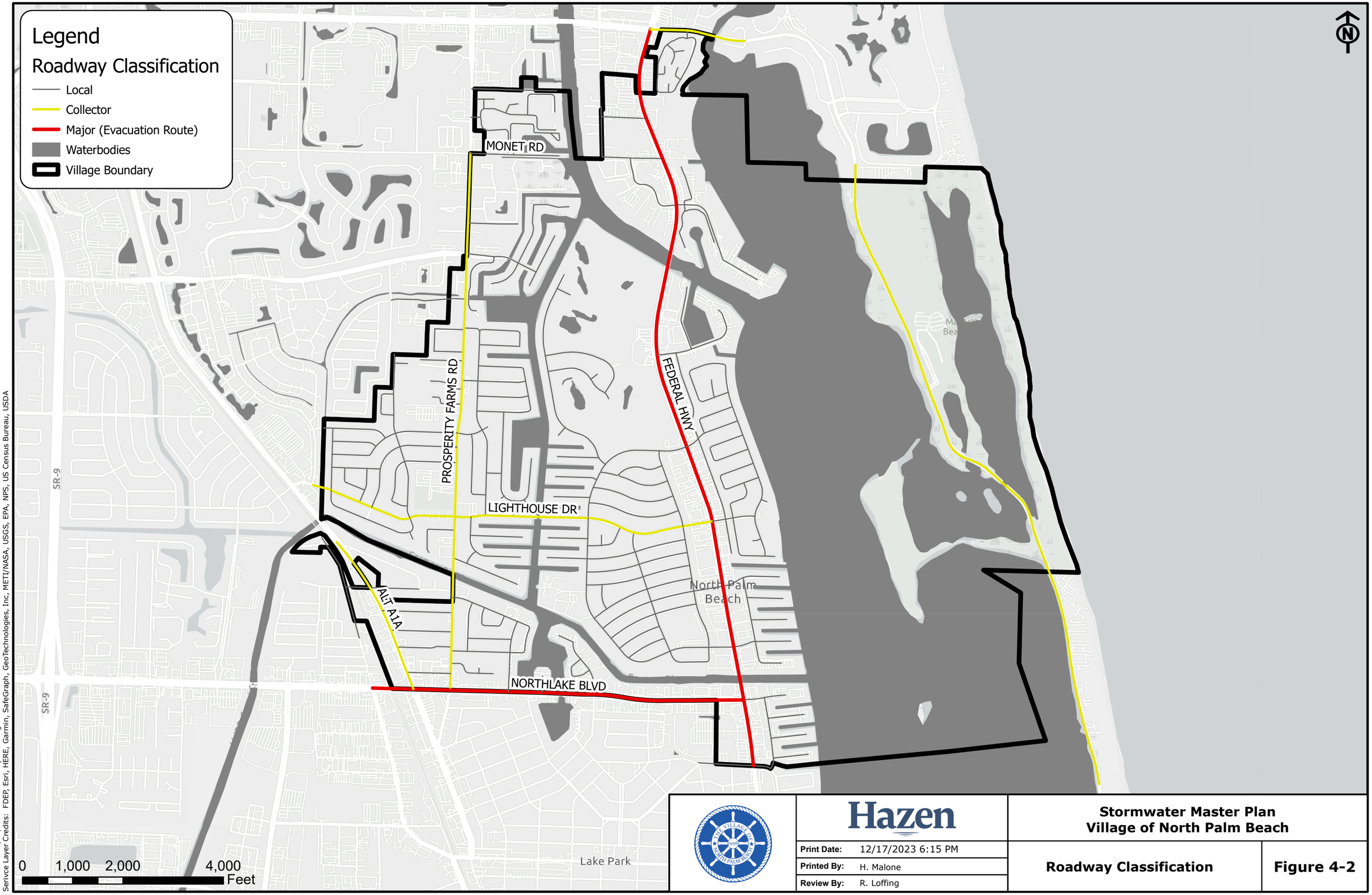
To facilitate scoring, a weighting factor was applied to each type of roadway based on their relative importance as well as the type of storm causing inundation of the roadway. Major, collector and local streets were ranked in decreasing order of importance and weight. Inundation resulting from a smaller, more frequent storm (10-year 24-hour) was given a higher weight than the inundation resulting from a heavier, less frequent storm event (100-year 72-hour). Any street type experiencing greater than 3 feet of flooding during the 100-year storm would fall within this category. Such flooding would limit the access of emergency vehicles and thus was given the highest weight in the LOS evaluation of a basin.

The Village's DEM was utilized to identify the existing elevations of all the roadways, against which the model derived water stage elevations for the 10-year and the 100-year storms were measured, to determine if a roadway flooded during the associated storm event. If the water stage elevation exceeded this DEM elevation, then the road was deemed to have been flooded by that storm event. For the purposes of this analysis, if the centerline of the street was determined to have been inundated, then the entire section of street was also assumed to have been inundated. Conversely, if the road centerline was above the water stage elevation, then the entire right of way was considered to not be flooded.

Table 4-1 identifies the weighting criteria associated with the type of storm event, category of roadway and depth of flooding. It is to be noted that all the roadway lengths are measured in total linear feet (LF) of inundated street centerline for each modeled basin and normalized by the area of the basin in acres. The final scores for each basin determined from this analysis represent the relative LOS of street flooding of that basin compared to the LOS of the other basins in the modeled area. Additionally, the final score for each modeled basin is also normalized by the area of the basin in acres. **Figure 4-3** shows roadway flooding depths for the 10-year storm.

Table 4-1: Performance Measure and Weight Factor for Flooded Roadways

	Performance Parameter	Performance Measure	Weight Factor
Score Based on Flooded Roads	**Evacuation Routes**	LF/acre inundated in the 10-year 24-hour flood	20
	Evacuation Routes	LF/acre inundated in the 100-year 72-hour flood	10
	Collector	LF/acre inundated in the 10-year 24-hour flood	5
	Collector	LF/acre inundated by 9-inches or more in the 100-year 72-hour flood	2
	Local	LF/acre inundated in the 10-year 24-hour flood	1



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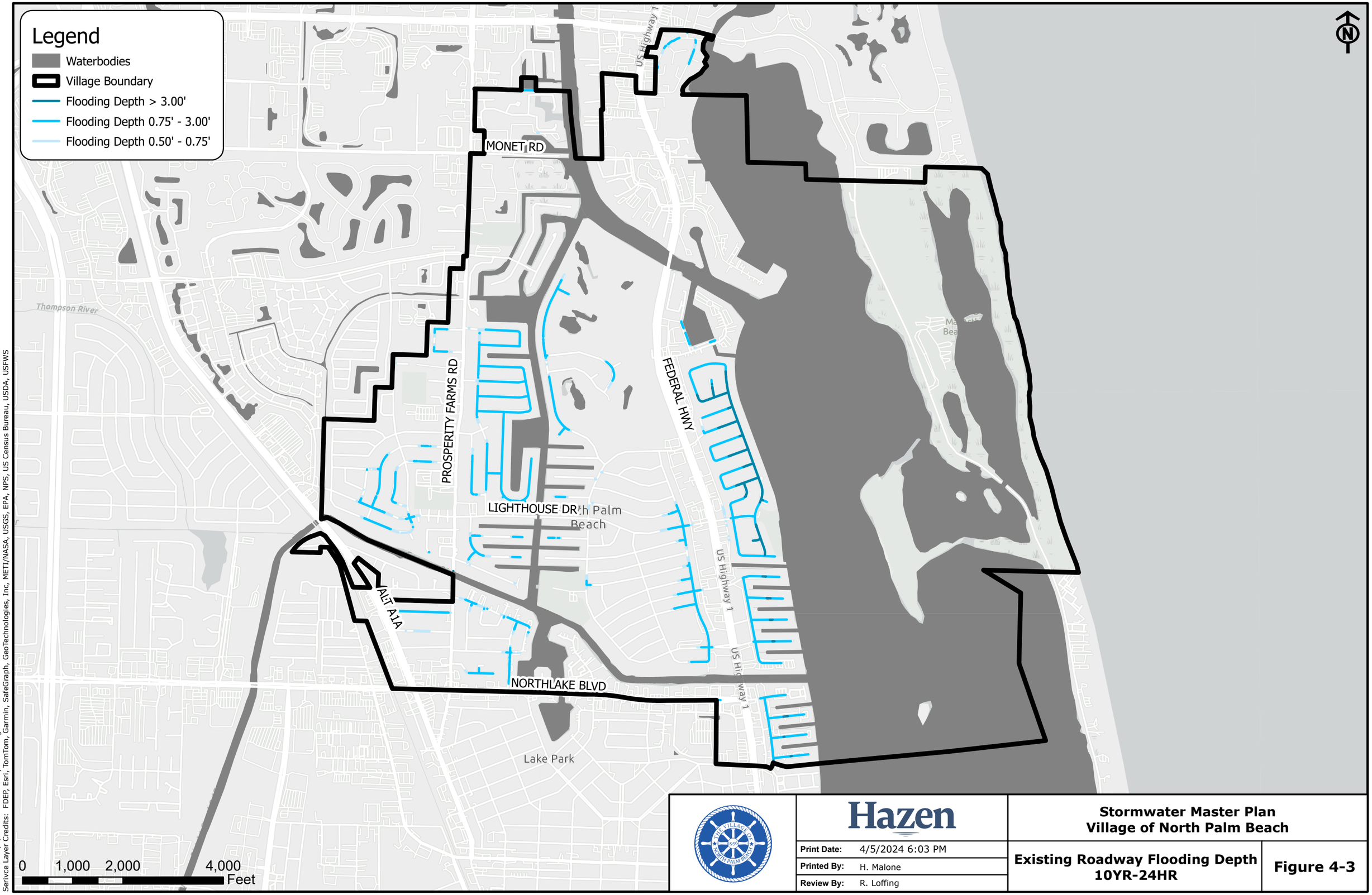

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Stormwater Master Plan
Village of North Palm Beach

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Existing Roadway Flooding Depth 10YR-24HR

Figure 4-3

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4.3.2 Structures

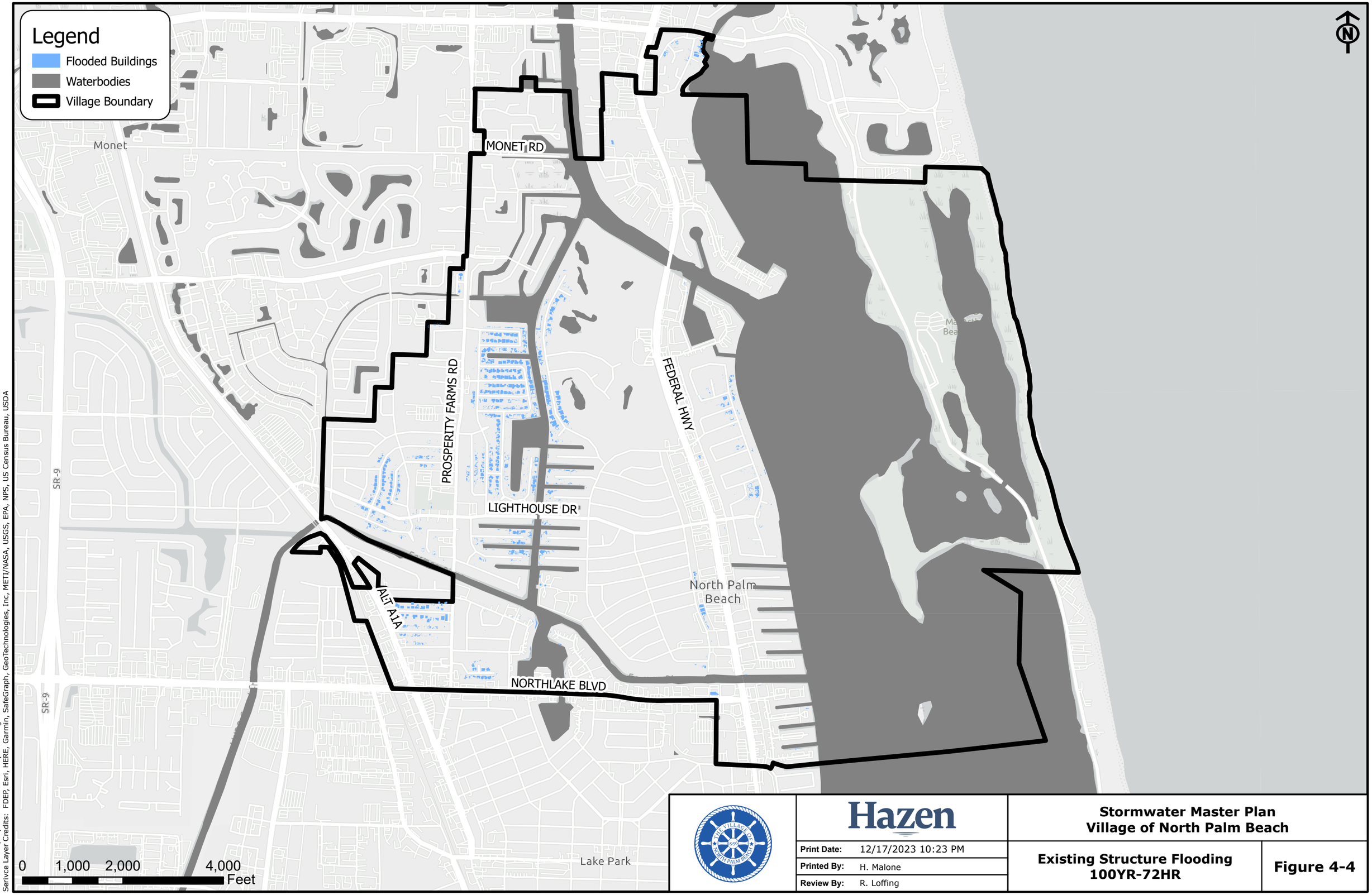
Building footprint data sourced from Palm Beach County GIS was utilized to identify the number of structures inundated by the 10-year, 24-hour and the 100-year, 72-hour storm events. Since finished floor elevations are not publicly available, the footprint dataset and the DEM elevation data were used to estimate these finished floor elevations by sampling the DEM within a 5-foot buffer, adjacent to the footprint of each structure. It was assumed that the water stage elevation exceeding this finished floor elevation of any structure results in that structure being inundated.

Structures were categorized into two main categories based on their functionality; 'Critical Structures' as previously identified and 'Residential/Non-Residential Structures' to encompass all remaining structures not included in the 'Critical' category.

As shown in **Table 4-2**, weight factors were assigned based on the structure category and the type of storm that resulted in inundation of the structure. It is to be noted that all the scoring for these flooded structures is based on a total count of the number of structures inundated within a basin. It does not account for the depth of flooding or how much of the structure is inundated. Additionally, the final score for each modeled basin is also normalized by the area of the basin in acres. The final scores for each basin determined from this analysis represent the relative LOS of structure flooding of that basin compared to the LOS of the other basins in the modeled area. **Figure 4-4** shows flooded structures for the 100-year storm.

Table 4-2: Performance Measure and Weight Factor for Flooded Structures

	Performance Parameter	Performance Measure	Weight Factor
Score Based on Flooded Structures	**Critical Structures**	Number of structures/acre impacted in 100-year 72-hour flood	1000
	Residential/Non-Residential Structures	Number of structures/acre impacted in 100-year 72-hour flood	750
	Critical Structures	Number of structures/acre impacted in 10-year 24-hour flood	2000
	Residential/Non-Residential Structures	Number of structures/acre impacted in 10-year 24-hour flood	1000



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Stormwater Master Plan
Village of North Palm Beach

Existing Structure Flooding 100YR-72HR

Figure 4-4

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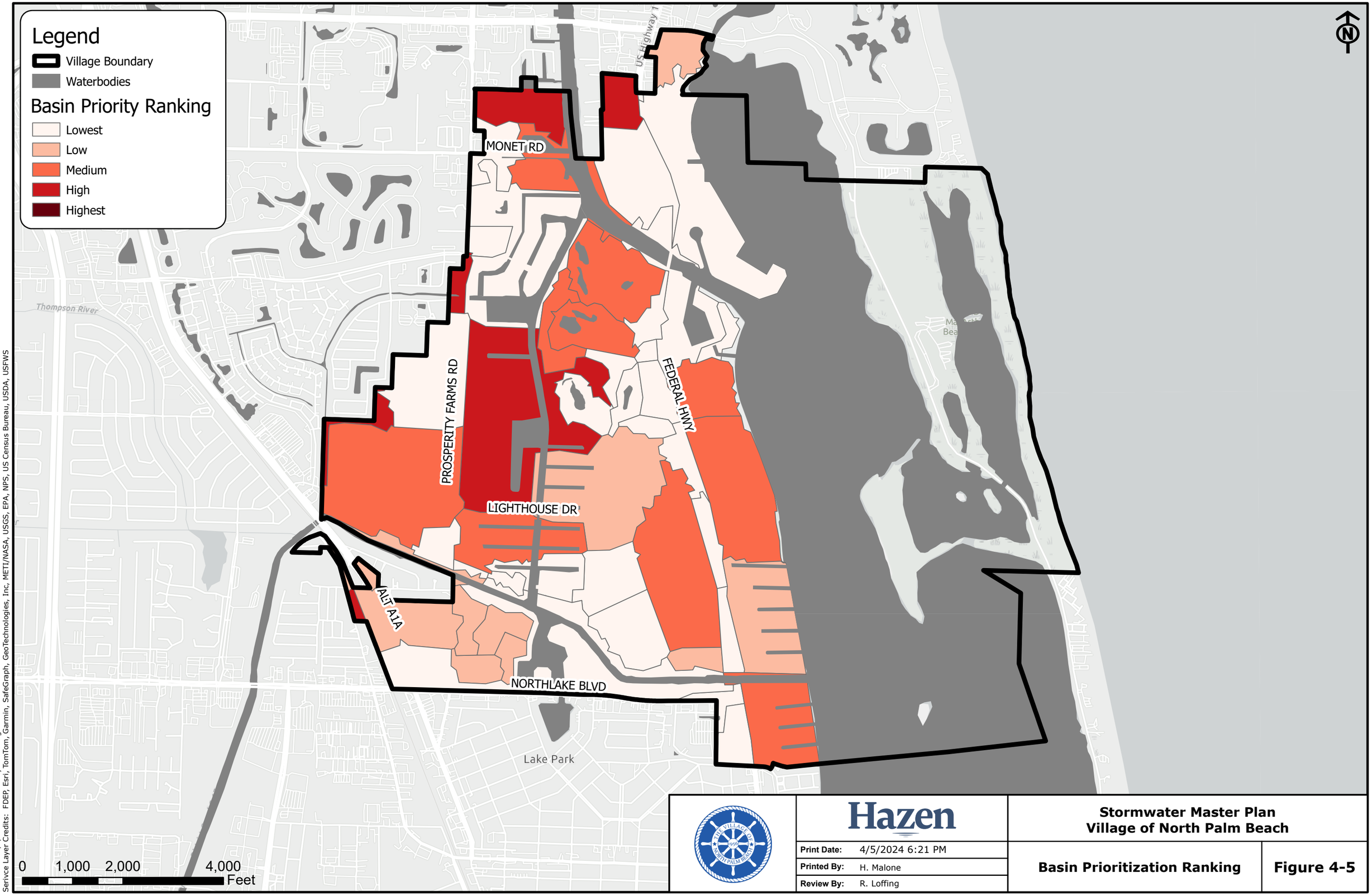
4.3.3 Recommendations

The final scores determined from the LOS analysis of flooded roadways and structures are added together to determine the overall score for each basin. It is to be noted that the LOS score of each basin is relative to the LOS of the other basins in the modeled area; a basin with a higher score than its surrounding basins has a lower LOS and should be prioritized for further stormwater management projects. The basin prioritization ranking is shown in **Figure 4-5.** It should also be noted that basin LOS was not the only factor included in determining the priority order and timing of projects reflected in the 5-year CIP and extended list of projects (beyond year 5) shown in **Table 7-1**. Also considered were relative ease and cost of implementation, as well as connection to other associated projects (particularly those with Climate Change elements).



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Stormwater Master Plan
Village of North Palm Beach

Basin Prioritization Ranking

Figure 4-5

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5. Requirements for Proposed Surface Water Management Systems

5.1 Design Criteria

Several design criteria are to be considered in the detailed development and evaluation of proposed improvements. The design frequency for proposed improvements relative to allowable discharge is the 25-year, 72-hour storm event. The design frequency for structure improvements is the 100-year, 72-hour storm event, while for roadways it is the 10-year, 24-hour storm events. The American Society of Civil Engineers (ASCE) 24-14, Flood Resistant Design and Construction, offers guidance to determine finished floor elevations for proposed structures as well. Further, FEMA's published Flood Insurance Rate Maps (FIRMs) for Palm Beach County, FL, with an effective date of October 5, 2017, provide guidance. **Appendix A-10** shows the FIRMs for the Village. These maps in conjunction with the criteria above should be used to establish minimum finished floor elevations for the design and permitting of the proposed stormwater improvements.

5.2 Water Quantity

The SFWMD allowable discharge rate by drainage basin in cubic feet per second per square mile (CSM) is listed below in **Table 5-1**. The **s**urface water management drainage basins within the Village are shown in **Figure 2-12,** presented in **Section 2** of this report.

Table 5-1: Allowable Discharge by Drainage Basin

Surface Water Management Drainage Basin	Maximum Allowable Discharge Rate[1]
Earman River Basin (C-17)	62.7 CSM
Lake Worth Lagoon	Pre vs Post

Since most of the Village discharges downstream of the SFWMD C-17 control structure, water quantity criteria is established by pre-improvement conditions. Regulatory agencies require a pre-/post-improvement comparison analysis to ensure that the proposed improvements do not negatively affect receiving waterbodies and downstream drainage basins. The modeling effort associated with this master plan supports the anticipated permitting effort; analyses derived from the modeling results could be used as documentation for approval of the proposed projects.

5.3 Water Quality

In July 2023, Hazen provided the Village with a comprehensive Water Quality Regulatory Compliance Requirements memorandum. That document, together with the information provided below should be used as a reference and guide relative to water quality related issues.

[1] Maximum allowable discharge rates shown are sourced from SFWMD Environmental Resource Applicant's Handbook Volume II and apply to the of 25-year, 72-hour design frequency.

5.3.1 Regulatory Authorities

As set forth by the Clean Water Act (CWA), directing state governments to establish their own surface water quality standards guided by and based on Environmental Protection Agency (EPA) rules, the FDEP, in coordination with other state and local agencies, monitors and regulates the management of stormwater runoff and its effects on ground and surface waters.

In accordance with the CWA, FDEP is authorized by the EPA to oversee the state of Florida's adopted Surface Water Quality Standards (Florida Administrative Code (F.A.C.) 62-302). Within Palm Beach County, jurisdiction over canals and other bodies of freshwater belongs to FDEP, SFWMD, USACE, Environmental Resources Management (ERM) or local drainage districts, including the Northern Palm Beach County Improvement District (NPBCID) for portions of the District located within the boundaries of the Village.

Many of these agencies have jurisdictional authority over the management and storage of surface waters, requiring the issuance of permits for stormwater management improvements.

The various government agencies involved with overseeing the adequate removal of pollutants (water quality) along with reference to their governing criteria are listed in **Table 5-2**.

Table 5-2: Water Quality/Quantity Regulatory Agencies

Regulatory Agencies	
Federal	EPA – National Pollutant Discharge Elimination System (NPDES)
	USACE – Section 404, CWA
State	FDEP – Chapter 62-302 and 303, F.A.C. and NPDES as administered by the EPA
	SFWMD – Rule 40E-4.091(1)(a) and Rule 62-330.010, F.A.C.
	Florida Department of Transportation (FDOT) – Chapters 14-86, 62-25 and 62-40 of the F.A.C. and Section 373.4596 F. S.
County	Palm Beach County – Chapter 11 of the Palm Beach CountyCode of Ordinances
Village	Village of North Palm Beach – Chapter 21, Article V of the Village's Code of Ordinances
Local Drainage Districts	Northern Palm Beach County Improvement District

5.3.2 Water Quality Criteria

Most waterbodies in South Florida are classified as Class III waters for their abilities to provide "Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife" and water quality criteria have been established to protect present and future beneficial uses of these waters. While some criteria are intended to protect human health relating to pathogens, others are designed to protect aquatic life relating to nutrients.

Waterbodies that do not meet water quality criteria standards are identified as "impaired" for the particular pollutants of concern – nutrients, bacteria, mercury, etc. Where this occurs, total maximum daily loads (TMDLs) defined as a scientific determination of the maximum amount of a given pollutant that a surface water can absorb and still meet the water quality standards that protect human health and

aquatic life, must be developed, adopted and implemented to reduce those pollutants and clean up the waterbody.

Currently, there are no waterbodies with TMDLs in the Village.

5.3.3 Future Changes to Stormwater Permitting

5.3.3.1 Federal

There are anticipated future updates to EPA's stormwater regulations. According the NPDES website, the agency proposed national rulemaking to strengthen the stormwater program including:

- providing incentives, technical assistance, and tools to communities to encourage them to implement strong stormwater programs,
- leveraging existing requirements for point source and non-point source pollution to strengthen municipal stormwater permits, and
- continuing to promote green infrastructure as an integral part of stormwater management.

In anticipation of these updates and in line with the Village's stormwater objectives and Environmental Committee, it is in the Village's best interest to continue to pursue projects that will address and benefit water quality conditions.

5.3.3.2 State

In 2020, the Florida Legislature passed Senate Bill 712, also known as the Clean Waterways Act, now Chapter 2020-150, Laws of Florida. This legislation carries a wide range of water-quality protection provisions aimed at minimizing the impact of known sources of nutrient pollution and strengthening regulatory requirements. In addition, the Clean Waterways Act directed FDEP and Florida's water control districts (WCDs) to update stormwater design and operation regulations under Part IV, Chapter 373 of the Florida Statutes (F.S.) to address nutrients using the latest scientific information.

FDEP is in the process of conducting meetings with the public to gain input as part of the rule making development. Some of the public comments received to date include:

- Provide more stringent local stormwater regulations that serve as a regulatory floor and not a ceiling for local governments.
- As a part of post-construction, require ongoing monitoring and maintenance of stormwater systems in order to ensure that they are properly functioning and not contributing to the degradation of water quality.
- Require that updated sea level rise projections and increases of both surface water runoff and rising water tables be included in stormwater system designs to avoid stormwater system failures and possible release of untreated stormwater.

- Provide the flexibility of using off-site mitigation/treatment within the same watershed to meet requirements.
- Address the cumulative impacts of hundreds of 10/2 a.k.a. "No Notice General" permits failing to meet net improvements. Further these permits should not be an option when proposed within a watershed listed as impaired or has an adopted TMDL.
- Promote and incentivize low impact development practices beyond stormwater ponds such as increased permeable surface areas, rain gardens, and bioswales.
- Provide new technologies and methods for treating stormwater such as binders, coagulants, treatment trains, or regional treatment nodes. Consistent criteria and assumptions should be established for each of these new processes.
- Consider restoring the bi-annual inspection report submittals to include staff reviews and inspections for the Environmental Resource Permit conditions and provide more detailed guidance for maintaining the stormwater management systems especially pertaining to the removal of sediment and/or muck within older ponds to restore the intended permitted design.

This rulemaking should be monitored and changes to Village programs and processes updated accordingly. The cost and time associated with updating stormwater design and operation regulations is unknown at this time. However, compliance through scheduled improvements as provided for in the Village's CIP is an ongoing focus and commitment of the Village.

FDEP published a Notice of Change on March 24, 2023, in the Florida Administrative Register for proposed amendments to Chapter 62-330 of the Florida Administrative Code, including Applicant's Handbook Volume I. These changes have not gone into effect as of the date of this Stormwater Master Plan. The changes to Chapter 62-330 that could impact the Village are as follows:

- Section 2(25) and (26) clarifies definitions for Best Management Practices (BMPs) and adds section citation for additional information.
- Section 3.1.2(e) includes conceptual approval permits in grandfathering language.
- Section 8.3 clarifies grandfathering language and clarifies and revises performance standard design requirements.
- Table 9.2 corrects the calculation for one land use event mean concentration (EMC) value which is utilized for predicting water quality impacts.
- Section 9.5.2 clarifies BMP references to include those listed in Volume II.

5.3.4 Stormwater Best Management Practices

The FDEP, SFWMD and ERM have policies and procedures in place for improving water quality through stormwater BMPs.

A stormwater BMP is an effective and feasible method or combination of methods used in preventing or reducing the amount of pollution generated by eroding soils and debris, activities from construction sites,

agricultural activities, pavements, motor vehicles, atmospheric deposition, vegetation, chemicals, and wastewater to levels compatible with water quality goals.

Source control measures address contaminants. They may reduce or eliminate pollutants deposited on land surfaces that may eventually come in contact with stormwater and be transported to receiving waters. Some of the common pollutants found in stormwater runoff are listed in **Table 5-3** along with their specific adverse impact on the health of waterways and the environment.

Table 5-3: Common Stormwater Runoff Pollutants[2]

Constituents	Sources	Adverse Impacts
Sediments	• disintegrating rock • eroding soil • accumulated organic material deposited on land surfaces	• increased turbidity • reduced light penetration • impaired respiration of fish and aquatic invertebrates • reduced reproduction resulting in decline of commercial and recreational fishing resources
Nutrients - **Nitrogen** - **Phosphorous**	• fertilizers • detergents • plant debris • atmospheric • septic tanks	• increase primary biological productivity • unwanted and uncontrolled growth of algae • undesirable aquatic weeds • surface algal scum • water discoloration • release of toxins from sediment
Heavy Metals - **Lead** - **Cadmium** - **Chromium** - **Copper Mercury** - **Zinc**	• motor vehicles • industry fallout • degradation of highway materials	• reproduction of fish and shellfish • accumulate in fish tissue posing a threat to humans • potential for ground water contamination
Oxygen Demanding Substances	• microorganisms • high concentrations of decaying organic matter • oxygen demanding substances	• oxygen deficit • reproduction of fish and other aquatic life forms
Petroleum Hydrocarbons - **Benzene** - **Toluene** - **Ethyl benzene** - **Xylene** - **Polynuclear aromatic hydrocarbons**	• parking lots • roadways • leaking storage tanks • vehicle emissions • improper disposal of waste oil	• benthic communities

Pathogens	• coliform bacteria
	• viruses
	• animal waste
	• failing septic systems
	• illicit sewage connections
	• boats and marinas
		• benthic communities
		  ○ low species diversity
		  ○ reduced abundance

Toxins	• pesticides • solvents • household and industrial chemical • detergents • synthetic organic surfactants • sanitary sewers • septic tanks	• fish respiration • water conditioning phosphate-based chemicals
Water Temperature	• increased flows • decreased vegetative cover • increased imperviousness	Changes to the following physical properties and characteristics of water: • salinity • solubility • alkalinity • dissolved oxygen • pH • hardness • conductivity

[2] A portion of this information was sourced from "Best Management Practices for South Florida Urban Stormwater Management Systems", dated April 2002 as prepared by SFWMD.

5.3.4.1 Source Control

Source Control practices that improve water quality by reducing the accumulation and generation of potential pollutants at or near their source do not require construction of a facility, but instead provide for the development of pollution control programs that include prevention, education, and regulation. Some examples of nonstructural BMPs are shown in Table 5-4**.**

Table 5-4: Examples of Nonstructural Best Management Practices[3]

Practice	Action	Examples
Planning and Regulatory Tools	Action plans and regulations that encourage or mandate management practices to prevent, reduce, or treat stormwater runoff	• Required setbacks from waterways • Minimum allowable impervious areas within a site • Mandated criteria for treating runoff
Ordinances and Regulatory Programs	Establish codes and ordinances to define objectives, permitting requirements, performance/design standards, and enforcement policies. Federal, state, local, and site-specific requirements provide the basis for building regulatory programs	Water management districts function under these codes and require permits for the construction and operation of water management systems, water usage, and water quality monitoring plans
Conservation Plan	Reduce or eliminate the amount of water potentially requiring stormwater treatment	• Appropriate lawn irrigation. • Adopt Xeriscape® landscape principles
Turf and Landscape Management	Employ turf and landscape management procedures consistent with vegetation use, growing season, and rainfall amounts. Provide routine irrigation, mowing, fertilization, targeted pest management, aeration, and dethatching of lawns and grasses planted for aesthetic and recreational uses, surface stabilization, and erosion control	• Perform mowing when no significant rainfall events are predicted • Post “no dumping” signs to prevent the disposal of cuttings and clippings in or near drainage facilities • Promote composting as a good disposal alternative
Catch Basin Cleaning	Remove accumulated sediments from catch basins on a regular basis to prevent clogging	Mechanical cleaners such as eductors, vacuums, or bucket loaders
Road Maintenance and Street Cleaning	Provide maintenance programs to address deteriorating roadway surfaces that contribute to contamination of stormwater and provide routine street cleaning for the removal of accumulated depositions of solids that may otherwise be transported as contaminants in the first flush of stormwater	• Repair of potholes and worn pavement • Minimize size of the impervious areas • Remove particles (>50 microns) and associated pollutants (i.e., solids and heavy metals) via mechanical broom and or vacuum sweepers, and street flushers
Canal/Ditch Maintenance	Check ditches that carry heavy flow concentrations for collapsed or blocked flow ways, or degradation of flow way lining materials	• Dredge buildup of sediments • Remove illegally dumped items to reduce possible pollutants and achieve aesthetic enhancement • Post “No littering” signs with call-in number to report dumping in progress
Modification of Structural Operations	Modify structural operation schedules to optimize water quality objectives. Successful operations will reduce risk, increase water supply reliability, and enhance water quality	• Divert low quality water away from critical habitat areas • Increase detention times in existing ponds • Store water for future use during drought periods • Recharge the ground water table • Mix clean water with degraded water to enhance quality
Educational and Outreach Programs	Implement public education and outreach programs into a community’s overall stormwater management plan to educate employees, the public, and businesses about the importance of protecting stormwater from improperly used, stored, and disposed pollutants	• Frequent and consistent campaign messages • Provide door hangers, pamphlets, guidebooks, signs and press releases • Neighborhood programs

[3] A portion of this information was sourced from “Best Management Practices for South Florida Urban Stormwater Management Systems”, dated April 2002 as prepared by SFWMD.

5.3.4.2 Structural BMPs

Structural BMPs involve building an engineered "structure" or "asset" for controlling the quality of stormwater runoff. These structures treat runoff at either the point of generation or the point of discharge to either the storm sewer system or receiving waters. Most require some level of routine maintenance. Structural BMPs can be categorized as retention systems, detention systems, or other systems. They may be used alone or together in linked fashion to reduce or alleviate the adverse effects of stormwater runoff.

Stormwater treatment systems for controlling stormwater runoff fall into two main categories: retention systems, and detention systems.

Per the SFWMD, ERP Applicant's Handbook Volume II, wet detention volume shall be provided for the first inch of runoff from the developed project, or the total runoff of 2.5 inches times the percentage of imperviousness, whichever is greater.

The volumetric requirements for new development and redevelopment are that retention, detention, or both retention and detention in the overall system including swales, lakes, canals, greenways, etc., be provided for in one of the following three criteria or equivalent combinations thereof:

Dry detention volume shall be provided equal to 75 percent of the above amounts computed for wet detention.

Retention volume shall be provided equal to 50 percent of the above amounts computed for wet detention.

In addition, commercial or industrial zoned projects must provide at least one-half inch of dry detention or retention pretreatment as part of the required retention/detention.

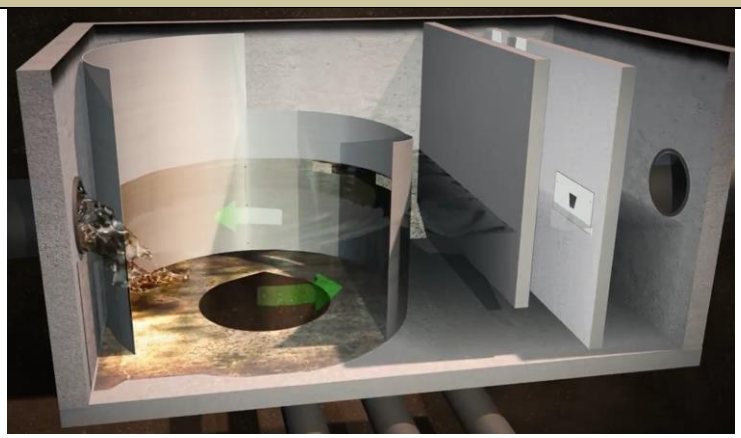
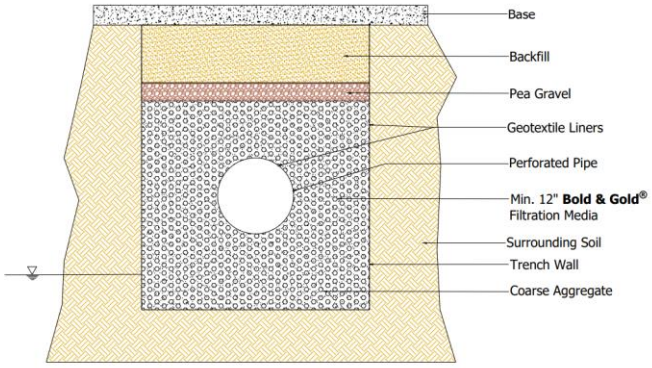
In addition to the standard stormwater treatment system BMPs outlined previously, there have been innovations proliferating in recent years to address water quality issues and reduce pollution in stormwater discharge. These technologies include but are not limited to advanced filtration media technology, hydrodynamic separators and settling chambers. Some examples of stormwater treatment systems and their advantages and or disadvantages are listed in **Table 5-5**, below. See **Table 5-6** for some examples of these technologies in the industry.

Table 5-5: Advantages and Disadvantages of Stormwater Treatment Systems[4]

System	Description	Advantages	Disadvantages
Wet and Dry Detention	Wet detention ponds are designed to maintain a permanent pool of water and temporarily store runoff until it is released at a controlled rate. These systems are more efficient in removing soluble pollutants (nutrients) than dry detention due to the biological activity in the vegetation and water column. Dry detention ponds detain a portion of runoff for a short period using a fixed opening to regulate outflow at a specified rate and allowing solids and associated pollutants time to settle out. In general, these systems are effective in removing total suspended solids but have low treatment efficiency for nutrients. Requirements call for a minimum of one foot from control elevation to bottom of detention area.	• reduces pollutant loads • maximizes groundwater recharge • reduces runoff volume/rates • long service life • low maintenance	• potential standing water • reduction of infiltration rates over time • space requirements
Exfiltration Trenches	Exfiltration trenches are perforated pipes buried in trenches backfilled with stone or aggregate. Runoff diverted into the pipe gradually infiltrates from the pipe into the trench and into the subsoil, eventually reaching the ground water. A filter cloth surrounding the rock trench is used to minimize clogging.	• groundwater recharge • efficient layout • retrofit situations	• short service life • high maintenance
Grassed Swales	Grassed swales are typically shallow, vegetated, trenches used for filtration and conveyance prior to runoff being discharged to treatment systems. Grassed swales should be mowed to stimulate vegetative growth, control weeds, and maintain the capacity of the system.	• attenuation of stormwater runoff • groundwater recharge • fits into limited spaces	• standing water •
Water Quality Inlets	Water quality inlets rely on settling to remove pollutants before discharging water to the storm sewer or other collection system. They are also designed to trap floating trash and debris. When inlets are coupled with oil/grit separators and/or hydrocarbon absorbents, hydrocarbon loadings from high traffic/parking areas may be reduced.	• limited space requirements • ideal for retrofit projects • long life • unaffected by soil conditions	• serves only small drainage area • high maintenance • not accepted by all regulatory agencies
Chemical Treatment	Chemical processes include coagulation coupled with solids separation to remove pollutants. Iron, aluminum metal salts, and alum are used to coagulate compounds, and then polymers are added to enhance flocculation and induce settling.	• reduces detention time requirements • works for relatively large areas • unaffected by soil conditions	• solid waste disposal issues • high maintenance

[4] A portion of this information was sourced from "Best Management Practices for South Florida Urban Stormwater Management Systems", dated April 2002 as prepared by the SFWMD.

