PUERTO RICO
PLANNING BOARD
GOVERNMENT OF PUERTO RICO

2026

# LOCAL HAZARD MITIGATION PLAN

## Municipality of Vega Alta

LOCAL HAZARD MITIGATION PLANS
Protect Through Planning

# PROFESIONAL LICENSED PLANNER CERTIFICATION

As per Act 160-1996 as amended (20 L.P.R.A § 3501 - 20 L.P.R.A § 3515), I _____, who bears Puerto Rico professional planning license number___, certify that this document has been prepared using the best available sources and is in accordance with the best practices of the planning profession as of _____, 2026. And I certify this herewith my professional seal.

# FEMA Approval

This Local Hazard Mitigation Plan for the Municipality of Vega Alta was approved by FEMA on

_____

## Statement of Funding

This Local Hazard Mitigation Plan was prepared for the Municipality of Vega Alta and the Puerto Rico Planning Board by the consulting firm AtkinsRéalis Caribe, LLP as per the stipulations of contract number 2026-000032 and any amendment thereof, duly registered in Puerto Rico's Office of the Comptroller.

## Language Requirement

In Accordance with Presidential Executive Order #14224, the 2026 version of the Vega Alta Local Hazard Mitigation Plan has been prepared in English for submission and consideration of FEMA.

A non-certified translation of the final draft for public discussion and the final approved LHMP to Spanish was prepared for the benefit of the population that is not English proficient.

Should any discrepancy arise between the English and the Spanish text, the English one shall prevail.

## Statement on maps

The maps presented on this document are related to a planning exercise. It is not the intention of these maps to establish any regulatory requirement, procedure or benefit.

# Government Officials

**Municipality of Vega Alta**

Hon. María M. Vega Pagán
Mayor

**Puerto Rico Planning Board**

Héctor Morales Martínez, esq.
President

Rebeca Rivera Torres, PLP
Alternate Member

Luis Lamboy Torres, PLP
Alternate Member

Emanuel Gómez Veléz, PLP
Alternate Member

# Collaborators

**Municipality of Vega Alta**

Elsie J. Rosario Nieves
Elizabeth Otero Martínez
Samuel Negrón Pérez
Miguel A. Navas Flores
Ramón Pabón Martínez
Angel Figueroa Medina
Leyna Huertas

**Puerto Rico Planning Board**

Ivette Colon, PLP
Vanessa Marrero, PLP
Erica Rivera Felicié, PLP
Onix Concepción Rodríguez, PLP

**AtkinsRealis Caribe, LLP**

William Pitre Cipolla, PMP, PLP

Ivelisse R. Gorbea Class, PLP
Yashira Santos, SIT, BSCE
Juan Rotger, PE
Yesenia Rodríguez, MArch, MLArch
Marsha Caride
Celso Ruiz, PMP
Ronald Pérez, PMP, PE
Alexander Burke, AICP
Hannah Heath

Executive Summary ..... 3
1. Introduction and Background ..... 0
1.1 Applicable Public Policies ..... 1
1.1.1 Federal Policies ..... 1
1.1.1.1 Federal Laws ..... 1
1.1.1.2 Federal Regulations ..... 3
1.1.2 Government of Puerto Rico Policies ..... 6
1.1.2.1 Puerto Rico Laws ..... 6
1.1.2.2 Puerto Rico Regulations ..... 9
1.1.3 Municipal Policies ..... 13
1.2 Scope and Previous Versions ..... 15
1.2.1 Primary Objectives ..... 15
1.2.2 Previous FEMA Comments ..... 15
1.3 LHMP Organization ..... 16
1.4 Changes to the Vega Alta LHMP (E2-a) ..... 19
2. Planning Process ..... 21
2.1 Planning Process Regulation ..... 21
2.2 History of the LHMP ..... 21
2.3 Plan Preparation, Revision Schedule and Methodology (a1-a) ..... 21
2.4 Planning Committee (A1-a, A1-b) ..... 22
2.5 Citizen participation (A3-a) ..... 23
2.5.1 Community Outreach and Public Participation Strategies ..... 23
2.5.2 Community Outreach and Public Participation Results ..... 24
2.6 Stakeholder involvement (A2-a) ..... 25
2.7 Hazard Analysis Data Sources ..... 26
2.8 FEMA Lifelines ..... 26
3. Municipal Profile ..... 28
3.1 Data Sources for Municipal Profiles ..... 28
3.2 Brief Historical Background ..... 28
3.3 Geography ..... 29
3.3.1 Physiography ..... 32

3.3.2 Geology ..... 34
3.3.3 Soils ..... 34
3.3.4 Hydrography ..... 35
3.3.5 Precipitation ..... 39
3.3.6 Temperature ..... 40
3.4 Demographics ..... 41
3.4.1 Current Population ..... 41
3.4.2 Socio-economic Characteristics ..... 46
3.4.2.1 Employment ..... 46
3.4.2.2 Employment by Industry ..... 47
3.4.2.3 Poverty Level ..... 49
3.4.2.4 Income ..... 50
3.4.2.5 Population with disabilities ..... 51
3.4.2.6 Population receiving supplemental nutritional support ..... 52
3.4.2.7 Health Insurance Coverage ..... 53
3.4.3 Housing stock and other related details ..... 54
3.5 Critical Infrastructure ..... 55
3.5.1 Lifeline: Safety and Security ..... 57
3.5.2 Lifeline: Food, Hydration and Shelter ..... 58
3.5.3 Lifeline: Health and Medicine ..... 59
3.5.4 Lifeline: Energy ..... 60
3.5.5 Lifeline: Communications ..... 60
3.5.6 Lifeline: Transportation ..... 61
3.5.7 Lifeline: Hazardous Materials ..... 62
3.5.8 Lifeline: Water Systems ..... 63
3.6 Recent Development (E1-a) ..... 65
4. Hazards Profiles and Risks Analysis (B1-a) ..... 69
4.1 Note on the Discussion of Hazards ..... 69
4.2 Regulatory Requirements ..... 69
4.3 Hazards that can Affect the Municipality ..... 70
4.4 Chronology of Events ..... 73
4.5 Risk Assessment Methodology ..... 73

4.5.1.1 HAZUS 6.1 ..... 73
4.5.1.2 Alternative GIS modeling ..... 74
4.5.1.3 Stochastic Risk Assessment ..... 74
4.6 Earthquake ..... 74
4.6.1 Description (B1-a) ..... 74
4.6.1.1 Affected Area (B1-b) ..... 76
4.6.1.2 Risk Magnitude (B1-c) ..... 84
4.6.1.3 Past Events (B1-d) ..... 86
4.6.1.4 Future Event Probabilities (B1-e) ..... 92
4.6.2 Risk Analysis (B2-a, B2-b) ..... 93
4.6.2.1 Estimated Losses ..... 93
4.6.2.2 Lifelines and Critical Infrastructure ..... 94
4.6.2.3 Social Vulnerabilities ..... 98
4.6.2.4 Natural and Cultural Resources ..... 101
4.6.2.5 Future Conditions (E1-a) ..... 102
4.7 Landslides ..... 104
4.7.1 Description (B1-a) ..... 104
4.7.1.1 Affected Area (B1-b) ..... 106
4.7.1.2 Risk Magnitude (B1-c) ..... 108
4.7.1.3 Past Events ..... 109
4.7.1.4 Future Event Probabilities ..... 111
4.7.2 Risk Analysis ..... 111
4.7.2.1 Estimated Losses ..... 111
4.7.2.2 Lifelines and Critical Infrastructure ..... 112
4.7.2.3 Social Vulnerabilities ..... 115
4.7.2.4 Natural and Cultural Resources ..... 118
4.7.2.5 Future Conditions ..... 118
4.8 Tsunami ..... 120
4.8.1 Description (B1-a) ..... 120
4.8.1.1 Affected Area (B1-b) ..... 121

4.8.1.2 Risk Magnitude (B1-c) ..... 121
4.8.1.3 Past Events (B1-d) ..... 124
4.8.1.4 Future event probabilities (B1-e) ..... 125
4.8.2 Risk Analysis (B2-a, B2-b) ..... 126
4.8.2.1 Estimated Losses ..... 126
4.8.2.2 Critical Infrastructure and Lifelines ..... 128
4.8.2.3 Social Vulnerabilities ..... 130
4.8.2.4 Natural and Cultural Resources ..... 132
4.8.2.5 Future Conditions (E1-a) ..... 133
4.9 Flooding ..... 135
4.9.1 Description (B1-a) ..... 135
4.9.1.1 Affected Area ..... 137
4.9.1.2 Risk Magnitude (B1-c) ..... 145
4.9.1.3 Past Events (B1-d) ..... 147
4.9.1.4 Special Considerations: Karst Formation ..... 154
4.9.1.5 Special Consideration: Floods by Stormwater Management Deficiencies 157
4.9.1.6 Future Event Probabilities (B1-e) ..... 158
4.9.2 Risk Analysis (B2-a, B2-b) ..... 159
4.9.2.1 Estimated Loses ..... 159
4.9.2.2 Lifelines and Critical Infrastructure ..... 163
4.9.2.3 Social Vulnerabilities ..... 166
4.9.2.4 Natural and Cultural Resources ..... 167
4.9.2.5 Special Consideration: Repetitive Losses and Severe Repetitive Losses 168
4.9.2.6 Future Conditions (E1-a) ..... 169
4.10 Tropical Cyclones and other Extreme Wind Events ..... 170
4.10.1 Description (B1-a) ..... 170
4.10.1.1 Affected Area (B1-b) ..... 172
4.10.1.2 Risk Magnitude (B1-c) ..... 172
4.10.1.3 Past Events (B1-d) ..... 174

4.10.1.4 Future event probabilities (B1-e) ..... 179
4.10.2 Risk Analysis (B2-a, B2-b) ..... 180
4.10.2.1 Estimated Losses ..... 180
4.10.2.2 Lifelines and Critical Infrastructure ..... 187
4.10.2.3 Social Vulnerabilities ..... 187
4.10.2.4 Natural and Cultural Resources ..... 188
4.10.2.5 Future Conditions (E1-a) ..... 188
4.11 Storm Surge ..... 188
4.11.1 Description ..... 188
4.11.1.1 Affected Area ..... 189
4.11.1.2 Risk Magnitude ..... 192
4.11.1.3 Past Events ..... 192
4.11.1.4 Future Events Probability ..... 193
4.11.2 Risk Analysis ..... 193
4.11.2.1 Estimated Losses ..... 193
4.11.2.2 Social Vulnerabilities ..... 197
4.11.2.3 Natural and Cultural Resources ..... 200
4.11.2.4 Future Conditions ..... 201
4.12 Extreme Heat ..... 204
4.12.1 Description (B1-a) ..... 204
4.12.1.1 Affected Area (B1-b) ..... 205
4.12.1.2 Risk Magnitude (B1-c) ..... 206
4.12.1.3 Past Events (B1-d) ..... 208
4.12.1.4 Future event probabilities (B1-e) ..... 208
4.12.2 Risk Analysis (B2-a, B2-b) ..... 209
4.12.2.1 Estimated Losses ..... 209
4.12.2.2 Lifelines and Critical Infrastructure ..... 209
4.12.2.3 Social Vulnerabilities ..... 211
4.12.2.4 Natural and Cultural Resources ..... 211
4.12.2.5 Future Conditions ..... 212

4.13 Drought ..... 212
4.13.1 Description (B1-a) ..... 212
4.13.1.1 Affected Area ..... 214
4.13.1.2 Risk Magnitude (B1-c) ..... 214
4.13.1.3 Past Events (B1-d) ..... 215
4.13.1.4 Future event probabilities (B1-e) ..... 217
4.13.2 Risk Analysis (B2-a, B2-b) ..... 218
4.13.2.1 Estimated Losses ..... 218
4.13.2.2 Critical Infrastructure and Lifelines ..... 219
4.13.2.3 Social Vulnerabilities ..... 219
4.13.2.4 Natural and Cultural Resources ..... 220
4.13.2.5 Future Conditions ..... 220
4.14 Wildfire (E1-a) ..... 221
4.14.1 Description (B1-a) ..... 221
4.14.1.1 Risk Magnitude ..... 222
4.14.1.2 Affected Area (B1-b) ..... 223
4.14.1.3 Risk Magnitude (B1-c) ..... 224
4.14.1.4 Past Events (B1-d) ..... 225
4.14.1.5 Future Event Probability (B1-e) ..... 226
4.14.2 Risk Analysis (B2-a, B2-b) ..... 226
4.14.2.1 Estimated Losses ..... 226
4.14.2.2 Critical Infrastructure ..... 226
4.14.2.3 Social Vulnerability ..... 227
4.14.2.4 Natural and Cultural Resources ..... 228
4.14.2.5 Future Conditions (E1-a) ..... 230
4.15 Long term Coastal Dynamics ..... 230
4.15.1 Description ..... 230
4.15.1.1 Affected Area ..... 233
4.15.1.2 Risk Magnitude ..... 236
4.15.1.3 Past Events ..... 243

4.15.1.4 Future Events Probability ..... 245
4.15.2 Risk Analysis ..... 246
4.15.2.1 Estimated Losses ..... 246
4.15.2.2 Lifelines and Critical Infrastructure ..... 246
4.15.2.3 Social Vulnerabilities ..... 250
4.15.2.4 Natural and Cultural Resources ..... 251
4.15.2.5 Future Conditions ..... 251
4.16 Pandemic/Epidemic ..... 252
4.16.1 Description (B1-a) ..... 252
4.16.1.1 Affected Area (B1-b) ..... 252
4.16.1.2 Risk Magnitude (B1-c) ..... 252
4.16.1.3 Past Events (B1-d) ..... 253
4.16.1.4 Future Events Probability (B1-e) ..... 255
4.16.2 Risk Assessment (B2-a, B2-b) ..... 256
4.16.2.1 Estimated Losses ..... 256
4.16.2.2 Critical Infrastructure and Lifelines ..... 256
4.16.2.3 Social Vulnerability ..... 257
4.16.2.4 Natural and Cultural Resources ..... 258
4.16.2.5 Future Conditions (E1-a) ..... 259
4.17 Hazard Prioritization ..... 259
4.18 Planning Mechanism ..... 260
4.18.1 Karst Special Planning Area Plan and Regulation (PRAPEC, by its Spanish Acronym) – 2014) ..... 260
4.18.2 Joint Regulation for the Evaluation and Issuance of Permits Related to Development, Land Use, and Business Operations (2023) ..... 261
4.18.3 Special Flood Hazards Areas Regulation (2021) ..... 262
4.18.4 Puerto Rico 2023 Building Code ..... 262
4.18.5 Regulation for the Design, Operation Criteria and Maintenance of Stormwater Systems in Puerto Rico ..... 263
4.18.6 Vega Alta Territorial Plan (2025) ..... 264
4.18.7 Vega Alta Emergency Operation Plan ..... 264
4.18.8 National Flood Insurance Program ..... 265

4.18.9 National Pollutant Discharge Elimination System (NPDES) ..... 266
4.18.10 Operational Guidelines for Determining Damages and Substantial Improvements in Puerto Rico (2025) ..... 267
4.18.11 Green Infrastructure and Nature Based Solutions ..... 267
4.18.12 Four – Year Investment Program ..... 269
**5. Municipal Capacities** ..... 271
5.1 Regulatory and Planning Mechanism (C1-a) ..... 271
5.2 Technical and Administrative Capacities (C1-a) ..... 271
5.3 Financial Capacity (C1-a) ..... 273
5.3.1 FEMA Funding Streams ..... 273
5.3.2 Non-FEMA Federal Funding Streams ..... 276
5.3.3 Local Funds ..... 278
5.4 Outreach and Communications Capacity (C1-a) ..... 278
5.5 Capacity Development (C1-b) ..... 279
6. Mitigation Action Plan ..... 281
6.1 Mitigation Goals and Objectives(C3-a) ..... 281
6.1.1 Municipal Goals and Objectives ..... 281
6.1.2 National Mitigation Investment Strategy ..... 283
6.2 Mitigation Strategy Selection Criteria ..... 283
6.3 Mitigation Strategy Categorization ..... 285
6.4 Mitigation Strategies (C4-a, C4-b, C5-a, C5-b, E2.b) ..... 287
6.5 Participation in NFIP (C2-a) ..... 313
**7. Plan Maintenance** ..... 314
7.1 Point of Contact ..... 314
7.2 Public Participation Continuation (D1-a) ..... 315
7.3 LHMP Oversight (D2-a) ..... 315
7.4 LHMP Evaluation and Monitoring (D2-b) ..... 316
7.5 LHMP Update and Revision (D2-c, D3-a) ..... 317
7.5.1 Revision after a major disaster declaration ..... 317
7.5.2 Five – year comprehensive update ..... 318
7.6 Integration with Other Planning Mechanisms (D3-a) ..... 318
8. Adoption and Approval (F1-a, F1-b) ..... 320
8.1 LHMP Adoption ..... 320

8.2 LHMP Approval ..... 320
Selected References ..... 321
Appendix A: Adoption and Approval ..... 333
Appendix B: Commitment Letter ..... 334
Appendix C: Planning Committee ..... **Error! Bookmark not defined.**
Appendix C – Public Participation and Outreach ..... 351
Appendix D: Stakeholder Involvement ..... 358
Appendix E: Municipal Organizational Chart ..... 366
Appendix F: Critical Infrastructure by Lifeline ..... 367

# List of Maps


Map 1: Vega Alta and Adjacent Municipalities ..... 30
Map 2: Vega Alta – Wards Subdivision ..... 31
Map 3: Vega Alta Physiography ..... 33
Map 4: Vega Alta – Hydrography Map – ..... 37
Map 5: Vega Alta - Watersheds Map- ..... 38
Map 6: Vega Alta– Subwatersheds - ..... 39
Map 7: Population Density ..... 45
Map 8: Critical Infrastructure by Lifeline ..... 57
Map 9: Roadways ..... 64
Map 10: Recent Developments 2020-2023 ..... 67
Map 11: Recent Developments 2024-2026 ..... 68
Map 12: Spectral Acceleration at 1.0 sec ..... 78
Map 13: Vega Alta Earthquake Spectral Acceleration at 0.3 sec ..... 80
Map 14: Spectral Displacement at 1.0 sec ..... 82
Map 15: Vega Alta Spectral Displacement at 0.3 sec ..... 83
Map 16: Earthquake Critical Facilities Exposure to Spectral Acceleration at 1.0 sec ..... 96
Map 17: Critical Facilities exposure to spectral acceleration at 0.3 sec ..... 97
Map 18: Earthquake: Population Exposed to Spectral Acceleration at 1.0 (g) sec ..... 99
Map 19: : Earthquake: Population Exposure to Spectral Acceleration at 0.3 (g) sec ..... 101
Map 20: Earthquake: Recent Development Exposure to Spectral Acceleration at 1.0 sec 103
Map 21: Earthquake: Recent Development Exposure to Spectral Acceleration at 0.3 sec 104
Map 22: Landslide Susceptibility ..... 107
Map 23: Landslides related to Hurricane María ..... 110
Map 24: Landslide: Critical Infrastructure Exposure ..... 114
Map 25: Landslide: Population Exposure ..... 117
Map 26: Landslide: Recent Development Exposure ..... 119
Map 27: Tsunami Impact Area ..... 123
Map 28: Tsunami: Structural Loss ..... 127
Map 29: Tsunami: Critical Infrastructure Exposure ..... 130
Map 30: Tsunami: Population Exposure ..... 131
Map 31: Tsunami: Recent Development Exposure ..... 134
Map 32: Vega Alta Flood Hazard Zones (FIRM) ..... 140
Map 33: Hazus Analysis for 500 - Year Flood Event ..... 145
Map 34: Vega Alta: Karst Formation ..... 156
Map 35: Building Loss to Flood Exposure 500 – year flood ..... 160
Map 36: building Loss to Flood Exposure 100-year ..... 161
Map 37: Flood Critical Facilities Exposure 500 yrs flood ..... 165
Map 38: Flood: Population Exposure 500 yrs event ..... 167
Map 39: Recent Development and Flood Risks ..... 170
Map 40: Total Damaged Buildings 100 – Year Event ..... 182

Map 41: Total Damaged Building 500 - Year Event ..... 183
Map 42: Total Economic Loss 100 – Year Event ..... 185
Map 43: Total Economic Loss 500 - Year Event..... 186
Map 44: Category 1 Storm Surge Area ..... 190
Map 45: Category 5 Storm Surge Impact Area..... 191
Map 46: Critical Infrastructure affected by a Cat 1 Storm Surge ..... 195
Map 47: Affected Critical Infrastructure Cat 5 Hurricane ..... 196
Map 48: Storm Surge: Population Exposure to Category 1 Surge ..... 198
Map 49: Strom Surge: Population Exposure to Category 5 Surge ..... 199
Map 50: Recent Development and Storm Surge Impact Category 1 ..... 202
Map 51: Recent Development and Storm Surge Impact Category 5 ..... 203

# List of Tables

Table 1: LHMP Organization ..... 16
Table 2: Changes to the Vega Alta LHMP ..... 19
Table 3: LHMP Planning Committee ..... 22
Table 4: Hazard and Risk Assessment of Data Sources ..... 26
Table 5: Population by Age Group 2024 ACS vs 2019 ACS ..... 42
Table 6: Current Labor Force Statistics ..... 46
Table 7: Employment by Industry 2024 ACS vs 2019 ACS ..... 47
Table 8: Vega Alta: Construction Permits Approved 2020-2026 ..... 65
Table 9: Hazards to be included in the Vega Alta 2026 LHMP ..... 71
Table 10: Order of Hazards to be Assessed ..... 72
Table 11: Moment - Magnitude Scale ..... 85
Table 12: Puerto Rico Seismic Activity 2013-2024 ..... 87
Table 13: Exposure to Earthquake Hazard ..... 94
Table 14: Expected Annual Loss to Earthquake ..... 94
Table 15: Landslide Risk Categories ..... 108
Table 16: Tsunami events in Puerto Rico ..... 124
Table 17: Tsunami Exposure ..... 126
Table 18: Flood Exposure ..... 159
Table 19: Expected Annual Loss to Flood ..... 159
Table 20: Total Structures at Risk ..... 162
Table 21: Aggregated Loss of dollars for 1% (100-year) and 0.2% (500 - year) events ..... 162
able 22: Detailed Loss for Non-Residential Buildings ..... 162
Table 23: Detailed Loss for Residential Buildings ..... 162
Table 24: NFIP Policies in force and coverage ..... 168
Table 25: NFIP Repetitive Losses ..... 168
Table 26: NFIP Severe Repetitive Losses ..... 169
Table 27: Saffir-Simpson Hurricane Scale ..... 173
Table 28: Tropical Storm Disaster Declaration ..... 175
Table 29: Tropical Cyclone Exposure ..... 180
Table 30: Expected Annual Loss to Tropical Cyclones ..... 180
Table 31: Registered Wildfires ..... 226
Table 32: Puerto Rico Sea Level Observations ..... 242
Table 33: Pandemics and Epidemic in Puerto Rico 1855 - 2020 ..... 253
Table 34: Number of People in Vega Alta without Healthcare Coverage ..... 257
Table 35 ..... 259
Table 36: Municipal Technical and Administrative Human Resources ..... 271
Table 37: Outreach and Communications Tools ..... 279

# List of Figures

Figure 1: FEMA Local Hazard Mitigation Planning Guide Cover ..... 3
Figure 2: Cover of FEMA's Local Mitigation Planning Handbook ..... 4
Figure 3: National Disaster Recovery Framework Cover ..... 5
Figure 4: Puerto Rico Land Use Plan Coversheet ..... 9
Figure 5: Puerto Rico SHMP Cover ..... 11
Figure 6: Puerto Rico Mitigation Action Plan, CDBG-DR MIT Cover ..... 12
Figure 7: Vega Alta Local Hazard Mitigation Plan ..... 13
Figure 8: Vega Alta Municipal Recovery Plan Cover ..... 14
Figure 9: Vega Alta Population by Sex (2024 ACS) ..... 41
Figure 10: Vega Alta Population by Age Group (ACS 2024)- ..... 43
Figure 11: Vega Alta Population Pyramid (2024 ACS -Five-years Estimates) ..... 44
Figure 12: Vega Alta Construction Permits Approved 2020-2026 – ..... 66
Figure 13: PRSN - 2024 Earthquakes Epicenter (PRSN, 2025) ..... 86
Figure 14: : Mean Annual Rainfall 1991-2020 (PR & USVI) ..... 111
Figure 15: Official Tsunami Evacuation Map ..... 121
Figure 16: National Flood Hazard Layer FIRMette (PR-2 and nearby communities in Vega Alta) ..... 138
Figure 17: National Flood Hazard Layer FIRMette (La Ponderosa, Vega Alta) ..... 139
Figure 18: National Flood Hazard Layer FIRMette (Parcelas Carmen, Vega Alta) ..... 141
Figure 19: National Flood Hazard Layer FIRMette (Sector Carmelita and PR-690, Bo. Sabana) ..... 142
Figure 20: ABFE vs FIRM 1% (100 years) ..... 143
Figure 21: Hurricane Tracks 1989-2017 (only Cat 2-5) ..... 171
Figure 22: Hurricane María (2017) as it approaches Puerto Rico ..... 172
Figure 23: Heat Island Effect Diagram (EPA, 2025) ..... 208
Figure 24 Puerto Rico's Percent Area in U.S. Drought Monitor Categories ..... 217
Figure 25: Municipality's Percent Area in U.S. Drought Monitor Categories ..... 217
Figure 26: Levels of Wildfire incidence accounting to SFLA ..... 224
Figure 27: Vega Alta - State of the Beach Study ..... 233
Figure 28: Vega Alta - State of the Beach (Erosion vs. Accretion) ..... 234
Figure 29: Vega Alta - Change in Width of Beach (July 2018) ..... 236
Figure 30: NOAA's Relative Sea Level Trend Map ..... 241
Figure 31; NOAA's Relative Sea Level Trend Map (Zoom to Puerto Rico) ..... 241
Figure 32: Relative Sea Level Trend 9759110 Magueyes Island, PR ..... 242
Figure 33: Relative Sea Level Trend 9755371 San Juan, PR ..... 243
Figure 34: – Short – Term Shoreline Changes ..... 245
Figure 35: PRAPEC Coversheet ..... 260
Figure 36: Joint Regulation Cover ..... 261
Figure 37: Regulation 40 (Cover) ..... 263
Figure 38: Territorial Plan ..... 264

Figure 39: Operational Guidelines Cover ..... 267

# List of Frequently Used Acronyms

| | |
|---|---|
| ABFE | Advisory Base Flood Elevation |
| ACS | American Community Survey |
| AMMED | Municipal Agency for Disaster and Emergency Management, by its Spanish acronym |
| BFE | Base Flood Elevation |
| BLE | Base Flood Engineering |
| BRIC | Building Resilient Infrastructure and Communities |
| CDBG-DR | Community Development Block Grant - Disaster Recovery |
| CDBG-MIT | Community Development Block Grant - Mitigation |
| CEACC | Committee of Experts and Advisors on Climate Change |
| COR3 | Central Office for Recovery, Reconstruction and Resiliency |
| CRS | Community Rating Systems |
| DEM | Digital Elevation Model |
| DHS | Department of Homeland Security |
| DNER | Department of Natural and Environmental Resources |
| DPS | Department of Public Safety |
| DTOP | Department of Transportation and Public Works |
| EAL | Expected Annual Loss |
| EOP | Emergency Operation Plan |
| EPA | Environmental Protection Agency |
| FEMA | Federal Emergency Management Agency |
| FHWA | Federal Highway Administration |
| FIRM | Flood Insurance Rate Map |
| FIS | Flood Insurance Study |
| FRA | Federal Railroad Administration |
| FTA | Federal Transit Administration |
| GIS | Geographic Information System |
| HMGP | Hazard Mitigation Grant Program |
| HUD | U.S. Department of Housing and Urban Development |
| IFRC | International Federation of the Red Cross |
| IRRM | Interim Risk Reduction Measures |
| LHMP | Local Hazard Mitigation Plan |
| LUMA | Luma Energy |
| MHHW | Mean Higher High Water |
| mph | Miles per hour |

| | |
|---|---|
| MSL | Mean Sea Level |
| NCEI | National Centers for Environmental Information |
| NDRF | National Disaster Recovery Framework |
| NID | National Inventory Dams |
| NIMS | National Incident Management System |
| NIST | National Institute of Standards and Technology |
| NOAA | National Oceanic and Atmospheric Administration |
| NTHMP | National Tsunami Hazard Mitigation Program |
| OMME | Municipal Emergency Management Office |
| OPM | Municipal Public Works, by its Spanish acronym |
| PRASA | Puerto Rico Aqueduct and Sewers Authority |
| PREMB | Puerto Rico Emergency Management Bureau |
| PREPA | Puerto Rico Electric Power Authority |
| PRHTA | Puerto Rico Highway and Transportation Authority |
| PRPB | Puerto Rico Planning Board |
| PRSN | Puerto Rico Seismic Network |
| PT | Territorial Plan, by its Spanish acronym |
| PUT-PR | Puerto Rico Land Use Plan, by its Spanish acronym |
| SHMO | State Hazard Mitigation Officer |
| SFLA | Southern Federal Land Assessment |
| UHI | Urban Heat Island |
| USACE | United States Army Corps of Engineers |
| USDA | United State Department of Agriculture |
| USDOT | United States Department of Transportation |
| USGS | United States Geological Survey |
| VSL | Value of Statistical Life |

# Executive Summary

This document constitutes the 2026 update of the Local Hazard Mitigation Plan (LHMP) for the Municipality of Vega Alta, Puerto Rico. The plan identifies natural hazards that may affect the municipality, evaluates risks to people, property, critical facilities, infrastructure, and FEMA Community Lifelines, and establishes mitigation strategies intended to reduce future losses and strengthen community resilience. The plan was prepared in accordance with the Robert T. Stafford Disaster Relief and Emergency Assistance Act, the Disaster Mitigation Act of 2000, and 44 CFR Part 201 through a coordinated effort involving the Municipality of Vega Alta, the Puerto Rico Planning Board, stakeholders, and the public. The update was funded through the Puerto Rico Planning Board and prepared by AtkinsRéalis Caribe, LLP.

**Introduction and Background**

The Municipality of Vega Alta and the Puerto Rico Planning Board updated the LHMP to provide a coordinated framework for reducing hazard-related risks and protecting residents, property, infrastructure, natural resources, and essential services. This document represents the second update of the municipal LHMP. The previous FEMA-approved plan was adopted in 2020. The 2026 update reflects current conditions, updated technical information, revised federal guidance, and mitigation priorities for the next planning cycle while maintaining eligibility for federal mitigation assistance programs.

The primary objectives of the plan are to:

- Identify and evaluate natural hazards threatening the municipality.
- Reduce risks to life, property, critical infrastructure, and community lifelines.
- Promote interagency coordination, public participation, and long-term resilience.

**Public Policy Framework**

The plan is consistent with applicable federal, Commonwealth, and municipal regulations governing hazard mitigation, emergency management, land-use planning, floodplain management, and resilience. Key federal authorities include the Stafford Act, Disaster Mitigation Act of 2000, National Flood Insurance Act, FEMA mitigation planning regulations (44 CFR Part 201), and the National Incident Management System. Relevant Puerto Rico policies include Act 161-2009, Act 33-2019, Act 107-2020, the Puerto Rico Land Use Plan, the Puerto Rico State Hazard Mitigation Plan, and the Puerto Rico Mitigation Action Plan.

**Planning Process**

The 2026 LHMP update was prepared through collaboration among the Municipality of Vega Alta, the Puerto Rico Planning Board, the Planning Committee, stakeholders, and the public. Public outreach included community meetings, public notices, stakeholder coordination, surveys, and opportunities to review and comment on the plan.

Community input identified flooding, drainage deficiencies, landslides, roadway accessibility issues, sinkholes, coastal hazards, and concerns regarding future development as recurring challenges requiring mitigation attention. The plan also incorporates FEMA Community Lifelines to evaluate essential services and identify opportunities to reduce cascading impacts during disasters.

**Municipal Profile**

Vega Alta is located along the northern coast of Puerto Rico and covers approximately 28 square miles. The municipality borders the Atlantic Ocean and includes eight wards(barrios): Bajura, Candelaria, Cienegueta, Espinosa, Mavilla, Maricao, Pueblo, and Sabana. The municipality is characterized by coastal plains, extensive karst formations, caves, sinkholes, wetlands, rivers, and the Cibuco River watershed. These geographic features influence local exposure to flooding, coastal hazards, landslides, tropical cyclones, earthquakes, and other natural hazards.

**Demographics and Social Vulnerability**

According to the U.S. Census Bureau ACS 2020-2024 Five-Year Estimates, Vega Alta has a population of 34,921 residents. Approximately 7,323 residents are 65 years of age or older and more than 7,000 residents are under 19 years of age. Nearly half of the municipal population falls within age groups that may require additional support during emergency response and recovery activities.

Socioeconomic indicators identify additional vulnerability factors including poverty, disability, reliance on food assistance programs, uninsured populations, limited labor-force participation, and households without vehicle access. These conditions can reduce preparedness and recovery capacity following disasters and support the need for targeted outreach and mitigation investments.

**Housing and Infrastructure**

Vega Alta contains more than 17,000 housing units, many of which were constructed before current building code standards. Older housing stock may be more susceptible to the effects of earthquakes, flooding, tropical cyclone winds, and other hazards.

The LHMP evaluates critical infrastructure using the FEMA Community Lifelines framework, including public safety facilities, emergency shelters, healthcare facilities, water systems, transportation infrastructure, communications systems, energy infrastructure, and hazardous materials facilities. Protecting these lifelines remains a priority because disruptions can significantly affect emergency response and recovery operations.

**Recent Development**

Development activity between 2020 and 2026 has remained concentrated in the northern coastal portions of the municipality and around the urban center. Several areas of recent development overlap locations exposed to flooding, tropical cyclone impacts, coastal hazards, and seismic activity. Continued integration of hazard information into permitting land-use decisions, infrastructure design, and capital investments will help reduce future vulnerability.

**Hazard Profiles and Risk Assessment**

The plan evaluates eleven hazards affecting Vega Alta:

- Earthquake
- Landslides
- Tsunami
- Flooding
- Tropical Cyclones and Extreme Winds
- Storm Surge
- Extreme Heat
- Drought
- Wildfire
- Long-Term Coastal Dynamics
- Pandemic/Epidemic

Each hazard assessment examines hazard characteristics, geographic extent, previous occurrences, future probability, vulnerable populations, critical infrastructure exposure, community lifelines, and future development considerations.

**Earthquake**

Earthquake risk affects all 34,921 residents, more than 17,000 housing units, critical facilities, and infrastructure throughout Vega Alta because the municipality is entirely exposed to seismic shaking. Older structures, public buildings, schools, and essential facilities constructed prior to modern seismic standards may be particularly

vulnerable to damage. Significant seismic events have the potential to disrupt all FEMA Community Lifelines simultaneously and impede emergency response and recovery operations. Mitigation priorities include seismic retrofitting of critical facilities, continuity planning for essential services, public preparedness programs, and incorporating current seismic design standards into public and private development projects.

**Landslides**

Landslide susceptibility is concentrated in the municipality's southern and interior sectors where steep slopes and karst formations coincide with residential development and transportation corridors. Heavy rainfall associated with tropical cyclones remains the primary triggering mechanism. Landslides can damage roadways, utility infrastructure, and structures while isolating communities and limiting emergency access. Mitigation priorities include slope stabilization projects, drainage improvements, geotechnical assessments, vegetation management, and land-use controls that discourage development in highly susceptible areas.

**Tsunami**

Tsunami exposure is concentrated along Vega Alta's northern coastal zone, where residential areas, recreational facilities, businesses, transportation infrastructure, and visitors may be affected by inundation. Although only a portion of the municipality is exposed, tsunami impacts can occur rapidly with limited warning time. Maintaining effective evacuation capabilities remains critical. Mitigation priorities include evacuation route improvements, public education and awareness programs, emergency warning systems, evacuation signage, and continued participation in tsunami preparedness initiatives.

**Flooding**

Flooding is one of the most significant hazards affecting Vega Alta. Flood-prone areas are concentrated along the Cibuco River watershed, Quebrada Honda, coastal lowlands, and additional drainage corridors. Flooding threatens residential neighborhoods, businesses, transportation infrastructure, public facilities, and utility systems. Historical flooding events have resulted in recurring damages and service disruptions throughout the municipality. Mitigation priorities include stormwater management improvements, drainage upgrades, floodplain management, culvert enhancements, elevation or protection of vulnerable structures, and continued participation in the National Flood Insurance Program (NFIP).

### Tropical Cyclones and Extreme Winds

Tropical cyclones represent one of the highest-risk hazards because they affect the municipality's entire population of 34,921 residents and all critical facilities and infrastructure. Historical events, including Hurricanes Irma, María, and Fiona, demonstrated the municipality's vulnerability to wind damage, flooding, landslides, storm surge, infrastructure failures, and prolonged utility outages. Tropical cyclones have the potential to affect all FEMA Community Lifelines simultaneously. Mitigation priorities include infrastructure hardening, emergency power improvements, vegetation management, shelter enhancements, and strengthening communications and utility systems.

### Storm Surge

Storm surge primarily affects low-lying coastal portions of Vega Alta, where residential communities, tourism assets, recreational areas, coastal roadways, and public infrastructure are vulnerable to inundation. Significant storm surge events can result in structural damage, transportation disruptions, coastal erosion, and interruption of essential services. Mitigation priorities include coastal resilience planning, evacuation planning, protection of critical facilities, hazard-informed land-use decisions, and preservation of natural protective features such as dunes and coastal vegetation.

### Long-Term Coastal Dynamics

Vega Alta's Atlantic coastline is subject to chronic shoreline change, erosion, and future sea-level rise impacts. Coastal infrastructure, recreational facilities, transportation assets, and private properties may experience increased vulnerability over time. Long-term coastal changes have the potential to increase future flood risks and accelerate infrastructure deterioration. Mitigation priorities include shoreline monitoring, resilient infrastructure design, ecosystem preservation, adaptive land-use planning, and implementation of long-term coastal resilience measures.

### Extreme Heat

Extreme heat affects the entire municipality but poses the greatest risk to vulnerable populations, including approximately 7,323 residents aged 65 years and older, children, individuals with chronic medical conditions, and outdoor workers. Rising temperatures may increase public health risks, place additional demands on energy infrastructure, and disproportionately affect socially vulnerable populations. Mitigation priorities include public awareness campaigns, cooling strategies, emergency response procedures, urban greening initiatives, and targeted outreach to vulnerable populations.

**Drought**

Drought conditions can impact municipal water supplies, agriculture, ecosystems, businesses, and residents throughout Vega Alta. Because water service disruptions affect the entire municipality, drought has the potential to impact all 34,921 residents if prolonged conditions occur. Previous drought events in Puerto Rico have resulted in water conservation measures and supply challenges. Mitigation priorities include water conservation programs, infrastructure improvements that reduce water losses, drought monitoring, alternative water supply planning, and resource management strategies.

**Wildfire**

Wildfire risk is generally concentrated in vegetated and undeveloped areas and may increase during extended periods of drought and high temperatures. Although wildfire exposure is lower than that associated with flooding or tropical cyclones, fires can threaten nearby residences, utility infrastructure, natural resources, and public health. Mitigation priorities include vegetation management, fuel reduction programs, public education initiatives, and enhanced emergency response coordination.

**Pandemic/Epidemic**

Pandemic and epidemic hazards affect the entire municipal population of 34,921 residents because disease transmission is not geographically constrained. Public health emergencies can disrupt healthcare services, schools, businesses, government operations, and economic activity. The COVID-19 pandemic demonstrated the widespread consequences of such events and the importance of preparedness and continuity planning. Mitigation priorities include continuity of operations planning, healthcare coordination, emergency communications, protection of vulnerable populations, and strengthening public health response capabilities.

# 1. Introduction and Background

The Municipality of Vega Alta and the Puerto Rico Planning Board (PRPB) are dedicated to protecting the well-being of Puerto Ricans by fostering cultural, social, and economic growth while prioritizing public health and safety. In this effort, the Municipality and the PRPB have agreed on a joint effort to update the Municipality's Local Hazard Mitigation Plan (LHMP). The LHMP provides a structured and comprehensive approach to reducing risks associated with natural hazards and strengthening overall community resilience. In recent years, Vega Alta has faced considerable impacts from natural disasters, emphasizing the urgent need for proactive actions to reduce vulnerabilities and safeguard critical infrastructure. These experiences highlight the importance of implementing a coordinated and systematic hazard mitigation strategy that is consistent with federal, state, and local policies.

An LHMP identifies and evaluates potential natural hazards and defines actions designed to reduce or eliminate risks to people, property, and the environment. The plan supports the municipality's land use planning efforts by establishing measures that assist Vega Alta in achieving its long-term sustainability and resilience objectives.

This LHMP complies with the requirements set forth by the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) and the federal regulations derived from it. Under this legislation, local governments in states and territories are required to develop and formally adopt a hazard mitigation plan as a condition for eligibility to receive certain types of funding administered by the Federal Emergency Management Agency (FEMA).

Risk mitigation plays a critical role in guiding future development and enhancing existing municipal infrastructure. To ensure an effective mitigation strategy, the LHMP is regularly updated to reassess natural hazards that may threaten the lives and property of residents and to incorporate appropriate and responsive mitigation measures.

This document represents the second revision of the LHMP for the Municipality of Vega Alta. The last LHMP Update plan received FEMA approval on May 1st, 2020 (Autonomous Municipality of Vega Alta, 2020). This 2026 update reflects evolving conditions and circumstances that have influenced the municipality over the past five years and incorporates newly enacted laws, programs, and regulatory requirements. Through this update, Vega Alta aims to preserve its eligibility for federal mitigation funding prior to future catastrophic events and to present a strengthened plan aligned with current standards and best practices.

The development of this plan was conducted through a coordinated process that incorporated input from state and local agencies, non-governmental organizations, and the public. The overarching goal is to enhance the municipality's capacity to anticipate, reduce, and effectively respond to natural hazards that may affect its jurisdiction.

The primary objectives of the LHMP are to:

- Identify and evaluate natural hazards that pose risks to the municipality.
- Establish strategies and actions to reduce or eliminate long-term threats to life, property, and critical services.
- Encourage interagency coordination and promote community involvement in disaster preparedness and mitigation initiatives.

## 1.1 Applicable Public Policies

This section outlines the relevant federal and state public policies that guide the development of the 2026 Vega Alta LHMP. The overview provided is not intended to be comprehensive. Additional public policies are referenced throughout the document, particularly in Section 5.1.

### 1.1.1 Federal Policies

#### *1.1.1.1 Federal Laws*

**Stafford Act and Disaster Mitigation Act of 2000**

The Stafford Act is primarily aimed at reducing loss of life and property, alleviating human suffering, minimizing economic impacts, and lowering the costs associated with disaster assistance. In 1988, Congress amended the Act to create the Hazard Mitigation Grant Program (HMGP), which became the principal source of federal mitigation funding following a disaster declaration by the President of the United States. Through this program, funds are made available to states and territories to implement cost-effective measures that reduce the risk of damage and losses from future hazard events.

**Disaster Mitigation Act of 2000**

Enacted on October 30, 2000, the Disaster Mitigation Act of 2000 (DMA 2000) further amended the Stafford Act to enhance disaster planning, response, and recovery at all levels of government. This legislation establishes eligibility requirements for municipalities to access federal mitigation funding, including the preparation and

adoption of a Local Hazard Mitigation Plan (LHMP). An LHMP demonstrates a jurisdiction's commitment to reducing risks associated with natural hazards and serves as a decision-making tool for implementing preventive and mitigation actions. It also provides a framework for the State to deliver technical assistance and establish funding priorities.

In accordance with DMA 2000 requirements, this LHMP is comprehensive and coordinated, incorporating the participation of state, local, and regional agencies, non-governmental organizations, and members of the public.

**National Flood Insurance Act**

The National Flood Insurance Act established the National Flood Insurance Program (NFIP) to provide affordable flood insurance coverage to homeowners, businesses, and renters located in flood-prone areas. The program was designed to reduce the financial burden on individuals and the federal government in the aftermath of flood-related disasters.

The Act also encourages participating communities to adopt and enforce minimum floodplain management standards aimed at reducing future flood risks. Communities that comply with these requirements become eligible for NFIP benefits and programs.

Access to flood insurance enables property owners to recover more rapidly following flood events without relying solely on federal disaster assistance. Supporting legislation, such as the Flood Disaster Protection Act of 1973, further requires federally regulated lenders to mandate flood insurance coverage for properties located in high-risk flood zones and financed through federally backed mortgages.

The Federal Emergency Management Agency (FEMA) has recognized the Municipality as part of the region that is within the PRPB's coverage within the National Flood Insurance Program. The municipality can request updates and amendments to flood hazard maps utilized by the NFIP through the PRPB.

Additionally, through participation in the Flood Mitigation Assistance Program, the municipality has identified specific mitigation strategies to reduce flood-related risks. Funding has also been allocated for the acquisition of structures located in high-risk flood areas as part of ongoing efforts to decrease vulnerability and exposure to future flood events.

### 1.1.1.2 *Federal Regulations*

**Mitigation Planning – 44 CFR Part 201**

This section of the Code of Federal Regulations describes the rules and procedures governing hazard mitigation planning as mandated under the Stafford Act. It outlines the requirements for the preparation and adoption of mitigation plans, which serve as the primary tool for reducing risks posed by natural hazards at the local level. Additionally, this section establishes the policies and planning processes that guide hazard mitigation efforts, underscoring the role of mitigation plans in directing the effective allocation of resources for disaster risk reduction.

**FEMA Local Hazard Mitigation Planning Guide**

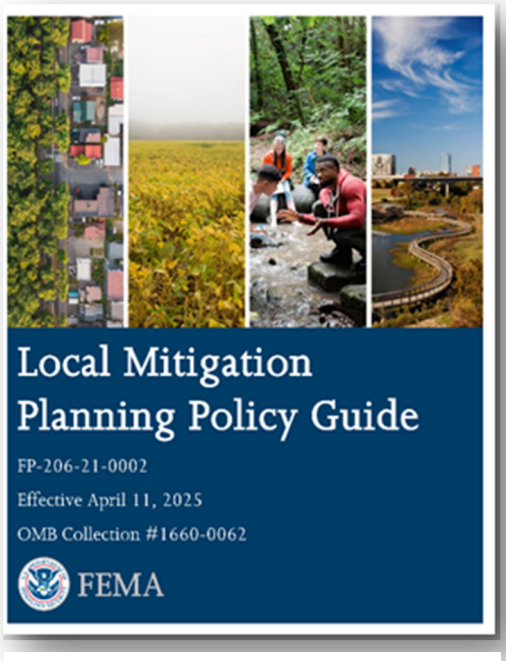



*Figure 1: FEMA Local Hazard Mitigation Planning Guide Cover*

The Local Hazard Mitigation Planning Policy Guide published by FEMA establishes the official framework and guidance that local governments are required to follow when preparing, reviewing, and updating their Local Hazard Mitigation Plans (LHMPs). This guidance is designed to ensure compliance with the requirements set forth in the Code of Federal Regulations (44 CFR Part 201).

The policy guide emphasizes data-driven planning tailored to local capacities, while prioritizing equity and inclusive stakeholder participation. It encourages communities to integrate hazard mitigation into broader planning and decision-making processes, thereby strengthening long-term resilience and reducing vulnerability to natural hazards (FEMA, Local Mitigation Planning Policy Guide, 2025).

The guide identifies the essential components that every mitigation plan is required to address. In addition, it provides practical resources such as resolution templates, checklists, and plan review criteria to support local governments throughout the planning process. The guide also explains FEMA's plan review and approval process, which may result in full approval, conditional approval pending formal adoption, or return of the plan for revisions and corrections.

**Local Mitigation Planning Handbook**

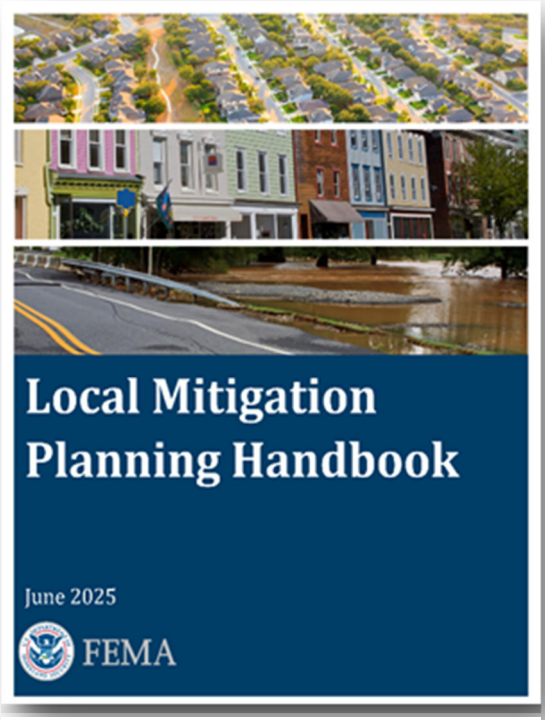



*Figure 2: Cover of FEMA's Local Mitigation Planning Handbook*

The *Local Mitigation Planning Handbook* is an operational resource developed by FEMA to assist local governments, including municipalities and special districts, in the development or update of their Local Hazard Mitigation Plans. This handbook serves as a companion to FEMA's mitigation planning policy guidance and offers a detailed, step-by-step methodology for complying with the requirements outlined in Title 44 of the Code of Federal Regulations, Part 201.

The primary purpose of the handbook is to support communities in identifying the natural hazards they face, evaluating institutional and administrative capabilities, and formulating effective strategies to reduce disaster-related impacts (FEMA, 2025). Ultimately, the handbook promotes the creation of safer and more resilient communities that are better prepared to anticipate, withstand, and recover from adverse events.

**National Disaster Recovery Framework**

The National Disaster Recovery Framework (NDRF) is a guide created by FEMA in the United States that establishes how recovery should be organized and coordinated after a disaster. Its main objective is to help affected communities rebuild in a stronger, more equitable, and more resilient way, involving all levels of government—local, state, tribal, territorial, and federal—along with private and community organizations.

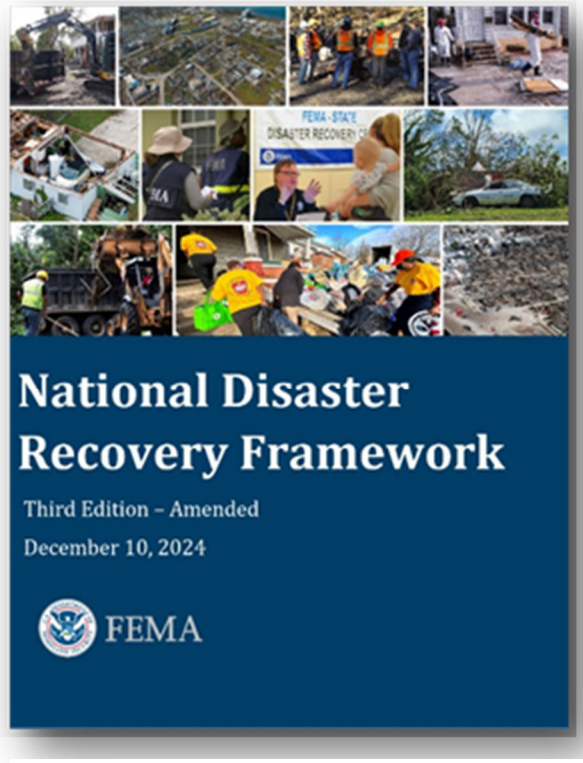



*Figure 3: National Disaster Recovery Framework Cover*

This framework promotes recovery that not only restores what was lost but also improves pre-disaster conditions. To achieve this, the NDRF defines guiding principles, specific roles for the actors involved, and coordination structures that facilitate collaboration among agencies. It also emphasizes the importance of planning before a disaster occurs and ensuring that recovery goals are defined by the affected communities themselves.

**National Flood Insurance Program**

The National Flood Insurance Program (NFIP), administered by FEMA, provides affordable flood insurance coverage to property owners, renters, and businesses while encouraging effective floodplain management practices to reduce future flood risks. Established in 1968, the NFIP supports communities in minimizing flood-related losses by requiring the adoption and enforcement of local floodplain management regulations. The program also offers insurance coverage for both structures and their contents in more than 22,000 participating communities nationwide.

Because most standard homeowners' insurance policies do not cover flood damage, the NFIP plays a critical role in protecting lives and property while reducing long-term disaster recovery costs. Additional information regarding the Municipality of Vega Alta's participation in the NFIP is provided in Section 4.2 of this plan.

**National Earthquake Hazards Reduction Program**

The National Earthquake Hazards Reduction Program (NEHRP) was established under the Earthquake Hazards Reduction Act of 1977 to advance the development, dissemination, and application of knowledge, tools, and practices that reduce risks associated with seismic events. This objective is achieved through coordinated, multidisciplinary, and interagency collaboration among NEHRP's participating federal

agencies and partners, including local jurisdictions such as the Municipality of Vega Alta.

The National Institute of Standards and Technology (NIST), within the U.S. Department of Commerce, serves as the lead agency for NEHRP. The program is further supported by three cooperating federal agencies: the Federal Emergency Management Agency (FEMA), the National Science Foundation (NSF), and the United States Geological Survey (USGS). Each agency contributes expertise and complementary activities related to research, preparedness, mitigation, and public safety.

**National Incident Management System**

The National Incident Management System (NIMS) is a standardized framework developed by the U.S. Department of Homeland Security and administered by FEMA to guide incident management across the nation. Its purpose is to enable effective coordination and cooperation among governmental agencies, private sector organizations, and community-based entities at all jurisdictional levels during the prevention, preparedness, response, and recovery phases of emergencies and disasters.

NIMS establishes a common organizational structure, terminology, and set of processes to ensure seamless coordination regardless of the incident's type, size, or complexity. Core components of the system include resource management, interoperable communications, ongoing preparedness activities, and the Incident Command System (ICS), which defines clear roles, responsibilities, and command structures during emergency operations.

Implementation of NIMS is also a prerequisite for jurisdictions seeking access to certain federal preparedness and response funding. By adopting NIMS, jurisdictions enhance operational efficiency, reduce duplication of efforts, and promote the effective and coordinated use of available resources.

### 1.1.2 Government of Puerto Rico Policies

#### *1.1.2.1 Puerto Rico Laws*

**Act No. 161-2009, as Amended**

Act No. 161-2009, known as the *Puerto Rico Permits Reform Act*, establishes a modern legal and administrative framework designed to comprehensively restructure the Commonwealth's permitting system. The primary goal of the Act is to create a

transparent, efficient, and streamlined process for the submission, evaluation, approval, or denial of permits issued by the Government of Puerto Rico.

To accomplish this objective, the law created the Office of Permits Management (OPM), consolidating permitting responsibilities that were previously distributed across multiple agencies. This centralization reduced procedural delays and improved consistency in the application of permitting standards. The Act also introduced specialized roles—including Authorized Professionals, Permit Managers, Service Representatives, and Permit Officers—each with defined responsibilities intended to expedite reviews and professionalize the permitting process.

A further objective of Act No. 161-2009 is to enhance oversight, accountability, and transparency within the permitting system. By strengthening internal controls and standardizing procedures, the Act seeks to ensure compliance while reducing administrative inefficiencies.

From a public policy perspective, the Act aims to promote economic development while safeguarding environmental protection. Legislative intent emphasizes that an efficient permitting system is essential to attract investment, encourage construction activity, support long-term job creation, and eliminate bureaucratic barriers that previously hindered economic growth. Analyses of the Act also highlight its role in centralizing governmental functions and implementing an Integrated Permitting System to reduce fragmentation, improve interagency coordination, and ensure regulatory uniformity throughout Puerto Rico.

**Act No. 33-2019, as Amended**

Act No. 33-2019 establishes the public policy of the Government of Puerto Rico regarding mitigation, adaptation, and resilience in response to observed variations in temperature and precipitation patterns. The legislation formally recognizes the need for integrated governmental action, including at the municipal level, to address the impacts of environmental instability.

This Act calls for the incorporation of concrete mitigation, adaptation, and resilience measures into territorial and land use planning instruments. By doing so, it promotes a proactive approach that strengthens communities' capacity to withstand environmental stressors and reduces long-term risks to public safety, infrastructure, and natural resources.

**Act No. 107-2020, as Amended**

Act No. 107-2020, as amended, known as the *Puerto Rico Municipal Code*, significantly expands the authority, responsibilities, and operational autonomy of municipal governments. The Code promotes local self-governance and enhances municipalities' capacity to manage their own affairs, including disaster preparedness and risk reduction.

Among the responsibilities granted to municipalities is the authority to design and implement programs and measures to prevent, respond to, and recover from emergencies, natural disasters, catastrophic accidents, and other hazardous events. This expanded role reinforces the importance of municipal governments in protecting public safety and community well-being.

The Municipal Code also grants municipalities enhanced autonomy over land use regulation within their jurisdictions. This authority includes the application of tools such as the transfer of development rights and the evaluation and issuance of construction permits, enabling municipalities to incorporate hazard mitigation principles directly into development decisions. These powers are essential for reducing exposure to natural hazards and safeguarding lives and property.

Overall, the Municipal Code recognizes territorial planning as a critical instrument for risk mitigation and establishes a legal framework that enables municipalities to take proactive, locally tailored actions to protect their communities from natural hazards and other adverse events.

### 1.1.2.2 Puerto Rico Regulations

**Puerto Rico Land Use Plan (PUT-PR by its Spanish acronym) - 2015**




*Figure 4: Puerto Rico Land Use Plan Coversheet*

In compliance with Act No. 550-2004, as amended, the Puerto Rico Land Use Plan (PUT, by its Spanish acronym) constitutes the primary territorial planning instrument prepared by the Puerto Rico Planning Board. The Plan is intended to direct land use, development, and conservation activities throughout the island in a coordinated, sustainable, and resilient manner, guided by a long-term planning horizon of ten (10) years (PRPB, 2015).

One of the primary functions of the Puerto Rico Land Use Plan (PUT) is to classify land throughout the Commonwealth into specific land use categories. Land classification serves as a land administration framework that establishes the types of zoning districts and allowable uses that may be applied to individual parcels. Under the PUT, land is classified according to the following scheme:

- Urban Land (SU, by its Spanish acronym):

  This category includes areas that are already developed and served by the necessary infrastructure and public services.

- Land for Development:

  This classification applies to land identified as suitable for future development and is subdivided into two categories:

  - Programmed Development Land (SUP, by its Spanish acronym): Land scheduled for development under established programs or plans.

- Non-Programmed Development Land (SUNP, by its Spanish acronym): Land available for development that has not yet been assigned to a specific development program.

- Rustic Land:

  Rustic lands are designated for protection, conservation, or limited use due to their environmental, agricultural, or ecological value. This classification is further subdivided into:

  - Common Rustic Land (SRC, by its Spanish acronym): Areas suitable for limited, low-intensity uses.

  - Specially Protected Rustic Land (SREP, by its Spanish acronym): Areas subject to heightened protection due to their environmental, natural, or cultural significance.

The PUT-PR aims to coordinate and harmonize land use planning efforts among state agencies and municipalities. It serves as the foundation for the preparation of municipal Land Use Plans (Planes de Ordenación Territorial, POT, by its Spanish acronym), which are adopted for an eight-year planning period (PRPB, 2015).

Currently, the PUT-PR is in the process of being updated for the 2026 -2032 planning cycle. This revision will incorporate robust citizen participation, clearly defined compliance and performance metrics, and an inclusive planning approach that integrates economic development, green infrastructure, sustainable transportation systems, and the conservation of natural resources.

**Puerto Rico State Natural Hazard Mitigation Plan (2026)**

Similar to requirements for local jurisdictions, the Stafford Act mandates that states and territories develop a hazard mitigation plan covering their entire jurisdiction. In the

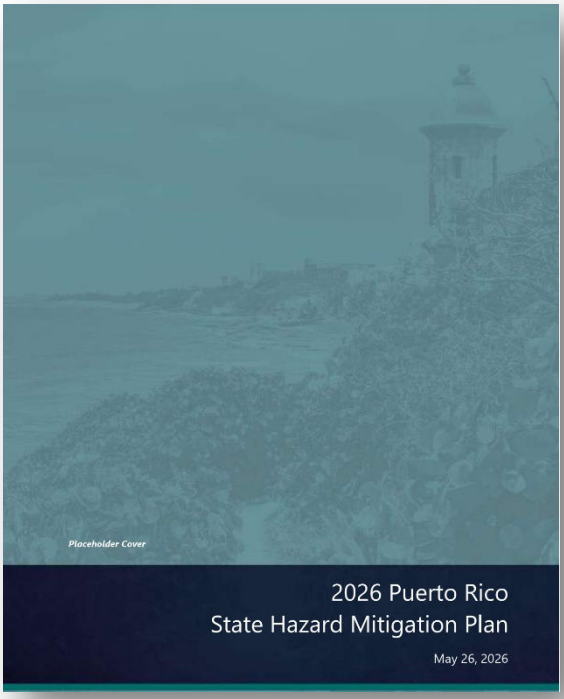



*Figure 5: Puerto Rico SHMP Cover*

case of Puerto Rico, the most recent State Hazard Mitigation Plan was completed in 2026. The Puerto Rico 2026 State Hazard Mitigation Plan outlines long-term strategies to address natural hazards that have the potential to disrupt daily activities, damage property, and threaten human life. These hazards—which in many cases are intensified by changing environmental conditions—can escalate into disasters that affect not only individuals, but entire communities, with wide-ranging impacts on public health, infrastructure, economic stability, and natural ecosystems (NMEAD, 2026).

This plan provides a comprehensive framework for identifying risks and implementing actions aimed at reducing vulnerability to these hazards. Through its emphasis on mitigation, the plan seeks to enhance community resilience, safeguard critical infrastructure and systems, and promote sustainable development across Puerto Rico (NMEAD, 2021).

The Municipality of Vega Alta reviewed the Puerto Rico 2026 State Hazard Mitigation Plan during the preparation of this LHMP update. Relevant risk profiles, state capabilities, mitigation goals, and relevant state actions were considered during the risk assessment, capacity assessment, and development of the municipal mitigation strategy.

**Puerto Rico Mitigation Action Plan, CDBG-DR MIT (2021, 2025)**

Originally approved by the U.S. Department of Housing and Urban Development (HUD) in 2021 and subsequently amended in August 2025, the Puerto Rico Mitigation Action Plan for the Community Development Block Grant–Mitigation (CDBG-MIT) Program is a strategic planning document prepared by the Puerto Rico Department of Housing (DV). The plan establishes the framework for the administration and management of federal mitigation funds allocated by HUD under the CDBG-MIT program

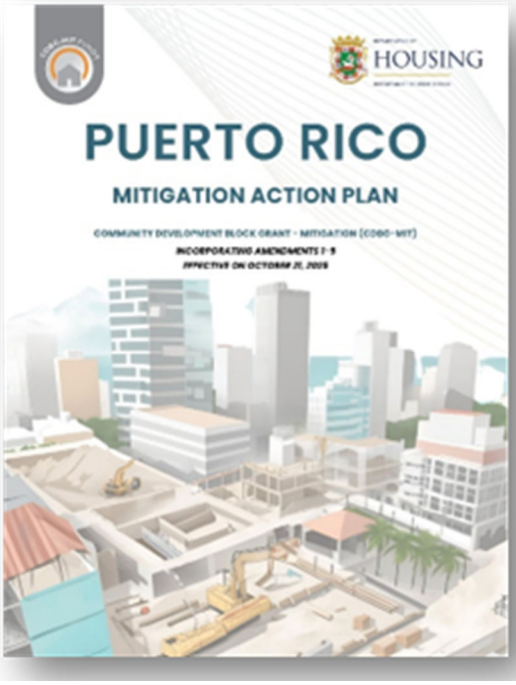



*Figure 6: Puerto Rico Mitigation Action Plan, CDBG-DR MIT Cover*

Its primary objective is to reduce risks and vulnerabilities to future disasters by enhancing the resilience of infrastructure, communities, and critical systems. Although these funds were appropriated by Congress to Puerto Rico following Hurricanes Irma and María in 2017, CDBG–MIT funding differs from CDBG–Disaster Recovery (CDBG-DR) in that it is specifically focused on preventing and mitigating future impacts. Accordingly, CDBG-MIT resources are directed toward sustainable, high-impact mitigation projects and are not required to be directly linked to disaster recovery activities associated with those hurricanes (PRDOH, 2025). This plan is designed to reduce exposure to hazards, safeguard lives and property, and enhance emergency response capabilities through targeted investments in infrastructure, housing, and land-use planning (PRDOH, 2025)

Other relevant planning regulations will be discussed as part of subchapter 5.1

### 1.1.3 Municipal Policies




*Figure 7: Vega Alta Local Hazard Mitigation Plan*

**Vega Alta Local Hazard Mitigation Plan (2020)**

Adopted by the Municipality on 2020, this is the most recent Hazard Mitigation Plan for the Municipality of Vega Alta . The identified hazards are divided into natural and anthropogenic.

Public participation was key in developing the plan. A total of 407 forms were collected, revealing that 72% of respondents had experienced hurricanes, 12% droughts, and 9% floods. The most vulnerable infrastructure identified by the population was the potable water system, followed by the electrical grid. Citizen priorities include strengthening emergency services, protecting private property, and safeguarding critical infrastructure.

Some of the mitigation strategies proposed by this plan are:

- **Flooding:** Projects include drainage improvements and flood control projects in the municipality's most flood-prone areas to reduce repetitive damages to infrastructure and properties.
- **Landslides:** Identify, evaluate, and relocate residents from high-risk landslide areas where mitigation is not feasible.
- **Strong Winds / Hurricanes:** Retrofit critical facilities with protective measures such as generators and storm shutters to maintain essential services after major storms.
- **Earthquakes / Liquefaction:** Enforce building codes and assess vulnerable structures to improve seismic resilience.
- **Tsunami:** Restrict future development in tsunami evacuation zones and promote community preparedness programs.
- **Coastal Erosion:** Protect and restore coastal natural features to reduce shoreline loss and protect nearby assets.

- **Storm Surge:** Limit development in coastal hazard areas and incorporate storm surge risk into land use planning.
- **Drought:** Promote water conservation and protect critical groundwater and water supply resources.
- **Wildfire:** Develop and maintain a wildfire risk inventory while expanding public education and prevention efforts.

## Vega Alta Municipal Recovery Plan




*Figure 8: Vega Alta Municipal Recovery Plan Cover*

As part of the CDBG-DR funds assigned by Congress to Puerto Rico in the aftermath of hurricanes Irma and María, municipalities were able to develop a recovery plan to guide recovery efforts and resiliency in the event of future stressors. In essence the Municipal Recovery Plans:

- Identify local post-disaster needs created or worsened by Irma and María
- Establish short-, medium-, and long-term recovery priorities
- Integrate resilience and hazard mitigation strategies
- Serve as a policy and project roadmap for future funding decisions

Each Municipal Recovery Plan has a list of recovery and resiliency projects that might be considered as new mitigation strategies for the LHMP.

## 1.2 Scope and Previous Versions

### 1.2.1 Primary Objectives

The primary objectives of the LHMP are to:

- Identify and assess natural hazards that pose a risk to the municipality.
- Develop strategies and actions to reduce or eliminate long-term risks to life, property, and essential services.
- Promote interagency coordination and community engagement in disaster preparedness and mitigation efforts.

### 1.2.2 Previous FEMA Comments

The following recommendations and requirements were made by FEMA upon approving the previous 2020 LHMP for Vega Alta.

*FEMA Comment*

**Element A3**. "Kudos to the Municipality of Vega Alta, the Mitigation plan provides evidence of public documents like local newspaper clippings, Facebook promo, letters to regulated agencies leads, municipal mayors and State official staff. **For next update of this plan** considered involving more the local media to help increase awareness and public participation. Publishing documents on the internet will allow more people to participate. Could consider for the next update include a list of comments from all stakeholders, including the public. This information will provide specific guidance for the next update plan. The process can consist of meetings with associations of owners and public representation on several boards and councils of the community, and the Vega Alta jurisdiction. Consider including a paper letter in the plan will show that the plan was placed in public libraries with other notice of preparedness of hazards and comments that were received and incorporated. Excellent work!"

*Municipality Response*

Social Media was used to promote public engagement. Letters to specific community organizations were sent as part of the outreach effort. Copy of the letters will be included in Appendix D.