Table 5-6: Stormwater Treatment System Innovations

System	Illustration	Description
Vortechs® Stormwater Treatment[5]		• large swirl chamber with fine particle removal down to 50 microns • shallow profile with an easy and cost-effective installation especially on sites with high groundwater or conflicts • unobstructed access to stored pollutants
Bold and Gold® Filtration Media[6]		• a biosorption activated media (BAM) used to remove total nitrogen, total phosphorous, total suspended solids and pathogens from polluted water • eight (8) patented mixes of Bold and Gold® are made of sand, clay and recycled tire • installed within BMPs to increase water quality benefits

5.3.5 Floodplain Management

Construction in floodplains is a major contributor to flood damage to homes and other personal property. The floodplain also provides benefits relative to maintaining water quality and environmental integrity. Portions of the Village lie within a FEMA designated Special Flood Hazard Area (SFHA) and are at risk of flooding. Per the Flood Disaster Protection Act of 1973, flood insurance is required to receive federal or federally related financial assistance for acquisition and/or construction of buildings in an SFHA.

Implemented in 1990, the National Flood Insurance Program (NFIP) established the Community Rating System (CRS), which is a program that rewards communities for floodplain management policies that exceed minimum standards. These rewards come in the form of adjusted (lower) flood insurance premiums, reflective of the reduced risk of flood damage for communities participating in activities

[5] All information for the Vortechs® Stormwater Treatment was referenced from the manufacturer, Contech Engineered Solutions LLC.
[6] All information for the Bold and Gold® Filtration Media was referenced from the manufacturer, Environmental Conservation Solutions.

consistent with CRS goals. Credit points are available in 18 different activities, resulting in CRS Class and insurance premium reductions.

Through its participation in the CRS, the Village is currently categorized as Class 5, earning a 25% discount. As of April 1, 2023, FEMA has implemented the NFIP pricing methodology called Risk Rating 2.0. Under this methodology, all NFIP policies in a participating community, including policies outside of the SFHA are eligible for the full discount.

6. Proposed Projects for the Village's Capital Improvement Program and Additional Recommendations

The recommended projects aim to improve the Village's level of service relative to flood protection and water quality, resilience and adaptation considering climate change, and renewal of aging assets. The Village has been proactive in not only dealing with current conditions, but also looking ahead to future climate and land use scenarios to serve the community well in the long term. The Village can use the recommendations presented in this master plan to secure funding and begin project implementation.

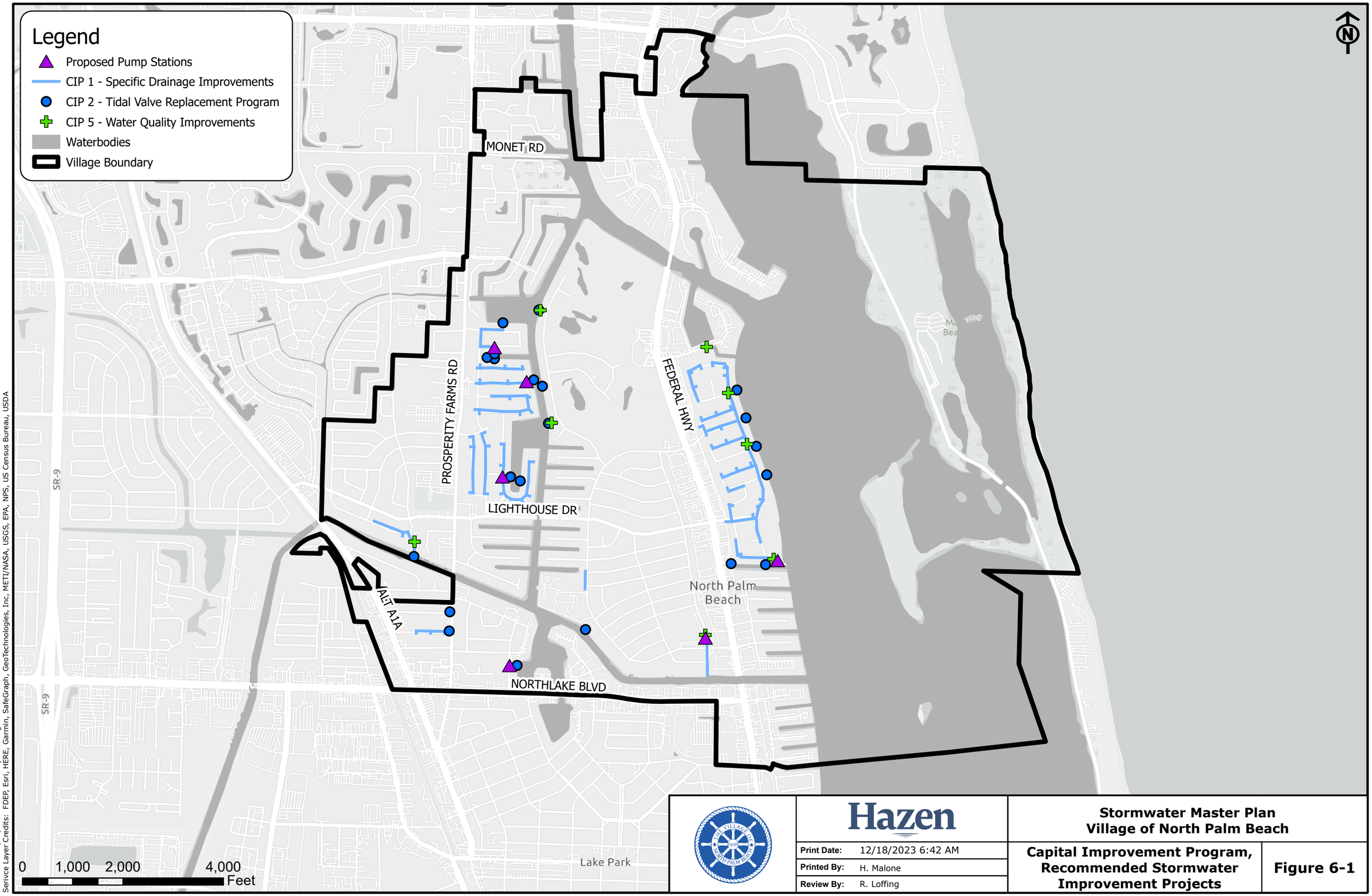
6.1 CIP Proposed Improvements

Two categories of recommendations for stormwater improvements within the Village were developed. The first category, CIP 1, includes project specific stormwater management improvements that can be implemented on a project-by-project basis to address localized flooding issues identified in the Stormwater Master Plan. The purpose of these projects is to improve the overall performance of the stormwater management system throughout the Village. These localized improvements consist mainly of the installation of new underground infrastructure with integrated water quality best management practices including green infrastructure and exfiltration trenches. Some of these projects involve extensions of existing systems, while others are initial investments. The Village should begin budgeting for the first of these projects as part of its 5-year Stormwater CIP, while others would come after that planning horizon. The CIP 1 stormwater improvements are defined in more detail in the following sections.

Figure 6-1 is a location map of the recommended projects.

The second category, CIP 2 through 5, is intended to be implemented throughout the Village's entire stormwater management system with the overall goal of improving system operational efficiency. It is suggested that the Village treat these as continuing programs that require annual or some other frequency of recurring funding until the improvements are completed Village-wide. These improvements include:

- CIP 2 – Tidal Valve Program
- CIP 3 – Swale Rehabilitation Program
- CIP 4 – Asset Cleaning, Inspection, Pipe Rehabilitation and Maintenance Program
- CIP 5 - Water Quality and Environmental Protection Program



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Service Layer Credits: FDEP, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA

Hazen		Stormwater Master Plan Village of North Palm Beach
Print Date:	12/18/2023 6:42 AM	Capital Improvement Program, Recommended Stormwater Improvement Projects
Printed By:	H. Malone	Figure 6-1
Review By:	R. Loffing	

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6.1.1 CIP No. 1 - Project Specific Stormwater Management Improvements

Proposed Budget Planning Horizon: Years 1 – 5

The Village-wide stormwater model was used to identify areas of significant flooding during heavy rainfall events. The flooding issues within these areas are caused by a combination of the following:

- Low ground surface elevations
- High water table elevations
- Lack of or undersized drainage infrastructure
- Poor grading
- Tidal influences.

A prioritized list of improvements, along with planning level cost estimates for each project was developed based on the level of service criteria established in **Section 4.3** of this Stormwater Master Plan. The conceptual design and planning level cost estimates for each project were developed based on the following assumptions:

- The conceptual layouts will need to be evaluated in more detail during the design phase of each project to verify feasibility.
- The cost estimates presented in this Master Plan are considered planning level unless otherwise noted.
- All costs are presented in 2023 dollars and must be escalated for future years.

The following factors were applied to the planning level construction cost estimates to obtain the total project cost estimates:

- 15 percent for General Conditions.
- 30 percent for Contingency for project unknowns at the planning level, such as alignment, materials, and site conditions.
- 30 percent for legal, administrative, and engineering services, including services during construction.

The following projects have been identified as meeting the prioritization criteria of significant areas of flooding, effectiveness of reducing flooding, and cost effectiveness. The projects are not presented in order of priority below, however, the initial recommendation for order of implementation is presented in Section 7.

6.1.1.1 Laurel Road Stormwater Improvements

Proposed Budget Planning Horizon: Future Years

Routine nuisance flooding occurs along portions of Laurel Road and Laurel Court. To alleviate flooding, this project includes the addition of drainage structures, exfiltration trenches, drainage pipes and a tidal valve with a new outfall to the Earman River. The new drainage infrastructure will be connected to the existing stormwater system located at the intersection of Laurel Road and Cinnamon Road. As part of this work, portions of existing pipelines will be increased in size and existing swales and driveways will be regraded to facilitate positive drainage. Acquisition of an easement will be required to drain Laurel Court to the Earman River, and its acquisition should be considered as part of the critical path of this project.

Benefits:

- Localized relief of driveway and road flooding
- Additional outfall
- Water quality treatment

6.1.1.2 Honey Road Stormwater Improvements

Proposed Budget Planning Horizon: Years 1 – 5

Routine nuisance flooding occurs along portions of Honey Road, due to its low-lying nature and its elevation compared to Prosperity Farms Road. To alleviate flooding, this project includes the addition of a check valve and a modified connection to the Prosperity Farms Road stormwater system that drains north to the Earman River. This modified connection, inclusive of the check valve, will address surcharging of flow from the Prosperity Farms system onto Honey Road.

Benefits:

- Localized relief of driveway and road flooding
- Relief from surcharging
- Water quality treatment

6.1.1.3 Conroy Drive Stormwater Improvements

Proposed Budget Planning Horizon: Years 1 – 5

Routine nuisance flooding occurs along portions of Conroy Drive due to its low-lying nature and its elevation compared to Prosperity Farms Road. To alleviate flooding, this project proposes to add drainage structures, exfiltration trenches, drainage pipes and a check valve with a modified connection to the Prosperity Farms Road stormwater system that drains north to the Earman River. This modified connection, inclusive of the check valve, will address surcharging of flow in the Prosperity Farms system onto Conroy Drive. As part of this work, existing swales and driveways will be regraded to facilitate positive drainage.

Benefits:

- Localized relief of driveway and road flooding

- Connectivity to outfall
- Water quality treatment

6.1.1.4 Fairhaven Drive Stormwater Improvements

Proposed Budget Planning Horizon: Future Years

Routine nuisance flooding occurs along portions of Fairhaven Drive and Northlake Drive. To alleviate flooding, this project proposes to construct a stormwater pump station with drainage force main to the Earman River. New drainage infrastructure will be connected to the existing stormwater system located on Northlake Drive, and both will connect to the pump station, which will operate jointly with the existing Northlake Drive gravity outfall to the Earman River. As part of this work, portions of existing pipelines will be increased in size and existing swales and driveways will be regraded to facilitate positive drainage.

Benefits:

- Localized relief of driveway and road flooding
- Increased discharge capacity

6.1.1.5 Anchorage Drive Stormwater Improvements

Proposed Budget Planning Horizon: Years 1 – 5

Routine nuisance flooding occurs along portions of Anchorage Drive between Inlet Road to the north and Ebbtide Drive to the south. The worst of the flooding is modeled to occur on the west side of Anchorage, north of the entrance to Anchorage Park. To alleviate flooding, this project proposes to install a drainage structure in the low area of the on-street parking and connect, via exfiltration trench to the existing outfall to the north.

Benefits:

- Localized relief of driveway and road flooding
- Water quality treatment

6.1.1.6 Eastwind Drive Stormwater Improvements

Proposed Budget Planning Horizon: Future Years

Routine nuisance flooding occurs along portions of Eastwind Drive. To alleviate flooding, this project proposes to add a stormwater pump station with drainage force main to the Earman River. The new drainage infrastructure will be located within the Eastwind Drive right-of-way and the adjacent school site. Acquisition of an easement will be required on the School Board of Palm Beach County property and should be obtained in advance.

Benefits:

- Localized relief of driveway and road flooding
- Increased discharge capacity

6.1.1.7 Westwind Drive Stormwater Improvements

Proposed Budget Planning Horizon:

Flooding occurs within portions of the residential neighborhoods bounded by and including Teal Way to the north, Lighthouse Drive to the south, the North Palm Beach Waterway to the east and Westwind Drive to the west. To alleviate flooding, this project proposes to add drainage structures, and to interconnect and extend drainage pipelines within their respective road rights-of-way. The work will also involve (future) construction of three stormwater pump stations with drainage force mains discharging to the North Palm Beach Waterways. As part of this work, portions of existing pipes will be increased in size and existing swales and driveways will be regraded to facilitate positive drainage. The project is expected to proceed in two phases with Phase 1 including the interconnection and extension of gravity drainage while Phase 2 will include the installation of the new pump stations.

Benefits:

- Localized relief of driveway and road flooding
- Increased discharge capacity, adaptation for future sea level rise
- Water quality treatment

6.1.1.8 North Palm Beach Country Club Golf Course Stormwater Improvements

Proposed Budget Planning Horizon:

The work will involve construction of a stormwater pump station and drainage force main in the vicinity of Hole No. 9 that will move stormwater to the east lake located on site adjacent to the driving range, permitting better onsite management of stormwater runoff.

Benefits:

- Stormwater management to balance lake elevations

6.1.1.9 Lakeside Drive Stormwater Improvements

Proposed Budget Planning Horizon:

Flooding occurs within portions of the residential neighborhoods bounded by and including Yacht Club Drive to the north, Ebbtide Drive to the south, the Lake Worth Lagoon to the east and Atlantic Aly to the west. To alleviate flooding, this project proposes to add drainage structures, and interconnect/extend drainage pipes within their respective road rights-of-way. The work will also involve construction of a stormwater pump station with drainage force main discharging to the Lake Worth Lagoon. As part of this work, portions of existing pipes will be increased in size and existing swales and driveways will be regraded to facilitate positive drainage.

Benefits:

- Localized relief of driveway and road flooding
- Increased discharge capacity, adaptation for future sea level rise
- Water quality treatment

6.1.1.10 Lakeside Park Seawall Replacement

Proposed Budget Planning Horizon:

The existing Lakeside Park Seawall is shown below in **Figure 6-2**. The Village established an ordinance in 2019 that amended the construction and engineering design standards for seawalls in the Village. The ordinance established new dimensional, compatibility, and elevation requirements for seawall caps. To bring this seawall into compliance with the ordinance, this project proposes to replace ±250 LF of seawall and concrete cap, complete with geotextile filter fabrics, stone backfill and miscellaneous restoration.



Figure 6-2: Lakeside Park Seawall

In addition, the project proposes to install ±250 LF of vegetated sand dune at the north end and ±150 LF at the south end of the park respectively. The length of the proposed sand dune was determined by assessing the elevation along the coast of Lakeside Park. LiDAR data was used to create an elevation profile along the east perimeter of the park; this profile is shown in **Figure 6-3**. The installation of sand dunes on both the North and South end of Lakeside Park is recommended to maintain a consistent profile that matches the established minimum seawall elevation of 5 ft NAVD per ordinance.

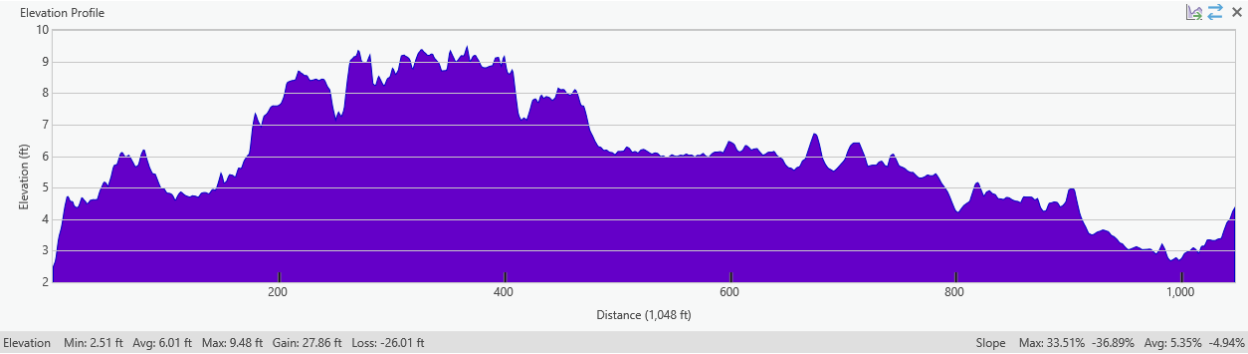


Figure 6-3: Elevation Profile Along the Coast of Lakeside Park

6.1.1.11 Anchorage Park Seawall Replacement

Proposed Budget Planning Horizon: Fiscal Year 2024

The Anchorage Park Seawall is shown below in **Figure 6-4**. The Village established an ordinance in 2019 that amended the construction and engineering design standards for seawalls in the Village. The ordinance established new dimensional, compatibility, and elevation requirements for seawall caps. To bring this seawall into compliance with the ordinance, this project proposes to install ±220 LF of seawall and concrete cap, complete with geotextile filter fabrics, stone backfill and miscellaneous restoration.

This will complete the Park's seawall upgrade, as the north section has already been completed. The



Anchorage Park Seawall Replacement project is budgeted for the fiscal year 2024.

Figure 6-4: Anchorage Park Seawall

6.1.2 CIP No. 2 - Tidal Valve Program

This program proposes to incorporate backflow prevention devices (tidal valves) to specific Village-owned outfalls that are tidally influenced. The approach used to determine tidal valve placement was based on identifying low lying areas found to be most susceptible to tidal flooding in the Village. Although there is existing drainage infrastructure within these low-lying areas, the influence of high tides and future sea level rise can allow backflow through the existing outfalls into the roadways and other contributing drainage areas.

Low lying areas within the Village were identified using LiDAR data provided for Palm Beach County. The elevations within these low-lying areas were compared to high tide information obtained from the Lake Worth Pier Station ID: 8722670. The observed tidal data and sea level rise accounted for as described in **Section 2.2.10.2** was used to develop tailwater assumptions and compared to these low lying areas to prioritize tidal valve placement as part of the initial 5-year Stormwater CIP. Future sea level rise estimated in **Section 2.2.10** can be relied upon to inform tidal valve placement beyond the initial 5-years. Note that changes to the projections are subject to change and should be monitored periodically.

Table 6-1 presents locations recommended for the Tidal Valve Program.

Table 6-1: Tidal Valve Program – Near-Term Recommended Locations

CIP No.	Location	Receiving Water
2-01	Fathom Road W (36”)	Lake Worth Lagoon
2-02	Anchorage Drive (18”)	Earman River
2-03	Dory Road S (24”)	Lake Worth Lagoon
2-04	Cruiser Road S (24”)	Lake Worth Lagoon
2-05	Country Club Drive (North) (27”)	North Palm Beach Waterway
2-06	Country Club Drive (Central) (18”)	North Palm Beach Waterway
2-07	Country Club Drive (South) (15”)	North Palm Beach Waterway
2-08	Lighthouse Drive (36”)	North Palm Beach Waterway
2-09	Lagoon Drive (36”)	North Palm Beach Waterway
2-10	Waterway Drive (15”)	North Palm Beach Waterway
2-11	Pelican Way (18”)	North Palm Beach Waterway
2-12	Robin Way (30”)	North Palm Beach Waterway
2-13	Westwind Drive (18”)	Earman River
2-14	Sandpiper Way (15”)	North Palm Beach Waterway
2-15	Teal Way (18”)	North Palm Beach Waterway

6.1.3 CIP No. 3 - Swale Rehabilitation Program

The Village owns almost 33 miles of roadways with over 350,000 square yards of adjacent swale area. The area was calculated based on a linear measurement of roadways, assumed swale widths, and

percentage of driveway aprons. The assumptions were developed using aerial photography at various locations.

The swales collect stormwater runoff from roadways, filter pollutants and sediments carried by the runoff, prevent erosion, and help to control flooding by providing volume storage and infiltration of runoff into the ground. Grass swales can become overgrown and lose effectiveness with time. This can happen through sediment build up or modification of the swales by the addition of landscaping and hardscaping. The overgrown or overbuilt swales can block stormwater from flowing off roadways/driveways and prevent it from reaching drainage inlets which can lead to ponding within the roadways and rights-of-way during rain events.

CIP 3 recommends implementation of an annual swale rehabilitation program to address ponding issues by providing additional storage volume and unimpeded surface flow for stormwater runoff from adjacent roadways and driveways. The swale restoration program will rehabilitate swales throughout the Village since restoration of isolated swales will not sufficiently and significantly resolve nuisance issues.

The rehabilitation program will help formalize a standard profile which will be locally adapted for the provision of drainage and water quality treatment. The work will include clearing, grubbing, regrading, and resodding for a more efficient management of stormwater runoff.

The Village should develop a long-range recurring budget for implementing the program which would allow all areas of the Village to be addressed within an approximate 20-to-30-year timeframe. Since it will not be feasible to implement the Swale Restoration Program immediately throughout the entire Village, priority should be given to areas of known nuisance flooding.

6.1.4 CIP No. 4 – Asset Cleaning, Inspection, Pipe Rehabilitation and Maintenance Program

The Village's existing stormwater assets consist of over 47,000 LF of drainage pipes ranging from less than 12-inches to 60-inches in diameter that drain stormwater off streets, sidewalks, parking lots, driveways, and rooftops, and prevent flooding during heavy rains. These assets are aged and, in many cases, require repair or replacement.

CIP No. 4 includes cleaning and television inspection, emergency point repairs as well as rehabilitation and maintenance of the stormwater management collection and conveyance (piping) system within the Village.

The recommended work to be performed under this program includes initial field condition investigation and assessment; system dewatering; removal of foreign materials from storm sewer lines and structures; and video inspection. Stormwater pipes and structures identified during video inspection as having displaced joints, cracks or breaks in pipes and structures, and other defects permitting groundwater infiltration and/or ingress of soil from around the exterior of pipes and structures will be scheduled for repair on an annual basis. **Table 6-2** presents the major elements for the program for the first five years.

Table 6-2: CIP No. 4 – Annualized Expenses

Storm Water Attributed Program	Year 1	Year 2	Year 3	Year 4	Year 5
Emergency Repairs (includes 2.5% escalation years 2 through 5)	$87,543	$80,508	$70,471	$63,227	$56,728

Storm Water Attributed Program	Year 1	Year 2	Year 3	Year 4	Year 5
Asset Cleaning and Video Inspection	$94,878	$97,250	$99,681	$102,173	$104,727
Pipe Rehabilitation and Maintenance	$139,411	$142,896	$146,468	$150,130	$153,883
Contingency at 20% of the above	$77,240	$76,957	$75,989	$75,727	$75,681
Engineering and/or Consultant Costs at 20% of the above	$64,366	$64,131	$63,324	$63,106	$63,068
Total	**$463,438**	**$461,742**	**$455,933**	**$454,363**	**$454,087**

As noted in Section 7, initial estimates indicate that funding this effort every other year may be appropriate. The anticipated emergency point repair cost assumes the pipe rehabilitation and maintenance program will increasingly reduce the frequency and costs of emergency repairs as the older and more vulnerable assets are replaced or repaired. Therefore, annual costs for emergency repairs are assumed to decrease over time.

The pipe rehabilitation and maintenance portion of the program assumes asset cleaning and video inspection reveals 20% of inspected mains require structure to structure lining and 5% require replacement. Further, it is assumed that a 20 - 30-year period will be required to incorporate all rehabilitation measures.

6.1.5 CIP No. 5 - Water Quality and Environmental Protection Program

There are numerous BMPs that have emerged to treat stormwater runoff and improve water quality. Some of these include vortex separation devices, filtration devices, geotextile liners and hydrocarbon absorbents. All of which help to settle and or remove pollutants from pavements, atmospheric deposition, vegetation, and chemicals. BMPs where water quality is a concern such as residential neighborhoods, recreational/open spaces, and commercial/light industrial areas within the Village may consider the use of any one or a combination of the following as part of their treatment train:

- Bold and Gold® Filtration Media (Environmental Conservation Solutions)
- StormCeptor® Stormwater Treatment (Contech Engineered Solutions LLC)
- Jellyfish Filter® (Contech Engineered Solutions LLC)
- Stormwater Inlet Filter® (Oldcastle Infrastructure)

Note that these are some examples, and that the industry has many such BMPs for varying applications. Different devices may be appropriate in different locations and for different applications.

The approach used to identify placement of these BMPs was based on the land use and identifying the areas within these land uses that contribute the greatest volume of runoff and associated pollutants to receiving waters.

Projects for the Village's consideration under CIP No. 5 are presented below in **Table 6-3**.

Table 6-3: CIP No. 5 – Pollution Abatement Systems

CIP No.	Location	Treatment	Receiving Water
5-01	Laurel Road	StormCeptor and Stormwater Inlet Filter	Earman River (C-17)
5-02	Eastwind Drive	StormCeptor and Stormwater Inlet Filter	Earman River (C-17)
5-03	Atlantic Aly	StormCeptor and Stormwater Inlet Filter	Lake Worth Lagoon
5-04	Fathom Road W	StormCeptor and Stormwater Inlet Filter	Lake Worth Lagoon
5-05	Dory Road S	StormCeptor and Stormwater Inlet Filter	Lake Worth Lagoon
5-06	Country Club Drive North	StormCeptor and Stormwater Inlet Filter	North Palm Beach Waterway
5-07	Country Club Drive South	StormCeptor and Stormwater Inlet Filter	North Palm Beach Waterway
5-08	Yacht Club Drive	StormCeptor and Stormwater Inlet Filter	North Palm Beach Waterway

6.1.6 Summary of Capital Improvements

Table 6-4 provides a compilation of the proposed project specific and programmatic capital improvements outlined above in **subsections 6.1.1 through 6.1.5**. Note that the Cash Flow Analysis included in **Section 7** incorporates the coupling of associated programmatic expenditures (such as tidal valves and water quality structures) by project location. It also aggregates certain of the programmatic expenditures (such as multiple tidal valves and multiple water quality structures) for efficiency in design, bidding, and construction.

Table 6-4: Summary of Proposed Capital Improvement Projects

CIP No.	Capital Improvement Project	Project Total Cost
CIP 1 - Specific Drainage Improvements		
1-01	Laurel Road Stormwater Improvements	$771,000
1-02	Honey Road Stormwater Improvements	$107,900
1-03	Conroy Drive Stormwater Improvements	$557,400
1-04	Fairhaven Drive Stormwater Improvements	$1,024,600
1-05	Anchorage Drive Stormwater Improvements	$150,500
1-06	Eastwind Drive Stormwater Improvements	$953,000
1-07	Westwind Drive Stormwater Improvements Phase 1	$6,716,900
1-08	Westwind Drive Stormwater Improvements Phase 2	$2,100,400
1-09	North Palm Beach Country Club Golf Course Stormwater Improvements	$509,000
1-10	Lakeside Drive Stormwater Improvements	$8,150,700
1-11	Lakeside Park Seawall Replacement	$1,510,600
1-12	Anchorage Park Partial Seawall Replacement	$824,700
	Subtotal Specific Drainage Improvements	**$23,376,700**
CIP 2 - Tidal Valve Replacement Program		
2-01	Fathom Rd W (36")	$71,000
2-02	Anchorage Dr N (18")	$25,000
2-03	Dory Rd S (24")	$34,000
2-04	Cruiser Rd S (24")	$34,000
2-05	Country Club Dr (North) (27")	$48,000
2-06	County Club Dr (Central) (18")	$25,000
2-07	Country Club Dr (South) (15")	$20,000
2-08	Lighthouse Dr (36")	$71,000
2-09	Lagoon Dr (36")	$71,000
2-10	Waterway Dr (15")	$20,000
2-11	Pelican Way (18")	$25,000
2-12	Robin Way (30")	$50,000
2-13	Westwind Dr (18")	$25,000
2-14	Sandpiper Way (15")	$20,000
2-15	Teal Way (18")	$25,000
	Subtotal Tidal Valve Replacement Program	**$564,000**
CIP 3 - Swale Rehabilitation Program		
3-01	Swale Rehabilitation	$8,000,000
	Subtotal Swale Rehabilitation Program	**$8,000,000**

CIP No.	Capital Improvement Project	Project Total Cost
CIP 4 - Asset Cleaning, Inspection, Pipe Rehabilitation and Maintenance Program		
4-01	Asset Cleaning, Inspection, Pipe Rehabilitation and Maintenance Program	$6,945,000
Subtotal Asset Cleaning, Inspection, Pipe Rehabilitation and Maintenance Program		**$6,945,000**
CIP 5 - Water Quality Improvements		
5-01	Dory	$166,300
5-02	Atlantic	$199,800
5-03	Fathom	$199,800
5-04	Eastwind	$225,800
5-05	Laurel	$249,000
5-06	Country Club Drive North	$172,200
5-07	Country Club Drive South	$83,300
5-08	Yacht Club Drive	$166,300
	Subtotal Water Quality Improvements	**$1,462,500**
Grand Total		**$40,348,200**

6.2 Flood Risk Modeling Results - Proposed Scenario

6.2.1 2023 Current Sea Level, Proposed Scenario

Appendix A-11 shows the flooding depth modeling results of the Proposed Scenario with 2023 Current Sea Level for the 10YR-24HR, 25YR-24HR and 100YR-72 storms, respectively.

6.2.2 2040 Intermediate-High Sea Level Rise, Proposed Scenario

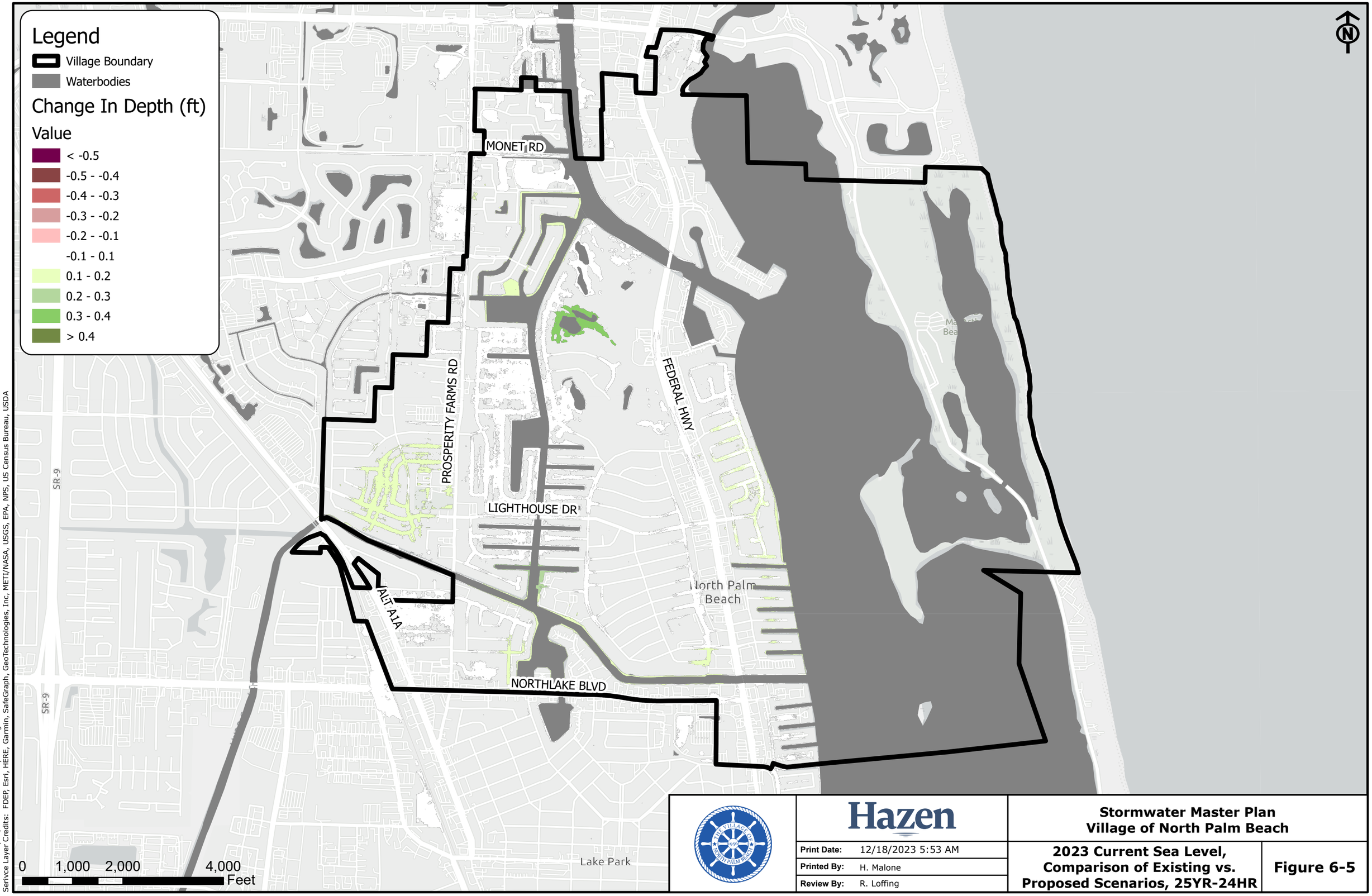
Appendix A-12 shows the flooding depth modeling results of the Proposed Scenario with 2040 Intermediate-High Sea Level Rise for the 10YR-24HR, 25YR-24HR and 100YR-72 storms, respectively.

6.2.3 2070 Intermediate-High Sea Level Rise, Proposed Scenario

Appendix A-15 shows the flooding depth modeling results of the Proposed Scenario with 2070 Intermediate-High Sea Level Rise for the 10YR-24HR, 25YR-24HR and 100YR-72 storms, respectively.

6.2.4 Comparison of Existing vs. Proposed Scenario

Figure 6-5 through **Figure 6-7** show comparison of flooding depth modeling results between the existing and proposed scenarios for 2023 Current Sea Level, 2040 Intermediate-High Sea Level Rise, and 2070 Intermediate-High Sea Level Rise during a 25YR-24HR storm.



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Plot date: 12/18/2023 5:53 AM By: rloffing
Service Layer Credits: FDEP, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA

Hazen

Stormwater Master Plan
Village of North Palm Beach

Print Date:	12/18/2023 5:53 AM
Printed By:	H. Malone
Review By:	R. Loffing

2023 Current Sea Level, Comparison of Existing vs. Proposed Scenarios, 25YR-24HR

Figure 6-5

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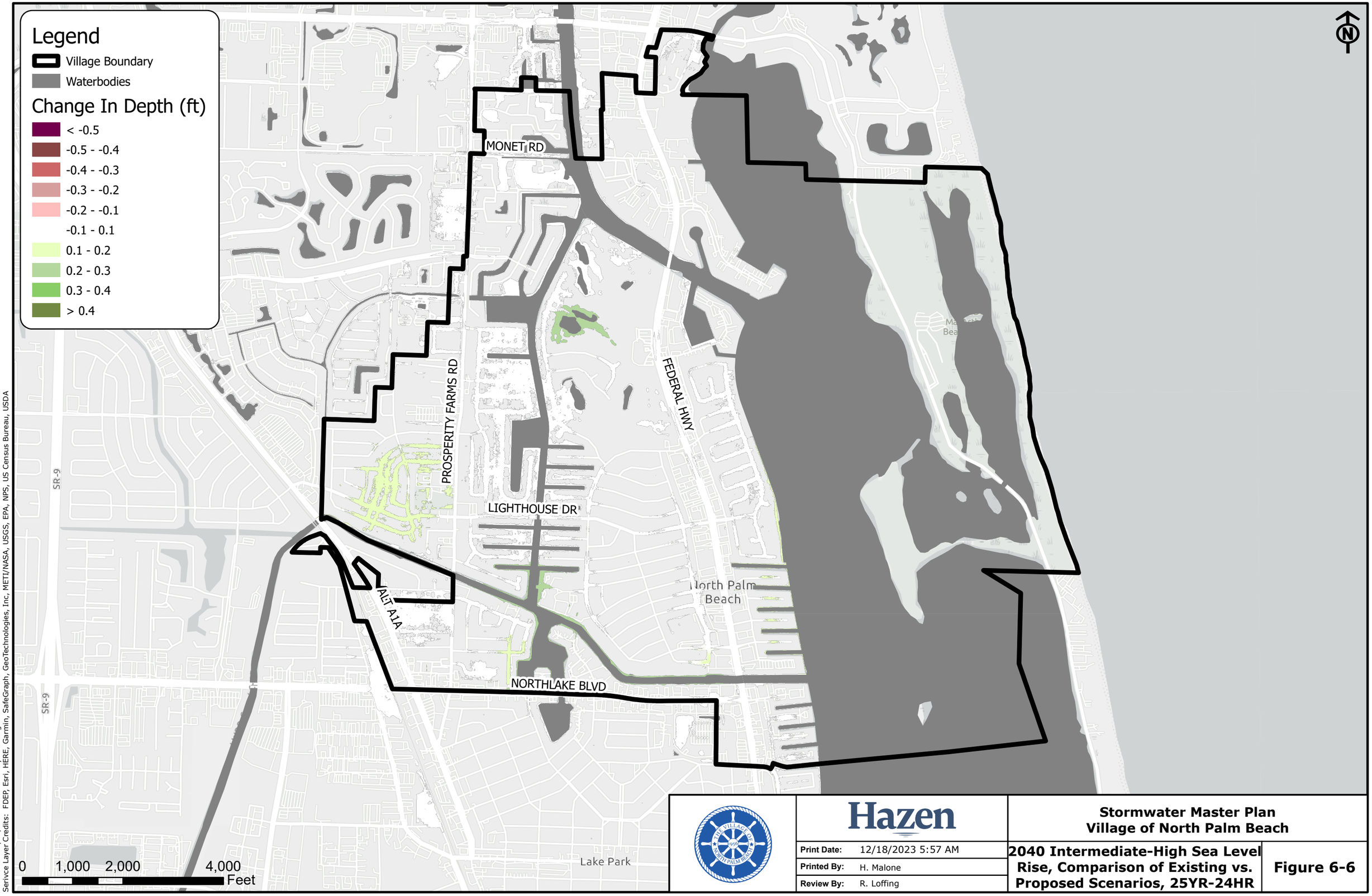

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Stormwater Master Plan
Village of North Palm Beach

2040 Intermediate-High Sea Level Rise, Comparison of Existing vs. Proposed Scenarios, 25YR-24HR

Figure 6-6

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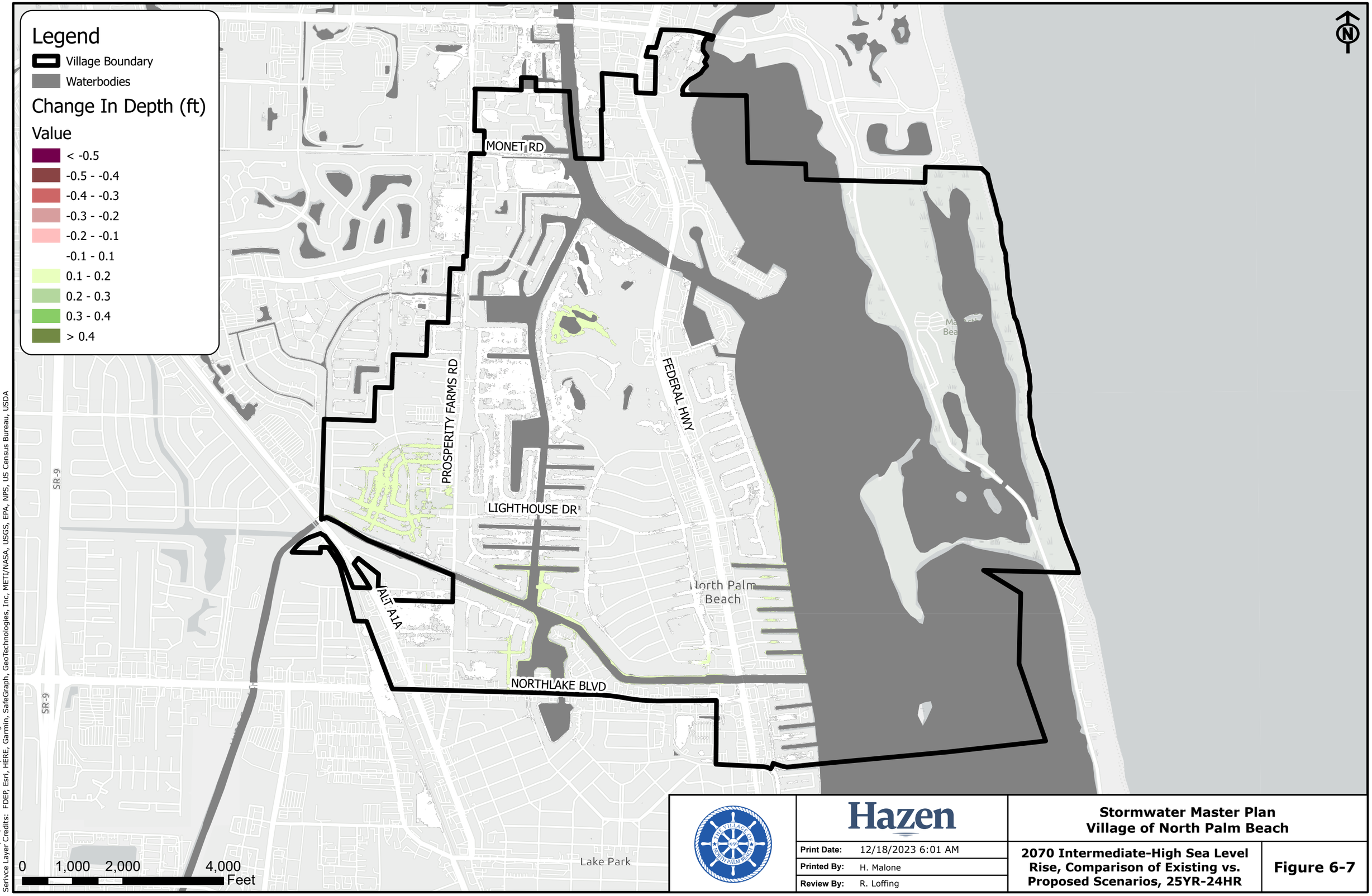

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Serivce Layer Credits: FDEP, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA

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Printed By:	H. Malone
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

2070 Intermediate-High Sea Level Rise, Comparison of Existing vs. Proposed Scenarios, 25YR-24HR

Figure 6-7

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6.3 Recommended Programs, Practices, and Policies

In addition to the recommended CIP projects, the Village would benefit from incorporating the following programs, practices, and policies.

6.3.1 Incentive Programs for Private Properties

It is recommended for the Village to incentivize private property owners to incorporate adaptations that would benefit their own property and others. This approach starts with community engagement to discuss possible applications so private owners understand present and future challenges that may be addressed by implementation of adaptations on their property. It is important to highlight the long-term economic and environmental benefits of incorporating adaptations to mitigate flooding on their specific site as well as how this would have a positive contribution for the entire community. An example of a private incentive is a cost-sharing program, where the Village and private property owners share in capital costs for BMPs. Other examples include stormwater fee credits, design-build-operate public-private partnerships, and retention credit trading programs. Strategic planning should consider which of these types of programs might be "right for the Village". The Village could develop and incorporate incentive programs into its regulations and policies to help jumpstart participation within the private sector. Additionally, the Village could offer incentives to raise critical components (mechanical, electrical, heating, ventilation, and air conditioning (HVAC)) above flood elevations. Further, it is recommended to restrict development in at-risk areas.

6.3.2 Green Infrastructure and Materials

The use of green infrastructure and materials provides benefit to a wide spectrum of projects. Incorporation of green infrastructure and materials would take effect through policy modifications as well as through programs promoting widespread integration. The recommendation is to modify the Village's policy to require the use of flood-resistant and/or saltwater resistant landscaping materials within flood prone areas, to formalize the adoption of suitable landscaping and construction materials and to standardize green infrastructure details for the continued use in proposed projects. It is recommended for the Village to incorporate green infrastructure and materials into proposed improvements wherever it proves to be beneficial. With elevated groundwater, green infrastructure may provide storage capabilities that will be required to approve drainage improvement projects through the permitting process.

An additional recommendation is to develop a green infrastructure and materials promotional program to showcase benefits associated with rainwater harvesting, bioswales, bioretention, permeable pavement or pavers, blue and green roofs, solar canopies, etc. Green infrastructure and materials information could be introduced and distributed to the community for input during outreach engagements and to help residents make their informed material selections.

6.3.3 Community Outreach and Engagement

An effective community outreach and engagement program is critical in fostering a culture of preparedness. Community outreach aids in merging the gap between residents' expectations and the Village's agenda, keeping the public informed of upcoming stormwater improvements and policy changes and providing the Village with valuable insight and feedback. It is recommended to engage and to educate the public, with the goal of communicating how to prepare for floods, what to expect during floods, and how to respond after floods, as well as to promote water quality initiatives and environmental stewardship. It is further recommended to establish a Flood Resilience Hub, a community-serving facility augmented to support residents and coordinate resource distribution and services before, during and after a flooding event.

7. Stormwater Utility Fee and Rate Recommendations

7.1 Impacts of CIP on Stormwater Utility Rates

The initial stormwater utility rate was developed in consideration of existing stormwater program administrative and renewal and replacement costs, while Section 6 of this master plan also incorporates capacity-based infrastructure capital improvement needs informed by the hydraulic modeling study. The existing rate equates to a cost of $7.78 per Equivalent Residential Unit (ERU), but that rate only covers certain operational and administrative costs, as well as limited assessment and capital investment costs associated with aging infrastructure. **Table 7-1** shows the summary of the specific and programmatic CIP costs developed and discussed in **Section 6**. The capital program proposed cannot be implemented in a reasonable timeframe using a pay-go approach. It is suggested that debt be issued, to both accelerate the implementation of needed improvements and better level the cost burden to customers over time.

The approach shown in **Table 7-1** includes both the project specific and programmatic capital. To address those costs, the plan considers Pay-Go for the first two years and then borrowing $10M in Year 3, then another $10M (which will have to be adjusted for inflation) in year 13 of the program. Spending over the initial 5-year planning period is estimated at just under $5M. The costs over the years beyond the first five years are just over $35M and extend through to completion of the swale rehabilitation and underground asset cleaning/maintenance/R&R programs. Thus, the overall costs of the program are approximately $40M. The borrowed funds described above would fall short of covering those costs, however, we anticipate that certain of the proposed projects' costs may be defrayed via grants or other supplemental funding. Additionally, greater clarity on the overall needs of the long-range programmatic improvements (swales and aging buried infrastructure) may inform that more or less funding is needed, and appropriate adjustments can be made in the second decade of the program.

Table 7-1: Proposed Capital Improvement Projects Implementation

CIP Project	Year 1	Year 2	Year 3	Year 4	Year 5	CIP Years 1-5	Future Years	Total
CIP 1 - Specific Drainage Improvements								
Honey Road Stormwater Improvements	$ 18,000	$ 44,950	$44,950			$107,900		$107,900
Conroy Drive Stormwater Improvements	$94,000	$231,700	$231,700			$557,400		$557,400
Anchorage Drive Stormwater Improvements			$ 25,000	$ 62,750	$62,750	$150,500		$150,500
Anchorage Park Partial Seawall Replacement	$482,850					$482,850	$ 341,850	$824,700
North Palm Beach Country Club Golf Course Stormwater Improvements	$86,000	$211,500	$211,500			$509,000		$509,000
Eastwind Drive Stormwater Improvements							$ 953,000	$953,000
Fairhaven Drive Stormwater Improvements							$1,024,600	$1,024,600
Westwind Drive Stormwater Improvements Phase 1							$ 6,716,900	$6,716,900
Westwind Drive Stormwater Improvements Phase 2							$ 2,100,400	$2,100,400
Lakeside Drive Stormwater Improvements							$ 8,150,700	$ 8,150,700
Lakeside Park Seawall Replacement							$1,510,600	$1,510,600
Laurel Road Stormwater Improvements							$771,000	$771,000
CIP 2 - Tidal Valve Replacement Program								
Country Club Dr (South) (15")							$20,000	$20,000
Waterway Dr (15")							$20,000	$20,000
Sandpiper Way (15")							$20,000	$20,000
Anchorage Dr N (18")							$25,000	$25,000
County Club Dr (Central) (18")							$25,000	$ 25,000
Pelican Way (18")							$25,000	$25,000
Westwind Dr (18")							$25,000	$25,000
Teal Way (18")							$25,000	$25,000
Dory Rd S (24")							$34,000	$34,000

CIP Project	Year 1	Year 2	Year 3	Year 4	Year 5	CIP Years 1-5	Future Years	Total
Cruiser Rd S (24")							$34,000	$34,000
Country Club Dr (North) (27")							$48,000	$48,000
Robin Way (30")							$50,000	$50,000
Fathom Rd W (36")							$71,000	$71,000
Lighthouse Dr (36")							$71,000	$71,000
Lagoon Dr (36")							$71,000	$71,000
CIP 3 - Swale Rehabilitation Program		$400,000		$400,000		$800,000	$7,200,000	$8,000,000
CIP 4 - Asset Cleaning, Inspection, Pipe Rehabilitation and Maintenance Program	$463,000		$463,000		$463,000	$1,389,000	$5,556,000	$6,945,000
CIP 5 - Water Quality Improvements								
Dory							$166,300	$166,300
Atlantic	$199,800					$199,800		$199,800
Fathom							$199,800	$199,800
Eastwind				$225,800		$225,800		$225,800
Laurel					$249,000	$ 249,000		$249,000
Country Club Drive North							$172,200	$172,200
Country Club Drive South							$83,300	$83,300
Yacht Club Drive					$166,300	$166,300		$166,300
Total Spending per Year	**$1,343,650**	**$888,150**	**$976,150**	**$688,550**	**$941,050**	**$4,837,550**	**$35,510,650**	**$40,348,200**
Balance of Available Funding	**$397,150**	**$19,200**	**$9,131,050**	**$8,295,900**	**$7,667,200**			

The 5,197 ERUs in the utility generated a revenue stream of approximately $485,000 in 2022. Approximately $457,900 of that sum was dedicated to program capital, and the remaining $27,100 was allocated for miscellaneous permitting costs. The resulting rates needed to fund the capital program and remaining administrative and permitting costs were estimated accordingly. **Table 7-2** reflects the approximate resulting rates, which will fund Pay-Go for the first two years and fund the debt service on the $10M borrowed thereafter.

Table 7-2: Projected Monthly Rate per ERU

Item	Budget	ERUs	Annual Cost/ERU	Monthly Rate/ERU
Capital	$875,000	5,197	$168.37	$14.03
Permitting	$27,100	5,197	$5.21	$0.43
Total	**$902,100**	**5,197**	**$173.58**	**$14.46**

This represents an 86% increase over the existing rate of $7.78/month/ERU.

7.2 Stormwater Utility Rate Modifications

It is recommended to maintain the approved rate structure in the Village's Code of Ordinances and that the Village update rate increases through appropriate Resolution(s).

7.3 Grant Funding

Additional funding sources are made up of relevant grants offering support for stormwater improvements. There are several agencies including FDEP and FEMA that have funding mechanisms in place that the Village would likely benefit from pursuing. **Table 7-3** details sources for grant funding that may be applicable to the proposed improvements.

Table 7-3: Grant Funding Sources

Grant	Applicable Types of Projects	Notes
Resilient Florida Grant Program (Planning)	• Planning Projects • Critical Asset Adaptation Projects	2021 was the first year this grant was offered, and it made $500 million dollars available to applicable resilience projects, as identified in a vulnerability assessment that complies with the requirements in s. 380.093 (3), F.S. Village is in the process of being awarded funds through this grant for CIP project 5a. There is a minimum 50% cost share and future funding will likely continue for other proposed improvements.
Hazard Mitigation Grant Program (HMGP)	• Projects addressing a known hazard (including flooding)	Florida's allocation is $188 million dollars. The cost share for this program is 75% federal/25% non-federal.
Flood Mitigation Assistance (FMA)	• Project Scoping, "seed money" • Community Flood Mitigation Projects • Technical Assistance • Flood Hazard Mitigation Planning • Individual Flood Mitigation Projects	Support is focused on flood mitigation for repetitive loss properties. $160 million dollars are available for the current cycle; funding caps are specific to the type of project and there is a variable cost share. Of particular interest is the project scoping type of project that could help with furthering the implementation of the proposed recommendations.
Building Resilient Infrastructure and Communities (BRIC)	• Hazard Risk Reduction Activities • Mitigation Projects • Enhance Climate Resilience and Adaptation	These grants are highly competitive and require a well-developed application. An estimated $919 million dollars is available in the current cycle and each project submittal has a high cap of $50 million dollars. The cost share for this program is 75% federal/25% non-federal.
Resilient Florida Grant Program (Implementation)	• Projects Identified in the Flood Vulnerability Assessment and Adaptation Strategies, addressing Critical Facilities	These grants are related to the FDEP Resilience Planning Grant that funded the Village's recent Flood Vulnerability Assessment and Adaptation Strategies reports. Applicable projects identified by previous assessments, have a $500,000 cap, and 10 months to complete.
319 Nonpoint Source Grant Program	• Implementation of Watershed-Based Plans to Restore Impaired Surface or Ground Waters • Stormwater Runoff Management	This grant program is authorized under Section 319 of the federal CWA for implementation projects that address the prevention, control, and abatement of nonpoint source (NPS) pollution. There is a minimum 50% cost share.

Appendix A-1: External Boundary Condition – S-44 External Hydrographs

S-44 Derived External Hydrograph by Design Storm

5Y-24H Simulation	
Time (hr)	Q (cfs)
0.00	748.61
0.25	753.86
0.50	759.11
0.75	764.35
1.00	769.60
1.25	782.26
1.50	794.92
1.75	807.58
2.00	820.24
2.25	832.90
2.50	845.56
2.75	858.22
3.00	870.88
3.25	883.54
3.50	896.20
3.75	908.86
4.00	921.52
4.25	934.18
4.50	946.84
4.75	959.50
5.00	972.16
5.25	984.82
5.50	1,008.96
5.75	1,029.81
6.00	1,048.30
6.25	1,057.83
6.50	1,075.47
6.75	1,100.33
7.00	1,139.78
7.25	1,183.33
7.50	1,231.12
7.75	1,279.55
8.00	1,332.39
8.25	1,382.09
8.50	1,432.39
8.75	1,479.35
9.00	1,526.81
9.25	1,570.76
9.50	1,611.07
9.75	1,651.71
10.00	1,688.59
10.25	1,725.73
10.50	1,758.97
10.75	1,792.42
11.00	1,821.86
11.25	1,851.46
11.50	1,876.96
11.75	1,902.57
12.00	1,924.00
12.25	1,923.28
12.50	1,922.57
12.75	1,921.85
13.00	1,921.14
13.25	1,920.42
13.50	1,919.71
13.75	1,918.99
14.00	1,918.28
14.25	1,917.56
14.50	1,916.85
14.75	1,916.14
15.00	1,915.42
15.25	1,885.48
15.50	1,851.46
15.75	1,821.86
16.00	1,796.61
16.25	1,767.31
16.50	1,740.93
16.75	1,717.45
17.00	1,692.70
17.25	1,672.16
17.50	1,651.71
17.75	1,631.35
18.00	1,607.02
18.25	1,586.84
18.50	1,566.75
18.75	1,546.74
19.00	1,526.81
19.25	1,506.98
19.50	1,487.22
19.75	1,467.56
20.00	1,447.98

10Y-24H Simulation	
Time (hr)	Q (cfs)
0.00	880.51
0.25	886.68
0.50	892.86
0.75	899.03
1.00	905.20
1.25	920.09
1.50	934.98
1.75	949.87
2.00	964.76
2.25	979.65
2.50	994.54
2.75	1,009.43
3.00	1,024.32
3.25	1,039.21
3.50	1,054.10
3.75	1,068.99
4.00	1,083.88
4.25	1,098.78
4.50	1,113.67
4.75	1,128.56
5.00	1,143.45
5.25	1,158.34
5.50	1,186.73
5.75	1,211.26
6.00	1,233.00
6.25	1,244.22
6.50	1,264.97
6.75	1,294.20
7.00	1,340.60
7.25	1,391.83
7.50	1,448.04
7.75	1,505.00
8.00	1,567.15
8.25	1,625.60
8.50	1,684.77
8.75	1,740.01
9.00	1,795.83
9.25	1,847.52
9.50	1,894.93
9.75	1,942.74
10.00	1,986.11
10.25	2,029.79
10.50	2,068.89
10.75	2,108.23
11.00	2,142.86
11.25	2,177.68
11.50	2,207.67
11.75	2,237.79
12.00	2,263.00
12.25	2,262.16
12.50	2,261.32
12.75	2,260.48
13.00	2,259.63
13.25	2,258.79
13.50	2,257.95
13.75	2,257.11
14.00	2,256.28
14.25	2,255.43
14.50	2,254.59
14.75	2,253.75
15.00	2,252.91
15.25	2,217.70
15.50	2,177.68
15.75	2,142.86
16.00	2,113.16
16.25	2,078.70
16.50	2,047.68
16.75	2,020.05
17.00	1,990.94
17.25	1,966.79
17.50	1,942.74
17.75	1,918.79
18.00	1,890.17
18.25	1,866.43
18.50	1,842.80
18.75	1,819.27
19.00	1,795.83
19.25	1,772.50
19.50	1,749.26
19.75	1,726.14
20.00	1,703.11

25Y-24H Simulation	
Time (hr)	Q (cfs)
0.00	1,080.12
0.25	1,087.69
0.50	1,095.26
0.75	1,102.83
1.00	1,110.40
1.25	1,128.67
1.50	1,146.93
1.75	1,165.20
2.00	1,183.46
2.25	1,201.73
2.50	1,220.00
2.75	1,238.26
3.00	1,256.53
3.25	1,274.79
3.50	1,293.06
3.75	1,311.32
4.00	1,329.59
4.25	1,347.86
4.50	1,366.12
4.75	1,384.39
5.00	1,402.65
5.25	1,420.92
5.50	1,455.75
5.75	1,485.83
6.00	1,512.51
6.25	1,526.27
6.50	1,551.72
6.75	1,587.59
7.00	1,644.50
7.25	1,707.34
7.50	1,776.30
7.75	1,846.16
8.00	1,922.41
8.25	1,994.11
8.50	2,066.69
8.75	2,134.45
9.00	2,202.92
9.25	2,266.33
9.50	2,324.49
9.75	2,383.14
10.00	2,436.34
10.25	2,489.92
10.50	2,537.89
10.75	2,586.15
11.00	2,628.63
11.25	2,671.33
11.50	2,708.12
11.75	2,745.08
12.00	2,776.00
12.25	2,774.97
12.50	2,773.94
12.75	2,772.90
13.00	2,771.87
13.25	2,770.84
13.50	2,769.81
13.75	2,768.77
14.00	2,767.75
14.25	2,766.71
14.50	2,765.68
14.75	2,764.65
15.00	2,763.62
15.25	2,720.43
15.50	2,671.33
15.75	2,628.63
16.00	2,592.20
16.25	2,549.92
16.50	2,511.87
16.75	2,477.98
17.00	2,442.27
17.25	2,412.64
17.50	2,383.14
17.75	2,353.76
18.00	2,318.66
18.25	2,289.54
18.50	2,260.54
18.75	2,231.68
19.00	2,202.92
19.25	2,174.31
19.50	2,145.80
19.75	2,117.44
20.00	2,089.19

25Y-72H Simulation	
Time (hr)	Q (cfs)
0.00	555.20
0.25	555.20
0.50	555.20
0.75	555.20
1.00	555.20
1.25	555.20
1.50	555.20
1.75	555.20
2.00	555.20
2.25	555.20
2.50	555.20
2.75	555.20
3.00	555.20
3.25	555.20
3.50	555.20
3.75	555.20
4.00	555.20
4.25	555.20
4.50	555.20
4.75	555.20
5.00	555.20
5.25	555.20
5.50	555.20
5.75	555.20
6.00	555.20
6.25	555.20
6.50	555.20
6.75	555.20
7.00	555.20
7.25	555.20
7.50	555.20
7.75	555.20
8.00	555.20
8.25	555.20
8.50	555.20
8.75	555.20
9.00	555.20
9.25	555.20
9.50	555.20
9.75	555.20
10.00	555.20
10.25	555.20
10.50	555.20
10.75	555.20
11.00	555.20
11.25	555.20
11.50	555.20
11.75	555.20
12.00	555.20
12.25	555.20
12.50	555.20
12.75	555.20
13.00	555.20
13.25	555.20
13.50	555.20
13.75	555.20
14.00	555.20
14.25	555.20
14.50	555.20
14.75	555.20
15.00	555.20
15.25	555.20
15.50	555.20
15.75	555.20
16.00	555.20
16.25	555.20
16.50	555.20
16.75	555.20
17.00	555.20
17.25	555.20
17.50	555.20
17.75	555.20
18.00	555.20
18.25	555.20
18.50	555.20
18.75	555.20
19.00	555.20
19.25	555.20
19.50	555.20
19.75	555.20
20.00	555.20

100Y-72H Simulation	
Time (hr)	Q (cfs)
0.00	745.80
0.25	745.80
0.50	745.80
0.75	745.80
1.00	745.80
1.25	745.80
1.50	745.80
1.75	745.80
2.00	745.80
2.25	745.80
2.50	745.80
2.75	745.80
3.00	745.80
3.25	745.80
3.50	745.80
3.75	745.80
4.00	745.80
4.25	745.80
4.50	745.80
4.75	745.80
5.00	745.80
5.25	745.80
5.50	745.80
5.75	745.80
6.00	745.80
6.25	745.80
6.50	745.80
6.75	745.80
7.00	745.80
7.25	745.80
7.50	745.80
7.75	745.80
8.00	745.80
8.25	745.80
8.50	745.80
8.75	745.80
9.00	745.80
9.25	745.80
9.50	745.80
9.75	745.80
10.00	745.80
10.25	745.80
10.50	745.80
10.75	745.80
11.00	745.80
11.25	745.80
11.50	745.80
11.75	745.80
12.00	745.80
12.25	745.80
12.50	745.80
12.75	745.80
13.00	745.80
13.25	745.80
13.50	745.80
13.75	745.80
14.00	745.80
14.25	745.80
14.50	745.80
14.75	745.80
15.00	745.80
15.25	745.80
15.50	745.80
15.75	745.80
16.00	745.80
16.25	745.80
16.50	745.80
16.75	745.80
17.00	745.80
17.25	745.80
17.50	745.80
17.75	745.80
18.00	745.80
18.25	745.80
18.50	745.80
18.75	745.80
19.00	745.80
19.25	745.80
19.50	745.80
19.75	745.80
20.00	745.80

5Y-24H Simulation	
Time (hr)	Q (cfs)
20.25	1,432.39
20.50	1,420.73
20.75	1,405.22
21.00	1,389.78
21.25	1,370.56
21.50	1,355.25
21.75	1,339.36
22.00	1,324.80
22.25	1,309.65
22.50	1,294.57
22.75	1,279.55
23.00	1,264.58
23.25	1,249.67
23.50	1,234.83
23.75	1,220.04
24.00	1,208.99
24.25	1,194.30
24.50	1,179.68
24.75	1,168.75
25.00	1,157.86
25.25	1,143.38
25.50	1,128.97
25.75	1,114.62
26.00	1,103.89
26.25	1,089.65
26.50	1,079.01
26.75	1,064.88
27.00	1,054.32
27.25	1,043.79
27.50	1,029.81
27.75	1,019.37
28.00	1,008.96
28.25	997.96
28.50	988.25
28.75	977.95
29.00	967.69
29.25	957.46
29.50	947.27
29.75	941.95
30.00	939.05
30.25	937.11
30.50	934.86
30.75	932.61
31.00	930.36
31.25	927.67
31.50	923.63
31.75	918.59
32.00	913.56
32.25	906.86
32.50	902.41
32.75	894.64
33.00	890.21
33.25	883.57
33.50	875.85
33.75	872.00
34.00	867.06
34.25	861.58
34.50	855.56
34.75	850.65
35.00	844.11
35.25	840.85
35.50	834.34
35.75	830.01
36.00	822.99
36.25	818.14
36.50	813.84
36.75	810.08
37.00	805.25
37.25	798.84
37.50	792.44
37.75	787.65
38.00	781.28
38.25	776.52
38.50	773.35
38.75	767.02
39.00	762.28
39.25	755.98
39.50	751.27
39.75	748.13
40.00	741.87
40.25	737.18
40.50	733.55
40.75	726.29

10Y-24H Simulation	
Time (hr)	Q (cfs)
20.25	1,684.77
20.50	1,671.05
20.75	1,652.82
21.00	1,634.66
21.25	1,612.05
21.50	1,594.04
21.75	1,575.35
22.00	1,558.22
22.25	1,540.41
22.50	1,522.67
22.75	1,505.00
23.00	1,487.39
23.25	1,469.86
23.50	1,452.40
23.75	1,435.01
24.00	1,422.01
24.25	1,404.74
24.50	1,387.53
24.75	1,374.68
25.00	1,361.87
25.25	1,344.84
25.50	1,327.89
25.75	1,311.01
26.00	1,298.40
26.25	1,281.64
26.50	1,269.13
26.75	1,252.50
27.00	1,240.08
27.25	1,227.70
27.50	1,211.26
27.75	1,198.98
28.00	1,186.73
28.25	1,173.79
28.50	1,162.38
28.75	1,150.26
29.00	1,138.19
29.25	1,126.16
29.50	1,114.17
29.75	1,107.91
30.00	1,104.50
30.25	1,102.22
30.50	1,099.58
30.75	1,096.93
31.00	1,094.29
31.25	1,091.12
31.50	1,086.37
31.75	1,080.44
32.00	1,074.52
32.25	1,066.65
32.50	1,061.41
32.75	1,052.27
33.00	1,047.06
33.25	1,039.25
33.50	1,030.17
33.75	1,025.64
34.00	1,019.83
34.25	1,013.38
34.50	1,006.31
34.75	1,000.53
35.00	992.84
35.25	989.00
35.50	981.35
35.75	976.25
36.00	967.99
36.25	962.29
36.50	957.23
36.75	952.81
37.00	947.14
37.25	939.59
37.50	932.07
37.75	926.43
38.00	918.94
38.25	913.34
38.50	909.61
38.75	902.16
39.00	896.59
39.25	889.18
39.50	883.64
39.75	879.95
40.00	872.58
40.25	867.07
40.50	862.79
40.75	854.26

25Y-24H Simulation	
Time (hr)	Q (cfs)
20.25	2,066.69
20.50	2,049.86
20.75	2,027.50
21.00	2,005.22
21.25	1,977.49
21.50	1,955.39
21.75	1,932.46
22.00	1,911.45
22.25	1,889.60
22.50	1,867.84
22.75	1,846.16
23.00	1,824.57
23.25	1,803.06
23.50	1,781.65
23.75	1,760.31
24.00	1,744.36
24.25	1,723.18
24.50	1,702.07
24.75	1,686.31
25.00	1,670.59
25.25	1,649.70
25.50	1,628.91
25.75	1,608.21
26.00	1,592.73
26.25	1,572.18
26.50	1,556.83
26.75	1,536.43
27.00	1,521.20
27.25	1,506.01
27.50	1,485.83
27.75	1,470.77
28.00	1,455.75
28.25	1,439.88
28.50	1,425.88
28.75	1,411.01
29.00	1,396.21
29.25	1,381.45
29.50	1,366.74
29.75	1,359.06
30.00	1,354.88
30.25	1,352.09
30.50	1,348.85
30.75	1,345.60
31.00	1,342.35
31.25	1,338.47
31.50	1,332.64
31.75	1,325.36
32.00	1,318.11
32.25	1,308.45
32.50	1,302.02
32.75	1,290.81
33.00	1,284.41
33.25	1,274.84
33.50	1,263.70
33.75	1,258.14
34.00	1,251.01
34.25	1,243.11
34.50	1,234.43
34.75	1,227.33
35.00	1,217.91
35.25	1,213.20
35.50	1,203.81
35.75	1,197.56
36.00	1,187.43
36.25	1,180.43
36.50	1,174.23
36.75	1,168.81
37.00	1,161.84
37.25	1,152.59
37.50	1,143.36
37.75	1,136.45
38.00	1,127.25
38.25	1,120.38
38.50	1,115.81
38.75	1,106.67
39.00	1,099.84
39.25	1,090.75
39.50	1,083.95
39.75	1,079.42
40.00	1,070.38
40.25	1,063.63
40.50	1,058.38
40.75	1,047.91

25Y-72H Simulation	
Time (hr)	Q (cfs)
20.25	555.20
20.50	555.20
20.75	555.20
21.00	555.20
21.25	555.20
21.50	555.20
21.75	555.20
22.00	555.20
22.25	555.20
22.50	555.20
22.75	555.20
23.00	555.20
23.25	555.20
23.50	555.20
23.75	555.20
24.00	555.20
24.25	555.20
24.50	555.20
24.75	555.20
25.00	555.20
25.25	559.47
25.50	563.74
25.75	568.01
26.00	572.28
26.25	576.55
26.50	580.82
26.75	585.10
27.00	589.37
27.25	593.64
27.50	597.91
27.75	602.18
28.00	606.45
28.25	610.72
28.50	614.99
28.75	619.26
29.00	623.53
29.25	627.80
29.50	632.07
29.75	636.34
30.00	640.62
30.25	644.89
30.50	649.16
30.75	653.43
31.00	657.70
31.25	661.97
31.50	666.24
31.75	670.51
32.00	674.78
32.25	679.05
32.50	683.32
32.75	687.59
33.00	691.86
33.25	696.14
33.50	700.41
33.75	704.68
34.00	708.95
34.25	713.22
34.50	717.49
34.75	721.76
35.00	726.03
35.25	730.30
35.50	734.57
35.75	738.84
36.00	743.11
36.25	747.38
36.50	751.66
36.75	755.93
37.00	760.20
37.25	764.47
37.50	768.74
37.75	773.01
38.00	777.28
38.25	784.85
38.50	792.42
38.75	799.99
39.00	807.56
39.25	815.13
39.50	822.71
39.75	830.28
40.00	837.85
40.25	845.42
40.50	852.99
40.75	860.56

100Y-72H Simulation	
Time (hr)	Q (cfs)
20.25	745.80
20.50	745.80
20.75	745.80
21.00	745.80
21.25	745.80
21.50	745.80
21.75	745.80
22.00	745.80
22.25	745.80
22.50	745.80
22.75	745.80
23.00	745.80
23.25	745.80
23.50	745.80
23.75	745.80
24.00	745.80
24.25	745.80
24.50	745.80
24.75	745.80
25.00	745.80
25.25	751.54
25.50	757.27
25.75	763.01
26.00	768.75
26.25	774.48
26.50	780.22
26.75	785.96
27.00	791.70
27.25	797.43
27.50	803.17
27.75	808.91
28.00	814.64
28.25	820.38
28.50	826.12
28.75	831.85
29.00	837.59
29.25	843.33
29.50	849.06
29.75	854.80
30.00	860.54
30.25	866.28
30.50	872.01
30.75	877.75
31.00	883.49
31.25	889.22
31.50	894.96
31.75	900.70
32.00	906.43
32.25	912.17
32.50	917.91
32.75	923.64
33.00	929.38
33.25	935.12
33.50	940.86
33.75	946.59
34.00	952.33
34.25	958.07
34.50	963.80
34.75	969.54
35.00	975.28
35.25	981.01
35.50	986.75
35.75	992.49
36.00	998.22
36.25	1,003.96
36.50	1,009.70
36.75	1,015.44
37.00	1,021.17
37.25	1,026.91
37.50	1,032.65
37.75	1,038.38
38.00	1,044.12
38.25	1,054.29
38.50	1,064.46
38.75	1,074.63
39.00	1,084.80
39.25	1,094.97
39.50	1,105.14
39.75	1,115.31
40.00	1,125.48
40.25	1,135.65
40.50	1,145.82
40.75	1,155.99

5Y-24H Simulation

Time (hr)	Q (cfs)
41.00	723.20
41.25	715.97
41.50	711.86
41.75	704.68
42.00	701.60
42.25	694.46
42.50	688.36
42.75	683.28
43.00	677.20
43.25	673.16
43.50	669.64
43.75	665.11
44.00	659.09
44.25	656.09
44.50	651.60
44.75	648.60
45.00	644.13
45.25	638.76
45.50	635.20
45.75	632.83
46.00	629.27
46.25	623.36
46.50	620.41
46.75	616.88
47.00	614.54
47.25	611.02
47.50	605.75
47.75	602.24
48.00	599.92

10Y-24H Simulation

Time (hr)	Q (cfs)
41.00	850.62
41.25	842.12
41.50	837.29
41.75	828.84
42.00	825.22
42.25	816.82
42.50	809.64
42.75	803.67
43.00	796.52
43.25	791.77
43.50	787.62
43.75	782.30
44.00	775.22
44.25	771.69
44.50	766.40
44.75	762.88
45.00	757.62
45.25	751.31
45.50	747.12
45.75	744.33
46.00	740.15
46.25	733.20
46.50	729.73
46.75	725.57
47.00	722.81
47.25	718.68
47.50	712.48
47.75	708.36
48.00	705.62

25Y-24H Simulation

Time (hr)	Q (cfs)
41.00	1,043.45
41.25	1,033.03
41.50	1,027.09
41.75	1,016.73
42.00	1,012.29
42.25	1,001.99
42.50	993.18
42.75	985.85
43.00	977.08
43.25	971.26
43.50	966.17
43.75	959.64
44.00	950.96
44.25	946.62
44.50	940.14
44.75	935.82
45.00	929.36
45.25	921.63
45.50	916.48
45.75	913.06
46.00	907.93
46.25	899.40
46.50	895.15
46.75	890.06
47.00	886.67
47.25	881.59
47.50	873.99
47.75	868.94
48.00	865.58

25Y-72H Simulation

Time (hr)	Q (cfs)
41.00	868.13
41.25	875.70
41.50	883.27
41.75	890.84
42.00	898.41
42.25	905.99
42.50	913.56
42.75	921.13
43.00	928.70
43.25	936.27
43.50	943.84
43.75	951.41
44.00	958.98
44.25	966.55
44.50	974.12
44.75	981.69
45.00	989.27
45.25	996.84
45.50	1,004.41
45.75	1,011.98
46.00	1,019.55
46.25	1,027.12
46.50	1,034.69
46.75	1,042.26
47.00	1,049.83
47.25	1,057.40
47.50	1,064.97
47.75	1,072.55
48.00	1,080.12
48.25	1,087.69
48.50	1,095.26
48.75	1,102.83
49.00	1,110.40
49.25	1,128.67
49.50	1,146.93
49.75	1,165.20
50.00	1,183.46
50.25	1,201.73
50.50	1,220.00
50.75	1,238.26
51.00	1,256.53
51.25	1,274.79
51.50	1,293.06
51.75	1,311.32
52.00	1,329.59
52.25	1,347.86
52.50	1,366.12
52.75	1,384.39
53.00	1,402.65
53.25	1,420.92
53.50	1,455.75
53.75	1,485.83
54.00	1,512.51
54.25	1,526.27
54.50	1,551.72
54.75	1,587.59
55.00	1,644.50
55.25	1,707.34
55.50	1,776.30
55.75	1,846.16
56.00	1,922.41
56.25	1,994.11
56.50	2,066.69
56.75	2,134.45
57.00	2,202.92
57.25	2,266.33
57.50	2,324.49
57.75	2,383.14
58.00	2,436.34
58.25	2,489.92
58.50	2,537.89
58.75	2,586.15
59.00	2,628.63
59.25	2,671.33
59.50	2,708.12
59.75	2,745.08
60.00	2,776.00
60.25	2,774.97
60.50	2,773.94
60.75	2,772.90
61.00	2,771.87
61.25	2,770.84
61.50	2,769.81

100Y-72H Simulation

Time (hr)	Q (cfs)
41.00	1,166.16
41.25	1,176.33
41.50	1,186.50
41.75	1,196.67
42.00	1,206.84
42.25	1,217.01
42.50	1,227.18
42.75	1,237.35
43.00	1,247.52
43.25	1,257.69
43.50	1,267.86
43.75	1,278.03
44.00	1,288.20
44.25	1,298.37
44.50	1,308.54
44.75	1,318.71
45.00	1,328.88
45.25	1,339.05
45.50	1,349.22
45.75	1,359.39
46.00	1,369.56
46.25	1,379.73
46.50	1,389.90
46.75	1,400.07
47.00	1,410.24
47.25	1,420.41
47.50	1,430.58
47.75	1,440.75
48.00	1,450.92
48.25	1,461.09
48.50	1,471.26
48.75	1,481.43
49.00	1,491.60
49.25	1,516.14
49.50	1,540.67
49.75	1,565.21
50.00	1,589.75
50.25	1,614.28
50.50	1,638.82
50.75	1,663.36
51.00	1,687.89
51.25	1,712.43
51.50	1,736.97
51.75	1,761.50
52.00	1,786.04
52.25	1,810.58
52.50	1,835.11
52.75	1,859.65
53.00	1,884.19
53.25	1,908.72
53.50	1,955.51
53.75	1,995.92
54.00	2,031.76
54.25	2,050.24
54.50	2,084.43
54.75	2,132.60
55.00	2,209.06
55.25	2,293.47
55.50	2,386.10
55.75	2,479.95
56.00	2,582.37
56.25	2,678.69
56.50	2,776.18
56.75	2,867.20
57.00	2,959.19
57.25	3,044.36
57.50	3,122.49
57.75	3,201.27
58.00	3,272.73
58.25	3,344.72
58.50	3,409.14
58.75	3,473.97
59.00	3,531.04
59.25	3,588.40
59.50	3,637.82
59.75	3,687.46
60.00	3,729.00
60.25	3,727.61
60.50	3,726.23
60.75	3,724.84
61.00	3,723.45
61.25	3,722.07
61.50	3,720.68

5Y-24H Simulation

Time (hr)	Q (cfs)

10Y-24H Simulation

Time (hr)	Q (cfs)

25Y-24H Simulation

Time (hr)	Q (cfs)