*FEMA Comment*

**Element E1.** "The jurisdiction approved the Municipal Ordinance number 12, series 2019 – 2020 on March 12, 2020. That Municipal Ordinance adopts the Mitigation Plan for

Municipality of Vega Alta. Municipal Ordinance should be incorporated to the Plan when final version is submitted to FEMA."

Municipality Response

Copy of the Ordinance was included as part of Appendix A in the 2020 LHMP.

## 1.3 LHMP Organization

Table 1 shows the layout for the 2026 of Vega Alta LHMP. To help LHMP reviewers and the public understand compliance, the table includes a column specifying which FEMA-required element (FEMA, 2025) is addressed by each section.

*Table 1: LHMP Organization*

| Chapter # | Title | Description | Review Tool<br><br>Elements met |
|---|---|---|---|
| N/A | Executive Summary | This section summarizes the most important findings from the planning process and explains how they are addressed in the LHMP. | Local Element |
| Chapter 1: | Introduction | This chapter discusses the planning background for Vega Alta It explains the organization of the LHMP and the most significant changes in the 2026 version compared to the 2020 version. It also addresses the public policies relevant to the update of the LHMP, and the planning process followed, including citizen participation and stakeholder involvement. | E2-a, A1-a, A1-b, A4-a, A2-a, A3-a |
| Chapter 2 | Municipal Profile | The municipal profile describes the municipality's relevant characteristics, including physical features, infrastructure, and | E1-a |

| Chapter # | Title | Description | Review Tool Elements met |
|---|---|---|---|
| | | demographic and socioeconomic traits. | |
| Chapter 3 | Hazard Profiles and Risk Analysis | This section is the most extensive in the plan. It covers the hazards identified for Vega Alta and examines the risks associated with each one. | B-1a, B-1b, B1-c, B1-d, B-e, B2-a, B2-b, E1-a |
| Chapter 4 | Mitigation Capabilities | This chapter elaborates on the municipality's capabilities to implement the mitigation strategies that will be proposed in Chapter 6. | C1-a, C-1b |
| Chapter 5 | Mitigation Strategies | This chapter establishes the mitigation goals of the Plan and the actions the municipality will take to reduce the risks associated with the identified natural events. It also serves to update the status of the mitigation actions included in the 2020 Plan. | C3-a, C4-a, C4-b, C5-a, C5-b, E2-b |
| Chapter 6 | Plan Maintenance | This chapter addresses the process for evaluating the effectiveness of the plan. It also explains the procedure for making modifications or updates to the plan. | D1-a, D2-a, D2-6, D2-c, E2-c |
| Chapter 7 | Adoption and Approval | This section includes information on the adoption of the plan by the municipality, FEMA's approval, and the expiration date of the 2026 Local Hazard Mitigation Plan. | F1-a, F1-b |
| N/A | References | This section presents the sources used in updating the plan. | A4-a |

| Chapter # | Title | Description | Review Tool<br><br>Elements met |
|---|---|---|---|
| N/A | Appendixes | This section includes all appendices and supplementary information related to the planning process of the Plan. | |

## 1.4 Changes to the Vega Alta LHMP (E2-a)

Table 2 shows the most significant changes that the 2026 version has from the 2020 version.

*Table 2: Changes to the Vega Alta LHMP*

| Element | Justification |
|---|---|
| Plan Language | Following Presidential Executive Order #14224, the 2026 version of Vega Alta LHMP has been originally prepared in English for submission and consideration of FEMA. An official translation of the final draft for public discussion and the final approved LHMP to Spanish will be prepared for the benefit of the population that are not English proficient. |
| Plan organization | The organization and chapters of the document have been modified to follow the template used in local mitigation plans prepared by the Puerto Rico Planning Board. However, this template has been adapted in the current plan to comply with current federal public policy. |
| Discussion of FEMA Lifelines | As per the Local Hazard Mitigation Policy, FEMA Lifelines are discussed as well as the strategies to mitigate hazard impacts on them. |
| Elimination of non-applicable public policy | For clarity and better readability, references to redundant public policy gaps have been removed. |
| Change to the name of hurricane: hazard | The hazard identified in the 2020 Plan as “hurricane” has been changed to “Extreme winds” to include wind events that are not necessarily associated with a hurricane or tropical storm. |
| Update of census data | The municipality and PRPB have chosen to use the most recent version of the American Community Survey for evaluating demographic data. In this case it has chosen to evaluate the data sets from the 2024 five-year American community survey. The five-year survey is chosen since there is more information in them than in the one-year survey. If any other dataset is used, it will be indicated in a footnote. |

| Element | Justification |
|---|---|
| Action Plan | The tables of mitigation strategies that were in different sections in the 2020 Plan are now located in a single section (section 6.2). The table format has been modified to be easier to read, and several columns have also been added to provide valuable information for the reader. |
| All the LHMP | Attention has been given to ensure that the content of the Plan does not reveal any personally identifiable information (PII). |

# 2. Planning Process

## 2.1 Planning Process Regulation

This LHMP was updated following the above-mentioned applicable public policies and procedures mentioned in Chapter 1.

This LHMP seeks to aid municipality in the task of preventing loss of life and property by the effects of natural hazards. Chapter 1 serves as a general introduction, Chapter 2 discusses the planning process followed, as well as stakeholder and public participation involvement. The LHMP identifies a general profile of the municipality using information provided by the US Census, such as population distribution, employment, housing stock, etc. (see Chapter 3 for more information). After describing the Municipality general profile, the Plan goes on to evaluate all identifiable natural hazards that can affect the municipality and its population, including the effects on lifelines, properties, population exposure, natural resources, etc. (see Chapter 4 for more information).

Chapter 5 defines the capabilities that the municipality has for implementing the LHMP. While Chapter 6, establishes the mitigation actions that the municipality will execute for the next five years. Chapter 7 discusses the provisions for LHMP Maintenance and Chapter 8 discusses the adoption and approval of the LHMP. The various appendixes hold supporting information.

## 2.2 History of the LHMP

The first Updated LHMP revision was completed in July 2012, and a second revision was approved in 2020 (Municipality of Vega Alta, 2020). This new 2026 version responds to changes in conditions and circumstances that have affected the municipality over the past five years. It also reflects changes based on updated FEMA Guidelines published in 2025.

## 2.3 Plan Preparation, Revision Schedule and Methodology (A1-A)

Following Federal Law, Local Hazard Mitigation Plans must be updated every five (5) years in order for the municipality to remain eligible for federal mitigation funding. To

prepare the 2026 LHMP, the Municipality hired AtkinsRéalis Caribe, LLP as an external consultant to provide professional mitigation planning services.

The Municipality followed the natural hazard mitigation planning process as established by FEMA in the Local Hazard Mitigation Planning Guide and the Local Hazard Mitigation Planning Handbook, as well as the recommendations provided by the mitigation planning staff of COR3. The Local Mitigation Plan Review Tool provides a summary of FEMA's current minimum standards to comply with mitigation planning requirements and identifies where each requirement is addressed within this Plan.

The planning process for the 2026 update of the Vega Alta LHMP begun officially on with the kick – off meeting between the Municipality's Mayor and the PRPB staff held on December 16, 2025. An official letter of agreement between the municipality and the PRPB was signed on 12/16/2025 . Copy of the letter of agreement can be found in Appendix B. Later a consulting firm, AtkinsRéalis Caribe LLP, was retained by the PRPB to support the mitigation planning efforts.

The revision phase reached completion upon the official delivery of the final draft to the State Hazard Mitigation Officer (SHMO), within the Central Office for Recovery, Reconstruction and Resiliency (COR3), on Click or tap to enter a date. The revision process lasted ___ days.

## 2.4 Planning Committee (A1-a, A1-b)

To support the revision of the Vega Alta LHMP, a Planning Committee was established, comprised of representatives from several municipal dependencies who were designated to guide the process. The members of the Committee are:

*Table 3: LHMP Planning Committee*

| Name | Position & Office | Email | Contact Number |
|---|---|---|---|
| Elsie J. Rosario Nieves | Director, Planning Office | erosario@vegaalta.pr.gov | 787-883-5900 x 1239 |
| Elizabeth Otero Martínez | Director, Federal Programs Office | eotero@vegaalta.pr.gov | 787-883-5900 x 1244 |
| Samuel Negrón Pérez | Geographic Information System, | snegron@vegaalta.pr.gov | 787-883-5900 x 1298 |

| Name | Position & Office | Email | Contact Number |
|---|---|---|---|
| | Technical Specialist | | |
| Miguel A. Navas Flores | Director Emergency Management Municipal Office | manvas@vegaalta.pr.gov | 787-883-5900 x 2143 |
| Ramón Pabón Martínez | Municipal Police Commissioner | rpabon@vegaalta.pr.gov | 787-883-5900 x 2123 |
| Angel Figueroa Medina | Chief Financial Officer | angelfigueroa@vegaalta.pr.gov | 787-883-5900 x 1501 |
| Leyna Huertas | Municipal Consultant | lhuertas@mcg-pr.com | 787-777-8044 |

The designation letter for the Planning Committee is included in Appendix B. This appendix also compiles the meeting minutes, documentation of the materials discussed throughout the process, and accompanying photographic evidence.

## 2.5 Citizen Participation (A3-a)

### 2.5.1 Community Outreach and Public Participation Strategies

The public participation approach selected for this LHMP revision incorporated the following activities:

- **Distribution of notification letters** to agencies, neighboring municipalities, community leaders, nonprofit organizations, neighborhood associations, business or industrial groups, and other interested stakeholders, informing them that the LHMP revision process had commenced and inviting their input. Documentation of these communications is included in Appendix D.

- **Publication of notices on the Municipality's website and official social media platforms** to inform the public that the LHMP revision was underway. These postings also provided an email address for submitting comments and made available a virtual survey to gather information regarding the community's

experiences with natural hazards. Evidence of these public notices is also maintained Appendix C.

- **Convening an initial community meeting** to introduce the LHMP revision process. This step involved:
    - Issuing a public announcement in a newspaper, on the Municipality's website, and across official social media channels at least 15days before the meeting.
    - Providing notice of an additional 15-day period for the public to submit comments or suggestions via email or in person at a specified location.

- **Holding a second community meeting** to discuss hazard assessment and analysis with the public and present the draft LHMP for public review and discussion. This stage included:
    - Publishing a newspaper announcement and posting notices on the Municipality's website and official social media outlets at least 15 days before the meeting.
    - Confirming in the announcement that the draft plan was available for review in printed and online versions.
    - Providing notice of an additional 15-day period for the public to submit comments or suggestions via email or in person at a specified location.

### 2.5.2 Community Outreach and Public Participation Results

**First Public Meeting Results**

A public meeting notification announcing the initiation of the LHMP update process was published on 2/13/2026 via a local newspaper called "Primera Hora" (See Appendix C). The notification informed the public that the meeting would be held on 2/24/2026 in Municipality's Reception Room, PR-2 Km 30.5 at 5:00pm. During this meeting, participants expressed and identified several risk areas during the map exercise (see maps on appendix C):

- **Machuchal Sector:** Flooding occurs in this area, although it is not shown on the official flood maps.
- **PR-630 at the intersection with PR-677:** Landslide risk is high and can isolate adjacent communities. Caves and sinkholes were also identified in the northern portion of Bajura Ward and marked on the landslide map.

- **Cerro Gordo:** Concerns were expressed regarding potential new development projects planned for the area that could impact natural resources and affect the area's hydrology.

In response, the Municipality implemented several measures to address the issues raised by the community. Appendix C includes the notes documented by the planning consulting firm during the activity, along with supporting evidence. All documentation complies with PII protection requirements.

- Machuchal Sector – Floodings in this sector is addressed in Mitigation Strategies PE-8

**Second Public Meeting Results**

A public meeting notification to present the draft of LHMP was published on Click or tap to enter a date. via _____. The notification informed the public that the meeting would take place on Click or tap to enter a date. in _____ at _____. It also stated that a printed copy of the draft LHMP would be available at _____ during regular work hours. Additionally, the public had the option of accessing the draft LHMP through the webpage _____. Copies of the public notification are included in Appendix C.

During this meeting, participants expressed the following concerns: _____

The Municipality took the following measures to address these citizen concerns: _____. Appendix C includes the notes documented by the planning consulting firm during the activity, along with supporting evidence. All documentation complies with PII protection requirements.

## 2.6 Stakeholder involvement (A2-a)

The Municipality carried out outreach efforts to external stakeholders, including government agencies and neighboring municipalities, through formal correspondence addressed to agency heads and mayors. Copies of these invitation letters are provided in Appendix D. Stakeholders were encouraged to submit input either via email or by participating in the public involvement process.

Input from internal stakeholders was obtained through the Planning Committee. Appendix D also includes any written responses or correspondence received from stakeholders during this outreach process.

## 2.7 Hazard Analysis Data Sources

The following table presents the datasets utilized for the evaluation of each hazard. Table 4 identifies the hazards considered in this LHMP and the corresponding data sources used to support their assessment.

*Table 4: Hazard and Risk Assessment of Data Sources*

| Hazard | Data Sources |
|---|---|
| Earthquake | USGS, FEMA |
| Landslides | USGS |
| Tsunami | NOAA, FEMA |
| Flooding | FEMA |
| Tropical Cyclone/Extreme Winds | FEMA |
| Extreme Heat | National Oceanic and Atmospheric Administration (NOAA) |
| Drought | National Drought Mitigation Center, North American Drought Monitor (NADM) |
| Long – Term Coastal Dynamics | NOAA, UPR- COREPI |
| Pandemic/Epidemic | PR Department of Health |

## 2.8 FEMA Lifelines

The *Local Mitigation Planning Handbook* and the *Local Hazard Mitigation Planning Policy Guide* highlight the importance of integrating critical lifelines into the hazard mitigation planning process. FEMA defines lifelines as essential services that sustain public safety, economic stability, and the continuity of government and daily life before, during, and after an emergency or disaster. These lifelines serve as a framework for prioritizing resources and actions that are essential to reducing loss of life and property and supporting efficient and rapid recovery following hazard events (FEMA, 2023).

FEMA identifies eight (8) primary lifelines:

- **Safety and Security:** Includes law enforcement, fire services, search and rescue operations, government services, and community safety functions.
- **Food, Hydration, and Shelter:** Encompasses food systems, water access, emergency shelter, and agricultural resources.
- **Health and Medical:** Includes medical care, public health services, patient movement, medical supply chains, and healthcare facility management.
- **Energy:** Covers the electrical power grid and fuel supply systems.
- **Communications:** Includes communications infrastructure, responder communications, alert and warning systems, financial services, 911 operations, and emergency dispatch.
- **Transportation:** Encompasses highways, motor vehicle systems, mass transit, railways, aviation, and maritime transportation.
- **Hazardous Materials:** Includes facilities and systems associated with hazardous materials, pollutants, and contaminants.
- **Water Systems:** Includes potable water infrastructure and wastewater collection and treatment systems.

Each of these lifelines is supported by sub-lifelines that allow jurisdictions to more precisely identify vulnerabilities and prioritize recovery actions. Together, they enable emergency managers and decisionmakers to rapidly assess conditions, focus response operations on the most critical needs, and coordinate actions that directly affect human life and community stability.

By monitoring the status and functionality of lifelines, jurisdictions can respond more effectively during emergencies, minimize cascading impacts, and accelerate more resilient recovery. A detailed discussion of lifelines and their relevance to the Municipality of Vega Alta is provided in Section 4.5.

# 3. Municipal Profile

The Municipality of Vega Alta is a coastal municipality located in northern part of Puerto Rico. Vega Alta is bordered by the Atlantic Ocean to the north, the municipalities of Morovis and Corozal to the south, Dorado and Toa Alta to the east, and Vega Baja to the west. Map 1 shows the municipality of Vega Alta and adjacent municipalities. Map 2 shows the wards (barrios) into which Vega Alta is subdivided.

## 3.1 Data Sources for Municipal Profiles

The Vega Alta LHMP has been updated using the most current demographic and socioeconomic data available. Municipal profiles and risk assessments rely primarily on the 2020–2024 Five-Year estimates from the American Community Survey (ACS). When specific information is not available through the ACS, alternative data sources are identified and cited in the corresponding footnotes.

In addition, the plan reflects the most up-to-date knowledge on hazards and mitigation practices. References to relevant plans, studies, and technical reports are provided in page-level footnotes and consolidated in the References section.

GIS layers included in Chapter 3 were mostly provided by the PRPB's GIS Office.

## 3.2 Brief Historical Background

Vega Alta was officially founded on June 19, 1775, by Francisco de los Olivos and later received Royal approval in 1779. The municipality developed along the fertile lands surrounding the Cibuco River, an area that was originally part of the Indigenous Taíno territory associated with Cacique Guacabó. Early settlers relied on cattle ranching, agriculture, and limited gold extraction from the river, establishing the economic foundations that supported the growth of the community.

Throughout the nineteenth century, Vega Alta evolved from a small rural settlement into an established agricultural town. Farming and livestock production dominated the local economy, with rice, corn, coffee, and other crops cultivated for both local consumption and trade. As the sugar industry expanded across Puerto Rico, sugarcane became increasingly important in Vega Alta, shaping the municipality's landscape, economy, and social development for generations.

The municipality's cultural identity remains closely tied to its agricultural heritage, coastal environment, and strong community traditions. The town continues to celebrate its heritage through annual cultural events and festivals, including the Carnaval Vegalteño, the Festival del Panapén, and festivities honoring the Immaculate Conception, the municipality's patron saint.

During the twentieth century, Vega Alta transitioned from a predominantly agricultural economy to a more diversified community with industrial, commercial, and service-sector employment. Despite modernization, the municipality has preserved many of its historical traditions and cultural landmarks, maintaining a strong sense of place rooted in its colonial origins, sugarcane legacy, and community values.

### 3.2.1 Geography

Vega Alta is a municipality located on the northern coast of Puerto Rico, approximately 19 miles (30 kilometers) west of San Juan within the Island's Northern Coastal Plain region. The municipality encompasses approximately 28 square miles and is characterized by a combination of coastal lowlands, karst topography, rolling hills, and riverine areas associated with the Cibuco River watershed.

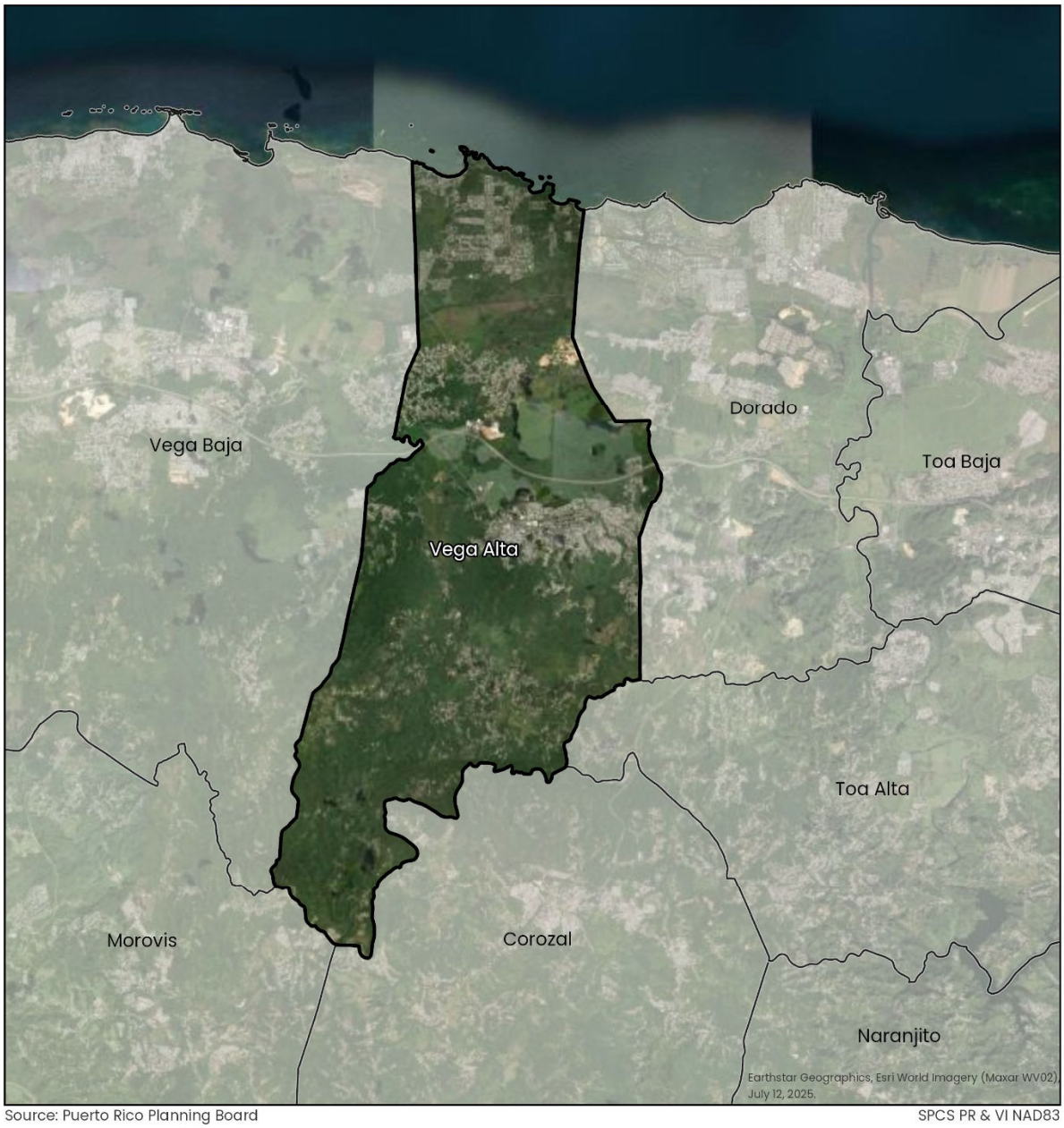
Its strategic location within Puerto Rico's northern region has contributed to its historical development as an agricultural community and, more recently, as a suburban municipality linked to the San Juan metropolitan area. Much of the terrain consists of relatively flat coastal lands that gradually rise toward the southern portion of the municipality, where elevations become more pronounced as they transition into the Northern Hill Region. This variation in elevation contributes to the diversity of natural landscapes found throughout Vega Alta.

The municipality is traversed by several waterways, including the Cibuco and Mavilla Rivers, and contains important natural resources such as coastal areas, forests, caves, and karst formations that contribute to its environmental and cultural significance. These geographic characteristics also influence the municipality's vulnerability to natural hazards, including flooding, hurricanes, coastal storms, and erosion.

Vega Alta is administratively divided into eight wards: Sabana, Bajura, Espinosa, Pueblo, Candelaria, Mavilla, Maricao, and Cienegueta (Map 2).

*Map 1:* Vega Alta *and Adjacent Municipalities*

# Geographic Area




Source: Puerto Rico Planning Board

SPCS PR & VI NAD83

Municipality of Vega Alta
Neighboring Municipalities

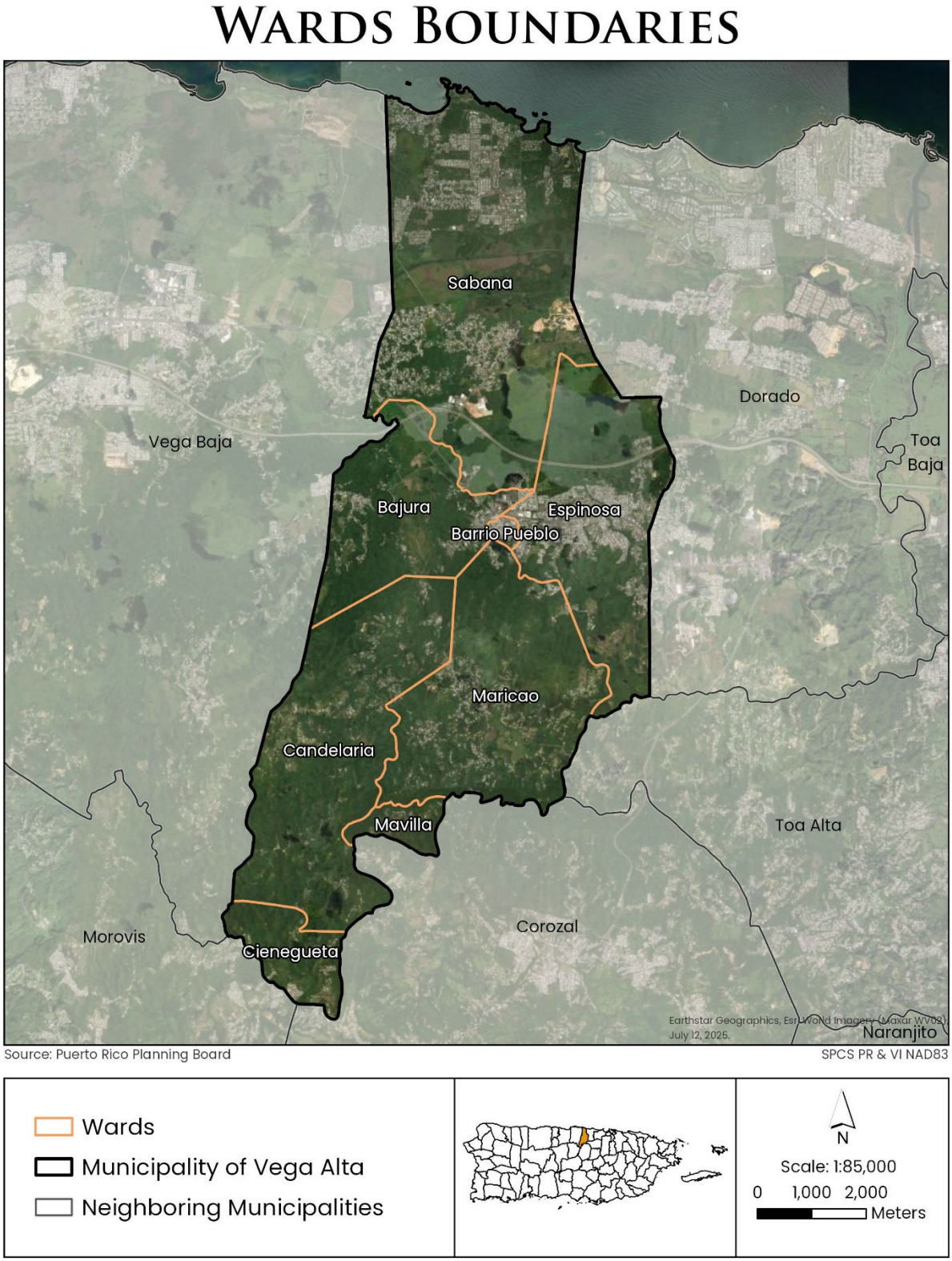


N

Scale: 1:110,000

0 1,500 3,000 Meters

*Map 2: Vega Alta – Wards Subdivision*



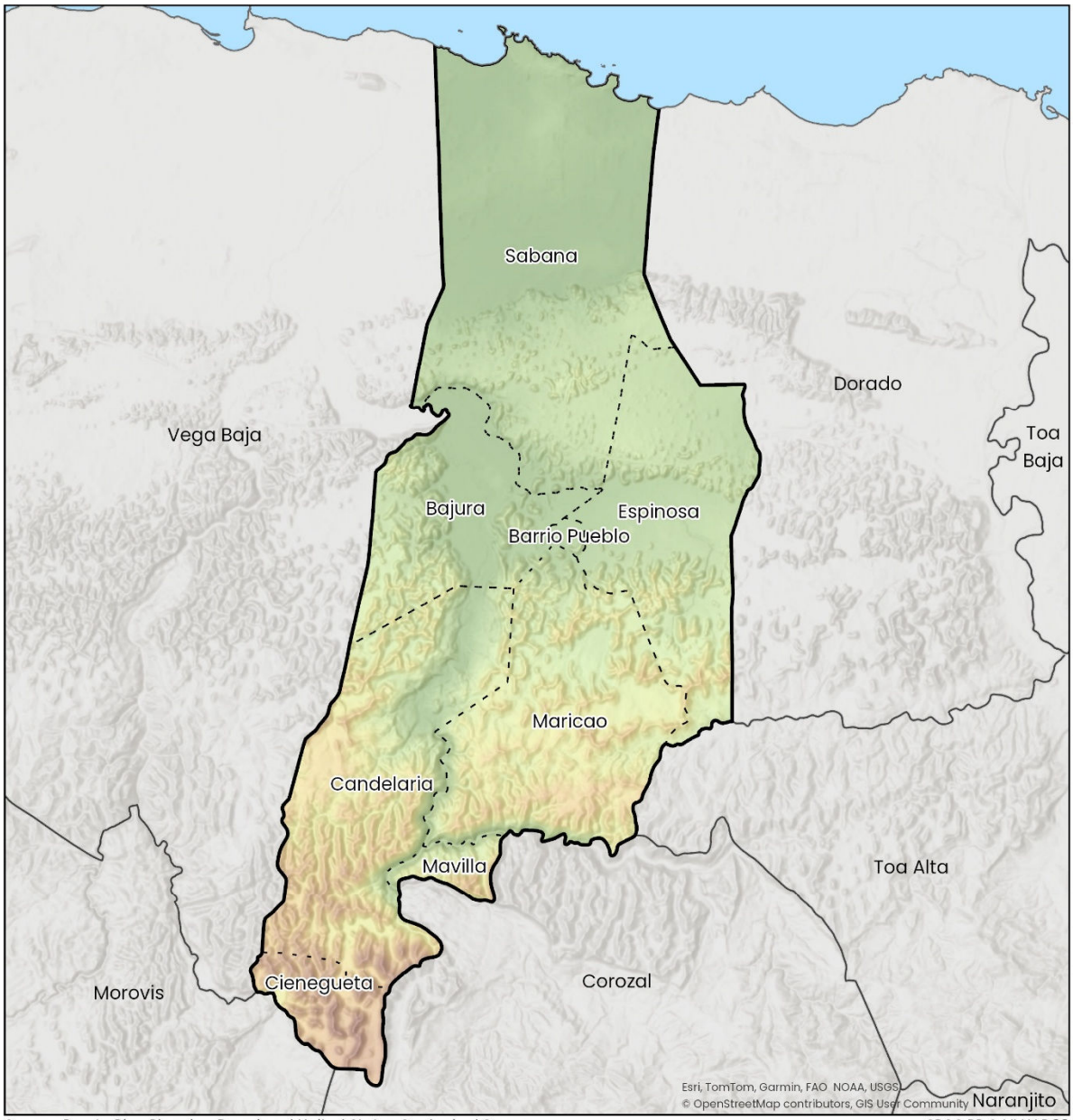
### 3.2.2 Physiography

Vega Alta is situated within Puerto Rico's Northern Coastal Plain and extends into portions of the Northern Karst Region. The municipality exhibits a diverse landscape composed of relatively flat coastal areas, gently rolling terrain, limestone hills (mogotes), sinkholes, and depressions formed through long-term dissolution of carbonate rocks. Elevations generally increase toward the southern portion of the municipality, where the terrain transitions into the Northern Hills region. This physiographic setting influences drainage patterns, groundwater movement, land development, and natural hazard susceptibility. As a result, the municipality contains numerous mogotes (steep-sided limestone hills), sinkholes, caves, and closed depressions that are among its most distinctive natural features. Notable cave systems, including the Santa Rosa-Monserrate cave network, reflect the area's complex underground hydrology and geological history.

Karst physiography is present throughout the municipality, and in addition to the physical characteristics previously described, the Municipality is also an essential part of the Northern Aquifer. The Northern Aquifer is composed primarily of limestone and karst formations, which provide excellent capacity for groundwater storage and conveyance. These characteristics make it an important source of water for domestic, agricultural, and industrial uses throughout the region. Other natural areas within the municipality include Bosque La Vega and Ciénega Prieta, which contribute to Vega Alta’s natural attractions and the diversity of flora found throughout the municipality.

*Map 3: Vega Alta Physiography*

# PHYSIOGRAPHY




Source: Puerto Rico Planning Board and United States Geological Survey

SPCS PR & VI NAD83

Elevation (Meters)

301.213

-7.76789

Wards

Municipality of Vega Alta

Neighboring Municipalities



N

Scale: 1:85,000

0 1,000 2,000

Meters

### 3.2.3 Geology

The municipality is underlain primarily by limestone formations that were deposited millions of years ago when much of northern Puerto Rico was covered by shallow marine environments. Over time, the gradual dissolution of these carbonate rocks by rainfall and groundwater created the characteristic karst landscape that defines much of Vega Alta today.

This geologic process has produced a variety of landforms, including limestone hills known as *mogotes*, sinkholes, caves, underground drainage systems, and closed depressions. These features are common throughout the municipality and contribute to both its scenic beauty and environmental significance. The extensive cave and groundwater systems found within the northern karst region are among the most important natural resources in Puerto Rico, serving as critical areas for groundwater storage and aquifer recharge.

The dominant geologic units in Vega Alta include the Aguada and Aymamón Limestone formations, which are widely distributed across Puerto Rico's northern coastal region. These formations weather differently from other rock types, resulting in a highly variable terrain with both surface and subsurface drainage features. Because water can infiltrate rapidly through fractured limestone, much of the municipality's hydrology is closely linked to its underlying geology.

The municipality's geologic setting has important implications for land use planning and hazard mitigation. While the karst landscape supports valuable ecological resources and groundwater supplies, it may also increase susceptibility to hazards such as localized flooding, sinkhole formation, and groundwater contamination. Understanding these geologic characteristics is therefore essential for guiding sustainable development and enhancing community resilience.

### 3.2.4 Soils

The soils of Vega Alta reflect the municipality's location within Puerto Rico's Northern Coastal Plain and Karst Region. Soil development has been influenced by the weathering of limestone bedrock, the accumulation of alluvial materials along river valleys, and long-term tropical climate conditions. As a result, soil characteristics vary across the municipality, ranging from shallow soils over limestone in upland areas to deeper and more productive soils in valleys and low-lying coastal zones.

Much of Vega Alta is underlain by moderately deep to shallow clayey soils that overlie limestone formations. In many areas, soils are well-drained due to the permeability of the underlying karst geology, which allows rainfall to infiltrate rapidly into the subsurface. Other locations, particularly near streams, floodplains, and coastal areas, contain deeper soils formed from sediments deposited by rivers and surface runoff.

From a hazard mitigation perspective, soil characteristics can affect drainage, erosion potential, and stormwater management. Areas with shallow soils over limestone may be susceptible to subsidence or sinkhole formation, while low-lying alluvial soils adjacent to rivers may experience flooding during heavy rainfall events. Understanding local soil conditions is therefore important for infrastructure planning, environmental management, and resilience to natural hazards.

### 3.2.5 Hydrography

Vega Alta's hydrographic system is defined by a network of rivers, streams, wetlands, and groundwater resources that are closely connected to the municipality's location within Puerto Rico's Northern Karst Region. Surface water drainage is primarily influenced by the Cibuco River watershed, one of the principal river systems along Puerto Rico's north coast. These water resources play an important role in supporting ecosystems, replenishing groundwater supplies, and conveying stormwater runoff toward the Atlantic Ocean.

The Cibuco River is the municipality's most significant waterway and forms part of the boundary between Vega Alta and Vega Baja (Map 4). Additional water features include the Mavilla River, Unibón River, Quebrada Honda, Quebrada Corea, and several smaller tributaries that drain the municipality's uplands and lowlands (Map 6). Together, these waterways contribute to the movement of water across the landscape and help shape the municipality's natural environment.

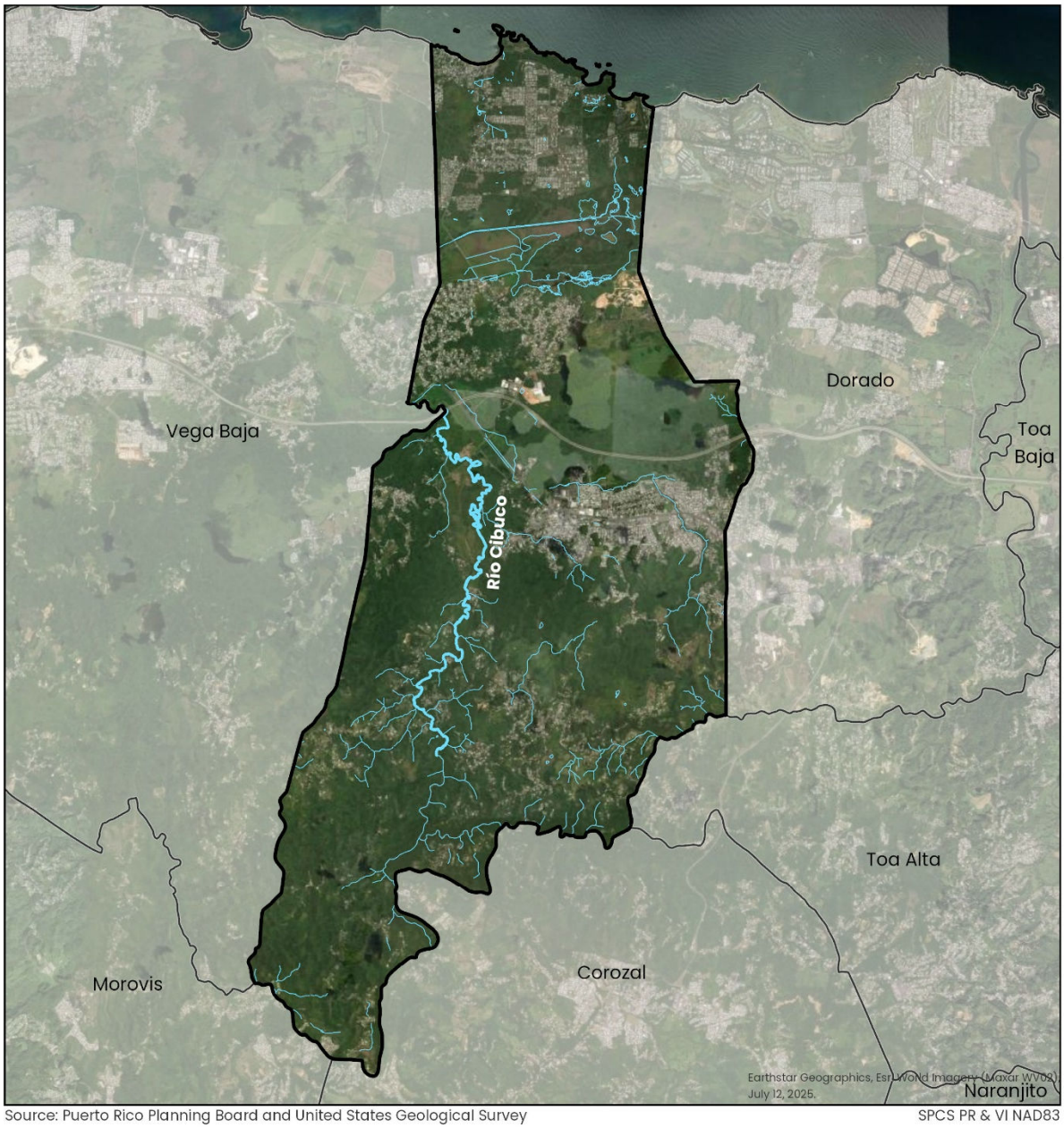
Because much of Vega Alta is underlain by limestone formations, a substantial portion of water movement occurs below the ground surface. Rainfall readily infiltrates through fractures, sinkholes, and other karst features, feeding aquifers and underground drainage systems that are characteristic of northern Puerto Rico. This interaction between surface water and groundwater makes the municipality's hydrology unique and highlights the importance of protecting both water quality and recharge areas.

From a hazard mitigation perspective, the hydrographic network influences the municipality's vulnerability to flooding during periods of intense rainfall, tropical storms, and hurricanes. Riverine flooding associated with the Cibuco River and its

tributaries has historically affected low-lying areas, transportation corridors, and nearby communities. As a result, the municipality's waterways are an important consideration in land use planning, stormwater management, and community resilience efforts.

*Map 4: Vega Alta – Hydrography Map –*

# HYDROGRAPHY




Source: Puerto Rico Planning Board and United States Geological Survey

SPCS PR & VI NAD83

Hydrography
Municipality of Vega Alta
Neighboring Municipalities



N

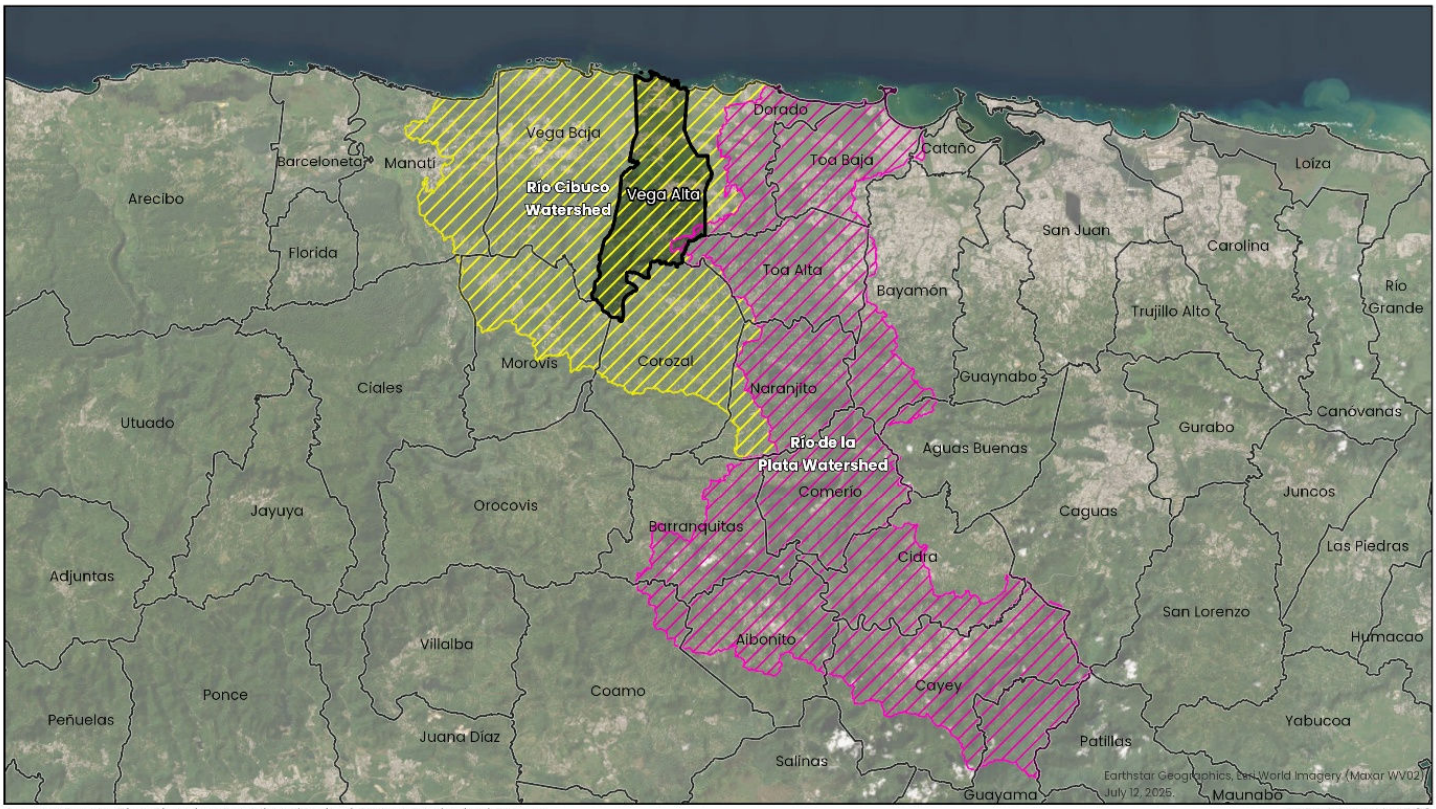
Scale: 1:85,000

0 1,000 2,000

Meters

*Map 5: Vega Alta - Watersheds Map-*

# HYDROGRAPHIC WATERSHEDS




Source: Puerto Rico Planning Board and United States Geological Survey

SPCS PR & VI NAD83

Watersheds
- Río Cibuco Watershed
- Río de la Plata Watershed

- Municipality of Vega Alta
- Neighboring Municipalities

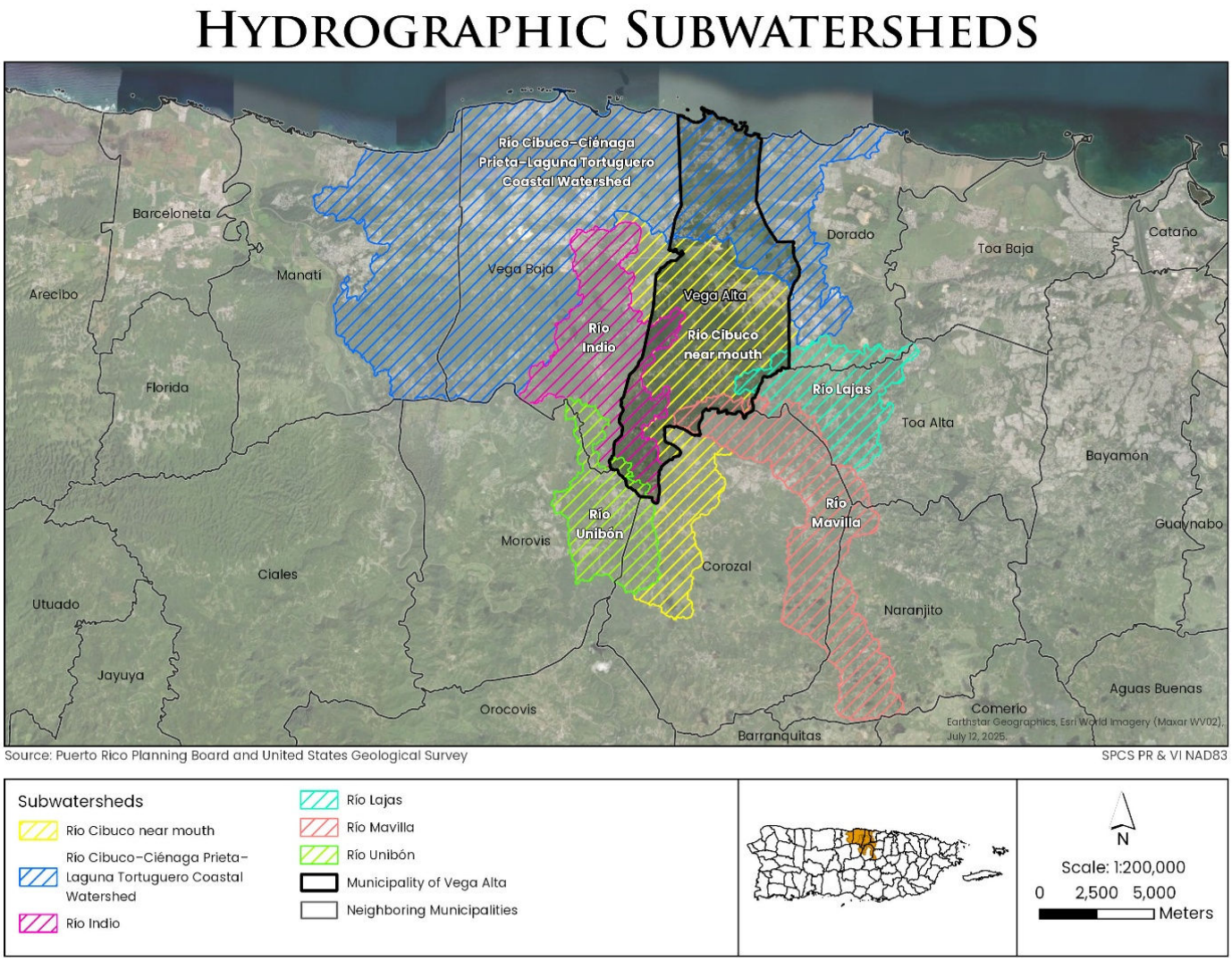


N

Scale: 1:370,000

0 4,500 9,000 Meters

*Map 6: Vega Alta– Subwatersheds -*




### 3.2.6 PRECIPITATION

Puerto Rico receives rain and hail as its two forms of precipitation. The principal rainy season occurs from August through October, and precipitation patterns are influenced by the island's topography and the prevailing Trade Winds.

Along the northern coastal region, average annual rainfall ranges from 60 to 90 inches. February and March are generally the driest months, while the final seven months of the year tend to receive the greatest amount of rainfall.

Rainfall distribution and frequency vary according to local topographic conditions and prevailing wind patterns, making the northern coastal municipalities particularly sensitive to seasonal precipitation variability.

These precipitation patterns contribute directly to flood hazards within the municipality. Two principal flood types are recognized: alluvial (basin) flooding and torrential flooding. Alluvial flooding results from persistent and widespread rainfall over a river basin, producing a gradual rise in river levels and eventual overflow into adjacent floodplains. These events usually develop slowly and may persist for a longer duration.

In contrast, torrential flooding occurs primarily in mountainous river systems as a result of intense rainfall events. These floods are characterized by a rapid increase in flow, sudden onset, and short duration, and they tend to produce the most severe impacts on the population.

Flat and low-lying coastal lands are particularly susceptible to periodic inundation due to their physical characteristics and the presence of wetlands, marshes, saltwater lagoons, and mangrove systems. (Municipality of Vega Alta, 2020)

### 3.2.7 Temperature

Regarding temperature, during the winter season the average daily minimum along Puerto Rico's coastline ranges from 19.9°C to 22°C (67.8°F to 71.6°F). In the mountainous interior, winter minimums fluctuate between 15.5°C and 16.6°C (59.9°F to 61.9°F). Winter maximum temperatures reach about 27.7°C (81.9°F) in coastal areas and between 22°C and 26.6°C (71.6°F to 79.8°F) in the interior highlands.

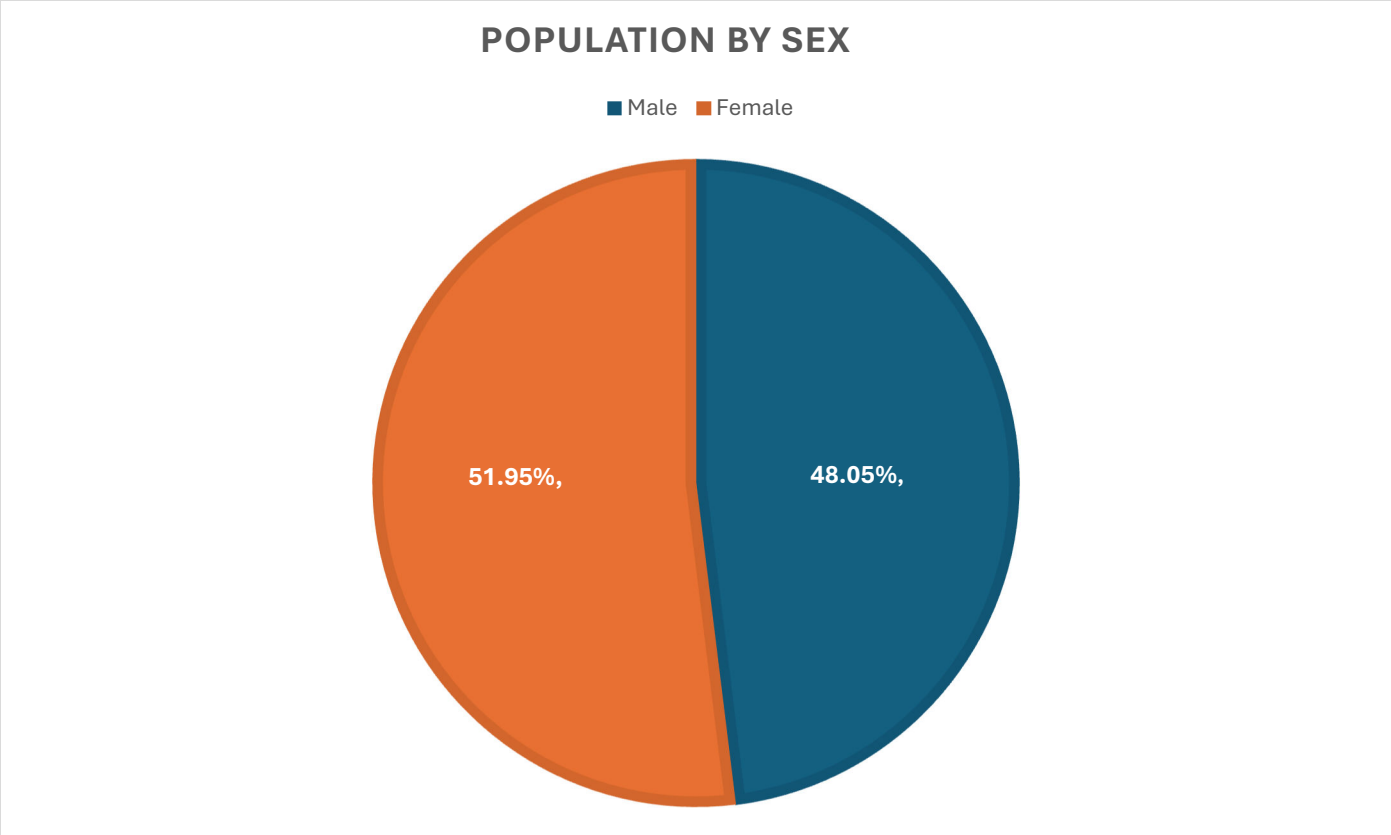
In summer, the average minimum temperature recorded in the mountainous interior ranges from 18.8°C to 21°C (65.8°F to 69.8°F), while coastal minimums range from 22°C to 24.4°C (71.6°F to 75.9°F). Summer maximum temperatures typically average 26.6°C to 29.4°C (79.8°F to 84.9°F) in higher elevations and about 29.4°C (84.9°F) along the coast.

## 3.3 Demographics

### 3.3.1 Current Population

According to the 2020 - 2024 American Community Five-Year Estimates Survey (ACS 2024)[1] the total population of Vega Alta is 34,921. Of these, 16,779 persons are male and 18,142 are female. The percentage split is 48.05% male, 51.95% female. The sex ratio is of 92.5 males per 100 females (US Census Bureau, 2025).

*Figure 9: Vega Alta Population by Sex (2024 ACS)*




*Source: US Census, ACS 2020-2024 Five-years Estimates*

According to 2024 ACS a total of 7,323 people in Vega Alta was 65 or older (20.97%). This constitutes more than a fifth of the total population of Vega Alta while 3,644 people (10.43%) of the population are 75 years of age or older.

Vega Alta has 7,053 residents (20.3% of the population) under the age of 19, including 2,642 children (7.6%) aged 9 years or younger. This LHMP identifies individuals younger than 19 and older than 65 as vulnerable populations due to their increased susceptibility to the impacts of natural hazards. As a result, 17,098 residents,

[1] Unless otherwise stated, all data and analysis are from the 2024 Five-Year American Community Survey (ACS) Data Set for Vega Alta.

representing 49.0% of Vega Alta's population, are considered particularly vulnerable to the effects of a natural disaster.

Table 5 distributes the current population of Vega Alta by age groups in cohorts of four years and compares the rate of change between 2024 and 2019 ACS 5-years estimates. For example, the total rate of change in Table 4 tells us that Vega Alta had a decrease of 5.89% from the total population from 2019 to 2024 estimates. Figure 9 shows the same age group distribution in a bar chart form. Figure 10 shows the population pyramid for Vega Alta. As can be seen in Figure 10 the irregular population pyramid shows the higher population share of the older groups versus the younger groups in the municipality. On the other hand, it is important to highlight that while the cohort groups between under 5 years and 15 to 19 years of age decrease at an average rate of 22.6%, the cohort groups between 75 to 84 years of age increase at an average rate of 35.2%.

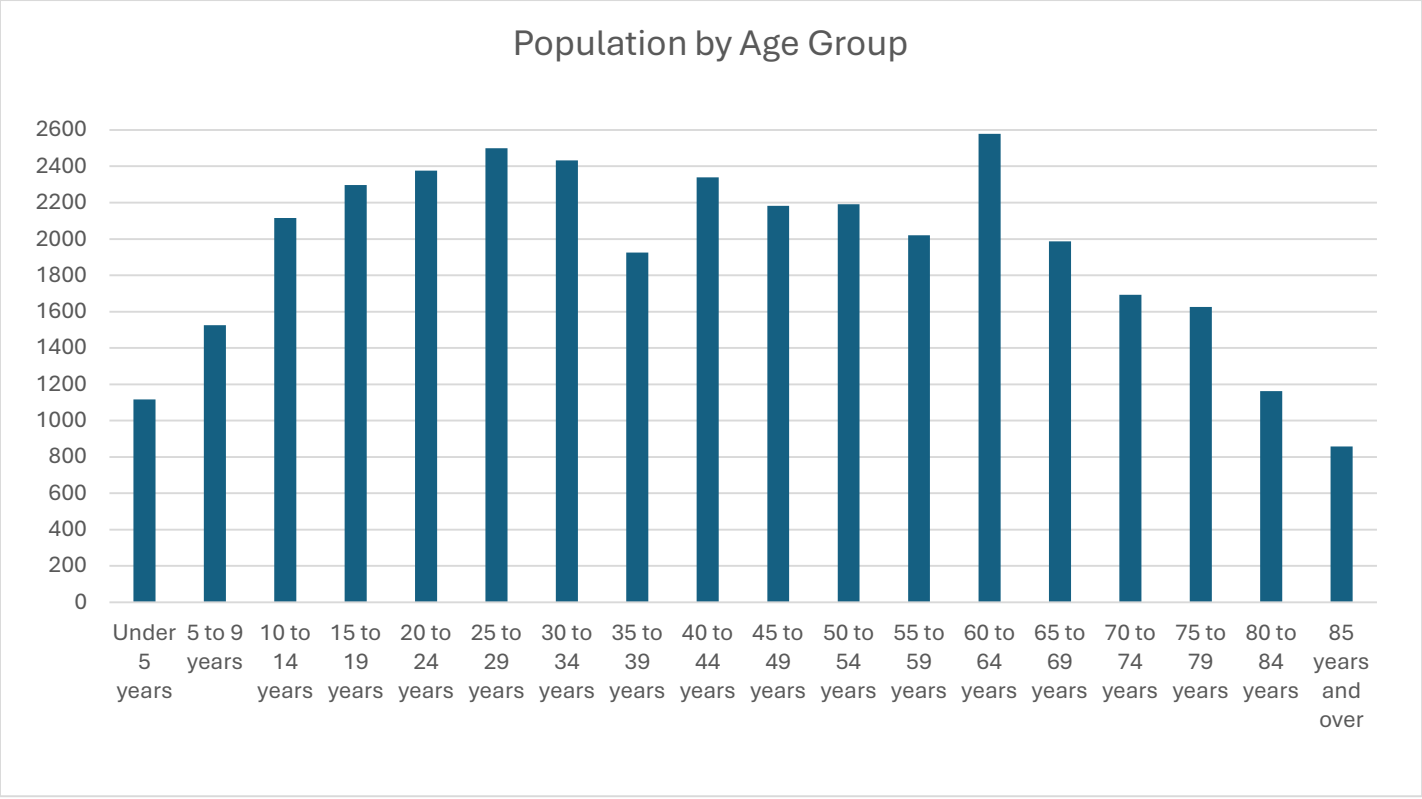
*Table 5: Population by Age Group 2024 ACS vs 2019 ACS*

| Age Cohort | Population 2024 | Percentage 2024 | Population 2019 | Percentage 2019 | Percentage Change |
|---|---|---|---|---|---|
| Under 5 years | 1,116 | 3.20% | 1,690 | 4.60% | -33.96% |
| 5 to 9 years | 1,526 | 4.40% | 2,063 | 5.60% | -26.04% |
| 10 to 14 years | 2,115 | 6.10% | 2,631 | 7.10% | -19.61% |
| 15 to 19 years | 2,296 | 6.60% | 2,569 | 6.90% | -10.63% |
| 20 to 24 years | 2,376 | 6.80% | 2,589 | 7.00% | -8.23% |
| 25 to 29 years | 2,499 | 7.20% | 2,606 | 7.00% | -4.11% |
| 30 to 34 years | 2,433 | 7.00% | 2,236 | 6.00% | 8.81% |
| 35 to 39 years | 1,925 | 5.50% | 2,331 | 6.30% | -17.41% |
| 40 to 44 years | 2,339 | 6.70% | 2,442 | 6.60% | -4.22% |
| 45 to 49 years | 2,182 | 6.20% | 2,350 | 6.30% | -7.15% |
| 50 to 54 years | 2,192 | 6.30% | 2,410 | 6.50% | -9.05% |
| 55 to 59 years | 2,020 | 5.80% | 2,361 | 6.40% | -14.44% |

| Age Cohort | Population 2024 | Percentage 2024 | Population 2019 | Percentage 2019 | Percentage Change |
|---|---|---|---|---|---|
| 60 to 64 years | 2,579 | 7.40% | 2,257 | 6.10% | 14.27% |
| 65 to 69 years | 1,986 | 5.70% | 1,812 | 4.90% | 9.61% |
| 70 to 74 years | 1,693 | 4.80% | 1,866 | 5.00% | -9.27% |
| 75 to 79 years | 1,625 | 4.70% | 1,255 | 3.40% | 29.48% |
| 80 to 84 years | 1,162 | 3.30% | 825 | 2.20% | 40.85% |
| 85 years and over | 857 | 2.50% | 813 | 2.20% | 5.41% |
| **Total** | **34,921** | | **37,106** | | **-5.89%** |

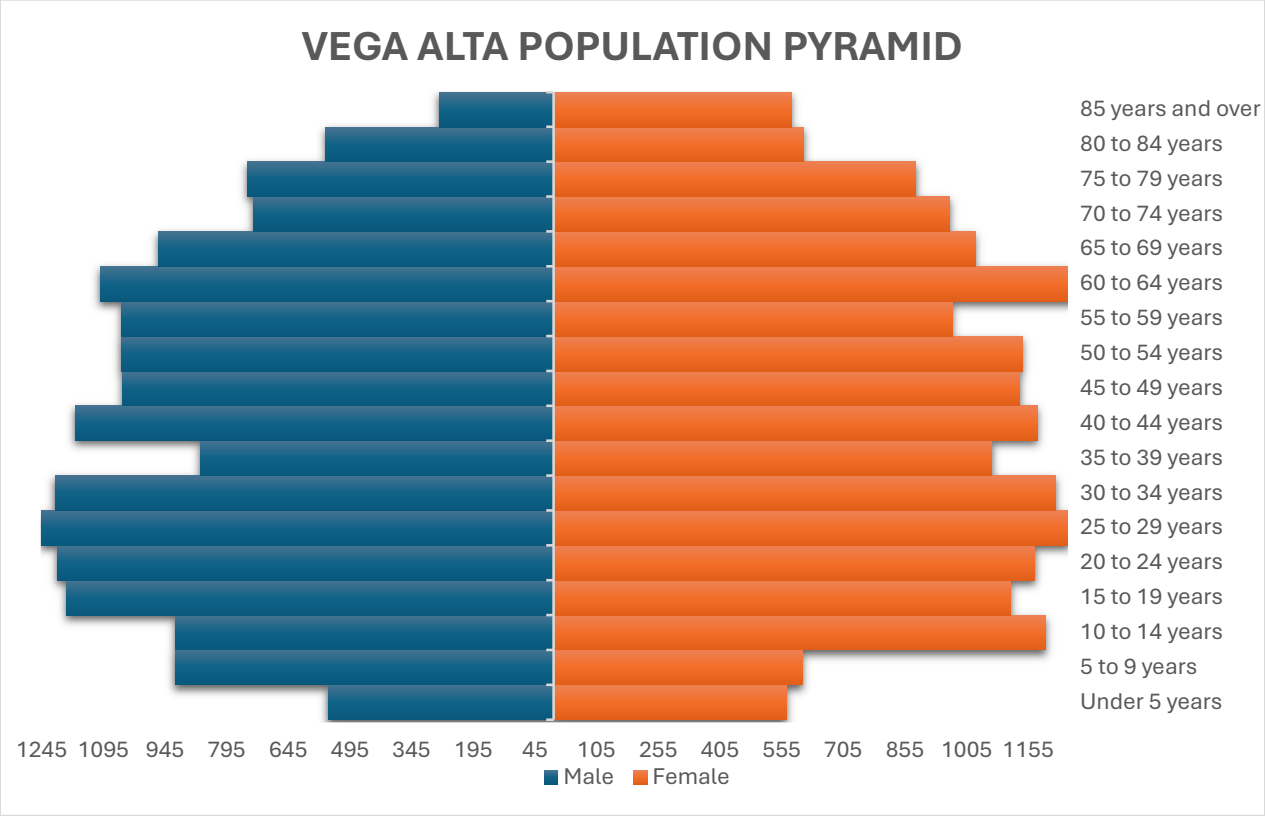
*Source: US Census, ACS 2020-2024 Five-years Estimates*

*Figure 10: Vega Alta Population by Age Group (ACS 2024)-*




*Source: US Census, ACS 2020-2024 Five-years Estimates*

*Figure 11: Vega Alta Population Pyramid (2024 ACS -Five-years Estimates)*

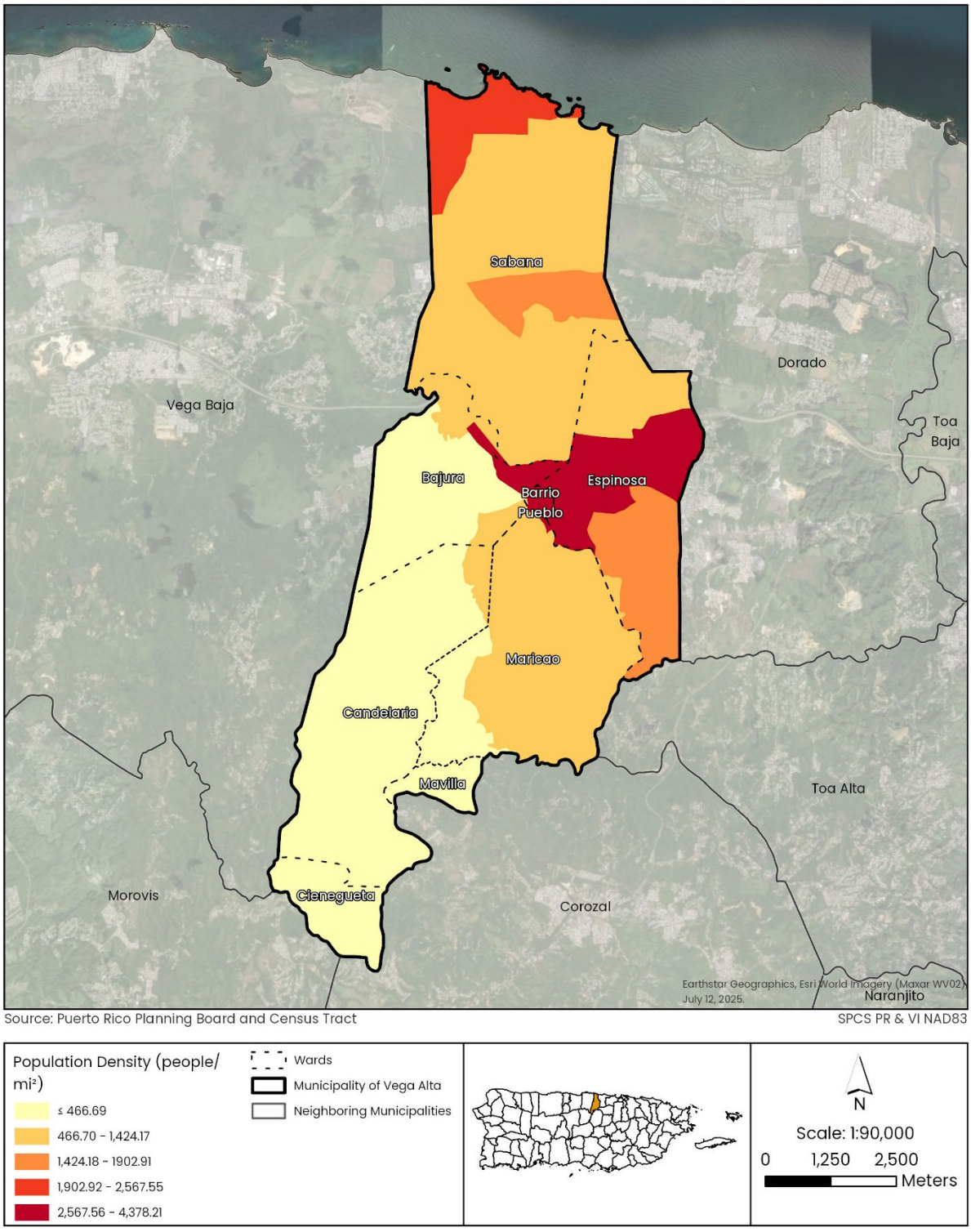



*Source: US Census, ACS 2020-2024 Five-years Estimates*

The following map shows the population density of Vega Alta by census tract. This map shows that the most densely populated census tracts are located in Barrio Pueblo and Espinosa with approximately 2,568 to 4,378 persons per square mile, followed by the coastal area of Cerro Gordo to the northwest part of the municipality.