25Y-72H Simulation

Time (hr)	Q (cfs)
61.75	2,768.77
62.00	2,767.75
62.25	2,766.71
62.50	2,765.68
62.75	2,764.65
63.00	2,763.62
63.25	2,720.43
63.50	2,671.33
63.75	2,628.63
64.00	2,592.20
64.25	2,549.92
64.50	2,511.87
64.75	2,477.98
65.00	2,442.27
65.25	2,412.64
65.50	2,383.14
65.75	2,353.76
66.00	2,318.66
66.25	2,289.54
66.50	2,260.54
66.75	2,231.68
67.00	2,202.92
67.25	2,174.31
67.50	2,145.80
67.75	2,117.44
68.00	2,089.19
68.25	2,066.69
68.50	2,049.86
68.75	2,027.50
69.00	2,005.22
69.25	1,977.49
69.50	1,955.39
69.75	1,932.46
70.00	1,911.45
70.25	1,889.60
70.50	1,867.84
70.75	1,846.16
71.00	1,824.57
71.25	1,803.06
71.50	1,781.65
71.75	1,760.31
72.00	1,744.36
72.25	1,723.18
72.50	1,702.07
72.75	1,686.31
73.00	1,670.59
73.25	1,649.70
73.50	1,628.91
73.75	1,608.21
74.00	1,592.73
74.25	1,572.18
74.50	1,556.83
74.75	1,536.43
75.00	1,521.20
75.25	1,506.01
75.50	1,485.83
75.75	1,470.77
76.00	1,455.75
76.25	1,439.88
76.50	1,425.88
76.75	1,411.01
77.00	1,396.21
77.25	1,381.45
77.50	1,366.74
77.75	1,359.06
78.00	1,354.88
78.25	1,352.09
78.50	1,348.85
78.75	1,345.60
79.00	1,342.35
79.25	1,338.47
79.50	1,332.64
79.75	1,325.36
80.00	1,318.11
80.25	1,308.45
80.50	1,302.02
80.75	1,290.81
81.00	1,284.41
81.25	1,274.84
81.50	1,263.70
81.75	1,258.14
82.00	1,251.01
82.25	1,243.11

100Y-72H Simulation

Time (hr)	Q (cfs)
61.75	3,719.29
62.00	3,717.92
62.25	3,716.53
62.50	3,715.14
62.75	3,713.76
63.00	3,712.37
63.25	3,654.35
63.50	3,588.40
63.75	3,531.04
64.00	3,482.10
64.25	3,425.30
64.50	3,374.19
64.75	3,328.67
65.00	3,280.70
65.25	3,240.90
65.50	3,201.27
65.75	3,161.80
66.00	3,114.65
66.25	3,075.53
66.50	3,036.59
66.75	2,997.81
67.00	2,959.19
67.25	2,920.74
67.50	2,882.46
67.75	2,844.35
68.00	2,806.41
68.25	2,776.18
68.50	2,753.58
68.75	2,723.54
69.00	2,693.61
69.25	2,656.36
69.50	2,626.68
69.75	2,595.87
70.00	2,567.66
70.25	2,538.30
70.50	2,509.07
70.75	2,479.95
71.00	2,450.95
71.25	2,422.06
71.50	2,393.28
71.75	2,364.63
72.00	2,343.20
72.25	2,314.74
72.50	2,286.40
72.75	2,265.22
73.00	2,244.11
73.25	2,216.05
73.50	2,188.12
73.75	2,160.30
74.00	2,139.51
74.25	2,111.91
74.50	2,091.29
74.75	2,063.89
75.00	2,043.42
75.25	2,023.02
75.50	1,995.92
75.75	1,975.69
76.00	1,955.51
76.25	1,934.19
76.50	1,915.38
76.75	1,895.41
77.00	1,875.53
77.25	1,855.70
77.50	1,835.95
77.75	1,825.63
78.00	1,820.01
78.25	1,816.26
78.50	1,811.91
78.75	1,807.54
79.00	1,803.18
79.25	1,797.96
79.50	1,790.13
79.75	1,780.36
80.00	1,770.61
80.25	1,757.64
80.50	1,749.01
80.75	1,733.95
81.00	1,725.35
81.25	1,712.50
81.50	1,697.53
81.75	1,690.06
82.00	1,680.48
82.25	1,669.86

5Y-24H Simulation

Time (hr)	Q (cfs)

10Y-24H Simulation

Time (hr)	Q (cfs)

25Y-24H Simulation

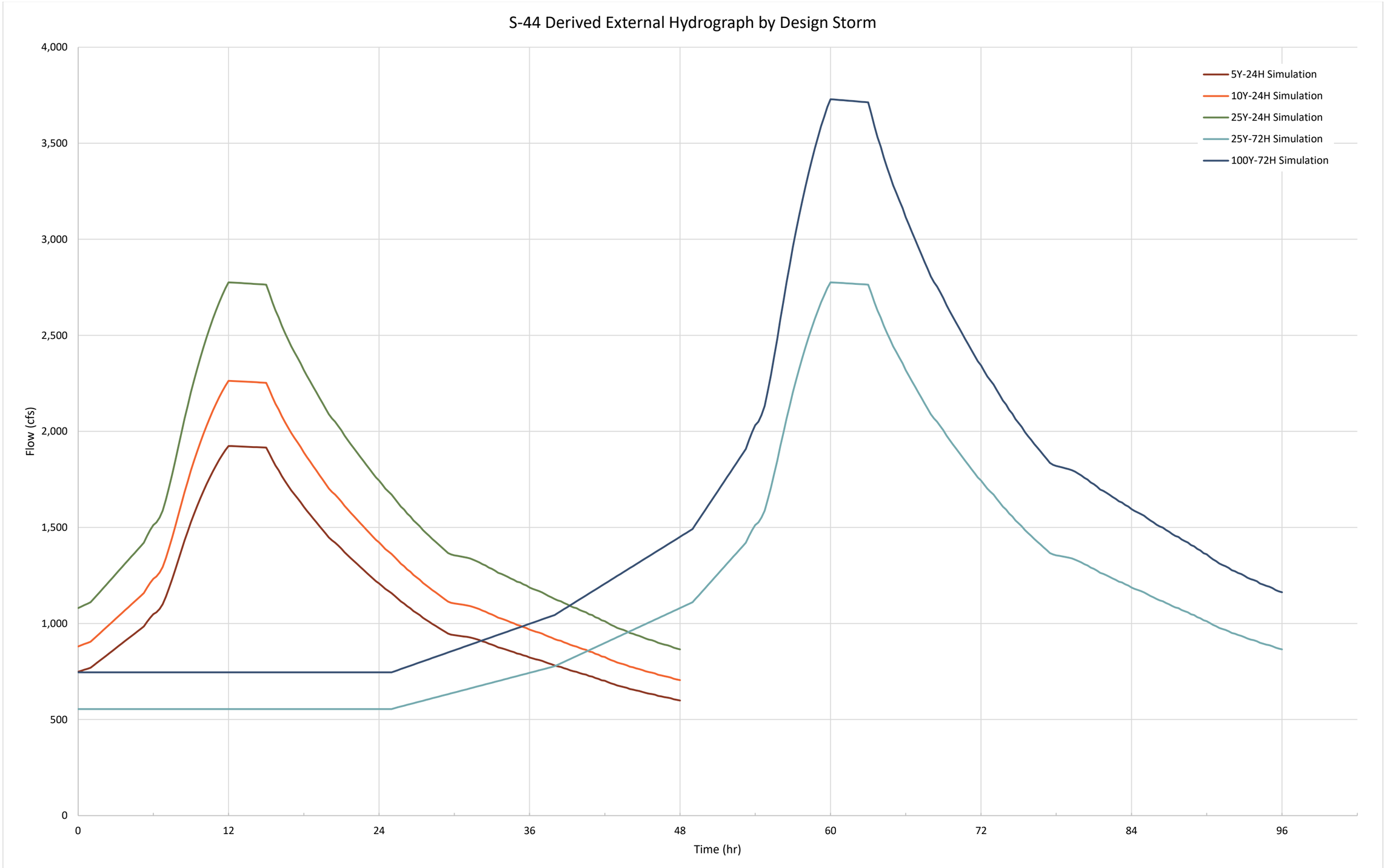
Time (hr)	Q (cfs)

25Y-72H Simulation

Time (hr)	Q (cfs)
82.50	1,234.43
82.75	1,227.33
83.00	1,217.91
83.25	1,213.20
83.50	1,203.81
83.75	1,197.56
84.00	1,187.43
84.25	1,180.43
84.50	1,174.23
84.75	1,168.81
85.00	1,161.84
85.25	1,152.59
85.50	1,143.36
85.75	1,136.45
86.00	1,127.25
86.25	1,120.38
86.50	1,115.81
86.75	1,106.67
87.00	1,099.84
87.25	1,090.75
87.50	1,083.95
87.75	1,079.42
88.00	1,070.38
88.25	1,063.63
88.50	1,058.38
88.75	1,047.91
89.00	1,043.45
89.25	1,033.03
89.50	1,027.09
89.75	1,016.73
90.00	1,012.29
90.25	1,001.99
90.50	993.18
90.75	985.85
91.00	977.08
91.25	971.26
91.50	966.17
91.75	959.64
92.00	950.96
92.25	946.62
92.50	940.14
92.75	935.82
93.00	929.36
93.25	921.63
93.50	916.48
93.75	913.06
94.00	907.93
94.25	899.40
94.50	895.15
94.75	890.06
95.00	886.67
95.25	881.59
95.50	873.99
95.75	868.94
96.00	865.58

100Y-72H Simulation

Time (hr)	Q (cfs)
82.50	1,658.20
82.75	1,648.68
83.00	1,636.02
83.25	1,629.69
83.50	1,617.08
83.75	1,608.68
84.00	1,595.07
84.25	1,585.68
84.50	1,577.34
84.75	1,570.06
85.00	1,560.70
85.25	1,548.27
85.50	1,535.87
85.75	1,526.59
86.00	1,514.24
86.25	1,505.01
86.50	1,498.87
86.75	1,486.59
87.00	1,477.42
87.25	1,465.21
87.50	1,456.07
87.75	1,449.99
88.00	1,437.85
88.25	1,428.77
88.50	1,421.72
88.75	1,407.66
89.00	1,401.66
89.25	1,387.66
89.50	1,379.69
89.75	1,365.77
90.00	1,359.81
90.25	1,345.97
90.50	1,334.14
90.75	1,324.30
91.00	1,312.52
91.25	1,304.69
91.50	1,297.86
91.75	1,289.08
92.00	1,277.42
92.25	1,271.60
92.50	1,262.89
92.75	1,257.08
93.00	1,248.41
93.25	1,238.02
93.50	1,231.11
93.75	1,226.51
94.00	1,219.63
94.25	1,208.17
94.50	1,202.45
94.75	1,195.61
95.00	1,191.06
95.25	1,184.24
95.50	1,174.03
95.75	1,167.24
96.00	1,162.73


S-44 Derived External Hydrograph by Design Storm
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Flow (cfs)
0
12
24
36
48
60
72
84
96
Time (hr)
5Y-24H Simulation
10Y-24H Simulation
25Y-24H Simulation
25Y-72H Simulation
100Y-72H Simulation

Appendix A-2: External Boundary Condition – Observed NOAA Tidal Data at the Lake Worth Pier Station & Projected Sea Level Rise Scenarios

Obseved NOAA Tidal Data at the Lake Worth Pier Station & Projected Sea Level Rise Scenarios

Date	Time (GMT)	Time Elapsed (hrs)	Observed (ft)	2040 Int-Low Stage (ft)	2040 Int-High Stage (ft)	2070 Int-Low Stage (ft)	2070 Int-High Stage (ft)
11/25/2022	1:00	0.00	1.38	1.68	2.04	2.36	2.73
11/25/2022	2:00	1.00	1.16	1.46	1.82	2.14	2.51
11/25/2022	3:00	2.00	0.62	0.92	1.28	1.60	1.97
11/25/2022	4:00	3.00	-0.19	0.11	0.47	0.79	1.16
11/25/2022	5:00	4.00	-1.05	-0.75	-0.39	-0.07	0.30
11/25/2022	6:00	5.00	-1.72	-1.42	-1.06	-0.74	-0.37
11/25/2022	7:00	6.00	-2.02	-1.72	-1.36	-1.04	-0.67
11/25/2022	8:00	7.00	-1.84	-1.54	-1.18	-0.86	-0.49
11/25/2022	9:00	8.00	-1.25	-0.95	-0.59	-0.27	0.10
11/25/2022	10:00	9.00	-0.36	-0.06	0.30	0.62	0.99
11/25/2022	11:00	10.00	0.6	0.90	1.26	1.58	1.95
11/25/2022	12:00	11.00	1.48	1.78	2.14	2.46	2.83
11/25/2022	13:00	12.00	2.09	2.39	2.75	3.07	3.44
11/25/2022	14:00	13.00	2.16	2.46	2.82	3.14	3.51
11/25/2022	15:00	14.00	1.8	2.10	2.46	2.78	3.15
11/25/2022	16:00	15.00	1.13	1.43	1.79	2.11	2.48
11/25/2022	17:00	16.00	0.29	0.59	0.95	1.27	1.64
11/25/2022	18:00	17.00	-0.58	-0.28	0.08	0.40	0.77
11/25/2022	19:00	18.00	-1.2	-0.90	-0.54	-0.22	0.15
11/25/2022	20:00	19.00	-1.41	-1.11	-0.75	-0.43	-0.06
11/25/2022	21:00	20.00	-1.2	-0.90	-0.54	-0.22	0.15
11/25/2022	22:00	21.00	-0.7	-0.40	-0.04	0.28	0.65
11/25/2022	23:00	22.00	-0.02	0.28	0.64	0.96	1.33
11/26/2022	0:00	23.00	0.63	0.93	1.29	1.61	1.98
11/26/2022	1:00	24.00	1.09	1.39	1.75	2.07	2.44
11/26/2022	2:00	25.00	1.28	1.58	1.94	2.26	2.63
11/26/2022	3:00	26.00	1.07	1.37	1.73	2.05	2.42
11/26/2022	4:00	27.00	0.52	0.82	1.18	1.50	1.87
11/26/2022	5:00	28.00	-0.24	0.06	0.42	0.74	1.11
11/26/2022	6:00	29.00	-1.13	-0.83	-0.47	-0.15	0.22
11/26/2022	7:00	30.00	-1.75	-1.45	-1.09	-0.77	-0.40
11/26/2022	8:00	31.00	-2.01	-1.71	-1.35	-1.03	-0.66
11/26/2022	9:00	32.00	-1.81	-1.51	-1.15	-0.83	-0.46
11/26/2022	10:00	33.00	-1.28	-0.98	-0.62	-0.30	0.07
11/26/2022	11:00	34.00	-0.42	-0.12	0.24	0.56	0.93
11/26/2022	12:00	35.00	0.53	0.83	1.19	1.51	1.88
11/26/2022	13:00	36.00	1.32	1.62	1.98	2.30	2.67
11/26/2022	14:00	37.00	1.78	2.08	2.44	2.76	3.13
11/26/2022	15:00	38.00	1.83	2.13	2.49	2.81	3.18
11/26/2022	16:00	39.00	1.55	1.85	2.21	2.53	2.90
11/26/2022	17:00	40.00	0.93	1.23	1.59	1.91	2.28
11/26/2022	18:00	41.00	0.1	0.40	0.76	1.08	1.45

Date	Time (GMT)	Time Elapsed (hrs)	Observed (ft)	2040 Int-Low Stage (ft)	2040 Int-High Stage (ft)	2070 Int-Low Stage (ft)	2070 Int-High Stage (ft)
11/26/2022	19:00	42.00	-0.73	-0.43	-0.07	0.25	0.62
11/26/2022	20:00	43.00	-1.24	-0.94	-0.58	-0.26	0.11
11/26/2022	21:00	44.00	-1.37	-1.07	-0.71	-0.39	-0.02
11/26/2022	22:00	45.00	-1.12	-0.82	-0.46	-0.14	0.23
11/26/2022	23:00	46.00	-0.67	-0.37	-0.01	0.31	0.68
11/27/2022	0:00	47.00	-0.06	0.24	0.60	0.92	1.29
11/27/2022	1:00	48.00	0.65	0.95	1.31	1.63	2.00
11/27/2022	2:00	49.00	1.11	1.41	1.77	2.09	2.46
11/27/2022	3:00	50.00	1.21	1.51	1.87	2.19	2.56
11/27/2022	4:00	51.00	0.95	1.25	1.61	1.93	2.30
11/27/2022	5:00	52.00	0.43	0.73	1.09	1.41	1.78
11/27/2022	6:00	53.00	-0.33	-0.03	0.33	0.65	1.02
11/27/2022	7:00	54.00	-1.07	-0.77	-0.41	-0.09	0.28
11/27/2022	8:00	55.00	-1.67	-1.37	-1.01	-0.69	-0.32
11/27/2022	9:00	56.00	-1.86	-1.56	-1.20	-0.88	-0.51
11/27/2022	10:00	57.00	-1.68	-1.38	-1.02	-0.70	-0.33
11/27/2022	11:00	58.00	-1.11	-0.81	-0.45	-0.13	0.24
11/27/2022	12:00	59.00	-0.25	0.05	0.41	0.73	1.10
11/27/2022	13:00	60.00	0.64	0.94	1.30	1.62	1.99
11/27/2022	14:00	61.00	1.36	1.66	2.02	2.34	2.71
11/27/2022	15:00	62.00	1.84	2.14	2.50	2.82	3.19
11/27/2022	16:00	63.00	1.92	2.22	2.58	2.90	3.27
11/27/2022	17:00	64.00	1.56	1.86	2.22	2.54	2.91
11/27/2022	18:00	65.00	0.95	1.25	1.61	1.93	2.30
11/27/2022	19:00	66.00	0.08	0.38	0.74	1.06	1.43
11/27/2022	20:00	67.00	-0.68	-0.38	-0.02	0.30	0.67
11/27/2022	21:00	68.00	-1.13	-0.83	-0.47	-0.15	0.22
11/27/2022	22:00	69.00	-1.31	-1.01	-0.65	-0.33	0.04
11/27/2022	23:00	70.00	-1.12	-0.82	-0.46	-0.14	0.23
11/28/2022	0:00	71.00	-0.62	-0.32	0.04	0.36	0.73
11/28/2022	1:00	72.00	-0.04	0.26	0.62	0.94	1.31
11/28/2022	2:00	73.00	0.54	0.84	1.20	1.52	1.89
11/28/2022	3:00	74.00	1	1.30	1.66	1.98	2.35
11/28/2022	4:00	75.00	1.1	1.40	1.76	2.08	2.45
11/28/2022	5:00	76.00	0.81	1.11	1.47	1.79	2.16
11/28/2022	6:00	77.00	0.32	0.62	0.98	1.30	1.67
11/28/2022	7:00	78.00	-0.32	-0.02	0.34	0.66	1.03
11/28/2022	8:00	79.00	-1.1	-0.80	-0.44	-0.12	0.25
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11/28/2022	10:00	81.00	-1.87	-1.57	-1.21	-0.89	-0.52
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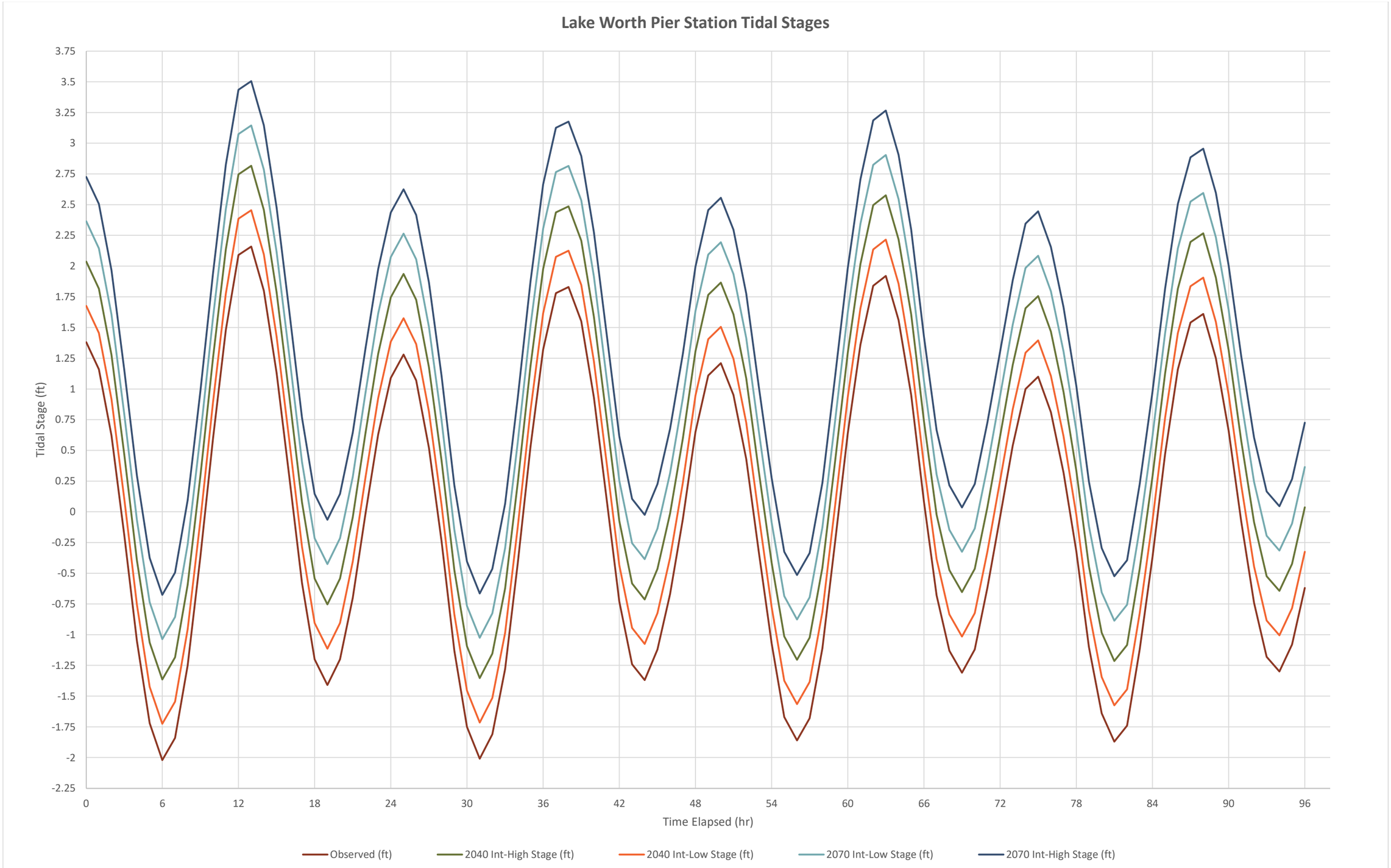
11/28/2022	14:00	85.00	0.47	0.77	1.13	1.45	1.82

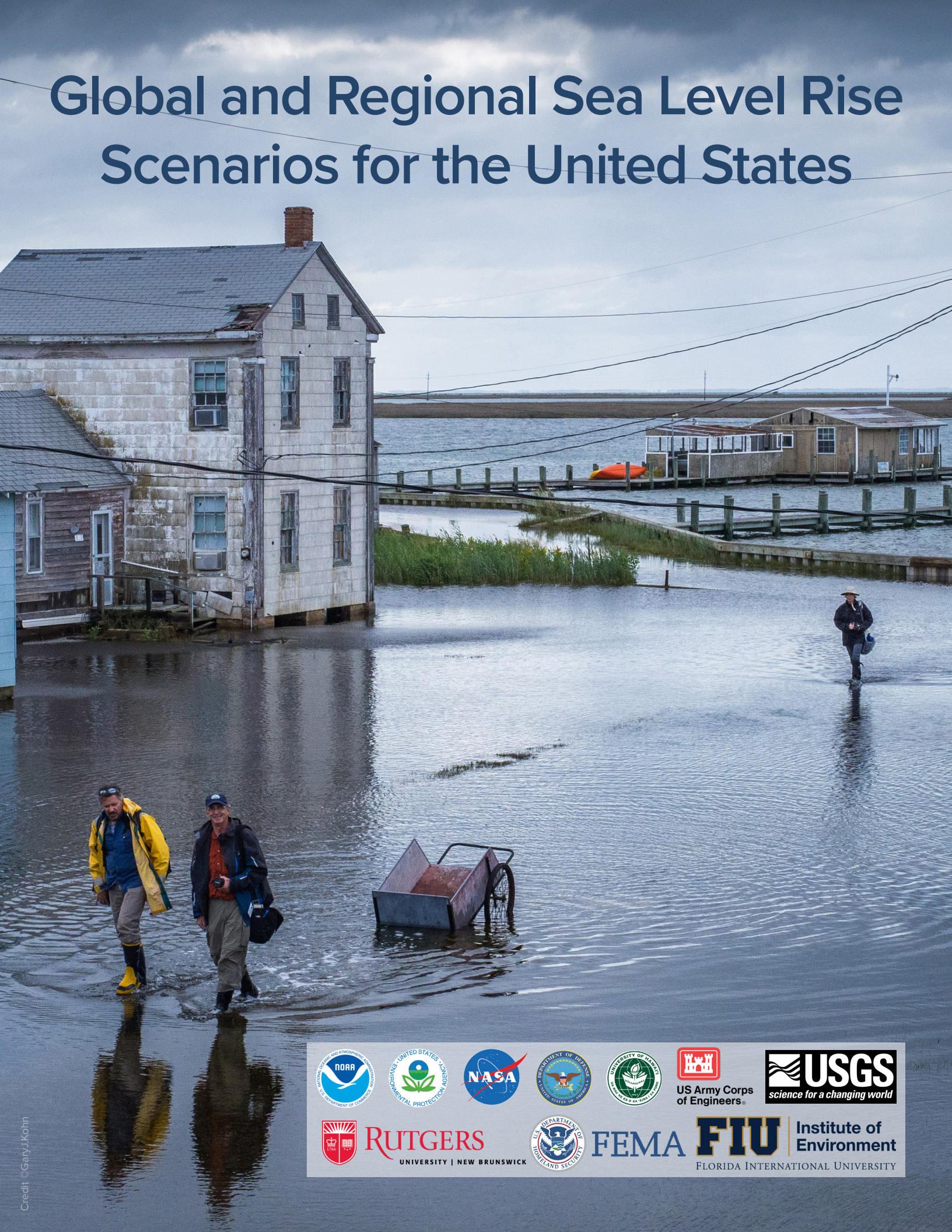
Date	Time (GMT)	Time Elapsed (hrs)	Observed (ft)	2040 Int-Low Stage (ft)	2040 Int-High Stage (ft)	2070 Int-Low Stage (ft)	2070 Int-High Stage (ft)
11/28/2022	15:00	86.00	1.16	1.46	1.82	2.14	2.51
11/28/2022	16:00	87.00	1.54	1.84	2.20	2.52	2.89
11/28/2022	17:00	88.00	1.61	1.91	2.27	2.59	2.96
11/28/2022	18:00	89.00	1.25	1.55	1.91	2.23	2.60
11/28/2022	19:00	90.00	0.66	0.96	1.32	1.64	2.01
11/28/2022	20:00	91.00	-0.08	0.22	0.58	0.90	1.27
11/28/2022	21:00	92.00	-0.74	-0.44	-0.08	0.24	0.61
11/28/2022	22:00	93.00	-1.18	-0.88	-0.52	-0.20	0.17
11/28/2022	23:00	94.00	-1.3	-1.00	-0.64	-0.32	0.05
11/29/2022	0:00	95.00	-1.08	-0.78	-0.42	-0.10	0.27
11/29/2022	1:00	96.00	-0.62	-0.32	0.04	0.36	0.73



Observed NOAA Tidal Data at the Lake Worth Pier Station and Projected Sea Level Tides

Appendix A-3: Excerpt from the 2022 “Global and Regional Sea Level Rise Scenarios for the United States” Technical Report

Global and Regional Sea Level Rise Scenarios for the United States



Credit ©GaryJ.Kohn

US Army Corps of Engineers

USGS science for a changing world

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FIU Institute of Environment
FLORIDA INTERNATIONAL UNIVERSITY



Cover Image: Flooding from 15-knot northerly winds on Smith Island, Maryland, on November 23, 2015. Credit ©Gary J. Kohn

National Oceanic and Atmospheric Administration
U.S. Department of Commerce
National Ocean Service
Silver Spring, Maryland
February, 2022

Recommended Citation:
Sweet, W.V., B.D. Hamlington, R.E. Kopp, C.P. Weaver, P.L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A.S. Genz, J.P. Krasting, E. Larour, D. Marcy, J.J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K.D. White, and C. Zuzak, 2022: Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nos-techrpt01-global-regional-SLR-scenarios-US.pdf

when assessing near-term trajectories. Beyond the possible influence of natural variability, there may also be a mismatch in the process representation between the observations and regionalized, model-based GMSL scenarios that leads to a projection that is too low in the latter. One possibility is non-linear or unresolved VLM in the region. The regionalized GMSL scenarios consider only long-term linear rates of VLM, while the observation-based extrapolations could represent a shift in the rate of VLM in the estimated acceleration.

An explanation of regional differences between observation-based extrapolations and model-based scenarios requires additional investigation, likely on a tide gauge-by-tide gauge basis. As a first step in this direction, the range between Low and High scenarios at each individual tide gauge (considering only the tide gauges with at least 30 years of data—102 of the full set of 121) is provided in Figure A1.2a, and the departure between the observation-based extrapolation and Intermediate scenario at each individual tide gauge is shown in Figure A1.2b. These figures show that the range between Low and High scenarios is generally lower than 20 cm in 2050 at the local level and that most observation-based extrapolations are within 15 cm of the Intermediate scenario in 2050. Of the 102 tide gauges used in this report, 65 have observation-based extrapolations that fall within the narrower Low to High ranges in 2050, and 80 of these 102 are within 15 cm of the Intermediate scenario. The majority of those falling below the Low scenario are found in the Northwest and southern Alaska regions, and the majority of those exceeding the High scenario are found in the two Gulf regions. This supports the regional comparisons shown in Figure 2.3 and Table 2.2 while also conveying that there is general agreement and consistency between the ranges of the observation-based extrapolations and regionalized GMSL scenarios even on a local, tide gauge-by-tide gauge level. A more definitive assessment of why some regions track higher (e.g., Eastern Gulf) or lower relative to others requires further analysis that should be done with consideration of the associated uncertainty and ranges.

As a general concluding statement on this near-term section, the link between the regional and global scenarios needs to be considered when drawing conclusions at the regional level based on the observation-based extrapolations. In practice, regionally identifying the scenario that upper-bounds the observation-based extrapolation at year 2050 (Table 2.2) may help compensate for potential interannual variability when projecting sea level for a particular location. The associated uncertainties in the approaches adopted here do emphasize the importance of ongoing monitoring using the observations and the need to update trajectories. As records continue to lengthen, likely ranges on near-term assessments will narrow. Additionally, satellite altimeter records are reaching sufficient length to be important in such monitoring. As a final note, the same framework used for extrapolating the observations forward can also be used to assess the increases—or offsets—observed over different recent time periods. These offsets are useful for adjusting baselines of the scenarios and are provided for each region in Table A1.2.

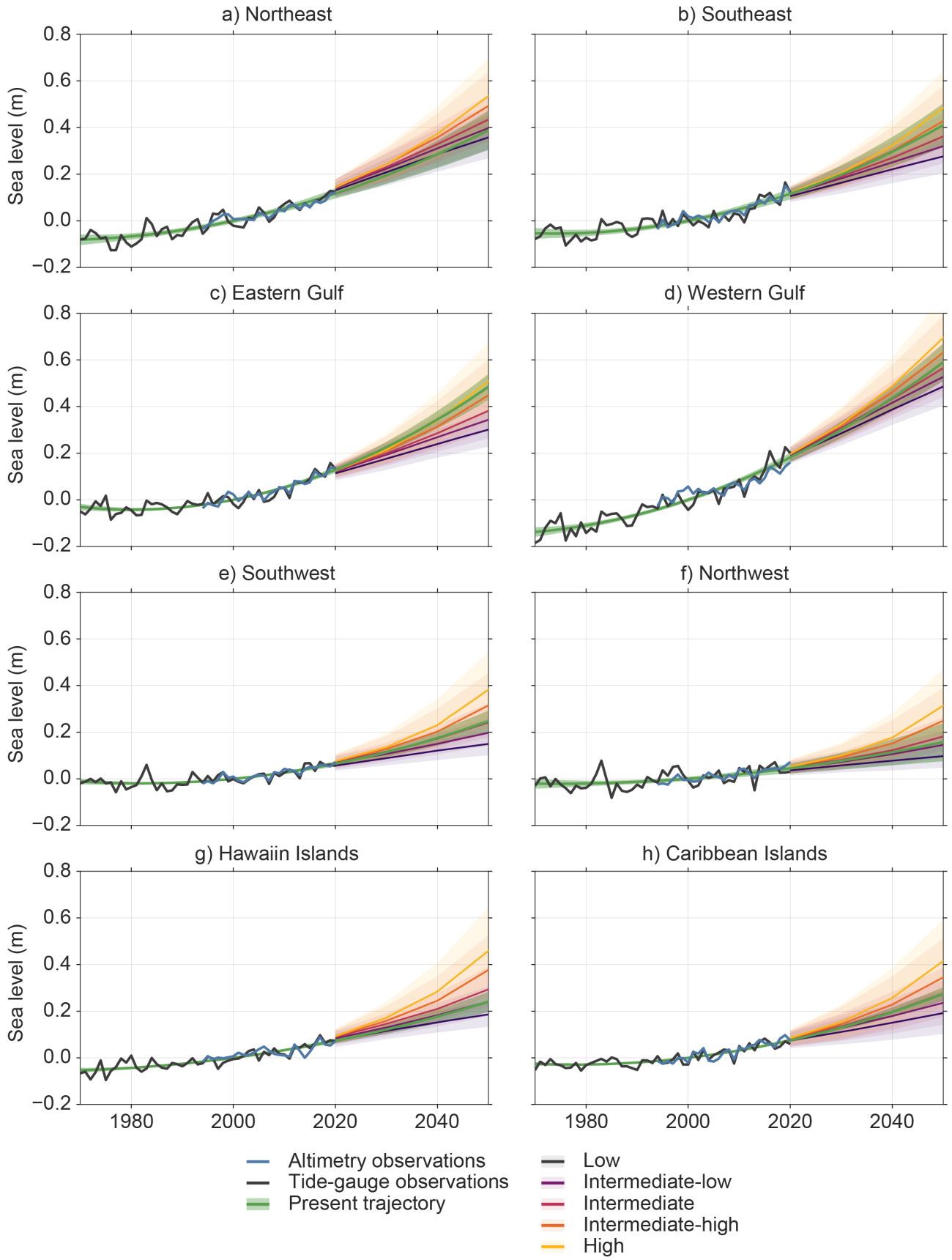


Figure 2.3: Observation-based extrapolations and five regionalized global mean sea level scenario projections, in meters, of relative sea levels for eight coastal regions around the United States from 2020 to 2050 relative to a baseline of 2000. Median values are shown by the solid lines, while the shaded regions represent the likely ranges for the observation-based extrapolations and each scenario. Tide-gauge data (1970 to 2020) are overlaid for reference, along with satellite altimetry observations, which do not include contributions from vertical land motion.

Table 2.2: Observation-based extrapolation and regionalized global mean sea level scenario–based estimates, in meters, of relative sea level in 2050 relative to a baseline of 2000 for eight coastal regions of the United States. Median [likely ranges] are shown. The two scenarios that bound the median observation-based extrapolation are also provided for each region and indicated by red dividing lines. In regions where the observation-based extrapolation is the same as a particular scenario, the scenario is indicated in red text and the bounding scenarios can be assumed to be the next higher or lower scenario (e.g., the Intermediate bounds the Northeast's observation-based extrapolation).

Observation Extrapolations	Low	Intermediate-Low	Intermediate	Intermediate-High	High	Median Bounding Scenarios
Northeast						
0.40 [0.30, 0.47]	0.36 [0.27, 0.45]	0.40 [0.31, 0.49]	0.43 [0.34, 0.54]	0.49 [0.38, 0.64]	0.54 [0.40, 0.69]	Int-Low
Southeast						
0.41 [0.32, 0.50]	0.28 [0.20, 0.35]	0.32 [0.25, 0.40]	0.36 [0.28, 0.46]	0.43 [0.32, 0.58]	0.49 [0.35, 0.64]	Int–Int-High
Eastern Gulf						
0.48 [0.43, 0.54]	0.30 [0.22, 0.38]	0.34 [0.26, 0.42]	0.38 [0.30, 0.48]	0.45 [0.34, 0.60]	0.51 [0.38, 0.68]	Int-High–High
Western Gulf						
0.59 [0.51,0.67]	0.49 [0.41, 0.57]	0.53 [0.44, 0.62]	0.57 [0.47, 0.67]	0.63 [0.51, 0.79]	0.69 [0.56, 0.87]	Int–Int-High
Southwest						
0.24 [0.20,0.29]	0.15 [0.10, 0.20]	0.20 [0.14, 0.26]	0.24 [0.18, 0.32]	0.31 [0.22, 0.45]	0.38 [0.26, 0.54]	Intermediate
Northwest						
0.16 [0.08, 0.24]	0.10 [0.05, 0.15]	0.15 [0.09, 0.20]	0.18 [0.12, 0.26]	0.25 [0.15, 0.39]	0.31 [0.19, 0.47]	Int-Low–Int
Hawaiian Islands						
0.24 [0.20, 0.28]	0.19 [0.13, 0.24]	0.24 [0.18, 0.31]	0.29 [0.22, 0.39]	0.38 [0.27, 0.53]	0.46 [0.31, 0.64]	Int-Low
Caribbean						
0.28 [0.24, 0.31]	0.19 [0.10, 0.29]	0.24 [0.14, 0.33]	0.28 [0.18, 0.39]	0.35 [0.22, 0.51]	0.42 [0.27, 0.59]	Intermediate

Appendix A-4: Excerpt from the National Resources Conservation Service Technical Release 55



United States Department of Agriculture

Natural Resources Conservation Service

Conservation Engineering Division

Technical Release 55

June 1986

Urban Hydrology for Small Watersheds

TR-55

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2/]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.