*Map 7: Population Density*

# Population Density




Source: Puerto Rico Planning Board and Census Tract

SPCS PR & VI NAD83

### 3.3.2 Socio-economic Characteristics

#### *3.3.2.1 Employment*

The 2024 ACS Five-Year Estimates indicate that Vega Alta has a labor force participation rate of 47.70%, meaning that slightly less than half of the population aged 16 years and over is actively participating in the labor force (Table 6). This represents an increase from the 43.00% participation rate reported in the 2015-2019 ACS Five-Year Estimates. Furthermore, Vega Alta's labor force participation rate exceeds that of Puerto Rico, which stood at 46.40% in 2024.

*Table 6: Current Labor Force Statistics*[2]

| Variable[3] | Estimate 2024 | Percentage | Estimate 2019 | Percentage | Percentage Change |
|---|---|---|---|---|---|
| Population 16 years and over | 29,787 | | 30,291 | | -1.66% |
| In Labor Force | 14,204 | 47.70% | 13,011 | 43.00% | 9.17% |
| Civilian Labor Force | 14,175 | 47.60% | 13,011 | 43.00% | 8.95% |
| Employed | 11,980 | 40.20% | 10,207 | 33.70% | 17.37% |
| Unemployed | 2,195 | 7.40% | 2,804 | 9.30% | -21.72% |
| Armed Forces | 29 | 0.10% | 0 | 0.00% | 2,900.00% |
| Not in Labor Force | 15,583 | 52.30% | 17,280 | 57.00% | -9.82% |

[3] US Census Table DP03: Selected Economic Characteristics. The civilian labor force includes non-institutionalized civilians aged 16 years and older who are either employed or actively seeking employment. The labor force is broader, as it includes both the civilian labor force and members of the Armed Forces on active duty. Institutionalized individuals, such as those residing in prisons or nursing homes, are not included in either category.

| Variable[3] | Estimate 2024 | Percentage | Estimate 2019 | Percentage | Percentage Change |
|---|---|---|---|---|---|
| Unemployment rate | | 15.50% | | 21.60% | -28.24% |

*Source: US Census, ACS 2020-2024 and 2015-2019 Five-years Estimates*

The 2024 ACS estimates showed an unemployment rate for the municipality of 15.50%. This represents a 28.24% decrease regarding the 2015-2019 Five-Year ACS unemployment rate which was 21.60%. In comparison to Puerto Rico the unemployment rate is higher (15.50% for Vega Alta vs 10.7% for Puerto Rico).

#### *3.3.2.2 Employment by Industry*

The following table below (Table 7), presents employment by industry within the municipality, comparing data from the 2020-2024 Five-Year ACS with the 2015-2019 Five-Year ACS. The final column reflects the percentage change in employment by industry between the two survey periods.

*Table 7: Employment by Industry 2024 ACS vs 2019 ACS*

| Industry | 2024 | Percent 2024 | 2019 | Percent 2019 | Percentage change |
|---|---|---|---|---|---|
| Agriculture, Forestry, fishing and hunting and mining | 180 | 1.50% | 20 | 0.20% | 800.00% |
| Construction | 823 | 6.90% | 614 | 6.00% | 34.04% |
| Manufacturing | 1,247 | 10.40% | 1,007 | 9.90% | 23.83% |
| Wholesale Trade | 361 | 3.00% | 351 | 3.40% | 2.85% |
| Retail Trade | 1,665 | 13.90% | 1,498 | 14.70% | 11.15% |
| Transportation and warehousing, and utilities | 593 | 4.90% | 285 | 2.80% | 108.07% |
| Information | 108 | 0.90% | 173 | 1.70% | -37.57% |
| Finance and Insurance, and real estate and rental and leasing | 654 | 5.50% | 611 | 6.00% | 7.04% |

| Industry | 2024 | Percent 2024 | 2019 | Percent 2019 | Percentage change |
|---|---|---|---|---|---|
| Professional, scientific, and management, and administrative and waste management services | 1,276 | 10.70% | 894 | 8.80% | 42.73% |
| Educational services, health care and social assistance | 2,242 | 18.70% | 2,473 | 24.20% | -9.34% |
| Arts, entertainment, recreation, and accommodation and food services | 1,258 | 10.50% | 1,121 | 11.00% | 12.22% |
| Other services, except public administration | 894 | 7.50% | 395 | 3.90% | 126.33% |
| Public administration | 679 | 5.70% | 765 | 7.50% | -11.24% |
| Total employee Population 16 years and over | 11,980 | - | 10,207 | - | 17.37% |

*Source: US Census, ACS 2020-2024 Five-years Estimates*

Table 7 shows the following employment characteristics for Vega Alta:

- The industry with the highest level of employment in Vega Alta in 2024 is "Educational services, healthcare and social assistance" accounting for 18.70% of Vega Alta workforce.
- In comparison with the 2019 ACS data shows that "Educational services, health care and social assistance industry" was also the largest employment sector based on the total workforce. However, employment in this industry decreased by 231 individuals, representing a 9.34% decline between 2019 and 2024. Despite this decrease, the municipality experienced an overall increase of 1,773 workers, equivalent to a 17.37% growth in the total workforce during the same period.
- Other industries representing more than 10% of the employed population in Vega Alta include: Retail Trade industry (13.90%); Professional, scientific, and management, and administrative and waste management services (10.70%); Arts, entertainment, recreation, accommodation and food services (10.50%), and Manufacturing (10.40%).
- Industries that experienced negative growth between 2019 and 2024 ACS surveys include:

    - Information: decreased by65 individuals or -37.57%
    - Public administration: decreased by86 individuals or -11.24%
- The industries that experienced the most significant growth between 2019 and the 2024 surveys were:
    - Agriculture, forestry, fishing, hunting and mining increased by 160 individuals representing an 800.00% increase over 2019 estimates.
- Other industries that recorded positive growth include:
    - Transportation and warehousing, and utilities (308 individuals or 108.07% percentage change).
    - Wholesale Trade (10 individuals or 2.85% percentage change).
    - Other services, except public administration, increased by 499 individuals (499 individuals, 126.33% percentage change regarding 2019 estimates).
    - Construction (209 individuals or 34.04% percentage change).
    - Finance and Insurance, real estate, rental and leasing (43 individuals or 7.04% percentage change).
    - Retail Trade (167 individuals or 11.15% percentage change).
    - Manufacturing (240 individuals or 23.83% percentage change).
    - Professional, scientific, and management, and administrative and waste management services (382 individuals or 42.73% percentage change).

#### *3.3.2.3 Poverty Level*

The table below shows the estimated poverty status for individuals over the past 12 months by age group. This information is used to evaluate the economic well-being of individuals and families. The following table is essential for understanding the economic conditions of different age groups and for guiding the development and implementation of policies aimed at reducing poverty as well as the vulnerability of the population. This table shows that approximately 40.80% of the total population of Vega Alta was below the poverty level according to 2024 estimates.

*Table 8: Vega Alta Individuals Below Poverty Level in the Last 12 months: 2019 and 2024 ACS 5-year estimates*

| Age Group | Individuals (2024) | Percentage (2024)[4] | Individuals (2019) | Percentage (2019) | Percentage Change |
|---|---|---|---|---|---|
| Under 5 years | 701 | 62.80% | 1108 | 65.60% | -36.73% |
| 5 to 17 years | 2,456 | 49.50% | 3350 | 53.80% | -26.69% |
| 18 to 34 years | 3,603 | 43.90% | 4059 | 49.30% | -11.23% |
| 35 to 64 years | 4,309 | 32.80% | 5787 | 41.80% | -25.54% |
| 65 years and over | 3,106 | 42.50% | 2451 | 37.40% | 26.72% |
| **Total** | **14,175** | **40.80%** | **16,755** | **45.90%** | **-15.39%** |

*Source: US Census, ACS 2019 and 2024 5- years Estimates*

Table 8 compares poverty status estimates from 2019 and 2024 ACS. While the overall proportion of residents living below the poverty level decreased during the period, poverty continues to affect a substantial segment of the population. Of particular concern, the number of residents aged 65 years and older living in poverty increased by approximately 27 percent. Because low-income and elderly populations often face greater challenges in preparing for, responding to, and recovering from disasters, this trend may increase social vulnerability and should be considered when developing and prioritizing mitigation actions.

#### *3.3.2.4 Income*

According to the 2024 ACS the median household income for Vega Alta was $25,538, while the mean household income was $41,686. The following table shows the household distribution by level of income between both estimate periods.

[4] Percentages are based on the total population of that certain age group except on the total row.

*Table 9: Vega Alta: Households by Income Level (2019 and 2024: 5-year ACS Estimates)*

| Category | Households 2024 | Percentage 2024 | Households 2019 | Percentage 2019 | Percentage Change |
|---|---|---|---|---|---|
| Less than $10,000 | 2,705 | 19.30% | 2,948 | 24.70% | -8.24% |
| $10,000 to $14,999 | 1,537 | 11.00% | 1,521 | 12.80% | 1.05% |
| $15,000 to $24,999 | 2,618 | 18.70% | 2,561 | 21.50% | 2.23% |
| $25,000 to $34,999 | 1,668 | 11.90% | 1,250 | 10.50% | 33.44% |
| $35,000 to $49,999 | 1,811 | 12.90% | 1,325 | 11.10% | 36.68% |
| $50,000 to $74,999 | 1,554 | 11.10% | 1,045 | 8.80% | 48.71% |
| $75,000 to $99,999 | 853 | 6.10% | 595 | 5.00% | 43.36% |
| $100,000 to $149,999 | 763 | 5.40% | 457 | 3.80% | 66.96% |
| $150,000 to $199,999 | 341 | 2.40% | 100 | 0.80% | 241.00% |
| $200,000 or more | 165 | 1.20% | 116 | 1.00% | 42.24% |
| Total | 14,015 | - | 11,918 | | 17.60% |

*Source: US Census, ACS 2019 and 2024 5- years Estimates.* Inflation-Adjusted Dollars by 2024 and 2019 respectively

This table shows that 19.30% in Vega Alta earned an annual income of less than $10,000 for the 2024 ACS, while 49% of households earned less than $25,000. In comparison for the 2015-2019 ACS, 24.70% of households earned less than $10,000 whereas 59% of households received an annual income of less than $25,000.

### *3.3.2.5 Population with Disabilities*

Table 10 presents data on individuals living with disabilities based on the 2020–2024 and 2015–2019 Five-Year Estimates of the American Community Survey datasets.

This Census data shows that the number of individuals living with a disability in Vega Alta increased from 7,560 in 2019 to 7,793 in 2024, representing a net increase of 233

individuals. Despite this overall increase, most age groups experienced a decline in the number of individuals living with a disability. The exception was the population aged 75 years and older, which recorded a 19.38% increase during the period. According to the 2024 ACS 5-year estimates, individuals living with a disability represent 22.42% of Vega Alta's total population. This information is particularly relevant to the LHMP update, as people with disabilities are among the populations most vulnerable to the impacts of natural hazard events and may face additional challenges during preparedness, response, and recovery efforts.

*Table 10: Vega Alta Population living with disabilities*

| Age Group | 2024 | 2019 | Net change | Percentage change |
|---|---|---|---|---|
| Under 5 years | 0 | 36 | -36 | -100.00% |
| 5 to 17 years | 497 | 635 | -138 | -21.73% |
| 18 to 34 years | 792 | 595 | 197 | 33.11% |
| 35 to 64 years | 2,799 | 2,882 | -83 | -2.88% |
| 65 to 74 years | 1,487 | 1,554 | -67 | -4.31% |
| 75 years and over | 2,218 | 1,858 | 360 | 19.38% |
| Total Population living with a disability | **7,793** | **7,560** | **233** | **3.08%** |

*Source: US Census, ACS 2019 and 2024 5- years Estimates*

### 3.3.2.6 Population Receiving Supplemental Nutritional Support

Table 11 provides information on households in Vega Alta that receive food assistance, based on data from the 2020–2024 and 2015–2019 American Community Survey.

*Table 11: Population Receiving Food Aid -*

| Data Set | 2024 | 2019 | Net Change | Percentage Change |
|---|---|---|---|---|
| Total Households in the municipality | 14,015 | 11,918 | 2,097 | 17.60% |
| Households receiving food assistance | 6,969 | 4,817 | 2,152 | 44.68% |

| | | | | |
|---|---|---|---|---|
| Percent of Households receiving food assistance | 49.70% | 40.40% | 9.30 | 23.02% |

As shown in this table the number of households in Vega Alta increased by 17.60% since 2019 ACS. During the same period, the number of households receiving food assistance increased by 45.0%, indicating that participation in food assistance programs grew at a faster rate than overall household growth. This trend suggests an increasing reliance on food assistance resources among residents. From a hazard mitigation perspective, food security is an important indicator of community vulnerability because households that depend on food assistance may face greater challenges in accessing adequate food following a disaster. Disruptions to transportation networks, supply chains, utility services, and food distribution programs can disproportionately affect these households, potentially increase their vulnerability and slow recovery efforts. Therefore, understanding the distribution and demand for food assistance services can help identify populations that may require additional support before, during, and after hazard events.

#### 3.3.2.7 Health Insurance Coverage

The next table shows the 2020-2024 health insurance coverage for the municipality.

*Table 12: 2024 and 2019 ACS Health Insurance Data*

| Variable | Estimate 2024 | Percentage 2024 | Estimate 2019 | Percentage 2019 | Rate of Change |
|---|---|---|---|---|---|
| Civilian noninstitutionalized population | 34,753 | | 36,526 | | -4.85% |
| With health insurance coverage | 33,326 | 95.90% | 34,524 | 94.50% | -3.47% |
| With private health insurance | 12,224 | 35.20% | 13,421 | 36.70% | -8.92% |
| With public coverage | 22,247 | 64.00% | 22,759 | 62.30% | -2.25% |
| No health insurance coverage | 1,427 | 4.10% | 2,002 | 5.50% | -28.72% |

*Source: US Census, ACS 2019 and 2024 5- years Estimates*

The data shows that 1,427 people (4.10%) in Vega Alta have no health insurance at all, while almost two thirds of the population (64.00%) depend on public health coverage. This data will be revisited when discussing the hazard of pandemic/epidemic.

### 3.3.3 Housing stock and other related details

According to the 2024 ACS estimates, Vega Alta had a total of 17,058 housing units, of those a total of 3,043 were vacant. This represents 17.84% of the total housing stock of the municipality.

The next table shows the year of construction of the housing units by year of construction.

*Table 13: 2024 Housing Units Per Year of Construction*

| Year Structure Built | Housing Units | Percentage |
|---|---|---|
| Built 2020 or later | 140 | 0.80% |
| Built 2010 to 2019 | 883 | 5.20% |
| Built 2000 to 2009 | 3,892 | 22.80% |
| Built 1990 to 1999 | 2,494 | 14.60% |
| Built 1980 to 1989 | 2,879 | 16.90% |
| Built 1970 to 1979 | 2,541 | 14.90% |
| Built 1960 to 1969 | 2,395 | 14.00% |
| Built 1950 to 1959 | 1,369 | 8.00% |
| Built 1940 to 1949 | 281 | 1.60% |
| Built 1939 or earlier | 184 | 1.10% |
| Total | **17,058** | **100%** |

*Source: US Census, ACS 2024 5- years Estimates*

The 2024 ACS shows that 46.4% of the housing stock was built between 1970 and 1999. The latest Building Code was adopted by the government of Puerto Rico in 2018, before that the most recent version of the Building Code was adopted in 2011. This means that at least 94.00% of the housing stock was built before the current building code.

Other data offered by the 2024 ACS, is that of the 14,015 occupied housing units, 9,736 (69.47%) were occupied by the owner and 4,279 (30.53%) were occupied by renters.

Finally, Table 14 shows the vehicle available per occupied housing units.

*Table 14: Vehicle per Occupied Housing Unit*

| Variable | Occupied Housing Units (2024) | Percentage (2024) | Occupied Housing Units (2019) | Percentage (2019) | Rate of Change |
|---|---|---|---|---|---|
| No vehicles available | 1,572 | 11.20% | 1821 | 15.28% | -13.67% |
| 1 vehicle available | 5,511 | 39.30% | 4,903 | 41.14% | 12.40% |
| 2 vehicles available | 4,465 | 31.90% | 3,537 | 29.68% | 26.24% |
| 3 or more vehicles available | 2,467 | 17.60% | 1,657 | 13.90% | 48.88% |
| **Total** | **14,015** | | **11,918** | | **17.60%** |

*Source: US Census, ACS 2019 and 2024 5- years Estimates*

The 2024 ACS shows that there are 1,572 (11.20%) occupied housing units that do not have available vehicles in Vega Alta. This represents a critical matter since the development pattern in the municipality is rural and/or suburban, where vehicular transportation is necessary for mobility.

## 3.4 Critical Infrastructure

Infrastructure refers to the essential physical and organizational systems that support the effective functioning of a society or economy. It includes critical networks such as transportation systems (roads, bridges, railways), energy generation and distribution, water supply, telecommunications, and other services that sustain economic activity and daily life. Collectively, infrastructure serves as the foundational framework that enables communities and economies to operate reliably and efficiently (NIST, n.d.).

Infrastructure is commonly classified into two categories: hard infrastructure and soft infrastructure.

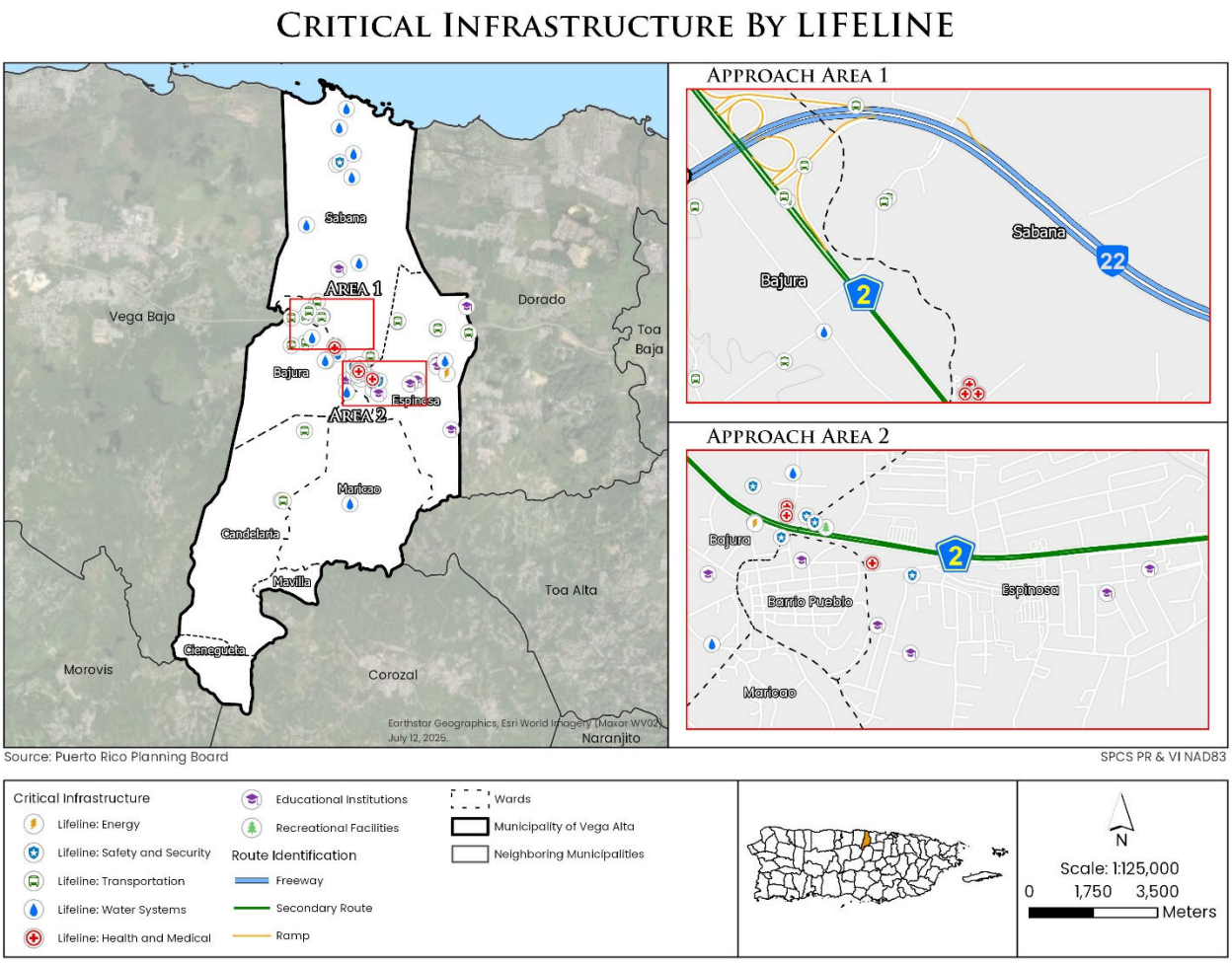
Hard infrastructure refers to the physical facilities and networks that underpin the functioning of a modern society and economy. This includes transportation systems such as roads, bridges, railways, and airports, as well as water systems, electrical grids, and telecommunications networks. These tangible assets enable the movement of people and goods, the distribution of energy and water, and the transmission of information.

Soft infrastructure refers to the institutions, services, and systems that support economic stability, public health, social order, and cultural development. This category includes educational institutions, healthcare systems, law enforcement agencies, emergency response services, parks, and recreational facilities. Unlike hard infrastructure, soft infrastructure is characterized by organizational frameworks and human-centered services that contribute to community well-being and effective governance.

As described in Section 2.8, FEMA defines *Community Lifelines* as the most essential services and systems necessary to sustain the uninterrupted operation of critical government and business functions, while also protecting public health, safety, and economic security. These lifelines constitute the fundamental components of a community and once stabilized, enable all other sectors of society to function effectively. During disaster events, any disruption to these lifelines requires immediate and coordinated action to restore stability and reduce cascading impacts. Accordingly, the assessment of existing infrastructure will be conducted in alignment with FEMA's Community Lifelines framework.

The Municipality of Vega Alta contains a diverse network of critical facilities that support community functions before, during, and after hazard events (Map 8, Appendix F). Consistent with FEMA's Community Lifelines framework, most critical infrastructure is concentrated within the urbanized corridor encompassing Barrio Pueblo, Bajura, Espinosa, and Sabana, particularly along the PR-2 transportation corridor and near the PR-22 (José de Diego Expressway) interchanges. This concentration increases operational efficiency during normal conditions but may also create cascading impacts if a hazard disrupts these key service hubs. Appendix F provides a list of the municipality's critical infrastructure by Lifeline type, as provided by the PRPB.

*Map 8: Critical Infrastructure by Lifeline*




### 3.4.1 LIFELINE: SAFETY AND SECURITY

The purpose of the Safety and Security Lifeline is to protect life and property while maintaining social stability during emergency situations. This lifeline focuses on reducing immediate risks to public safety and personal security through the operation of public safety agencies, controlled access to affected areas, and the prevention of crime, civil unrest, and violence. It also encompasses ensuring safety and security at emergency shelters, distribution centers, and other critical facilities during disaster response and recovery operations.



FEMA indicates that disruption of this lifeline can result in social disorder and heightened community vulnerability, making rapid restoration a critical priority. Response actions require close coordination among federal, state, and local agencies, the deployment of security personnel, the implementation of traffic control measures, and the protection of critical infrastructure.

In Vega Alta, safety and security assets are primarily clustered within the municipal core and include the Office of Emergency Management/ Municipal Police, the Irmo Figueroa Concepción Government Center, the Vega Alta Fire Station, the Puerto Rico Police Station, and the Municipal Police Station in Sabana. These facilities form the backbone of emergency response, incident command, law enforcement, and public safety operations. The concentration of these facilities within Barrio Pueblo and adjacent sectors supports rapid response to populated areas and key transportation corridors

### 3.4.2 Lifeline: Food, Hydration and Shelter




The Food, Hydration, and Shelter Lifeline is intended to ensure that disaster-affected populations have prompt access to essential necessities, including food, potable water, and safe shelter. This lifeline encompasses the provision of ready-to-eat meals, water distribution, the establishment of temporary shelters, and coordination with governmental and volunteer organizations to meet basic human needs. Disruptions to this lifeline pose an immediate threat to life; therefore, rapid response actions are prioritized to restore food availability and housing stability as quickly as possible.

In Vega Alta this lifeline is supported by a combination of public facilities, schools, community centers, water supply infrastructure, and transportation networks that enable the distribution of essential resources during emergencies. Although the municipality does not contain a large concentration of designated shelter facilities, several educational and community service facilities located within the urban core and surrounding neighborhoods have the potential to support emergency sheltering, commodity distribution, and disaster assistance operations.

The municipality's principal support area is located within the Barrio Pueblo-Bajura-Espinosa corridor, where multiple educational facilities, medical services, government offices, and transportation routes are concentrated. Schools such as Francisco Felicié

Martínez School, José M. Pagán de Jesús School, Ileana de Gracia School, and Antonio Paoli School, along with community facilities and recreational venues, may be utilized as temporary shelters, points of distribution (PODs), or disaster recovery support centers, subject to local emergency management procedures. The municipality's Vega Alta Reception Center and other community facilities further enhance local response and recovery capacity.

Access to food, water, and emergency supplies is largely dependent on the continued operation of the municipality's transportation network, particularly PR-2, PR-22, and associated secondary roads, which connect population centers to regional supply chains. Any disruption to these transportation corridors could temporarily affect the delivery of food, potable water, fuel, and other life-sustaining resources.

### 3.4.3 Lifeline: Health and Medicine




The purpose of this lifeline is to ensure the continuity of essential medical services and the protection of public health during emergencies and disasters. It focuses on stabilizing healthcare delivery, ensuring access to hospitals, clinics, medications, and healthcare personnel, and maintaining the capacity to respond effectively to life-threatening conditions

FEMA indicates that disruption of this lifeline can have serious consequences; therefore, priority actions focus on restoring medical facilities, deploying emergency response teams, ensuring the availability of critical medical supplies, and coordinating efforts among federal, state, and local agencies

The municipality's health and medical services are concentrated in the urban center, where the CDT, IPA 307, Vega Alta Community Health, FMC Vega Alta, and Fresenius Kidney Care provide primary and specialized medical services, including dialysis treatment. The close proximity of these facilities creates an important healthcare cluster that supports both routine medical needs and emergency response activities. Protection of access routes to these facilities is critical, particularly along PR-2 and connecting local roads.

### 3.4.4 Lifeline: Energy




Energy Lifeline is designed to ensure the reliable and safe delivery of electricity, gas, and essential fuels during emergencies and disaster events. This lifeline is vital to sustaining the operation of critical facilities and services, including hospitals, water and wastewater systems, telecommunications, and other infrastructure that depend on uninterrupted energy supply.

FEMA recognizes that disruptions to energy services pose a direct threat to life safety and community stability. Accordingly, priority response actions include the rapid restoration of the electrical grid, the deployment of generators to critical facilities, coordination with fuel suppliers, and the implementation of temporary measures to maintain service continuity.

The municipality's electric distribution system is supported by four primary substations: Substation #9101 Vega Alta Pueblo, Substation #9105 Vega Alta 13kV, Substation #9103 Santa Ana, and Substation #9201 Bo. Breñas. These facilities provide electrical service to residential, commercial, governmental, and critical service areas throughout Vega Alta. Disruptions affecting these substations could have cascading impacts on healthcare, water systems, communications, and emergency response capabilities.

### 3.4.5 Lifeline: Communications

The purpose of this lifeline is to ensure the availability and reliability of essential communication systems during emergencies and disaster events. These systems include telephone networks, internet services, radio, television, and public alert and warning platforms, all of which are critical for coordinating response activities, disseminating timely information, and maintaining communication between authorities and the public.




FEMA indicates that disruption of the Communications Lifeline can severely impair life-saving operations and effective resource management. Accordingly, priority actions include the restoration of telecommunications infrastructure, deployment of temporary communication solutions such as satellite systems, ensuring redundancy

within critical networks, and maintaining accessible communication channels for the public.

The Communications Lifeline in Vega Alta is supported primarily through emergency management, public safety, and municipal government facilities that enable emergency coordination, information sharing, and continuity of operations during hazard events. Key facilities include the Office of Emergency Management/Municipal Police, the Irmo Figueroa Concepción Government Center, the Puerto Rico Police Station, the Municipal Police Station in Sabana, and the Vega Alta Fire Station. These assets are concentrated within the Barrio Pueblo-Bajura-Espinosa corridor, where several other critical lifelines converge, facilitating interagency coordination and emergency response activities. Although no dedicated telecommunications facilities were identified in the available critical infrastructure inventory, the municipality's communications capabilities rely on the continued operation of these public safety facilities, commercial telecommunications networks, and supporting power infrastructure. Consequently, maintaining redundant communication systems, backup power, and interoperable emergency communications remains essential to sustaining response and recovery operations following disaster events.

### 3.4.6 Lifeline: Transportation




The purpose of the Transportation Lifeline is to ensure the safe and efficient movement of people, goods, and essential services during emergencies and disaster events. This lifeline supports the continued operation or rapid restoration of land, air, and maritime transportation routes, enabling access to critical resources such as food, potable water, medical care, and emergency response equipment.

FEMA indicates that disruptions to transportation systems directly affect the ability to save lives and distribute essential supplies. Accordingly, priority actions include reopening roadways, repairing damaged bridges, restoring airport and port operations, and coordinating with state and private entities to maintain the logistics chain. Map 9 shows the roadway network of the Municipality of Vega Alta.

The municipal road system has two major access routes: the José de Diego Expressway (PR-22) and its principal commercial corridor, PR-2. Other primary roads include PR-690, which connects the urban center to northern Vega Alta; PR-693 and PR-691, which serve as connector routes to Dorado; and PR-647, the municipality's

most important rural roadway, extending from the urban center to the Cienegueta sector.

Additional secondary and tertiary roads include PR-676, which connects Bajura to Vega Baja (Pueblo Nuevo sector); PR-678 (Pámpanos Road), which serves as a connector to PR-820 leading toward Lajas River in Toa Alta; PR-677 (Maricao Road), which connects to PR-630 toward the Abras Ward of Corozal; and Camino Raspadura, the sole access route to the Mavilla Ward.

Numerous bridges are located along PR-22, PR-2, PR-620, PR-647, PR-675, PR-690, and PR-694. These structures are critical for maintaining regional mobility, emergency access, and supply distribution during disasters. The concentration of transportation assets near the PR-22/PR-2 corridor highlights the importance of maintaining bridge functionality and roadway access to support evacuation and emergency operations.

### 3.4.7 Lifeline: Hazardous Materials




The purpose of this lifeline is to prevent hazardous material releases, control spills, and protect communities located near industrial facilities, chemical plants, and hazardous materials transportation corridors.

FEMA indicates that disruption or failure of the Hazardous Materials Lifeline can result in severe consequences, including widespread contamination and the impairment of essential services. Accordingly, priority actions include identifying hazardous materials, activating specialized Hazardous Materials (HazMat) response teams, coordinating with federal and state agencies, and implementing rapid response protocols. Although hazardous materials may be present throughout the municipality, incidents involving hazardous materials are more likely to occur within industrial areas.

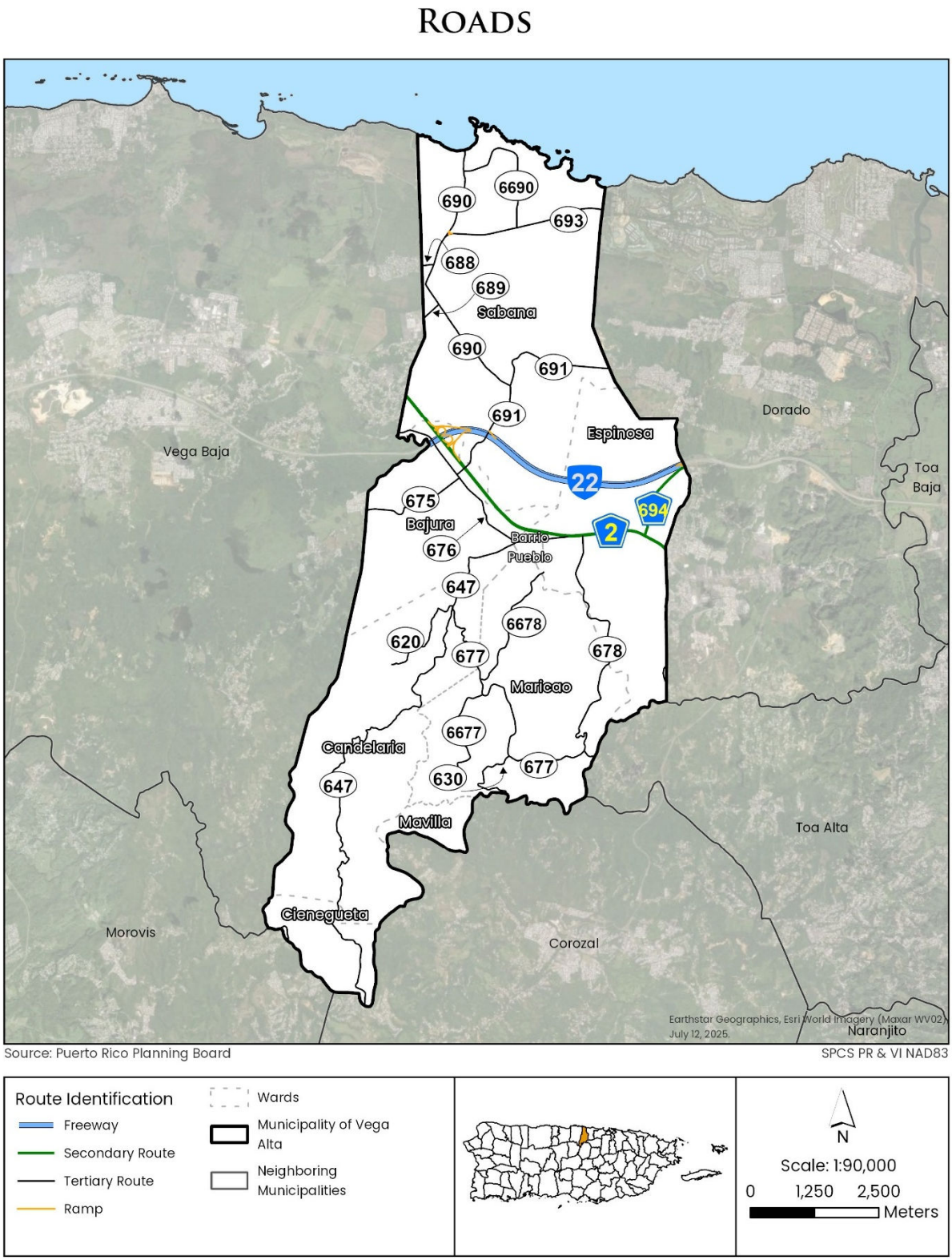
### 3.4.8 Lifeline: Water Systems




This lifeline highlights the critical role of water infrastructure in disaster response and recovery. Its primary objective is to ensure reliable access to and the timely restoration of drinking water and wastewater services, which are essential to public health, safety, and economic stability. The Water Systems Lifeline is structured around two core components: Potable Water Infrastructure, which includes water intake, treatment, storage, and distribution; and Wastewater Management, encompassing the collection, storage, treatment, and discharge of wastewater. By prioritizing the protection and functionality of water systems, FEMA seeks to maintain sanitation, support healthcare services, and minimize cascading impacts on food safety and overall community resilience.

Water infrastructure includes several potable water, sanitary sewer, and pumping facilities distributed throughout the municipality. Key assets include the Vega Alta Wastewater Treatment Plant, PAS Vega Alta, multiple EBAS sanitary pump stations (including Maricao, Sabana Hoyos II, Ileana de Gracia, and Barriada Correa), the Pica El Peje Francés Pump Station, and water supply generator facilities serving the AAA system. These facilities are essential for maintaining drinking water service, wastewater management, and public health during and after hazard events. The concentration of water and wastewater facilities in the northern and central sectors underscores their importance to municipal continuity of operations

*Map 9: Roadways*



## 3.5 Recent Development (E1-a)

Hazard mitigation planning must also account for future development conditions. To assess anticipated development trends within the municipality, historical patterns were evaluated using data on construction permits approved between 2020 and 2026. This period begins with the year following approval of the previous hazard mitigation plan. It should be noted that data for 2026 are completed by June 30, 2026.

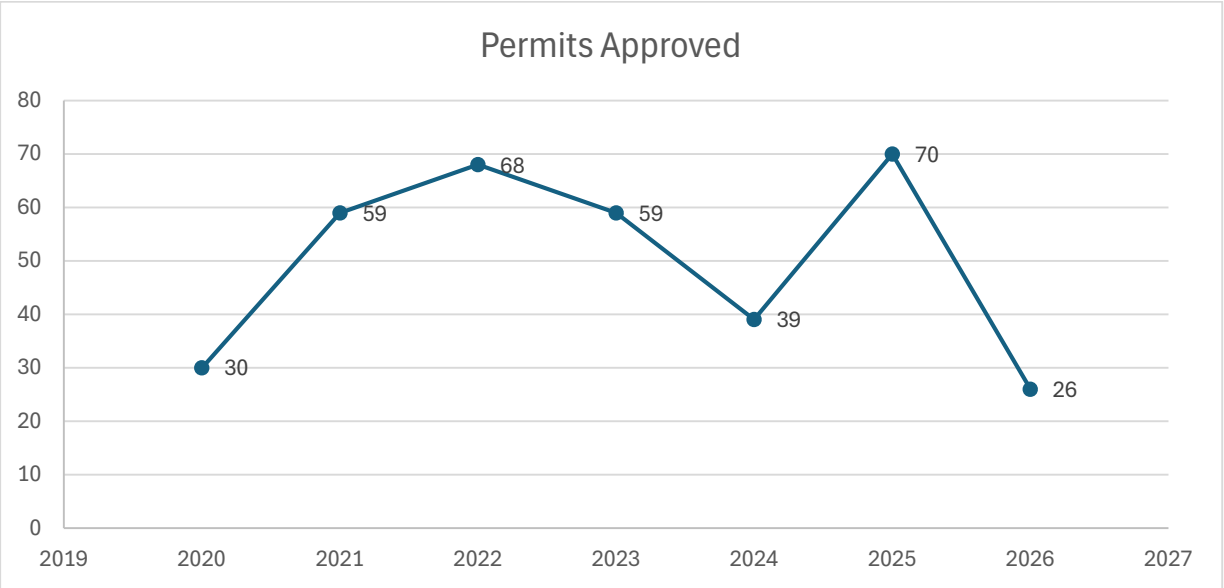
The data indicate a notable increase in construction activity during the COVID-19 pandemic period (2020–2023). This rise in permit approvals may be associated with the availability of federal stimulus funding provided during that time; however, additional analysis would be required to confirm any direct relationship. Based on the available data, the Municipality of Vega Alta records an average of 54 construction permits approved per year. Table 8 and Figure 14 present the number of constructions permit approved between 2020 and 2026. Maps 21 and 22 illustrate the spatial distribution of these permits.

*Table 8: Vega Alta: Construction Permits Approved 2020-20265*

| Construction Permits 2020-2026 | |
|---|---|
| **Year** | **Permits Approved** |
| 2020 | 30 |
| 2021 | 59 |
| 2022 | 68 |
| 2023 | 59 |
| 2024 | 39 |
| 2025 | 70 |
| 2026 | 26 |

[5] 2026 total only accounts for permits up to June 20, 2026

*Figure 12: Vega Alta Construction Permits Approved 2020-2026*[6] –

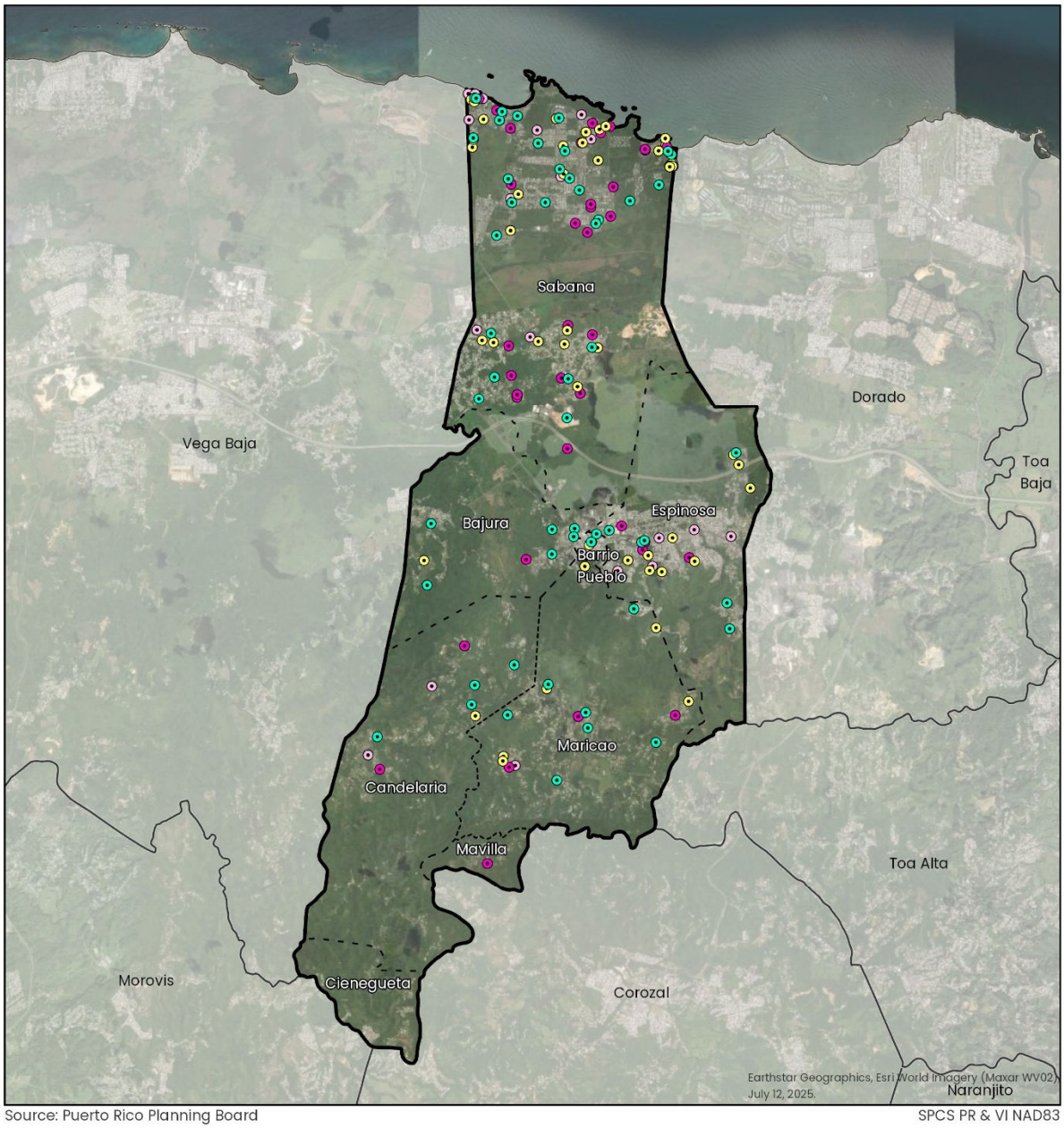



Recent development in Vega Alta continues to be concentrated in the municipality's northern coastal areas, particularly within Sabana Ward, and around the urban center encompassing Barrio Pueblo and Espinosa (Maps 10 and 11). Comparison of the 2020-2023 and 2024-2026 periods indicates that development patterns have remained generally consistent, with most new construction occurring within or adjacent to existing developed areas. This trend suggests continued infill and consolidation of established communities rather than substantial expansion into previously undeveloped areas. However, the concentration of development in northern coastal sectors may increase exposure to coastal and flood-related hazards, underscoring the importance of incorporating hazard mitigation considerations into future land use and development decisions.

[6] 2026 total only accounts for permits up to June 20, 2026

*Map 10: Recent Developments 2020-2023*

# Recent Development 2020 - 2023




Source: Puerto Rico Planning Board

SPCS PR & VI NAD83

Construction Permits Granted

Year Created and Count

- 2020 (30)
- 2021 (58)
- 2022 (68)
- 2023 (59)

Wards

Municipality of Vega Alta

Neighboring Municipalities

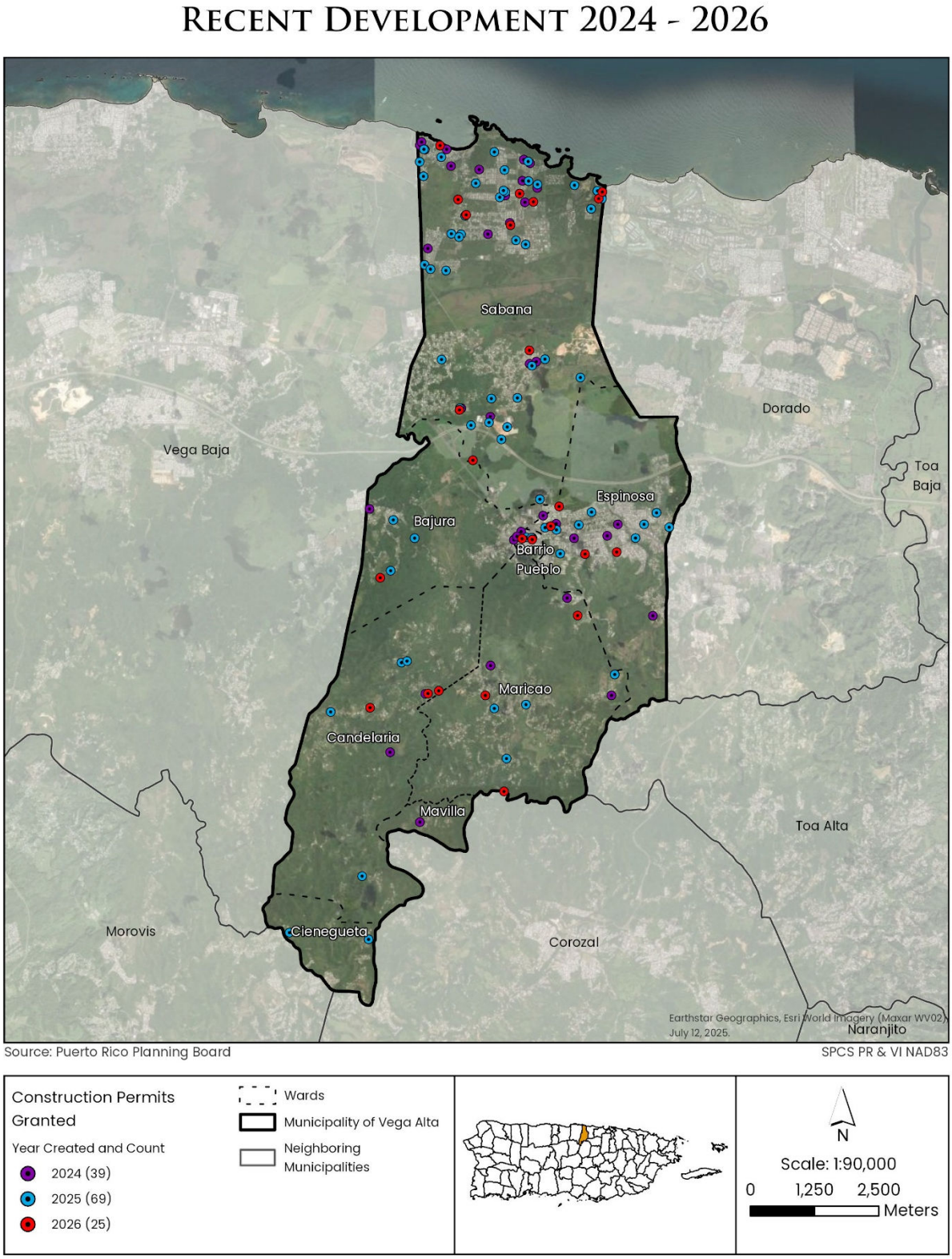


N

Scale: 1:90,000

0 1,250 2,500 Meters

*Map 11: Recent Developments 2024-2026*



# 4. Hazards Profiles and Risks Analysis (B1-a)

## 4.1 Note on the Discussion of Hazards

The 2020 LHMP divided the discussion of the considered hazards into two separate and non-continuous sections. This arrangement made the analysis of the hazard cumbersome since the reader had to go back and forth between two different sections of this large document. In order to improve this, this new LHMP discusses both the profile of the hazard and the risk associated in one single section.

## 4.2 Regulatory Requirements

Federal regulation 44 C.F.R. § 201.6(c)(2) establishes the requirements related to hazard identification and risk assessment for LHMP. The Plan LHMP must include the following:

- An assessment that provides the basis for identifying the proposed activities aimed at reducing losses associated with the identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses related to the identified hazards. The hazard assessment must include:
    - A description of the type, location, and extent of all natural hazards that may affect the jurisdiction. It must contain information on previous occurrences of hazard events and the probability of future hazards.
    - A description of the jurisdiction's vulnerability to the identified hazards. This description must include a comprehensive summary of each hazard and its impact on the community. This Plan must describe vulnerability in terms of:
        - The number of existing structures, infrastructure, and critical facilities located within identified hazard areas;
        - An estimate of the potential monetary losses to structures identified as vulnerable, along with a description of the methodology used to prepare the estimate; and, lastly,
        - A general description of land use and development patterns within the community so that mitigation options can be considered in future land-use decisions.
    - A description of all structures insured under the National Flood Insurance Program (NFIP) that have experienced repetitive damage from different flood events. It must explicitly indicate whether the community participates in the NFIP and complies with its regulations. It must also

include a table showing repetitive property losses along with a table of NFIP claims and losses.

## 4.3 Hazards that can Affect the Municipality

To determine the hazards to be addressed in this LHMP, the Municipality reviewed and integrated information from the 2026 Puerto Rico State Hazard Mitigation Plan, the 2020 Vega Alta Local Hazard Mitigation Plan, and the latest LHMP's of the municipalities that share a boundary with Vega Alta.[7] The following table summarizes the hazards addressed in these Hazard Mitigation Plans. A check mark indicates that the hazard was included in the corresponding plan, while an "X" denotes that it was not.

*Table 16: Historical Hazards Inventories*

| Hazard | 2026 PRSHMP | 2020 Vega Alta LHMP | Neighboring Municipalities |
|---|---|---|---|
| Earthquake/Liquefaction | ✓ | ✓ | ✓ |
| Landslides | ✓ | ✓ | ✓ |
| Tsunami | ✓ | ✓ | ✓ |
| Flooding | ✓ | ✓ | ✓ |
| Storm Surge | ✗ | ✓ | ✓ |
| Coastal Erosion | ✓ | ✓ | ✓ |
| Sea Level Rise | ✗ | ✓ | ✓ |
| Extreme Winds Hazard | ✓ | ✓ | ✓ |
| Extreme Heat | ✓ | ✓ | ✓ |
| Drought | ✓ | ✓ | ✓ |
| Wildfire | ✓ | ✓ | ✓ |
| Pandemic/Epidemic | ✓ | ✗ | ✗ |
| Tropical Cyclones | ✓ | ✓ | ✓ |

[7] The Municipalities of Dorado, Toa Alta, Corozal, Morovis, Vega Baja.

After reviewing the hazard profiles contained in these documents, the Municipality of Vega Alta determined that the following hazards shall be assessed and evaluated as part of the 2026 LHMP:

*Table 9: Hazards to be included in the Vega Alta 2026 LHMP*

| Hazard | Included in Vega Alta 2026 LHMP | Comments |
|---|---|---|
| Earthquake | Yes | It is included given Puerto Rico's location among major fault lines and the 2020 Seismic activity. |
| Landslides | Yes | It is included given the high propensity for landslides in Vega Alta's territory. |
| Tsunami | Yes | It is included given Puerto Rico's location among major fault lines and the 2020 Seismic activity. |
| Flooding | Yes | It is included given the presence of flood zones in the municipality. |
| Tropical Cyclones/Extreme Winds | Yes | It is included given that the southeastern region of Puerto Rico has been the most recurrent point-of-entry for hurricanes that make landfall in Puerto Rico in recorded history. (National Oceanic and Atmospheric Administration, 2026) |
| Storm Surge | Yes | Included in the plan as Vega Alta does have a coastline. |
| Long Term Coastal Dynamics | Yes | Included in the plan as Vega Alta does have a coastline. |
| Extreme Heat | Yes | A new inclusion, various of Vega Alta neighboring communities included this hazard. The Municipality understands |

| Hazard | Included in Vega Alta 2026 LHMP | Comments |
|---|---|---|
| | | that the inclusion of this hazard in the updated LHMP is warranted. |
| Drought | Yes | It is included given the 2014-2016 droughts and recent periods of moderate drought |
| Wildfire | Yes | Vega Alta's neighboring communities included this hazard. The Municipality understands that the inclusion of this hazard in the updated LHMP is warranted. |
| Pandemic/Epidemic | Yes | The municipality of Vega Alta included this in the previous LHMP. It will be considered by the LHMP update given the COVID -19 emergency declaration of 2020. |

The hazards shall be evaluated in the following order:

*Table 10: Order of Hazards to be Assessed*

| Classification | Hazard |
|---|---|
| Geological Hazards | Earthquake |
| | Landslides |
| | Tsunami |
| Hydrological Hazards | Flooding |
| Meteorological Hazards | Tropical Cyclone/Extreme Winds |
| | Extreme Heat |

| Classification | Hazard |
|---|---|
| | Drought |
| Environmental Hazards | Wildfire |
| Biological Hazards | Pandemic/Epidemic |

## 4.4 Chronology of Events

To prevent duplication of data and for easy reference in the discussion of each hazard profile the reader will find a chronology of events in the discussion of the hazard itself.

## 4.5 Risk Assessment Methodology

This section describes the methodologies employed to evaluate the identified hazards. Given that each hazard presents distinct characteristics, data needs, and levels of uncertainty, multiple analytical approaches were utilized to ensure a thorough, accurate, and comprehensive risk assessment.

### *4.5.1* HAZUS 6.1

HAZUS is a Geographic Information System (GIS)–based risk assessment tool developed by FEMA to estimate potential losses associated with natural hazards. The software applies scientific modeling and spatial datasets to evaluate the impacts of events such as earthquakes, floods, hurricanes, and tsunamis on buildings, infrastructure, population, and the local economy. HAZUS generates detailed estimates of physical damage, economic losses, and social consequences, thereby supporting hazard mitigation planning, emergency preparedness, and recovery efforts. By integrating data on hazard intensity, exposure, and vulnerability, HAZUS enables decision-makers to prioritize mitigation strategies and allocate resources effectively. The following hazards were evaluated using the HAZUS 6.1 platform:

- Earthquake
- Tropical Cyclone/Extreme Winds
- Tsunami
- Flooding

### 4.5.2 Alternative GIS modeling

Certain hazards are not currently modeled in HAZUS; however, they can be evaluated using alternative GIS-based techniques. ESRI® ArcGIS Pro™ 3.6 was utilized to assess hazard vulnerability by incorporating digital risk datasets and the hazard information database previously described. Using these spatial data layers, vulnerability was estimated by identifying the number of critical facilities and buildings located within hazard-prone areas. It is important to note that this method may overestimate exposure levels. In this LHMP, the following hazards were assessed using this GIS-based approach:

- Landslides
- Storm Surge

### 4.5.3 Stochastic Risk Assessment

The stochastic risk assessment methodology was applied to evaluate hazards that are not addressed by existing hazard models or GIS-based analyses. This method is particularly appropriate for hazards that lack defined geographic boundaries and therefore cannot be reliably examined through spatial analysis. The approach allows for the incorporation of estimated annual losses and impact data; however, the accuracy of the results is highly dependent on the availability and quality of the underlying datasets.

In the case of this LHMP, the hazards evaluated using this methodology are:

- Long Term Coastal Dynamics
- Extreme Heat
- Drought
- Wildfire
- Pandemic/Epidemic

This methodology is particularly appropriate for hazards that lack clearly defined geographic boundaries and therefore cannot be evaluated through GIS-based analysis. It allows for the incorporation of estimated annual losses and impact data; however, the accuracy of the assessment is highly dependent on the availability and quality of the underlying datasets.

## 4.6 Earthquake

### 4.6.1 Description (B1-a)

An earthquake is a sudden movement of the Earth's crust generated by seismic waves that propagate outward in all directions from the focus, or point of origin (FEMA, 1997).

The focus is the location within the Earth where the displacement of rocks along a fault initiates, while the epicenter refers to the point on the Earth's surface situated directly above the focus (Puerto Rico Seismic Network, 2019). Earthquakes may occur due to changes in pressure within the Earth's crust, including tectonic plate movement, rock rupture, volcanic activity, landslides, or the collapse of underground cavities.

Most earthquakes result from the release of accumulated stress generated by the displacement of rocks along faults within the Earth's outer crust. These faults are generally located along the boundaries of the planet's major tectonic plates. The highest levels of tectonic instability occur at plate margins where slow, opposing movements create substantial pressure due to plates traveling in different directions and at varying speeds. This deformation along plate boundaries causes stress to build in the surrounding rock. When the accumulated stress surpasses the strength of the rock, a rupture occurs, releasing stored energy in the form of seismic waves that propagate outward and produce an earthquake (NMEAD, 2021).

Earthquakes can impact extensive geographic areas, causing tens of billions of dollars in property damage, significant loss of life, numerous injuries, and widespread disruption to the social and economic stability of affected communities. Most structural damage and earthquake-related fatalities result from building collapse triggered by ground shaking (NMEAD, 2021). The severity of impacts depends on the amplitude and duration of seismic shaking, which are influenced by factors such as earthquake magnitude, proximity to the fault rupture, and the local and regional geologic conditions (NMEAD, 2021). Additional hazards associated with earthquakes include landslides where soil and rock masses move downslope and liquefaction, a process in which saturated soils lose their rigidity and behave like a fluid. Liquefaction can cause foundations and structures that rely on soil stability to shift, tilt, or collapse.

Puerto Rico is located near the boundary between the North American and Caribbean tectonic plates, within a subduction zone where one plate gradually descends beneath the other. This tectonic environment is characterized by significant seismic activity and lateral displacement. The relative movement between these two plates is approximately 2 centimeters per year (Puerto Rico Seismic Network, 2019). According to the Puerto Rico Seismic Network, seismic activity in the region is concentrated in eight (8) primary zones:

- The Puerto Rico Trench to the North,
- The North and South Slope Faults of Puerto Rico,
- The "Sombrero Zone", to the Northeast,
- The Mona Passage to the West

- The Mona Canyon to the West,
- The Virgin Islands and Anegada depressions to the East,
- The Muertos Trough to the South,
- The southwest of Puerto Rico

To describe earthquake size, seismology uses three (3) primary terms: intensity, magnitude, and ground acceleration. Intensity measures the level of shaking experienced by structures and the natural environment at a specific location. It varies based on the distance from the earthquake's focus and the duration of the shaking. Magnitude refers to the amount of energy released during the event, as recorded by seismometers. Ground acceleration expresses the force of the seismic waves acting on the ground and is commonly used to characterize the severity of an earthquake (PRSN, 2019).

Earthquakes can generate a variety of secondary hazards, including liquefaction, landslides, seismic wave amplification, and tsunamis. For the purposes of this analysis, the primary secondary hazard of concern is earthquake-induced liquefaction, as it is a condition for which mitigation strategies can be effectively developed once susceptible areas are identified and mapped. Liquefaction refers to the process in which certain saturated soils temporarily lose their structural strength and behave like a dense fluid, significantly reducing their load-bearing capacity (PRSN, 2019). Liquefaction typically occurs in areas underlain by medium- to fine-grained sandy soils that are saturated with water and of relatively recent geologic origin. These conditions are most found along river margins and within Quaternary (Q) alluvial deposits. Another secondary hazard associated with earthquakes is the amplification of seismic waves. Seismic wave amplification occurs in thick alluvial deposits where seismic waves decelerate, increasing their oscillation and causing the ground to experience stronger and more prolonged shaking.

#### *4.6.1.1 Affected Area (B1-B)*

The following maps measure the spectral acceleration and spectral displacement in HAZUS run scenarios.

Spectral Acceleration is measure used mainly in earthquake engineering to describe how strongly the ground motion from an earthquake would accelerate a structure with a specific natural period. This measure answers the question "If a building (or any structure) vibrates naturally at a certain period, how much acceleration would it experience during an earthquake?" or, how hard the ground is pushing on the building at a specific vibration period? The higher the spectral acceleration, stronger the forces

acting on the structure will be, which can cause structural failure if the building isn't designed for it (USGS, 2019).

Spectral Displacement measures how far a structure is expected to move (deform) during an earthquake, based on its natural vibration period and damping. In other words, it answers: "For a building with a given natural period, what is the maximum displacement it would experience during earthquake shaking?" (National Institute of Building Sciences, 2020).

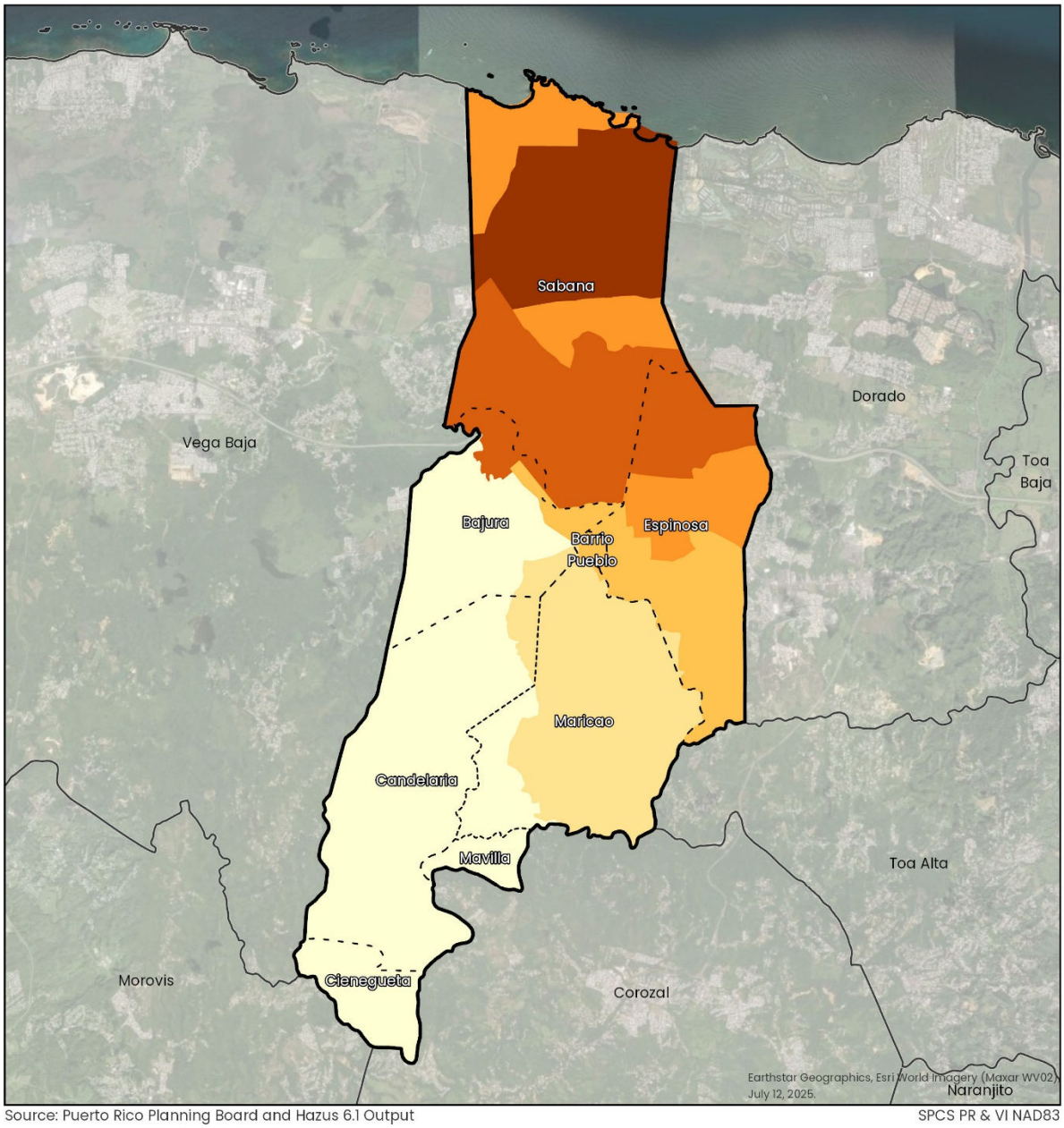
Furthermore, the maps show the Hazus scenario for .03 seconds and 1.0 seconds. The difference relates to how an earthquake impacts different types of structures based on the natural vibration period the building. The maps showing the 0.3-second scenario can affect buildings that are short, stiff structures like 1 or 2-story buildings. These buildings are rigid, so they vibrate quickly when the ground shakes. While the 1.0-second scenario that is more important for buildings are taller, more flexible structures, like mid- to high-rise buildings. These buildings are taller and less stiff and therefore sway more slowly (over a longer period) during an earthquake (FEMA, Hazus Earthquake Model User Guidance, 2024).

The spectral acceleration analysis indicates that earthquake shaking potential varies across Vega Alta, with the highest seismic demands occurring in the northern portion of the municipality, particularly within Sabana Ward and portions of Espinosa and Barrio Pueblo. While earthquake impacts are possible throughout the municipality, the combination of higher spectral acceleration values and concentrated development in the northern and central sectors increases the relative vulnerability of these areas. Continued implementation of seismic design standards, infrastructure resilience measures, and risk-informed land use planning will be important to reducing future earthquake losses and enhancing community resilience.

The spectral acceleration maps for Vega Alta illustrate the expected intensity of earthquake-induced ground shaking across the municipality for structures with different natural vibration periods. The 1.0-second spectral acceleration (Map 23) map represents the response of taller and more flexible structures, including multi-story buildings and certain critical facilities. The 0.3-second spectral acceleration map (Map 24) represents the response of shorter, stiffer structures, such as single-family residences, low-rise commercial buildings, and many public facilities. Spectral acceleration is expressed as a fraction of gravitational acceleration (g) and provides an indication of the seismic forces that structures may experience during a significant earthquake event.