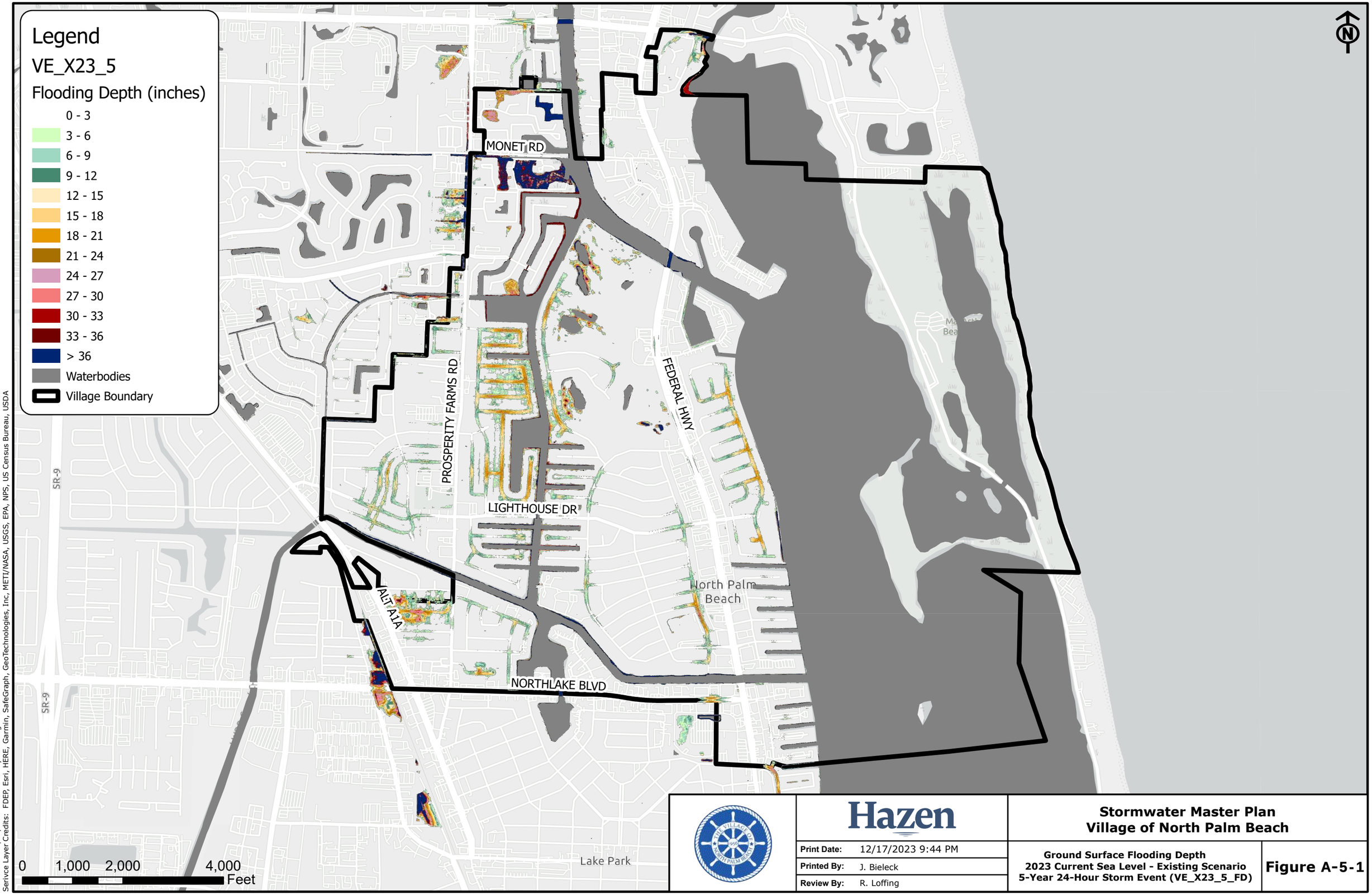
[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Appendix A-5: Existing Scenario with 2023 Current Sea Level Flooding Depths



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Hazen

Stormwater Master Plan
Village of North Palm Beach

Print Date:	12/17/2023 9:44 PM
Printed By:	J. Bieleck
Review By:	R. Loffing

Ground Surface Flooding Depth
2023 Current Sea Level - Existing Scenario
5-Year 24-Hour Storm Event (VE_X23_5_FD)

Figure A-5-1

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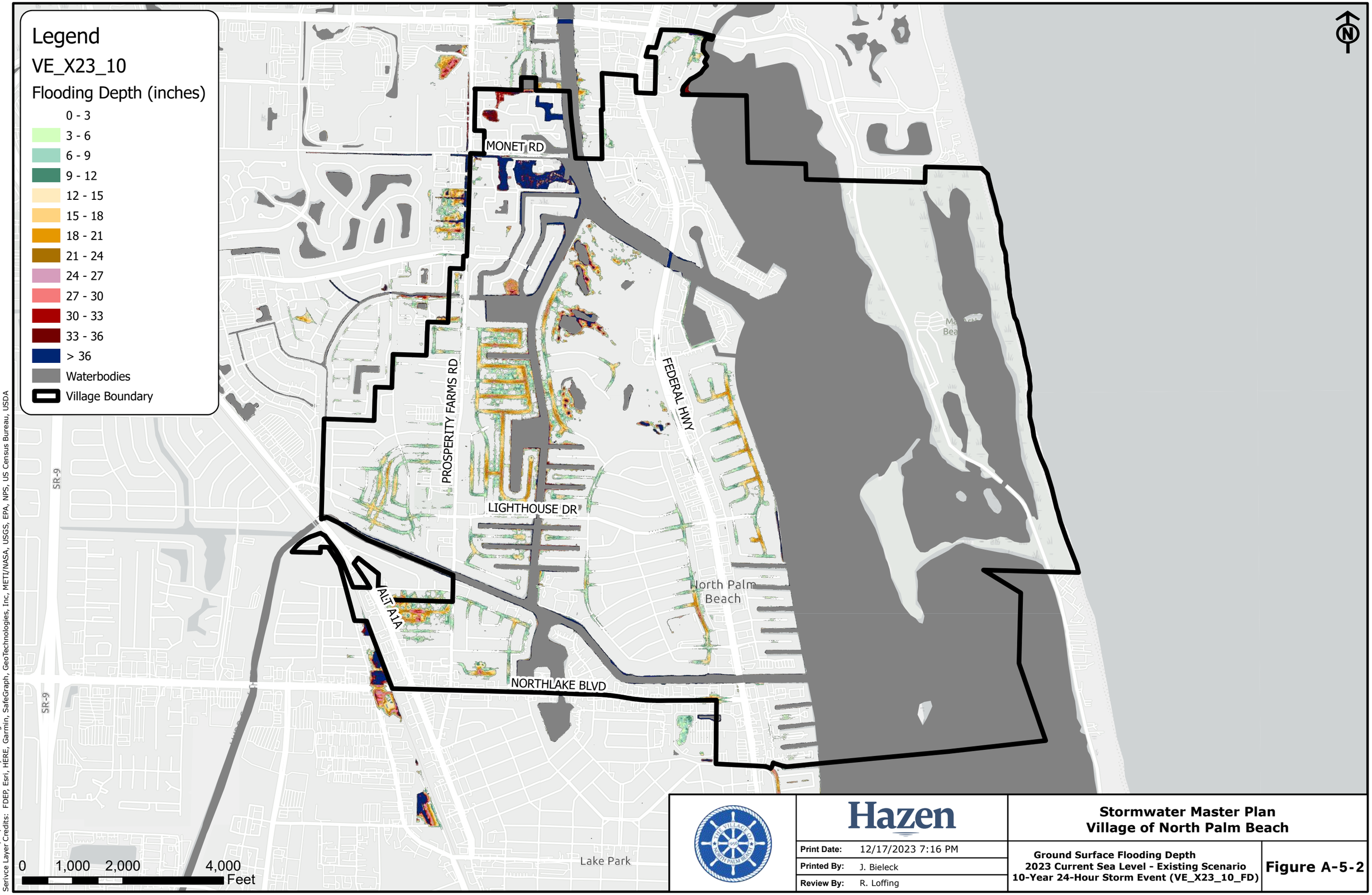

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Village of North Palm Beach

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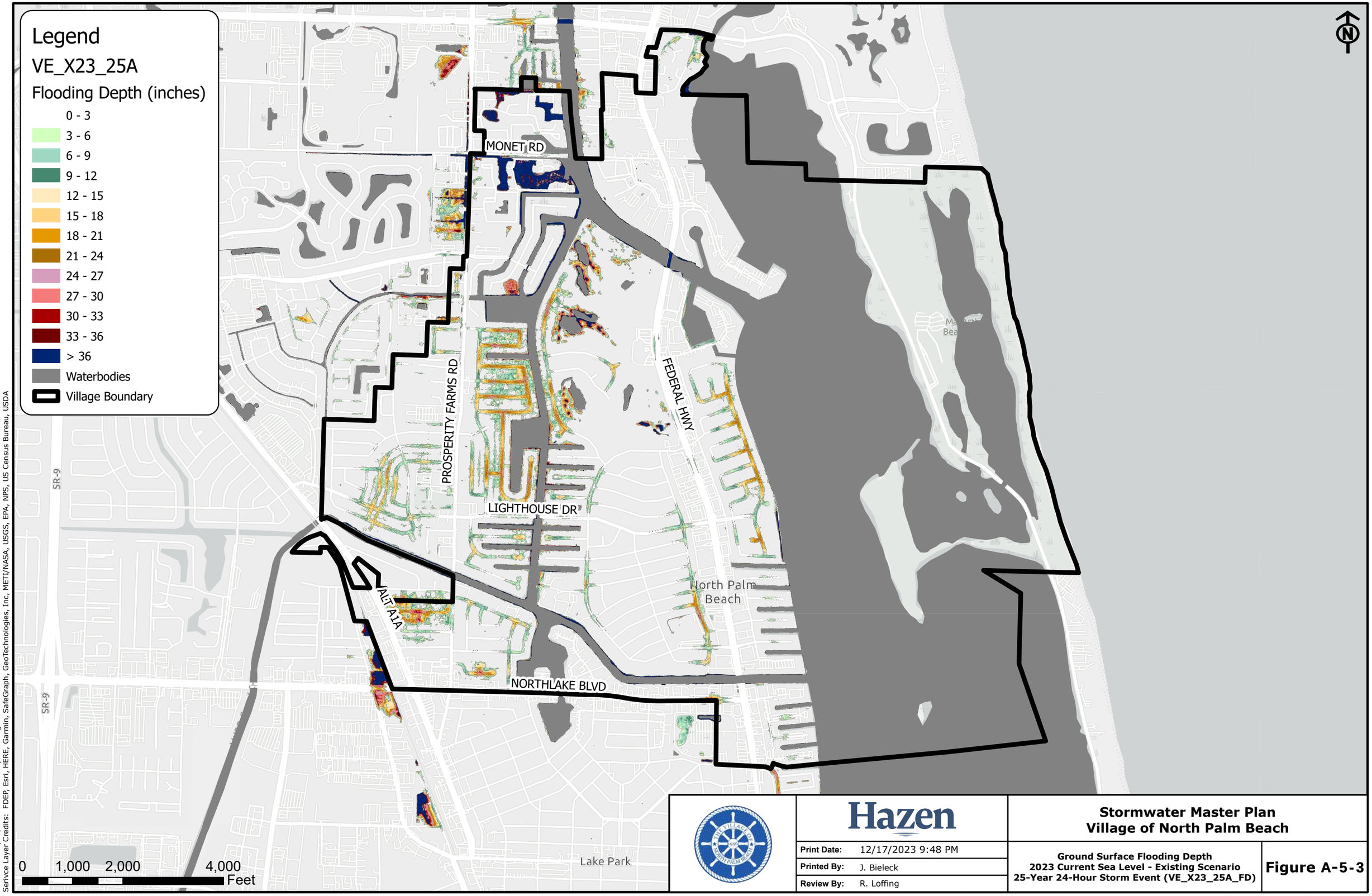
2023 Current Sea Level - Existing Scenario
10-Year 24-Hour Storm Event (VE_X23_10_FD)

Figure A-5-2



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Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2023 Current Sea Level - Existing Scenario
25-Year 24-Hour Storm Event (VE_X23_25A_FD)

Figure A-5-3

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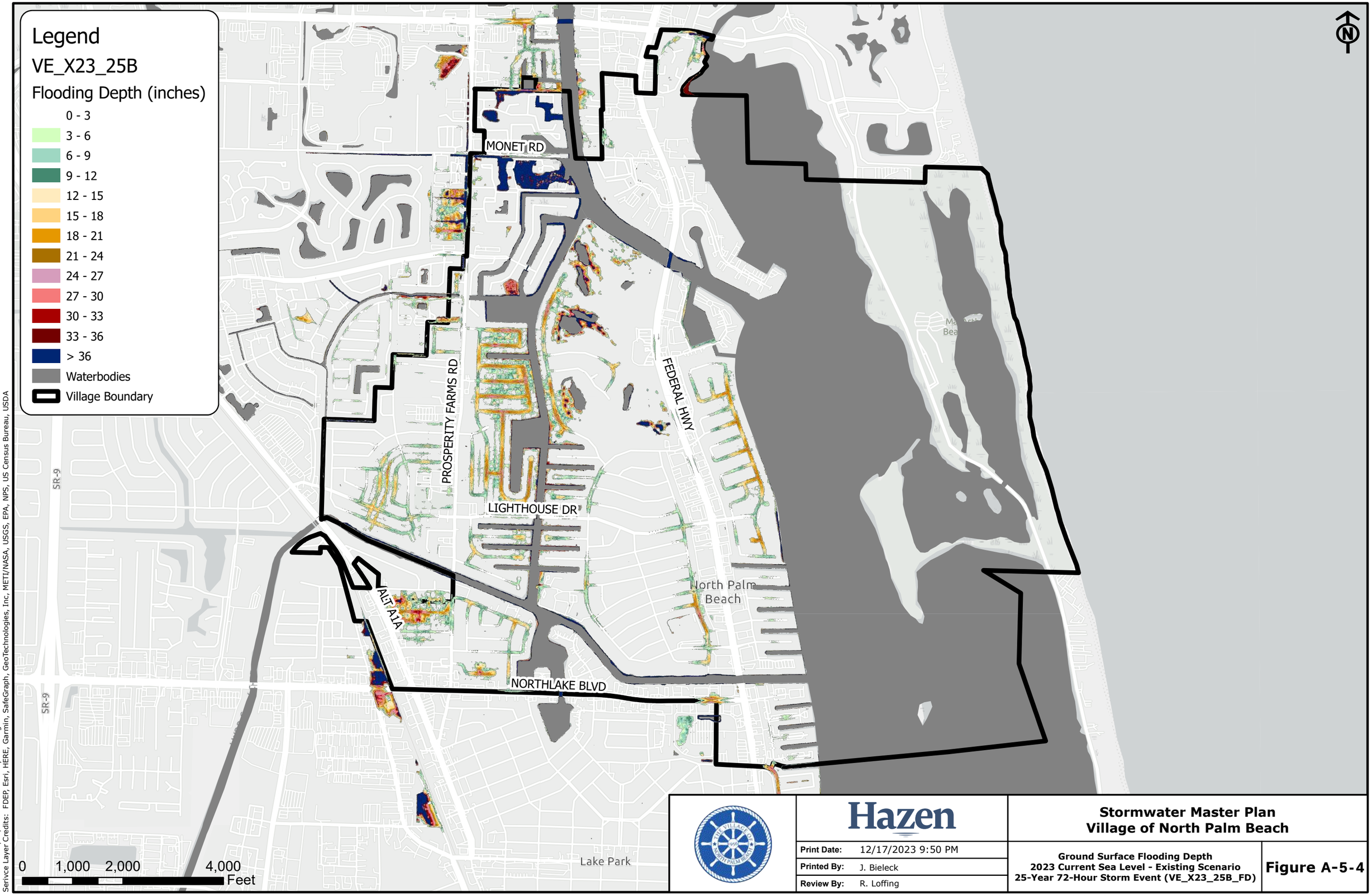

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Stormwater Master Plan
Village of North Palm Beach

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Ground Surface Flooding Depth
2023 Current Sea Level - Existing Scenario
25-Year 72-Hour Storm Event (VE_X23_25B_FD)

Figure A-5-4

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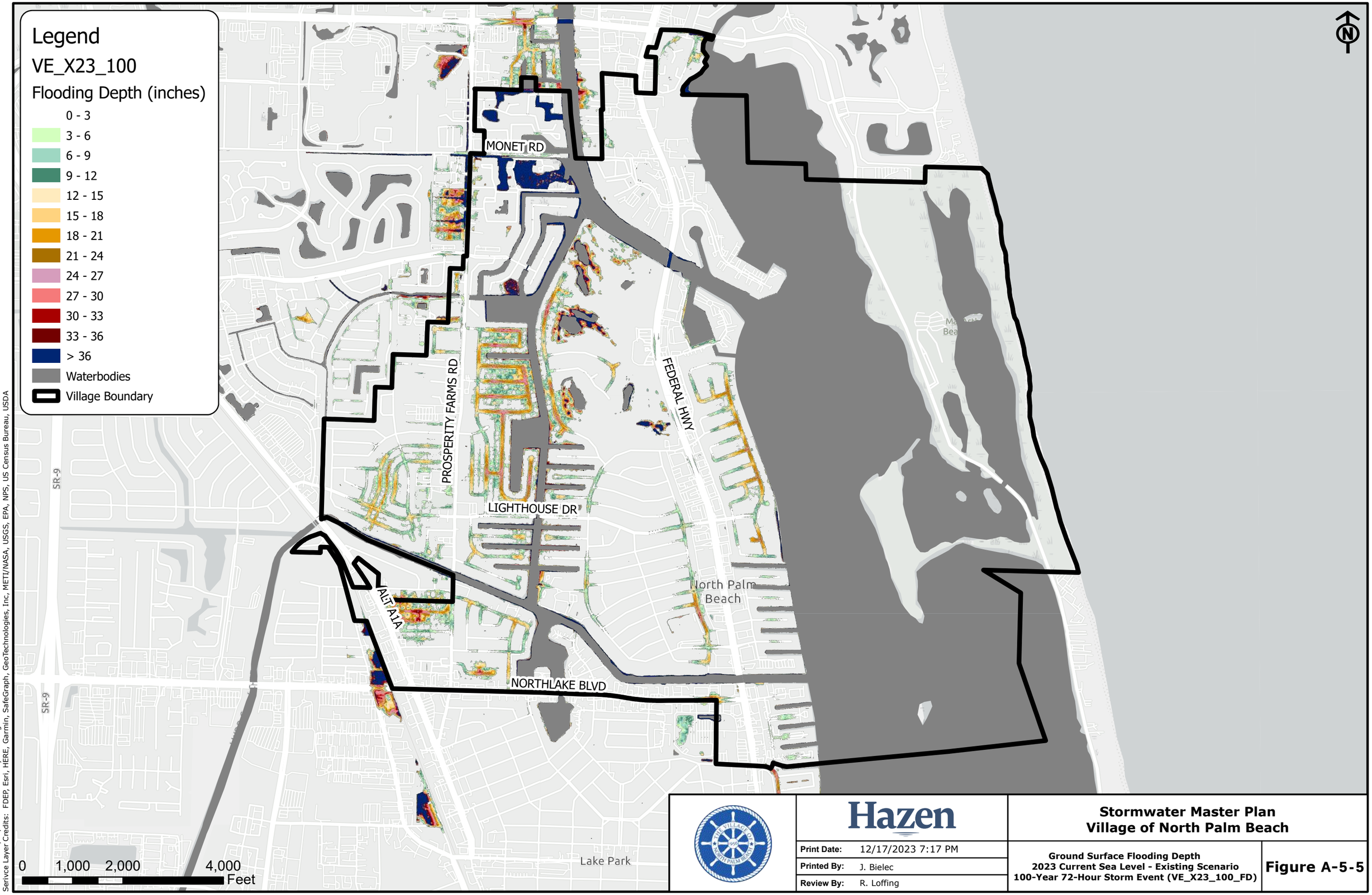

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Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2023 Current Sea Level - Existing Scenario
100-Year 72-Hour Storm Event (VE_X23_100_FD)

Figure A-5-5

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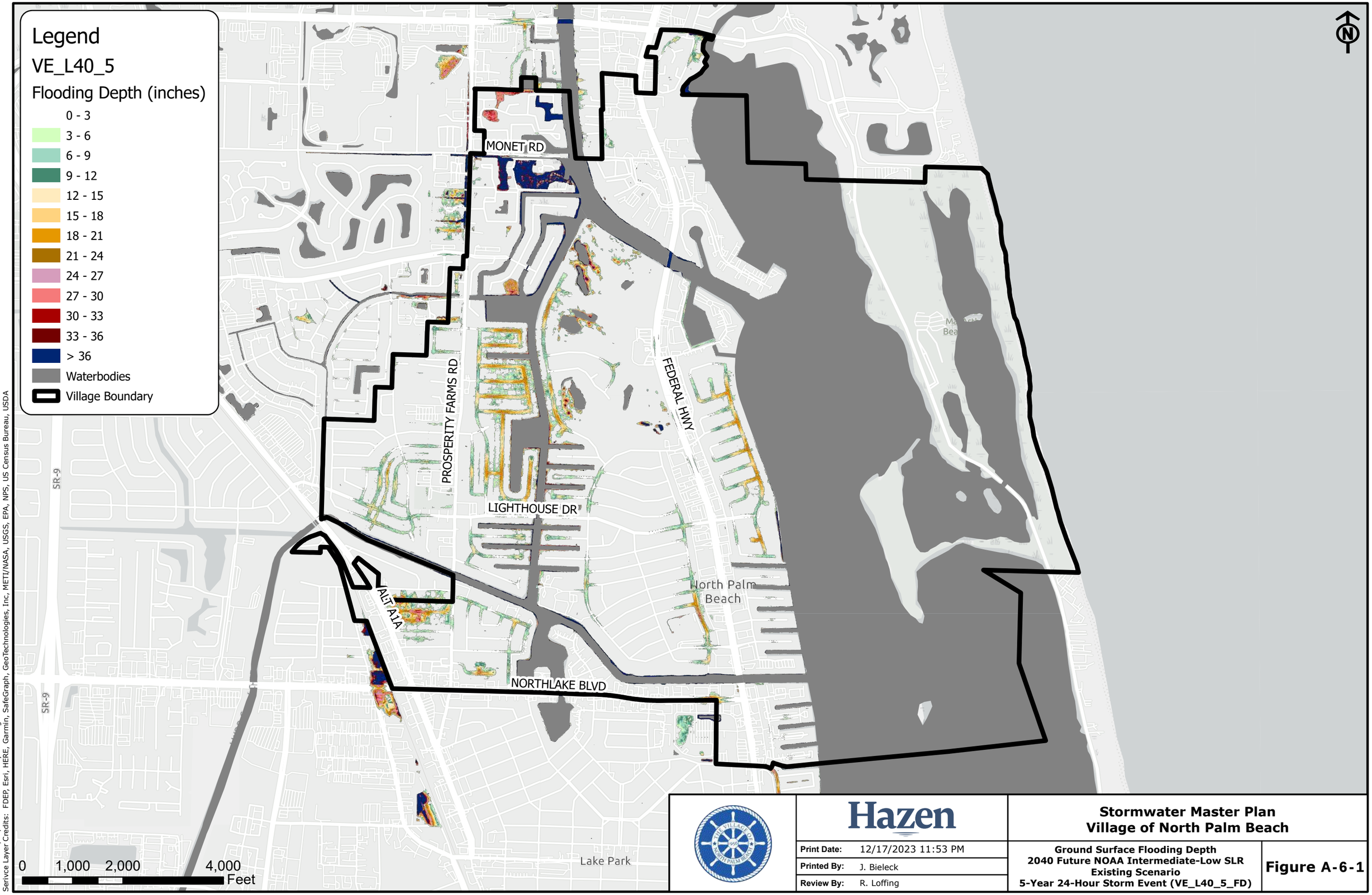
Appendix A-6: Existing Scenario with 2040 Intermediate-Low Sea Level Flooding Depths



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Print Date:	12/17/2023 11:53 PM
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Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-Low SLR
Existing Scenario
5-Year 24-Hour Storm Event (VE_L40_5_FD)

Figure A-6-1

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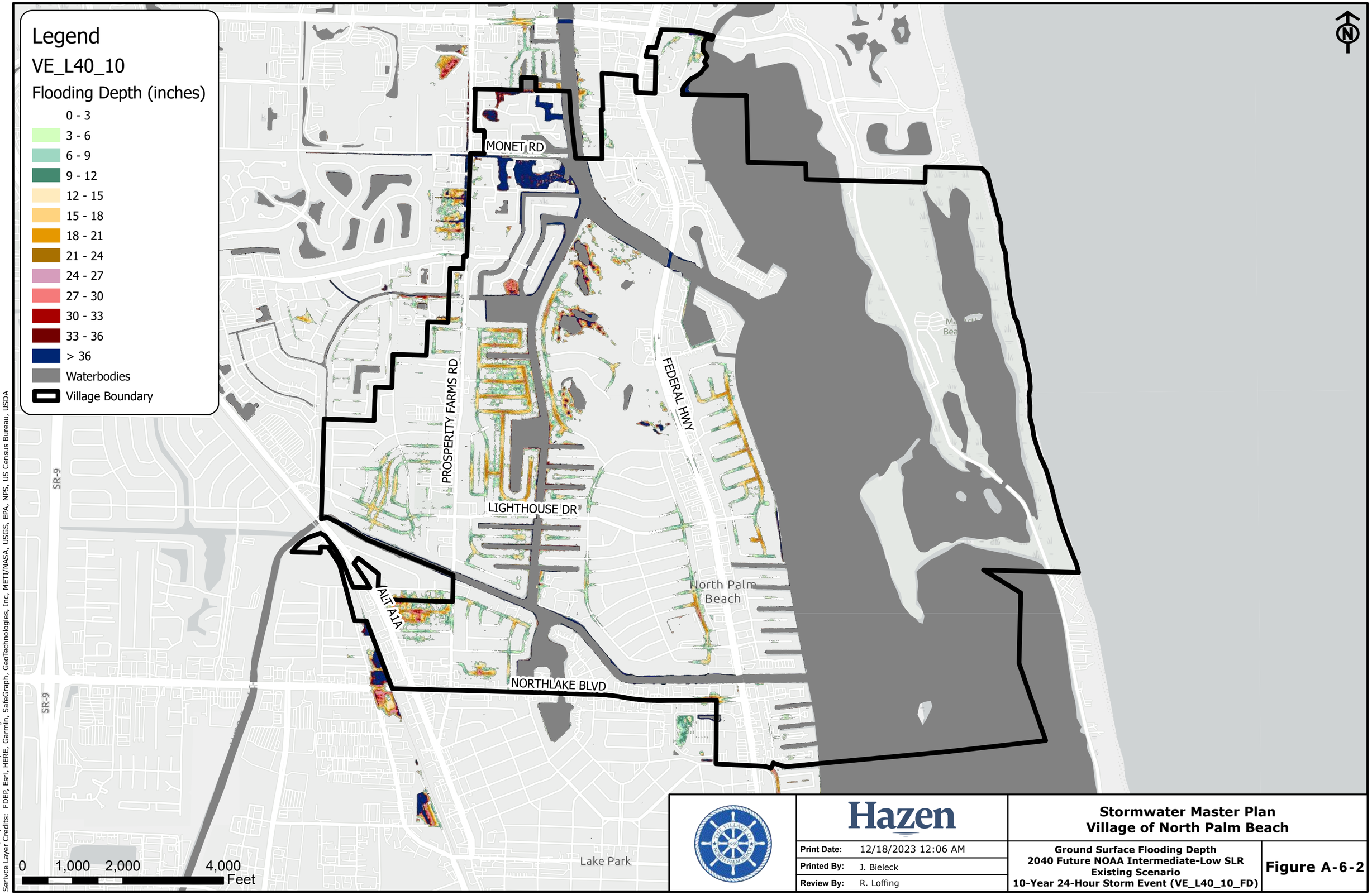

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Print Date:	12/18/2023 12:06 AM
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Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-Low SLR
Existing Scenario
10-Year 24-Hour Storm Event (VE_L40_10_FD)

Figure A-6-2

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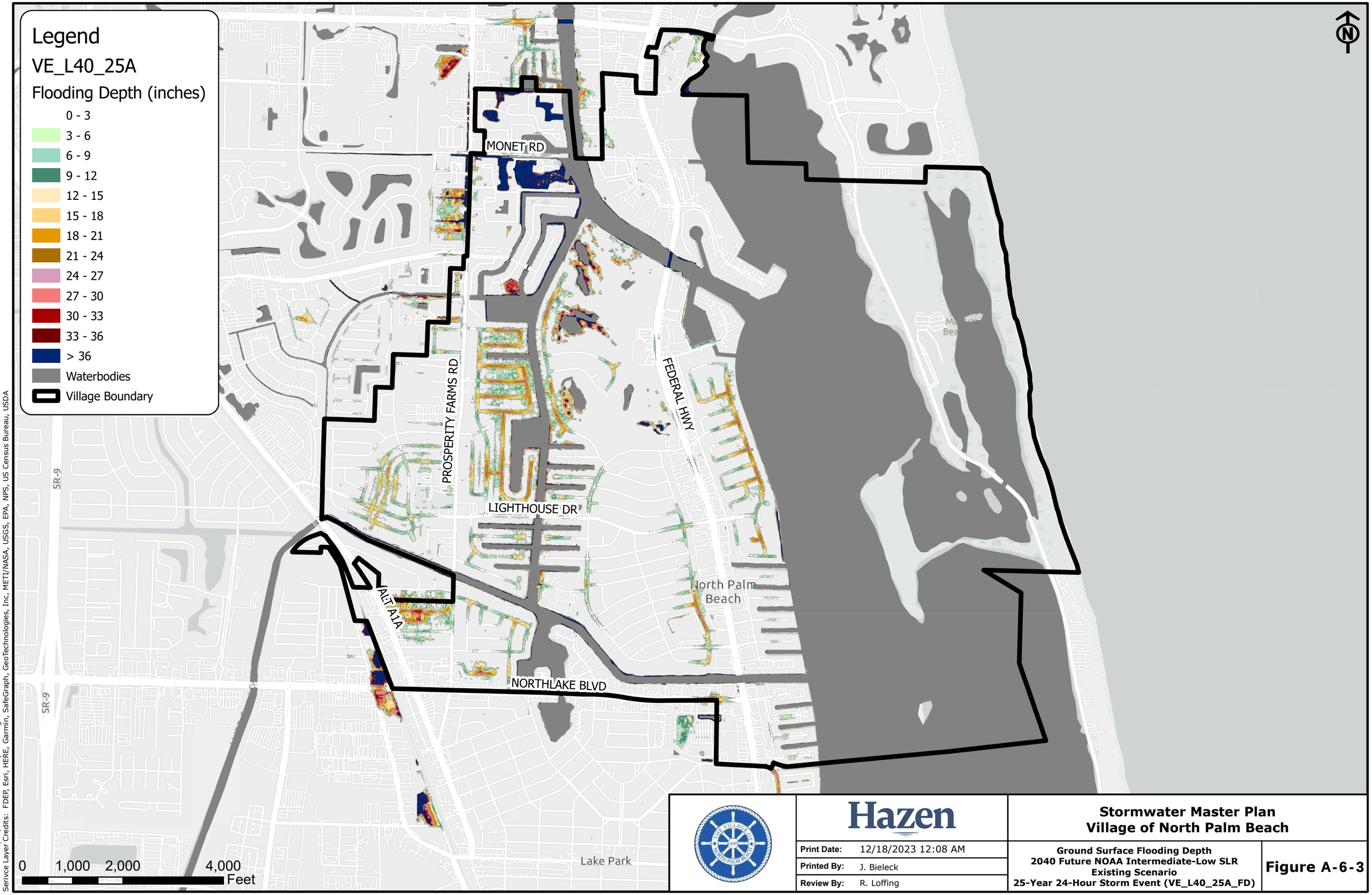

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Hazen

Print Date:	12/18/2023 12:08 AM
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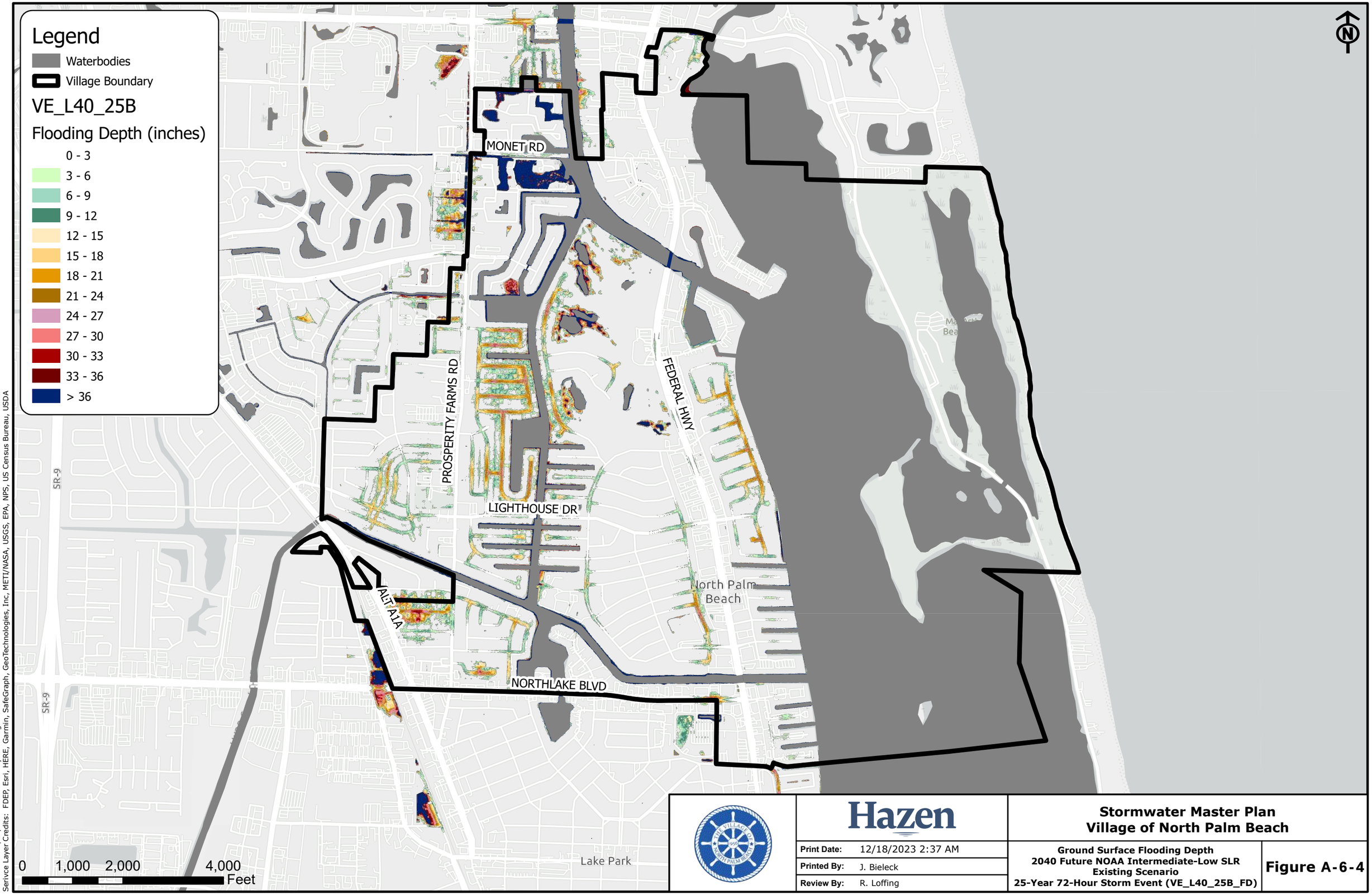
Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-Low SLR
Existing Scenario
25-Year 24-Hour Storm Event (VE_L40_25A_FD)

Figure A-6-3



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Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-Low SLR
Existing Scenario
25-Year 72-Hour Storm Event (VE_L40_25B_FD)

Figure A-6-4

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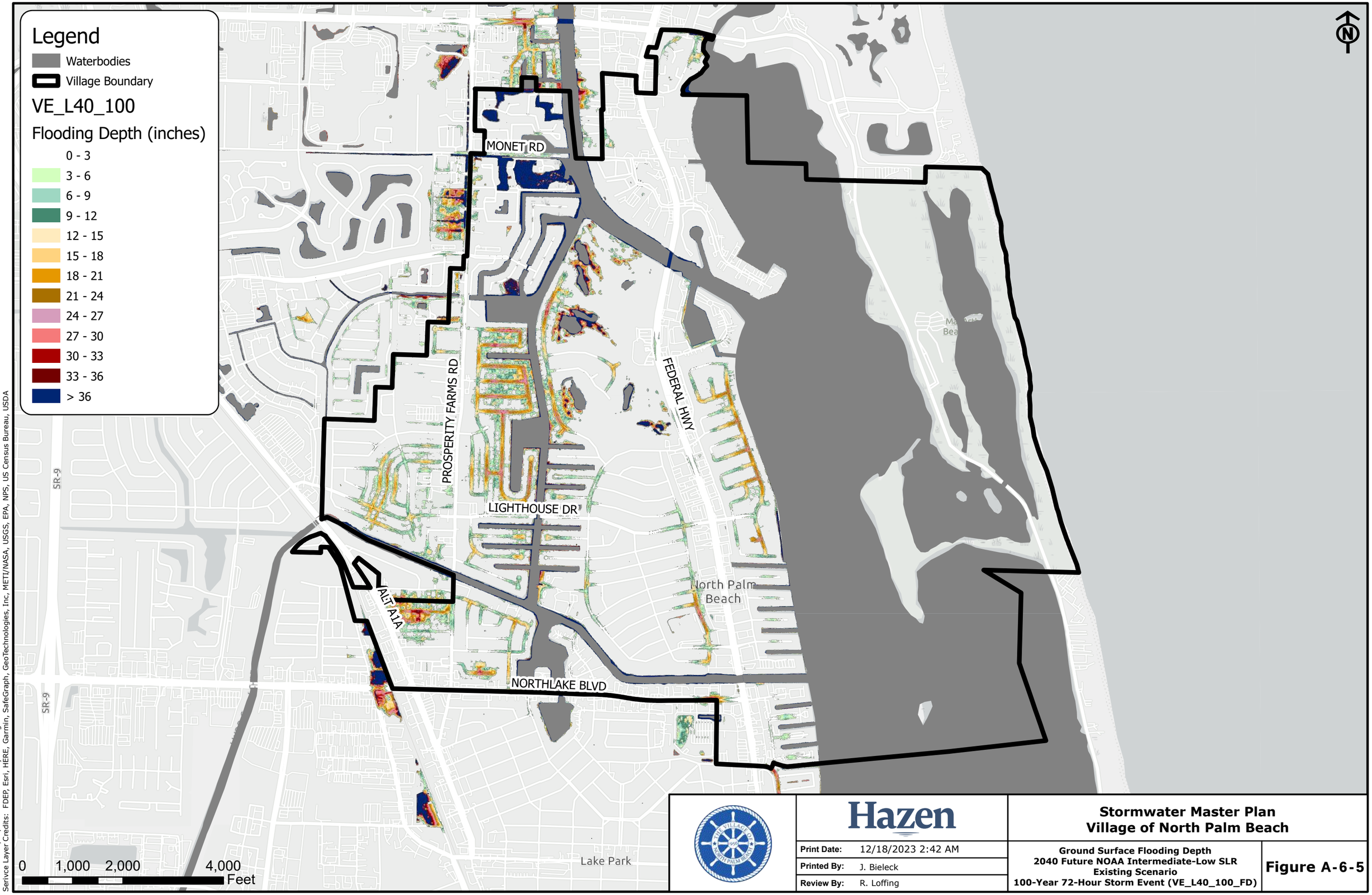

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Service Layer Credits: FDEP, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA

Hazen

Print Date:	12/18/2023 2:42 AM
Printed By:	J. Bieleck
Review By:	R. Loffing

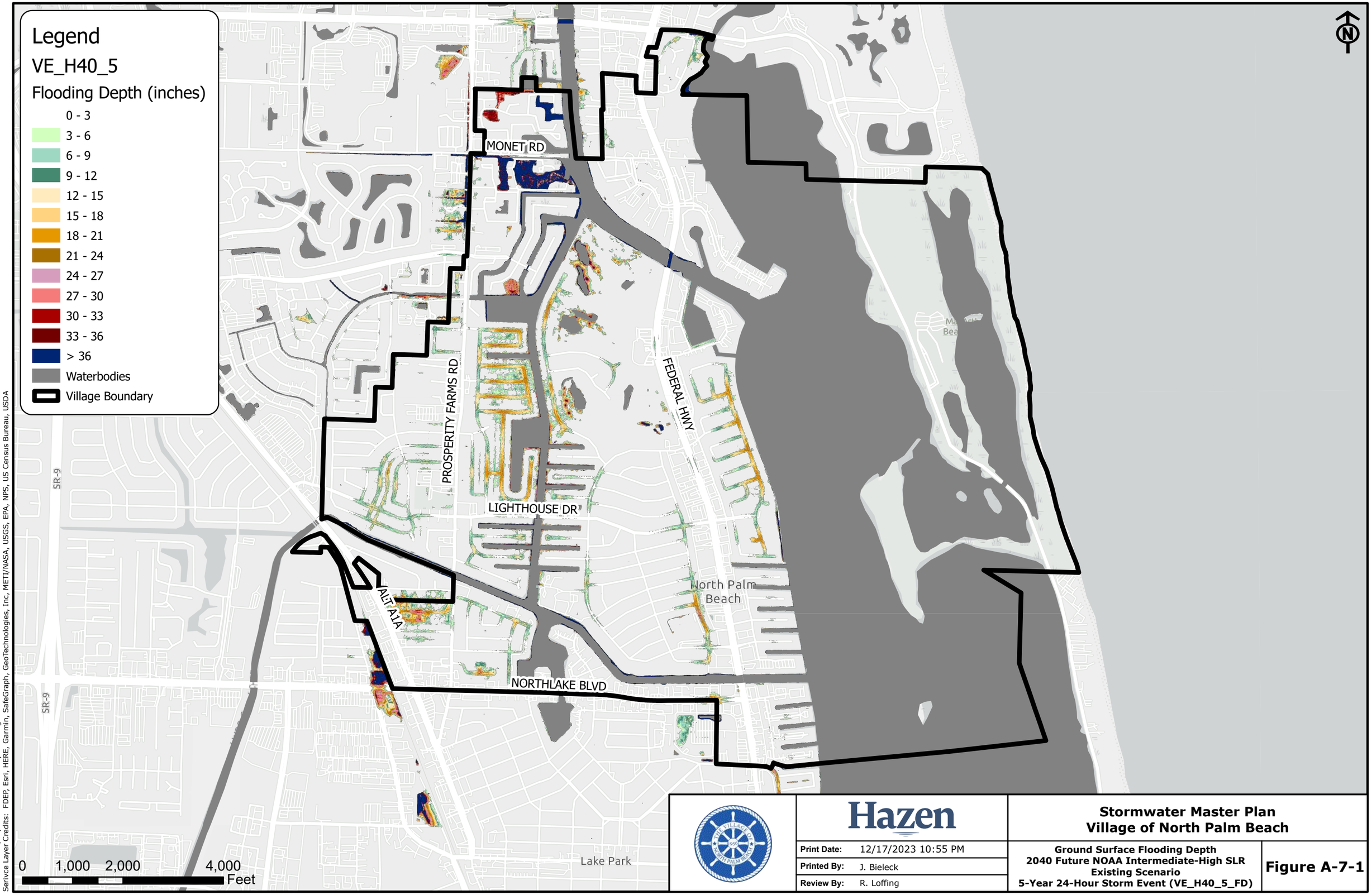
Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-Low SLR
Existing Scenario
100-Year 72-Hour Storm Event (VE_L40_100_FD)