*Map 12: Spectral Acceleration at 1.0 sec*

# Earthquake: Spectral Acceleration at 1.0 sec (g)




Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83

Spectral Acceleration (g)

- ≤ 0.420224
- 0.420225 - 0.436179
- 0.436180 - 0.453486
- 0.453487 - 0.475450
- 0.475451 - 0.488491
- 0.488492 - 0.521883

Wards

Municipality of Vega Alta

Neighboring Municipalities



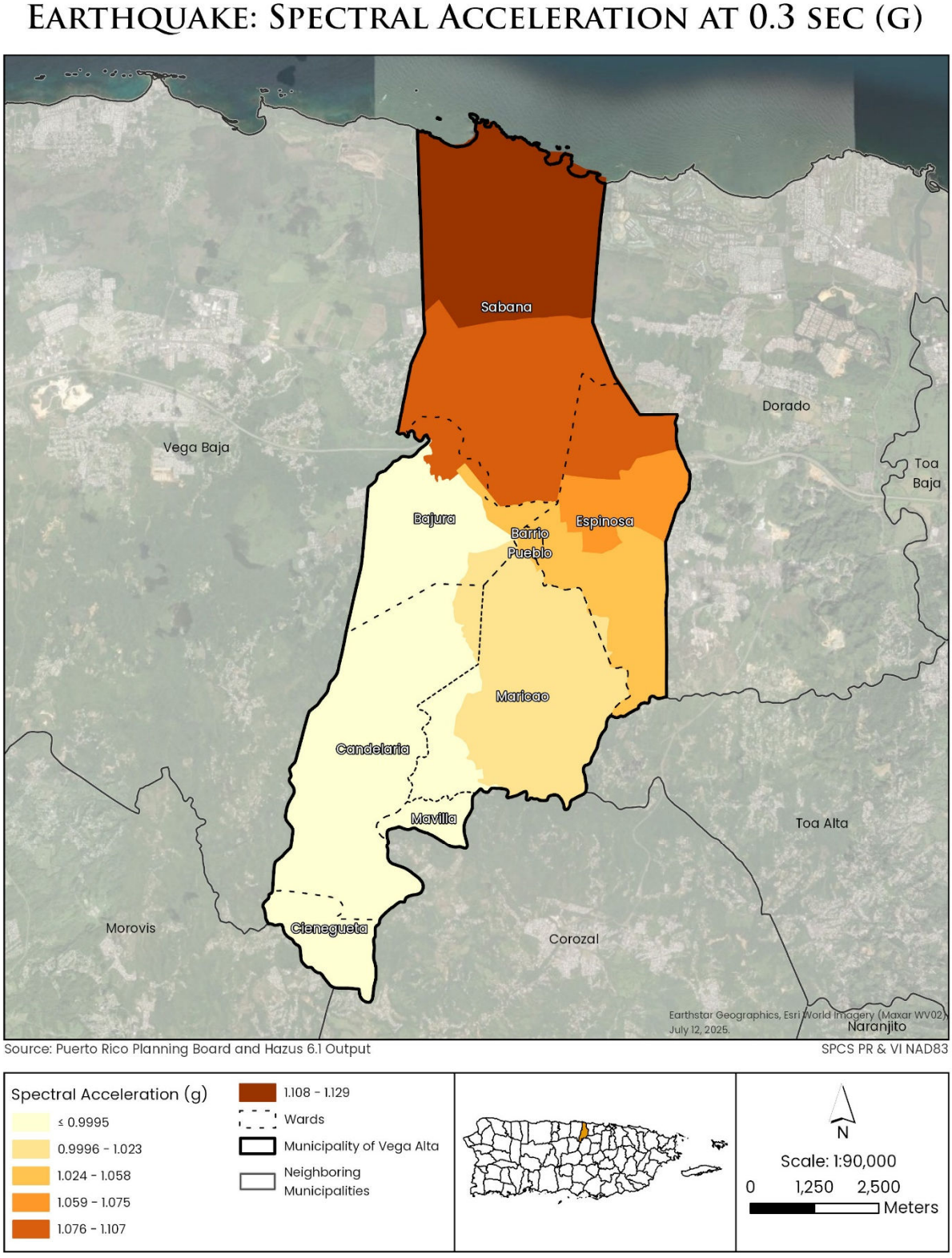
N

Scale: 1:90,000

0 1,250 2,500

Meters

*Map 13: Vega Alta Earthquake Spectral Acceleration at 0.3 sec*



Both maps display a consistent spatial pattern across Vega Alta, with the highest spectral acceleration values concentrated in the northern portion of the municipality, particularly within Sabana Ward, and extending into portions of Espinosa, Barrio Pueblo, and adjacent northern sectors. The lowest values occur in the southern wards, including Cienegueta, Mavilla, and portions of Candelaria. This north-to-south gradient suggests that site conditions and local geology may contribute to greater amplification of seismic waves in the northern part of the municipality.

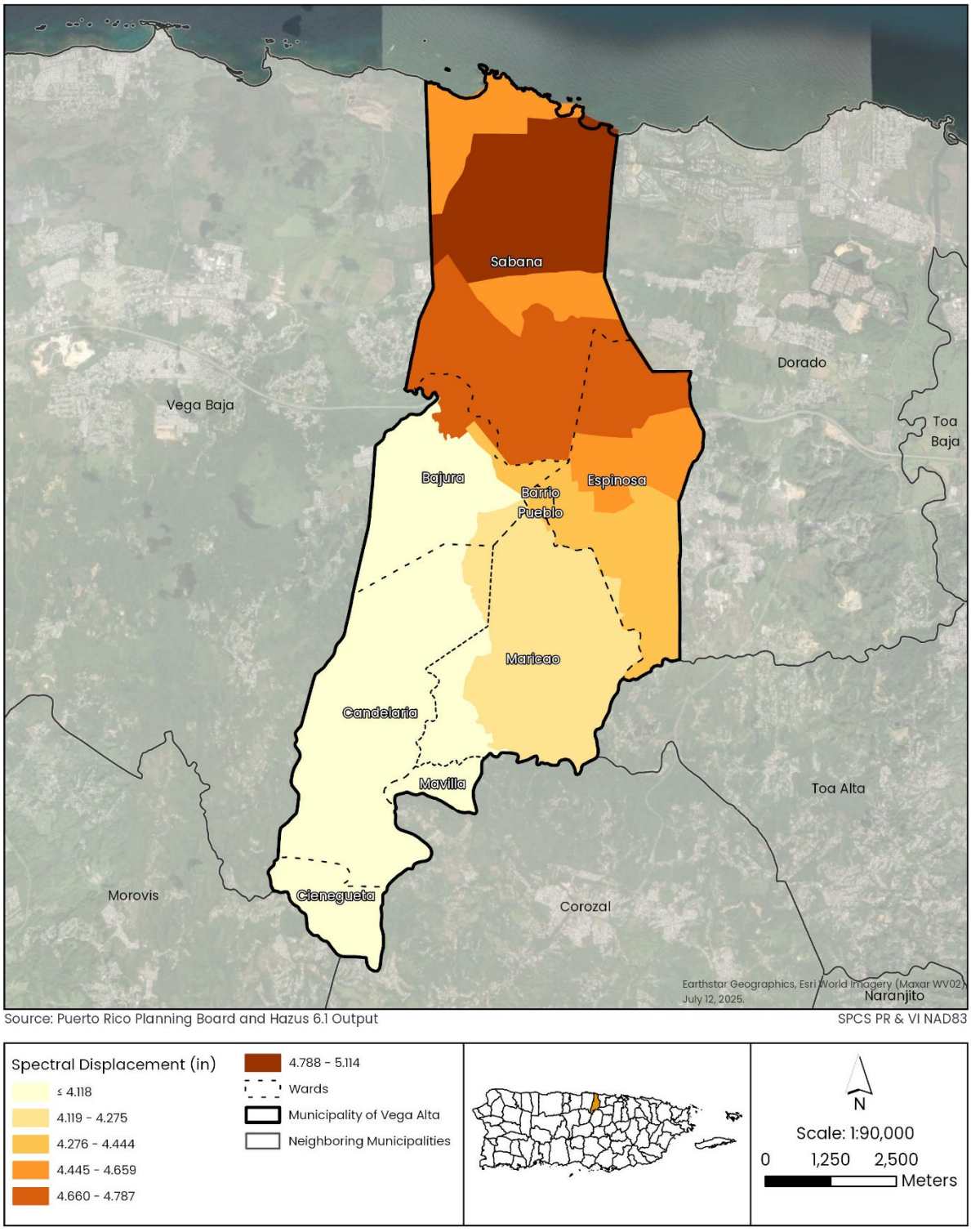
Map 13 shows spectral acceleration values ranging from approximately 1.00 g to 1.13 g, while Map 12 shows values ranging from approximately 0.42 g to 0.52 g. Although these values vary throughout the municipality, all areas of Vega Alta are subject to substantial earthquake ground motion capable of causing structural damage, particularly in older buildings or structures not designed to current seismic standards. The higher values observed in the northern wards indicate greater potential for earthquake-induced structural stresses, increased building damage, and disruption of infrastructure systems.

These maps help identify areas where mitigation efforts may provide the greatest benefit. Potential mitigation considerations include seismic evaluation and retrofit of critical facilities, incorporation of earthquake-resistant design practices in public infrastructure projects, enforcement of up-to-date building codes, and prioritization of emergency response planning for areas where higher seismic demand overlaps with concentrations of population and essential services.

From a vulnerability perspective, the concentration of residential development, commercial activity, and critical facilities within the northern and central portions of Vega Alta coincides with the areas exhibiting the highest modeled seismic demand. As a result, these sectors may experience comparatively greater potential for structural damage, disruption of essential services, and economic losses during a major earthquake. Future development and infrastructure investments, particularly within Sabana, Espinosa, and Barrio Pueblo, should continue to incorporate current seismic design standards and earthquake-resistant construction practices to reduce risk and improve community resilience.

*Map 14: Spectral Displacement at 1.0 sec*

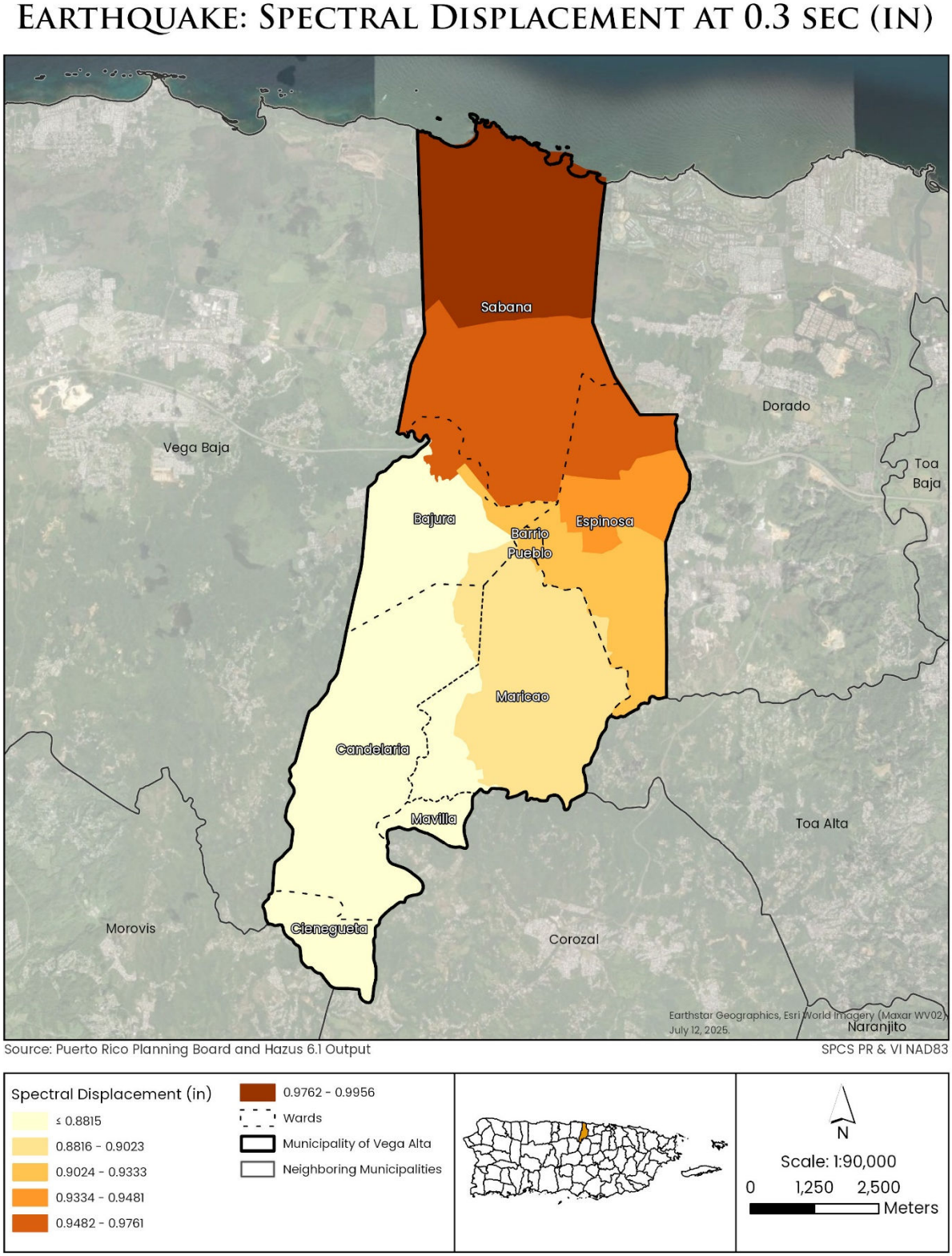
# EARTHQUAKE: SPECTRAL DISPLACEMENT AT 1.0 SEC (IN)




Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83

*Map 15: Vega Alta Spectral Displacement at 0.3 sec*



The spectral displacement analysis indicates that the highest levels of expected earthquake-induced structural movement occur in the northern portion of Vega Alta, particularly within Sabana Ward and portions of Espinosa and Barrio Pueblo. Similar to the spectral acceleration analysis, displacement values generally decrease toward the southern wards of the municipality. While spectral acceleration represents the seismic forces acting on structures, spectral displacement represents the expected structural movement and deformation resulting from those forces. Elevated displacement values increase the potential for structural drift, damage to building components, disruption of utility systems, and functional impairment of critical facilities.

Similar to spectral acceleration, maps 14 and 15 indicate a clear spatial pattern across Vega Alta, with the highest spectral displacement values occurring in the municipality's northern wards, particularly Sabana, and portions of Espinosa and Barrio Pueblo. Displacement values gradually decrease toward the southern wards, including Cienegueta, Mavilla, and Candelaria. For the 1.0-second period, displacement values range from approximately 4.1 inches to over 5.1 inches, while the 0.3-second period values range from approximately 0.88 inches to 1.0 inch. This pattern suggests that structures located within the northern portion of the municipality may experience greater earthquake-induced movement than structures in southern areas.

Because areas with the highest displacement values largely coincide with the municipality's principal residential, commercial, and public development concentrations, these sectors may experience a greater risk of earthquake-related damage and service disruption. The results underscore the importance of maintaining compliance with current seismic building codes, incorporating earthquake-resistant design into future development, evaluating the seismic performance of critical facilities, and prioritizing mitigation investments in areas where elevated seismic demand overlaps with concentrations of population and essential infrastructure. These measures will help reduce future losses and improve the overall resilience of Vega Alta to earthquake hazards.

#### *4.6.1.2 Risk Magnitude (B1-C)*

The size of an earthquake, commonly associated with the Richter Scale, is widely recognized but often misunderstood. The concept of a logarithmic magnitude scale was first introduced by Charles Richter in the 1930s to measure earthquakes in Southern California using high-frequency recordings from nearby seismograph

stations. This original scale, designated as ML where "L" stands for "local" eventually became known as the Richter magnitude.

As global seismic monitoring networks expanded, it became evident that the Richter method was accurate only within specific frequency and distance ranges. To accommodate a broader range of seismic signals recorded worldwide, additional magnitude scales were developed as extensions of Richter's original concept, including the body-wave magnitude (Mb) and the surface-wave magnitude (Ms). Each of these scales applies to a particular frequency range and type of seismic waves, and within their respective valid ranges, they provide magnitudes equivalent to the Richter scale. (USGS, 2024)

Due to the limitations of the ML, Mb, and Ms scales, a more universally applicable scale moment magnitude (Mw) was developed. For large-magnitude earthquakes, Mw provides the most accurate and reliable estimate of earthquake size.

Moment is a physical quantity proportional to the amount of slip that occurs along a fault multiplied by the area of the fault surface that undergoes rupture. It reflects the total energy released by an earthquake. Moment can be derived from seismogram data and geodetic measurements and subsequently converted into a magnitude value using a standardized formula. The resulting measure, known as moment magnitude, provides a consistent and comparable estimate of earthquake size across the full range of magnitudes a capability that earlier scales do not offer (USGS, 2024). Table 11 below shows the Moment – Magnitute

*Table 11: Moment - Magnitude Scale*[8]

| Range | Description |
|---|---|
| Mw < 3.0 | Usually not felt by people. |
| Mw 3.0 – 4.9 | Minor earthquakes, often felt but rarely cause damage. |
| Mw 5.0 – 5.9 | Moderate can cause slight damage to poorly built structures. |
| Mw 6.0 – 6.9 | Strong can cause significant damage in populated areas. |
| Mw 7.0–7.9 | Major, serious damage over large areas. |

[8] Source: USGS, 2025

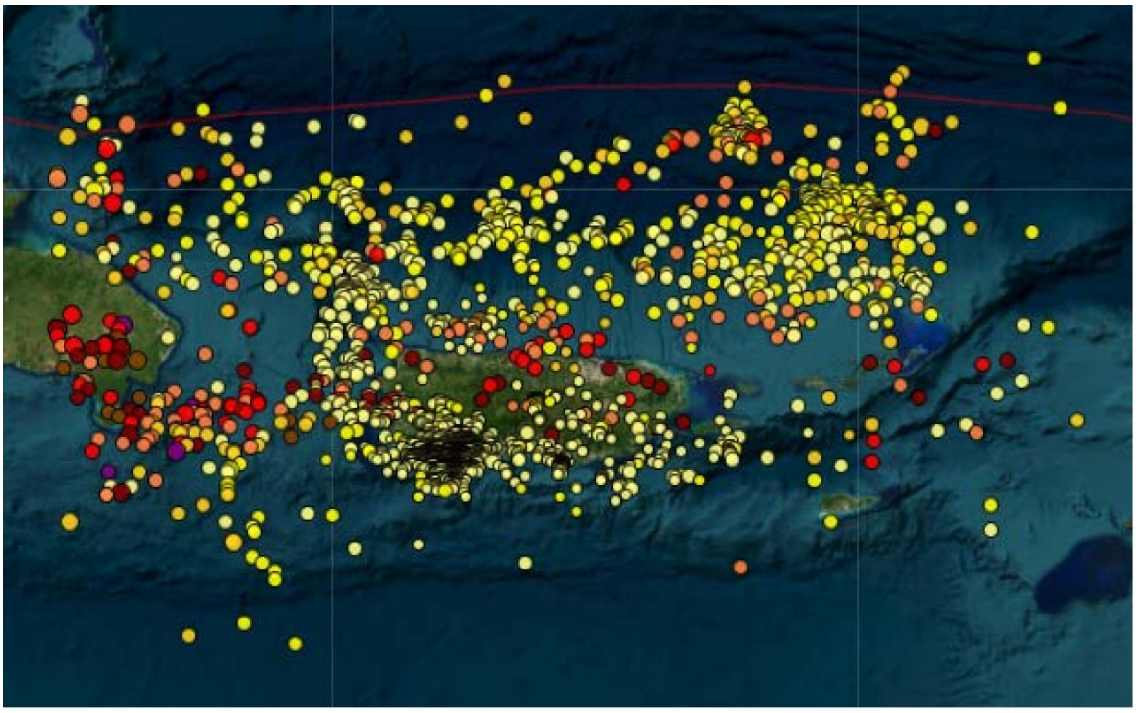
| Range | Description |
|---|---|
| Mw ≥ 8.0 | Great earthquakes, catastrophic damage over very large regions. |

#### 4.6.1.3 Past Events (B1-D)

Earthquakes occur naturally daily, and their impacts increase significantly with greater magnitude. High-magnitude events can be particularly destructive, causing extensive property damage, loss of life, and severe disruption to affected regions. Puerto Rico is located near several active seismic zones including the Puerto Rico Trench, the Mona Canyon, the Anegada Trough, the Muertos Trough, and the southern fault system placing the island at heightened risk for seismic events. Seismicity in the southeastern region of Puerto Rico is primarily associated with faults in the Virgin Islands and Anegada depressions. In the southwestern region, activity is influenced by the Punta Montalva fault (Roig Silva, 2010), an area that has experienced a notable increase in seismic activity in recent years (Weilert & Laó-Dávila, 2023).

Figure 12 is a screengrab sourced from a report published by the Puerto Rico Seismic Network (in Spanish). This report illustrates the epicenters of earthquakes recorded in the Puerto Rico and U.S. Virgin Islands region in 2024 (PRSN, 2025).

*Figure 13: PRSN - 2024 Earthquakes Epicenter (PRSN, 2025)*



**Earthquake Chronology**

Table 12 below shows the chronological list of the seismic activity in Puerto Rico for the period of 2012 to 2024 as reported by the PRSN (PRSN, n.d.).

*Table 12: Puerto Rico Seismic Activity 2013-2024*

| Year | Description of seismic events |
|---|---|
| 2024 | The largest earthquake of 2024 occurred on May 14, 2024, at 8:30:11 p.m. (Puerto Rico local time). The magnitude 5.6 Ml earthquake was located 94.3 km north-northwest of Aguadilla (PR) at a depth of 7 km. This moderate earthquake was widely felt throughout Puerto Rico, with a maximum intensity of V (Modified Mercalli Intensity Scale, MMI) in Aguadilla (PR).<br><br>During 2024, aftershocks from the South-Southwest Puerto Rico seismic sequence continued. This sequence began on December 28, 2019, with a magnitude 4.7 Ml earthquake. The main event of this sequence occurred on January 7, 2020, in the southern region of Puerto Rico, 12.7 km south of Guayanilla, with a magnitude of 6.4 Mw. This strong earthquake, at a depth of 7 km, had a maximum intensity of VIII in Guánica, Puerto Rico, and caused major damage across the island.<br><br>From the start of the South-Southwest Puerto Rico seismic sequence in 2019 through April 2024, 27,497 earthquakes associated with this sequence have been processed (Figure 2). More than 1,688 felt earthquakes and over 492 significant events with magnitudes greater than 3.5 have been recorded. Of these, 42 earthquakes had magnitudes greater than 4.5. |
| 2023 | The largest earthquake of 2023 occurred on December 9, 2023, at 10:27:22 a.m. (Puerto Rico local time). The magnitude 5.7 Ml earthquake was located 192.28 km east-northeast of San Juan, PR, at a depth of 7 km. This moderate earthquake was widely felt throughout Puerto Rico and the Virgin Islands, with a maximum intensity of V (Modified Mercalli Intensity Scale, MMI) in St. Thomas (USVI).<br><br>During 2023, aftershocks from South-Southwest Puerto Rico seismic sequence continued. This sequence began on December 28, 2019, with a magnitude 4.7 Ml earthquake. The main event of this sequence occurred on January 7, 2020, in the southern region of Puerto Rico, 12.7 km south of Guayanilla, with a magnitude of 6.4 Mw. This strong earthquake, at a depth of 7 km, had a maximum intensity of VIII in Guánica, Puerto Rico, and caused major damage across the island. |

| Year | Description of seismic events |
|---|---|
| 2022 | The seismic sequence in the South-Southwest region of Puerto Rico, which began on December 28, 2019, continues. From its onset until the March 2022 report by the Puerto Rico Seismic Network, a total of 19,436 earthquakes associated with this sequence had been recorded. In that report, 1,502 events were documented for 2022, of which 30 were reported as felt. The regions with the highest seismic activity during March 2022 were in the southern area of Puerto Rico. |
| 2021 | The largest earthquake of 2021 occurred on January 24, 2021, at 7:21:41 p.m. (Puerto Rico local time). The magnitude 5.4 Ml earthquake was located 44.82 km southeast of Virgin Gorda, BVI, at a depth of 94 km. This moderate earthquake was widely felt throughout Puerto Rico and the Virgin Islands, with a maximum intensity of V (Modified Mercalli Intensity Scale, MMI) in Tortola, British Virgin Islands. |
| 2020 | The year 2020 was marked by significant seismic activity. An earthquake of magnitude 5.8 was recorded on January 6, 2020, followed by another of 6.4 on January 7, 2020, located 8 km from Indios, Puerto Rico. It is important to clarify that, starting from the 4.7 magnitude event recorded on December 28, 2019, up to October 22, 2020, approximately over 1,200 earthquakes of magnitude 2.0+ have been felt on the island.<br><br>Tectonic activity in Puerto Rico is dominated by the convergence between the North American and Caribbean plates, with the island compressed between the two. To the north of Puerto Rico, the North American plate subducts beneath the Caribbean plate along the Puerto Rico Trench. To the south of the island, and south of the January 7 earthquake, the upper crust of the Caribbean plate subducts beneath Puerto Rico in the Muertos Trough. However, the January 6 earthquake and other recent events are occurring in the offshore deformation zone, connected by the Punta Montalva fault on land and the Guayanilla Canyon offshore.<br><br>Between December 28, 2019, and January 23, 2020, southern Puerto Rico recorded 90 seismic events of magnitude 4.0 or greater, including the 6.5 magnitude earthquake on January 7, 2020, according to the USGS. These seismic movements led state authorities to request a disaster declaration from the President of the United States. This Disaster Declaration was issued on January 16, 2020, under number DR-4473. The Municipality of Vega Alta was not included among those designated to receive Individual Assistance funds from FEMA. |
| 2019 | During 2019, the Puerto Rico Seismic Network (PRSN) located a total of 6,510 earthquakes in the Puerto Rico and Virgin Islands region (our seismic responsibility area, between latitudes 17°N–20°N and longitudes 63.5°W–69°W). Compared to |

| Year | Description of seismic events |
|---|---|
| | 2018 (3,974 earthquakes), the detected and located seismicity in 2019 increased. The year 2019 ended with 2,536 more earthquakes than the previous year. In 2019, the month with the highest activity was December with 1,291 earthquakes, while August had the lowest seismicity with 303 earthquakes.<br><br>The region with the highest recorded seismicity during 2019 was the Mona Canyon with 1,288 seismic events, followed by the southern region of Puerto Rico with 885 earthquakes (Table 3). Earthquake depths ranged from 1 km to 191 km, and magnitudes varied from 0.34 Md to 6.0 Mw. Of the total earthquakes in 2019, 70 were reported as felt. On December 28, 2019, an active period of seismic activity began, with a 4.7 magnitude earthquake, followed several hours later by another of 5.0 magnitude south of the island. |
| 2018 | During 2018, the Puerto Rico Seismic Network (PRSN) located a total of 3,974 earthquakes in the Puerto Rico and Virgin Islands region (our seismic responsibility area, between latitudes 17°N–20°N and longitudes 63.5°W–69°W). Compared to 2017 (3,129 earthquakes), the detected and located seismicity increased by 845 more earthquakes than the previous year. In 2018, the month with the highest activity was December with 549 earthquakes, while February had the lowest seismicity with 227 earthquakes.<br><br>The region with the highest recorded seismicity during 2018 was the southern region of Puerto Rico with 412 seismic events, followed by the 19°N Fault Zone with 349 earthquakes. Earthquake depths ranged from 2 km to 185 km, and magnitudes varied from 0.63 Md to 4.67 Md. Of the total earthquakes in 2018, 29 were reported as felt within our area of responsibility. |
| 2017 | During 2017, the Puerto Rico Seismic Network (PRSN) located a total of 3,129 earthquakes in the Puerto Rico and Virgin Islands region (our seismic responsibility area, between latitudes 17°N–20°N and longitudes 63.5°W–69°W). Compared to 2016 (3,948 earthquakes), the detected and located seismicity decreased by 20%, which means 819 fewer earthquakes than the previous year. In 2017, the month with the highest activity was April with 518 earthquakes, while October had the lowest seismicity with 48 seismic events.<br><br>The region with the highest recorded seismicity during 2017 was the Sombrero Seismic Zone with 856 seismic events, followed by the Virgin Islands Platform with 327 earthquakes. Earthquake depths ranged from 1 km to 180 km, and magnitudes |

| Year | Description of seismic events |
|---|---|
| | varied from 0.85 Md to 4.8 Mb. Of the total earthquakes in 2017, 24 were reported as felt within our area of responsibility. |
| 2016 | During 2016, the Puerto Rico Seismic Network (PRSN) located a total of 3,947 earthquakes in the Puerto Rico and Virgin Islands region (our seismic responsibility area, between latitudes 17°N–20°N and longitudes 63.5°W–69°W). Compared to 2015 (3,235 earthquakes), the detected and located seismicity increased by 22.0%, or 712 more earthquakes than the previous year. In 2016, the month with the highest activity was September with 566 earthquakes, while March had the lowest seismicity with 169 earthquakes.<br><br>The region with the highest recorded seismicity during 2016 was the Sombrero Seismic Zone with 973 seismic events, followed by the Virgin Islands Platform with 497 earthquakes. Earthquake depths ranged from 1 km to 177 km, and magnitudes varied from 0.76 Md to 4.6 Ml. Of the total earthquakes in 2016, 28 were reported as felt within our area of responsibility. |
| 2015 | During 2015, the Puerto Rico Seismic Network (PRSN) located a total of 3,235 earthquakes in the Puerto Rico and Virgin Islands region (our seismic responsibility area, between latitudes 17°N–20°N and longitudes 63.5°W–69°W). Compared to 2014 (3,420 earthquakes), the detected and located seismicity decreased by 5.4%, or 185 fewer earthquakes than the previous year. In 2015, the month with the highest activity was July with 473 earthquakes, while April had the lowest seismicity with 157 earthquakes.<br><br>The region with the highest recorded seismicity during 2015 was the Sombrero Seismic Zone with 588 seismic events, followed by the 19°N Fault Zone with 477 earthquakes. Earthquake depths ranged from 1 km to 211 km, and magnitudes varied from 0.80 Md to 4.80 Md (duration magnitude). Of the total earthquakes in 2015, 23 were reported as felt within the area of responsibility. |
| 2014 | During 2014, the Puerto Rico Seismic Network (PRSN) located a total of 3,420 earthquakes in the area of responsibility (AOR) known as the Puerto Rico and Virgin Islands Region (latitude 17.00˚ to 20.00˚N and longitude 63.50˚ to 69.00˚W). Compared to 2013 (2,293 earthquakes), the detected and located seismicity increased by 49%, which is 1,127 more earthquakes than the previous year. In this year, the month with the highest seismicity was January with 709 earthquakes, and the month with the lowest seismicity was November with 192 earthquakes.<br><br>Of the total seismicity in 2014, 29 earthquakes (0.85%) were reported as felt, all located within our AOR. The magnitudes (Md) of the seismic events calculated for this year by PRSN ranged from 1.0 to 6.4, although for felt events they ranged from |

| Year | Description of seismic events |
|---|---|
| | 2.53 Md to 6.4 Mwp. During 2014, depths varied between 1 km and 182 km, while for felt earthquakes they ranged from 6 km to 134 km. Earthquakes with depths of 0 to 25 km were the most frequent with 1,385 events, while those between 175 km and 200 km were the least frequent this year. The region with the highest recorded seismicity during 2014 was the 19ºN Fault Zone with 905 seismic events, followed by the Sombrero Seismic Zone with 483 earthquakes. |
| 2013 | During 2013, the Puerto Rico Seismic Network (PRSN) located a total of 2,293 earthquakes in the Puerto Rico and Virgin Islands region (latitude 17.00˚ to 20.00˚N and longitude 63.50˚ to 69.00˚W). Compared to 2012 (2,852 earthquakes), the detected and located seismicity decreased by 20%, which is 559 fewer earthquakes than the previous year. In this year, the month with the highest seismicity was September with 272 earthquakes, and the month with the lowest seismicity was February with 114 earthquakes.<br><br>Of the total seismicity in 2013, 44 earthquakes (1.92%) were reported as felt, all located within the Puerto Rico and Virgin Islands region. The magnitudes of the seismic events calculated for this year by PRSN ranged from 1.0 to 5.12, although for felt events they ranged from 2.36 to 5.12. During 2013, depths varied between 1 km and 182 km, while for earthquakes they ranged from 4 km to 112 km. The region with the highest recorded seismicity during 2013 was the Sombrero Seismic Zone with 504 seismic events, followed by the Virgin Islands Platform with 246 earthquakes. Through its educational program, PRSN reached 14,099 people in Puerto Rico and the U.S. and British Virgin Islands during 2013. |

**2020 Seismic Sequence**

In early January 2020, Puerto Rico experienced a significant seismic sequence that began with a series of foreshocks and culminated in a major earthquake on January 7. The main shock registered a magnitude of 6.4 Mw and struck along the island's southern coast, severely affecting the municipalities of Guayanilla, Ponce, and Yauco. This event was preceded by a magnitude 5.8 Mw earthquake on January 6, which had already caused widespread concern and notable structural damage (USGS, n.d.). The seismic activity was associated with the complex interaction between the Caribbean and North American tectonic plates, a region characterized by active subduction zones and fault systems. The resulting shaking was felt across the island, causing power outages, school closures, and the collapse of numerous structures, including residential and public buildings.

The aftermath of the earthquake resulted in extensive damage to homes and critical infrastructure, displacing thousands of residents and prompting a federal emergency declaration. The southern region experienced prolonged aftershocks—some exceeding magnitude 5.0, which continued for weeks, intensifying public concern and creating sustained disruption. This event underscored Puerto Rico's heightened vulnerability to seismic hazards and highlighted the importance of preparedness measures and resilient construction practices. The incident received a Presidential Disaster Declaration under the Stafford Act (DR-4473-PR)(FEMA, n.d.). Although the Municipality of Vega Alta was not included in the Disaster Declaration, it recognizes that Puerto Rico's location along active tectonic boundaries place all jurisdictions at risk of seismic events capable of causing millions of dollars in damages and significant disruptions to daily life.

According to the Puerto Rico Seismic Network (PRSN), from the onset of the South–Southwest Puerto Rico seismic sequence in 2019 through April 2024, a total of 27,497 earthquakes associated with this sequence were recorded and processed. Of these events, more than 1,688 were reported as felt, and over 492 registered magnitudes greater than 3.5. Additionally, 42 earthquakes reached magnitudes exceeding 4.5.

#### *4.6.1.4 Future Event Probabilities (B1-E)*

Unlike atmospheric hazards, earthquakes cannot be predicted with current scientific capabilities. However, advances in seismology allow for the development of probabilistic forecasts. Historical records indicate that Puerto Rico has experienced four major destructive earthquakes since 1670—specifically in 1670, 1787, 1867, and 1918. This sequence suggests a recurrence interval ranging from 51 to 117 years, with an average interval of approximately 83 years for significant events. It is important to note, however, that each of these earthquakes originated on different fault systems; therefore, this record alone cannot be used to establish a precise recurrence rate.

For more comprehensive analyses, geologic maps of specific zones are examined to identify active faults and other relevant structural features. These datasets are then correlated with historical earthquake intensity distributions, seismic attenuation models, and statistical records. This integrated approach produces maps of seismically active areas that delineate regions with varying potential for strong earthquake activity. Identifying these high-risk zones is essential for informed land-use planning and effective emergency preparedness.

In the case of Puerto Rico, the PRSN cites a probabilistic seismic hazard study conducted in 1987 by Dr. William McCann, which estimated a 33–50% probability of a

strong earthquake (Intensity VII or higher on the Modified Mercalli Scale) occurring in various parts of the island within a 50-year period (PRSN, 2025).

Further research conducted by the U.S. Geological Survey in 2003 identified an area west–southwest of Puerto Rico as the region most likely to experience strong earthquakes on the island (Figure 1). This probabilistic analysis does not account for secondary hazards such as tsunamis, liquefaction, or seismic wave amplification, which predominantly affect low-lying coastal areas and high-elevation zones susceptible to landslides.

### 4.6.2 Risk Analysis (B2-a, B2-b)

#### *4.6.2.1 Estimated Losses*

The Federal Emergency Management Agency's HAZUS Earthquake Analysis provides estimates of Annualized Earthquake Losses defined as the long-term average annual economic impact of earthquakes on the general building stock within a given geographic area as well as annualized estimates of population loss.

The Annualized Earthquake Loss is calculated using the Riemann Sums Method, which averages the annual losses associated with multiple return periods and then multiplies each average loss by its corresponding differential probability to produce a single loss estimate for each Census tract. (FEMA, National Risk Index Data - Technical Documentation, 2025)

Table 21 presents the exposure to earthquake hazards. While no monetary measure can fully reflect the value of human life, FEMA's Benefit-Cost Analysis methodology uses a population equivalence approach based on the Value of a Statistical Life (VSL) to approximate the economic value of avoided fatalities and injuries. Under this approach, each avoided fatality, or the equivalent of ten injuries prevented, is assigned an economic value of $11.6 million in 2020 dollars, based on the Value of a Statistical Life (VSL) adopted by FEMA from the U.S. Department of Homeland Security's 2021 guidance. All historical loss figures are subsequently adjusted to December 2024 dollars to account for inflation.

The HAZUS 6.1 analysis indicates that the municipality's total exposure to an earthquake event is $414,725,979,000.00. This estimate includes $4,143,979,000.00 in building value exposure and $410,582,000,000.00 in population exposure.

*Table 13: Exposure to Earthquake Hazard*

| Exposure - Impacted Area (sq mi) | Exposure - Building Value (in million $) | Exposure - Population | Exposure - Population Equivalence (in million $) | Exposure – Total (in million $) |
|---|---|---|---|---|
| 28.06 | $4,144 | 35,395 | $410,582_ | $414,726 |

The expected annual loss for each Census tract or jurisdiction represents the average yearly economic impact, expressed in dollars, anticipated from natural hazard events. Table 16 presents the expected annual earthquake-related losses for both buildings and population.

*Table 14: Expected Annual Loss to Earthquake*

| Expected Annual Loss - Building Value | Expected Annual Loss - Population | Expected Annual Loss - Population Equivalence | Expected Annual Loss -Total |
|---|---|---|---|
| $2,937,822.20 | 0.2072 | $2,403,310.90 | $5,341,133.10 |

#### *4.6.2.2 Lifelines and Critical Infrastructure*

Earthquakes can affect a community's lifelines in the following ways:

- Safety and Security – An earthquake can cause the structural failure of critical facilities such as police stations and fire stations, generate increased demand for search-and-rescue operations, and result in population displacement requiring emergency sheltering. Such conditions may also create challenges in maintaining public order and ensuring community security.

- Food, Hydration, and Shelter – A seismic event can cause damage to water treatment plants and distribution systems, resulting in contamination or loss of potable water. Disruptions to transportation routes and storage facilities may also interrupt food supply chains. Widespread structural damage can increase the demand for temporary shelters. Additionally, the loss of refrigeration capacity may lead to significant spoilage of perishable goods.
- Health and Medicine - Hospitals and clinics may experience structural damage or a reduction in operational capacity during an earthquake. A surge in injuries

requiring emergency medical attention can overwhelm existing healthcare facilities. Disruptions to pharmaceutical supply chains and medical logistics may also occur. Additionally, compromised sanitation conditions in emergency shelters can elevate the risk of disease outbreaks.

- Energy - Damage to power plants, substations, and transmission lines can result in widespread power outages. Ruptures in gas lines may create fire and explosion hazards. Interruptions in the fuel supply chain can also impede the operation of generators and emergency response vehicles.

- Communications - Damage to cell towers, fiber-optic cables, and communication hubs can result in significant loss of connectivity. Emergency call surges may overload telecommunications networks, further degrading service availability. These disruptions can impair coordination among emergency response agencies and hinder the timely dissemination of critical information.

- Transportation - Collapse or severe damage to roads, bridges, and tunnels can significantly restrict mobility. Airports and seaports may become inoperable due to damage to runways or docks. Rail systems, including the Tren Urbano, may also be disrupted because of track deformation or landslides.

- Hazardous Materials – An earthquake may cause spills from industrial facilities, chemical plants, or storage tanks, increasing the risk of environmental contamination affecting air, soil, and water resources. Additionally, damage to sites containing hazardous materials may result in fires or explosions.

- Water Systems - Breakage of water mains and sewer lines can result in localized flooding and contamination. Such damage may also reduce firefighting capacity due to diminished water pressure and lead to long-term disruptions in wastewater collection and sanitation services.

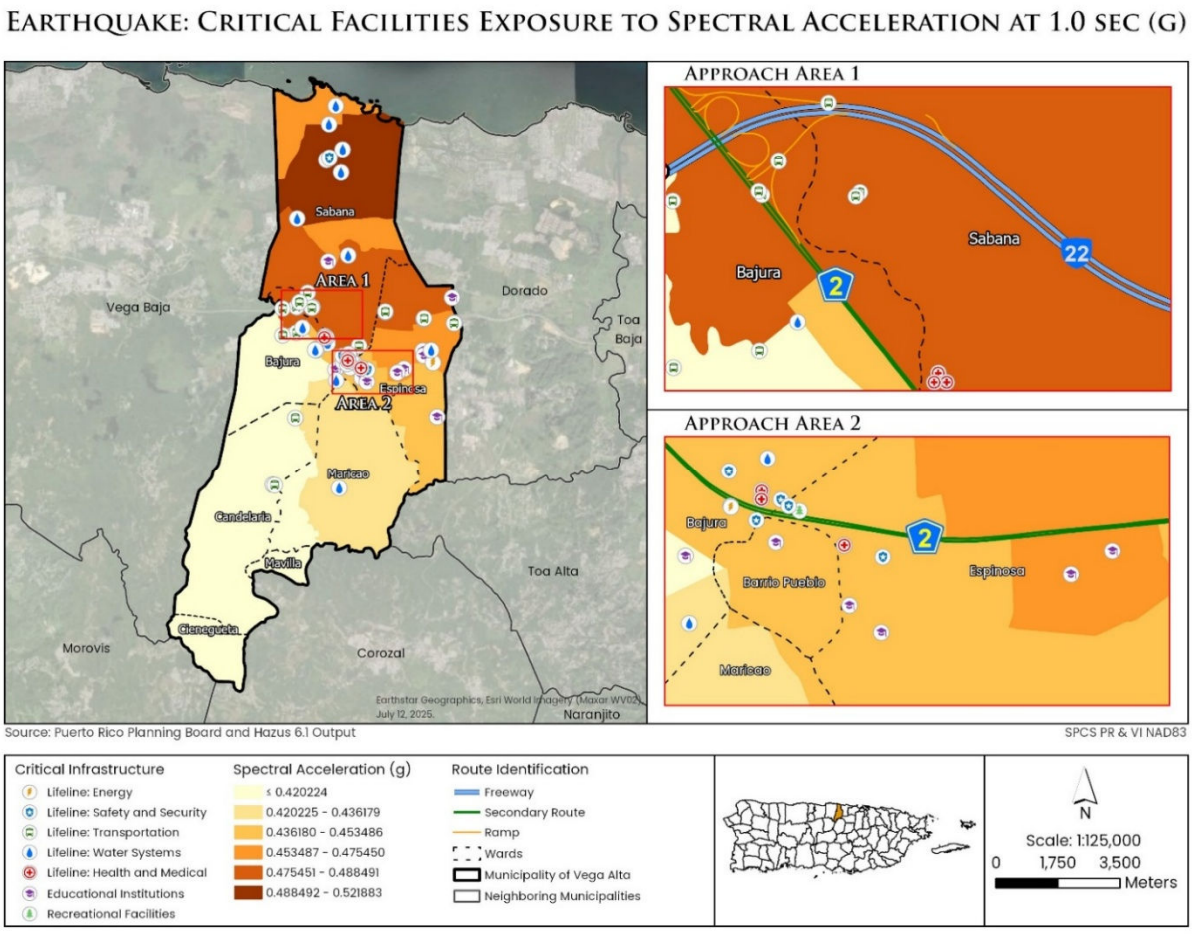
The spectral acceleration maps at 0.3-second and 1.0-second periods indicate that Vega Alta experiences a gradient of seismic demand increasing from the southern interior wards toward the northern coastal areas (Maps 16 and 17). Under both scenarios, the highest spectral acceleration values are concentrated in Sabana Ward, followed by portions of Bajura, Pueblo, and Espinosa Wards. As a result, many critical facilities supporting community lifelines are located within areas subject to moderate-to-high seismic forces.

The 1.0-second spectral acceleration map represents the expected response of taller and more flexible structures. Acceleration values range from approximately 0.42 g to 0.52 g, with the highest values again occurring in Sabana Ward and the northern coastal portion of the municipality.

Although acceleration values are lower than those shown for the 0.3-second scenario, the spatial distribution remains similar. Critical facilities exposed to the highest long-period shaking include:

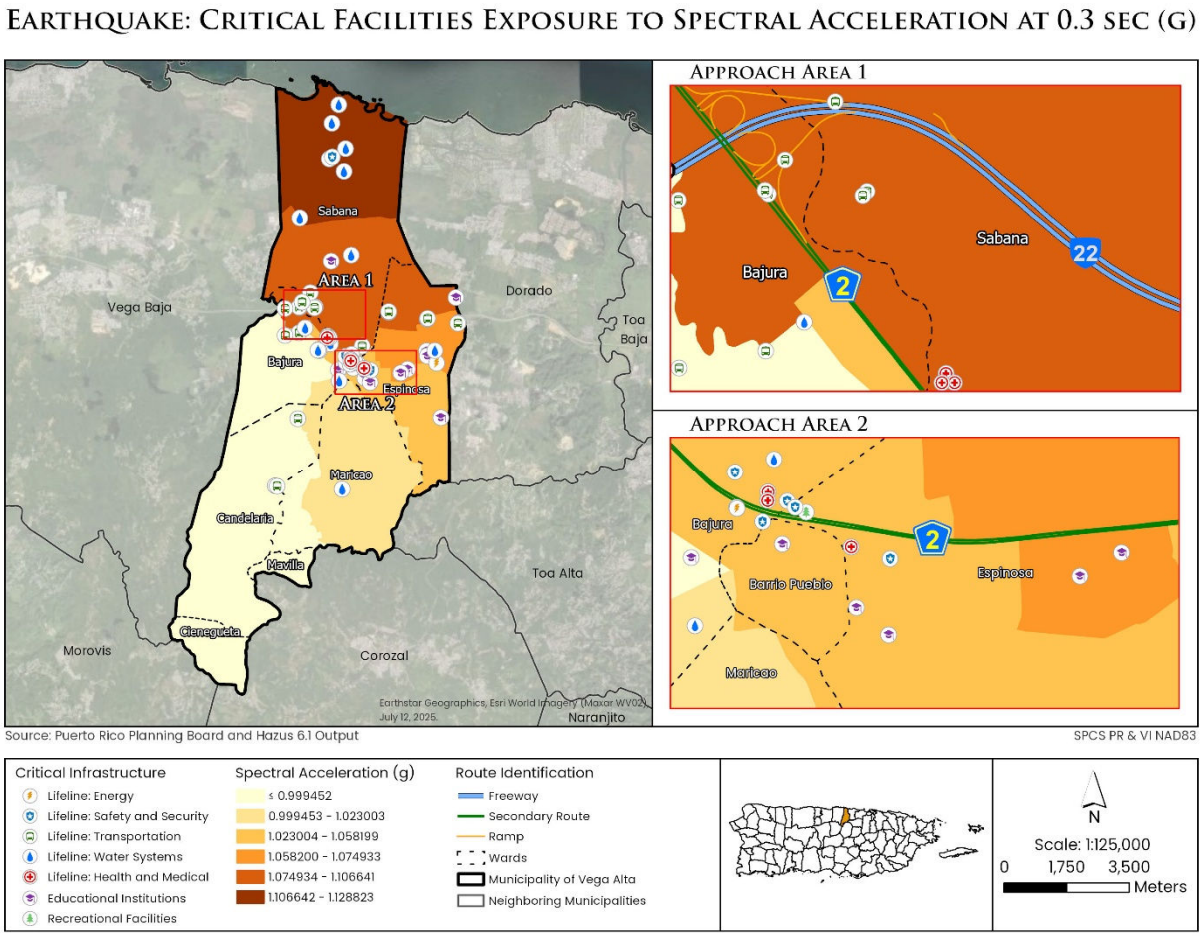
- Water system facilities are located throughout Sabana and Bajura.
- Transportation infrastructure along PR-2 and associated interchanges.
- Health and medical facilities near the Pueblo-Espinosa area.
- Emergency service facilities are clustered around the municipal center.
- Educational facilities distributed throughout northern Vega Alta.

*Map 16: Earthquake Critical Facilities Exposure to Spectral Acceleration at 1.0 sec*



The concentration of infrastructure within northern Vega Alta suggests that seismic impacts affecting this area could disrupt transportation access, emergency response activities, utility service delivery, and community recovery operations.

*Map 17: Critical Facilities exposure to spectral acceleration at 0.3 sec*




The 0.3-second spectral acceleration map represents the expected response of shorter, stiffer structures, including many low-rise buildings and critical service facilities. The highest values range from approximately 1.11 g to 1.13 g and occur primarily in northern Vega Alta, particularly within Sabana Ward. Values gradually decrease toward the southern portion of the municipality.

The map indicates that several critical facilities are located within the higher acceleration zones, including:

- Water system facilities in Sabana and Bajura.
- Transportation-related infrastructure along PR-2 and adjacent corridors.

- Health and medical facilities are located between Bajura, Pueblo, and Espinosa.
- Public safety facilities are clustered near the urban center.
- Educational and recreational facilities in northern wards.

Particularly notable is the concentration of multiple lifeline facilities within Approach Area 2, where health, safety and security, transportation, educational, and energy facilities are located within the same moderate-to-high acceleration zone. Damage to structures within this area could create cascading impacts across multiple FEMA Community Lifelines.

#### *4.6.2.3 Social Vulnerabilities*

Social vulnerability to earthquakes in Puerto Rico is shaped by high levels of poverty, aging infrastructure, and limited access to essential resources, all of which disproportionately affect the ability of communities to withstand and recover from seismic events. Many residents face compounding disadvantages—such as disability, low educational attainment, and limited vehicle access—that reduce their capacity to evacuate, access information, or secure aid after a damaging earthquake. Research on disaster governance also shows that systemic governmental neglect and energy insecurity intensify the impacts of disasters, leaving communities with fewer resilience mechanisms in the aftermath of earthquakes.

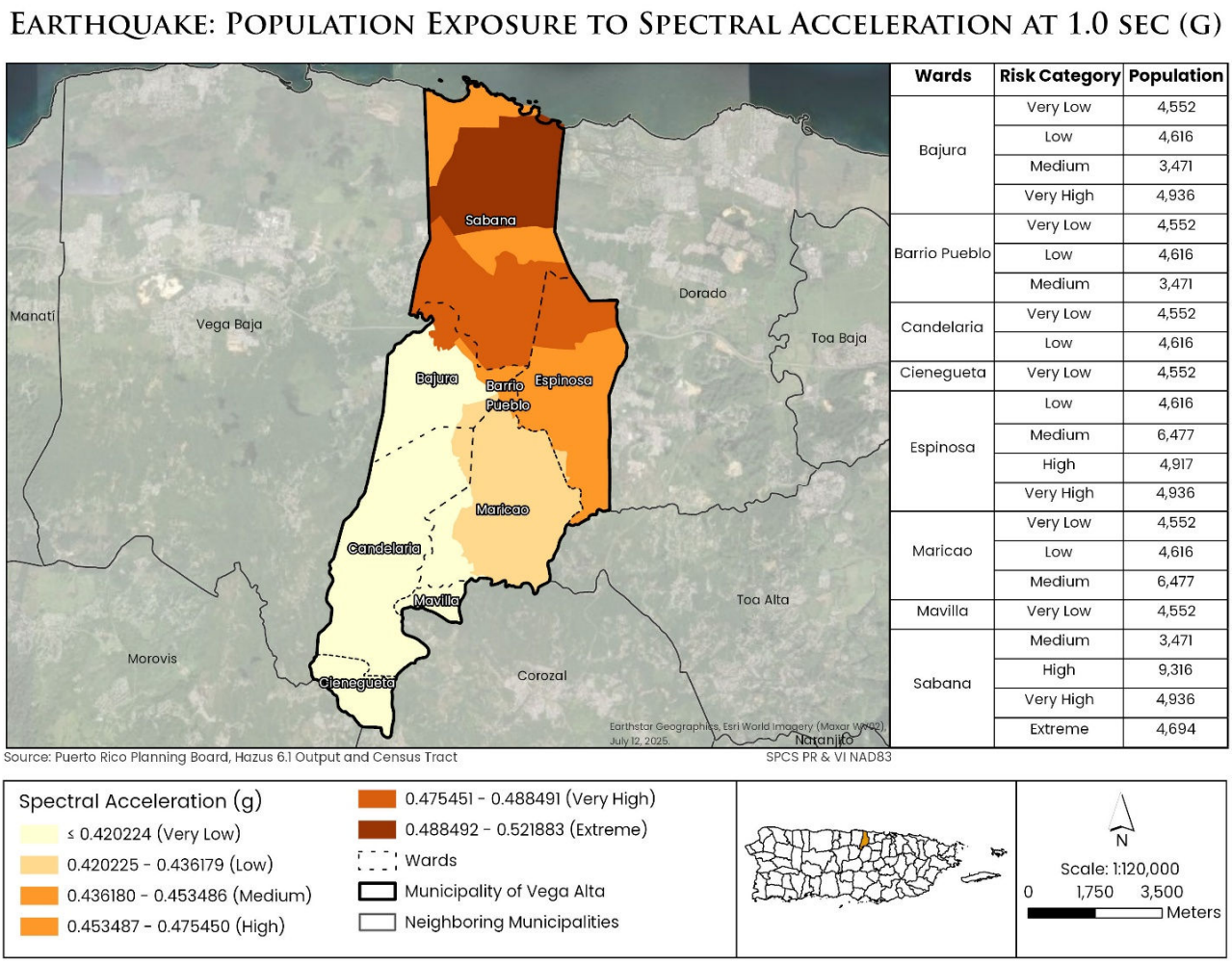
Puerto Rico's disaster research literature identifies long-standing structural inequities that heighten vulnerability, including political and economic marginalization that limit long-term recovery and exacerbate risk accumulation across hazard types. Federal assessments further find that many census tracts exhibit high social vulnerability scores (US Census Bureau, 2024), (US Census Bureau, 2025), meaning that an earthquake's impacts are likely to intersect with broader socio-economic fragility . Overall, these combined factors demonstrate that earthquakes in Puerto Rico pose not only a physical hazard but also a deep social challenge tied to historical, economic, and infrastructural conditions that shape uneven disaster outcomes. For more details about Social Vulnerabilities see section 3.4.4.

The population exposure maps (Maps 18 and 19) combine the earthquake spectral acceleration analysis with population distribution data to identify where residents are most likely to be exposed to varying levels of seismic ground shaking. Unlike the spectral acceleration maps, which illustrate the intensity of expected earthquake forces across the municipality, these maps evaluate the human exposure component of risk by identifying the number of people residing within each spectral acceleration risk category. This approach is consistent with FEMA's emphasis on assessing

vulnerability by considering both hazard intensity and the population potentially affected by the hazard.

The maps depict population exposure to spectral acceleration at both 0.3 seconds (SA-0.3) and 1.0 second (SA-1.0). While the two maps represent different structural response periods, both reveal a similar geographic pattern in which the highest earthquake hazard levels are concentrated in the northern portion of Vega Alta and decrease toward the southern wards. Consequently, population exposure to earthquake ground shaking is not evenly distributed throughout the municipality.

*Map 18: Earthquake: Population Exposed to Spectral Acceleration at 1.0 (g) sec*




| Wards | Risk Category | Population |
|---|---|---|
| Bajura | Very Low | 4,552 |
| | Low | 4,616 |
| | Medium | 3,471 |
| | Very High | 4,936 |
| Barrio Pueblo | Very Low | 4,552 |
| | Low | 4,616 |
| | Medium | 3,471 |
| Candelaria | Very Low | 4,552 |
| | Low | 4,616 |
| Cienegueta | Very Low | 4,552 |
| Espinosa | Low | 4,616 |
| | Medium | 6,477 |
| | High | 4,917 |
| | Very High | 4,936 |
| Maricao | Very Low | 4,552 |
| | Low | 4,616 |
| | Medium | 6,477 |
| Mavilla | Very Low | 4,552 |
| Sabana | Medium | 3,471 |
| | High | 9,316 |
| | Very High | 4,936 |
| | Extreme | 4,694 |

Among all wards, Sabana exhibits the greatest population exposure to the highest earthquake hazard categories. Under the SA-1.0 scenario (Map 18), approximately 4,694 residents are exposed to Extreme risk conditions, and 4,936 residents are exposed to Very High-risk conditions. Similarly, Under the SA-0.3 scenario, approximately 7,605 residents are located within the Extreme risk category, and an

additional 6,424 residents are located within the Very High-risk category. These figures indicate that a substantial portion of the municipal population resides in areas expected to experience the strongest earthquake ground motions.

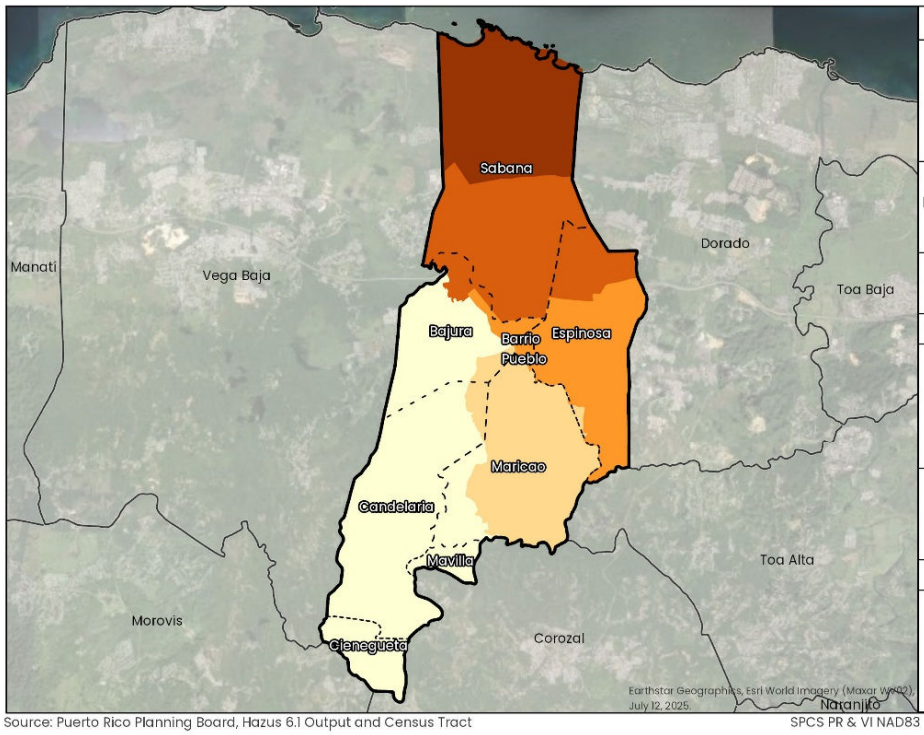
The exposure analysis also identifies significant populations within elevated hazard categories in Espinosa, where approximately 6,477 residents are exposed to Medium risk conditions, 4,917 residents to High-risk conditions, and 4,936 residents to Very High-risk conditions. The urban core area encompassing Barrio Pueblo is similarly located within moderate-to-high seismic hazard zones, placing municipal services, commercial activity, and residential development in areas of elevated earthquake exposure.

In contrast, the southern wards of Cienegueta, Mavilla, and portions of Candelaria are predominately associated with Very Low and Low risk categories. Although residents in these wards remain exposed to earthquake hazards, the expected ground shaking intensities are comparatively lower than those projected for northern Vega Alta.

The analysis suggests that residents in Sabana, Espinosa, Barrio Pueblo, and Bajura may be more vulnerable to earthquake impacts due to their location within higher spectral acceleration zones. These populations may face increased risks associated with structural damage, falling debris, disruption of utility services, transportation interruptions, and reduced access to emergency response resources immediately following a major seismic event.

*Map 19: : Earthquake: Population Exposure to Spectral Acceleration at 0.3 (g) sec*

## Earthquake: Population Exposure to Spectral Acceleration at 0.3 sec (g)




| Wards | Risk Category | Population |
|---|---|---|
| Bajura | Very Low | 4,552 |
| | Low | 4,616 |
| | Medium | 3,471 |
| | Very High | 4,936 |
| Barrio Pueblo | Very Low | 4,552 |
| | Low | 4,616 |
| | Medium | 3,471 |
| Candelaria | Very Low | 4,552 |
| | Low | 4,616 |
| Cienegueta | Very Low | 4,552 |
| Espinosa | Low | 4,616 |
| | Medium | 6,477 |
| | High | 4,917 |
| | Very High | 4,936 |
| Maricao | Very Low | 4,552 |
| | Low | 4,616 |
| | Medium | 6,477 |
| Mavilla | Very Low | 4,552 |
| Sabana | Medium | 3,471 |
| | High | 4,917 |
| | Very High | 6,424 |
| | Extreme | 7,605 |

Source: Puerto Rico Planning Board, Hazus 6.1 Output and Census Tract

SPCS PR & VI NAD83




### 4.6.2.4 Natural and Cultural Resources

Earthquakes can produce a wide range of impacts on natural and cultural resources:

- Landslides and Soil Instability: Seismic activity can trigger landslides, rockfalls, and soil liquefaction, altering natural landforms and damaging ecological habitats.
- Water Quality and Hydrology: Ground shaking may modify river pathways, impair aquifers, and increase sedimentation in water bodies, which can degrade water quality and disrupt aquatic ecosystems.
- Vegetation and Wildlife: Ground deformation and related secondary hazards such as flooding or fires can lead to habitat loss, fragmentation, and adverse effects on biodiversity.

- Coastal and Marine Environments: Submarine earthquakes may generate tsunamis, resulting in coastal erosion, coral reef degradation, and the deterioration of marine and estuarine ecosystems.

While the following damage can happen to Cultural Resources:

- Seismic forces can cause significant structural damage or the complete collapse of heritage structures, archaeological sites, and monuments.
- Museums and Archives: Earthquakes may lead to the loss, damage, or deterioration of artifacts, archival materials, and collections due to structural failures or insufficient seismic protection.
- Community Identity and Tourism: Damage to culturally important sites can undermine community identity and reduce tourism activity, thereby affecting local economic stability.

#### 4.6.2.5 Future Conditions (E1-a)

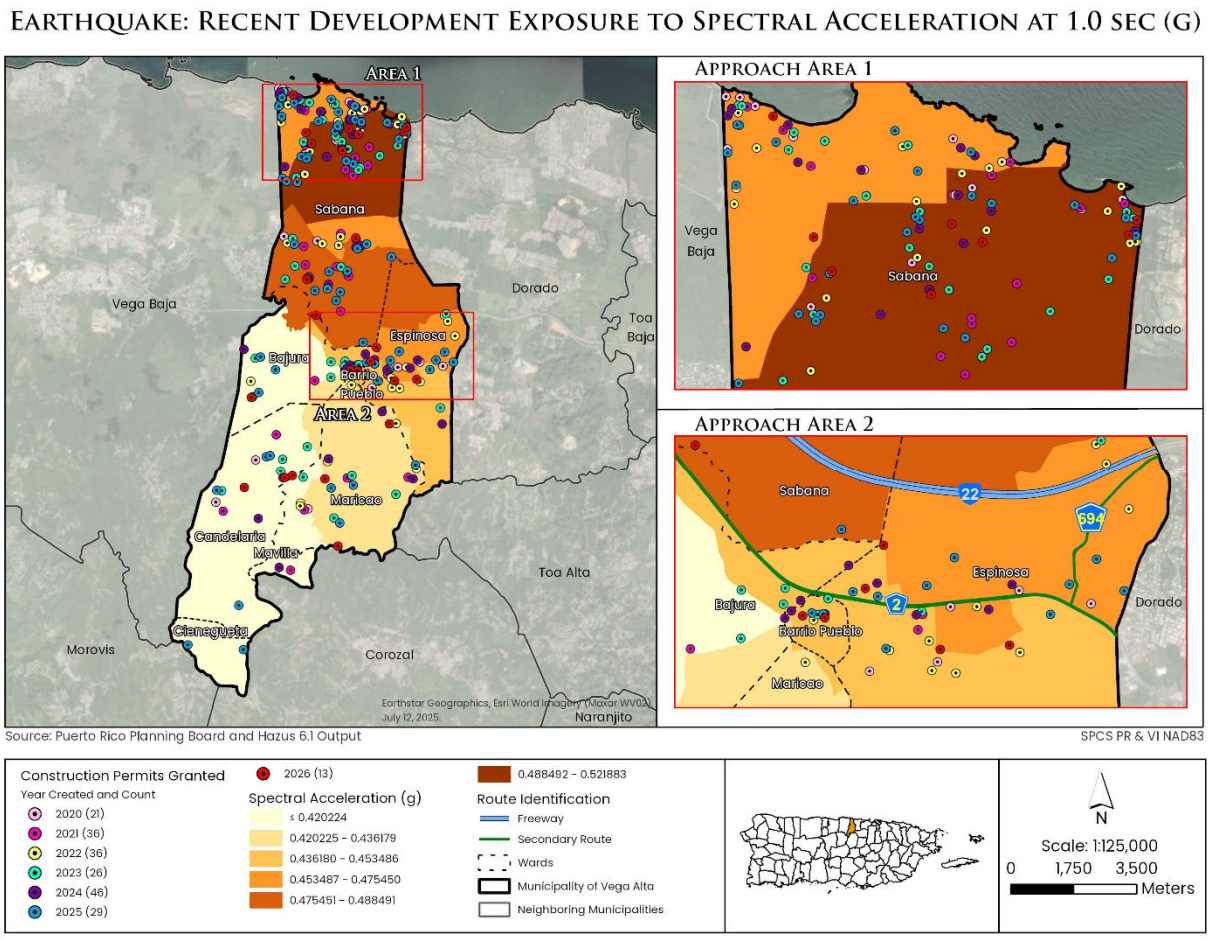
As discussed in Section 3.5, the elevated number of constructions permit issued by the Municipality reflects a sustained level of economic activity. To further support this analysis, Maps 20 and 21 highlight the areas with the highest spectral acceleration values at 0.3 and 1.0 seconds alongside the distribution of authorized construction permits. Taken together, these findings indicate that future exposure to earthquake hazards is unlikely to diminish in the near term, as development continues to expand within zones of elevated seismic vulnerability.

The analysis shows that recent development in Vega Alta has been concentrated primarily within two areas:

- Area 1 encompasses the northern coastal portion of the municipality, particularly within Sabana Ward, where the highest concentration of new development activity is observed.

- Area 2 encompasses the urbanized central sector, including portions of Barrio Pueblo, Espinosa, and adjacent developed areas along the PR-2 corridor and surrounding transportation network.

*Map 20: Earthquake: Recent Development Exposure to Spectral Acceleration at 1.0 sec*

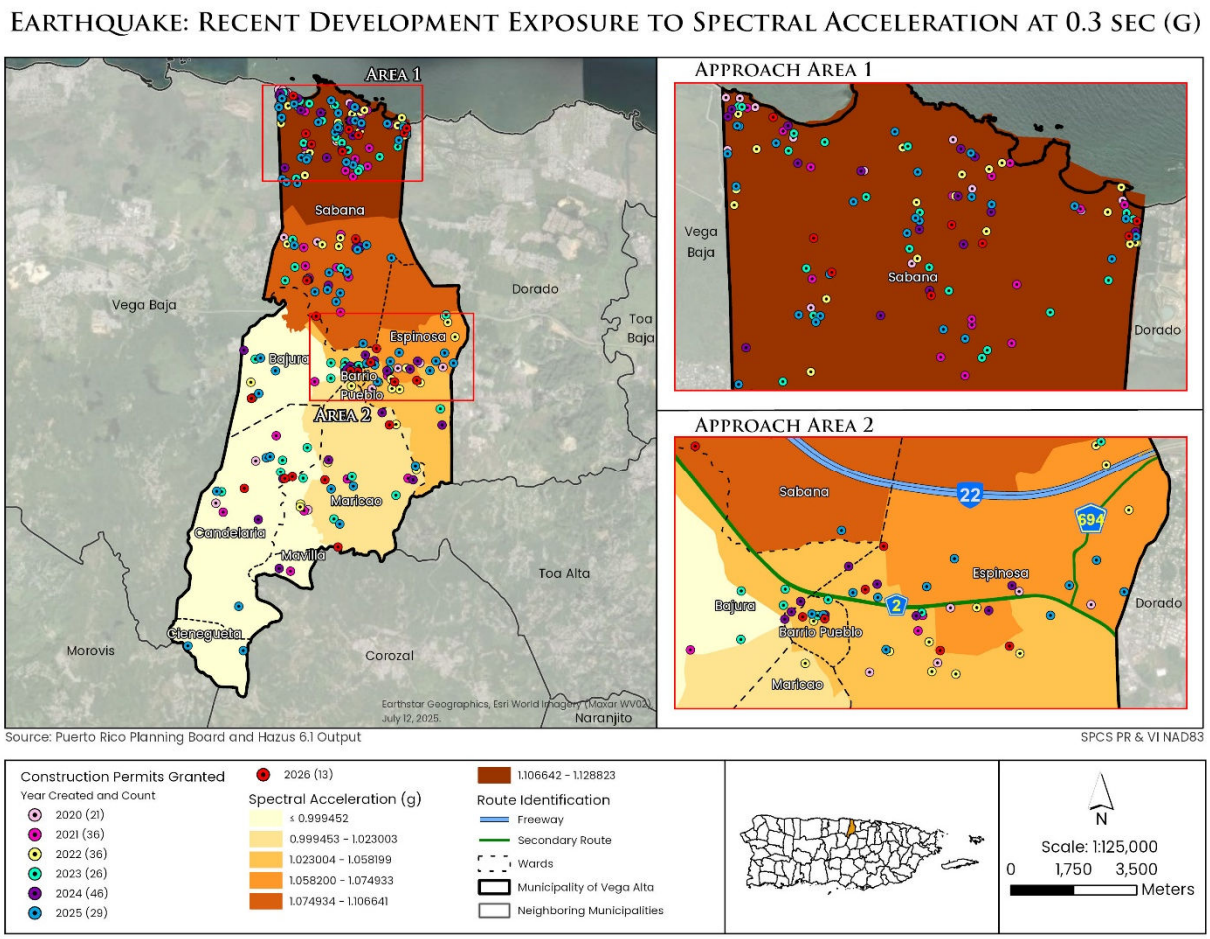



These areas coincide with the highest modeled spectral acceleration values identified in the earthquake hazard assessment. As a result, a significant portion of recent and future development is occurring within areas expected to experience the strongest earthquake-induced ground shaking.