Figure A-6-5

File = O:\GIS\Projects\45107-003\ArcGISPro\VNPB_SWMP\VNPB_SWMP_Results_RKL.aprx Saved by rloffing Save date = 12/18/2023 2:11 AM

Appendix A-7: Existing Scenario with 2040 Intermediate-High Sea Level Flooding Depths



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Print Date:	12/17/2023 10:55 PM
Printed By:	J. Bieleck
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-High SLR
Existing Scenario
5-Year 24-Hour Storm Event (VE_H40_5_FD)

Figure A-7-1

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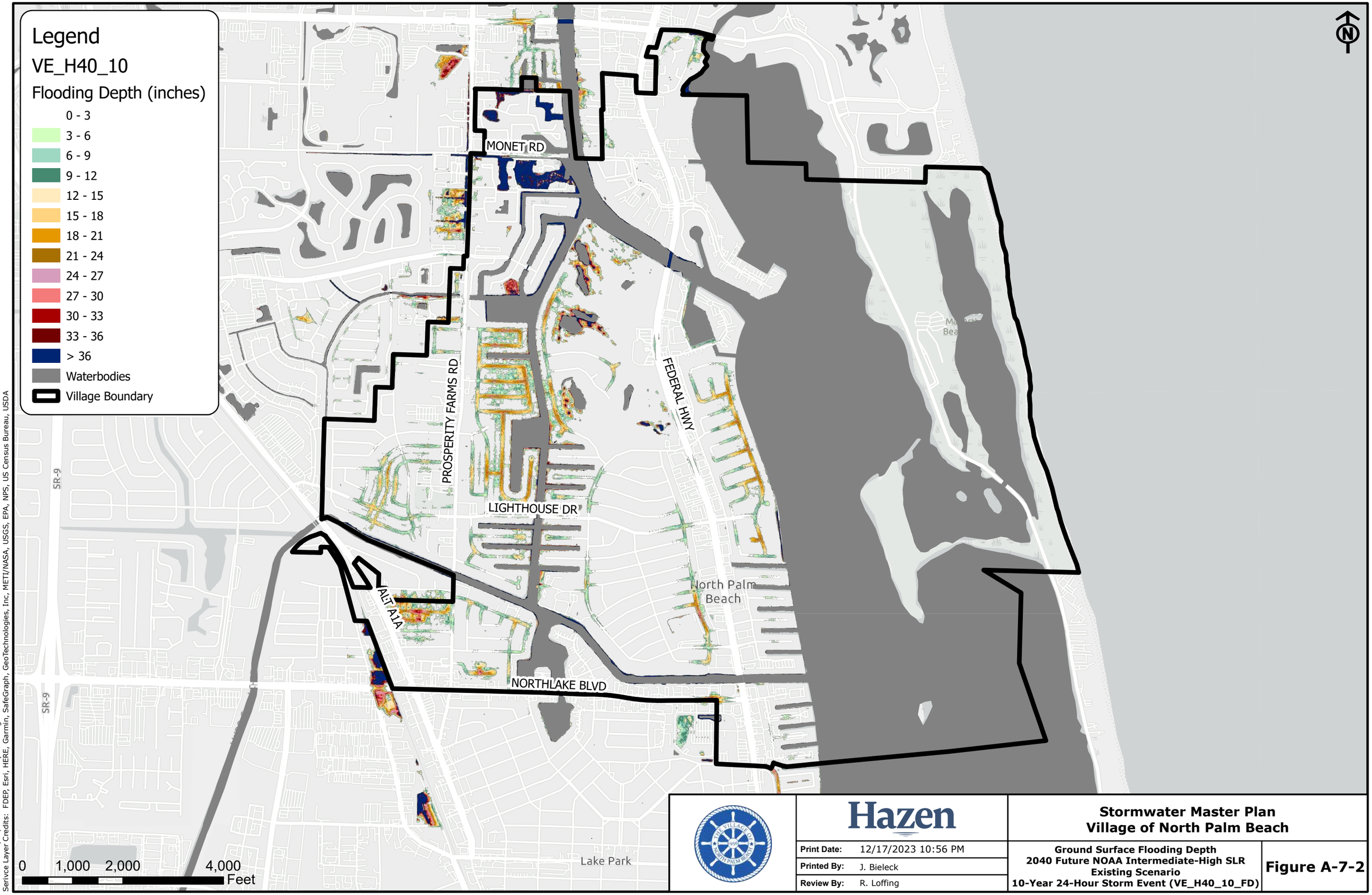

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Hazen

Print Date:	12/17/2023 10:56 PM
Printed By:	J. Bieleck
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-High SLR
Existing Scenario
10-Year 24-Hour Storm Event (VE_H40_10_FD)

Figure A-7-2

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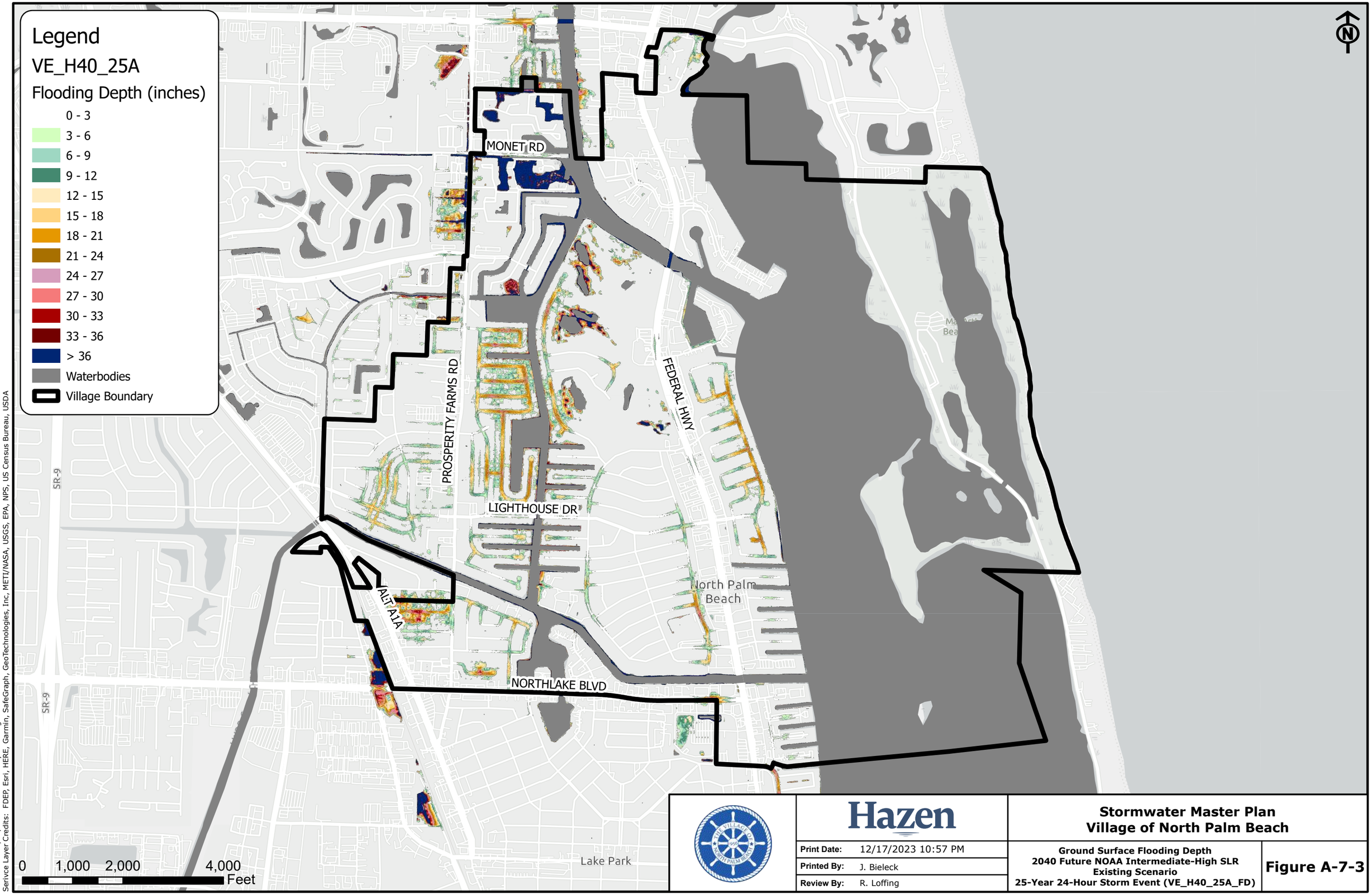

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Hazen

Print Date:	12/17/2023 10:57 PM
Printed By:	J. Bieleck
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Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-High SLR
Existing Scenario
25-Year 24-Hour Storm Event (VE_H40_25A_FD)

Figure A-7-3

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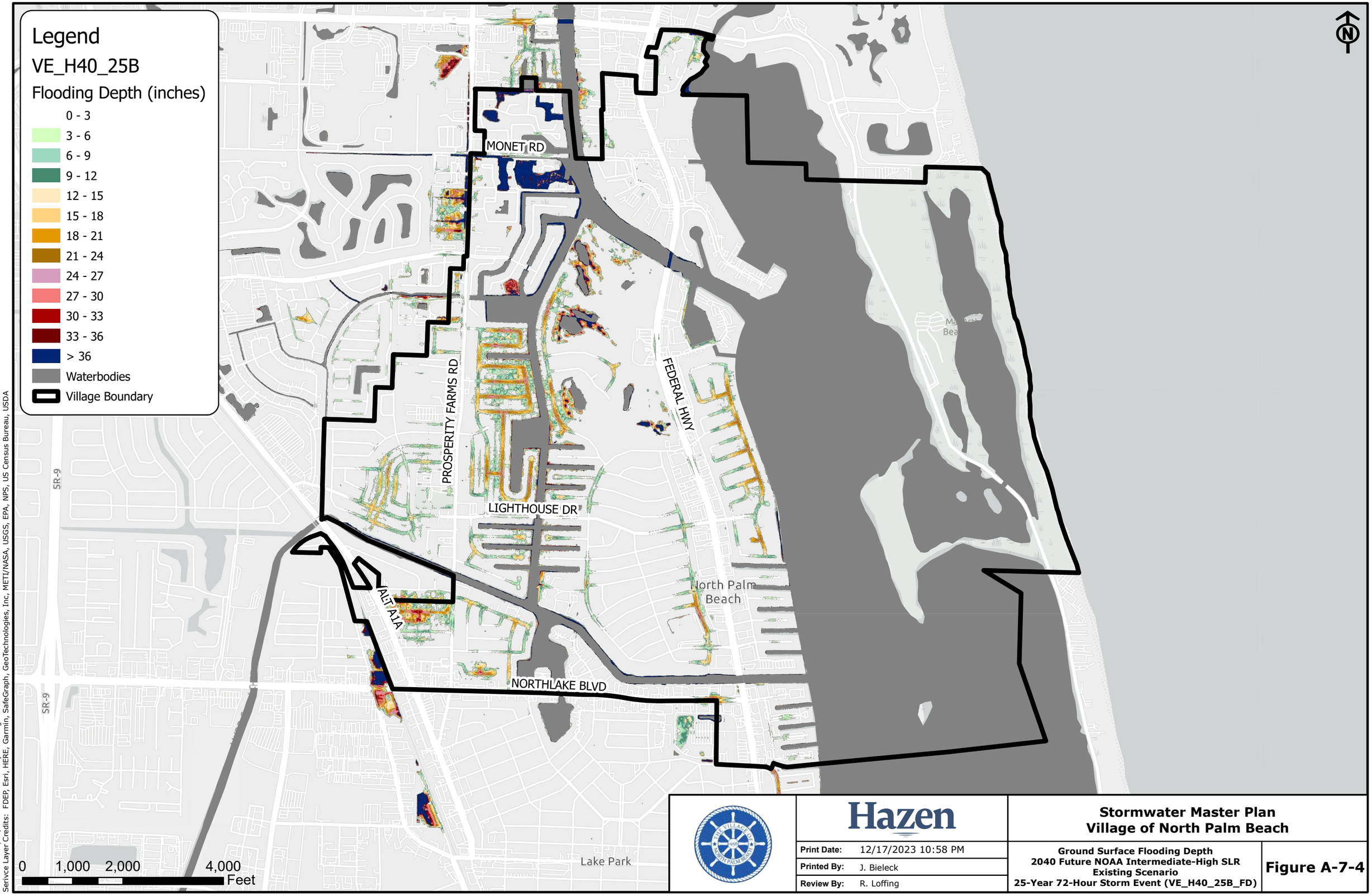

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Hazen

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Printed By:	J. Bieleck
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-High SLR
Existing Scenario
25-Year 72-Hour Storm Event (VE_H40_25B_FD)

Figure A-7-4

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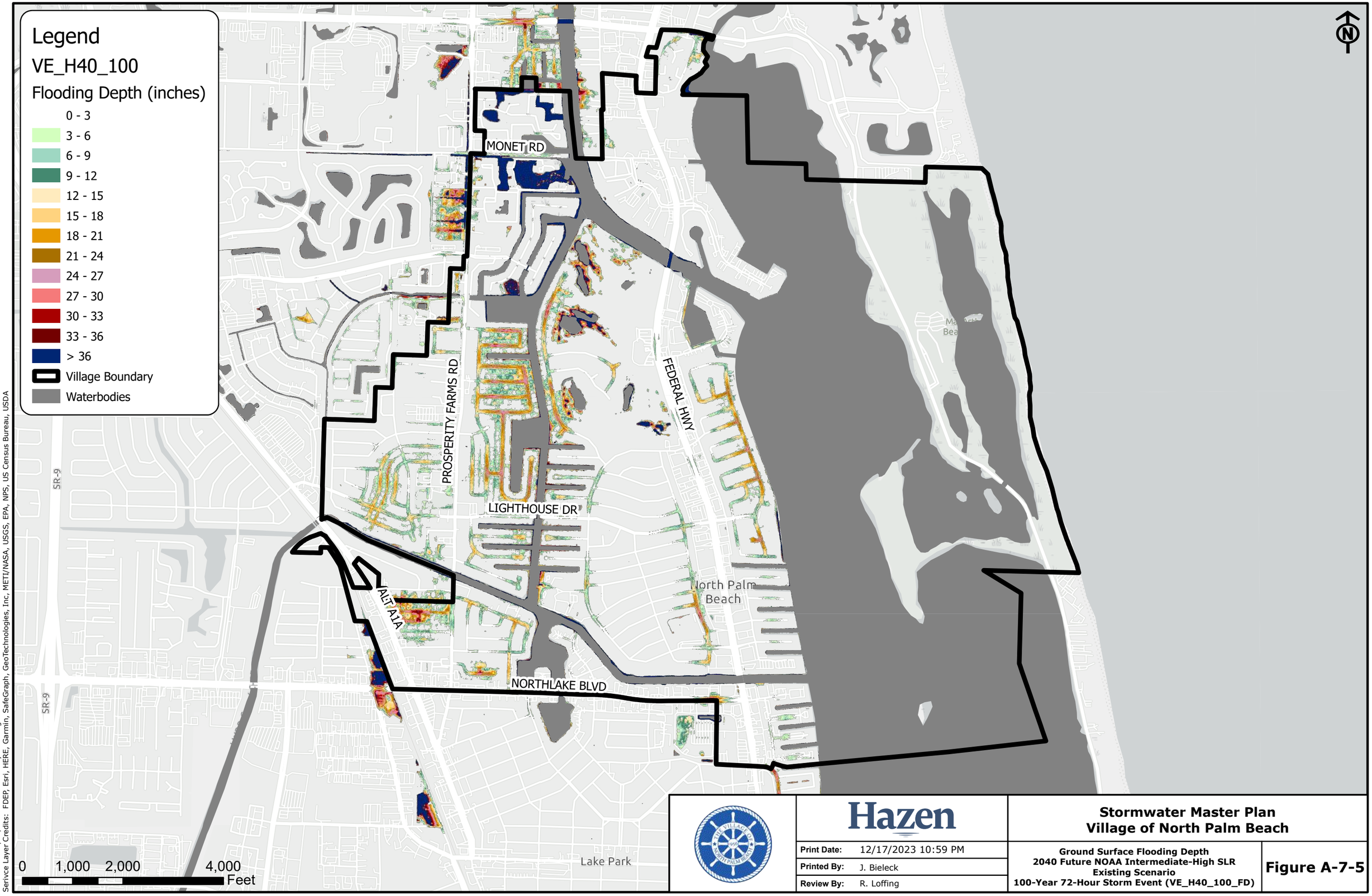

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Hazen

Print Date:	12/17/2023 10:59 PM
Printed By:	J. Bieleck
Review By:	R. Loffing

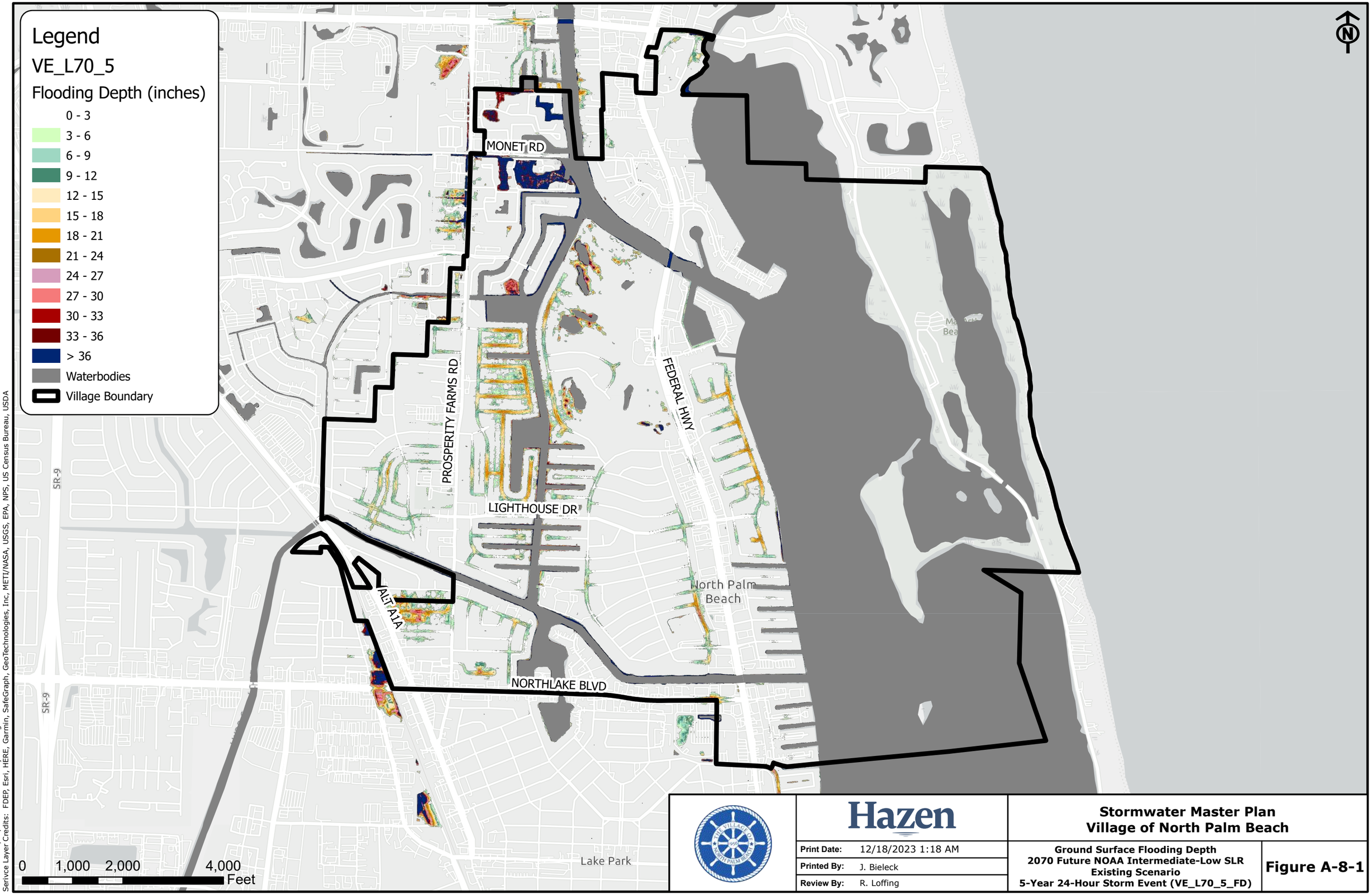
Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-High SLR
Existing Scenario
100-Year 72-Hour Storm Event (VE_H40_100_FD)

Figure A-7-5

File = O:\GIS\Projects\45107-003\ArcGISPro\VNPB_SWMP\VNPB_SWMP_Results_RKL.aprx Saved by rloffing Save date = 12/17/2023 9:50 PM

Appendix A-8: Existing Scenario with 2070 Intermediate-Low Sea Level Flooding Depths



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Hazen

Stormwater Master Plan
Village of North Palm Beach

Print Date:	12/18/2023 1:18 AM
Printed By:	J. Bieleck
Review By:	R. Loffing

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-Low SLR
Existing Scenario
5-Year 24-Hour Storm Event (VE_L70_5_FD)

Figure A-8-1

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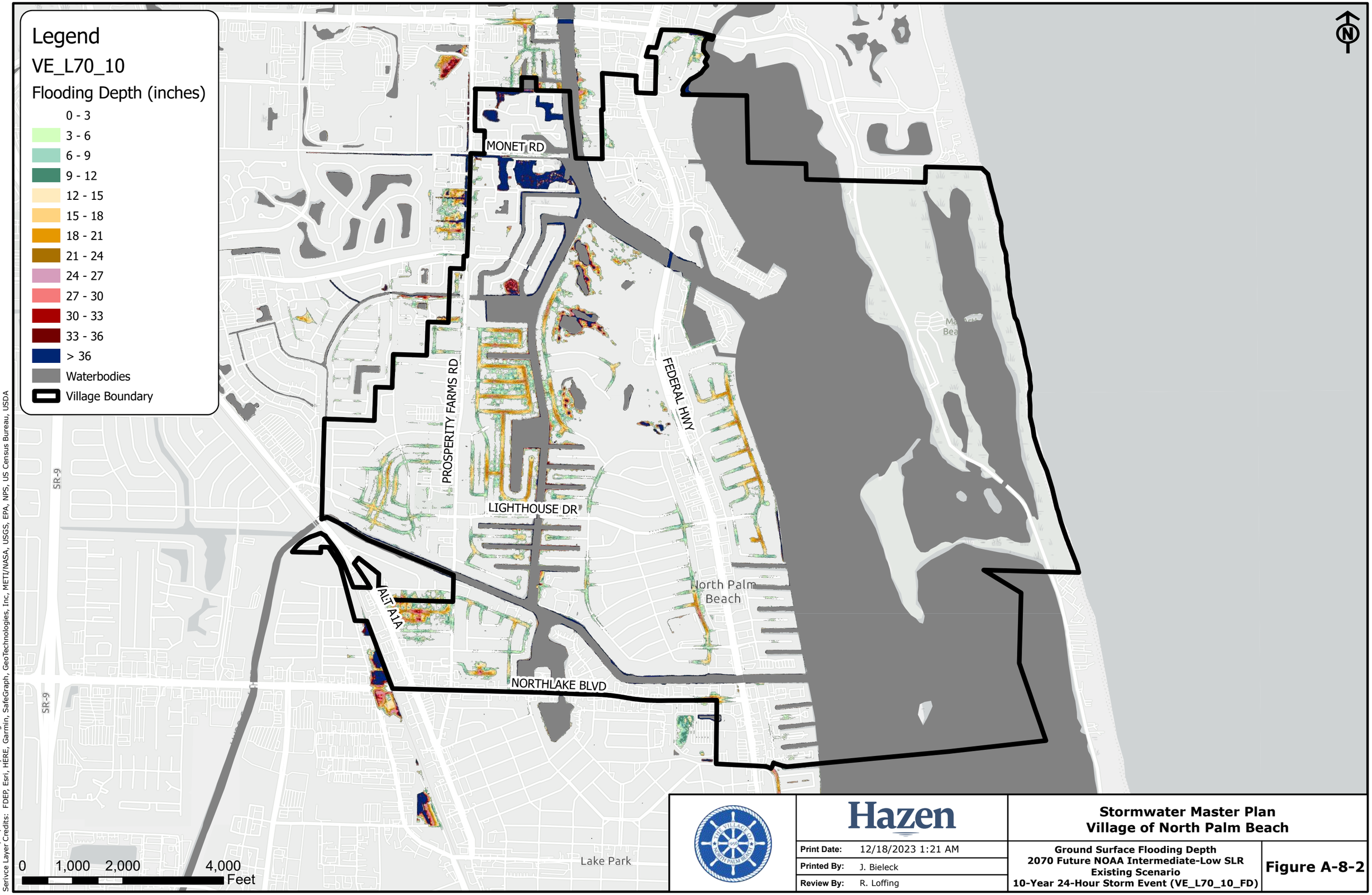

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Hazen

Stormwater Master Plan
Village of North Palm Beach

Print Date:	12/18/2023 1:21 AM
Printed By:	J. Bieleck
Review By:	R. Loffing

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-Low SLR
Existing Scenario
10-Year 24-Hour Storm Event (VE_L70_10_FD)

Figure A-8-2

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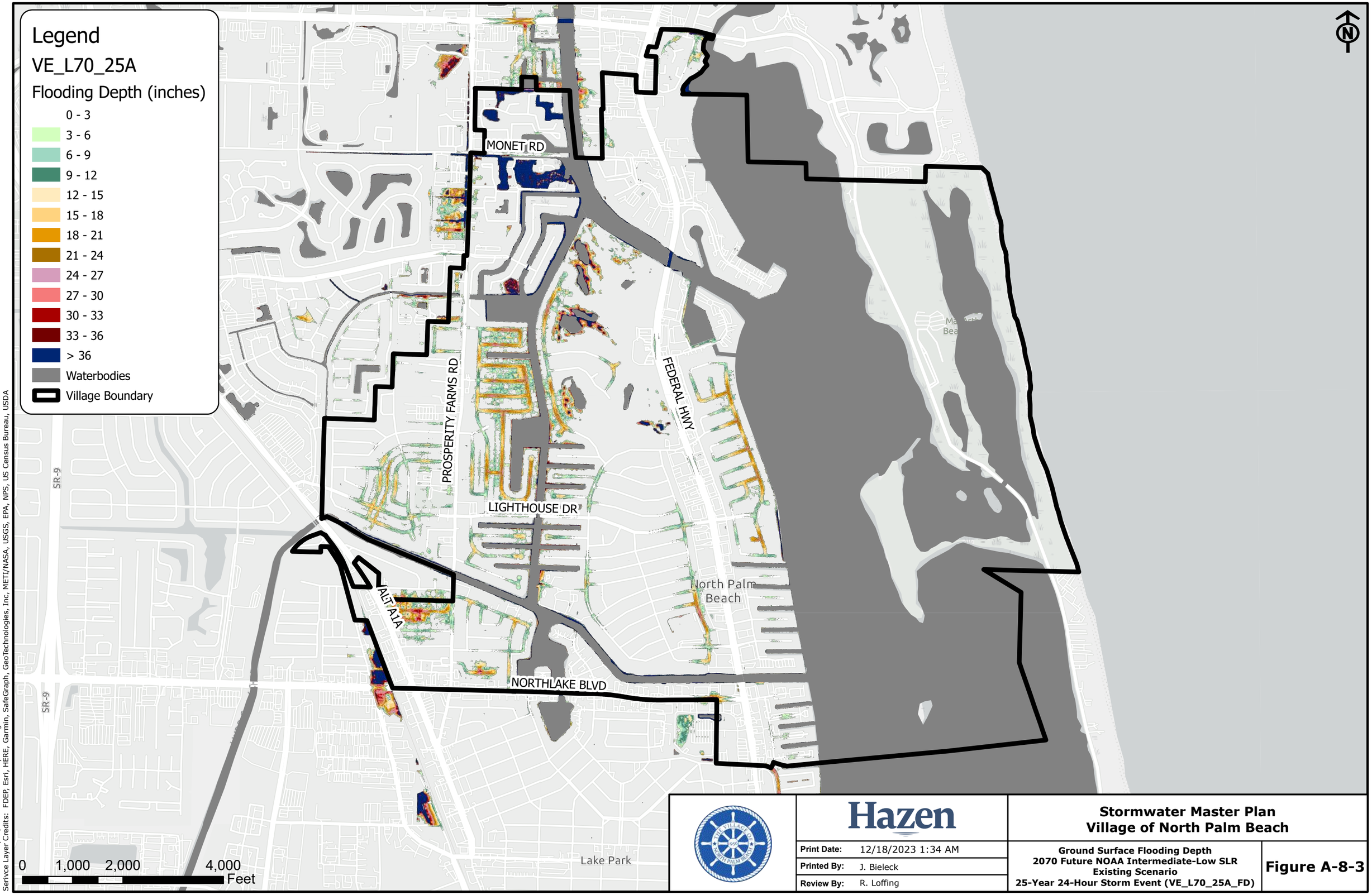

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Hazen

Stormwater Master Plan
Village of North Palm Beach

Print Date:	12/18/2023 1:34 AM
Printed By:	J. Bieleck
Review By:	R. Loffing

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-Low SLR
Existing Scenario
25-Year 24-Hour Storm Event (VE_L70_25A_FD)

Figure A-8-3

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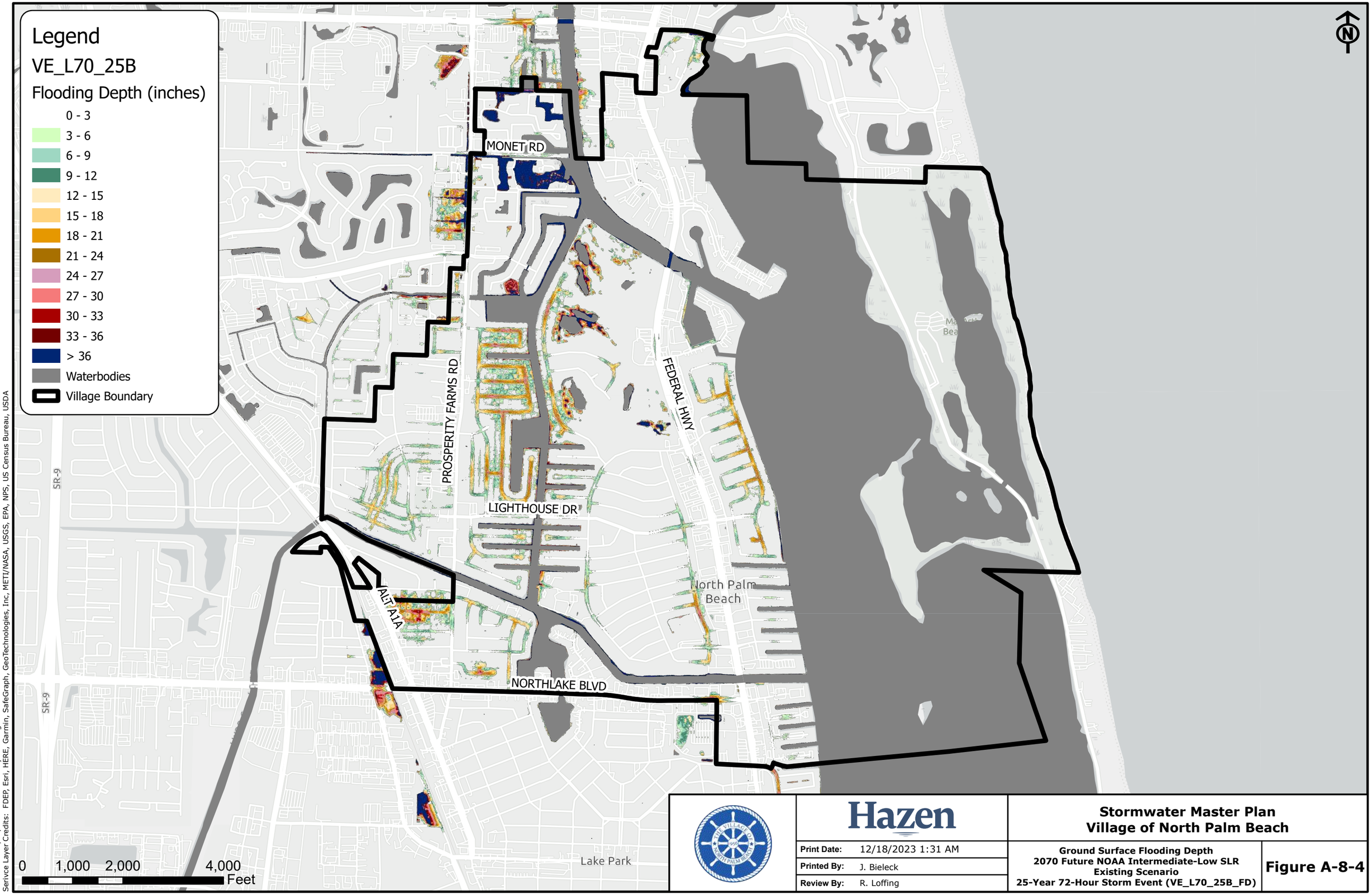

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Hazen

Stormwater Master Plan
Village of North Palm Beach

Print Date:	12/18/2023 1:31 AM
Printed By:	J. Bieleck
Review By:	R. Loffing

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-Low SLR
Existing Scenario
25-Year 72-Hour Storm Event (VE_L70_25B_FD)

Figure A-8-4

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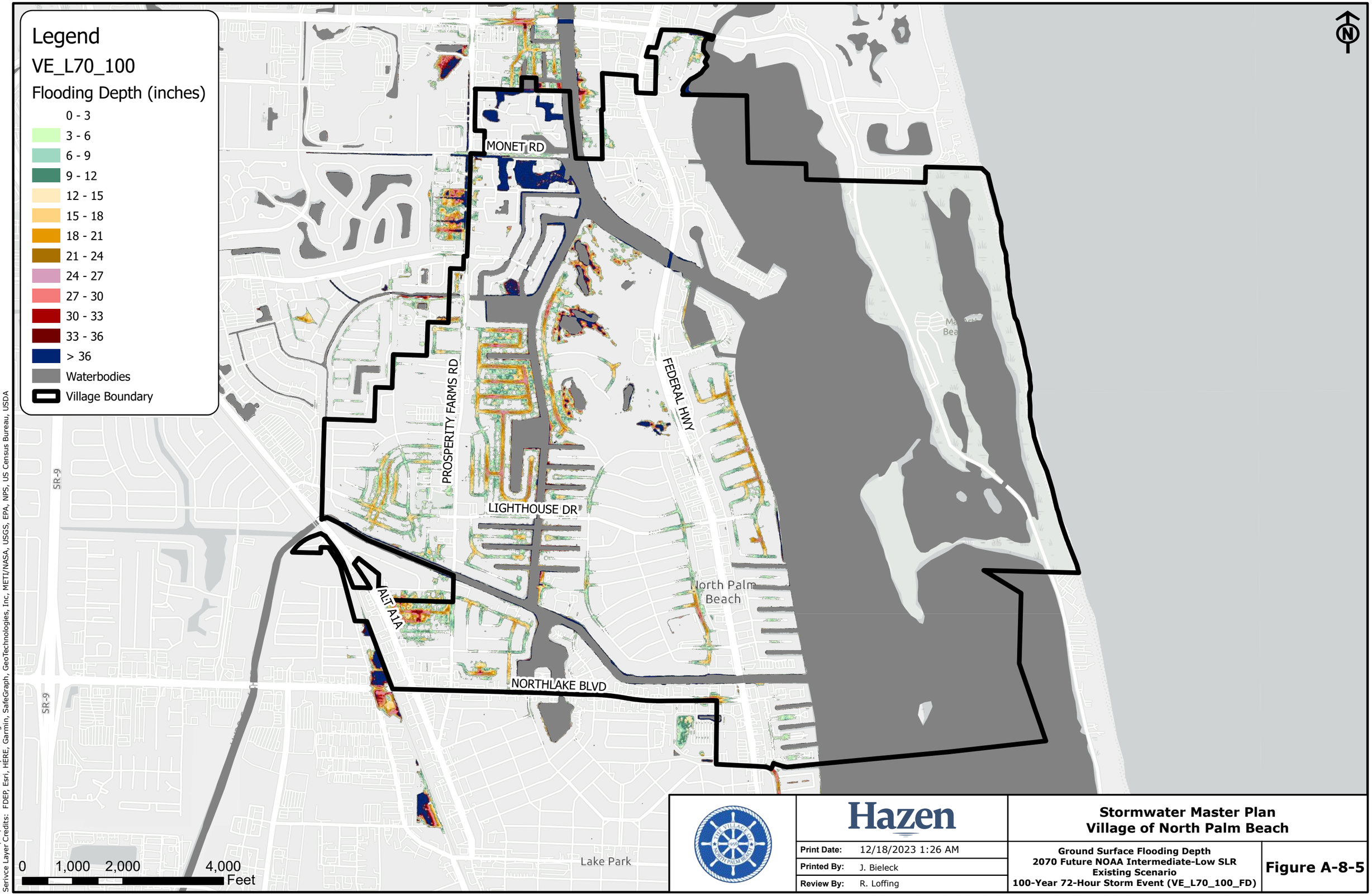