The overlap between development activity and elevated seismic hazard indicates that the municipality's exposure to earthquake risk may continue to increase as additional residential, commercial, and public assets are constructed in these areas. While compliance with current seismic building codes helps reduce structural vulnerability, the concentration of development within higher hazard areas increases the number and value of assets potentially affected by future earthquake events.

:

*Map 21: Earthquake: Recent Development Exposure to Spectral Acceleration at 0.3 sec*




Therefore, continued enforcement of seismic design standards, integration of earthquake hazard information into development review procedures, protection of critical infrastructure, and incorporation of hazard mitigation principles into future land use decisions will be important to limiting future losses and enhancing the long-term resilience of Vega Alta. This analysis demonstrates that future growth patterns should remain an important consideration in the municipality's ongoing earthquake risk reduction and hazard mitigation efforts.

## 4.7 Landslides

### 4.7.1 Description (B1-a)

Landslides are a natural geomorphological process characterized by the downslope movement of soil, rock, or debris due to terrain instability. These

events occur when environmental conditions align such that gravitational forces acting on surface materials exceed their natural resistance. The term landslide encompasses multiple types of ground displacement including rockfalls, slope failures, and debris flows, all of which pose significant risks to life and property. Such movements can obstruct transportation routes and carry with them vegetation, homes, bridges, vehicles, and other infrastructure, causing extensive disruption and damage (FEMA, 1997).

Prolonged and intense rainfall associated with meteorological systems such as tropical waves, troughs, and tropical cyclones is one of the primary triggers of landslide events. Additionally, population growth and the expansion of informal construction increase the municipality's exposure to landslide hazards. Potable water supply and wastewater systems including sanitary pipes, septic tanks, and storm sewers whether properly authorized or informally installed, can further exacerbate slope instability. The likelihood of landslides rises significantly when these systems leak or are inadequately sited or constructed (USGS, n.d.).

Multiple factors contribute to the development of landslides, including soil type, terrain slope, degree of soil saturation, erosion processes, the presence of depressions or subsurface voids, human activities, and seismic events. The Building Performance Assessment Report (BPAR) prepared after Hurricane Georges warns that "landslides will become a major problem in the future as more houses are built and more development occurs in areas susceptible to these risks." This observation underscores the increasing vulnerability associated with continued development in high-risk zones (FEMA, 1997).

Many landslides in Puerto Rico fall into a specific subtype known as debris flows. These events typically occur in mountainous areas with steep slopes during periods of intense rainfall. As rainwater infiltrates the ground, the soil becomes saturated and the underlying subsurface layer loses its cohesion. This loss of stability causes the material to detach often at the interface where the subsurface meets the bedrock resulting in a rapid downslope flow of soil, rock, and water. There are many types of landslides; however, those associated with water saturation of the ground are as follows (PREMB, 2021):

- Slow landslide: Slow and sustained movement of earth or rock descending down the slope. Recognized by its content of tree trunks, pieces of twisted fences or retaining walls, and leaning posts or fences.

- Debris flow: A mass of rapid movement in which loose soils, rocks, organic matter combine with infiltrated air and water to form a viscous flow sliding down the hillside.
- Debris avalanche: A variety of very fast or extremely fast debris flow.
- Mudflow: A mass of rapid flow containing wet material of at least 50 percent sand, silt, and clay particles.

#### 4.7.1.1 Affected Area (B1-B)

The landslide susceptibility analysis indicates that the greatest landslide hazard in Vega Alta is concentrated within the municipality's southern wards, particularly Cienegueta, Mavilla, Candelaria, and portions of Maricao (Map 22). These areas coincide with steeper terrain and karst landscapes characterized by increased potential for slope instability. In contrast, the more urbanized northern wards, including Sabana, Espinosa, Barrio Pueblo, and Bajura, generally exhibit lower landslide susceptibility.

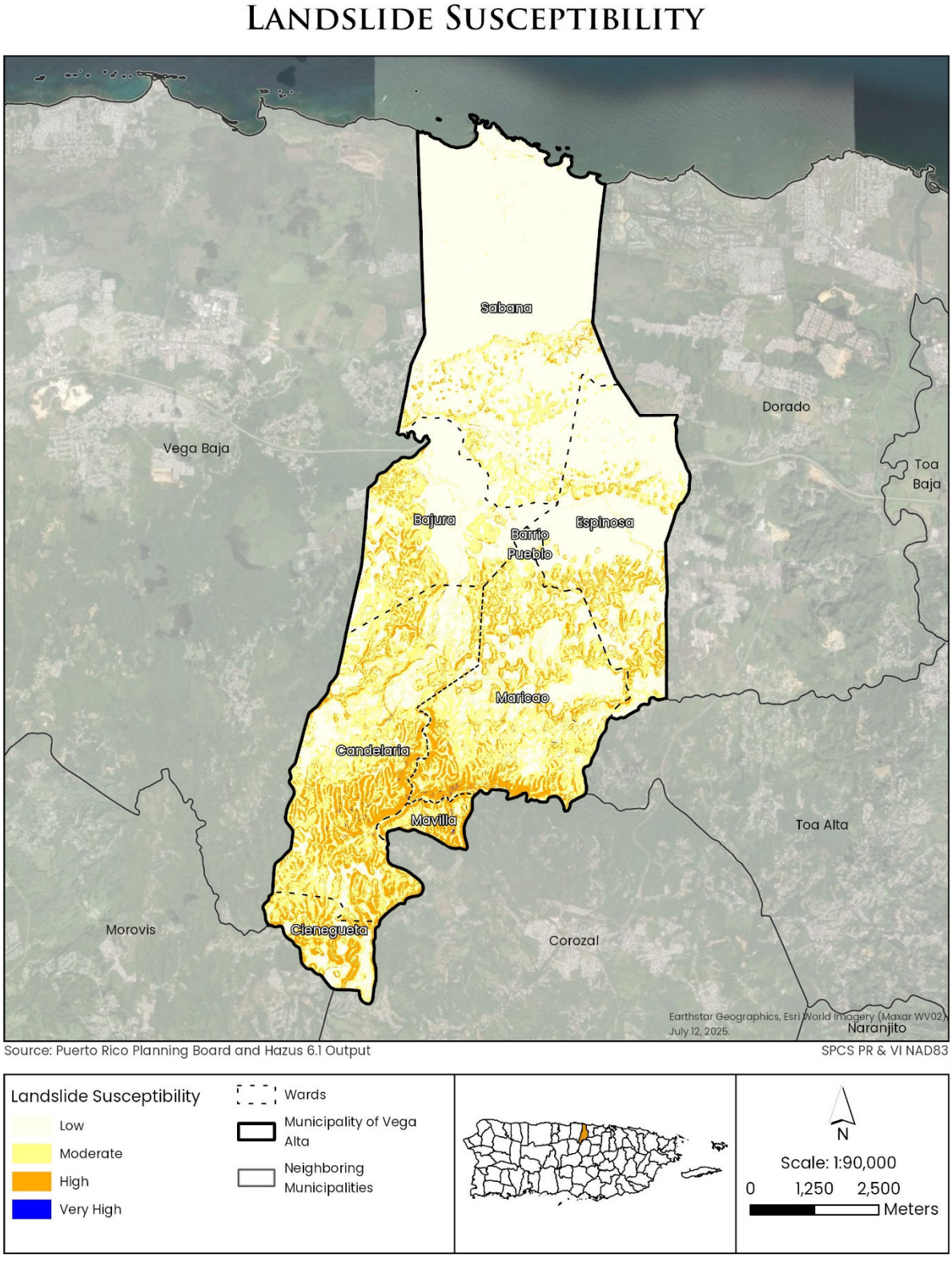
Although the southern wards generally contain lower population densities than the urbanized northern portion of the municipality, landslide susceptibility remains an important hazard because it can affect transportation infrastructure, utilities, residential structures, agricultural lands, and emergency access routes.

Landslides within these areas have the potential to:

- Damage homes and other structures located on or near steep slopes.
- Undermine roads, bridges, and retaining structures.
- Disrupt utility services, including water, electricity, and telecommunications infrastructure.
- Restrict access for emergency responders during and after severe weather events.
- Isolate communities by blocking transportation corridors.
- Accelerate erosion and destabilize adjacent properties.

The hazard may be particularly significant during tropical storms and hurricanes, when prolonged rainfall can saturate soils and increase the likelihood of slope failures. In some locations, the combination of steep terrain and karst geology may also increase the complexity of stabilization and recovery efforts following a landslide event.

*Map 22: Landslide Susceptibility*



### 4.7.1.2 Risk Magnitude (B1-C)

Landslides typically occur in steep, mountainous areas during periods of intense or prolonged rainfall. As water infiltrates the ground, the soil becomes saturated, weakening natural drainage systems and reducing the structural capacity of the terrain, which can ultimately lead to slope failure. Certain areas are inherently more susceptible to landslides than others, particularly those with greater slope gradients. Vegetation plays a critical role in maintaining soil cohesion and reducing surface erosion; therefore, slopes lacking vegetation are generally more prone to instability.

Slope stability is influenced by several factors, including elevation, steepness, vegetative cover, and underlying geology. In general, increases in slope height and inclination correlate with a greater likelihood of terrain instability. Below are key factors that contribute to the occurrence of landslides:

- The base of inclined slopes
- Areas near small depressions where drainage converges
- The lower portion of slopes is composed of fill - material
- The base or crest of a very steep slope
- Locations with a history of previous landslides
- Hillsides that have been developed and where septic systems are present
- Steep slopes underlain by clay-rich soils
- Hills or slopes with inclinations greater than 12 degrees and elevations exceeding 300 meters

The hazard categories are derived from the USGS classification index, which evaluates slope and soil characteristics as defined by the agency. Table 14 outlines these categories—low, moderate, high, and very high—and describes the corresponding levels of hazard.

*Table 15: Landslide Risk Categories*

| Category | Description |
|---|---|
| **Low** | Areas with minimal slopes and stable soil; landslides are unlikely except under extreme conditions. |
| **Moderate** | Areas with some susceptibility; landslides may occur during prolonged or intense rainfall. |

| Category | Description |
|---|---|
| **High** | Areas with significant susceptibility; landslides are likely during heavy rain or seismic activity. |
| **Very High** | Areas extremely prone to landslides; frequent events during storms or earthquakes. |

The municipality incorporates landslide prevention and mitigation measures as an integral component of its earthquake response protocol (Municipality of Vega Alta, 2025).

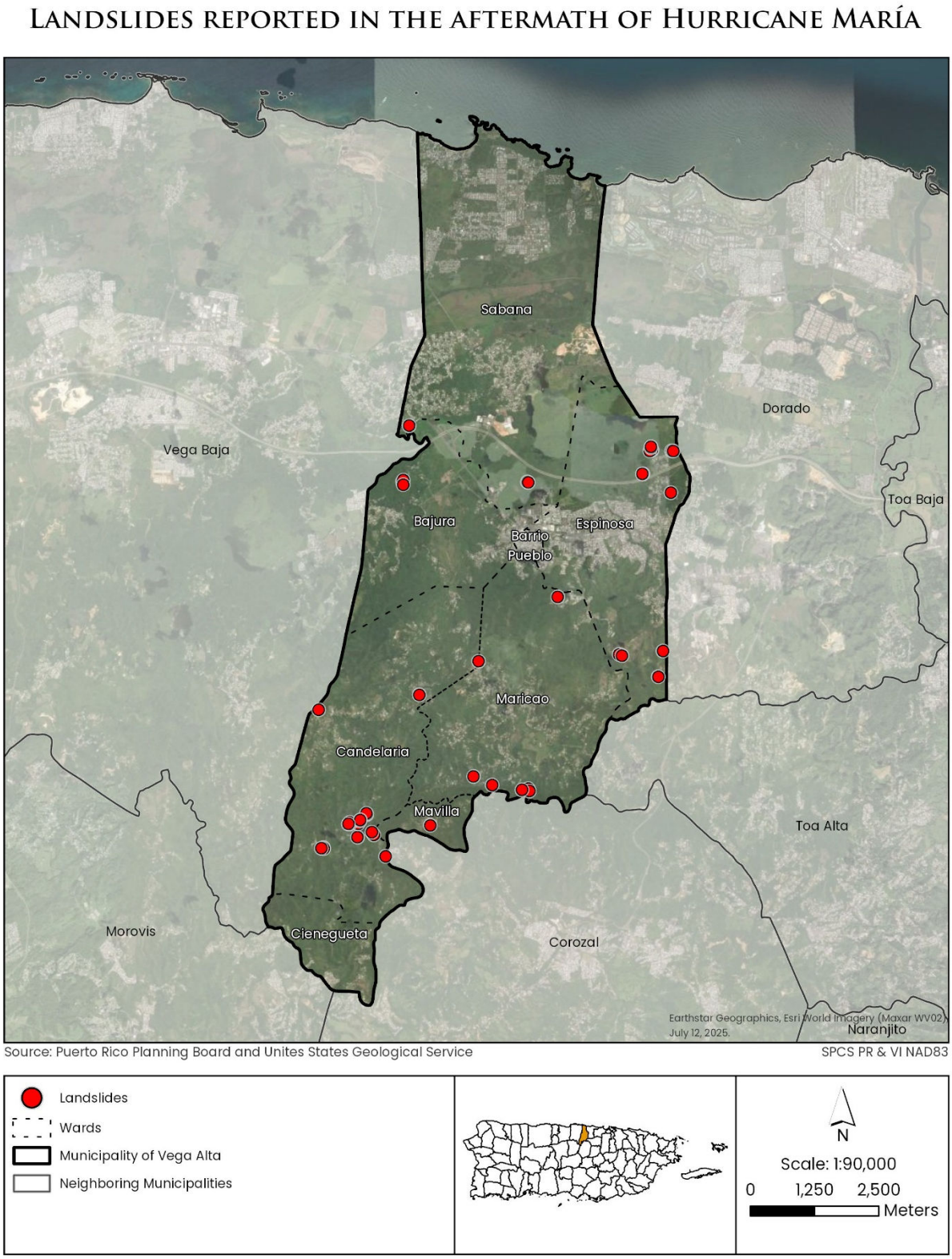
#### *4.7.1.3 Past Events*

As noted earlier, landslides are frequently associated with heavy rainfall events. Map 23 illustrates the landslides reported following Hurricane María in 2017, which align with the areas of greatest susceptibility shown in the map. Landslides are often connected to rain events and the prevalence of roadways (Larsen & Park, 1997) (Larsen & Torres-Sanchez, 1998). According to data from the U.S. Geological Survey (USGS), more than 200 individual landslides were identified following Hurricane María (Hughes, Bayouth García, Martínez Milian, Schulz, & Baum, 2019).

The distribution of landslides reported following Hurricane María provides important historical evidence of Vega Alta's susceptibility to slope failure and serves as a valuable indicator of areas that have experienced actual landslide impacts during an extreme rainfall event. Consistent with FEMA hazard mitigation planning requirements, historical hazard occurrence data helps validate modeled susceptibility analyses by demonstrating where past events have occurred and identifying areas that may be vulnerable to future impacts.

The map indicates that landslides associated with Hurricane María were reported throughout multiple areas of Vega Alta; however, the highest concentration of documented occurrences is located within the municipality's southern and south-central wards, particularly Mavilla, Cienegueta, Candelaria, and Maricao. Additional landslide occurrences were reported in portions of Bajura, Espinosa, Barrio Pueblo, and southern Sabana, indicating that slope instability was not limited exclusively to the southern sector. Nevertheless, the clustering of reported events in the municipality's interior and southern wards demonstrates that these areas experienced the most significant landslide impacts during the storm.

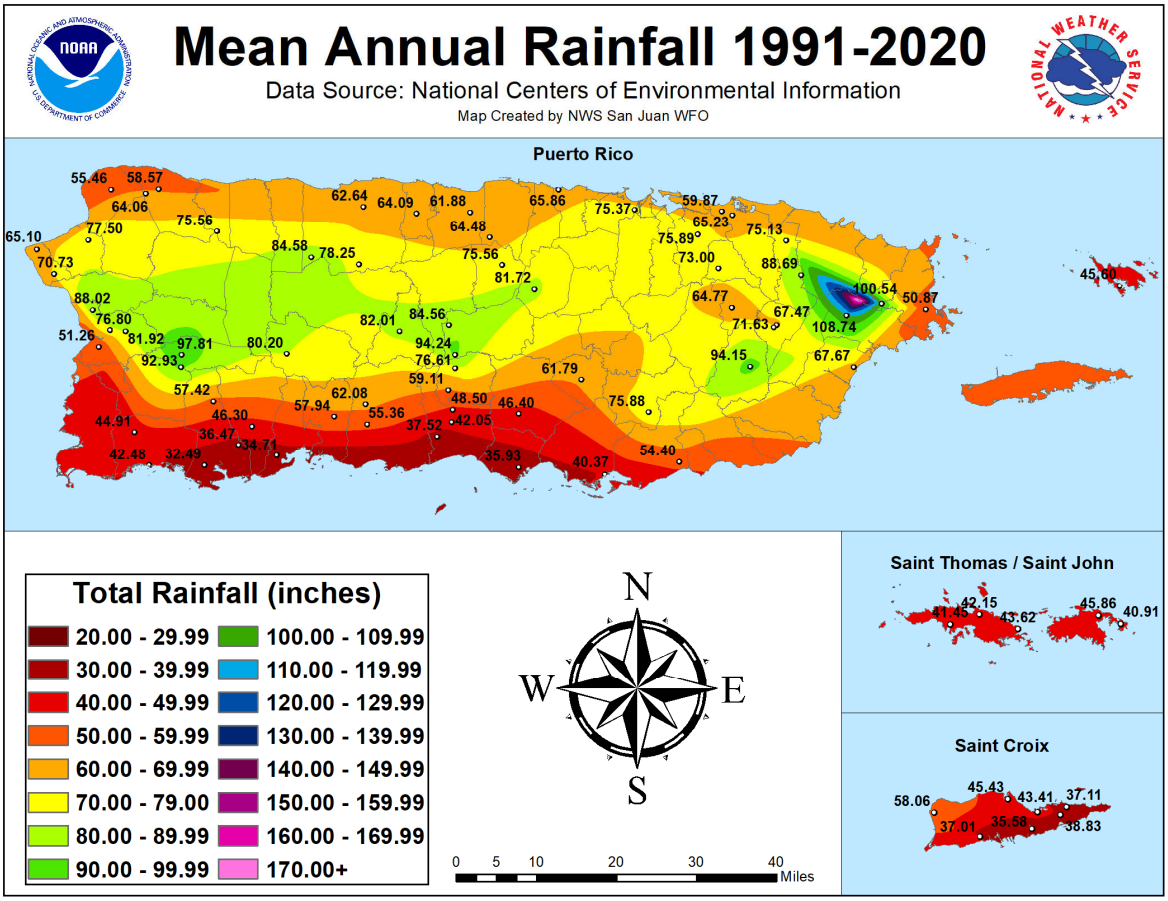
*Map 23: Landslides related to Hurricane María*



#### 4.7.1.4 Future Event Probabilities

Although landslides can also result from earthquakes or human activities, most landslides in Puerto Rico are triggered by rainfall. As previously discussed, these events can occur during any type of rain event. Figure 14 presents the Mean Annual Rainfall for Puerto Rico and the U.S. Virgin Islands from 1991 to 2020. The Municipality of Vega Alta lies entirely within a zone that receives between 65.86 and 75.37 inches of rainfall annually. Given these precipitation levels, landslides are expected to continue occurring in the municipality.

*Figure 14: : Mean Annual Rainfall 1991-2020 (PR & USVI)*




### 4.7.2 Risk Analysis

#### 4.7.2.1 Estimated Losses

In the Municipality of Vega Alta , as in many other parts of Puerto Rico, landslides most often occur during or immediately after major storms that produce intense, prolonged

rainfall. Rainfall-induced landslides are closely linked to severe weather systems or consecutive rain events that saturate steep and vulnerable soils.

At present, no standardized models exist to quantify structural or content losses resulting from landslides or other mass-movement events. Consequently, USGS susceptibility indices were applied empirically using the best available data to estimate potential impacts from these hazards in Vega Alta . These indices classify risk into four levels: low, moderate, high, and very high. Due to data limitations, it is not currently possible to calculate monetary losses associated with building damage.

#### 4.7.2.2 Lifelines and Critical Infrastructure

Landslides can impact FEMA Lifelines in the following ways:

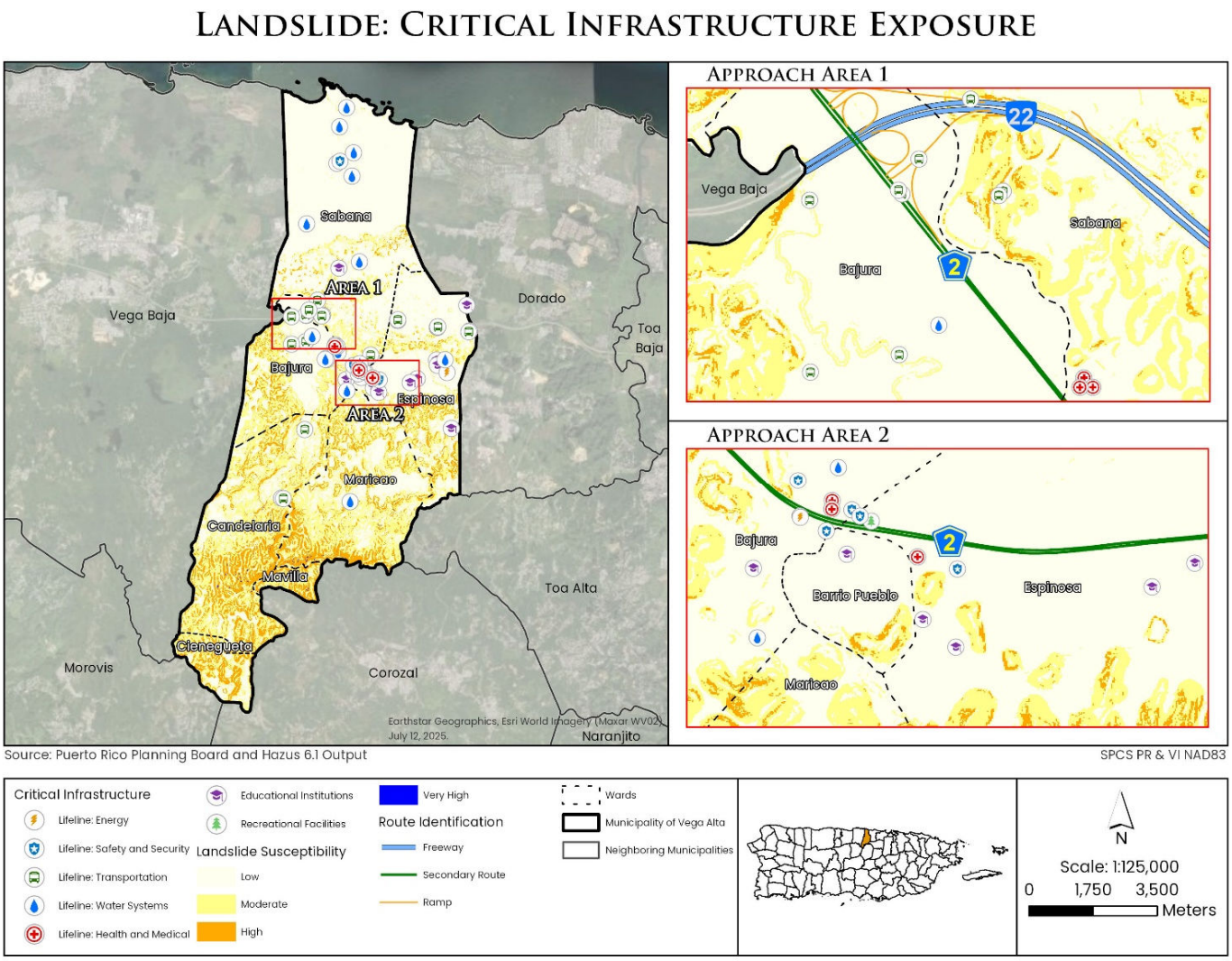
- Safety and Security: Landslides can trap and injure or kill individuals through rapidly moving debris, hinder rescue operations, and create life-safety risks when emergency services become isolated or damaged (Center for Disaster Resilient Communities, n.d.).
- Food, Hydration, and Shelter: Landslides can destroy homes and agricultural areas, resulting in displacement and increased food insecurity. They may also disrupt local water and sanitation systems, heightening contamination risks, especially within temporary shelter environments (IFRC, 2023).
- Health and Medicine: Landslides can cause direct injuries such as trauma or suffocation, while longer-term impacts may include outbreaks of waterborne and vector-borne diseases, as well as psychological distress and trauma among survivors (Center for Disaster Resilient Communities, n.d.).
- Energy: Landslides can severely damage power lines, electrical substations, and fuel supply infrastructure, resulting in widespread power outages that hinder both public services and emergency response operations.
- Communications: Damage to communication cables, fallen utility poles, and restricted access to telecommunications infrastructure can disrupt alert and warning systems, hinder coordination among emergency responders, and impair public information networks.
- Transportation: Landslides can render roads, railways, bridges, and tunnels impassable or destroy them entirely as debris obstructs critical routes, severely limiting mobility for the public and restricting access for emergency response services.
- Hazardous Materials: Landslides can rupture containment structures, pipelines, storage tanks, or industrial facilities, leading to the release of hazardous

chemicals or pollutants and potentially triggering HAZMAT emergencies (FEMA, 2024).

- Water Systems: Landslides can damage water intakes, treatment plants, distribution lines, and wastewater collection and treatment facilities, leading to contamination, reduced water pressure, and significant service interruptions (IFRC, 2023).

Map 24 shows the identified critical infrastructure that could be affected by Landslides. The map shows that the highest landslide susceptibility is concentrated within the southern half of the municipality, particularly in Cienegueta, Mavilla, Candelaria, and portions of Maricao, while lower susceptibility predominates in the northern coastal areas. Although many critical facilities are located within lower-susceptibility areas associated with the municipality's more urbanized northern sector, several important facilities and transportation corridors either intersect or are located adjacent to moderate- and high-susceptibility zones.

*Map 24: Landslide: Critical Infrastructure Exposure*




The analysis identifies several categories of critical infrastructure potentially exposed to landslide hazards, including:

- Health and medical facilities
- Water system infrastructure
- Transportation facilities and corridors
- Public safety and security facilities
- Educational institutions
- Energy infrastructure
- Recreational facilities

The greatest concentration of critical facilities occurs within the municipality's urban core, particularly near Barrio Pueblo, Bajura, and Espinosa, where multiple essential services are clustered along the PR-2 transportation corridor. While much of this area is located within lower susceptibility zones, several facilities are positioned immediately adjacent to areas of moderate and locally elevated landslide susceptibility.

#### *4.7.2.3 Social Vulnerabilities*

Social vulnerability to landslides in Puerto Rico is the product of topography, poverty, aging populations, fragile infrastructure, and geographic isolation, all of which shape the severity of impacts after major storms or seismic events. Academic and federal analyses consistently show that landslides disproportionately burden communities that already struggle with access to transportation, healthcare, income stability, and emergency response. Addressing these vulnerabilities requires hazard mitigation strategies that integrate geospatial risk analysis, social vulnerability indicators, community-based planning, and infrastructure reinforcement tailored to rural and mountainous municipalities (West, Rodríguez Cruz, & Hughes, 2023).

Of particular concern, rural residents often depend on a single road that can be destroyed or blocked by slope failures, isolating entire communities. Focus groups on the municipality of Utuado highlighted that landslides cut off access to medical facilities, emergency response, and even water and food, sometimes for months. This situation can also happen in this municipality. This creates immediate life-threatening conditions for people with health conditions, mobility limitations, or emergency medical needs (West, Rodríguez Cruz, & Hughes, 2023).

The population exposure analysis indicates that residents living within the municipality's landslide-prone areas are concentrated primarily in the southern and south-central wards of Maricao, Mavilla, Candelaria, and Cienegueta, where moderate to high landslide susceptibility coincides with residential development. Although these wards contain fewer residents than the more urbanized northern portion of Vega Alta, they represent the areas where populations are most directly exposed to potential landslide impacts due to the greater likelihood of slope failure.

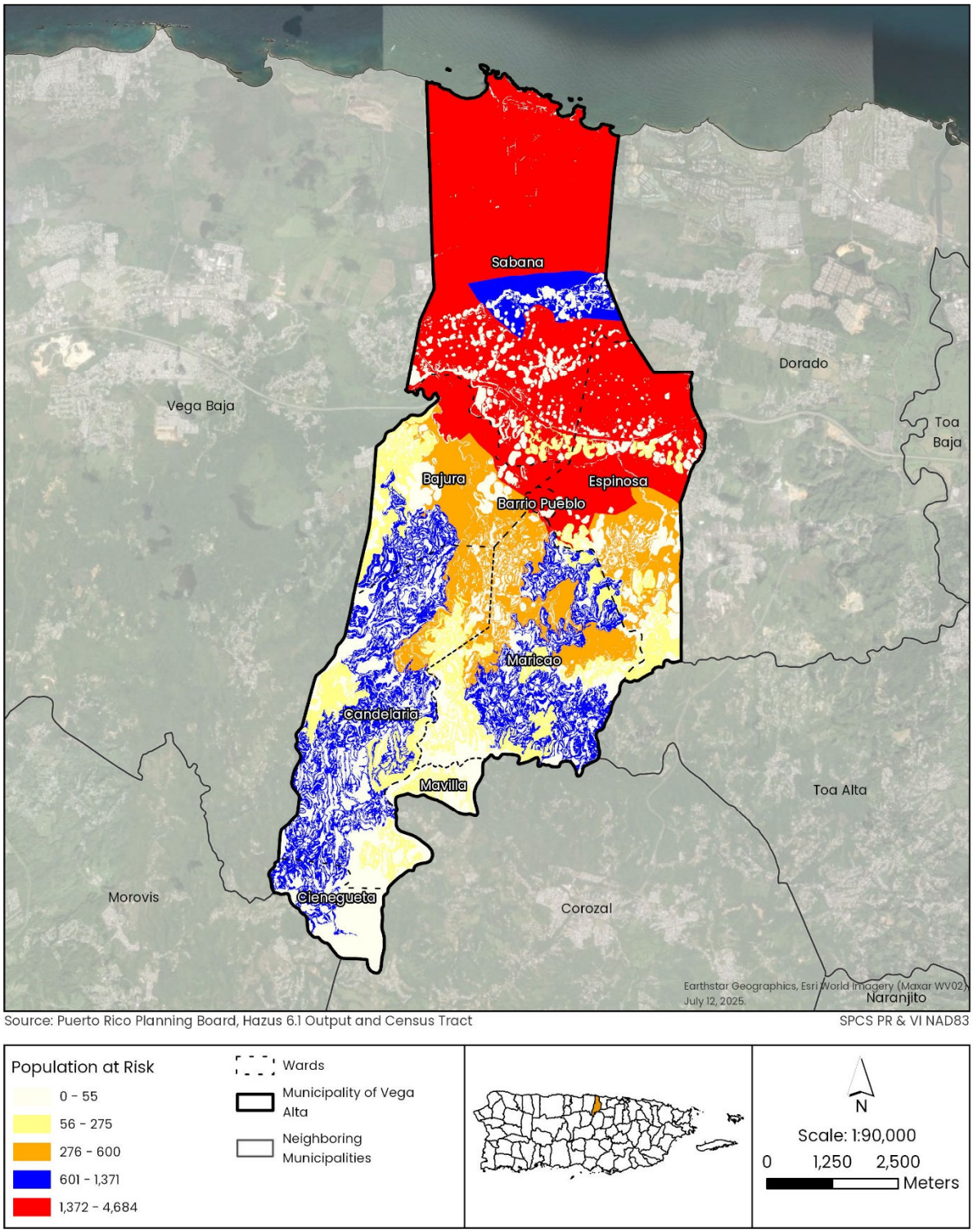
The map indicates that exposed population levels in landslide-susceptible areas generally range from approximately 601 to 1,371 residents in portions of Maricao and Mavilla, while exposure in Candelaria and Cienegueta is generally lower, ranging from approximately 56 to 600 residents depending on the census tract. Collectively, these

southern wards contain the majority of the municipality's population residing within areas of elevated landslide susceptibility.

In contrast, Sabana, Espinosa, and Barrio Pueblo contain larger total populations; however, most residents in these wards are located outside the municipality's highest landslide susceptibility zones. As a result, these areas may exhibit greater population density but comparatively lower direct exposure to landslide hazards.

*Map 25: Landslide: Population Exposure*

# Landslide: Population Exposure




Source: Puerto Rico Planning Board, Hazus 6.1 Output and Census Tract

SPCS PR & VI NAD83

#### 4.7.2.4 Natural and Cultural Resources

Landslides are among the most destructive natural hazards, producing impacts that extend far beyond the immediate physical damage they cause (Eliot, Cloyd, & Philbin, 1994). Their effects on natural resources are profound and often irreversible. When a landslide occurs, vast areas of vegetation are uprooted or buried, leading to the loss of critical habitats and a decline in biodiversity. The displacement of soil not only strips away fertile layers essential for agriculture but also introduces large volumes of sediment into rivers and reservoirs. This sedimentation degrades water quality, disrupts aquatic ecosystems, and can compromise drinking water supplies. Furthermore, landslides frequently alter hydrological systems by blocking river channels, creating temporary dams that increase flood risk and modify groundwater recharge patterns.

The cultural dimension of landslide impacts is equally significant. Archaeological sites, historic monuments, and culturally significant landscapes are highly vulnerable to burial or destruction during such events. These losses are irreplaceable, erasing tangible links to the past and diminishing cultural heritage. In many regions, landslides have damaged centuries-old structures, including churches, colonial buildings, and sacred sites, resulting in costly restoration efforts or permanent loss. Beyond physical damage, the alteration of cultural landscapes such as terraced fields or ceremonial grounds undermines community identity and traditions deeply tied to the land. Economically, these impacts ripple through local economies dependent on cultural tourism, reducing visitor numbers and income for communities that rely on heritage-based activities.

#### 4.7.2.5 Future Conditions

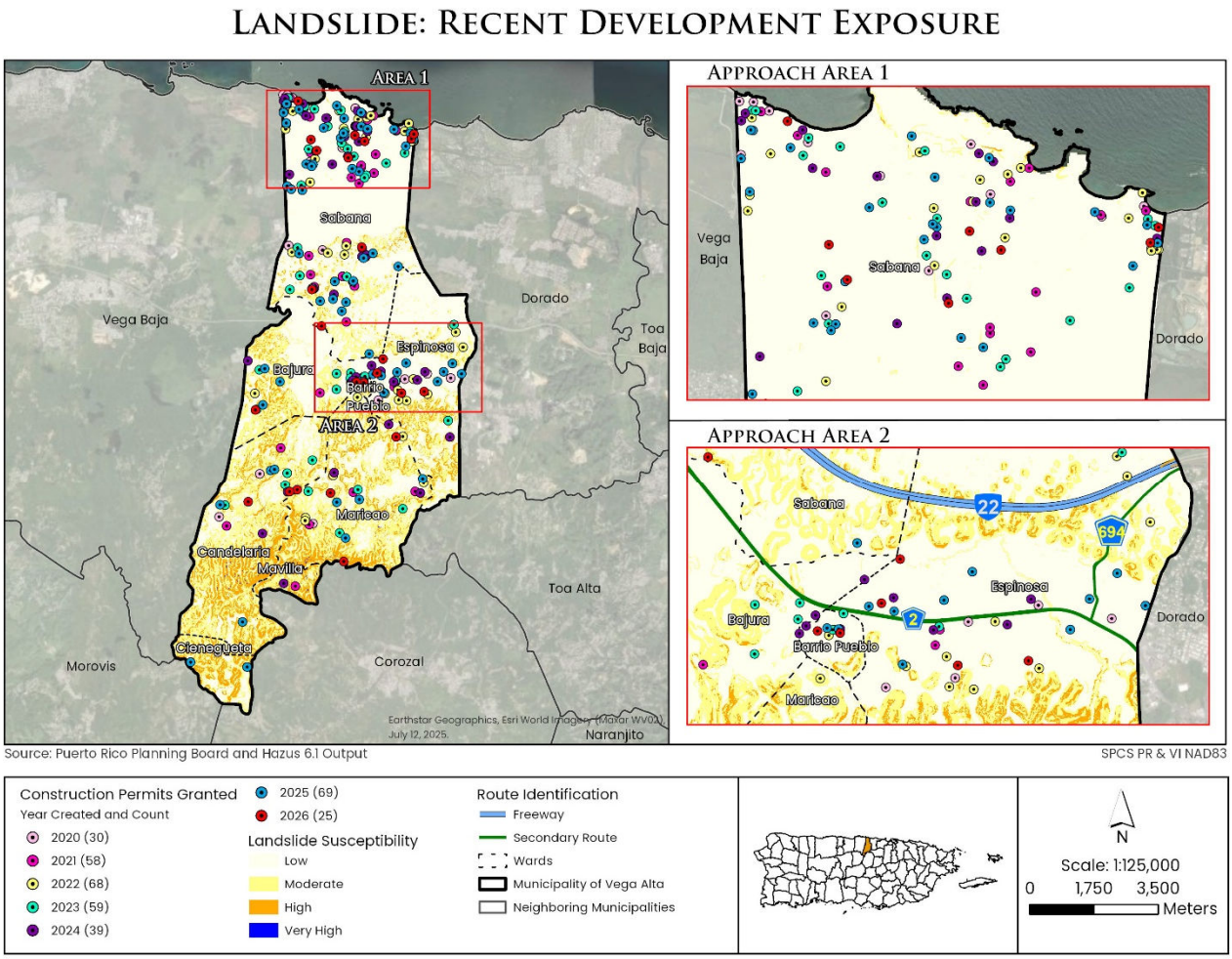
Based on the spatial distribution of construction permits issued between 2020 and 2026 and the mapped landslide susceptibility zones, most recent development in Vega Alta is concentrated within the northern coastal sector (Sabana) and the urbanized central corridor (Barrio Pueblo-Espinosa), which are predominantly located in areas of low to moderate landslide susceptibility (Map 26). However, a portion of the recent development footprint extends into the municipality's southern and southwestern sectors, where moderate to high susceptibility areas are more prevalent.

The highest concentration of recent permits is observed in the northern portion of the municipality, where landslide susceptibility is generally low, indicating a relatively limited exposure to landslide hazards. In contrast, scattered development associated with permits issued between 2020 and 2026 is present near the transitional slopes

south of Barrio Pueblo, Maricao, and Candelaria, where moderate and locally high susceptibility zones occur. Although development within high susceptibility areas appears limited, these locations may experience increased risk from slope instability, particularly during prolonged rainfall events.

Overall, landslide exposure of recent development in Vega Alta is considered low to moderate, as most new construction has occurred outside the areas of highest susceptibility. Nevertheless, continued development near hillside and transitional slope environments should be evaluated through site-specific geotechnical assessments and implementation of appropriate erosion and slope stabilization measures to minimize future landslide risk, consistent with FEMA hazard mitigation planning principles.

*Map 26: Landslide: Recent Development Exposure*



## 4.8 Tsunami

### 4.8.1 Description (B1-a)

A tsunami, or tidal wave, is a series of waves typically caused by a vertical displacement of the ocean floor resulting from an underwater earthquake. Tsunamis can also be triggered by submarine landslides or volcanic eruptions in a specific region. The characteristics of a tsunami vary depending on whether the wave is moving through deep water or approaching the shore. In deep waters, these waves can travel at speeds of up to 500 miles per hour and appear as low waves, generally less than one foot above sea level, often unnoticed by vessels at sea. The distance between wave crests is usually very wide. As the waves near coastal areas, their speed decreases significantly while their height increases dramatically because the wave frequency rises as its amplitude diminishes. This phenomenon can produce massive waves, sometimes exceeding 98 feet in height. However, tsunamis are often sudden, large surges in sea level along the coast, resembling a powerful tide rushing inland.

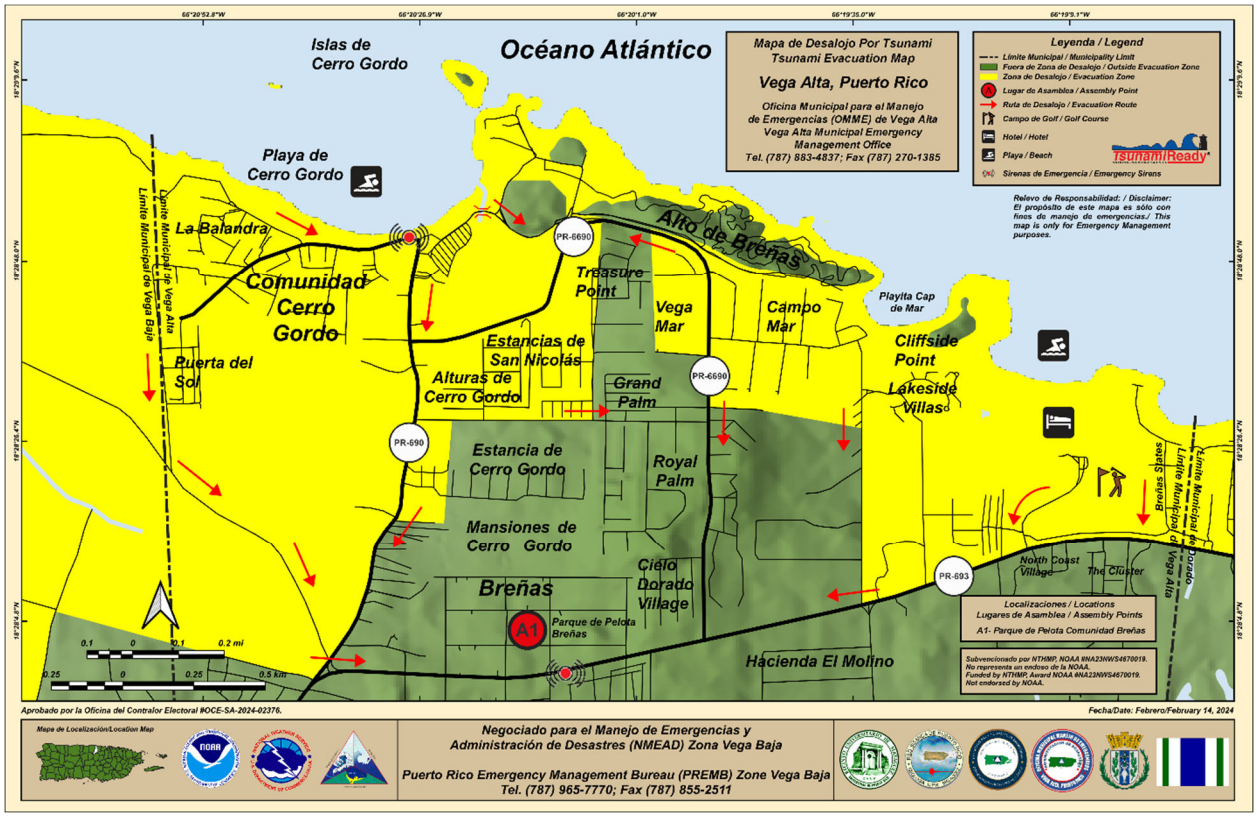
Additional warning signs may precede a tsunami. These include a noticeable retreat of the sea—where water recedes from the shore—or a rapid and excessive rise in coastal sea level. Typically, a loud roar from the ocean can be heard, similar to the sound of a low-flying aircraft. Other noises may occur as powerful waves crash against reefs, rocks, and objects dragged by the current.

Although tsunami hazards cannot be prevented, municipalities can implement mitigation measures through individual and collective preparedness, maintain alert systems to warn vulnerable communities, and ensure an effective response after such an event. In Puerto Rico, efforts have been coordinated under the National Tsunami Hazard Mitigation Program (NTHMP) at the University of Puerto Rico at Mayagüez (UPRM) and by UNESCO's IOCARIBE for regional areas. This program aims to reduce tsunami impacts through disaster assessment, alert messaging guidance, and mitigation strategies. NTHMP develops tsunami inundation maps, disseminates information through media for community drills, and promotes awareness of past events. Mitigation efforts include improving information dissemination, reducing risks, creating evacuation plans, producing educational materials, and implementing NOAA's Tsunami Ready Program, among other initiatives.

### 4.8.1.1 AFFECTED AREA (B1-B)

As Figure 18 shows the Tsunami Evacuation Map developed by PREMB and other partners[9]. In the event of a Tsunami, the areas most impacted in Vega Alta will be Comunidad Cerro Gordo, La Balandra, Puerta del Sol, Estancias de San Nicolas, Alturas de Cerro Gordo, Vega Mar, Campo Mar, Lakeside Villas.

*Figure 15: Official Tsunami Evacuation Map*




### 4.8.1.2 RISK MAGNITUDE (B1-C)

Tsunami events rank among the most severe natural disasters. Among the hazards associated with a tsunami event are the following:

- **Flooding of low-lying coastal areas:** This occurs when tsunami waves penetrate inland, causing property destruction and fatalities due to drowning.
- **Damage to coastal properties and buildings**: Homes and structures located near the shoreline can suffer severe damage, rendering them uninhabitable. Additionally, these waves cause significant coastal erosion and undermine

[9] NOAA, NWS, PRSN and University of Puerto Rico, Mayagüez

building foundations by washing away sand and soil, increasing their reach and force.

- **Floating debris and large objects**: A tsunami can carry debris or even large vessels inland, creating additional hazards and potentially causing major accidents and further tragedies.

Although this natural phenomenon moves slowly across the ocean, the force of a tsunami's waves can cause thousands of deaths and extensive property damage, including homes, critical facilities, and municipal infrastructure. If the disturbance originates near a coastal area, the tsunami can devastate the community within minutes (NOAA, n.d.). Developing and implementing an early warning system is essential to mitigate or reduce the impacts of such events. Likewise, it is critical that communities vulnerable to tsunamis are prepared to respond promptly and effectively once an alert is issued (NOAA, n.d.).

In 1995, the U.S. Congress designated NOAA to lead the National Tsunami Hazard Mitigation Program (NTHMP). This program represents a federal–state partnership that includes NOAA, FEMA, the U.S. Geological Survey, and 28 states and territories. Its primary goal is to reduce tsunami impacts on U.S. coasts through activities such as public education and awareness, community-level planning, risk assessments for specific areas, and guidance on tsunami alerts (NOAA, n.d.).

The TsunamiReady Program, created by NOAA's National Weather Service, aims to minimize loss of life and property from tsunamis and promote preparedness. In Puerto Rico, the Seismic Network (RSPR) manages funds for both the NTHMP and TsunamiReady Program, in coordination with the NWS Forecast Office in San Juan, FEMA, PREMB, Municipal Emergency Management Offices (OMMEs), and local communities.

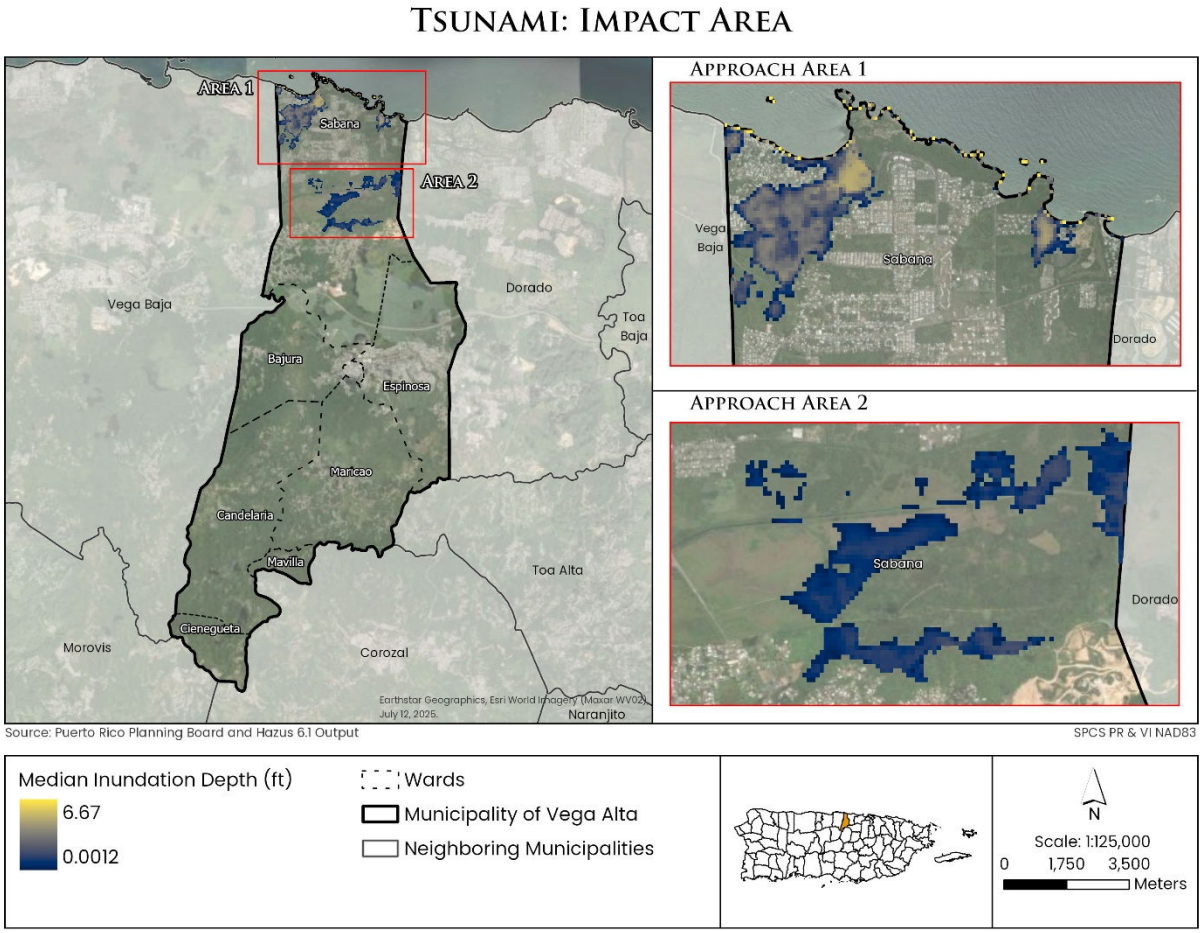
Currently, 46 municipalities across the island participate in the TsunamiReady Program, including Vega Alta. The municipality of Vega Alta has a tsunami evacuation map and holds TsunamiReady certification. Map 27 shows the modeled extent of the tsunami in Vega Alta.

The tsunami inundation analysis indicates that Vega Alta's tsunami exposure is concentrated almost exclusively within the municipality's northern coastal zone, particularly in Sabana Ward, where low-lying coastal lands are most susceptible to inundation. The modeled impact area extends inland from the Atlantic coastline and

includes portions of developed residential areas, recreational resources, transportation facilities, and environmentally sensitive coastal lands.

The analysis identifies two primary areas of concern, both located within Sabana Ward, where tsunami waves may propagate across relatively flat terrain and reach inland areas beyond the immediate shoreline. Although the overall geographic extent of tsunami exposure is considerably smaller than the municipality's flood hazard areas, tsunami events present a unique risk because of their rapid onset, limited warning time, and potential for life-threatening inundation.

*Map 27: Tsunami Impact Area*




Approach Area 1 encompasses the northernmost portion of the municipality adjacent to the Atlantic Ocean. This area contains the greatest concentration of potential tsunami exposure and includes residential communities, beach-related recreational areas, coastal roadways, and utility infrastructure.

The modeling indicates that tsunami inundation may extend inland through low-elevation coastal zones, with localized areas experiencing the greatest inundation depths near the shoreline. The presence of developed neighborhoods within the coastal fringe increases the potential for direct impacts to residents, visitors, structures, and transportation access routes. Because much of the exposed area lies near the coast, evacuation time may be limited following a locally generated tsunami event.

This area also contains infrastructure that supports coastal recreation and tourism activities. Consequently, seasonal and transient populations may increase the number of individuals requiring evacuation during a tsunami emergency.

Approach Area 2 highlights a second concentration of tsunami inundation extending inland across low-lying portions of Sabana Ward. The mapped inundation pattern suggests that topography may channel tsunami flows through depressional areas and natural drainage corridors, allowing water to penetrate farther inland than might otherwise be expected based solely on distance from the shoreline.

#### 4.8.1.3 Past Events (B1-D)

The following tables show the most recent recorded Tsunami Events in Puerto Rico.

*Table 16: Tsunami events in Puerto Rico*

| Tsunami Event | Description |
|---|---|
| 1946 Tsunami | In Puerto Rico, the sea receded at Aguadilla (24 m) and Mayagüez (76 m) before returning as destructive waves. The combined earthquake and tsunami resulted in 75 fatalities and left 20,000 people homeless. At San Juan, the tsunami was recorded on a tide gauge 35 minutes after the earthquake, following a second shock (Ms 7.9) nearly as strong as the August 4 quake but located about 100 km to the northwest. The waves were also detected at distant locations, with travel times of 2:02 hours to Bermuda, 4:02 to Daytona Beach, and 4:42 to Atlantic City (Lander, Whiteside, & Lockridge, 2002). |
| 1918 Tsunami | On October 11, 1918, Puerto Rico experienced one of the most powerful earthquakes in its history. Official reports indicate that 116 people lost their lives, and economic losses were estimated at $4 million—twice the island's annual budget at the time. The earthquake generated a tsunami that struck the island's western coast within minutes of the initial shaking. Waves reached heights of up to 20 feet, at the island's northwestern |

| Tsunami Event | Description |
|---|---|
| | corner, appearing almost immediately after the quake. Approximately 40 of the fatalities were attributed to the tsunami itself (PRSN, 2025).<br>In all areas where the wave was observed, witnesses reported that the sea first receded, exposing reefs and sections of the seabed never seen before, even during the lowest tides. The water then surged back, reaching equally high levels. In some locations, the large wave was followed by one or two smaller ones, and in enclosed bays, the water remained turbulent for some time. At Punta Borinquen in Aguadilla, the lighthouse keeper noted that the water began to recede during the earthquake and later rose to 15 feet. Near Punta Aguejereada, the wave reached between 18 and 20 feet, arriving 4 to 7 minutes after the quake. In Aguadilla, 32 people drowned, and nearly 300 beachside huts were destroyed. The tsunami reached Mayagüez about 20 minutes after the earthquake, with a height of approximately 5 feet (PRSN, 2025). |
| 1867 Tsunami | On November 18, an earthquake of magnitude 7.3 was felt strongly in the Virgin Islands and the eastern region of Puerto Rico. The epicenter was in the Anegada Passage, between the islands of St. Thomas, St. Croix, and Vieques. The resulting tsunami reached heights of nearly 20 feet in St. Thomas and St. Croix. At San Juan and Arroyo, water levels increased by approximately 0.9 to 1.5 meters, accompanied by significant wave activity near the Vieques Islands. In Fajardo, only a minor wave was documented, whereas in Yabucoa, a pronounced sea withdrawal occurred prior to a return surge that penetrated approximately 137 meters inland (Lander, Whiteside, & Lockridge, 2002). No fatalities were recorded (Castro Rivera, n.d.). |

#### 4.8.1.4 Future event probabilities (B1-E)

The occurrence of a tsunami cannot be predicted, nor can its timing be determined with precision. However, because tsunamis are closely associated with seismic events such as earthquakes, their future likelihood depends on the probability of future seismic activity. Vulnerability studies have estimated a 33% to 50% probability of experiencing strong ground shaking (Modified Mercalli Intensity VII or higher) in different parts of the island within a 50-year period (PRSN, n.d.). Consequently, given that the areas of greatest seismic activity around Puerto Rico are located underwater

to the northwest southeast and southwest of the island, it is plausible that the next significant earthquake could generate a tsunami.

Earthquakes and tsunamis are relatively infrequent phenomena, and not all earthquakes generate tsunamis. Nevertheless, when a major earthquake occurs beneath the ocean floor, the likelihood of a tsunami increases substantially. This implies that the probability of a tsunami is directly correlated with the probability of a strong earthquake, particularly in coastal areas. This probability serves as a key parameter for risk classification, based on historical records and contributions from planning committees and existing studies.

### 4.8.2 Risk Analysis (B2-a, B2-b)

#### *4.8.2.1 Estimated Losses*

FEMA's tsunami exposure data indicate that tsunami impacts in Vega Alta are concentrated within the municipality's northern coastal zone, primarily in Sabana Ward, where the tsunami inundation area overlaps developed residential and commercial areas. The National Risk Index estimates that approximately 0.45 square miles of land area are exposed to tsunami hazards, encompassing an estimated 2,071 residents and approximately $513.1 million in building value. The total exposed value, including population equivalency, is estimated at $24.54 billion, highlighting the significant concentration of assets located within the tsunami hazard area.

Table 25 presents the exposure to tsunamis, as registered in FEMA National Risk Index.

*Table 17: Tsunami Exposure*

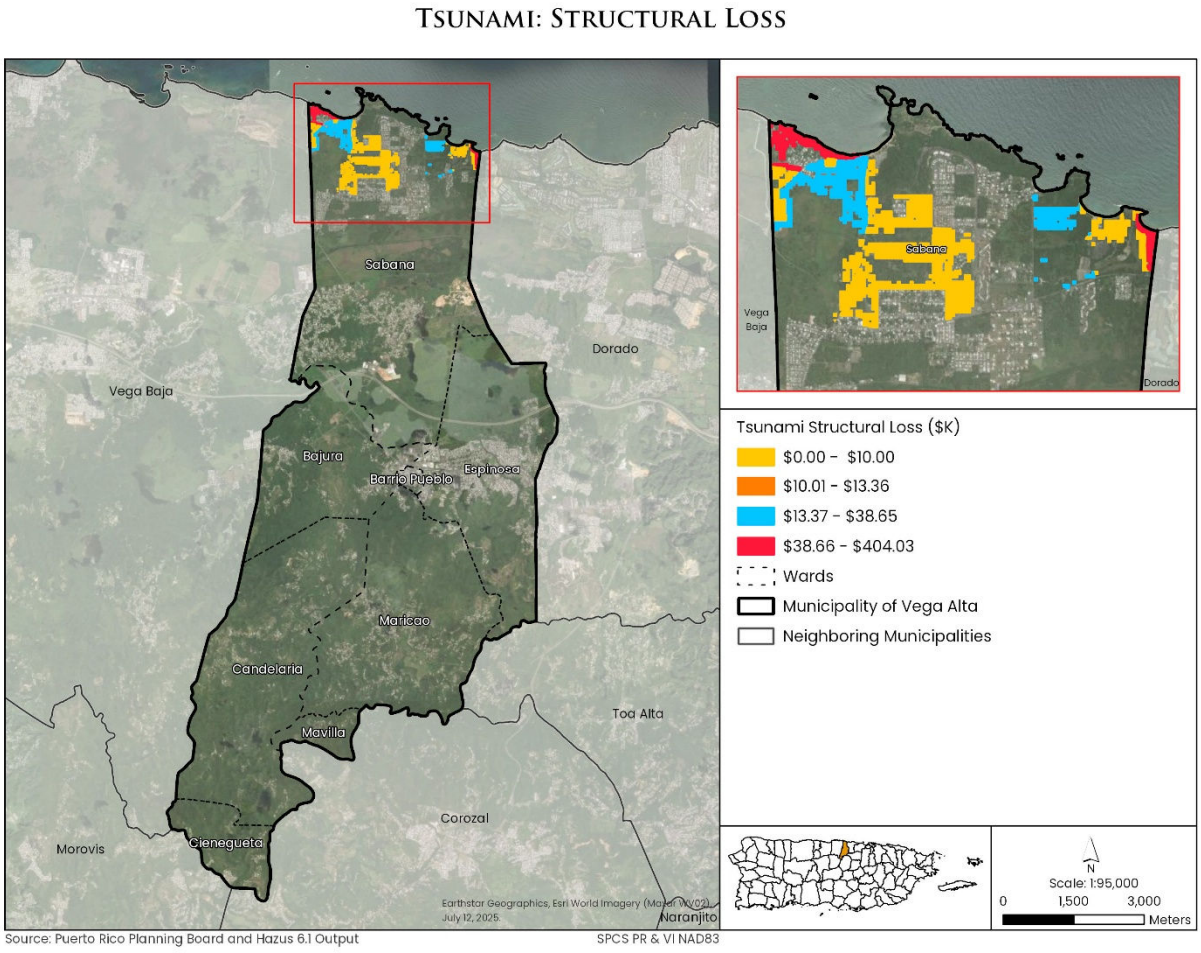
| Exposure - Impacted Area (sq mi) | Exposure - Building Value | Exposure - Population | Exposure - Population Equivalence (in million $) | Exposure – Total (in million $) |
|---|---|---|---|---|
| 0.447397 | $513,082,550.54 | 2,071 | $24,027 | $24,540 |

*Source: FEMA NRI*

The tsunami structural loss analysis shows that the highest estimated losses are concentrated along the immediate coastline and low-lying coastal communities of northern Vega Alta (Map 28). Several census blocks along the coast exhibit the highest loss categories, with estimated structural losses ranging from approximately $38,660 to $404,030 per analysis cell, while inland portions of the tsunami inundation area

generally exhibit lower estimated losses. The spatial distribution of losses reflects both the presence of developed coastal properties and the increased vulnerability of structures located nearest to the shoreline.

*Map 28: Tsunami: Structural Loss*




Overall, tsunami risk in Vega Alta is geographically limited but potentially severe due to the concentration of population and property value within the exposed coastal zone. Continued emphasis on tsunami evacuation planning, public warning systems, hazard awareness, coastal development practices, and protection of critical infrastructure located within the inundation area will help reduce future losses and enhance community resilience.

#### 4.8.2.2 Critical Infrastructure and Lifelines

A tsunami event poses a severe and cascading threat to community functionality due to rapid onset, widespread inundation, strong currents, and extensive debris transport. Tsunamis can significantly disrupt all FEMA Community Lifelines, both immediately and over prolonged recovery periods. Lifeline impacts are often interdependent, creating compounding effects that hinder response, relief, and long-term recovery efforts (FEMA 2021).

- The Safety and Security lifeline is critically compromised during tsunami events due to sudden flooding, debris, and limited evacuation time. Law enforcement, fire services, and emergency shelters may be damaged or rendered inaccessible by inundation or coastal erosion. Search and rescue operations are often required on a large scale, placing heavy strain on emergency responders while access routes are obstructed by debris, collapsed structures, or washed-out roadways. Additionally, damaged correctional facilities and disrupted communications can elevate secondary public safety risks (FEMA, 2021; NOAA, n.d.).

- Tsunami impacts frequently contaminate potable water systems through saltwater intrusion, chemical releases, and damage to treatment facilities. Food distribution systems may be interrupted due to flooded warehouses, damaged ports, and loss of refrigeration. Housing stock in coastal and low-lying areas is particularly vulnerable; entire neighborhoods may be destroyed or declared uninhabitable due to structural damage or mold contamination. As a result, large, displaced populations require mass care, sheltering, and long-term housing solutions, significantly stressing local and regional resources (FEMA, 2020).

- Healthcare systems face immediate challenges following a tsunami, including physical damage to hospitals and clinics, loss of power, and limited access for patients and staff. Medical surges are common due to drowning, trauma, and exposure-related injuries. Public health risks increase as standing water and debris contribute to disease transmission, while ongoing disruptions to water and sanitation systems exacerbate health vulnerabilities. Long-term mental health impacts are also common among affected populations and first responders (FEMA, 2017; World Health Organization , 2019).

- Electrical substations, fuel storage facilities, and distribution infrastructure located in coastal or low-elevation areas are at high risk of inundation and

corrosion damage during tsunami events. Power outages can persist for extended periods, affecting all other lifelines such as water treatment, healthcare delivery, telecommunications, and emergency operations. Fuel supply disruptions may hinder debris removal, emergency response, and generator operations, further delaying restoration efforts (FEMA, 2017).

- Tsunami waves and associated flooding can damage fiber-optic lines, cellular towers, and switching facilities, resulting in widespread loss of voice and data communications. These disruptions impair emergency notifications, situational awareness, interagency coordination, and public information dissemination. Communication outages during evacuation and response phases can significantly increase risk to life and complicate rescue operations (FEMA, 2020).

- Transportation systems are among the most heavily impacted lifelines during tsunami events. Roads, bridges, ports, rail lines, and airports may be destroyed, undermined, or obstructed by debris and sediment. Port facilities are particularly vulnerable and may experience prolonged closures, affecting regional supply chains and economic recovery. Impaired transportation networks limit evacuation, emergency access, and delivery of critical supplies during response and recovery operations (NOAA, 2023).

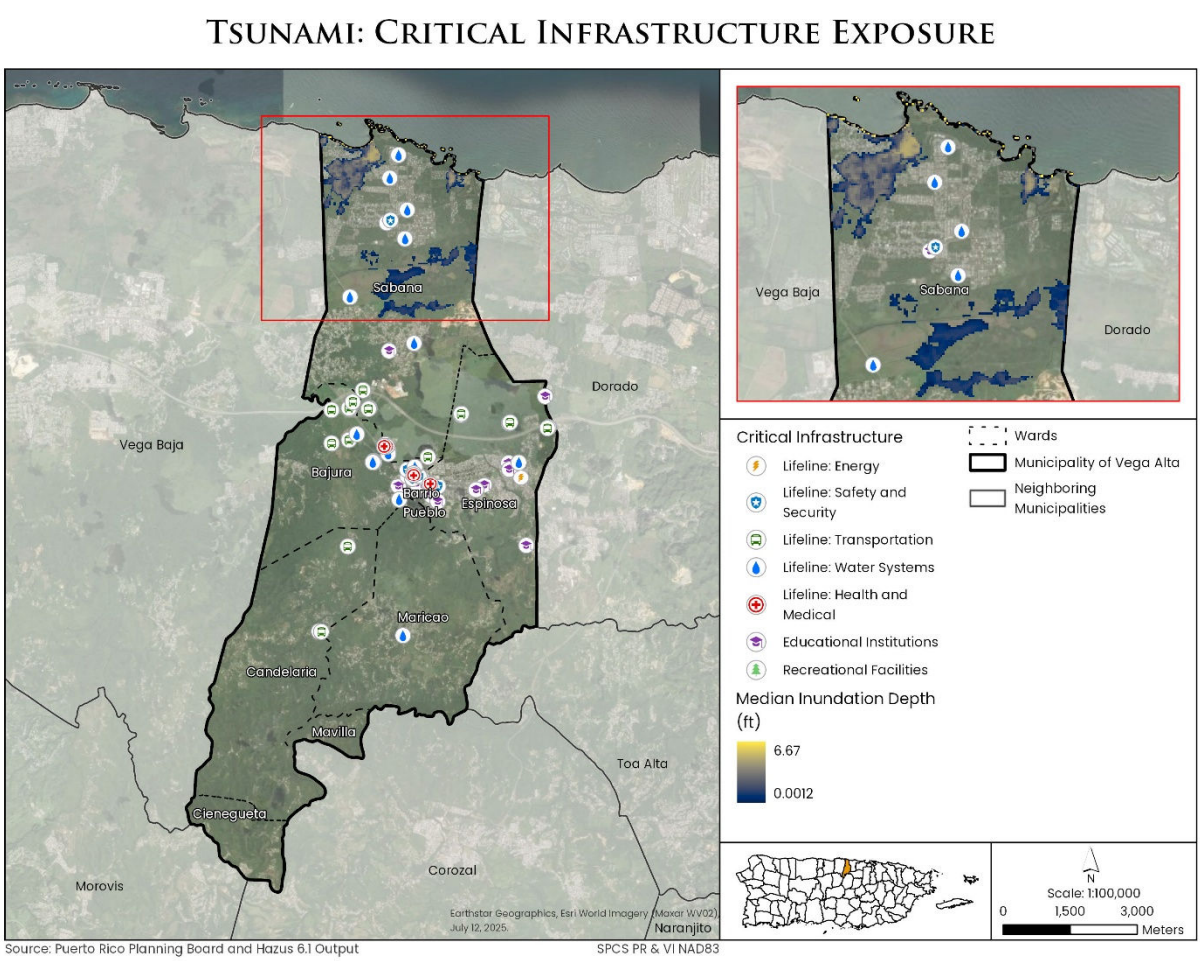
- Water and wastewater infrastructure is highly susceptible to tsunami damage due to inundation, pipeline breaks, pump station failures, and contamination from saltwater and hazardous materials. Wastewater system failures can result in environmental contamination and public health hazards. Restoration of water service is often complex and time-consuming, particularly where underground infrastructure has shifted or corroded due to saltwater exposure (FEMA, 2017).

The tsunami critical infrastructure exposure analysis indicates that infrastructure vulnerability in Vega Alta is primarily concentrated within Sabana Ward, the municipality's only area directly intersecting the modeled tsunami inundation zone (Map 29). Unlike flooding, earthquake shaking, or tropical cyclone impacts that affect broader portions of the municipality, tsunami exposure is geographically limited; however, facilities located within the coastal zone may experience severe impacts due to rapid inundation, debris forces, erosion, and limited warning times.

The analysis shows that most of Vega Alta's critical infrastructure is located outside the tsunami impact area, particularly within the Bajura-Pueblo-Espinosa urban corridor. Nevertheless, several critical facilities associated with the Water Systems

and Safety and Security Community Lifelines are located within or immediately adjacent to the modeled tsunami inundation zone in northern Sabana, creating localized vulnerabilities that could affect emergency operations and essential services.

*Map 29: Tsunami: Critical Infrastructure Exposure*



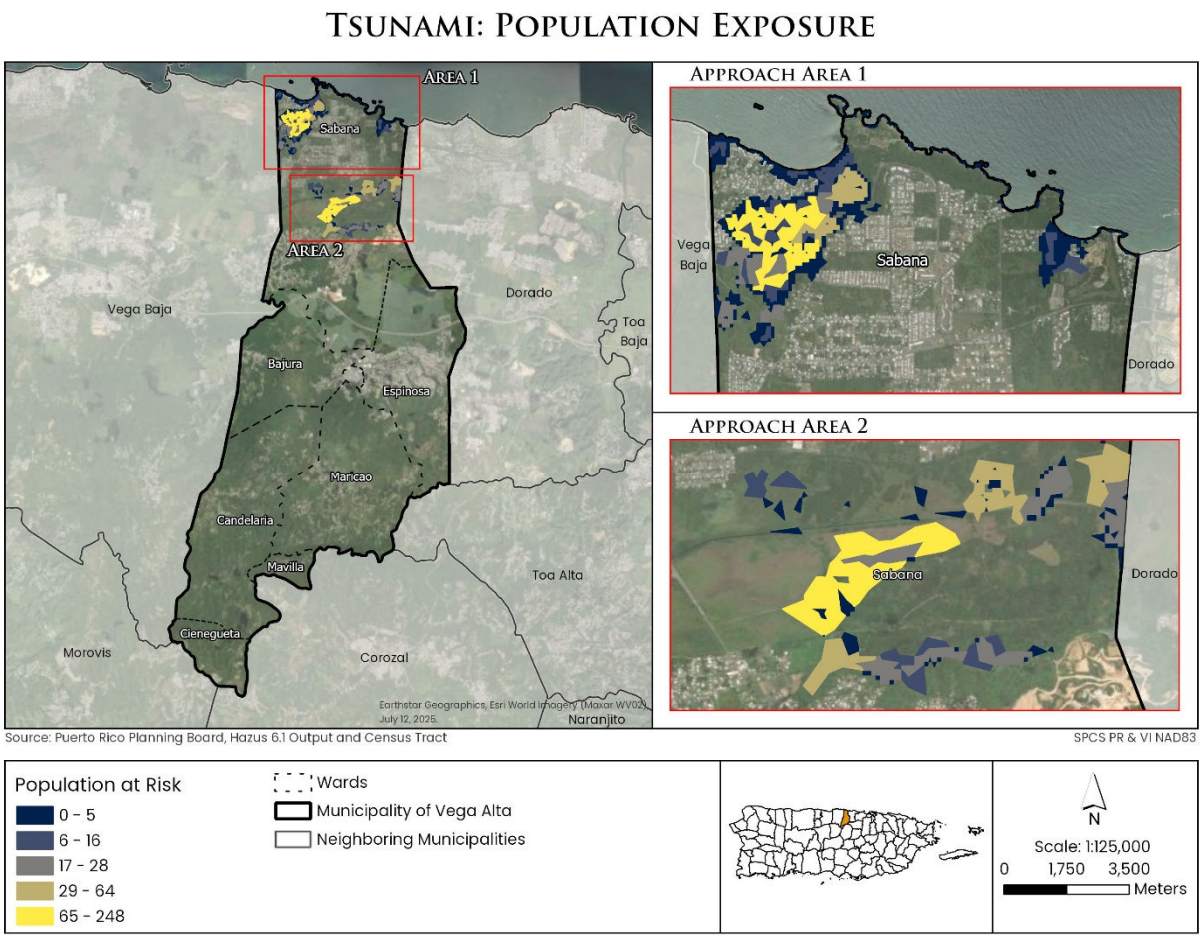

### 4.8.2.3 Social Vulnerabilities

Social vulnerability during a tsunami event reflects pre-existing social, economic, and health conditions that influence how individuals and communities prepare for, respond to, and recover from rapid-onset coastal hazards. Research by U.S. scholars demonstrates that populations with lower incomes, limited access to transportation, and residence in hazard-prone coastal zones face disproportionately higher risk during tsunami evacuations (Cutter, Boruff, & Shirley, 2003). Older adults and people with disabilities are particularly vulnerable due to reduced mobility, dependence on

medical and social support systems, and challenges accessing timely warnings and evacuation assistance ( (Peek & Stough, 2010)). Studies of community resilience further show that inadequate risk communication, lack of hazard awareness, and weak institutional planning can significantly amplify disaster impacts, even when physical exposure is similar (Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2007). Language barriers and social isolation may delay protective actions, increasing mortality and injury risk during time-compressed tsunami events. Collectively, these factors produce uneven disaster outcomes and underscore the importance of integrating social vulnerability considerations into tsunami preparedness and emergency planning.

Map 30 shows the population exposure to tsunami.

*Map 30: Tsunami: Population Exposure*



The tsunami population exposure analysis indicates that human exposure in Vega Alta is concentrated within the municipality's northern coastal area, specifically in Sabana Ward, where the modeled tsunami inundation zone overlaps with populated census tracts. While tsunami impacts are geographically limited compared to other hazards such as flooding and hurricanes, the hazard presents a significant life-safety concern due to potentially short warning times and the rapid arrival of tsunami waves following a seismic event.

The analysis identifies two primary areas of population exposure within Sabana Ward, both characterized by varying concentrations of residents located within or adjacent to the modeled inundation area.

The highest concentration of exposed population is located within the northwestern portion of Sabana Ward, near the coastline and the municipal boundary with Vega Baja. Several census blocks within this area contain an estimated 65 to 248 residents, representing the highest population exposure category depicted on the map.

This area includes established residential neighborhoods situated within low-lying coastal terrain vulnerable to tsunami inundation. Additional census blocks surrounding this cluster contain between 29 and 64 residents, creating a broader zone of exposure extending inland from the coastline.

#### 4.8.2.4 Natural and Cultural Resources

A tsunami's waves scour coastal areas, eroding beaches, dunes, and cliffs, and reshaping geomorphology through sediment redistribution. They remove coastal vegetation, including mangroves, saltmarshes, and coastal forests, severely weakening ecological buffers against future events and disrupting habitat for wildlife. Submerged ecosystems, such as coral reefs and seagrass beds, suffer mechanical damage or smothering from debris and sediment, reducing biodiversity and undermining fisheries (Institute for Environmental Research and Education, 2025).

Saltwater intrusion contaminates freshwater ecosystems and aquifers, compromising drinking water and agriculture. Inland, fish and other aquatic organisms are often displaced or perish due to abrupt changes in salinity, wave force, and sedimentation. Studies on the 2011 Tōhoku tsunami showed changes in seafloor sediment structure that affected benthic invertebrate activity over time, highlighting lasting ecological legacies. Overall, these effects can take years or decades to recover from, especially when compounded by diminished habitat complexity and altered physical conditions (Institute for Environmental Research and Education, 2025).

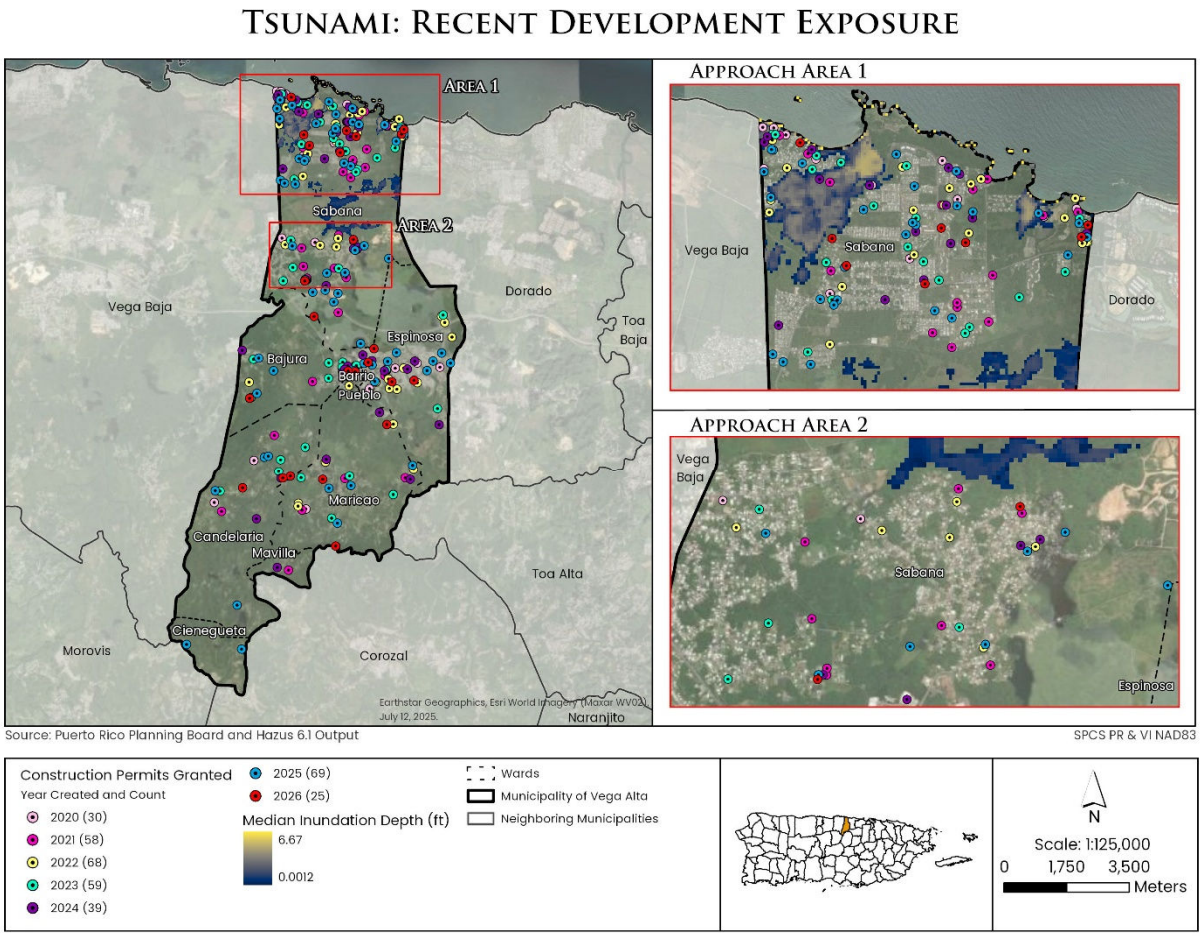
Cultural heritage in coastal regions—including historic towns, monuments, and archaeological sites—is profoundly impacted. Physical destruction often occurs due to wave forces, flooding, debris impact, and prolonged inundation. Buildings and monuments can collapse or suffer structural failure, while artifacts and intangible cultural practices may be irretrievably lost. (Okamura, et al., 2013).

#### 4.8.2.5 Future Conditions (E1-a)

The recent development exposure analysis indicates that a portion of the development activity occurring in Vega Alta since 2020 is located within or adjacent to the modeled tsunami inundation area, primarily within Sabana Ward. Although tsunami exposure remains geographically limited compared to other hazards affecting the municipality, the concentration of new development within portions of the coastal zone has the potential to increase future exposure of people, structures, and infrastructure to tsunami-related impacts.

The map shows construction permits issued between 2020 and 2026 distributed throughout the municipality; however, the greatest overlap between recent development and the tsunami inundation area occurs in northern Sabana, where new residential, commercial, and supporting infrastructure development has occurred within low-lying coastal areas.

*Map 31: Tsunami: Recent Development Exposure*




Approach Area 1 contains the highest concentration of recent development intersecting the tsunami impact area. Numerous permitted projects are located within or immediately adjacent to the modeled inundation zone extending along the northern coastline.

This area includes portions of established and expanding residential communities where recent construction activity has continued despite the presence of coastal hazards. Several permitted developments are located near census blocks previously identified as having the highest tsunami population exposure, suggesting the potential for incremental increases in future life-safety risk.

The overlap between recent development and the inundation zone indicates that future tsunami events could affect newer structures in addition to the existing built environment. While modern construction practices may improve structural performance, residents and visitors occupying these developments would remain

vulnerable to evacuation challenges associated with a rapidly developing tsunami event.

## 4.9 Flooding

### 4.9.1 Description (B1-a)

Floods, generally caused by excessive rainfall (FEMA, 1997), are classified into two main categories: general floods and flash floods.

- General floods are long-duration events that can last several days and include riverine, coastal, and urban floods. Coastal floods are associated with storm surges, waves, and heavy rains generated by hurricanes and tropical storms, while urban floods result from the alteration of natural drainage due to urban development. Riverine floods occur when rivers overflow due to excessive water runoff though rainfall or structural failures, causing water to spill into surrounding land. Flash floods often stem from stationary storms, hurricanes, or dam failures, affecting both mountainous areas and urbanized zones.

- Flash floods happen when prolonged rainfall falls over a watershed (water basin). The latter result from intense precipitation over a short period in specific areas. The magnitude of flash floods events depends on factors such as basin topography and physiography, weather patterns, soil saturation, and surface impermeability. Flash floods mainly originate from slow-moving storms over specific areas or from intense rainfall associated with hurricanes and tropical storms (NMEAD, 2021). However, they can also occur after the collapse of dams or levees within minutes or hours, due to extreme rainfall or the sudden release of water from retention basins or other stormwater control facilities. Although more frequent in mountain streams, these events can occur in urban areas where impermeable surfaces limit infiltration.

The periodic flooding of land adjacent to rivers, streams, and coasts—known as floodplains—is a predictable natural phenomenon based on recurrence intervals. These intervals represent the average time, in years, between events of equal or greater magnitude. The longer the recurrence interval, the greater the magnitude of the event, which implies a significant increase in risk and the extent of the affected area. Floodplains flood periodically according to recurrence intervals, defined as the average time between events of equal magnitude. For example, a 100-year flood has a 1% annual probability, while a 500-year flood corresponds to 0.2%. These frequencies are calculated through statistical analysis of historical flow records and extreme events.

Table 27 shows the different flood zone classifications for Puerto Rico adopted by the PRPB (PRPB, 2021).

*Table 27: Puerto Rico Flood Zones*

| Flood Zone | Description |
|---|---|
| Zone A | Special Flood Hazard Area with a recurring period of one hundred (100) years determined by using approximate methodologies with no base flood elevation or Floodway determined. |
| Zone AE | Special Flood Hazard Areas with a recurring period of one hundred (100) years determined by detailed methodologies with base flood elevations indicated. According to the scope of the study, may include the Floodway determination. |
| Zone AO/AH | Shallow Special Flood Hazard Areas with a recurring period of one hundred (100) years with a base flood depth fluctuating between 0.30 meters (one (1) foot) and 0.91 meters (three (3) feet). The average flood depths are obtained from detailed hydraulic analysis. |
| Zone A99 | Areas prone to flooding from a flooding event with a one percent (1%) annual chance of occurring. These special areas are within a flood protection or control system where enough progress has been made in its construction, even though it has not been completed, but specific statutory progress has been reached to complete it. This zone does not detail base flood elevations or flooding depths, so it is recommended to use, if required, the previous flood elevation for Zone 99. Mandatory flood insurance purchase requirements apply. |
| Zone D | Flooding area that is not determined but is possible. |
| Zone VE | Coastal high flood hazard area with a recurring period of one hundred (100) years with velocity and energy (storm surge) and a determined base flood elevation. |
| Zone X Shaded | flooding area with 0.2% chance of occurring each year or the one hundred (100) year flood with a water depth of less than 0.3 meters, with drainage areas of less than 2.6 square kilometers or areas protected by levees against the one hundred (100) year flood. |
| Zone X (unshaded) | Area determined to be outside the five hundred (500) year storm flood. |

### 4.9.1.1 Affected Area

**Flood Hazard Insurance Map**

Map 31 depicts the Federal Emergency Management Agency (FEMA) flood hazard zones within the Municipality of Vega Alta. The map identifies areas subject to the 1-percent annual chance flood event (commonly referred to as the 100-year floodplain), the 0.2-percent annual chance flood event (500-year floodplain), and designated regulatory floodways. These flood hazard areas are primarily concentrated along the Cibuco River corridor and associated drainage features, extending through portions of Bajura, Barrio Pueblo, Sabana, and adjacent low-lying coastal areas. Additional flood-prone areas are present near the municipality's northern coastal zone, where low elevations and proximity to tidal waters increase susceptibility to flooding.

The mapped flood hazard zones are significant because they contain residential neighborhoods, transportation corridors, public infrastructure, commercial establishments, and community assets that may experience flood-related impacts during severe rainfall events, riverine flooding, coastal storm events, and hurricanes. Given Vega Alta's location within the Cibuco River watershed and its exposure to tropical cyclones, these areas have historically been vulnerable to flooding and remain susceptible to future flood events.

The reviewed FIRMettes corroborate local observations and historical flooding conditions documented by the Municipality (Figures 16 to 19). The areas identified in the FIRMettes are located within FEMA-designated Special Flood Hazard Areas (SFHAs), including flood-prone sectors along the Cibuco River corridor and the low-lying coastal zone of Sabana Ward. These areas are susceptible to riverine flooding, stormwater accumulation, and flooding associated with intense rainfall events and tropical cyclones. The following communities are most susceptible to flooding events:

- Nuevas Cerro Gordo Parcels
- Carmelita
- El Corozo
- Ojo de Agua
- Balandras del Arrecife
- Cachete
- Cerro Gordo Balnearies
- PR-647
- Candongo
- Fátima Bridge
- La Esperanza

- Machuchal Korea
- La Ponderosa
- Bajura
- Nevelio Dávila Sector

Communities along Quebrada Honda

- Cerro Gordo Sector
- Entrance to Lake Side Village
- Breñas
- Villa Alegría Parcels
- PR- 690
- El Corozo/Carmelita
- PR-2 -CDT
- El Batey
- El Manantial
- Extensión Santa Ana
- Moran La Balandra Sector

*Figure 16: National Flood Hazard Layer FIRMette (PR-2 and nearby communities in Vega Alta)*

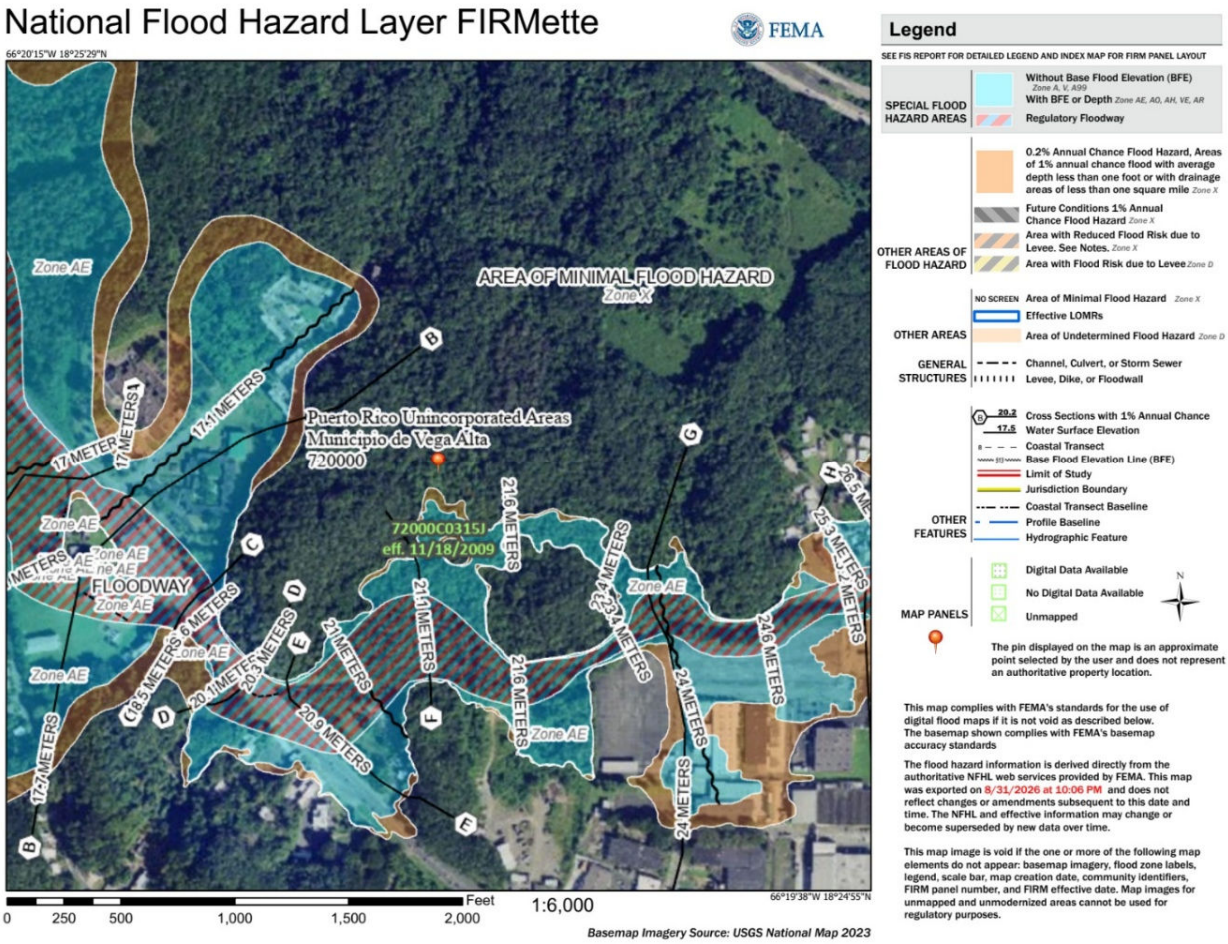
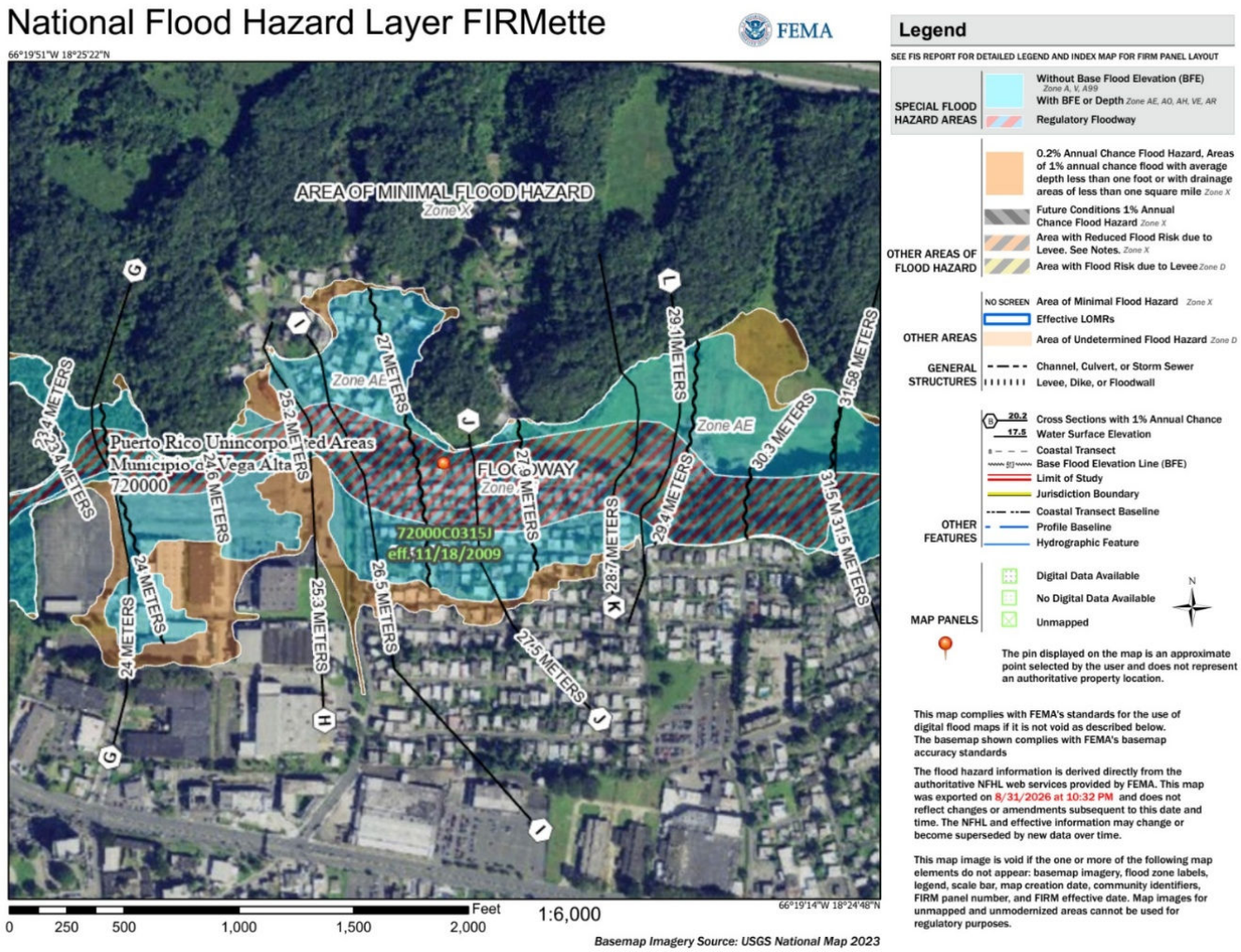


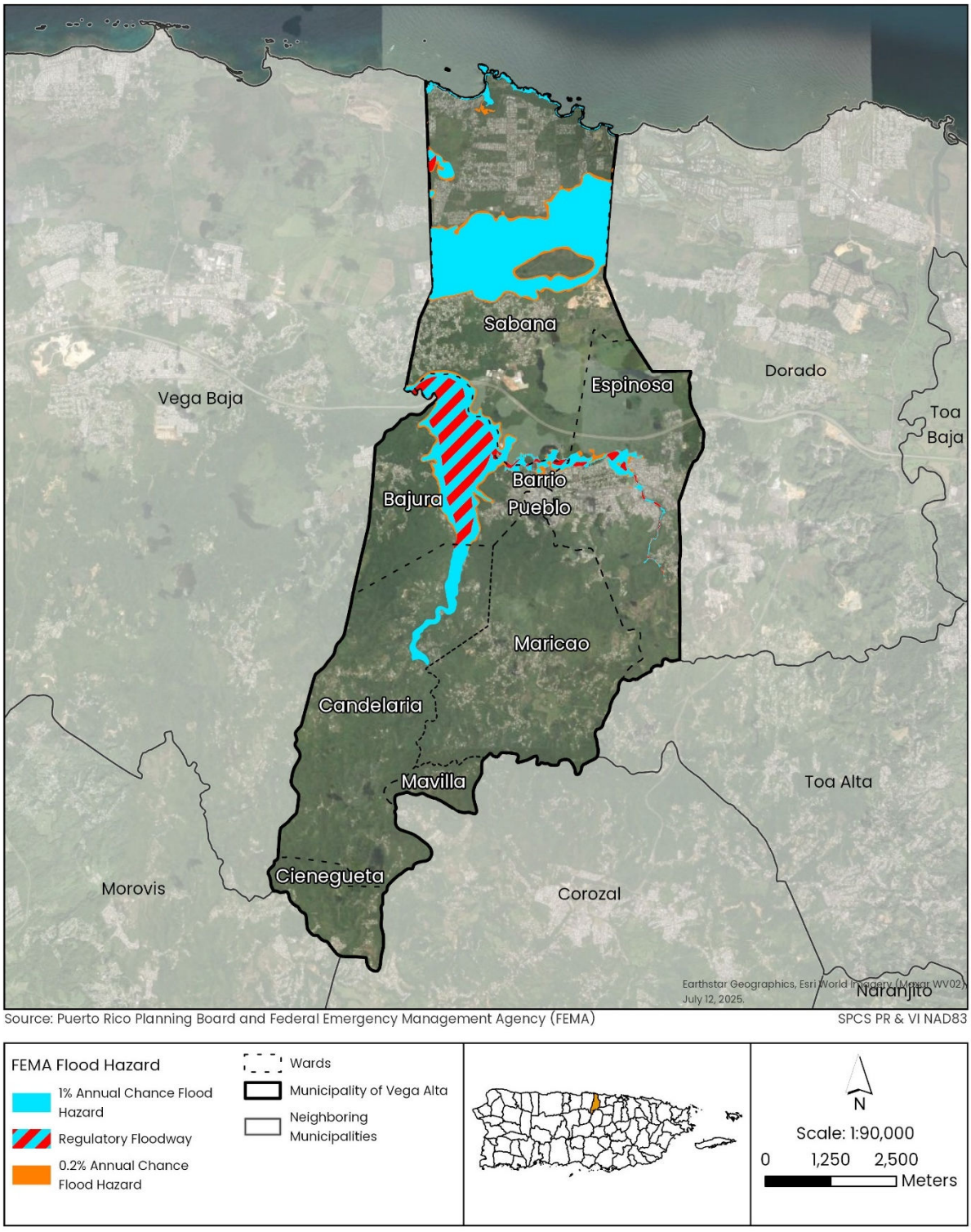
Figure 16 shows a significant portion of PR-2 located within a Special Flood Hazard Area (SFHA), predominantly designated as AE, extending from Bajuras Ward to the urban center (Ward Pueblo). Flooding in this area is primarily associated with the Cibuco River. There are proposed mitigation strategies specifically addressing the impacts of this flooding on this critical transportation corridor, with the goal of improving roadway resilience and maintaining connectivity during flood events (Strategy P-2).

*Figure 17: National Flood Hazard Layer FIRMette (La Ponderosa, Vega Alta)*



*Map 32: Vega Alta Flood Hazard Zones (FIRM)*

# Flood Hazard Zones

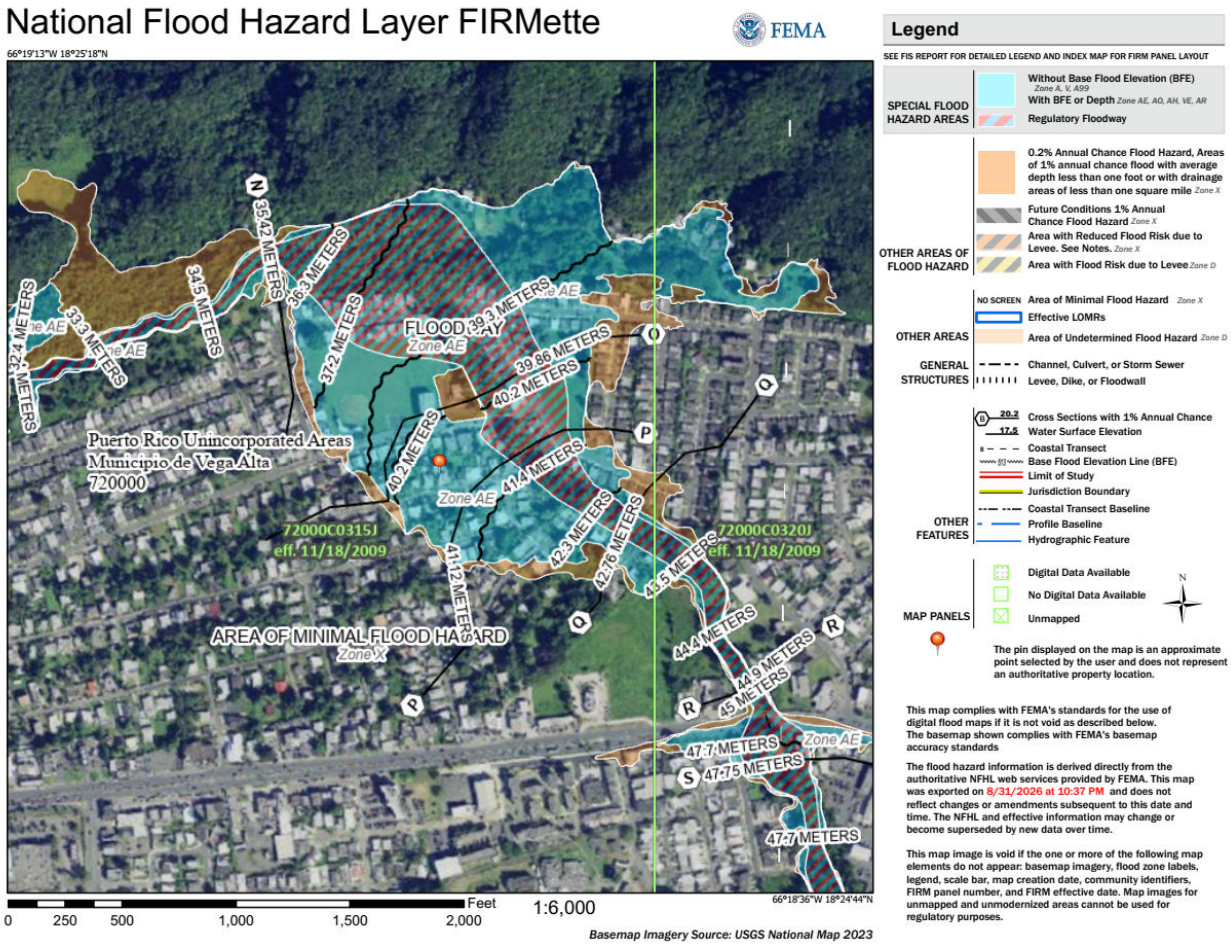



Source: Puerto Rico Planning Board and Federal Emergency Management Agency (FEMA)

SPCS PR & VI NAD83

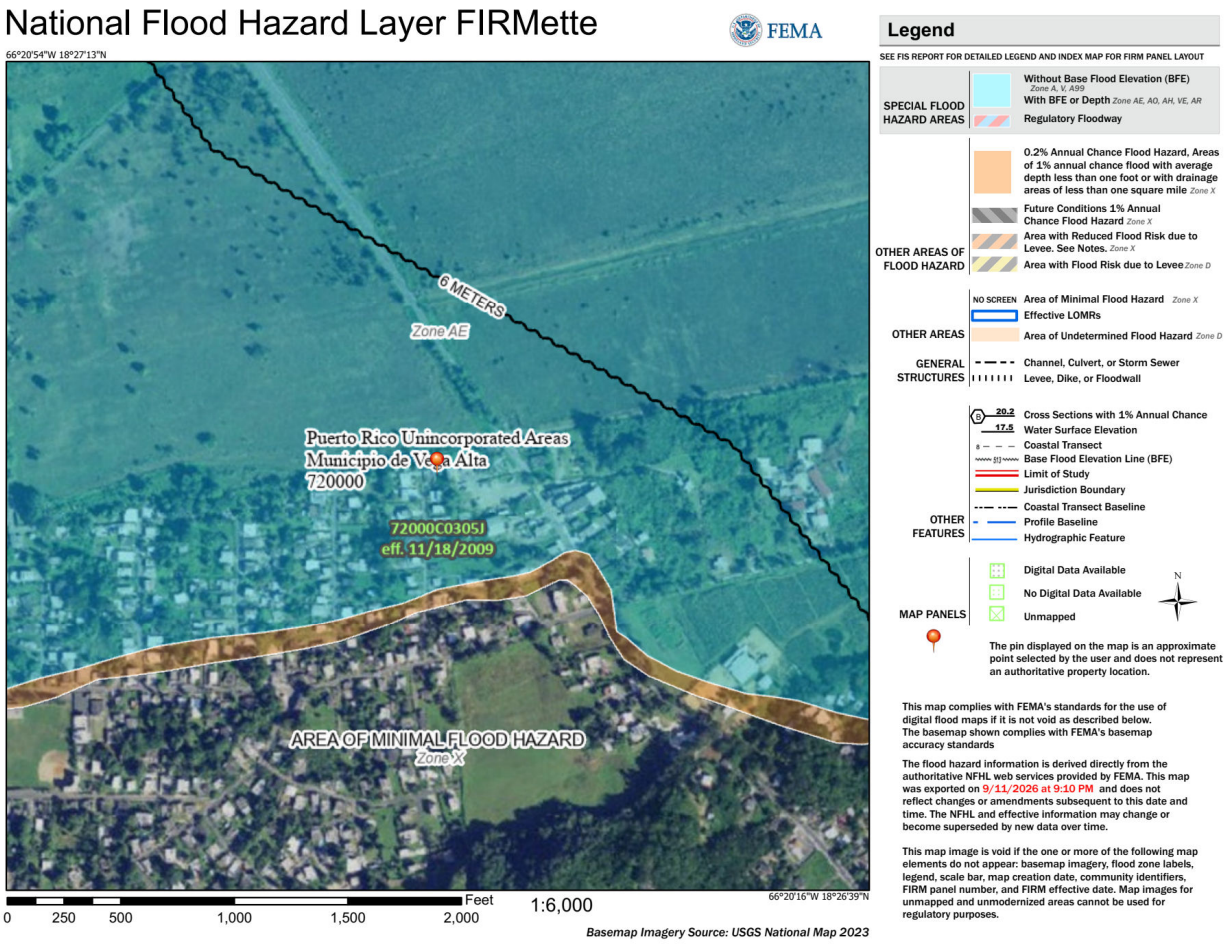
Figure 17 illustrates the continuation of flooding associated with the Cibuco River as it extends toward Ward Pueblo, affecting the La Poderosa and Inmaculada sectors. Similar flooding conditions are depicted in Figure 18, where impacts extend to the Parcelas Carmen area near the boundary with the Municipality of Dorado. These areas are located within Special Flood Hazard Areas (SFHAs), primarily designated as AE zones and regulatory floodways.

*Figure 18: National Flood Hazard Layer FIRMette (Parcelas Carmen, Vega Alta)*




Finally, Figure 19 highlights a significant flood-prone area within the Carmelita Sector, located near PR-690 and north of Ward Pueblo. This area is affected by flooding associated with the Cibuco watershed and the tributary systems draining to Tortuguero Lagoon. Most of the affected areas are located within the AE flood zone, indicating a high risk of inundation during major flood events.

*Figure 19: National Flood Hazard Layer FIRMette (Sector Carmelita and PR-690, Bo. Sabana)*




## Advisory Base Flood Elevation (ABFE)

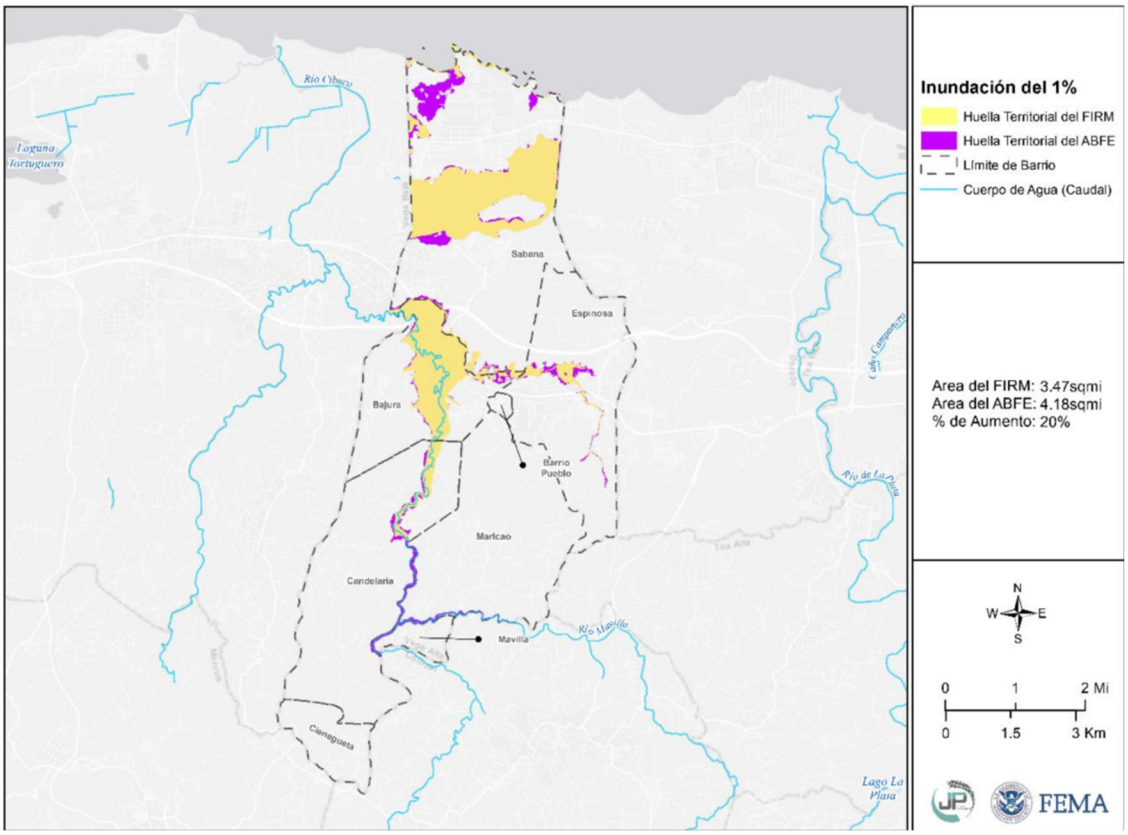
Likewise, FEMA uses another type of map for the purpose of developing regulations and construction permits known as the Advisory Base Flood Elevation Maps (ABFE). ABFEs are developed after the occurrence of a high-impact atmospheric event, and several factors related to the latest engineering analysis are taken into consideration to determine whether an analysis is necessary. Some of the factors considered in the analysis include the age of the analysis, the territory covered by the analysis, and the engineering models/data used in the analysis. ABFEs have been produced for states such as Mississippi (Hurricane Katrina), New York, and New Jersey (Hurricane Sandy). Following Hurricane María's passage through Puerto Rico in 2017, and due to the availability of better data, FEMA developed ABFEs for Puerto Rico. It should be noted that the Puerto Rico Planning Board adopted the ABFEs on an emergency basis in March 2018. At present, Puerto Rico has two (2) types of flood maps: the FIRMs (2009),

which are used solely for flood insurance rates, and the ABFEs (2018), which are used to regulate construction on the Island.

For comparison purposes, this subsection includes the difference in the extent of land affected by flooding based on the FIRMs prior to Hurricane María in September 2017 and the ABFEs developed by FEMA for Puerto Rico. After Hurricane María in 2017, the areas designated as flood-prone throughout the Island increased by 20%. Thus, this reflected an increase of 41%.

The next Figure (in Spanish) shows the difference between the extent of the FIRM maps before Hurricane María and the Advisory Base Flood Elevation (ABFE) for an event of 1% chance (100 years flood) maps after the hurricane. In the Municipality of Vega Alta, the difference represents an increase of approximately 20%, from 3.47 square miles to 4.18 square miles, meaning that the areas exposed to flooding are more extensive than previously determined and greater than those highlighted in the municipality's previous Plan. The new area includes the expansion of previously identified areas, as well as new areas along several bodies of water in the Municipality, including the Cibuco River and tributaries.

*Figure 20: ABFE vs FIRM 1% (100 years)*



**HAZUS Modeling**

Flooding source identification and hazard loss estimation were performed using Federal Emergency Management Agency's (FEMA) Hazus platform, a nationally standardized tool for multi-hazard risk assessment. The Hazus flood module was used to delineate streams in areas where no engineering studies have been developed and also used to estimate potential monetary losses associated with structural damage.

Input data included depth grids produced by a Base Level Engineering (BLE) study in 2018 post hurricanes Irma and María. This BLE study did not review all potential riverine flooding sources so additional modeling was developed with Hazus hydrology and hydraulics to review other potential losses associated with streams with drainage areas of one square mile or more.

Topographic data used by Hazus for depth calculations and damage estimation was sourced from the USGS 3D Elevation Program (3DEP) seamless 1/3 arc-second Digital Elevation Model (DEM), at an approximate resolution of 10 feet. This dataset provides current coverage of Puerto Rico and its surrounding islands.

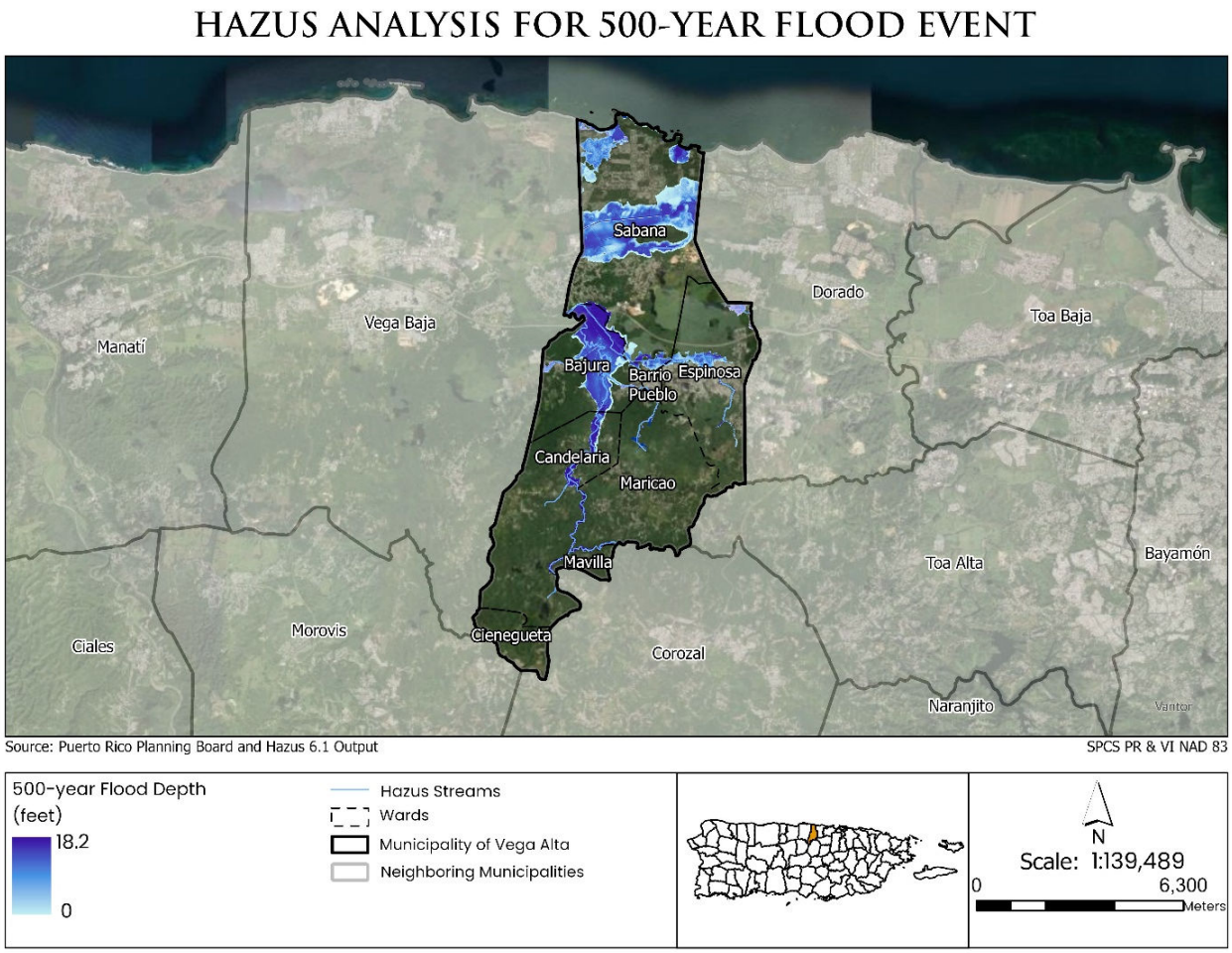
The 3DEP seamless DEM for Puerto Rico is derived from two lidar collection efforts: a 2016–2017 USGS lidar survey and a 2018 USGS post-Hurricane María lidar survey. The 2018 collection, conducted following the significant coastal geomorphic changes caused by Hurricane María, represents the most current available terrain data for the island and forms the primary basis of the 3DEP elevation layer used in this analysis.

The areas documented in the maps included within the LHMP may have streamlines represented but with no depth grids associated with them. Due to the inconsistency of available regression equations and other data necessary for computation of flood risk and losses with Hazus's hydrology and hydraulics models, some streams that were delineated were unable to be completed during modeling runs. These stream areas may need to be reviewed for future flood studies and potential flood risk identification but, due to the lack of data, they were unable to be included in the Hazus studies.

The Hazus 6.1 analysis indicates that potential inundation associated with the 500-year flood event may extend beyond areas identified in the 2018 Advisory Base Flood Elevation (ABFE) mapping (Map 32 and Figure 23). The largest flood extents occur in Sabana Ward and along the Cibuco River floodplain, extending south through Bajura, Pueblo, Candelaria, and portions of Mavilla Ward. Maximum modeled flood depths reach approximately 18 feet within Bajura Ward. The analysis also indicates that

portions of developed areas in Pueblo and Espinosa may be exposed to flood impacts. The results highlight the importance of floodplain management, drainage improvements, protection of critical infrastructure, and consideration of flood risk in future development decisions throughout the municipality.

*Map 33: Hazus Analysis for 500 - Year Flood Event*




### *4.9.1.2 Risk Magnitude (B1-C)*

Flood events can represent one of the most severe atmospheric threats, as there is no other event worldwide that causes greater loss of life (FEMA, 1997). This is due to the high frequency of such events and the population's lack of awareness regarding the magnitude of the damage they can cause, whether physical harm or property damage. It should be noted that most disaster declarations in the U.S. are related to flood events. The majority of flood-related incidents involve people being swept away

by fast-moving water, along with their vehicles (FEMA, 1997). Each year, the devastation caused by floods results in billions of dollars in asset losses. Highly urbanized areas with dense populations are particularly vulnerable to flash floods, as the construction of buildings, roads, and parking lots create impermeable surfaces, reducing the land's natural ability to absorb water (NSWL, n.d.).

Floods are the most common natural disaster, occurring when water overflows and submerges land that is typically dry. They are often triggered by heavy rainfall, rapid snowmelt, or storm surges from tropical cyclones or tsunamis in coastal regions.

Floods can cause extensive destruction, including loss of life and severe damage to homes, property, and critical public health infrastructure. Between 1998 and 2017, floods impacted more than 2 billion people worldwide. Those living in floodplains, in poorly constructed buildings, or without access to warning systems and hazard awareness are the most vulnerable (WHO, 2025).

Three common types of floods include:

- Flash floods: Result from sudden, intense rainfall that rapidly raises water levels, overwhelming rivers, streams, channels, or roads.
- River floods: Occur when prolonged rainfall or snowmelt causes rivers to exceed their capacity.
- Coastal floods: Caused by storm surges linked to tropical cyclones or tsunamis.

Regarding the impact on life, property, and operations, floods cause loss of life and property damage, including residences, buildings, infrastructure, agriculture, and sanitation and drainage systems. After a flooding event, the aftermath can increase the occurrence of various diseases, such as leptospirosis, and lead to rises in contaminated water (Malilay, 2000).

According to a Congressional Budget Office (CBO) report, "Over the past 10 years, damage from flooding in the United States has averaged $46 billion per year (in 2023 dollars)" (CBO, 2024). This estimate includes costs such as:

- The replacement of residential and commercial property;
- Repairs for or rebuilding of public infrastructure;
- Emergency response measures;
- Costs associated with the continued loss of property use (for example, the provision of temporary housing);
- Commercial losses resulting from business interruptions; and

- Damage to crops, livestock, and timber" (CBO, 2024).

Although the effectiveness of adaptation projects varies, estimates by the U.S. Army Corps of Engineers indicate that approximately two-thirds of its projects—excluding those in the highest and lowest sixth of benefit–cost ratios—are expected to reduce flood damages by $2 to $6 for every dollar invested over a 50-year project lifespan(CBO, 2024).

#### 4.9.1.3 Past Events (B1-D)

For the most part, flooding events in Puerto Rico are related to tropical systems (tropical waves, tropical depressions, tropical storms and hurricanes). Consequently, flooding hazards occur most frequently during Atlantic hurricane season, which extends from June 1 through November 30.

However, flooding events can occur outside this window as shown in the case of the April- May 2024 Floods, the February 2022 floods and the Three Kings' Flooding of 1992. The following table summarizes the major flooding events in the period of 2010 – 2025.

*Table 16: Major flooding events in Puerto Rico 2010-2025*

| **Event** | **Date** | **Disaster Declaration Number** | Vega Alta **Included?** | **Description** |
|---|---|---|---|---|
| Tropical Storm Ernesto | 8/13/2025 to 8/16/2025 | DR-4850- PR<br><br>EM-3610-PR | Public Assistance – Yes (Categories A-G)<br><br>Public Assistance Yes (Category B) Individual Assistance - NO | The storm's slow movement and moisture-rich environment contributed to prolonged precipitation, particularly in central and eastern municipalities. Parts of Central Puerto Rico recorded 12–14 inches of rainfall in localized areas.<br><br>The municipality of Barranquitas measured 11.20 inches over a 48-hour period, while Villalba reported 10.20 inches. Eastern municipalities, including Vieques and Culebra, observed 8–10 inches of rain. Multiple rivers exceeded their banks, including the La Plata River, resulting in significant inundation |

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| | | | | of adjacent communities. Flash flooding occurred in urban and rural areas, rendering primary and secondary roads impassable. Floodwaters caused structural failures in bridges and washed-out critical road segments, isolating several communities. Stormwater drainage systems in metropolitan areas, notably San Juan, were overwhelmed, leading to localized urban flooding.<br><br>Emergency Response and Disruptions<br><br>Evacuations were conducted in flood-prone areas such as Toa Baja to mitigate loss of life. |
| Puerto Rico Severe Storms, Flooding, Landslides, and Mudslides | 4/29/2024 to 5/10/2024 | DR-4805-PR | Public Assistance – No<br><br>Individual Assistance - No | In April 2024, Puerto Rico was struck by a series of severe storms that delivered prolonged heavy rainfall—some areas received more than 10 inches—leading to widespread flooding and landslides. Central and western municipalities saw rivers overflow, with the Manatí and Cibuco rivers breaching their banks and inundating highways like PR-2. Urban areas, especially in the southwest (Cabo Rojo, Mayagüez, Ponce), faced flash flood warnings as heavy afternoon downpours overwhelmed drainage systems. Floodwater turned streets into torrents, trapping residents on rooftops and prompting |

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| | | | | emergency evacuations in over 20 municipalities. |
| Hurricane Fiona | 9/17/2025 to 9/21/2022 | DR-4671-PR | Public Assistance – Yes<br><br>Individual Assistance - Yes | Hurricane Fiona struck Puerto Rico in September 2022, unleashing torrential rains—up to 31.22 inches of rainfall over 72 hours in Ponce, nearly matching the accumulation from Hurricane María. This deluge led to catastrophic flooding, with 7 to 20 inches common across most of the island and localized spots exceeding 30 inches. |
| Puerto Rico Severe Storm, Flooding and Landslide | 2/4/2022 to 2/6/2022 | DR-4649-PR | Public Assistance: No<br><br>Individual Assistance: Yes | In February 2022, Puerto Rico experienced a severe storm that brought prolonged heavy rainfall, causing widespread flooding across the island. Rainfall totals ranged from 3 to 10 inches in many areas, with localized peaks reaching up to 16 inches in Toa Alta. The intense precipitation overwhelmed drainage systems, leading to urban flooding in San Juan, Guaynabo, and coastal towns such as Dorado and Vega Baja. Rivers swelled beyond their banks, inundating roads and isolating communities, while landslides compounded the damage in mountainous regions. Emergency responders issued flash flood warnings and conducted evacuations as homes and businesses were submerged. |

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| Puerto Rico Severe Storm and Flooding | 9/13/2020 | DR-4571-PR | Public Assistance - No<br><br>Individual Assistance - No | Puerto Rico was battered by a severe storm and flooding on September 13, 2020, resulting in widespread flood damage and infrastructure disruption. Torrential rains overwhelmed drainage systems and caused rivers to overtop in areas like Arecibo, where one home was destroyed, over 100 suffered major damage, and more than 20 experienced minor flooding. Roads and bridges were submerged or damaged, isolating communities and impeding emergency response efforts. Floodwaters inundated homes and public facilities, prompting evacuation orders and flash flood warnings across several municipalities. |
| Tropical Storm Isaías | 7/29/2020 to 7/30/2020 | DR-4560-PR | Public Assistance - No<br><br>Individual Assistance - No | Although the center of Tropical Storm Isaías did not make landfall on the island, the system left a large amount of rain in its path, causing flooding throughout Puerto Rico. Rainfall accumulation of up to 10 inches was recorded around the island. |
| Hurricane María | 9/20/2017 | DR-4339-PR | Public Assistance – Yes | Widespread flooding severely affected the whole Island. For example, in San Juan, water levels reached up to 6 feet in some areas and numerous structures losing their roofs. The coastal neighborhood of La Perla was largely destroyed, while Cataño suffered extensive damage, with |

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| | | | Individual Assistance - Yes | the Juana Matos community estimated to be 80% destroyed. Strong winds, heavy rains, and flash floods near the La Plata Lake dam in Toa Baja impacted thousands of residents. Survivors reported that floodwater rose 6 feet in just 30 minutes, and some areas experienced depths of up to 15 feet (4.6 m). |
| Hurricane Irma | 9/5/2017 | DR-4336-PR | Public Assistance – No<br><br>Individual Assistance - No | On September 5, 2017, Hurricane Irma impacted Puerto Rico; an Emergency Declaration was issued for the Island. On September 6, 2017, a Major Disaster Declaration was issued following Hurricane Irma's passage.<br><br>Two people died due to torrential rains before the hurricane: a man died in Orocovis after falling from his ladder while repairing his roof; another man on the coast in Capitanejo died after being struck by lightning. Wave heights in Puerto Rico reached 9 meters, and sustained winds of 111 mph were recorded in Culebra. |
| Tropical Storm María[10] | 9/8/2011 to 9/114/2011 | DR-4040-PR | Public Assistance - No | Tropical Storm (later Hurricane) María formed in early September 2011 and passed near Puerto Rico, bringing significant heavy rainfall and tropical storm conditions to the island. The storm caused |

[10] Tropical Storm María was a tropical system that pass to the northeast of Puerto Rico in 2011 and that caused flooding in the Island. Not to be confused with the 2017 Hurricane María. The name "María" was retired from the official Atlantic hurricane season list of names after 2017.

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| | | | Individual Assistance - No | widespread flooding that inundated numerous roadways and homes; floodwaters near Patillas destroyed several homes and bridges, and approximately 150 houses in Yabucoa were flooded and damaged. |
| Hurricane Irene | 8/22/2011 | DR-4017-PR | Public Assistance - No<br><br>Individual Assistance - No | Total rainfall reached 22 inches over three days, with the eastern region being the most affected—the same area that had already received over 6 inches earlier in August during the close passage of Tropical Storm Emily. The Río Grande de Manatí in Manatí recorded its third-highest level in history, surpassed only during Hurricane Hortense (1996) and Hurricane Georges (1998). The Puerto Nuevo River near Hato Rey reached its fourth-highest level on record. Flooding was severe enough to cause infrastructure stress and dangerous conditions across multiple municipalities. Tragically, there was one direct fatality attributed to Irene, due to drowning. |
| Puerto Rico Severe Storms, Flooding. Mudslides and Landslides | 5/20/2021 to 6/8/2021 | DR-4004-PR | Public Assistance - No | In May 2021, Puerto Rico experienced a series of intense rainfall events that caused flash flooding, river overflows, mudslides, and landslides, particularly in mountainous and interior regions. Although May is normally one of the wettest months of the year, several storm systems produced |

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| | | | Individual Assistance - No | short-duration but high-intensity rainfall, overwhelming local drainage systems and destabilizing steep terrain. |
| Sub-Tropical Storm Otto | 10/3/2010 to 10/8/2010 | DR-1946-PR | Public Assistance - No<br><br>Individual Assistance - No | An extensive rain band covered Puerto Rico while Otto moved as a distant tropical cyclone north of the Island (NOAA). This resulted in heavy and continuous rainfall that caused serious flooding.<br><br>(Eco Exploratorio). |
| Puerto Rico Severe Storms and Flooding | 5/26/2010 to 5/31/2010 | DR-1919-PR | Public Assistance - Yes<br><br>Individual Assistance - No | In May 2010, Puerto Rico was hit by a series of severe storms that produced torrential rainfall and widespread flooding across the island. Rainfall exceeded 12 inches in some areas, overwhelming drainage systems and causing rivers to overflow their banks. Low-lying communities and urban centers experienced significant inundation, with roads submerged and bridges damaged, isolating several municipalities. Flash floods swept through residential areas, forcing evacuations and leaving homes and businesses underwater. Landslides triggered by saturated soil compounded the crisis, blocking access routes and delaying emergency response efforts. The event resulted in extensive infrastructure damage and highlighted the island's |

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| | | | | vulnerability to prolonged heavy rain events during the wet season. |

In summary, between 2010 and 2025 there were a total of 13 major disaster declarations caused by flooding or events that had flood related damage. Of those, the municipality of Vega Alta was declared eligible for either Public Assistance or Individual Assistance in five instances.

#### 4.9.1.4 Special Considerations: Karst Formation

The karst formation in Puerto Rico is a limestone region that covers approximately 27.5% of the island's surface encompassing northern and southern limestone areas as well as scattered limestone outcrops throughout the island. The most pronounced karst topography occurs in found the northern limestone, known as the "karst belt," which spans approximately 142,544 hectares, or 65% of that region.

Tropical solution processes have shaped this belt into a landscape of mogotes, cone hills, sinkholes, blind valleys, caves, rugged canyon walls, and disappearing streams. These features were formed through the dissolution of Oligocene and Miocene limestone under tropical conditions (Lugo, et al., 2021) (PRPB, 2014). This terrain contains the island's largest freshwater aquifers, mature forests, wetlands, estuaries, and extensive cave systems, which are critical to Puerto Rico's hydrology and biodiversity. Its rugged topography and shallow soils have limited large scale agriculture and dense urban development, leaving much of the area relatively undisturbed. However, the karst region remains vulnerable to human activities such as vegetation clearing, wetland drainage, paving, groundwater extraction, and pollution. Such activities can destabilize the landscape and impair its essential ecological and hydrological functions (Lugo, et al., 2021) (PRPB, 2014).

The karst belt in northern Puerto Rico, part of which lies within the Municipality of Vega Alta, is a unique limestone landscape shaped by tropical solution processes. It is characterized by mogotes, sinkholes, caves, and underground aquifers. This region contains the island's largest freshwater reserves, supports mature forests, wetlands, and diverse ecosystems, and plays a critical role in maintaining water quality and biodiversity (Lugo, et al., 2021) (PRPB, 2014).

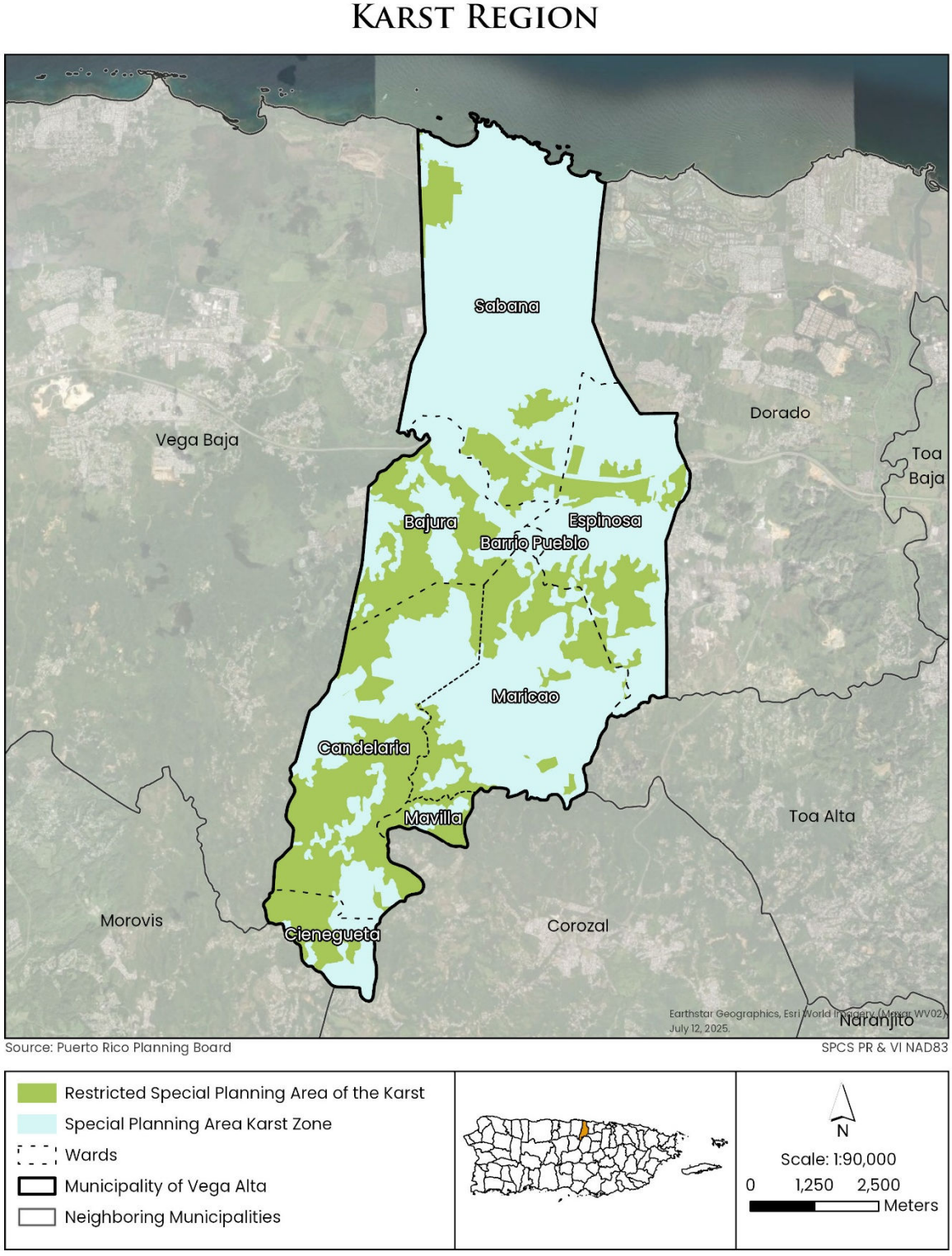
Economically and environmentally, the region reduces flood risks, sustains agriculture in surrounding areas, and offers recreational and tourism opportunities. Its rugged topography has limited intense urban development, preserving ecological integrity. However, the region remains vulnerable to deforestation, groundwater extraction, and pollution (Lugo, et al., 2021) (PRPB, 2014). According to Lugo, et al. protecting this region is essential for water security.