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Hazen

Print Date:	12/18/2023 1:26 AM
Printed By:	J. Bieleck
Review By:	R. Loffing

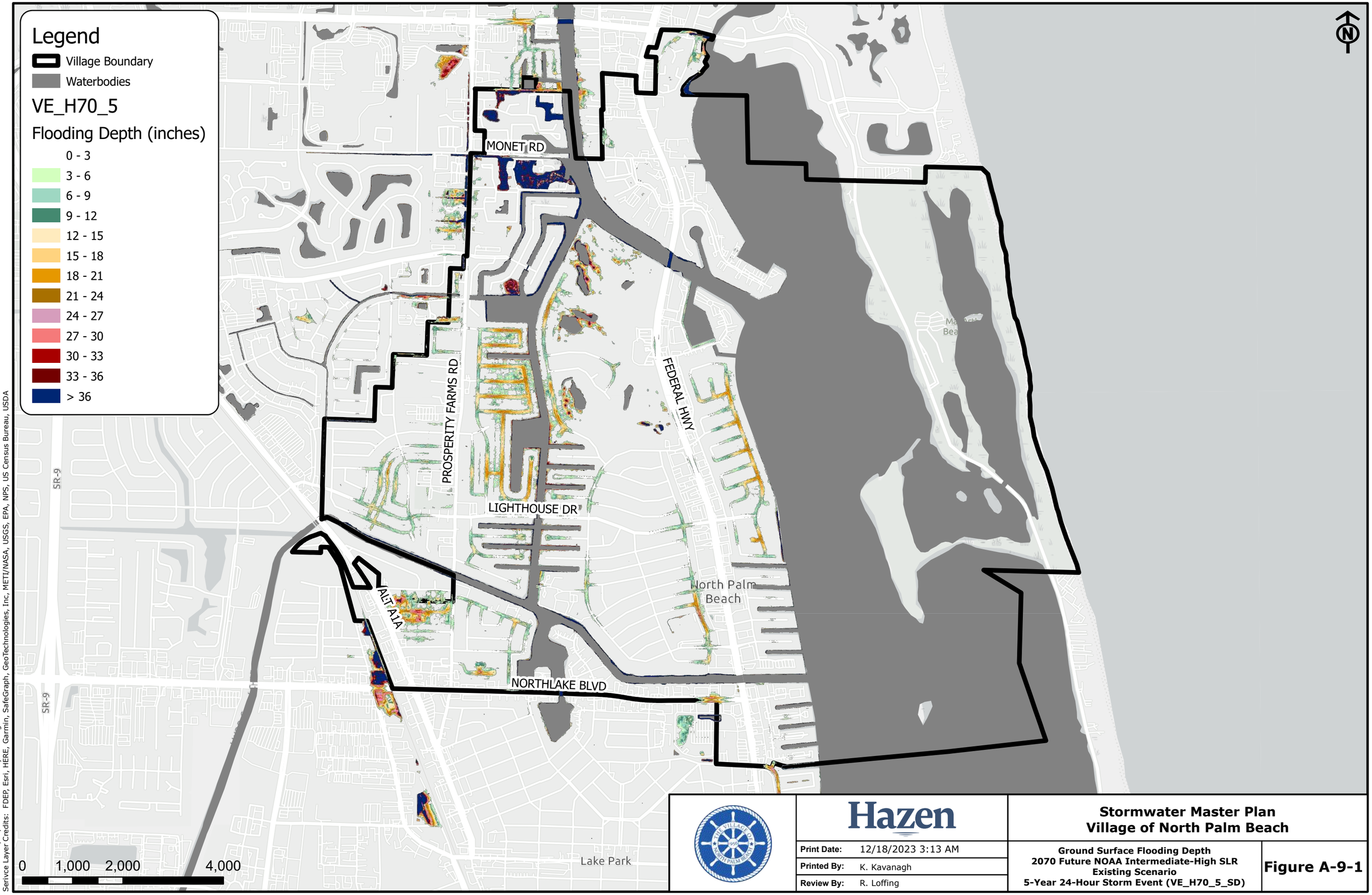
Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-Low SLR
Existing Scenario
100-Year 72-Hour Storm Event (VE_L70_100_FD)

Figure A-8-5

File = O:\GIS\Projects\45107-003\ArcGISPro\VNPB_SWMP\VNPB_SWMP_Results_RKL.aprx Saved by rloffing Save date = 12/18/2023 1:13 AM

Appendix A-9: Existing Scenario with 2070 Intermediate-High Sea Level Flooding Depths



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Hazen

Print Date:	12/18/2023 3:13 AM
Printed By:	K. Kavanagh
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-High SLR
Existing Scenario
5-Year 24-Hour Storm Event (VE_H70_5_SD)

Figure A-9-1

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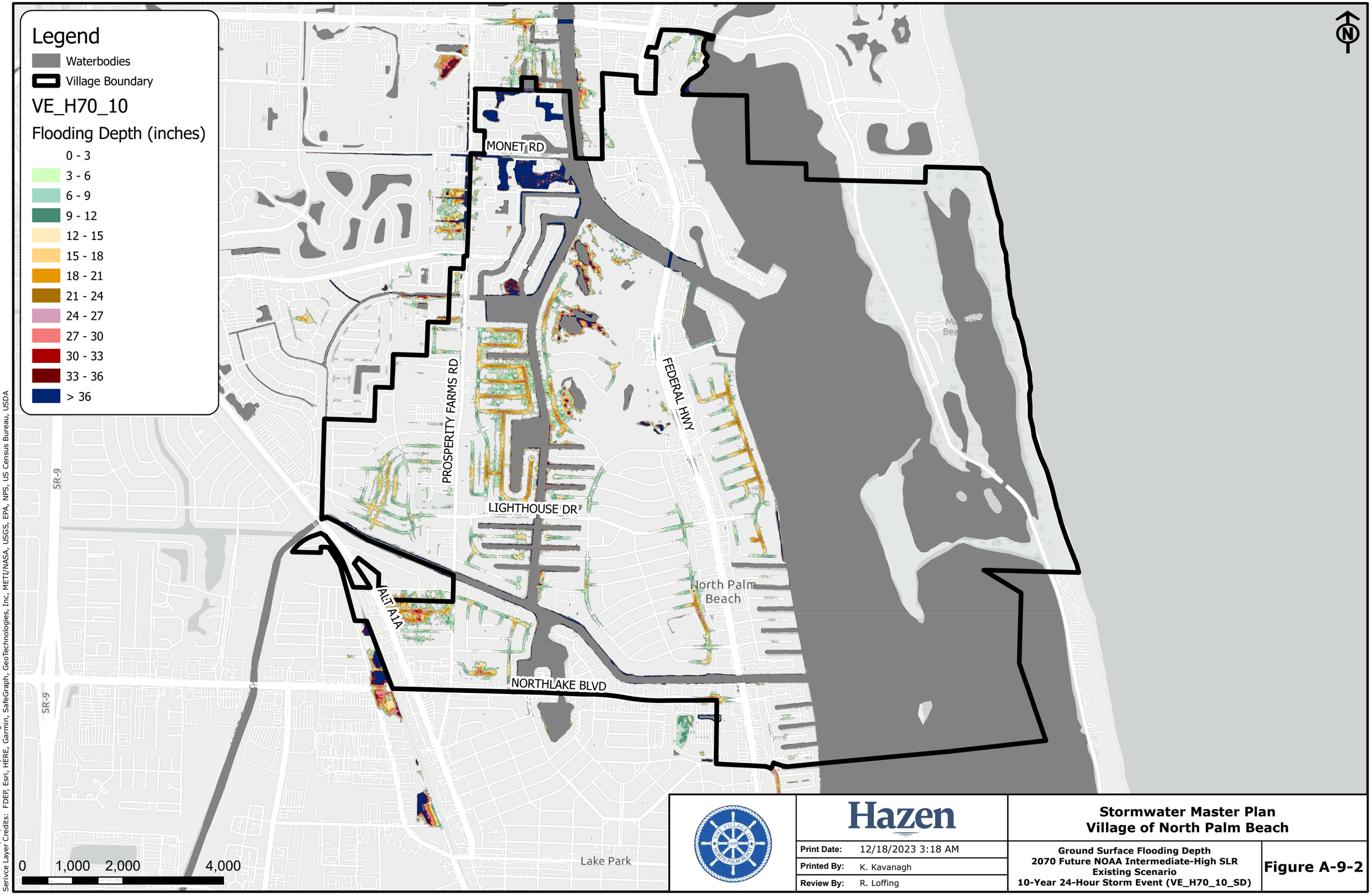

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Hazen

Print Date:	12/18/2023 3:18 AM
Printed By:	K. Kavanagh
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-High SLR
Existing Scenario
10-Year 24-Hour Storm Event (VE_H70_10_SD)

Figure A-9-2

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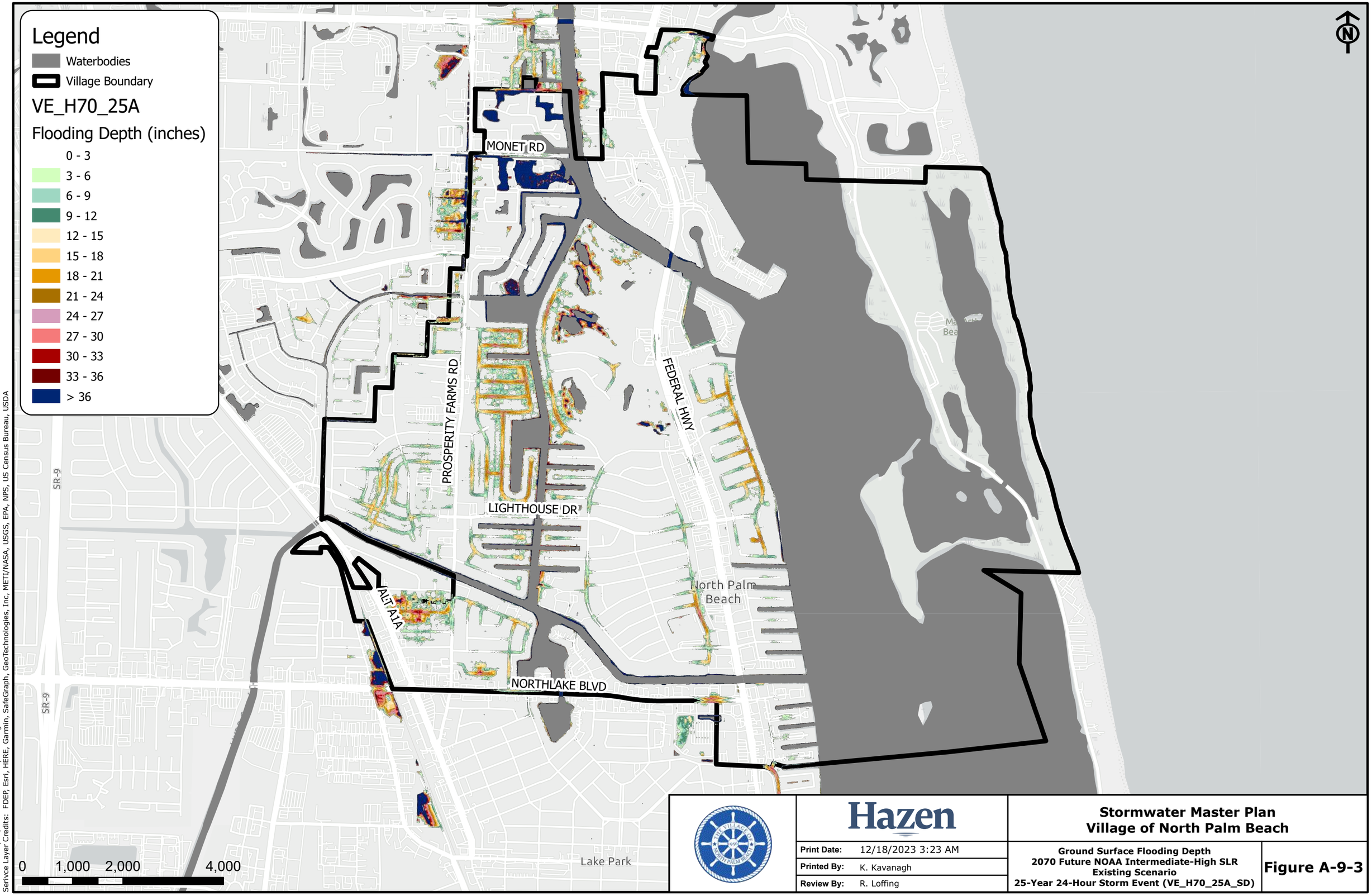

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Hazen

Print Date:	12/18/2023 3:23 AM
Printed By:	K. Kavanagh
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-High SLR
Existing Scenario
25-Year 24-Hour Storm Event (VE_H70_25A_SD)

Figure A-9-3

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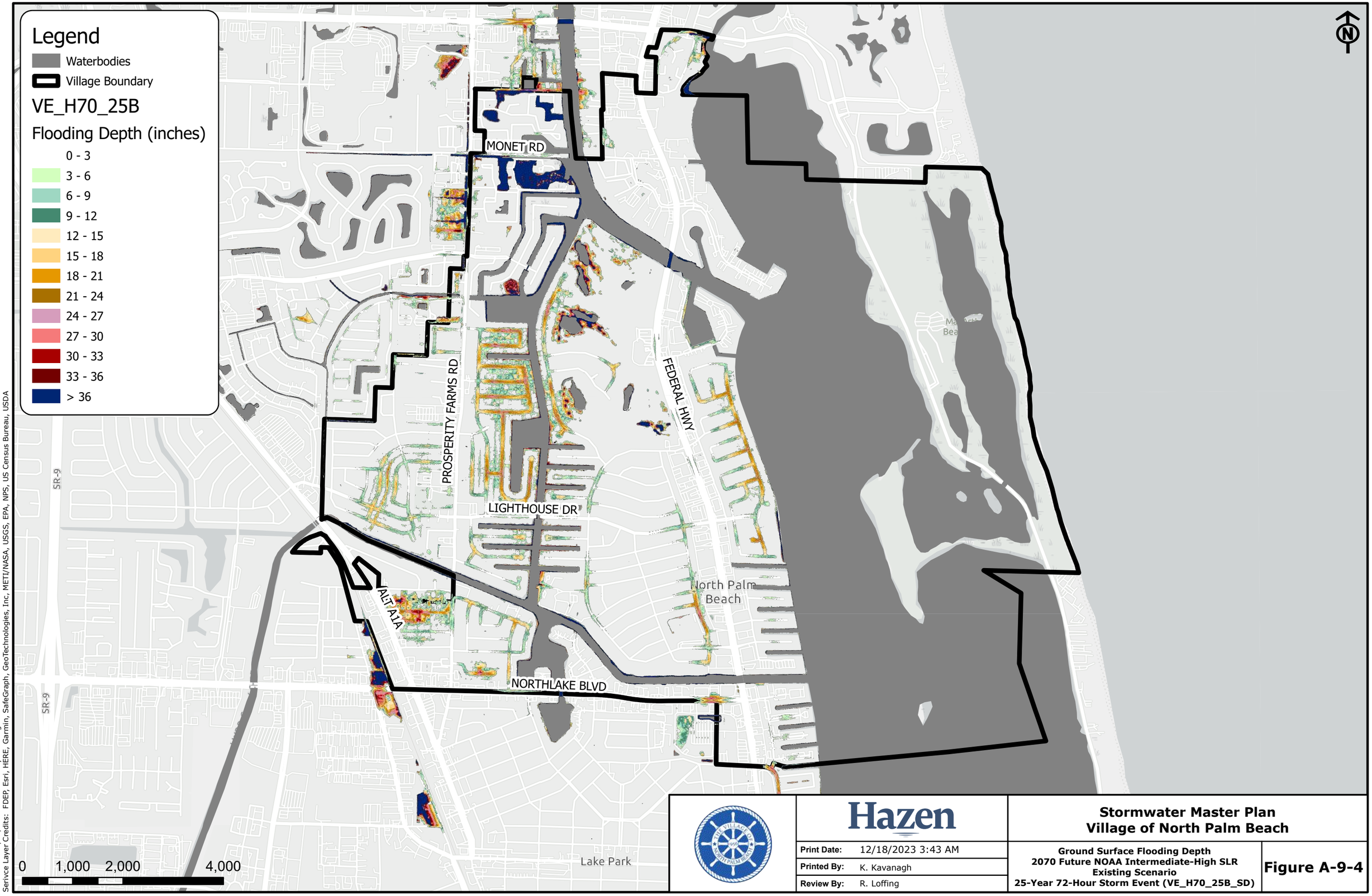

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Hazen

Print Date:	12/18/2023 3:43 AM
Printed By:	K. Kavanagh
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-High SLR
Existing Scenario
25-Year 72-Hour Storm Event (VE_H70_25B_SD)

Figure A-9-4

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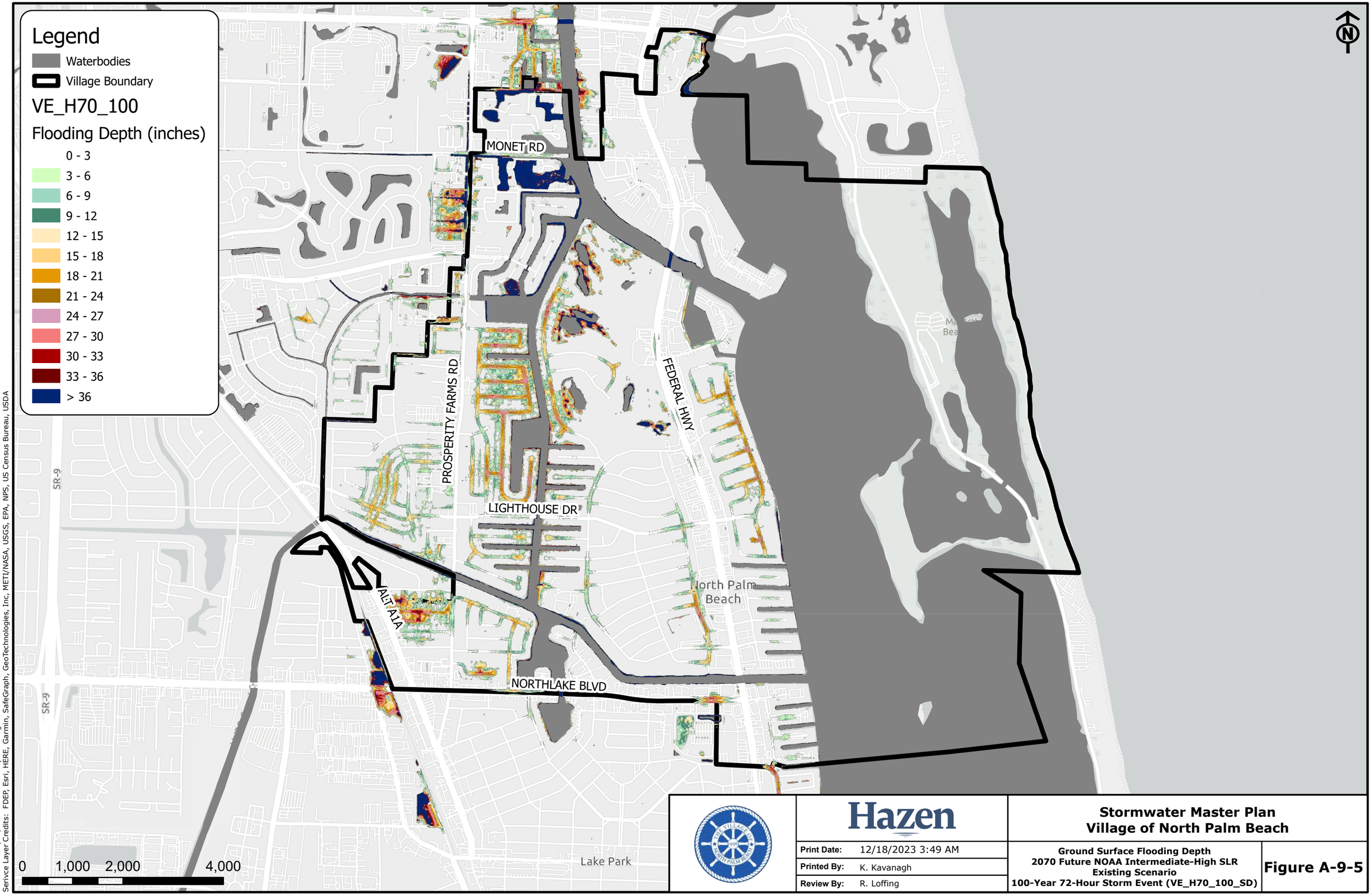

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Hazen

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Printed By:	K. Kavanagh
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-High SLR
Existing Scenario
100-Year 72-Hour Storm Event (VE_H70_100_SD)

Figure A-9-5

File = O:\GIS\Projects\45107-003\ArcGISPro\VNPB_SWMP\VNPB_SWMP_Results_RKL.aprx Saved by rloffing Save date = 12/18/2023 3:07 AM

Appendix A-10: FEMA FIRM Panels for the Village (Effective Date 10/05/2017)

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded tenth-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations (BFEs) shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Transverse Mercator State Plane Florida East FIPS Zone 0901 Feet. The **horizontal datum** was NAD83 HARN, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242** or visit its website at http://www.ngs.noaa.gov/.

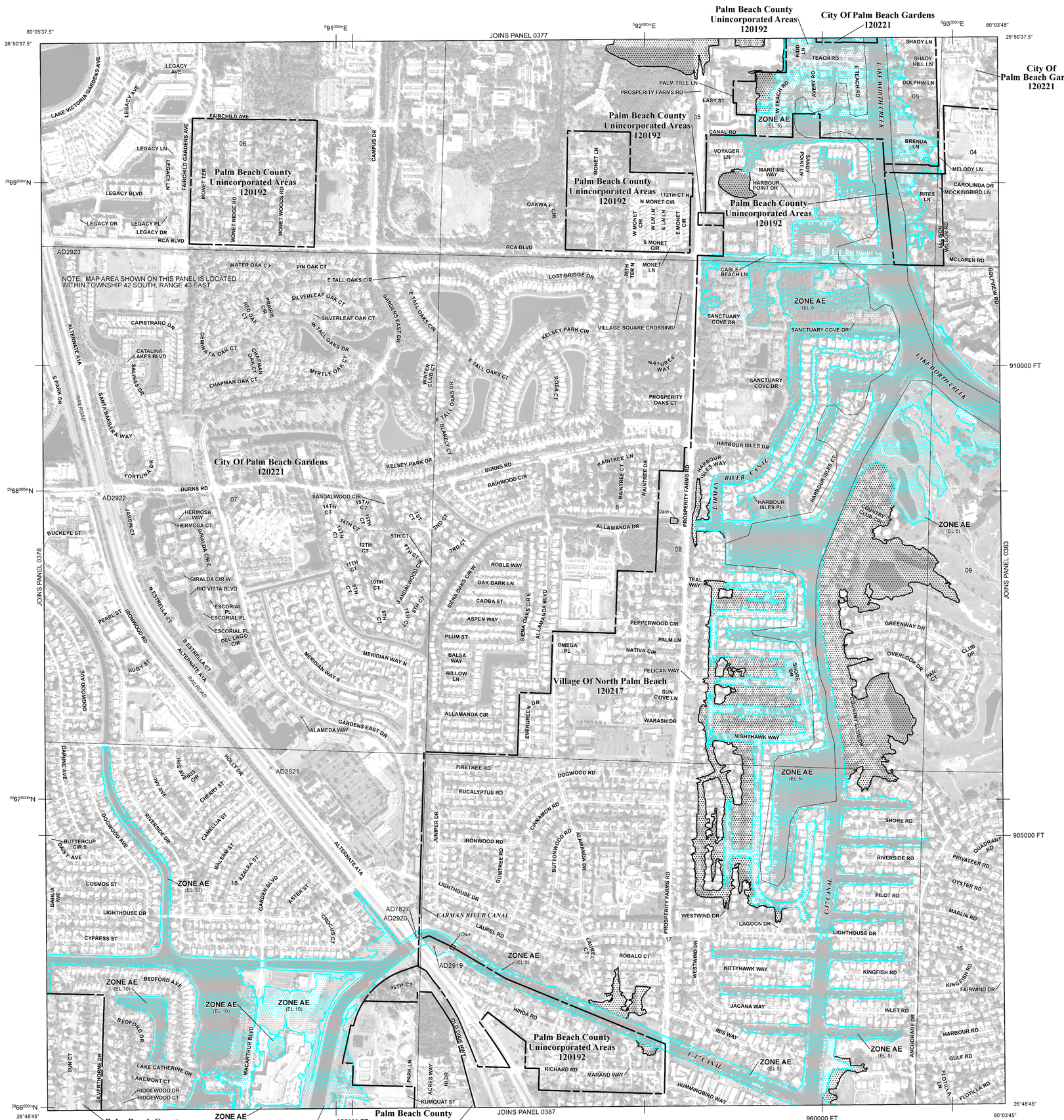
Base map information shown on this FIRM was provided in digital format by Palm Beach County. The original orthophotographic base imagery was provided in color with a one-foot pixel resolution at a scale of 1" = 200' from photography flown November 2010 - January 2011.

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information and questions about this map, available products associated with this FIRM including historic versions of this FIRM, how to order products or the National Flood Insurance Program in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Map Service Center website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website. Users may determine the current map date for each FIRM panel by visiting the FEMA Map Service Center website or by calling the FEMA Map Information eXchange.



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Areas to be protected from 1% annual chance flood event by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988

- A — A — Cross section line
- 23 — 23 — Transect line
- 97°07'30", 32°22'30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
- 4275000mE — 1000-meter Universal Transverse Mercator grid ticks, zone 17
- 6000000 FT — 5000-foot grid values: Florida State Plane coordinate system, East Zone (FIPSZONE = 901), Transverse Mercator projection
- DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 — River Mile

MAP REPOSITORIES
Refer to Map Repositories List on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
OCTOBER 5, 2017

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 250 500 750 1,000 FEET
150 0 150 300 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0379F

FIRM

FLOOD INSURANCE RATE MAP

PALM BEACH COUNTY, FLORIDA AND INCORPORATED AREAS

PANEL 379 OF 1200

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PALM BEACH COUNTY	120192	0379	F
NORTH PALM BEACH, VILLAGE OF	120217	0379	F
PALM BEACH GARDENS, CITY OF	120221	0379	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
12099C0379F

EFFECTIVE DATE
OCTOBER 5, 2017

Federal Emergency Management Agency

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded tenth-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations (BFEs) shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Transverse Mercator State Plane Florida East FIPS Zone 0901 Feet. The **horizontal datum** was NAD83 HARN, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242** or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was provided in digital format by Palm Beach County. The original orthophotographic base imagery was provided in color with a one-foot pixel resolution at a scale of 1" = 200' from photography flown November 2010 - January 2011.

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

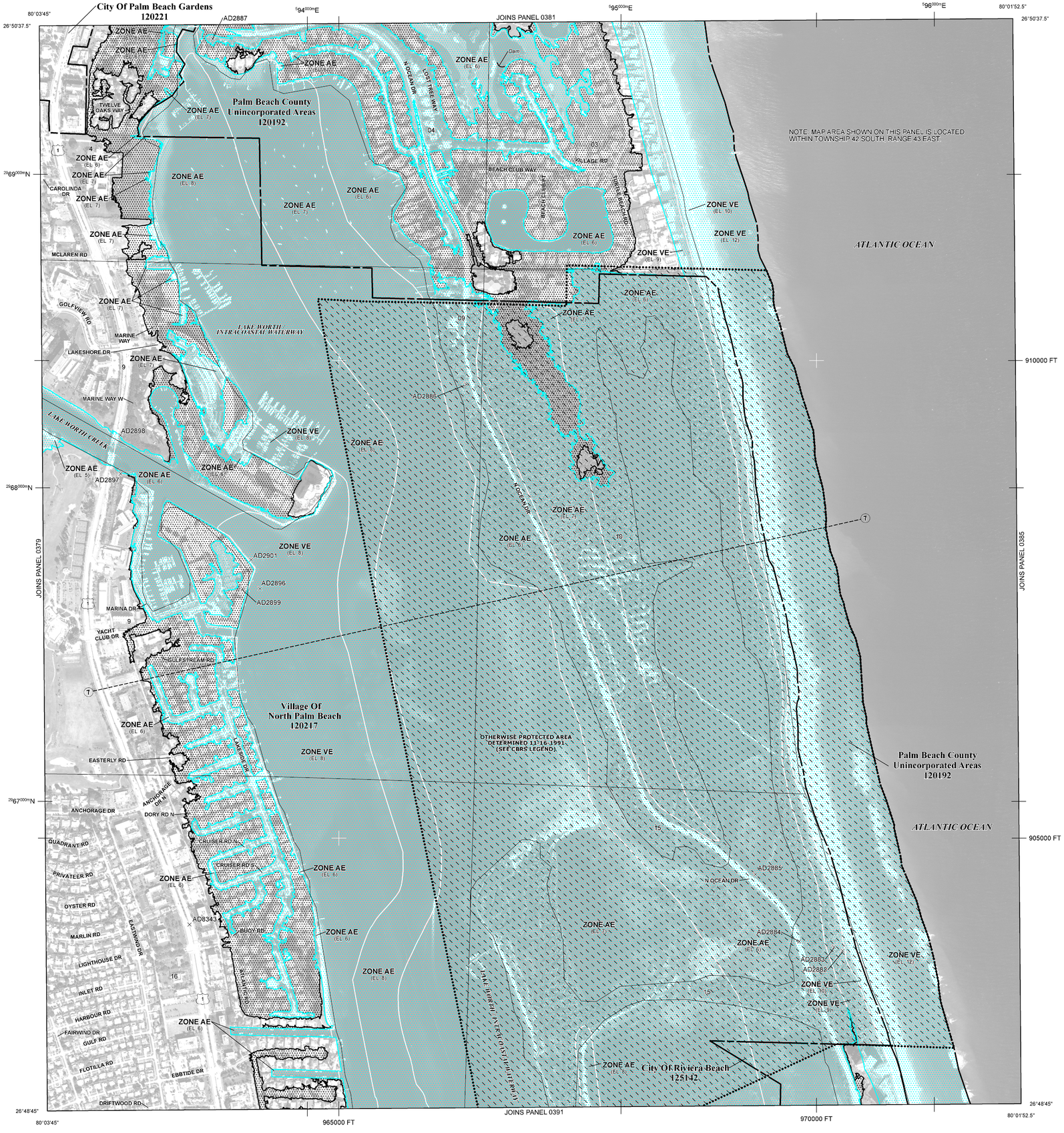
Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information and questions about this map, available products associated with this FIRM including historic versions of this FIRM, how to order products or the National Flood Insurance Program in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Map Service Center website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website. Users may determine the current map date for each FIRM panel by visiting the FEMA Map Service Center website or by calling the FEMA Map Information eXchange.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) LEGEND

11-16-91 Otherwise Protected Area (OPA)
FLOOD INSURANCE NOT AVAILABLE FOR STRUCTURES NEWLY BUILT OR SUBSTANTIALLY IMPROVED ON OR AFTER NOVEMBER 16, 1991, IN DESIGNATED OPAs WITHIN THE CBRS.

Boundaries of the John H. Chafee Coastal Barrier Resources System (CBRS) shown on this FIRM were transferred from the official CBRS source map(s) for this area and are depicted on this FIRM for informational purposes only. The official CBRS maps are enacted by Congress via the Coastal Barrier Resources Act, as amended, and maintained by the U.S. Fish and Wildlife Service (FWS). The official CBRS maps used to determine whether or not an area is located within the CBRS are available for download at http://www.fws.gov. For an official determination of whether or not an area is located within the CBRS, or for any questions regarding the CBRS, please contact the FWS field office for this area at (404) 679-7106.



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Areas to be protected from 1% annual chance flood event by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988

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- 6000000 FT — 5000-foot grid values: Florida State Plane coordinate system, East Zone (FIPSZONE = 901), Transverse Mercator projection
- DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 — River Mile

MAP REPOSITORIES
Refer to Map Repositories List on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
OCTOBER 5, 2017

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 250 500 750 1,000 FEET
150 0 150 300 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0383F

FIRM

FLOOD INSURANCE RATE MAP

PALM BEACH COUNTY, FLORIDA

AND INCORPORATED AREAS

PANEL 383 OF 1200

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
NORTH PALM BEACH, VILLAGE OF	120217	0383	F
PALM BEACH COUNTY	120192	0383	F
PALM BEACH GARDENS, CITY OF	120221	0383	F
RIVIERA BEACH, CITY OF	125142	0383	F

THIS MAP INCLUDES BOUNDARIES OF THE COASTAL BARRIER RESOURCES SYSTEM ESTABLISHED UNDER THE COASTAL BARRIER RESOURCES ACT OF 1982 AND/OR SUBSEQUENT ENABLING LEGISLATION.

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
12099C0383F

EFFECTIVE DATE
OCTOBER 5, 2017

Federal Emergency Management Agency

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

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Coastal Base Flood Elevations (BFEs) shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Transverse Mercator State Plane Florida East FIPS Zone 0901 Feet. The **horizontal datum** was NAD83 HARN, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

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National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242** or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was provided in digital format by Palm Beach County. The original orthophotographic base imagery was provided in color with a one-foot pixel resolution at a scale of 1" = 200' from photography flown November 2010 - January 2011.

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

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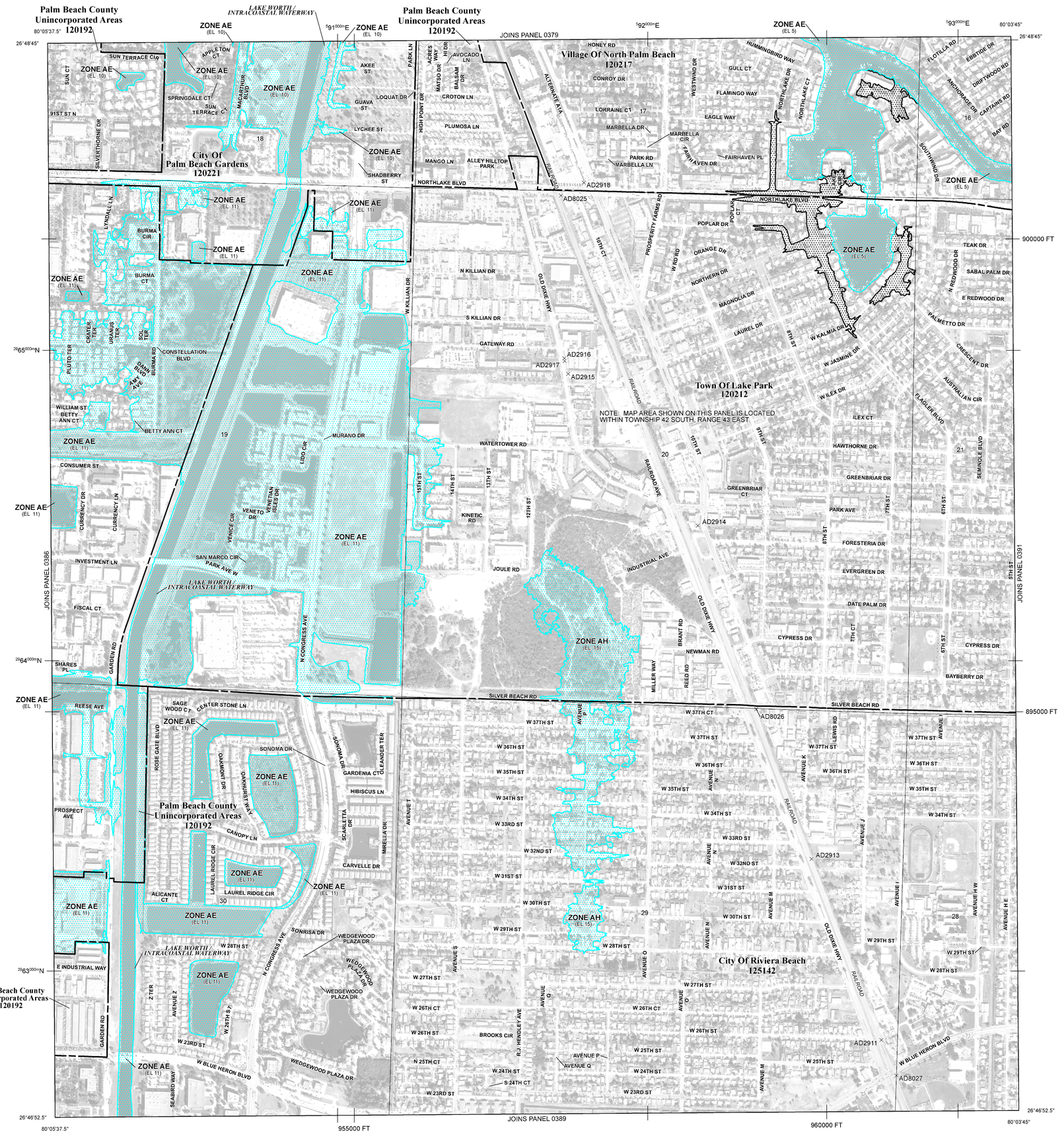

LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

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ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary
0.2% annual chance floodplain boundary
Floodway boundary
Zone D boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities
513 — Base Flood Elevation line and value; elevation in feet*
(EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*
* Referenced to the North American Vertical Datum of 1988
A — A — Cross section line
23 — 23 — Transect line
97°07'30", 32°22'30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
4275000mE — 1000-meter Universal Transverse Mercator grid ticks, zone 17
6000000 FT — 5000-foot grid values: Florida State Plane coordinate system, East Zone (FIPSZONE = 901), Transverse Mercator projection
DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
M1.5 — River Mile

MAP REPOSITORIES
Refer to Map Repositories List on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
OCTOBER 5, 2017

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 250 500 750 1,000 FEET
150 0 150 300 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0387F

FIRM

FLOOD INSURANCE RATE MAP

PALM BEACH COUNTY, FLORIDA AND INCORPORATED AREAS

PANEL 387 OF 1200

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
LAKE PARK, TOWN OF	120212	0387	F
NORTH PALM BEACH, VILLAGE OF	120217	0387	F
PALM BEACH COUNTY	120192	0387	F
PALM BEACH GARDENS, CITY OF	120221	0387	F
RIVIERA BEACH, CITY OF	125142	0387	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
12099C0387F

EFFECTIVE DATE
OCTOBER 5, 2017

Federal Emergency Management Agency

NOTES TO USERS

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To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded tenth-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

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The **projection** used in the preparation of this map was Transverse Mercator State Plane Florida East FIPS Zone 0901 Feet. The **horizontal datum** was NAD83 HARN, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

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Silver Spring, Maryland 20910-3282
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Base map information shown on this FIRM was provided in digital format by Palm Beach County. The original orthophotographic base imagery was provided in color with a one-foot pixel resolution at a scale of 1" = 200' from photography flown November 2010 - January 2011.

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

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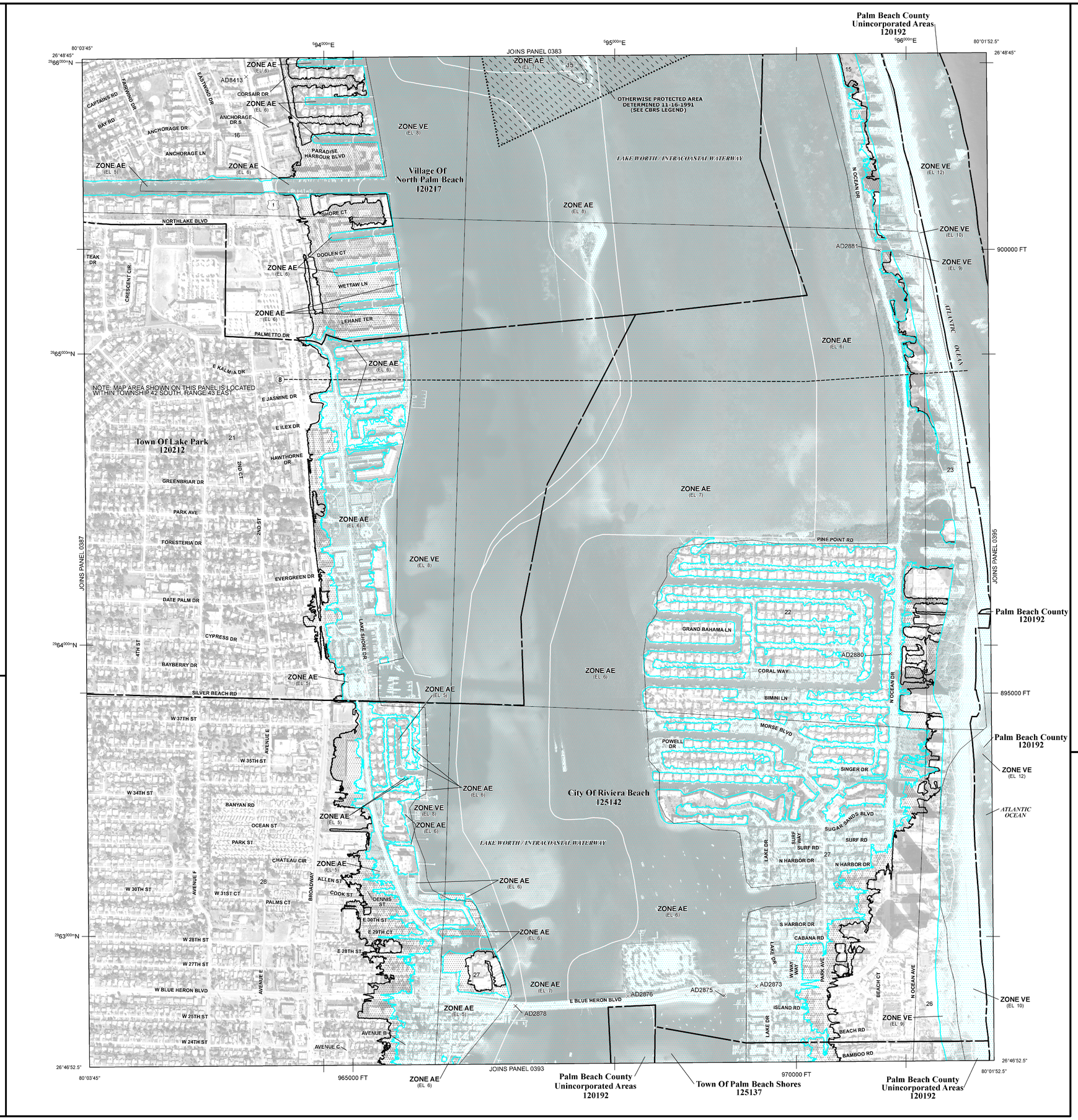
COASTAL BARRIER RESOURCES SYSTEM (CBRS) LEGEND

11-16-91 Otherwise Protected Area (OPA)
FLOOD INSURANCE NOT AVAILABLE FOR STRUCTURES NEWLY BUILT OR SUBSTANTIALLY IMPROVED ON OR AFTER NOVEMBER 16, 1991, IN DESIGNATED OPAs WITHIN THE CBRS.