The Municipality of Vega Alta is located almost entirely within Puerto Rico's Northern Karst Region, with designated Karst Special Planning Areas extending across all municipal wards as shown on Map 34. The most extensive concentrations of restricted karst lands are found in the southern and central portions of the municipality, particularly within the wards of Cienegueta, Candelaria, Maricao, Bajura, and Espinosa. Smaller karst areas are also present in Sabana Ward. This widespread distribution of karst features reflects the municipality's underlying limestone geology, characterized by sinkholes, depressions, underground drainage systems, and highly permeable soils.

From a hazard mitigation perspective, the interaction between karst terrain and flooding presents unique challenges. While karst systems can facilitate infiltration and subsurface drainage under normal conditions, intense rainfall events associated with tropical storms and hurricanes can exceed the capacity of these natural systems, resulting in ponding, localized flooding, and the activation of closed depressions. These conditions may be further exacerbated where urban development and roadway infrastructure have altered natural drainage patterns.

Particular attention should be given to karst areas located near the Cibuco River watershed and its associated flood-prone lowlands. Several communities and developed areas within Bajura, Espinosa, Pueblo, and portions of Maricao are situated near zones where watershed flooding and karst-related drainage limitations may interact. During extreme precipitation events, floodwaters originating from the Cibuco River basin can accumulate in low-lying areas underlain by karst formations, potentially prolonging inundation and complicating stormwater conveyance. As more frequent and intense rainfall events tend to prevail, these areas may experience increased flood exposure and greater stress on existing drainage infrastructure.

*Map 34: Vega Alta: Karst Formation*



The presence of extensive karst resources therefore represents both an environmental asset and a planning consideration for hazard mitigation. Future resilience efforts should continue to evaluate the relationship between flood hazards, watershed dynamics, groundwater conditions, and land development patterns within the municipality's karst zones to reduce risks to nearby residents, infrastructure, and critical facilities.

#### 4.9.1.5 Special Consideration: Floods by Stormwater Management Deficiencies

Urban drainage systems — whether natural or constructed — are designed to convey surface water runoff to receive water bodies. When storm drains, channels, or swales become obstructed, insufficient or overwhelmed by heavy rainfall and expanding urbanization, they can overflow and flood surrounding areas. As a result, floodwaters may spread beyond FEMA's mapped floodplains, even entering zones typically considered low or moderate risk (e.g., Zones B, C, or X) (FEMA, Reducing Damage from Localized Flooding, 2025).

Puerto Rico's stormwater runoff is conditioned by the island's climate, topography and land cover. Annual rainfall varies from less than 1,000 millimeters (mm) to over 4,000 mm (40 to 157 inches). The island's watersheds are largely mountainous, with steep slopes, and stream valleys are typically narrow and well-incised. Intense but short-duration storms are common, leading to rapid flooding with peak discharges that can be several orders of magnitude higher than base flows. All of Puerto Rico's watersheds have experienced significant alterations. It is estimated that more than 11% of the island is covered by developed surfaces, within areas reaching up to 40% in regions such as the San Juan Metropolitan Area. These changes have significantly modified stormwater drainage patterns and downstream floodwater levels (FEMA, 2024).

Paved surfaces severely limit the infiltration of rainwater, increasing both the volume and velocity of surface runoff. As a result, storm drains can easily become overwhelmed. In addition, runoff from paved surfaces reaches streams and rivers much faster, exceeding their capacity to convey water and causing higher and more frequent flood levels in adjacent areas. Moreover, contaminants from both point and non-point pollution sources are more likely to reach surface water bodies when transported by runoff over paved surfaces instead of being partially or totally degraded by vegetated soils. Higher flows also have a greater capacity to remove and transport soil and other loose materials from streambanks and riverbeds, facilitating erosion and scouring (FEMA, 2024).

Paradoxically, river flow between rain events tend to decrease after urbanization. Paved surfaces act as a barrier that isolates the soil, preventing the infiltration of rainwater that otherwise would have gradually discharged from the ground and into streams days later, a process that is critical for maintaining base flows for riparian fish and wildlife species, but also to sustain public water supply. In response, various hard infrastructure measures (hard infrastructure measures such as flood-control pump stations, concrete trapezoidal channels, and curved side gutters have been widely implemented across Puerto Rico.  While effective at quickly conveying runoff, these structures often neglect ecological, social, cultural, and aesthetic considerations. These practices often involve significant operation and maintenance costs and, in many instances, can exacerbate downstream erosion, scouring and water quality problems.

A more sustainable approach would be to take advantage of the ecological services that green areas and other nature-based solutions to manage runoff flows and improve water quality. Such strategies are increasingly critical to protect communities from the growing water-related impacts of climate change in Puerto Rico (FEMA, 2024).

#### *4.9.1.6 Future Event Probabilities (B1-e)*

A sustained increase in the frequency of extreme rainfall events has been identified in recent decades. As stated above, the Island of Puerto Rico has had 13 flood – related flood major disaster declaration in the last fifteen years. This means that the average frequency of a flooding event is approximately every 14 months.

Any mitigation action adopted to reduce the effects of flooding in the Municipality of Vega Alta must consider, for example, that 100-year return events or those with a 1% annual probability could become 50-year return events or have a 2% annual probability in the future. This means that flood events of a certain magnitude and impact on the municipality may increase, particularly in high-risk areas. Though there are many floods control projects in Vega Alta, the probability of future events is considered high.

### 4.9.2 Risk Analysis (B2-a, B2-b)

#### *4.9.2.1 Estimated Loses*

Flooding represents one of the most significant natural hazards affecting Vega Alta due to the concentration of development along riverine corridors, low-lying areas, and the municipality's northern coastal plain. According to FEMA National Risk Index data, approximately 0.29 square miles of the municipality are exposed to flood hazards, encompassing an estimated 1,827 residents and approximately $189.5 million in exposed building value. The total exposed value, including population equivalency, is estimated at $21.38 billion (Table 17).

*Table 18: Flood Exposure*

| Exposure - Impacted Area (sq mi) | Exposure - Building Value | Exposure - Population | Exposure - Population Equivalence | Exposure - Total |
|---|---|---|---|---|
| .289142 | $189,512,065.41 | 1,827 | $21,194,406,489.59 | $21,383,918,534.01 |

*Source: FEMA NRI*

While Table 18 presents the expected annual flood related losses for both buildings and population.

*Table 19: Expected Annual Loss to Flood*

| Expected Annual Loss - Building Value | Expected Annual Loss - Population | Expected Annual Loss - Population Equivalence | Expected Annual Loss -Total |
|---|---|---|---|
| $5,001,782.53 | 0.0279 | $323,117.20 | $5,324,899.74 |

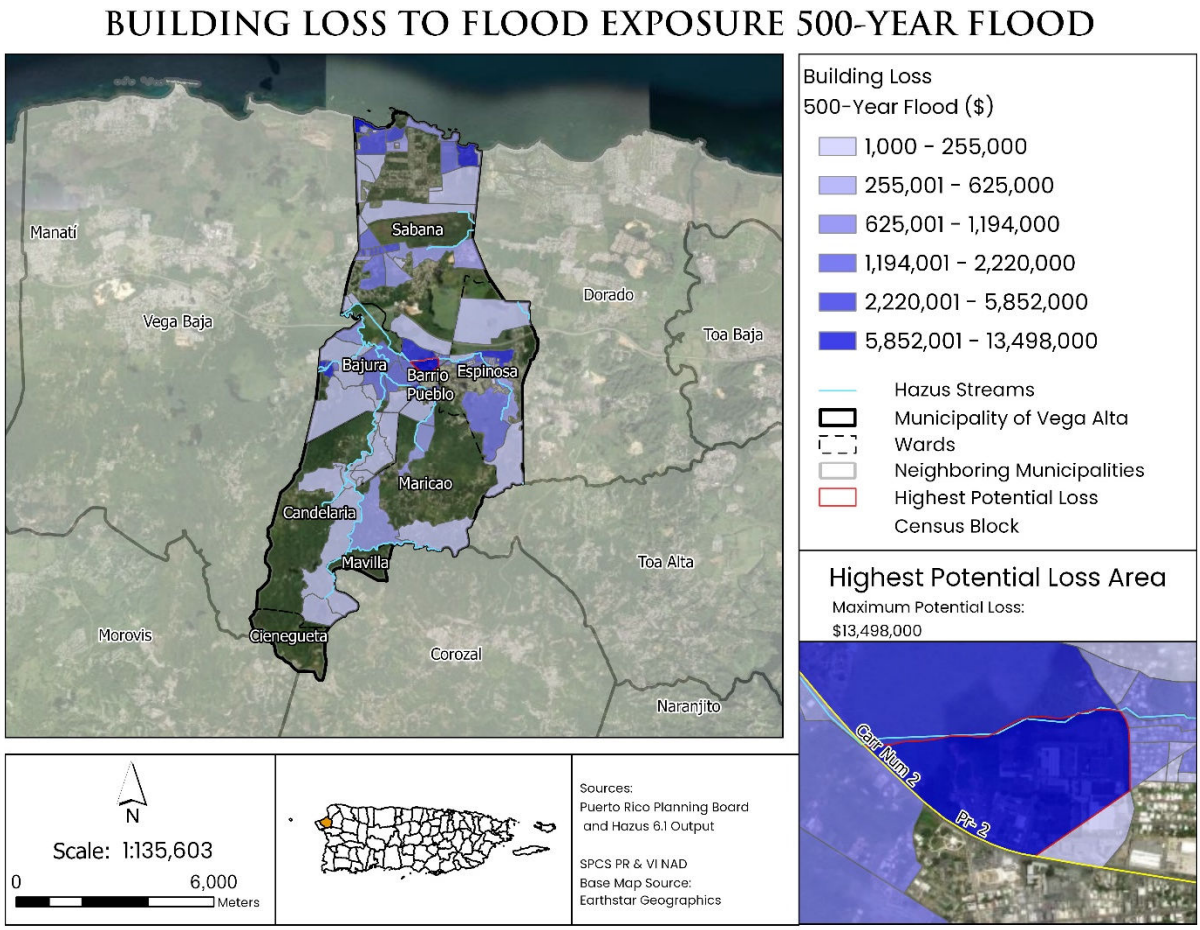
*Source: FEMA NRI*

Hazus flood-loss modeling estimates that approximately 16,249 structures are exposed to flood risk in Vega Alta, including 16,230 residential structures and 19 nonresidential structures (Table 19). Expected annual flood losses are estimated at approximately $5.3 million, reflecting the recurring nature of flood-related damages within the municipality.

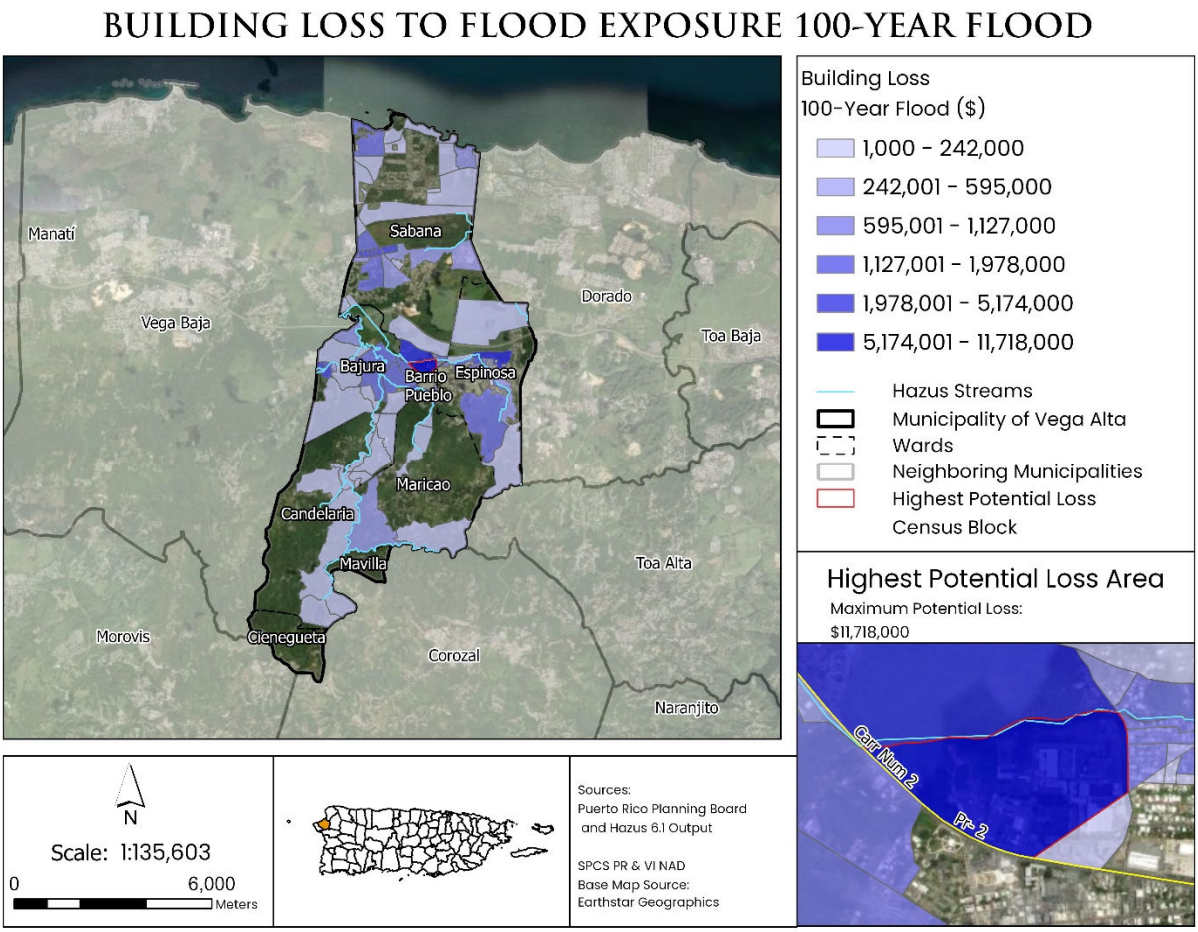
The spatial distribution of potential losses indicates that the greatest flood-related building damages are concentrated within the municipality's developed central and northern sectors, particularly along stream corridors in Barrio Pueblo, Bajura, Espinosa, and Sabana (Map 35). The highest potential-loss census block identified by the Hazus

analysis is located near the PR-2 corridor in the Barrio Pueblo area, where estimated building losses reach approximately $11.7 million during the 1-percent annual chance (100-year, Map 36) flood event and $13.5 million during the 0.2-percent annual chance (500-year, Map 35) flood event. These elevated losses reflect the concentration of residential, governmental, transportation, and community assets located within flood-prone areas.

*Map 35: Building Loss to Flood Exposure 500 – year flood*



*Map 36: building Loss to Flood Exposure 100-year*




For the 100-year flood event, total projected losses are estimated at approximately $66.5 million, including $51.9 million in residential losses and $14.5 million in nonresidential losses (Table 20). Under the more severe 500-year flood event, total losses increased to approximately $99.2 million, with residential losses accounting for approximately $82.2 million and non-residential losses reaching approximately $17.1 million. Residential properties account for the majority of expected damages under both scenarios, representing more than three-quarters of total projected losses.

For the 100-year flood event, total projected losses are estimated at approximately $66.5 million, including $51.9 million in residential losses and $14.5 million in nonresidential losses. Under the more severe 500-year flood event, total losses increased to approximately $99.2 million, with residential losses accounting for approximately $82.2 million and non-residential losses reaching approximately $17.1 million. Residential properties account for most expected damages under both scenarios, representing more than three-quarters of total projected losses.

*Table 20: Total Structures at Risk*

| Structures | |
|---|---|
| Non-Residential | 19 |
| Residential | 16,230 |
| Total | **16,249** |

*Table 21: Aggregated Loss of dollars for 1% (100-year) and 0.2% (500 - year) events*

| Occupancy Type | Losses in Dollars. 1% Event | Losses in Dollars. 0.2% Event |
|---|---|---|
| Non-Residential | $14,511,000 | $17,068,000 |
| Residential | $51,945,000 | $82,174,000 |
| **Total** | **$66,456,000** | **$99,242,000** |

*able 22: Detailed Loss for Non-Residential Buildings*

| Occupancy | Losses in Dollars, 1% Event | Losses in Dollars, 0.2% Event |
|---|---|---|
| Commercial | $0 | 0$ |
| Education | $5,800,000 | $6,883,000 |
| Government | $8,711,000 | $10,185,000 |
| Religious | $0 | $0 |
| Agriculture | $0 | $0 |
| Industrial | $0 | $0 |
| **Total** | **$14,511,000** | **$17,068,000** |

*Table 23: Detailed Loss for Residential Buildings*

| Residential, Detailed Losses | Losses in Dollars, 1% Event | Losses in Dollars, 0.2% Event |
|---|---|---|
| Structure | $17,943,000 | $32,254,000 |
| Contents | $9,686,000 | $17,893,000 |
| Relocation | $16,974,000 | $22,112,000 |
| Rental Income | $7,420,000 | $9,993,000 |
| **Total** | **$52,023,000** | **$82,252,000** |

Overall, the flood-loss assessment demonstrates that Vega Alta faces substantial economic risk from both frequent and extreme flood events, with impacts concentrated in developed areas adjacent to streams and floodplains. The predominance of residential losses, combined with the potential effects on government and educational facilities, underscores the importance of continued floodplain management, drainage improvements, infrastructure resilience measures, and mitigation actions aimed at reducing future flood-related damages throughout the municipality.

#### 4.9.2.2 Lifelines and Critical Infrastructure

Flooding is among the most disruptive natural hazards, affecting all eight FEMA Community Lifelines. These lifelines represent essential services that support public health, safety, and economic stability. Below is an analysis of some of the impacts that flooding can have on lifelines:

- Safety and Security - Flooding can damage emergency services infrastructure such as police stations, fire departments, and emergency operations centers. Blocked evacuation routes and submerged roads hinder rescue efforts, while prolonged outages increase vulnerability to crime and civil unrest.

- Food, Water, Shelter - Floodwaters can contaminate drinking water supplies and damage water treatment facilities. Food supply chains may be severely disrupted when warehouses and grocery stores are flooded. Damage to residential structures can result in displacement, creating urgent demand for temporary shelters.

- Health and Medical - Hospitals and clinics may become inaccessible or experience power outages during flood events. Flood conditions can contribute to increased incidence of waterborne diseases and mold-related illnesses increase significantly. Disruptions to medical supply chains may delay both emergency care and routine treatments.
- Energy (Power and Fuel) - Flooding can submerge electrical substations and transformers, causing widespread outages. Fuel distribution networks may be disrupted due to impassable roads and damaged transportation routes. Prolonged power loss can significantly affect critical facilities such as hospitals and water treatment plants.
- Communications – Flooding can damage cell towers, fiber-optic cables, and emergency communication systems, reducing the capacity to coordinate

rescue and recovery operations. This disruption can delay the dissemination of critical information.

- Transportation- Flooding can wash out or undermine roads, bridges, and rail lines, rendering them impassable. Airports and seaports may be forced to suspend operations, delay evacuation and the delivery of emergency supplies. Also, transportation disruptions amplify the overall impact of the disaster.

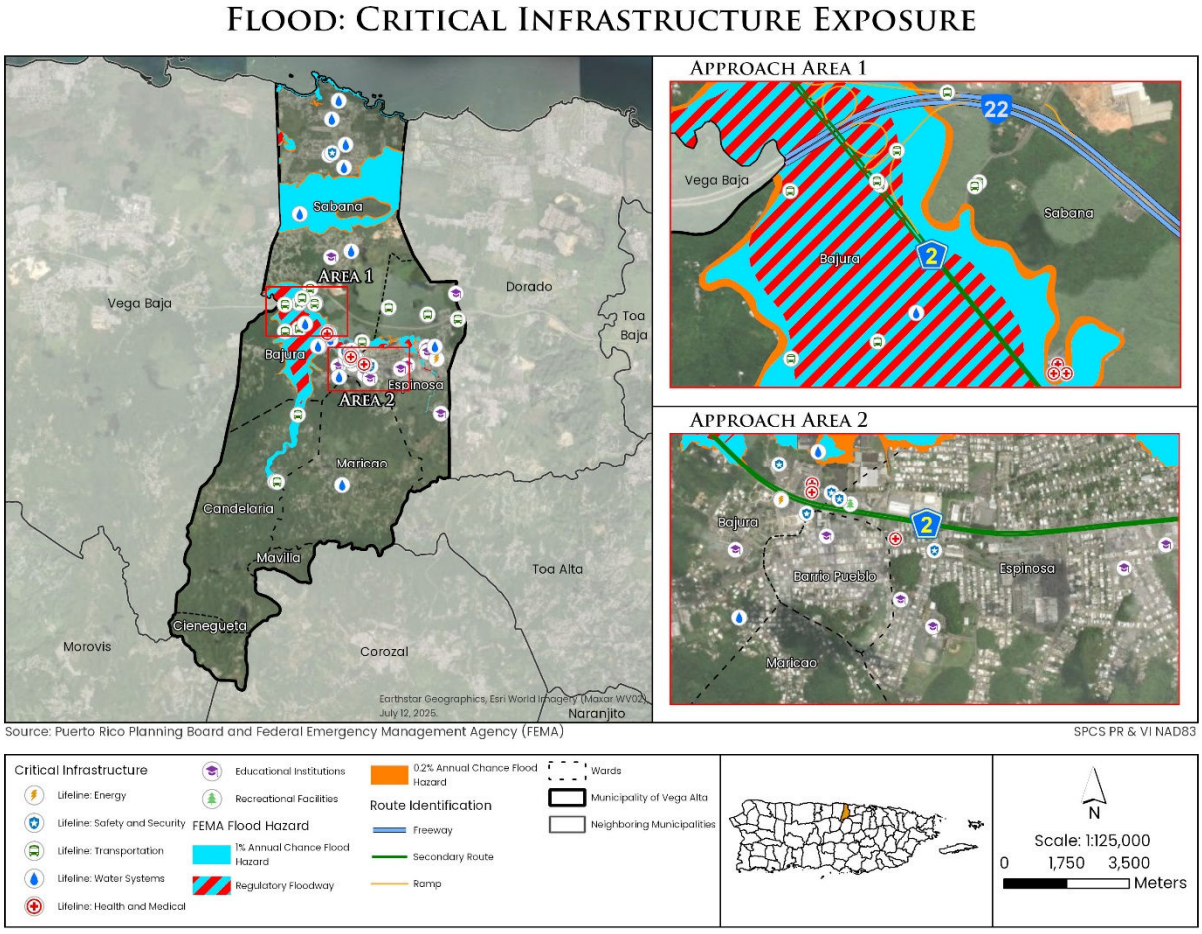
- Hazardous Materials - Floodwaters can mobilize and disperse hazardous substances from industrial sites, sewage systems, and fuel storage tanks, increasing the risk of environmental contamination. Cleanup efforts can become complex, costly and time-consuming, potentially resulting in long-term public and environmental impacts.

- Water Systems - Floodwaters can contaminate drinking water supplies and damage water treatment facilities. Excessive inflow from floodwaters may overwhelm sewer systems, causing untreated sewage to backflow into streets and homes. Flood conditions can exceed the design capacity of storm drains and retention basins, resulting in urban flooding and infrastructure damage. The accumulation of sediment and debris clog drainage systems, reducing effectiveness and increasing flood risk during subsequent storms events.

Map 37 shows the location of the critical facilities in relation to the flood zones.

The flood exposure analysis indicates that the highest concentration of vulnerable critical infrastructure is located within the Sabana-Bajura corridor and the Pueblo-Espinosa urban area. Water system facilities, transportation infrastructure, healthcare facilities, and public safety assets are exposed to both the 1% annual chance flood hazard area and, in some cases, the regulatory floodway. Flooding within these areas has the potential to disrupt multiple FEMA Community Lifelines simultaneously, affecting emergency response capabilities, utility services, transportation access, and public health functions. As a result, protection of critical infrastructure within the northern floodplain and along the Cibuco River corridor should remain a priority for future mitigation planning and investment.

*Map 37: Flood Critical Facilities Exposure 500 yrs flood*




Approach Area 1 represents one of the municipality's most vulnerable flood exposure clusters. The analysis shows multiple transportation facilities, water system infrastructure, and healthcare facilities located within or adjacent to the regulatory floodway and 1% annual chance floodplain.

Particularly noteworthy is the exposure of facilities along the PR-2 transportation corridor and associated secondary roadway network, which serves as a critical east-west transportation route connecting Vega Alta with neighboring municipalities. Flooding within this area could impede emergency response operations, restrict evacuation movements, and limit access to critical services. Several transportation-related assets appear to be situated immediately adjacent to the floodway, increasing susceptibility to inundation during major flood events.

The concentration of water infrastructure within this area further increases vulnerability because flood-related damage could compromise water delivery systems serving both residents and businesses.

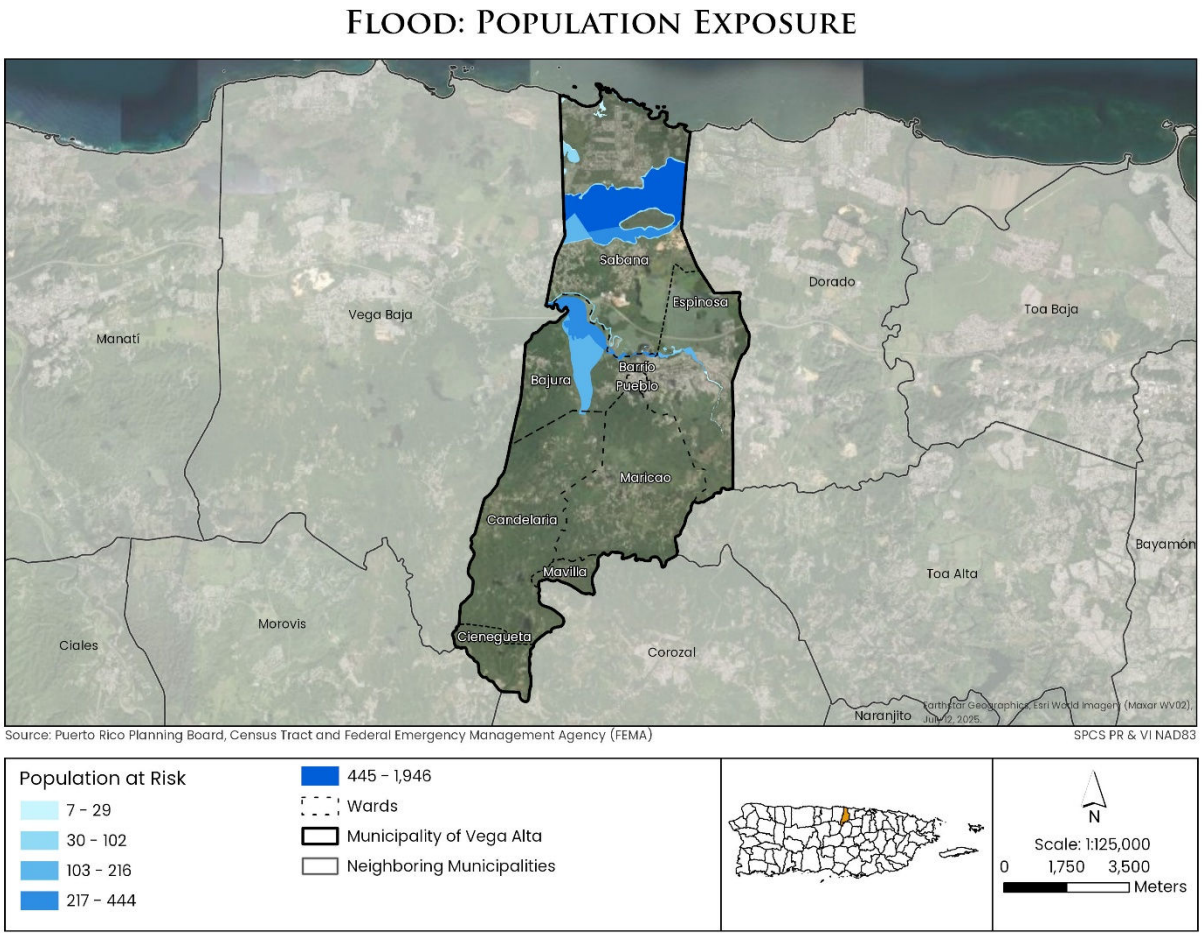
#### 4.9.2.3 Social Vulnerabilities

The 500-year flood population exposure analysis indicates that flood risk is not uniformly distributed throughout Vega Alta (Map 37). The highest concentrations of potentially affected residents are located in the northern portion of the municipality, particularly within Sabana Ward and portions of Bajura, Barrio Pueblo, and Espinosa. The mapped exposure areas include census blocks with estimated at-risk populations ranging from fewer than 30 residents to nearly 2,000 residents per block, demonstrating that both low-density and relatively concentrated residential areas may be affected by extreme flooding events.

Population exposure is influenced by the municipality's settlement pattern, with many residential areas concentrated within low-lying portions of the coastal plain and along drainage corridors associated with the Cibuco River watershed. Flood vulnerability is further shaped by Vega Alta's extensive karst landscape, where intense rainfall can overwhelm natural subsurface drainage systems, resulting in localized ponding, prolonged inundation, and increased flood depths in depressional areas. As a result, flood hazards have the potential to affect residents through direct property damage, restricted access to transportation routes, temporary displacement, and disruptions to essential services.

The overlap between populated areas, flood-prone lands, and karst terrain highlights the importance of implementing flood mitigation measures, preserving natural drainage functions, and directing future development away from areas with documented flood exposure. These considerations are particularly relevant as more frequent and intense precipitation events may increase future flood risk throughout the municipality.

*Map 38: Flood: Population Exposure 500 yrs event*




### 4.9.2.4 Natural and Cultural Resources

In most flood events, water resources are exposed to high levels of contaminants associated with rising water, sewage accumulation, and other hazardous or toxic substances left behind by flooding (Malilay, 2000). This contamination can facilitate the spread of diseases in municipal water bodies and adversely affect local flora and fauna, including humans. For example, prolonged stagnant water after a flood can promote diseases such as dengue and leptospirosis. Following Hurricane María, stagnant water contributed to leptospirosis outbreaks and mosquito proliferation. Leptospirosis is a bacterial disease that affects both humans and animals and can spread through urine from infected animals. These contaminated residues often remain in stagnant water after flooding events.

Floods also lead to the accumulation of debris, including structural remnants, soil, sediments, organic waste, and personal belongings. If not properly managed, this

debris can contaminate land and water when burned, abandoned, buried, or dumped into water bodies.

#### 4.9.2.5 Special Consideration: Repetitive Losses and Severe Repetitive Losses

In Vega Alta there are properties insured under the National Flood Insurance Program (NFIP). These properties participate in the NFIP covered by the PRPB. Section 6.5 provides further details on how the municipality can use the NFIP as a mechanism for mitigation planning.

The Municipality has included properties that have experienced repetitive losses and/or severe repetitive losses located in identified flood hazard areas. These properties currently lack descriptions of the type of structures (residential, commercial, institutional, among others). Including this information helps to understand the vulnerability of properties affected by flooding within the jurisdiction and increases the likelihood of qualifying for flood control or prevention grants through programs such as Flood Mitigation Assistance (FMA), Hazard Mitigation Grant Program (HMGP), Housing and Urban Development (HUD), CDBG-DR, and others.

As of December 2025, the information regarding NFIP coverage for the Municipality of Vega Alta are as follow:

*Table 24: NFIP Policies in force and coverage*

| Amount of NFIP Policies | Total Disbursement for both RL and SRL Losses |
|---|---|
| 110 | $71,242 |

This information includes properties covered by the NFIP that have experienced repetitive losses (RL) and/or severe repetitive losses (SRL) located in identified flood hazard areas.

*Table 25: NFIP Repetitive Losses*

| Structures with Repetitive Loses (RL) | Insured structures (RL) | Total Repetitive Losses (RL) |
|---|---|---|
| 4 | 0 | 9 |

*Table 26: NFIP Severe Repetitive Losses*

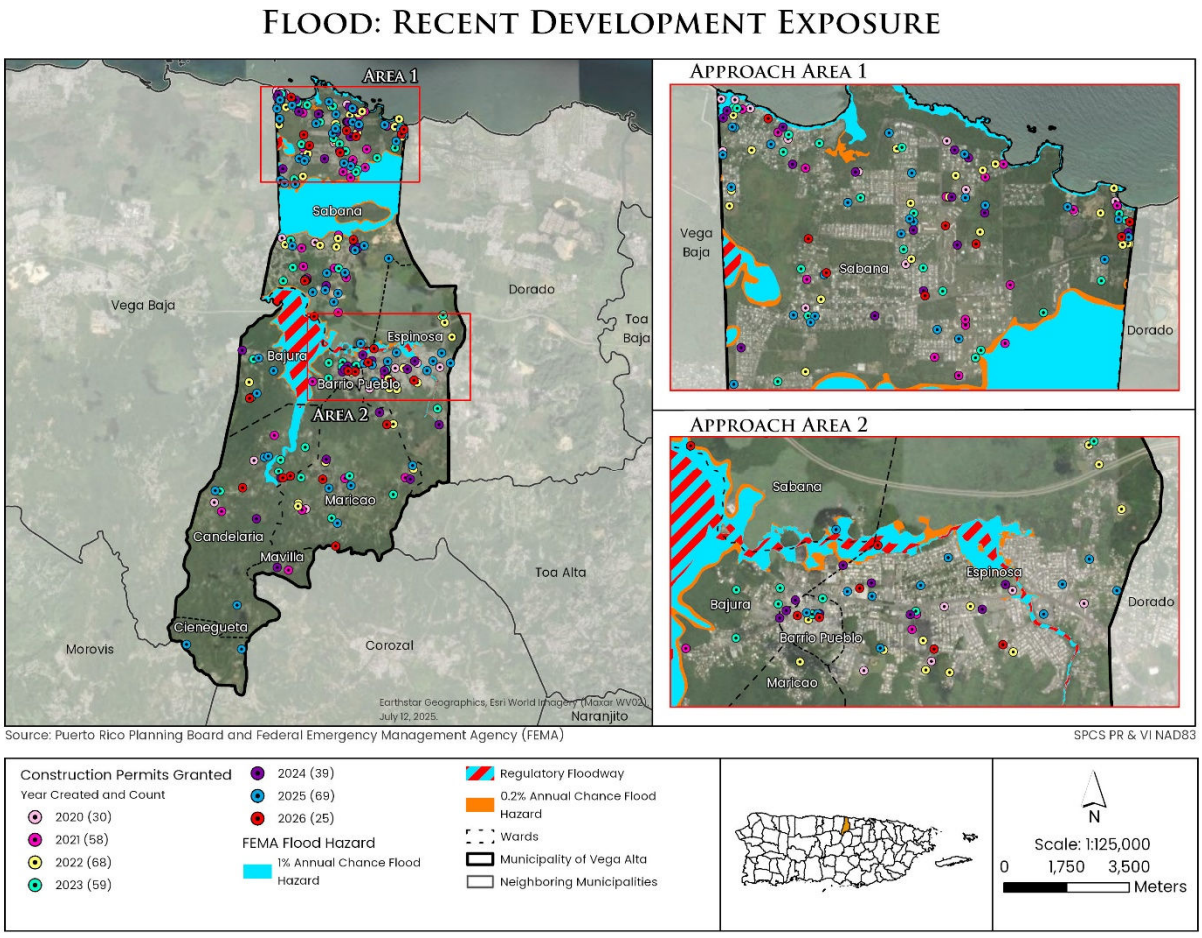
| Structures with Severe Repetitive Loses (SRL) | Insured structures S(RL) | Total Repetitive Losses (SRL) |
|---|---|---|
| 0 | 0 | 0 |

#### 4.9.2.6 Future Conditions (E1-a)

Recent development exposure analysis indicates that a portion of construction permits issued between 2020 and 2026 are located within or adjacent to FEMA Special Flood Hazard Areas (SFHAs), including both the 1-percent and 0.2-percent annual chance floodplains. The most significant concentration of exposed development is located in northern Vega Alta, particularly within Sabana, Bajura, Barrio Pueblo, and Espinosa wards, where flood hazard areas coincide with established and expanding urbanized areas. Development occurring near regulatory floodways is of particular concern because these areas are subject to greater flood depths, velocities, and potential infrastructure impacts during major flood events.

As development continues to grow in these areas, the number and value of assets exposed to flooding may increase. The interaction of floodplain conditions, coastal influences, watershed flooding, and the municipality's karst physiography further contributes to flood susceptibility and may exacerbate localized flooding during extreme precipitation events. These findings support the continued application of floodplain management requirements, hazard-informed land use planning, and mitigation actions aimed at reducing future development within vulnerable areas.

*Map 39: Recent Development and Flood Risks*




## 4.10 TROPICAL CYCLONES AND OTHER EXTREME WIND EVENTS

### 4.10.1 DESCRIPTION (B1-A)

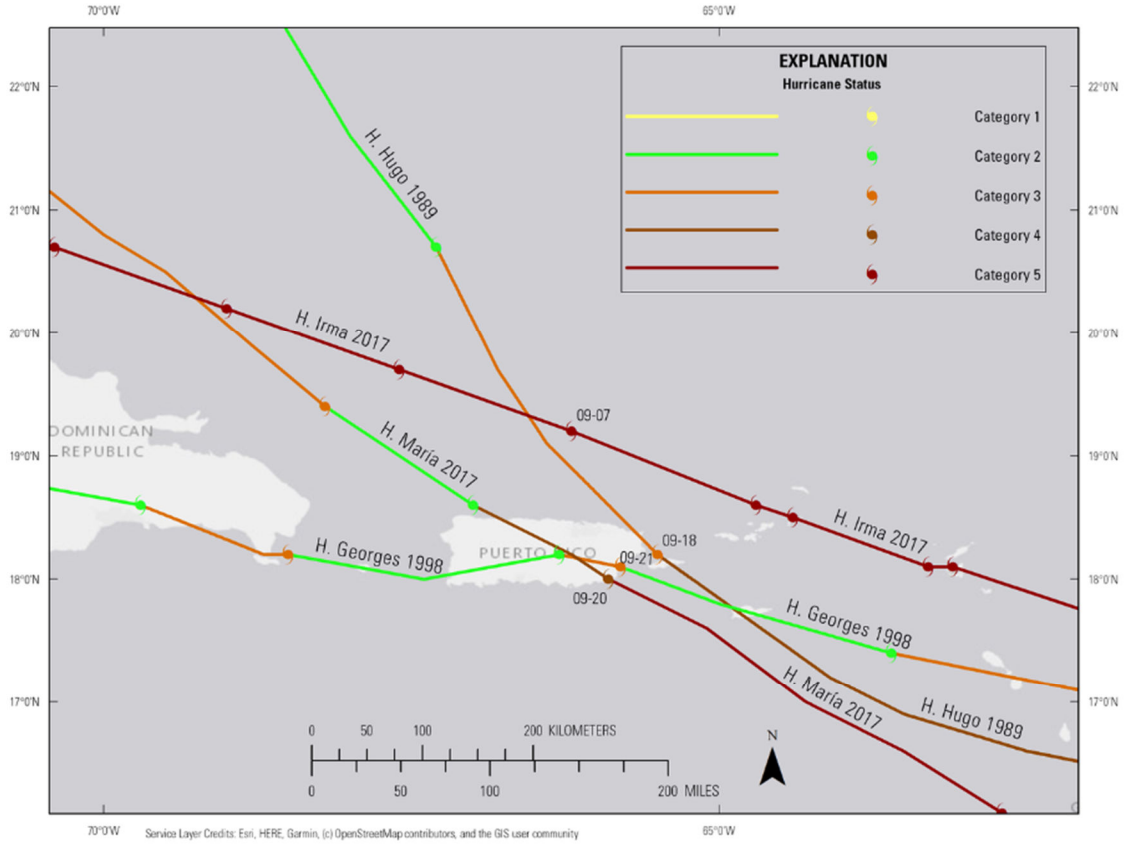
Winds consist of air currents generated in the atmosphere due to variations in pressure. Although these currents are constantly present, when their intensity increases, they can become a high-level hazard. For the purposes of this Plan, we will focus on events severe wind events associated with tropical cyclones and their extreme force(Castro Rivera & López Marrero, Cartilla de los Ciclones, 2018).

This sub-chapter is titled Tropical Cyclones and other Extreme wind Events in order to include phenomena such as tropical storms and tropical depressions. However, hurricanes pose the greatest threat due to their high destructive potential, wide geographic impact, rapid development, and sometimes unpredictable paths. In addition, hurricanes are often accompanied by high tides, storm surges, and heavy rainfall, which may result in landslides and riverine flooding. Since these

accompanying hazards are addressed in separate sections, this section will focus specifically on the impact of wind within the municipality.

Figure 22 shows the path of category 2 – 5 hurricanes that have affected Puerto Rico since 1989.[11]

*Figure 21: Hurricane Tracks 1989-2017 (only Cat 2-5)*[12]




*Sources/Usage: Public Domain.* View Media Details

***Figure 1.*** *Hurricane tracks for Hugo (1898), Georges (1998), Irma (2017) and Maria (2017). Data provided by NOAA. Base image is intellectual property of Esri and is used herein under license. Copyright Esri and its creator.*

***Figura 1:*** *Trayectorias de los huracanes Hugo (1989), Georges (1998), Irma (2017) y María (2017). Datos provistos por la NOAA. La imagen de base es propiedad intelectual de Esri y se usa aquí bajo licencia. Los derechos de autor y reproducción son propiedad de Esri y sus licenciatarios.*

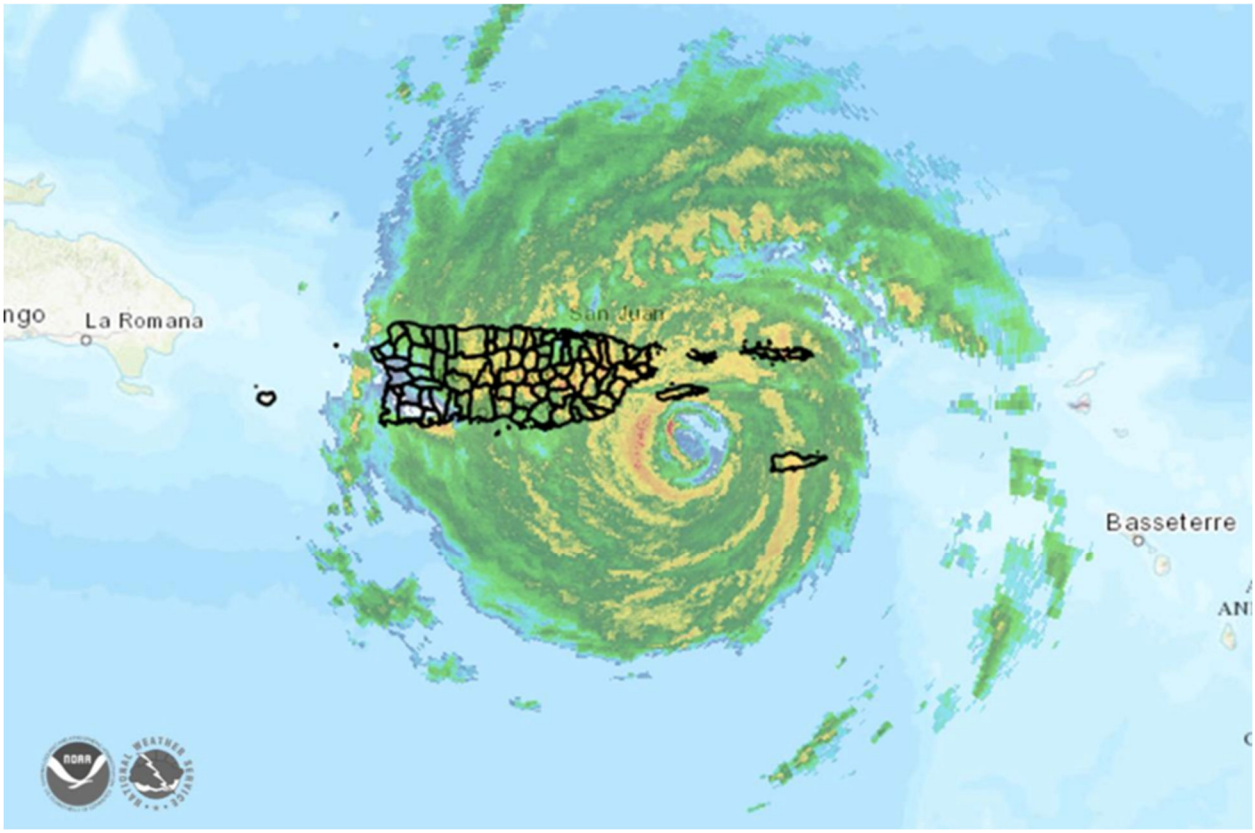
[11] Hortense (1996) and Fiona (2022) are not shown since they were category 1 hurricanes when they hit Puerto Rico.

[12] htt.s://www.usgs/gov/mission-areas/natural-hazards/science/Puerto-rico-natural-hazards-hurricanes-peligros-naturales-de

### 4.10.1.1 Affected Area (B1-b)

Tropical Cyclones are atmospheric systems that can affect the whole island. For example, Figure 23 shows the size of hurricane María (2017) as it approached Puerto Rico.

*Figure 22: Hurricane María (2017) as it approaches Puerto Rico*




### 4.10.1.2 Risk Magnitude (B1-c)

Tropical cyclones are the most frequent natural hazard in Puerto Rico, with hurricanes being the most dangerous. Hurricanes are tropical atmospheric systems characterized by sustained wind speeds exceeding seventy-four (74) miles per hour. They develop over warm ocean waters and result from instability caused by the interaction of warm and cool air masses. Tropical cyclones are classified according to sustained wind intensity as follows:

- Tropical Depression: An organized system of clouds with a defined circulation and maximum sustained winds below 39 mph. This represents the formative stage of a tropical cyclone.

- Tropical Storm: An organized system of clouds with a defined circulation and maximum sustained winds ranging from 39 to 73 mph.
- Hurricane: The most intense form of a tropical cyclone, with sustained winds of 74 mph or greater. Hurricanes have a well-defined center with very low barometric pressure. They are categorized from one (I) to five (V), and the strongest can reach wind speeds exceeding 155 mph (Castro Rivera & López Marrero, 2018).

Table 26 shows the Saffir - Simpson Scale of hurricanes and gives historical examples of those passing through or near Puerto Rico.

*Table 27: Saffir-Simpson Hurricane Scale*

| Category | Wind Speed | Description | Historical Example |
|---|---|---|---|
| Tropical Storm | 39 – 73 mph | Strong enough to cause tree damage, power outages, and localized flooding, but generally less destructive than a hurricane. | Eloise (1975)<br>Claudette (1979)<br>Frederic (1979)<br>Jeanne (2004)<br>Irene (2011)<br>Isaias (2020)<br>Ernesto (2024) |
| 1 | 74–95 mph | Winds can cause minor damage to roofs, siding, and trees, with potential for power outages. | Santa Clara[13] (1956)<br>Hortense (1996)<br>Fiona (2022) |
| 2 | 96–110 mph | Strong winds can cause extensive damage to roofs and trees, leading to widespread power loss. | Marilyn (1995) |
| 3 | 111–129 mph | Devastating winds can destroy roofs and walls of homes, uproot trees, and cause prolonged outages. | Hugo (1989)<br>Georges (1998) |
| 4 | 130–156 mph | Catastrophic winds can cause severe structural damage, most trees snapped or uprooted, and power outages lasting weeks. | San Ciriaco (1899)<br>San Ciprian (1932)<br>Donna (1960)<br>David (1979)<br>María (2017) |
| 5 | 157 mph or higher | Catastrophic winds can result in total roof failure and building collapse, | San Felipe II (1928)<br>Irma (2017) |

[13] Officially known as Hurricane Betsy

| Category | Wind Speed | Description | Historical Example |
|---|---|---|---|
| | | rendering areas uninhabitable for weeks or months. | |

To assess the vulnerability posed by hurricanes, this LHMP utilizes the 100 – year wind event and 500-year wind event as benchmark design standards. A 100-year wind event refers to a wind speed that has a 1% chance of being equaled or exceeded in any given year. Similarly, a 500-year wind event has a 0.2% annual probability of being equaled or exceeded. These terms describe statistical return periods and do not imply that such events occur only once every 100 or 500 years. Rather, they express the likelihood of occurrence in any single year. Wind returns period values are derived through statistical analysis of historical wind speed records using extreme value probability models. These analyses estimate wind intensities associated with specific recurrence intervals and are widely applied in engineering, insurance modeling, and hazard mitigation planning.

These values are critical for structural design standards like the American Society of Civil Engineers Standard 7 (ASCE 7), which specify wind loads for different risk categories, and for insurance companies assessing potential storm damage. For example, typical 3-second gust wind speeds at 33 ft above ground (Exposure Category C) are about 100 mph for a 100-year event and approximately 110–115 mph for a 500-year event. These design speeds ensure safety for buildings, bridges, and critical infrastructure, and help guide emergency planning and financial risk management.

#### *4.10.1.3 Past Events (B1-D)*

The following table shows the extreme wind events that received a disaster declaration since 2004. One column identifies whether the Municipality of Vega Alta was designated for Public Assistance (PA), Individual Assistance (IA), or both under each declaration.

*Table 28: Tropical Storm Disaster Declaration*

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| Tropical Storm Ernesto | 8/13/2024 to 8/16/2024 | DR-4850-PR | Public Assistance (Categories (A-G)– Yes<br><br>Public Assistance Yes<br><br>Individual Assistance (Category B)- No | The storm's slow movement and moisture-rich environment contributed to prolonged precipitation, particularly in central and eastern municipalities. Parts of Central Puerto Rico recorded 12–14 inches of rainfall in localized areas.<br><br>Multiple rivers exceeded their banks, including the La Plata River, resulting in significant inundation of adjacent communities. Flash flooding occurred in urban and rural areas, rendering primary and secondary roads impassable. Floodwater caused structural failures in bridges and washed-out critical road segments, isolating several communities. Stormwater drainage systems in metropolitan areas, notably San Juan, were overwhelmed, leading to localized urban flooding.<br><br>Emergency Response and Disruptions<br><br>Evacuations were conducted in flood-prone areas such as Toa Baja to mitigate loss of life. |

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| Hurricane Fiona | 9/17/2022 to 9/21/2022 | DR-4671-PR | Public Assistance – Yes<br><br>Individual Assistance - Yes | Hurricane Fiona struck Puerto Rico in September 2022, unleashing torrential rains—up to 31.22 inches of rainfall over 72 hours in Ponce, nearly matching the accumulation from Hurricane María. This deluge led to catastrophic flooding, with 7 to 20 inches common across most of the island and localized spots exceeding 30 inches. |
| Tropical Storm Isaías | 9/29/2020 to 9/30/2020 | DR-4560-PR | Public Assistance - No<br><br>Individual Assistance - No | Although the center of Tropical Storm Isaías did not make landfall on the island, the system left a large amount of rain in its path, causing flooding throughout Puerto Rico. Rainfall accumulation of up to 10 inches was recorded around the island. |

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| Hurricane María | 9/20/2017 | DR-4339-PR | Public Assistance – Yes<br><br>Individual Assistance - Yes | Widespread flooding severely affected the whole Island. For example, in San Juan, water levels reached up to 6 feet in some areas and numerous structures losing their roofs. The coastal neighborhood of La Perla was largely destroyed, while Cataño suffered extensive damage, with the Juana Matos community estimated to be 80% destroyed. Strong winds, heavy rains, and flash floods near the La Plata Lake dam in Toa Baja impacted thousands of residents. Survivors reported that floodwater rose 6 feet in just 30 minutes, and some areas experienced depths of up to 15 feet (4.6 m). |
| Hurricane Irma | 9/5/2017 | DR-4336-PR | Public Assistance – No<br><br>Individual Assistance - No | On September 5, 2017, Hurricane Irma impacted Puerto Rico; an Emergency Declaration was issued for the Island. On September 6, 2017, a Major Disaster Declaration was issued following Hurricane Irma's passage.<br><br>Two people died due to torrential rains before the hurricane: a man died in Orocovis after falling from his ladder while repairing his roof; another man on the coast in Capitanejo died after being struck by lightning. Wave heights in Puerto Rico reached 9 meters, and sustained winds of 111 mph were recorded in Culebra. |

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| Tropical Storm María[14] | 9/8/2011 to 9/11/2011 | DR-4040-PR | Public Assistance: No<br><br>Individual Assistance: No | Tropical Storm (later Hurricane) María formed in early September 2011 and passed near Puerto Rico, bringing significant heavy rainfall and tropical storm conditions to the island. The storm caused widespread flooding that inundated numerous roadways and homes; floodwaters near Patillas destroyed several homes and bridges, and approximately 150 houses in Yabucoa were flooded and damaged |
| Hurricane Irene | 8/22/2011 | DR-4017-PR | Public Assistance: Yes<br><br>Individual Assistance: No | Total rainfall reached 22 inches over three days, with the eastern region being the most affected—the same area that had already received over 6 inches earlier in August during the close passage of Tropical Storm Emily. The Río Grande de Manatí in Manatí recorded its third-highest level in history, surpassed only during Hurricane Hortense (1996) and Hurricane Georges (1998). The Puerto Nuevo River near Hato Rey reached its fourth-highest level on record. Flooding was severe enough to cause infrastructure stress and dangerous conditions across multiple municipalities. Tragically, there was one direct fatality attributed to Irene, due to drowning. |

[14] Tropical Storm María was a tropical system that pass to the northeast of Puerto Rico in 2011 and that caused flooding in the Island. Not to be confused with the 2017 Hurricane María. The name "María" was retired from the official Atlantic hurricane season list of names after 2017.

| Event | Date | Disaster Declaration Number | Vega Alta Included? | Description |
|---|---|---|---|---|
| Tropical Storm Jeanne | 9/14/2004 to 9/19/2004 | DR-1152-PR | Public Assistance: Yes<br><br>Individual Assistance Yes | Tropical Storm Jeanne crossed Puerto Rico on September 15, 2004, as a strong tropical storm with maximum sustained winds around 70 mph (110 km/h), producing gusts up to 72 mph (≈116 km/h). The winds caused widespread power and water outages, with numerous reports of structural damage to homes, uprooted trees, fallen utility poles, and significant impacts on infrastructure across the island.<br><br>The storm resulted in eight fatalities in Puerto Rico—four direct and four indirect, including deaths during preparations and carbon monoxide poisoning. Damages were estimated at approximately $169.5 million (2004 USD), making Jeanne the most destructive tropical cyclone to impact Puerto Rico since Hurricane Georges in 1998. |

#### *4.10.1.4 Future event probabilities (B1-e)*

According to the Colorado State University Tropical Cyclones, Radar, Atmospheric Modeling and Software Team, the following average annual probabilities apply for storms coming ashore or passing within 50 miles of Puerto Rico: (Colorado State University, 2026)

- Average probability of a named storm coming ashore or within 50 miles of Puerto Rico: **40%**
- Average probability of a hurricane coming ashore or within 50 miles of Puerto Rico: **24%**
- Average probability of a major hurricane coming ashore or within 50 miles of Puerto Rico: **9%**

### 4.10.2 Risk Analysis (B2-a, B2-b)

#### *4.10.2.1 Estimated Losses*

Tropical cyclones represent one of the most significant natural hazards affecting the Municipality of Vega Alta due to its location along Puerto Rico's northern coast and its exposure to hurricane-force winds, heavy rainfall, flooding, and storm surge impacts. Historical events such as Hurricanes Irma and María demonstrated the municipality's vulnerability to widespread structural damage, infrastructure disruption, and economic losses.

According to the FEMA National Risk Index (NRI), tropical cyclones have the potential to affect approximately 28.07 square miles of the municipality, exposing an estimated 35,353 residents and approximately $4.14 billion in building assets. When population exposure is converted into economic terms, the total exposed value within the municipality reaches approximately $414.2 billion, highlighting the substantial concentration of people and assets vulnerable to hurricane-related impacts.

Table 30 presents the exposure to tropical cyclones as registered in FEMA National Risk Index.

*Table 29: Tropical Cyclone Exposure*

| Exposure - Impacted Area (sq mi) | Exposure - Building Value (in 000) | Exposure - Population | Exposure - Population Equivalence (in 000) | Exposure – Total (in 000) |
|---|---|---|---|---|
| 28.07 | $ 4,141,229 | 35,353 | $410,091,722 | $414,232,950 |

*Source FEMA NRI*

The expected annual loss for each Census tract or jurisdiction represents the average yearly economic impact, expressed in dollars, anticipated from natural hazard events. Table 31 presents the expected annual hurricane-related losses for both buildings and population.

*Table 30: Expected Annual Loss to Tropical Cyclones*

| Expected Annual Loss - Building Value | Expected Annual Loss - Population | Expected Annual Loss - Population Equivalence | Expected Annual Loss -Total |
|---|---|---|---|
| $17,107,371.90 | 0.0588 | $681,590.11 | $17,788,962.01 |

*Source FEMA NRI*

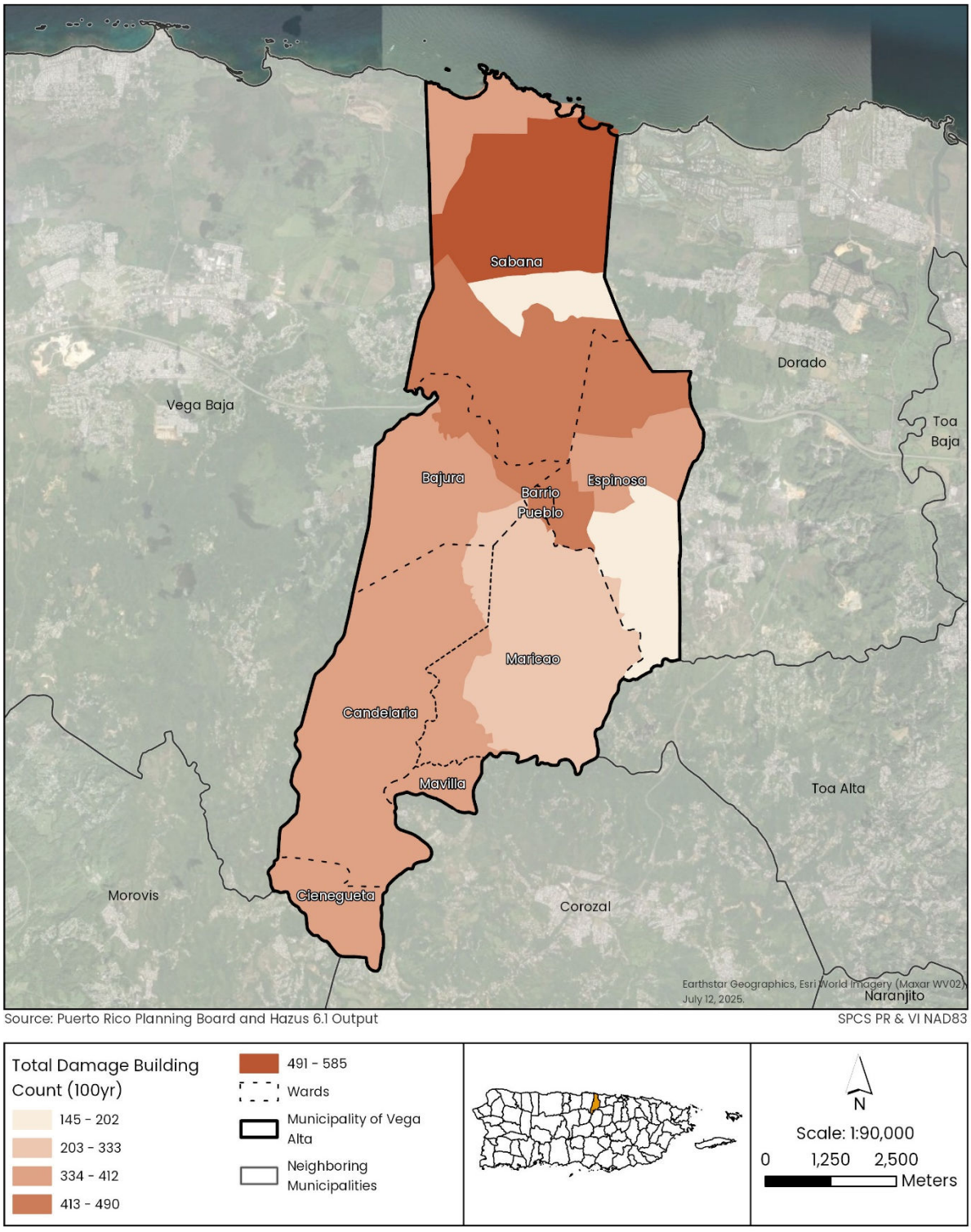
HAZUS 6.1 modeling further illustrates the potential for significant structural damage throughout the municipality. The 100-year tropical cyclone event shows widespread impacts across all wards, with estimated damaged buildings ranging from approximately 145 to 585 structures per ward (Map 40). The highest concentrations of damaged buildings are projected in the northern and central portions of the municipality, particularly in Sabana, Bajura, Barrio Pueblo, and Espinosa, where higher development densities increase exposure to hurricane winds and associated hazards.

Under the more severe 500-year tropical cyclone event, estimated damaged buildings increase substantially, ranging from approximately 239 to 748 structures per ward. The greatest building losses continue to be concentrated within the northern and central wards, particularly Bajura, Sabana, Espinosa, and Barrio Pueblo, which exhibit the highest damage classes on the HAZUS maps. These areas contain significant residential, commercial, and public infrastructure assets that could experience extensive damage during a severe hurricane event.

The spatial distribution of projected damages indicates that while all wards within Vega Alta are susceptible to tropical cyclone impacts, the northern coastal and more densely developed sectors present the greatest concentrations of exposed structures. The southern wards, including Candelaria, Maricao, Mavilla, and Cienegueta, also exhibit notable damage potential, although projected losses are generally lower than those observed in the municipality's northern urbanized areas.
The results of the FEMA NRI and HAZUS analyses demonstrate that tropical cyclones remain a high-risk hazard for Vega Alta due to the municipality's substantial building inventory, population exposure, and coastal location.

*Map 40: Total Damaged Buildings 100 – Year Event*

## Tropical Cyclone: Total Damaged Buildings 100-Year Event

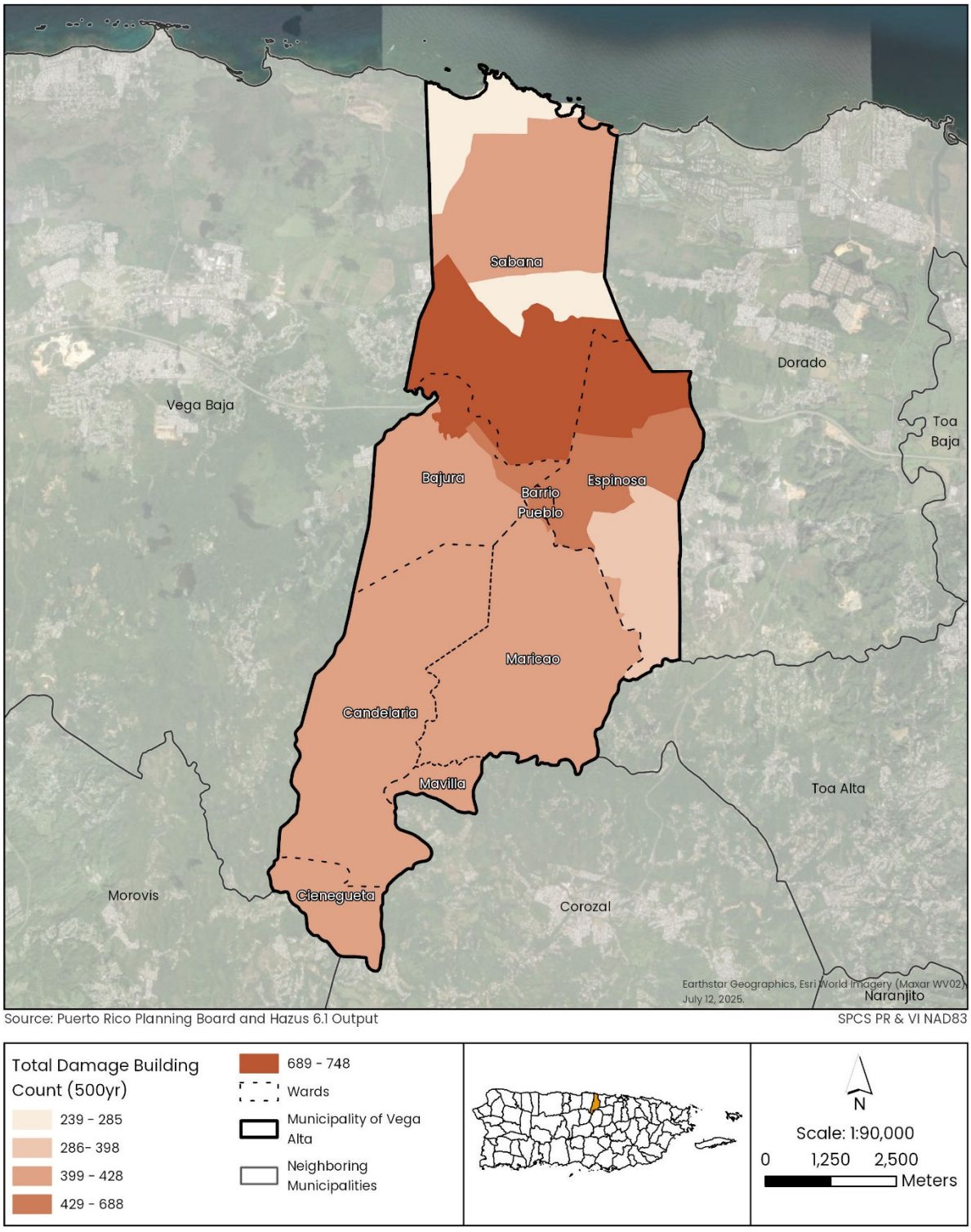



Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83

*Map 41: Total Damaged Building 500 - Year Event*

## Tropical Cyclone: Total Damaged Buildings 500-Year Event




Source: Puerto Rico Planning Board and Hazus 6.1 Output

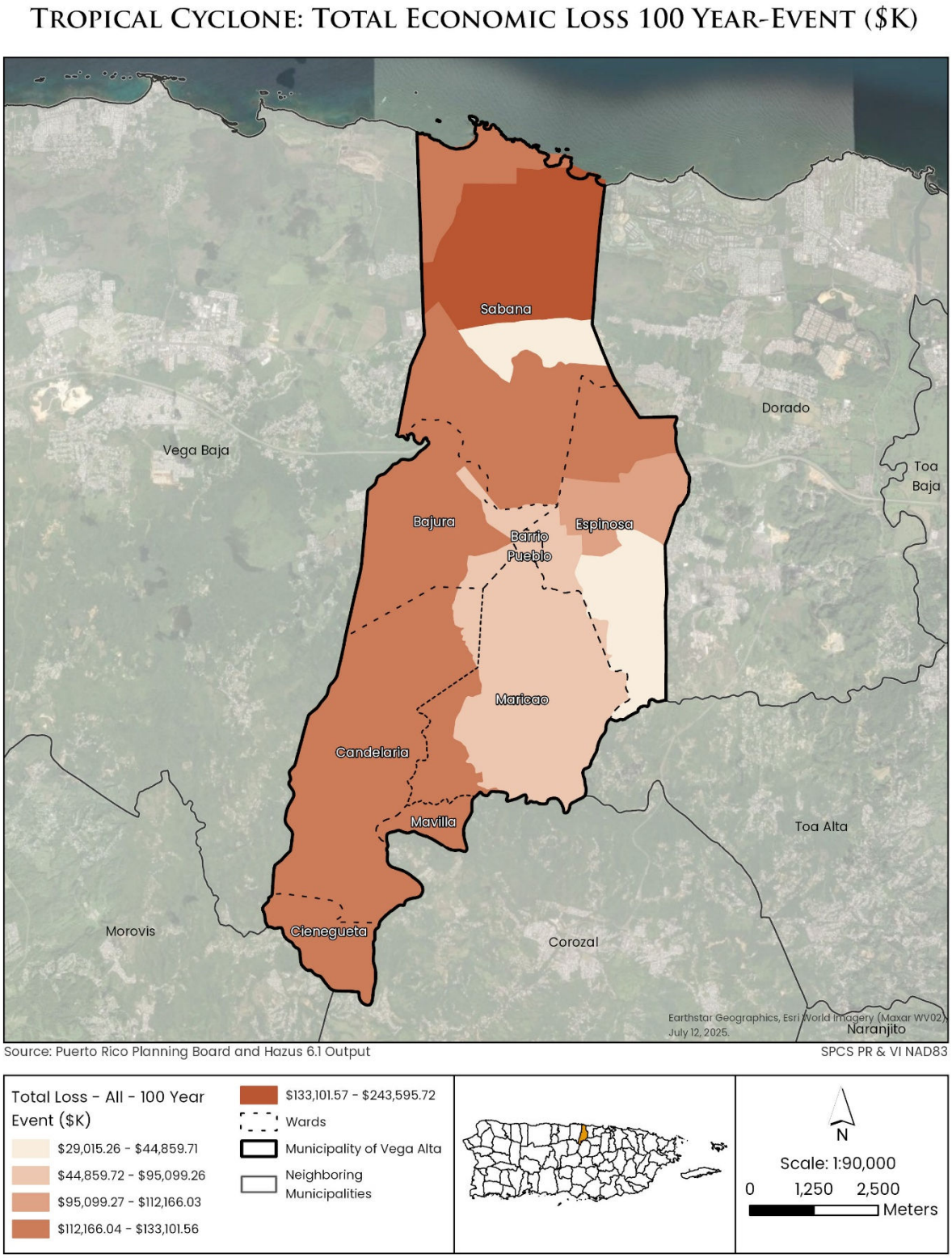
SPCS PR & VI NAD83

Hazus results indicate that tropical cyclones could cause significant economic losses throughout Vega Alta under both the 100-year and 500-year event scenarios (Maps 42 and 43). The highest losses are consistently concentrated in Sabana Ward, with estimated losses increasing from approximately $133 million to $244 million under the 100-year event to $320 million to $489 million under the 500-year event. Most remaining wards are projected to experience moderate to high losses, reflecting the widespread distribution of residential, commercial, and public assets throughout the municipality. The results suggest that northern Vega Alta, where development density is greatest, is particularly vulnerable to tropical cyclone impacts and should remain a priority area for mitigation and resilience initiatives.