Boundaries of the John H. Chafee Coastal Barrier Resources System (CBRS) shown on this FIRM were transferred from the official CBRS source map(s) for this area and are depicted on this FIRM for informational purposes only. The official CBRS maps are enacted by Congress via the Coastal Barrier Resources Act, as amended, and maintained by the U.S. Fish and Wildlife Service (FWS). The official CBRS maps used to determine whether or not an area is located within the CBRS are available for download at http://www.fws.gov. For an official determination of whether or not an area is located within the CBRS, or for any questions regarding the CBRS, please contact the FWS field office for this area at (404) 679-7106.



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Areas to be protected from 1% annual chance flood event by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988

- A–A — Cross section line
- 23–23 — Transect line
- 97°07'30", 32°22'30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
- 4275000mE — 1000-meter Universal Transverse Mercator grid ticks, zone 17
- 6000000 FT — 5000-foot grid values: Florida State Plane coordinate system, East Zone (FIPSZONE = 901), Transverse Mercator projection
- DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 — River Mile

MAP REPOSITORIES
Refer to Map Repositories List on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
OCTOBER 5, 2017

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 250 500 750 1,000 FEET
150 0 150 300 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0391F

FIRM

FLOOD INSURANCE RATE MAP

PALM BEACH COUNTY, FLORIDA

AND INCORPORATED AREAS

PANEL 391 OF 1200

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
LAKE PARK, TOWN OF	120212	0391	F
NORTH PALM BEACH, VILLAGE OF	120217	0391	F
PALM BEACH COUNTY	120192	0391	F
PALM BEACH SHORES, TOWN OF	125137	0391	F
RIVIERA BEACH, CITY OF	125142	0391	F

NOTE-
THIS MAP INCLUDES BOUNDARIES OF THE COASTAL BARRIER RESOURCES SYSTEM ESTABLISHED UNDER THE COASTAL BARRIER RESOURCES ACT OF 1982 AND/OR SUBSEQUENT ENABLING LEGISLATION.

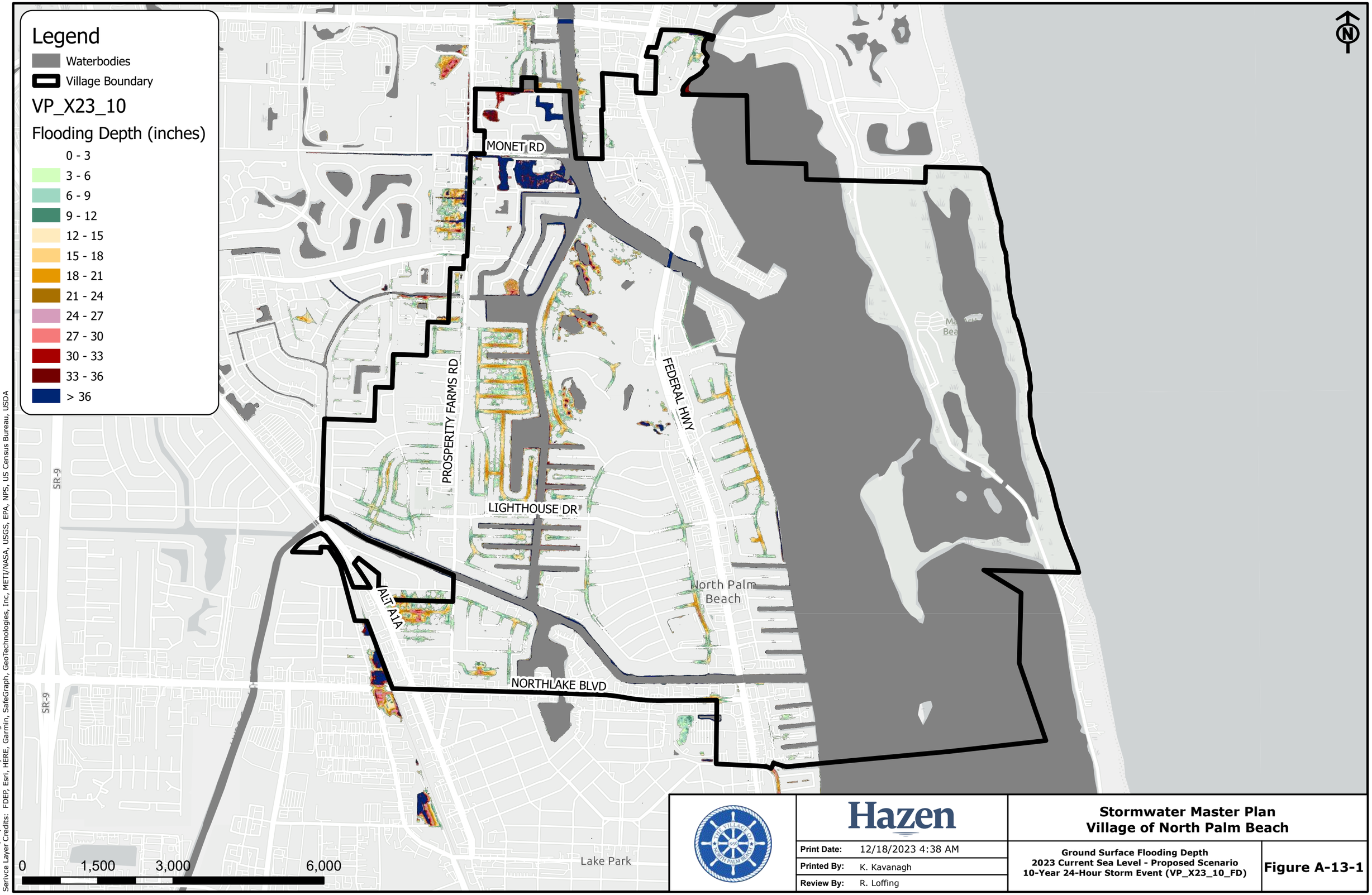
Notice to User. The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
12099C0391F

EFFECTIVE DATE
OCTOBER 5, 2017

Federal Emergency Management Agency

Appendix A-11: Proposed Scenario with 2023 Current Sea Level Flooding Depths



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Service Layer Credits: FDEP, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA

Hazen

Print Date:	12/18/2023 4:38 AM
Printed By:	K. Kavanagh
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2023 Current Sea Level - Proposed Scenario
10-Year 24-Hour Storm Event (VP_X23_10_FD)

Figure A-13-1

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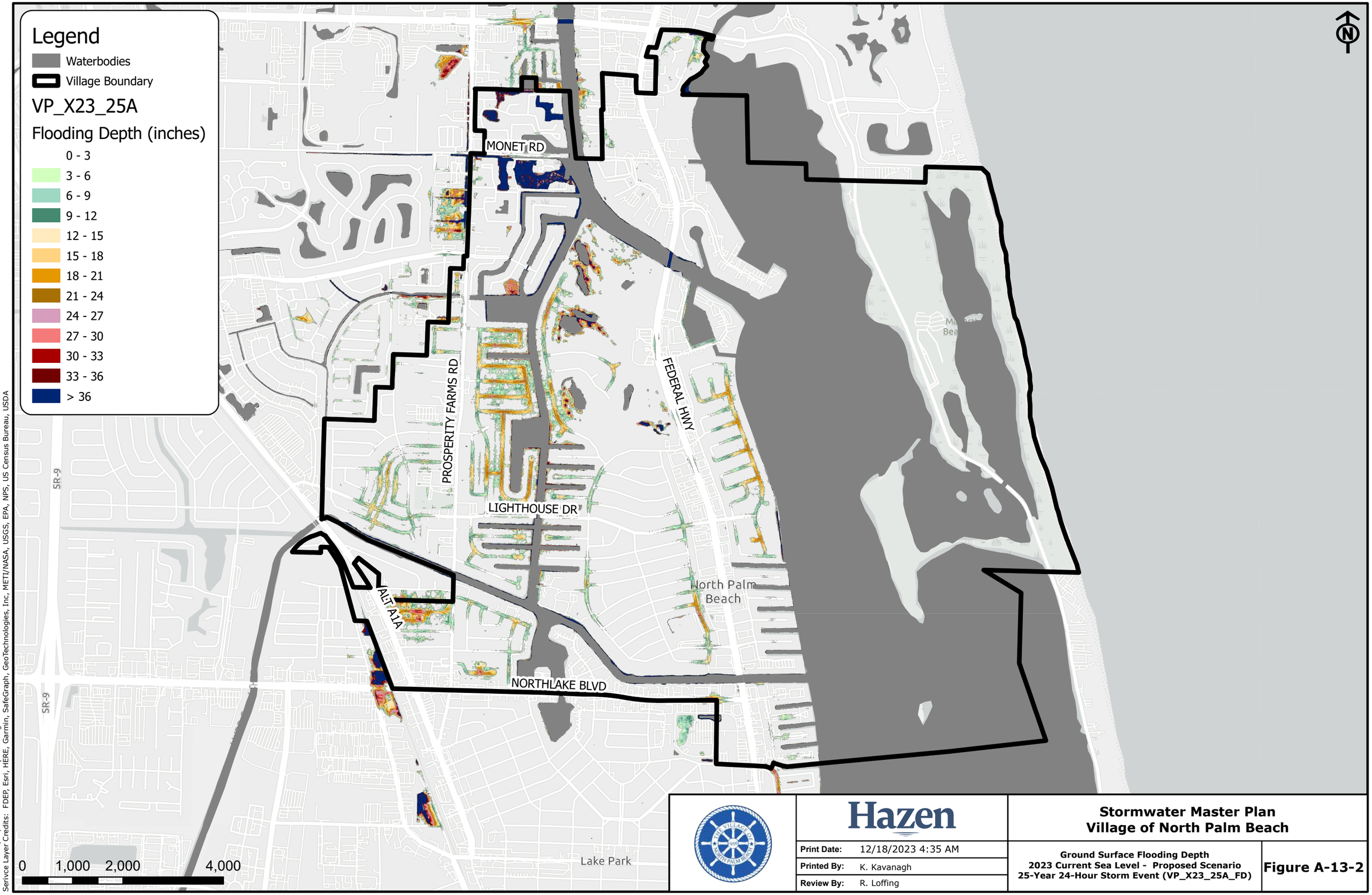

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Service Layer Credits: FDEP, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA

Hazen

Stormwater Master Plan
Village of North Palm Beach

Print Date:	12/18/2023 4:35 AM
Printed By:	K. Kavanagh
Review By:	R. Loffing

Ground Surface Flooding Depth
2023 Current Sea Level - Proposed Scenario
25-Year 24-Hour Storm Event (VP_X23_25A_FD)

Figure A-13-2

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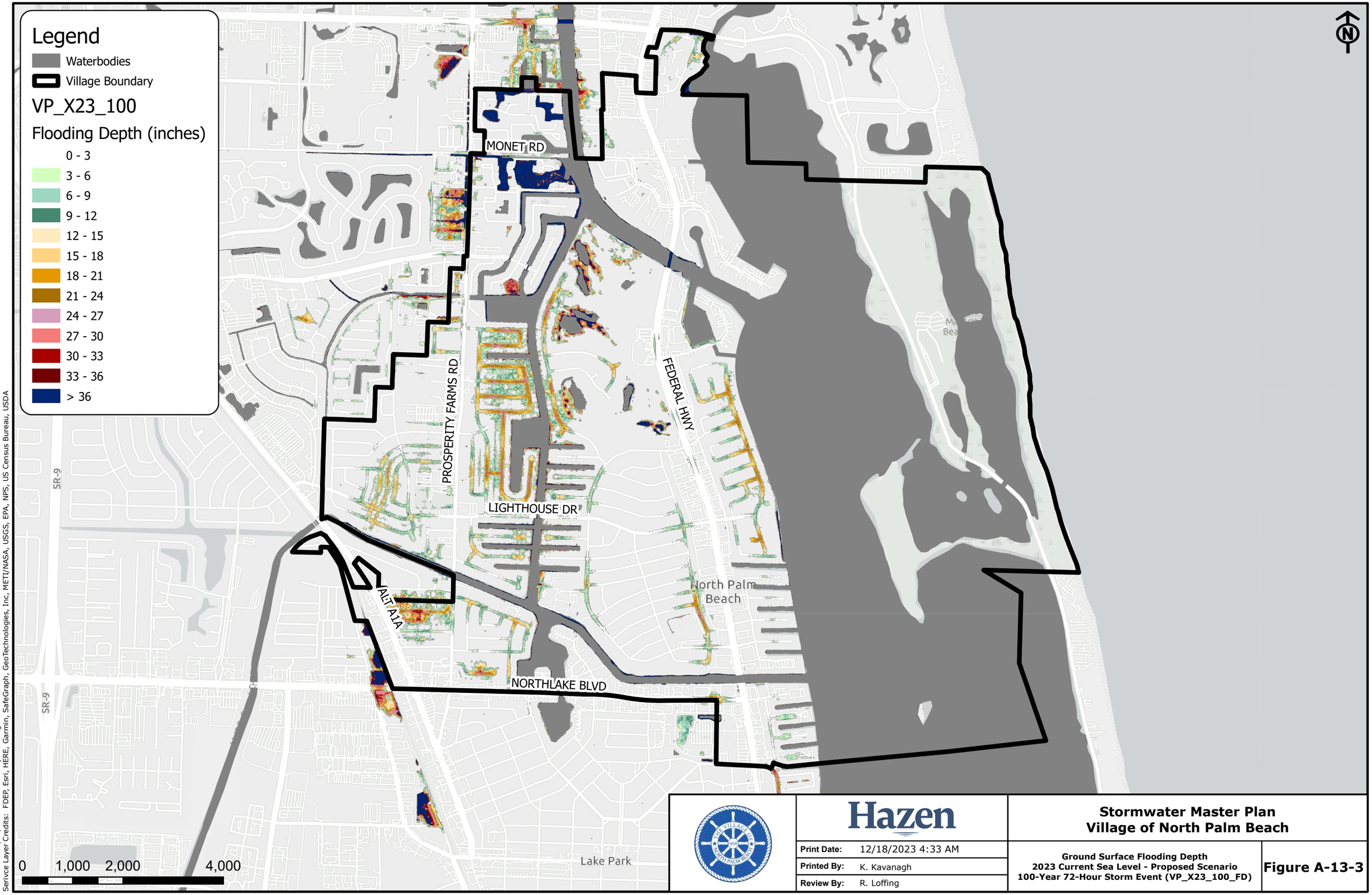

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Stormwater Master Plan
Village of North Palm Beach

Print Date:	12/18/2023 4:33 AM
Printed By:	K. Kavanagh
Review By:	R. Loffing

Ground Surface Flooding Depth
2023 Current Sea Level - Proposed Scenario
100-Year 72-Hour Storm Event (VP_X23_100_FD)

Figure A-13-3

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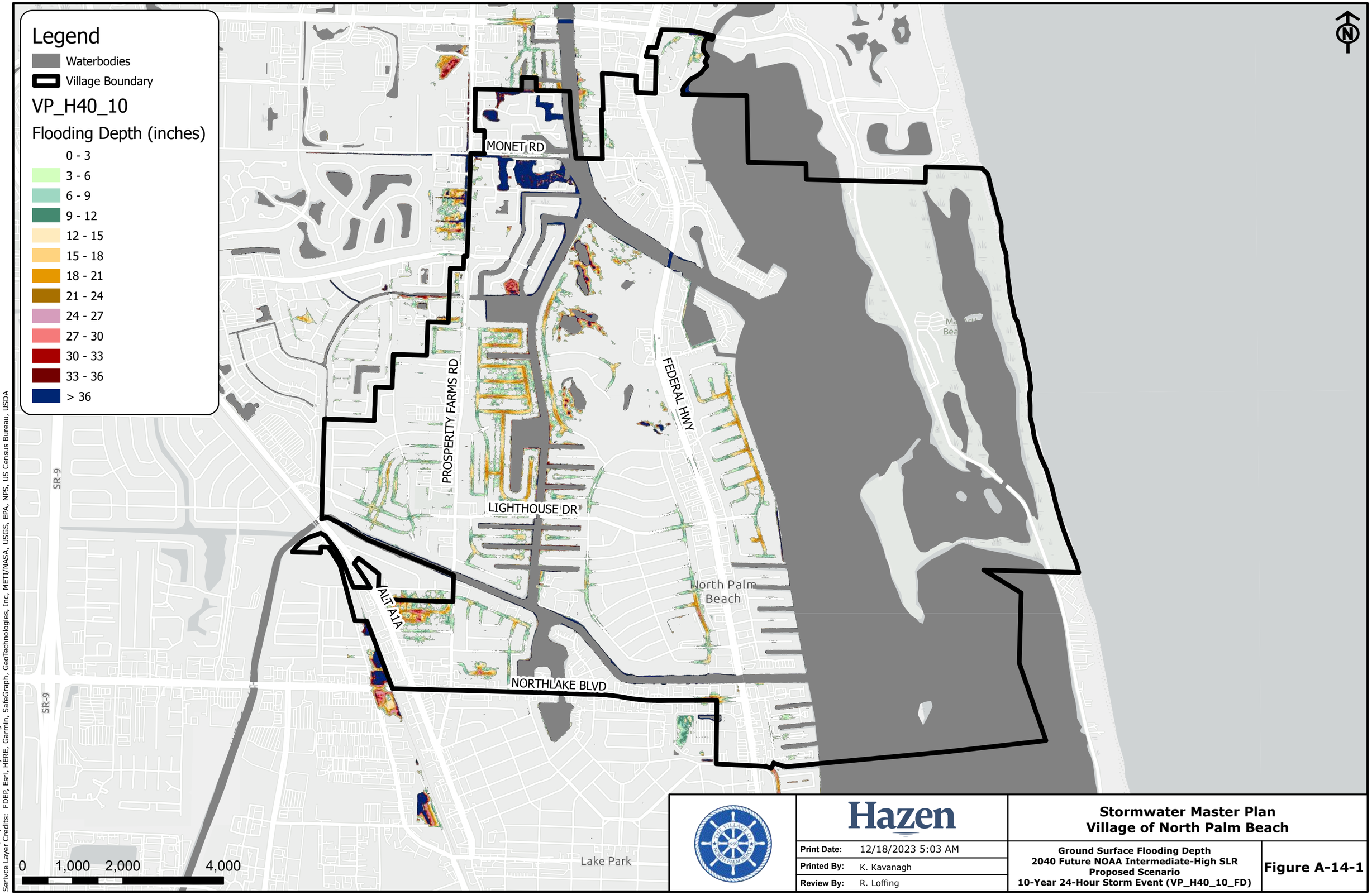
Appendix A-12: Proposed Scenario with 2040 Intermediate-High Sea Level Flooding Depths



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Hazen

Print Date:	12/18/2023 5:03 AM
Printed By:	K. Kavanagh
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-High SLR
Proposed Scenario
10-Year 24-Hour Storm Event (VP_H40_10_FD)

Figure A-14-1

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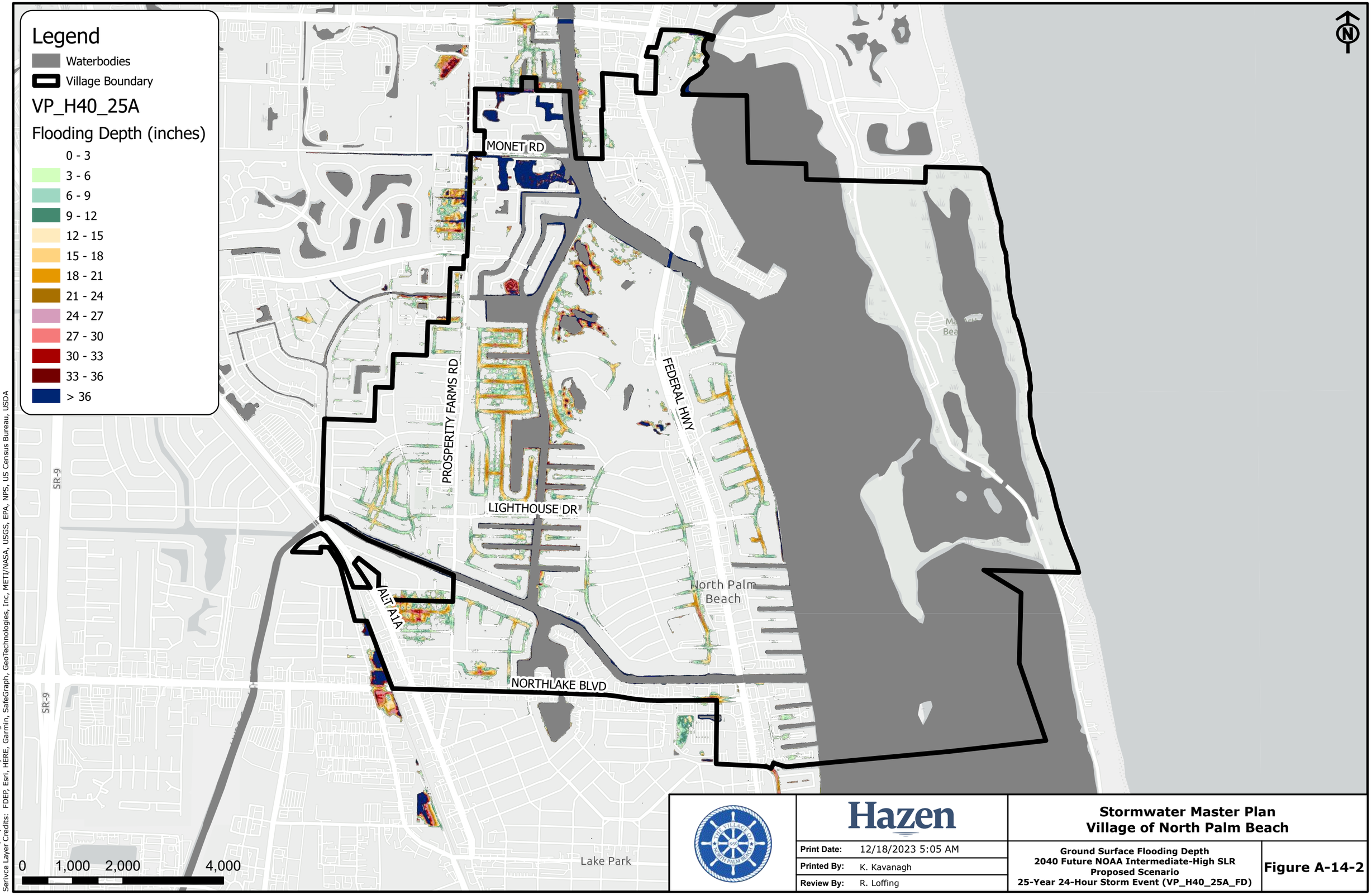

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Print Date:	12/18/2023 5:05 AM
Printed By:	K. Kavanagh
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-High SLR
Proposed Scenario
25-Year 24-Hour Storm Event (VP_H40_25A_FD)

Figure A-14-2

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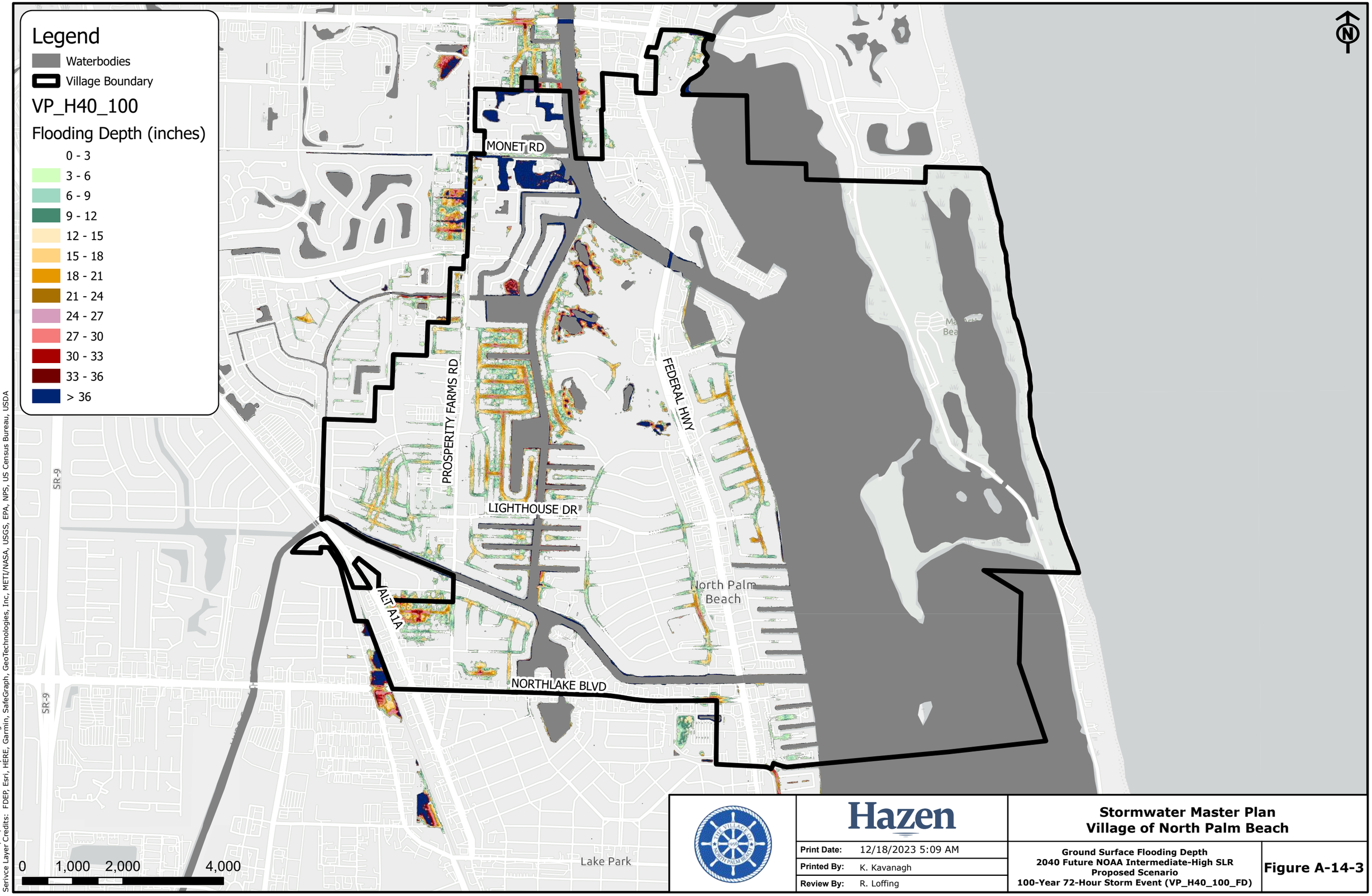

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Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2040 Future NOAA Intermediate-High SLR
Proposed Scenario
100-Year 72-Hour Storm Event (VP_H40_100_FD)

Figure A-14-3

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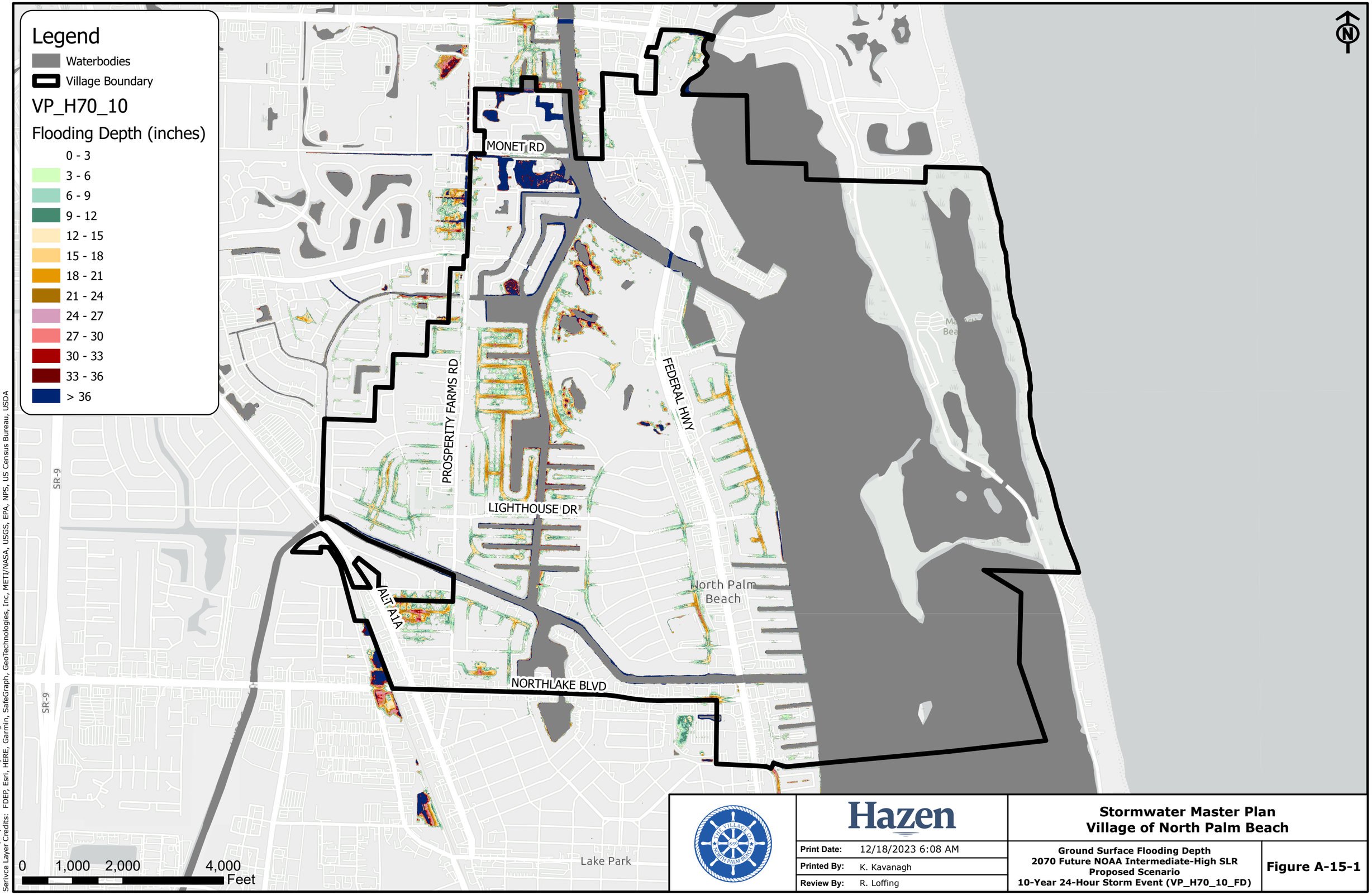
Appendix A-13: Proposed Scenario with 2070 Intermediate-High Sea Level Flooding Depths



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Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-High SLR
Proposed Scenario
10-Year 24-Hour Storm Event (VP_H70_10_FD)

Figure A-15-1

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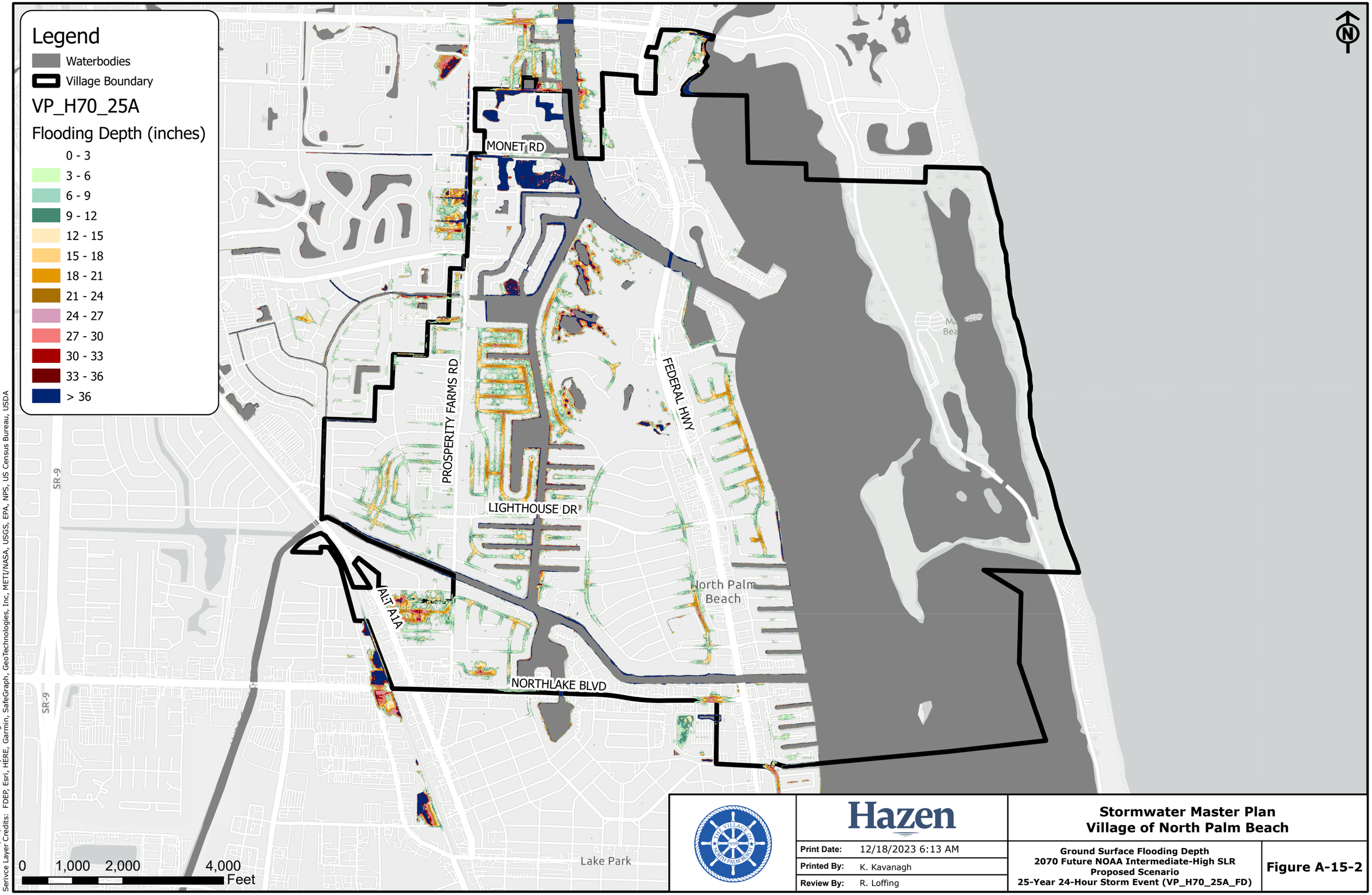

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Hazen

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Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-High SLR
Proposed Scenario
25-Year 24-Hour Storm Event (VP_H70_25A_FD)

Figure A-15-2

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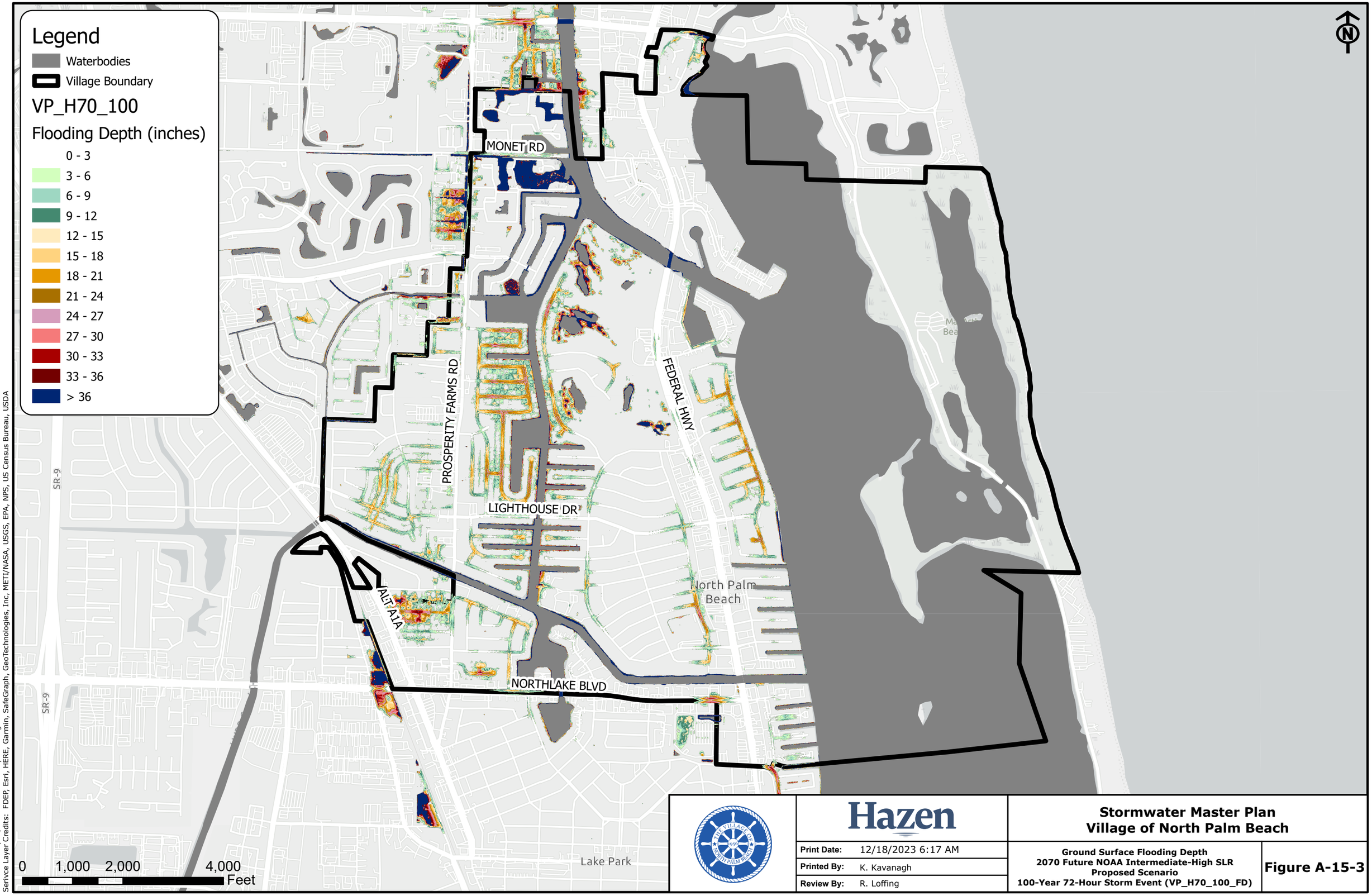

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Printed By:	K. Kavanagh
Review By:	R. Loffing

Stormwater Master Plan
Village of North Palm Beach

Ground Surface Flooding Depth
2070 Future NOAA Intermediate-High SLR
Proposed Scenario
100-Year 72-Hour Storm Event (VP_H70_100_FD)

Figure A-15-3

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