Under the 100-year event scenario, the greatest economic losses are projected within Sabana Ward, where estimated losses range between approximately $133 million and $244 million. Moderate losses are also projected in Bajura, Candelaria, Cienegueta, and portions of Espinosa, reflecting the concentration of residential, commercial, and public assets located within these areas. Lower estimated losses are observed in portions of Maricao and eastern Espinosa, where development intensity is generally lower.

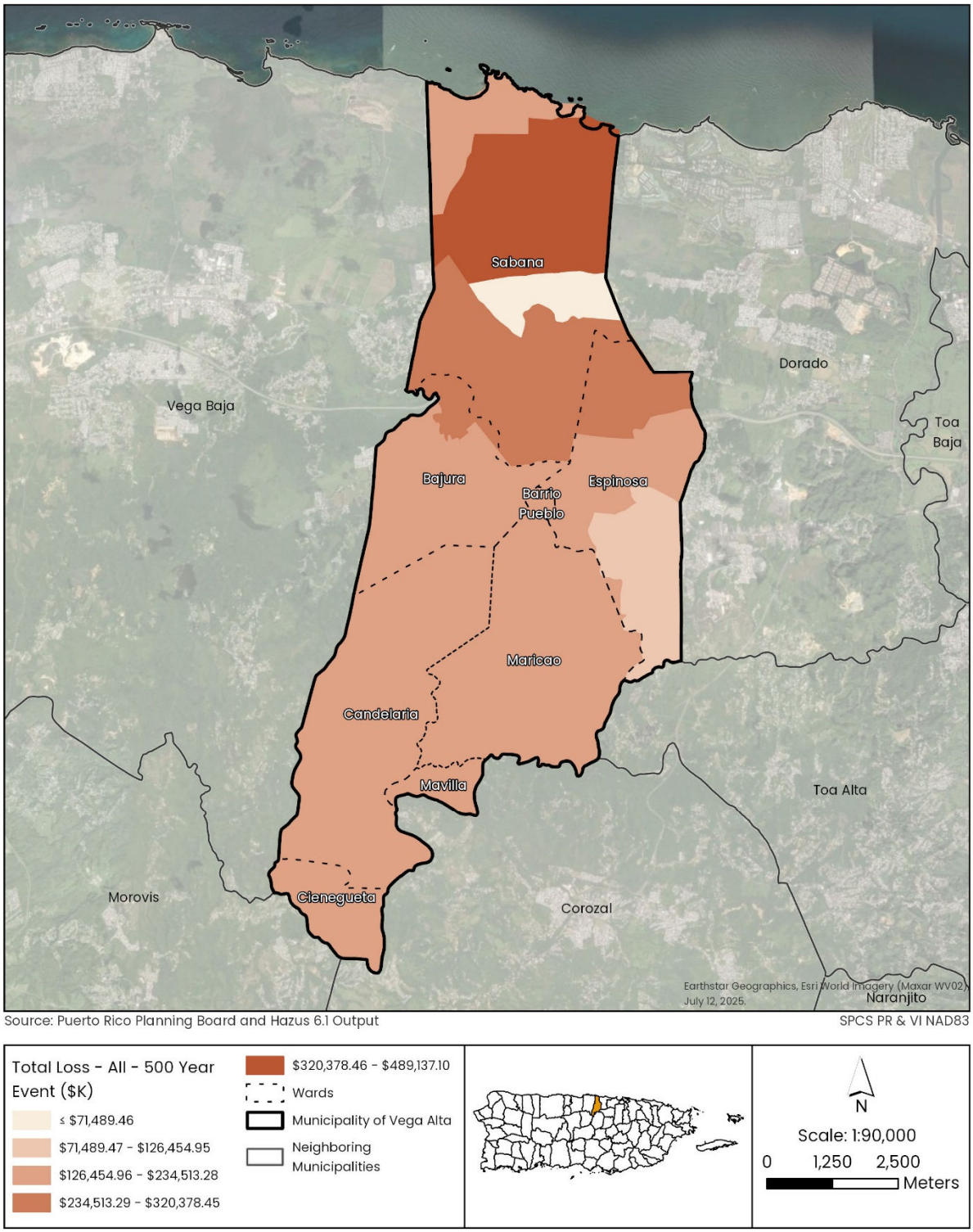
Under the more severe 500-year event scenario, projected losses increase substantially throughout the municipality. Sabana continues to exhibit the highest estimated losses, reaching approximately $320 million to $489 million, while most other wards experience losses ranging from approximately $126 million to $320 million. The increase in losses between the two scenarios reflects the greater extent and severity of tropical cyclone impacts, including stronger winds, increased rainfall, and associated damage to structures, infrastructure, and economic activity.

*Map 42: Total Economic Loss 100 – Year Event*



*Map 43: Total Economic Loss 500 - Year Event*

## Tropical Cyclone: Total Economic Loss 500 Year-Event ($K)




Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83

### 4.10.2.2 Lifelines and Critical Infrastructure

Hurricane winds have profound effects on all eight FEMA Community Lifelines, disrupting essential services and infrastructure.

- Safety and Security systems are compromised when high winds damage police stations, fire departments, and emergency operations centers, while debris and fallen power lines obstruct emergency routes, delaying rescue efforts.
- Food, Hydration, and Shelter lifelines suffer as winds destroy agricultural fields, damage food storage facilities, and tear roofs off homes and shelters, leaving communities vulnerable and displacing thousands.
- In the Health and Medicine sector, hospitals and clinics experience roof failures and structural damage, forcing evacuations and interrupting critical care, while pharmacies and supply chains face severe disruptions.
- The Energy lifeline is particularly vulnerable, as hurricane winds topple transmission towers, snap utility poles, and damage substations, causing widespread power outages that cascade into other lifelines.
- Communications systems fail when telecommunication towers and antennas are blown down, severing cellular and internet connectivity and hindering emergency coordination.
- Transportation networks are crippled by blocked roads, damaged bridges, and wind-related destruction at airports and seaports, delaying relief efforts and supply deliveries.
- Facilities handling Hazardous Materials face increased risks when wind-driven debris ruptures tanks or pipelines, creating environmental hazards and complicating cleanup operations.
- Finally, Water Systems are disrupted as treatment plants and pumping stations sustain roof and equipment damage, while elevated storage tanks and distribution infrastructure collapse, interrupting access to clean water for drinking and sanitation. These cascading failures underscore the critical need for wind-resistant design standards and proactive planning to protect lifelines and maintain community resilience during hurricane events.

For planning purposes this LHMP shall assume that all critical infrastructure is equally exposed to this hazard.

### 4.10.2.3 Social Vulnerabilities

As discussed before in Section 4.6.1.1 a tropical cyclone can impact the whole island. For this LHMP we are going to assume that all the population of Vega Alta is vulnerable

to this hazard. For further details on the Municipality's social vulnerability see section 3.4.4.

#### 4.10.2.4 Natural and Cultural Resources

Hurricane winds caused extensive damage to both natural and cultural resources by exerting extreme mechanical forces on landscapes and built environments. In natural settings, strong winds uproot trees, strip foliage, and break branches, leading to deforestation and habitat loss. This disruption affects biodiversity and can alter ecosystem functions for years. Coastal vegetation such as mangroves is particularly vulnerable, as wind-driven forces weaken root systems and reduce their ability to protect shorelines. Agricultural areas also suffer severe losses, with crops flattened or destroyed, impacting food supply and local economies.

Cultural resources, including historic buildings, monuments, and archaeological sites, are equally at risk from hurricane winds. High wind speeds can dislodge roofing materials, collapse walls, and damage structural integrity, especially in older or unreinforced constructions. Museums, archives, and heritage sites may experience irreparable harm if protective measures are inadequate. The loss of these cultural assets not only affects community identity but also has economic implications for tourism and preservation efforts. Understanding wind speed thresholds and incorporating them into design standards and conservation planning is essential to mitigate these risks and safeguard both natural and cultural heritage.

#### 4.10.2.5 Future Conditions (E1-a)

The risk of hurricane is a municipal – wide risk. Every part of the recent development approved by the municipality is equally in risk of being affected by a tropical cyclone.

## 4.11 Storm Surge

### 4.11.1 Description

A storm surge is the inland movement of seawater that occurs when a hurricane makes a direct impact on the coast. These storm surges occur due to an atypical increase in the water levels of water bodies. Primarily, storm surges are produced by an excessive rise in water along coastlines as a consequence of a massive low-pressure system, rainfall, and strong winds, characteristic of a hurricane or tropical storm (Castro Rivera & López Marrero, 2018).

These factors, inherent to a storm surge, create dangerous conditions at sea and cause extensive devastation after passing through coastal areas. Consequently, this type of natural hazard results in loss of life and severe damage to infrastructure and structures located in the affected areas. They are particularly dangerous when they occur during high tide, combined with the effects of swells and wave action. These factors make it difficult to predict this type of event because they depend on the diversity of tropical systems, the geological formations of the impacted area, and meteorological forecasts (FEMA, 1997).

The maximum potential storm surge for a particular location depends on a series of different factors. Storm surge is a very complex phenomenon because it is sensitive to even slight changes in storm intensity, forward speed, size (radius of maximum winds—RMW), angle of approach to the coast, central pressure (which contributes minimally compared to wind), and the shape of coastal features such as bays and estuaries.

Coastal areas are usually prone to storm surge impacts when an imminent hurricane threat is present. The behavior, magnitude, and impact of storm surge over land vary depending on the hurricane's trajectory. Likewise, the topography and coastal bathymetry of the municipality play an important role in relation to the impact of the surge on affected areas (FEMA, 1997).

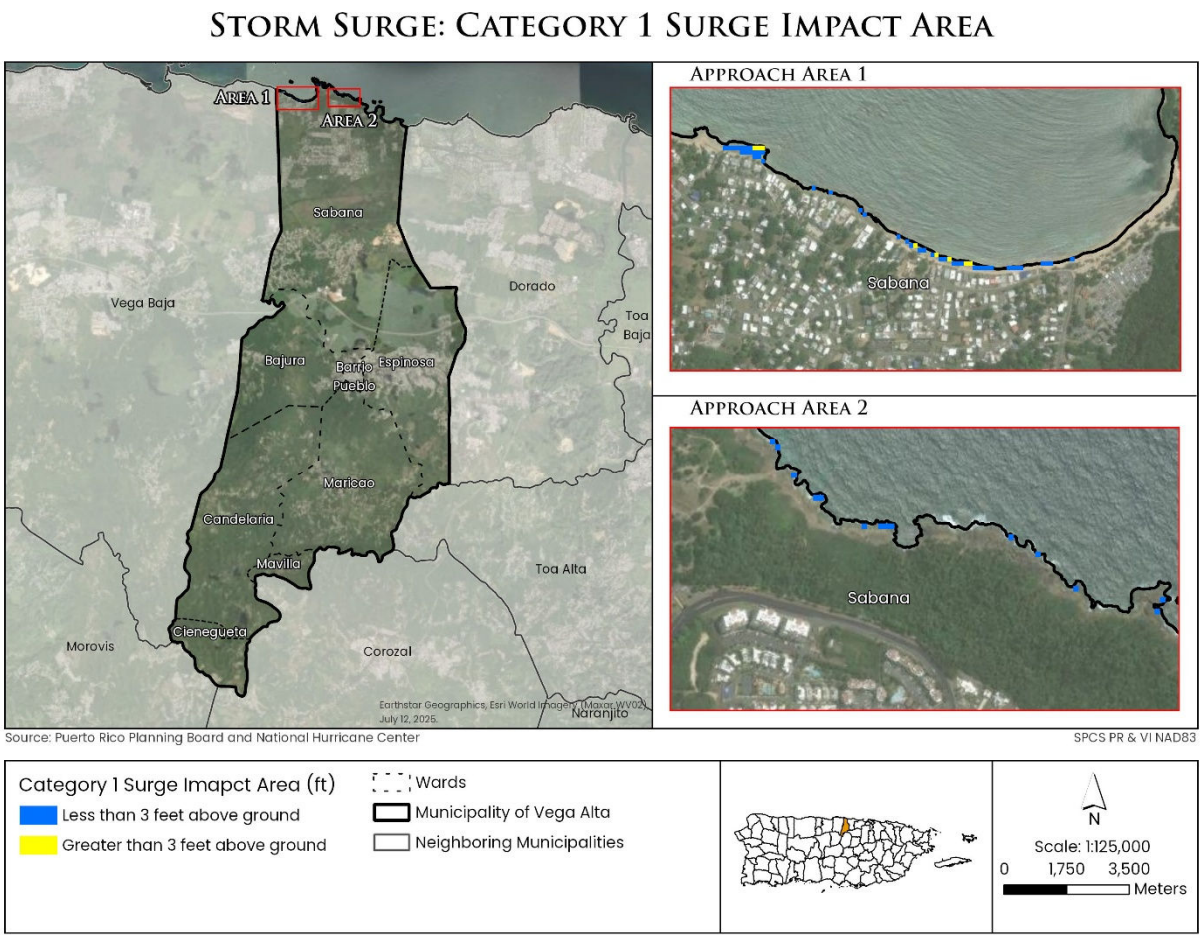
#### *4.11.1.1 Affected Area*

Storm surge exposure in Vega Alta is primarily concentrated along the northern coastline within Sabana Ward. Category 1 hurricane scenarios indicate limited inundation confined mainly to shoreline areas, while Category 5 scenarios result in substantially greater inland flooding affecting developed residential areas and critical coastal infrastructure (Maps 44 and 45). The most vulnerable areas are characterized by low elevations and proximity to the coast, where storm surge may penetrate through natural drainage corridors and depressional areas. These findings indicate that coastal neighborhoods, transportation facilities, and utility systems located within Sabana face the greatest storm surge risk and should remain a priority for mitigation, emergency preparedness, and resilience planning efforts.

The areas identified in Approach Areas 1 and 2 demonstrate how storm surge can extend inland through low-elevation coastal terrain and natural drainage pathways. These conditions increase the potential for direct impacts to residential structures, transportation infrastructure, and public services. The risk may be compounded when

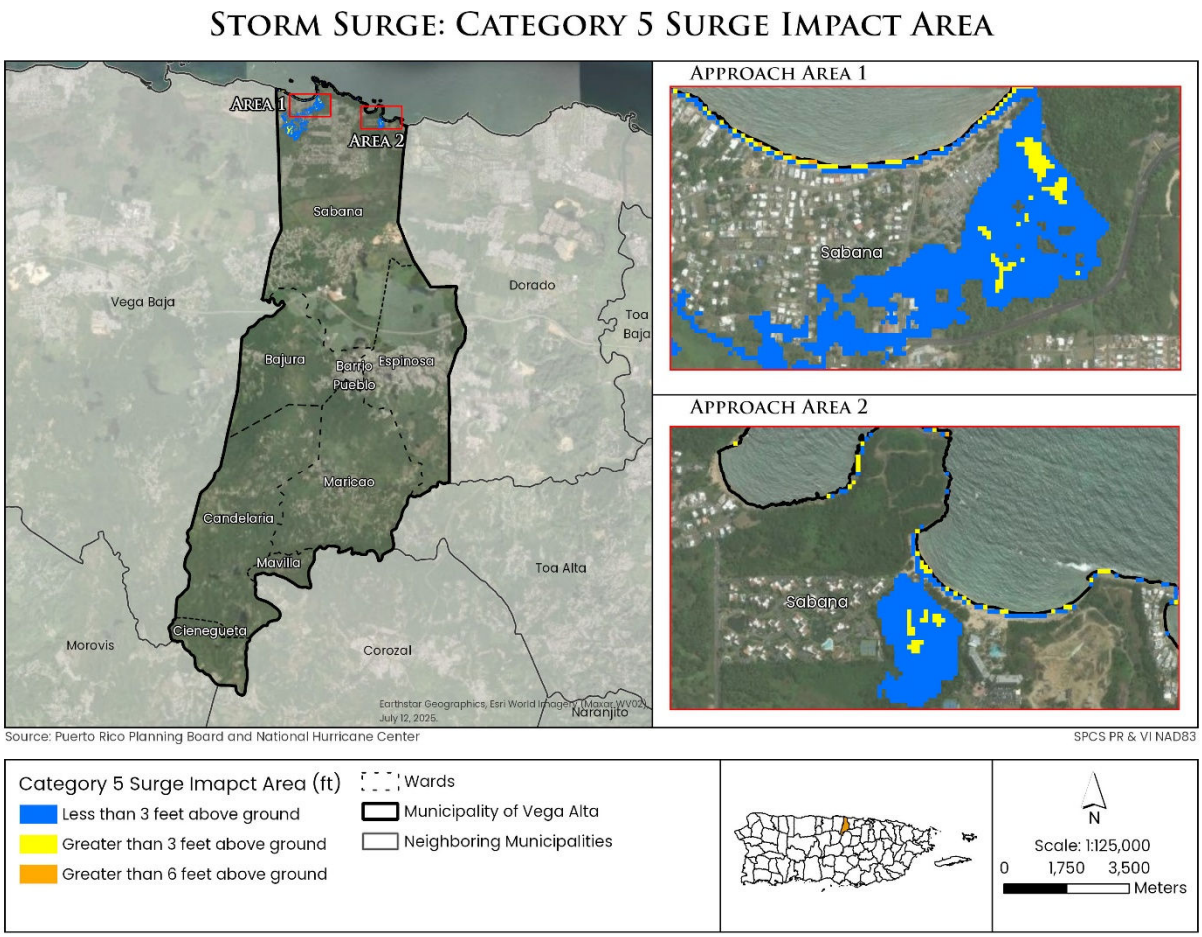
storm surge occurs simultaneously with heavy rainfall, resulting in combined coastal and inland flooding that can overwhelm local drainage systems.

*Map 44: Category 1 Storm Surge Area*




Under the Category 1 storm surge scenario, inundation is generally limited to narrow sections of the coastline and coastal fringe areas. Most affected locations experience surge depths of less than three feet above ground level, with only isolated areas exposed to greater depths. While the spatial extent of inundation is relatively limited, storm surge impacts may still affect coastal residences, local roadways, utility infrastructure, beach access facilities, and recreational assets located immediately adjacent to the shoreline.

*Map 45: Category 5 Storm Surge Impact Area*




In contrast, the Category 5 storm surge scenario results in significantly greater inland penetration of floodwaters, particularly within the coastal communities of Sabana. The mapped inundation area expands beyond the immediate shoreline into developed residential areas, with portions of the affected area experiencing water depths exceeding three feet above ground level. The analysis indicates that neighborhoods located behind the beachfront and near coastal depressional areas would be increasingly vulnerable to structural damage, access restrictions, utility disruptions, and prolonged recovery operations following a major hurricane event.

Although storm surge exposure is geographically limited compared to other hazards affecting Vega Alta, the concentration of development within vulnerable coastal areas elevates the potential consequences of a major hurricane. Future coastal dynamics,

increased erosion, and the possibility of stronger tropical cyclones may further increase the municipality's susceptibility to storm surge impacts over time.

#### 4.11.1.2 Risk Magnitude

The maps included in the storm surge section of the risk assessment, with reference to the geographic areas affected by this natural hazard, show the impact of this event based on flood depth and according to the occurrence of Category 1 and Category 5 hurricane events. In summary, flood depth represents the severity or magnitude of the storm surge risk, and likewise, there is a correlation between the magnitude of the storm event and the depth of flooding and the extent of land area that will be affected. That is, in most instances, as a storm escalates to higher-magnitude categories, a greater number of neighborhoods and sectors may be impacted by flooding events of greater depth.

Similar to other coastal hazards, storm surges have the potential to expose the population and infrastructure supporting lifelines. Likewise, areas within the municipality that are already prone to flooding may be more severely affected by flooding resulting from storm surge events.

#### 4.11.1.3 Past Events

Hurricane María (2017) generated measurable storm surge and storm tide impacts along Puerto Rico's southeastern and eastern coasts. Post-storm field investigations conducted by the U.S. Geological Survey (USGS) documented storm-tide inundation heights generally ranging from approximately 6 to 9 feet above ground level in coastal municipalities including Humacao, Naguabo, and Ceiba (Byrne, 2019). Lower storm surge levels, typically between 1 and 4 feet, were observed along portions of the northern and western coasts. Although the most catastrophic impacts of Hurricane María were driven by extreme rainfall and inland flooding, storm surge contributed to coastal flooding, shoreline erosion, and damage to marinas and port facilities, particularly along exposed eastern shorelines (Byrne, 2019) (Pasch, Penny, & Berg, 2023).

Hurricane Georges (1998) generated storm surge impacts along the southern and eastern coasts, exacerbating coastal inundation and contributing to damage in low-lying coastal communities (Guiney, 1999). More recently, Hurricane Fiona (2022) caused storm surge and wave-driven coastal flooding along Puerto Rico's southern coast, particularly in municipalities facing the Caribbean Sea, despite making landfall

as a hurricane of relatively lower wind intensity (Pasch, Reinhart, & Alaka, Hurricane Fiona, 2023).

#### 4.11.1.4 Future Events Probability

The NOAA defines the term storm surge as the rise in ocean level resulting from the effects of wind and the drop in atmospheric pressure associated with hurricanes and other storms. In other words, storm surge is caused primarily by the strong winds of a hurricane or tropical storm; therefore, the probability of occurrence of a storm surge event in the municipality is directly associated with—and increases following—events of strong winds such as hurricanes and will increase or may intensify as such events occur.

To this end, the Sea, Lake, and Overland Surges from Hurricanes model (known as SLOSH, by its English acronym) is a computerized model used by NOAA for the assessment of coastal flooding risk and the operational prediction of storm surge.

According to FEMA, coastal flood risk areas are determined through a statistical analysis of records of riverine flow or currents, storm tides, and rainfall; information obtained through consultations with the community; and hydrologic and hydraulic analysis. Coastal flood risk areas are delineated or defined in the Flood Insurance Rate Maps (FIRM). These maps also communicate two regulatory flood mapping elements: the extent of land at risk of base flooding (1% annual probability) and the related flood levels in these areas, known as Base Flood Elevations (BFE).

### 4.11.2 Risk Analysis

#### 4.11.2.1 Estimated Losses

Storm surges pose a significant threat to FEMA-defined community lifelines by inundating critical infrastructure located in coastal and low-lying areas. Transportation lifelines are frequently disrupted when roads, bridges, ports, and evacuation routes are flooded or damaged, restricting evacuation, emergency response, and supply chain movement. Energy lifelines, including power plants, substations, and fuel distribution systems, are highly vulnerable to saltwater intrusion and flooding, which can result in equipment failure and prolonged power outages. Communications lifelines may also be compromised when cell towers, fiber-optic networks, 911 systems, and backup power supplies are damaged or inaccessible due to storm surge flooding. These cascading failures reduce situational awareness and hinder coordination among emergency responders and government agencies.

Collectively, impacts on these lifelines significantly reduce a community's ability to protect lives and property during storm surge events. (NOAA, n.d)

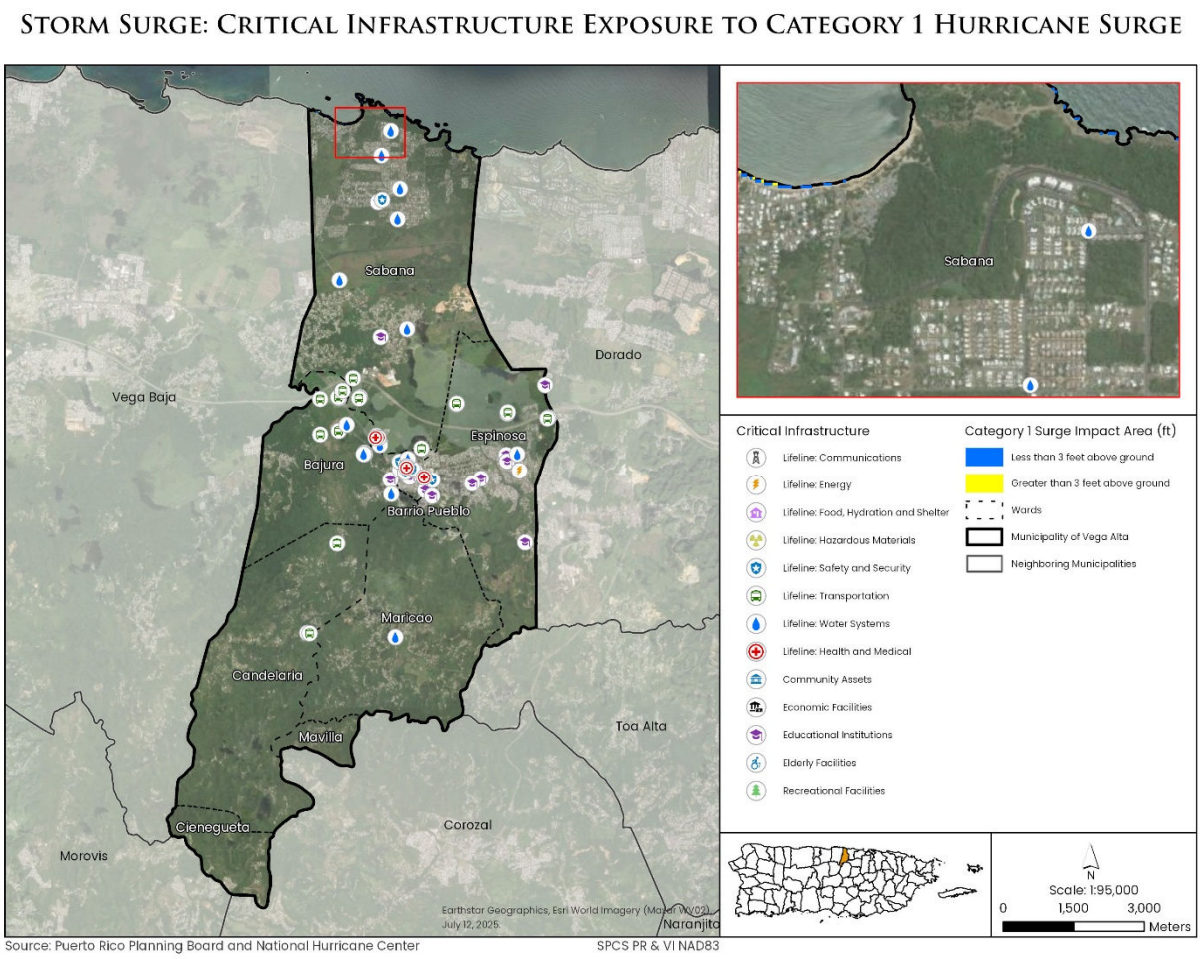
Storm surges also have severe consequences for FEMA's health and medical lifeline by flooding hospitals, clinics, long-term care facilities, and pharmaceutical supply chains, sometimes requiring evacuations or service closures. Damage to water and wastewater infrastructure threatens the food, water, and shelter lifeline by limiting access to safe drinking water and sanitation services. Flooded treatment plants and damaged pipelines can lead to water contamination, boil-water advisories, and increased public health risks. Safety and security lifelines are further strained when police, fire, and emergency medical service facilities are damaged or when flooded roadways limit response times. Prolonged disruption of these lifelines slows community recovery and exacerbates social, economic, and health vulnerabilities. These impacts underscore FEMA's emphasis on hazard mitigation, lifeline stabilization, and resilience planning to reduce storm surge.

The storm surge critical infrastructure analysis in Vega Alta indicates that direct exposure to hurricane-induced coastal inundation is concentrated along the northern coastline, primarily within Sabana Ward. While the majority of the municipality's critical facilities are located inland and remain outside of the mapped storm surge zones, several facilities associated with the water system and public safety lifelines are situated in close proximity to vulnerable coastal areas.

The analysis further demonstrates that even when critical facilities are not directly inundated, access to those facilities may be compromised by surge-related flooding. Emergency response operations, utility restoration activities, and service delivery efforts could be affected if coastal roads become impassable during or immediately following a major hurricane event. As a result, the operational resilience of critical infrastructure depends not only on facility location but also on the functionality of surrounding transportation and utility networks.

Map 46 shows the critical infrastructure that would be affected by a storm surge caused by a category 1 hurricane, while Map 46 shows the same but for a category 5 hurricane.

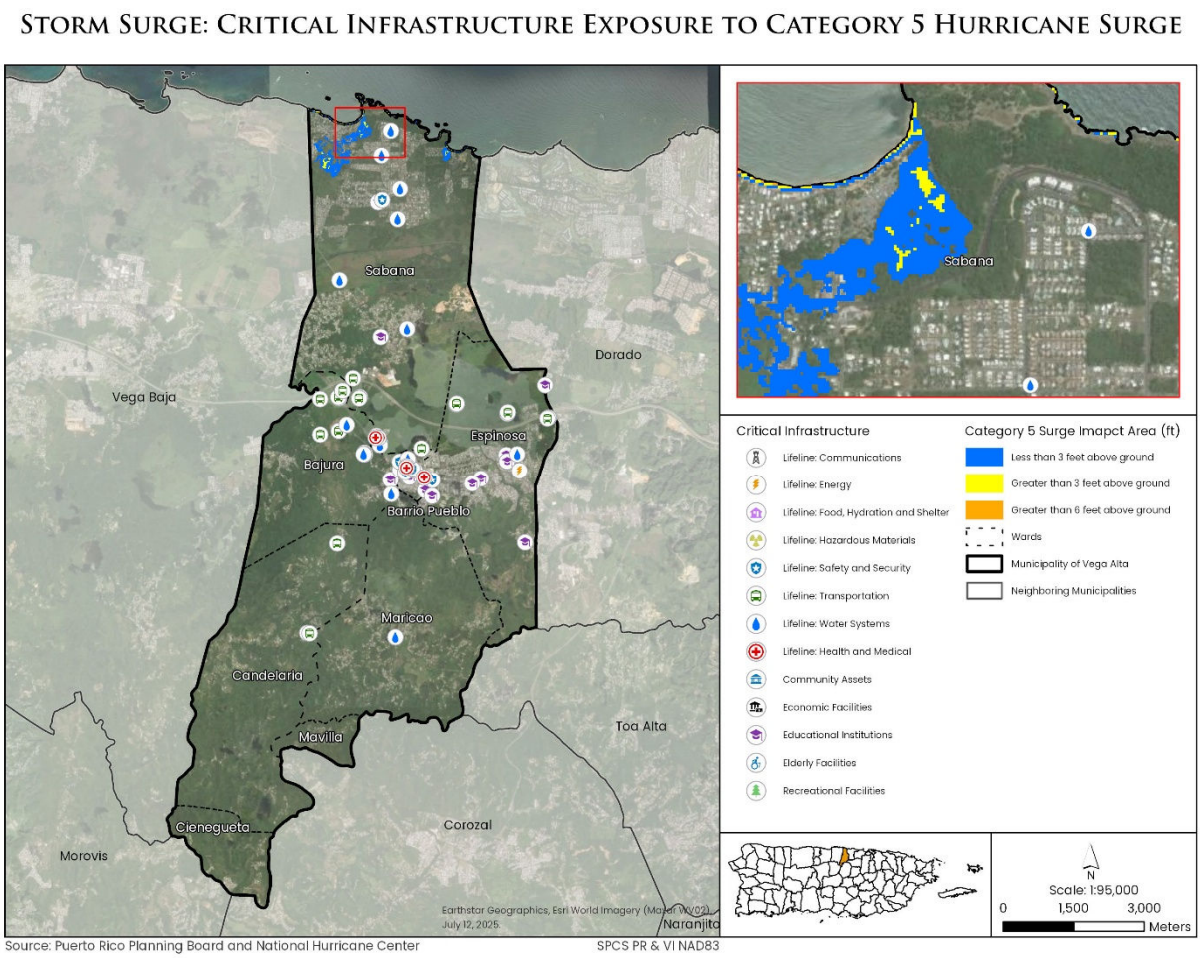
*Map 46: Critical Infrastructure affected by a Cat 1 Storm Surge*




Under the Category 1 hurricane storm surge scenario, inundation is generally confined to a narrow band along the shoreline. As shown in the analysis, only limited portions of the coastal area are affected, resulting in relatively low direct exposure to critical facilities. Although few facilities are located within the mapped surge area, coastal access routes, utility connections, and supporting infrastructure may still experience disruptions due to flooding, erosion, debris deposition, and wave action.

Under the Category 5 hurricane storm surge scenario, the extent of inundation expands significantly inland across portions of northern Sabana. The surge zone encompasses larger developed areas and extends into locations where critical infrastructure assets are present near the coastline. Water system facilities appear to represent the most exposed critical infrastructure category, with several facilities located near the projected surge impact area. In addition, transportation assets, public safety functions, and supporting utility infrastructure serving coastal communities may experience indirect impacts resulting from roadway flooding, restricted access, service interruptions, and damage to interconnected systems.

*Map 47: Affected Critical Infrastructure Cat 5 Hurricane*




Because storm surge exposure is concentrated within the municipality's coastal zone, the greatest risk is associated with facilities serving northern coastal communities. Future coastal dynamics, shoreline change, and the potential for more intense tropical cyclones may increase the extent and frequency of surge-related impacts over time.

Consequently, the municipality should continue evaluating opportunities to strengthen infrastructure resilience through facility hardening, backup power systems, redundancy in utility services, emergency access planning, and the protection of key lifeline infrastructure located within coastal hazard areas.

#### *4.11.2.2 Social Vulnerabilities*

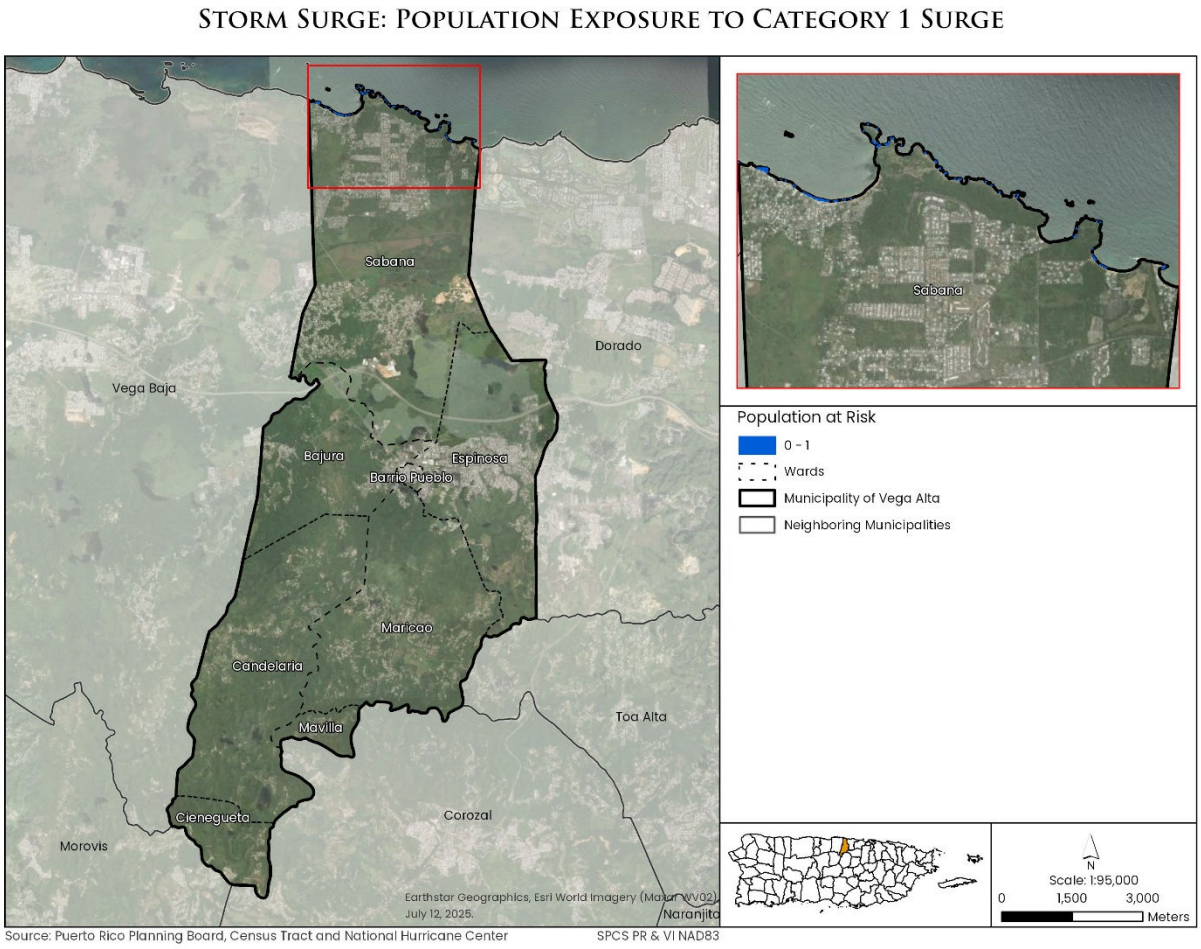
Storm surge events represent a significant social hazard for Puerto Rico due to the Island's extensive coastline, high population density in coastal municipalities, and legacy socioeconomic vulnerabilities. Storm surge–related flooding frequently results in displacement, housing damage, and prolonged interruption of essential services, particularly in low-lying coastal communities and estuarine areas. Studies of hurricanes impacting Puerto Rico, including Hurricane María, have shown that flood exposure and displacement are disproportionately concentrated among low-income households, older adults, and communities with limited access to transportation, healthcare, and economic resources, which delays recovery and increases long-term vulnerability. FEMA and NOAA analyses further indicate that socially vulnerable populations are more likely to reside in surge-prone areas and experience compounded impacts when storm surge coincides with power outages, roadway flooding, and disruptions to water and medical services. (Chowdhury, et al., 2025)

Storm surge flooding also poses serious public health, economic, and equity challenges for Puerto Rico. Flooding of homes, healthcare facilities, and water and wastewater systems increases risks of injury, water contamination, and adverse mental health outcomes, particularly in communities that experience extended power outages and limited access to medical care. Economic impacts are often prolonged, as small businesses, informal workers, and coastal livelihoods face income losses and slower recovery due to limited insurance coverage and financial capacity. Research and federal reviews of disaster recovery programs highlight that inequities in disaster assistance and rebuilding resources can exacerbate social and wealth disparities on the Island, reinforcing the need for mitigation actions that integrate social vulnerability, equitable recovery, and community resilience into storm surge planning. (Chowdhury, et al., 2025)

Storm surge exposure modeling for a Category 1 hurricane indicates a relatively limited impact on the resident population of Vega Alta (Map 48). The mapped surge inundation area is confined primarily to low-lying coastal sections of Sabana Ward along the municipality's northern shoreline. Population exposure within the Category 1

storm surge extent is minimal, with affected census blocks containing an estimated 0 to 1 person at risk.

*Map 48: Storm Surge: Population Exposure to Category 1 Surge*

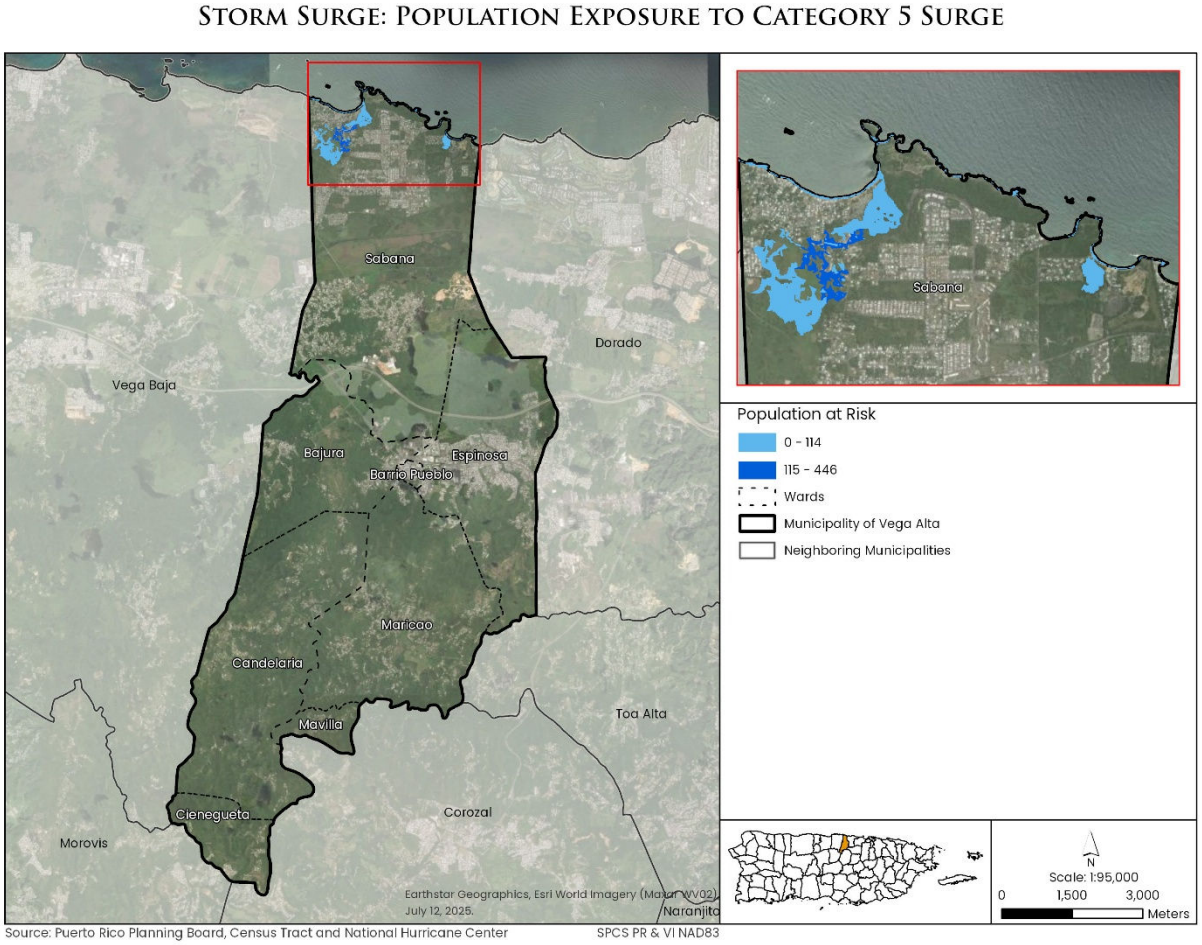



Under a Category 5 hurricane scenario, the extent of storm surge in inundation expands substantially along the northern coastline of Vega Alta. The highest concentrations of exposed population remain within Sabana Ward, where low-lying coastal communities are vulnerable to inundation from extreme surge conditions.

Population exposure increases considerably compared to the Category 1 scenario, with affected census blocks containing an estimated 115 to 446 residents at risk in the areas experiencing the greatest surge impacts. Additional coastal areas exhibit lower exposure levels ranging from approximately 0 to 114 residents, reflecting variations in residential density and proximity to surge-prone areas.

The spatial analysis indicates that storm surge exposure remains concentrated near the coastline and does not extend significantly into the municipality's interior wards. Consequently, the primary life-safety concerns associated with storm surge are concentrated within northern coastal neighborhoods where residents may face rapid inundation, restricted evacuation access, and prolonged isolation during severe hurricane events.

*Map 49: Strom Surge: Population Exposure to Category 5 Surge*




Although the number of exposed residents is relatively small compared to the municipality's total population, storm surge poses a significant life-safety risk because of its rapid onset, destructive force, and potential to isolate affected communities. Residents within identified surge zones may require evacuation prior to hurricane landfall, particularly during major storm events.

#### 4.11.2.3 Natural and Cultural Resources

Storm surge poses a significant natural hazard to Puerto Rico's coastal and near-coastal environments due to the Island's extensive shoreline, low-lying coastal plains, and concentration of sensitive ecosystems. Surge-driven flooding and wave action can cause severe erosion, saltwater intrusion, and habitat degradation in mangroves, coastal wetlands, estuaries, seagrass beds, and coral reef systems that are critical to biodiversity, fisheries, and natural coastal protection. These ecosystems can experience vegetation die-off, sediment redistribution, and long-term loss of ecological functions such as flood attenuation and water filtration following storm surge events. Repeated storm surge exposure can permanently alter coastal geomorphology and reduce the buffering capacity of natural systems, increasing vulnerability of inland areas and amplifying future flood risk across Puerto Rico's coastal municipalities (Ganz, Duan, & Ji, 2023).

Storm surge also presents substantial risks to Puerto Rico's cultural and historic resources, many of which are concentrated in coastal zones and historic town centers. Flooding and erosion associated with storm surge events can damage or destroy historic buildings, archaeological sites, cemeteries, and cultural landscapes, including Spanish-era structures and Indigenous archaeological resources located near the coast. In addition to physical damage, storm surge–related displacement can disrupt traditional cultural practices and undermine community identity tied to historic places and coastal livelihoods. FEMA and its federal partners recognize the vulnerability of cultural resources to coastal flooding and support mitigation, documentation, and recovery efforts through programs such as the Heritage Emergency National Task Force, emphasizing the importance of incorporating cultural resource protection into hazard mitigation planning for Puerto Rico.

Storm surge impacts in Vega Alta could cause significant damage to both environmental and cultural resources, particularly if coastal erosion, habitat loss, and failures at the petroleum storage facility occur simultaneously. Flooding and wave action could erode beaches and destroy coastal habitats such as wetlands and mangroves, which serve as critical ecosystems for wildlife and natural buffers against flooding. Saltwater intrusion and contamination from potential oil spills could further degrade these environments, affecting marine life, fisheries, and water quality. From a cultural perspective, coastal communities, recreational areas, and sites of local significance could be damaged or lost, disrupting community identity and heritage. A catastrophic failure of the oil reservoirs would amplify these impacts by releasing hazardous materials into coastal and inland areas, leading to long-term ecological

damage, loss of natural resources, and lasting effects on both the environment and the cultural landscape of Vega Alta.

#### 4.11.2.4 Future Conditions

This hazard poses a direct threat to coastal infrastructure, shoreline businesses, the agricultural sector, and the oil and maritime industry within Vega Alta. Storm surge, in particular, can significantly intensify these impacts by causing sudden and severe coastal flooding that extends inland beyond typical tidal limits.

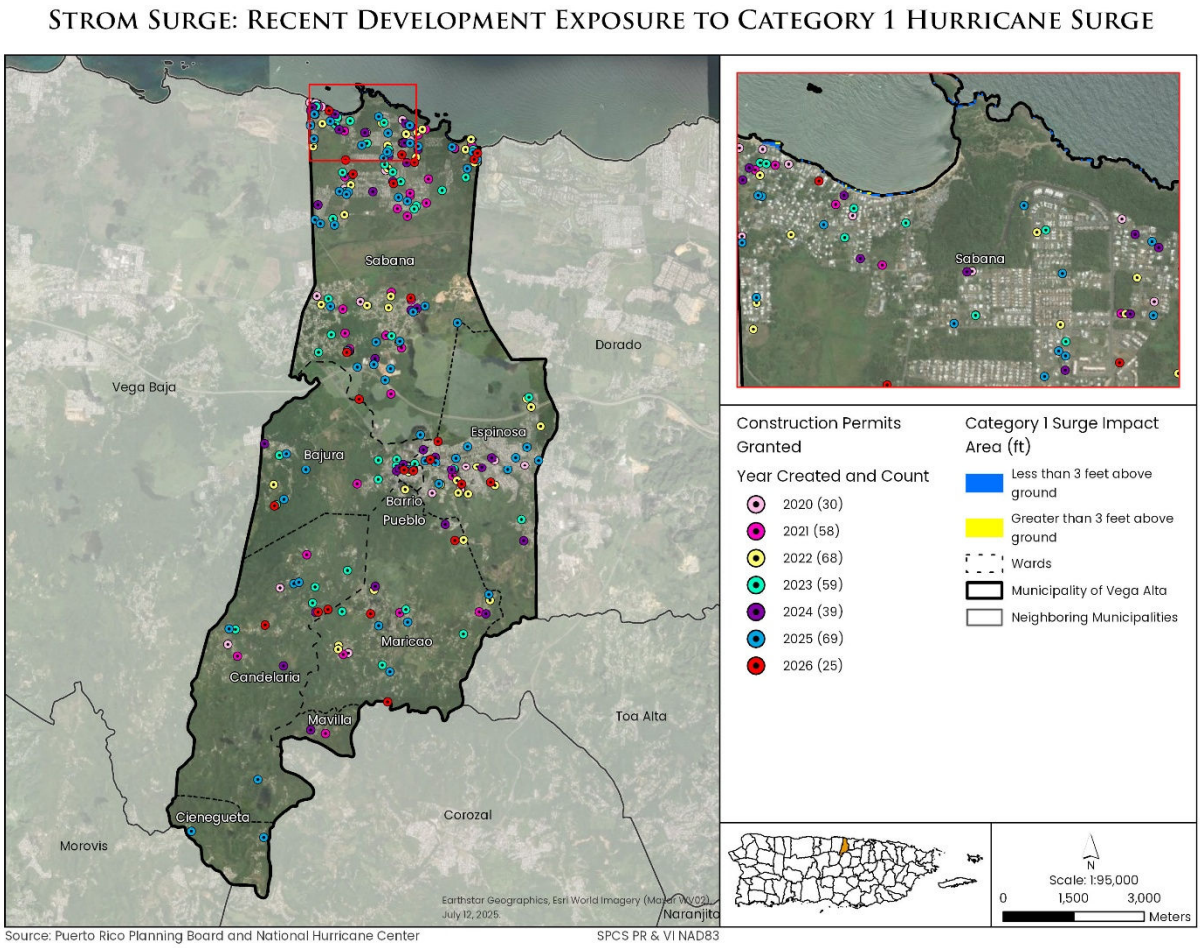
During a storm surge event, elevated sea levels combined with powerful wave action can inundate low-lying coastal areas, including port facilities, fuel storage infrastructure, and nearby communities. In Vega Alta, where critical assets such as docks, pipelines, and storage tanks are located near sea level, storm surge can lead to physical damage, corrosion, and system failures. Floodwaters can disrupt port operations, damage loading and unloading systems, and temporarily halt maritime activity. This directly affects the oil and maritime industries by interrupting fuel imports, storage, and distribution.

In addition, shoreline businesses and coastal infrastructure are highly susceptible to structural damage and economic losses due to prolonged inundation and debris carried by surge waters. The agricultural industry, particularly in low-lying alluvial valleys near the coast, can experience crop loss, soil salinization, and long-term land degradation as saltwater penetrates farmland and irrigation systems.

Furthermore, storm surge can overwhelm drainage systems already stressed by heavy rainfall, worsening inland flooding and delaying recovery efforts. Given the concentration of critical infrastructure in vulnerable coastal zones, storm surge represents a multi-dimensional threat that affects economic activity, environmental quality, and public safety in Vega Alta.

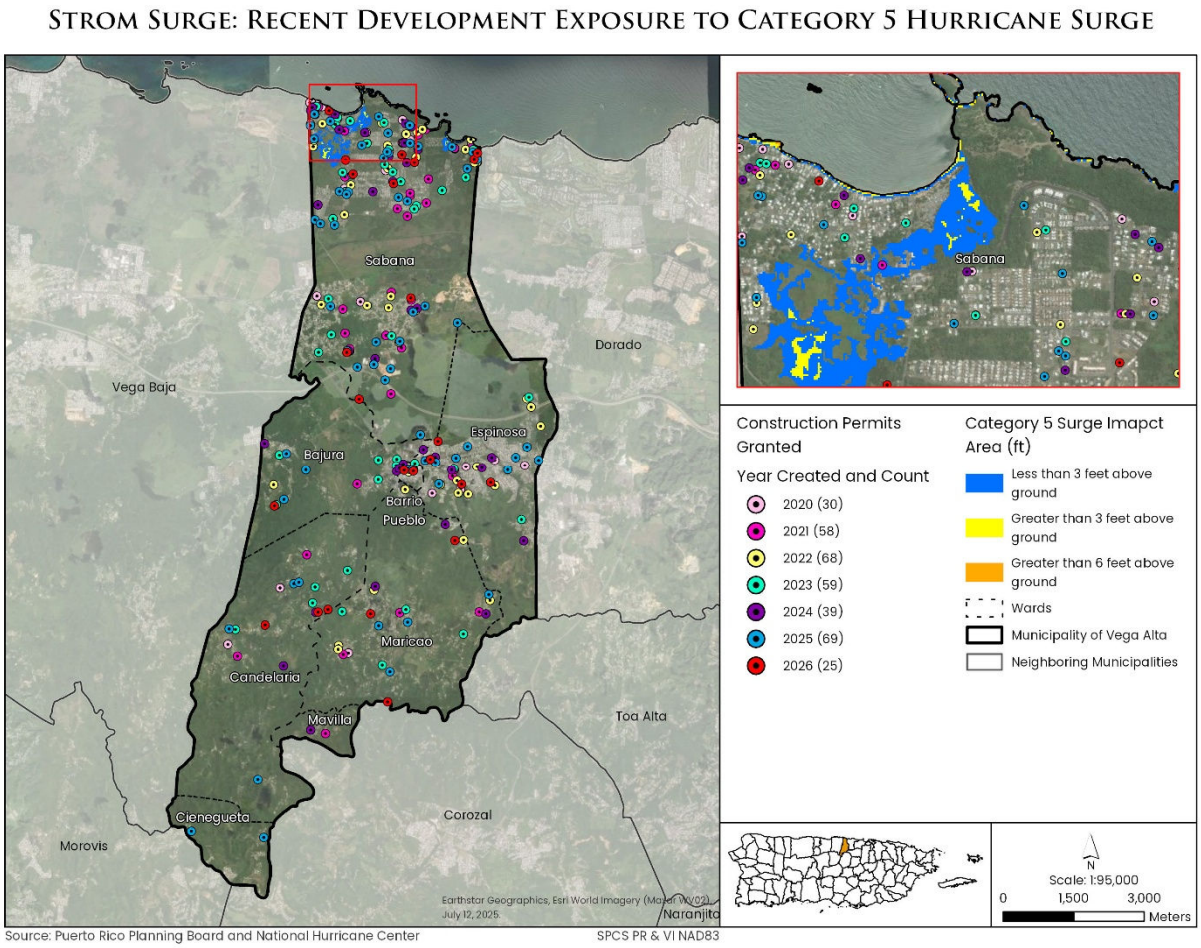
*Maps 50 and 51 show the construction permits approved for the period of 2020 -2026.* The analysis suggests that recent development trends in Vega Alta are gradually increasing the amount of property and infrastructure located near storm surge hazard areas, particularly within Sabana Ward. While Category 1 events present limited direct impacts, Category 5 hurricanes could affect a substantially larger number of recently developed properties. Therefore, managing future coastal growth and maintaining resilient development standards should remain a priority mitigation objective for the Municipality of Vega Alta.

*Map 50: Recent Development and Storm Surge Impact Category 1*




Under the Category 1 hurricane storm surge scenario, inundation is generally limited to a narrow coastal fringe along the shoreline. Although only a small number of recently permitted structures appear to be located within or immediately adjacent to the mapped surge impact area, several recent developments are situated nearby. As a result, even developments located outside of the direct inundation zone may experience indirect impacts from storm surge events, including roadway flooding, restricted access, utility disruptions, coastal erosion, and temporary interruptions to essential services.

*Map 51: Recent Development and Storm Surge Impact Category 5*




The Category 5 hurricane storm surge scenario presents greater risk to recent development. The mapped inundation area extends inland into developed sections of northern Sabana, encompassing a larger number of permitted structures constructed or approved since 2020. The analysis indicates that recent developments are located within or immediately adjacent to areas projected to experience surge depths exceeding three feet above ground level. Consequently, future hurricane events of greater intensity could expose a growing number of residential properties and associated infrastructure to direct storm surge damages.

## 4.12 Extreme Heat

### 4.12.1 Description (B1-a)

There is no universally accepted definition for extreme heat or heat waves. For the purposes of this Plan, the definition adopted by the Department of Homeland Security (DHS) is used. It is defined as a prolonged period of 48 to 72 hours of intense heat and humidity, with temperatures above 90 °F. Under these conditions, evaporation is reduced and the body is forced to make a significant effort to maintain its normal temperature, which has caused the death of many people in attempts to stabilize physically. In general, extreme heat represents the highest rate of deaths among weather-related hazards.

A study titled Heat Risk Perception and Vulnerability in Puerto Rico: Insights for Climate Adaptation in the Caribbean, published in the academic journal International Journal of Environmental Research and Public Health, analyzes how Puerto Rico residents perceive health risks associated with extreme heat and how these perceptions relate to vulnerability and protective behaviors during extreme heat events that occurred in the summer of 2020 (Guzmán-Colon, Guido, Amaya-Ardilla, Cabrera-Rivera, & Méndez-Lázaro, 2025). The research was conducted through a cross-sectional telephone survey of 500 adults in metropolitan and non-metropolitan areas. This study defined the metropolitan area as the municipalities of Carolina, Cataño, Toa Baja, and Trujillo Alto. The non-metropolitan zone consists of the remaining municipalities of Puerto Rico.

The questionnaire included sociodemographic variables, health status, prior heat exposure, risk perception, and mitigation strategies. Statistical analysis employed chi-square tests and multinomial and logistic regression models.

The results reveal that, although most participants expressed concern about climate change and high temperatures, less than half perceived heat as a high health risk, and only one-fourth considered it likely to suffer a heat-related illness in the next five years. Risk perception was significantly higher among men, people aged 50 to 64, the unemployed, individuals with fair health, multiple chronic conditions, and those who had experienced heat-related symptoms. In contrast, older adults (65+) reported low levels of risk perception despite their high vulnerability.

Forty-four percent (44%) of respondents indicated having suffered heat-related symptoms during the summer, and 68% reported nighttime thermal discomfort, a factor closely linked to health problems. The most common strategies to mitigate heat were the use of fans (84%) and air conditioning (64%), although economic limitations

and instability of the electrical system reduced their effectiveness. Regional differences were also notable: residents in non-metropolitan areas showed greater risk perception than those in metropolitan zones.

The study concludes that there is a significant gap between actual vulnerability and risk perception, especially among older adults. It recommends strengthening risk communication targeted at vulnerable groups, addressing nighttime heat exposure, and improving electrical infrastructure to ensure equitable access to cooling systems. Proposed solutions include decentralized energy systems, cooling centers with backup power, and passive designs that reduce electrical dependence, thus contributing to community resilience in the face of increasing extreme heat events.

#### 4.12.1.1 Affected Area (B1-B)

Extreme heat events can impact the entire municipality, particularly in urbanized areas where the heat island effect may occur. Based on previously presented information, adverse climate effects have been observed, including severe droughts, increased frequency of strong wind events and flooding, higher heat index levels, among others. Due to the municipality's geography and location, the entire region is highly susceptible to extreme heat conditions.

Urban heat islands refer to urbanized areas where structures such as buildings, roads, and other infrastructure absorb and emit the sun's heat more than natural landscapes such as forests and water bodies. Daytime temperatures in urban areas are about 1–7 °F higher than temperatures in outlying areas; nighttime temperatures are about 2–5 °F higher (EPA, 2025).

Heat islands develop due to a combination of factors:

- Loss of Natural Landscapes – Urban areas often replace trees, vegetation, and water bodies—natural elements that cool the air through shade, transpiration, and evaporation—with hard, dry surfaces like roads, rooftops, and parking lots. These surfaces provide little shade or moisture, leading to higher temperatures.
- Properties of Urban Materials – Common construction materials such as asphalt and concrete absorb and retain more heat than natural surfaces. They reflect less solar energy and release heat slowly, causing temperatures to remain elevated, especially after sunset.
- Urban Design and Geometry – The layout of buildings affects airflow and heat retention. Dense developments with narrow streets and tall structures create

"urban canyons" that trap heat and block cooling winds, turning buildings into thermal masses that release heat gradually.

- Human-Generated Heat – Activities such as transportation, industrial operations, and air conditioning add waste heat to the environment, intensifying the heat island effect.
- Weather and Geographic Conditions – Clear, calm weather amplifies heat islands by maximizing solar energy absorption and limiting heat dispersion. Conversely, wind and cloud cover help reduce the effect. Geographic features like mountains can also influence wind patterns, either blocking cooling breezes or channeling heat through urban areas (EPA, 2025).

As part of the Integrated Revision of the Municipality of Vega Alta's Territorial Plan, the Municipality proposed a Minor Modification to the Puerto Rico Land Use Plan that increases urban land by 9.84%, from 3,207.64 cuerdas[15] (approximately 1,261 hectares) to 3,523.28 cuerdas (approximately 1,385 hectares). As a result, urban land would represent 19.33% of the municipality's total territory and provide capacity for an additional 838.04 cuerdas (approximately 329 hectares) of programmed developable land (Suelo Urbanizable Programado, SUP), a land use designation established under the Puerto Rico Land Use Plan for areas identified for future urban development subject to applicable planning and infrastructure requirements. This projected urban expansion may intensify the urban heat island effect, potentially increasing extreme heat conditions affecting urban areas, infrastructure, and vulnerable populations throughout the municipality. The municipality can help mitigate these projected impacts by incorporating policies and strategies that reduce heat accumulation, expand cooling opportunities, and protect vulnerable populations from the increasing frequency and intensity of extreme heat events. (EPA, 2025)(Vega Alta, 2025)

#### *4.12.1.2 Risk Magnitude (B1-C)*

Local NWS offices often work with community agencies to decide when heat alerts should be issued. Because the United States is so geographically and culturally diverse, heat tolerance varies by region. For example, residents of Puerto Rico are generally more accustomed to temperatures above 90ºF than those living in Alaska.

Nevertheless, the NWS uses the following standard alerts (NWS, n.d.):

- Excessive Heat Warning – Issued 12 hours before dangerous heat conditions are expected. This occurs when the heat index is forecast to reach 105ºF or higher

[15] One cuerda is equivalent to approximately 3,930.4 square meters (0.393 hectares or 0.97 acres).

for more than three hours over two consecutive days, or 115°F or higher for any period of time.

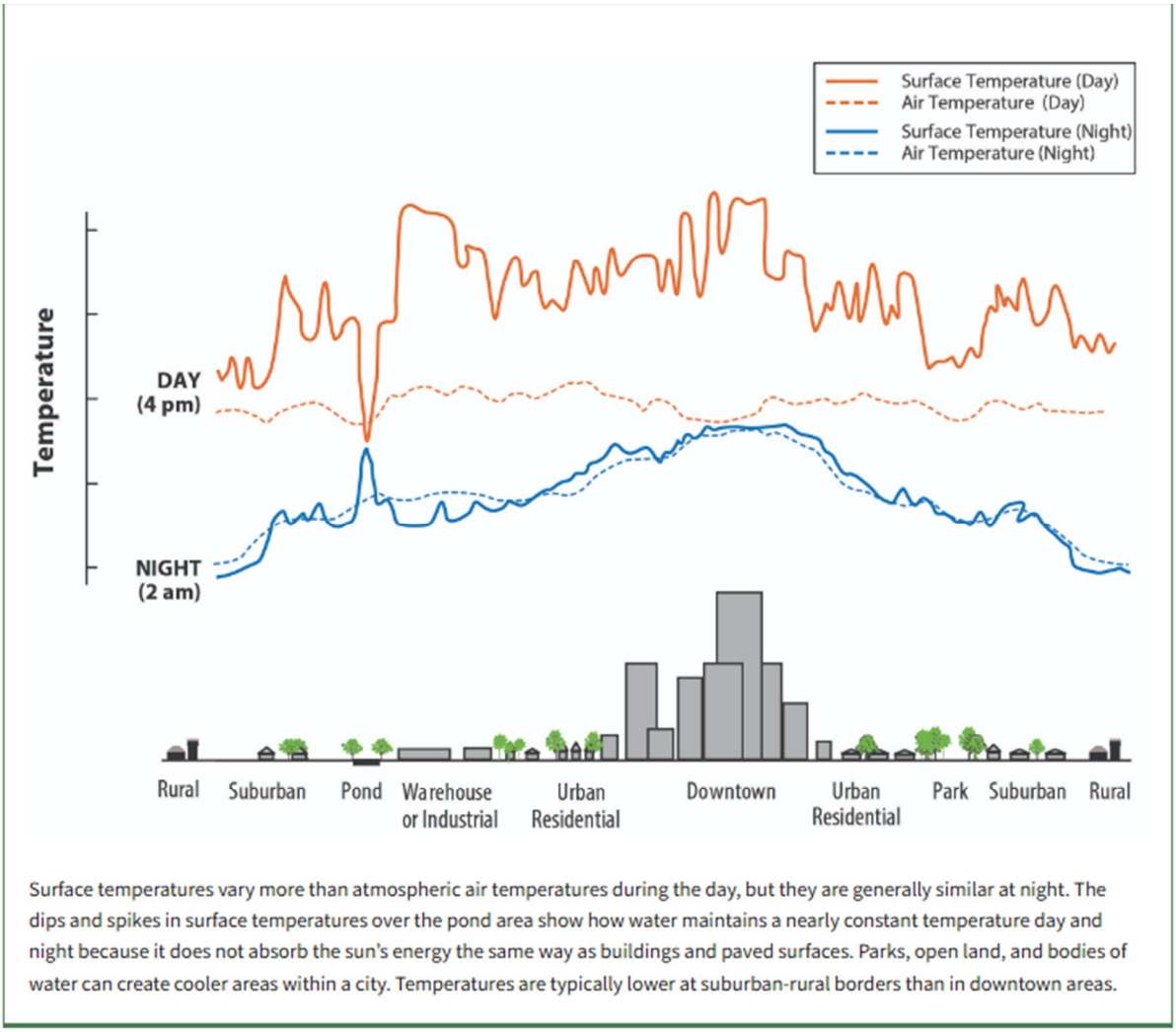
- Excessive Heat Watch – Issued when an extreme heat event is possible within the next 24 to 72 hours.
- Heat Advisory – Issued 12 hours before conditions where the heat index is at least 105°F but less than 115°F for three consecutive days.
- Extreme Heat Outlook – Issued when there is potential for extreme heat within the next three to seven days, providing advance notice for those who need extra time to prepare.

It must be emphasized that Urban Heat islands (UHI) phenomena can occur regardless of whether there is an extreme heat warning event. UHI is a relative temperature difference between urban and surrounding rural areas caused by factors like heat-absorbing surfaces, lack of vegetation, and human activities. It exists year-round, even during mild or cool weather, because cities consistently retain more heat than natural landscapes. Extreme heat events can amplify UHI, making UHI effects more dangerous, but UHI does not require extreme heat to form—it simply means urban areas are warmer than their surroundings under similar conditions.

UHIs are typically assessed by comparing temperatures in urban areas to those in surrounding regions. Even within a city, temperatures can vary significantly. Some neighborhoods are hotter due to dense concentrations of heat-absorbing surfaces like buildings and pavements, while areas with trees and greenery remain cooler. These variations create what are known as intra-urban heat islands. In diagrams illustrating this effect, urban parks, ponds, and residential zones generally appear cooler than central downtown districts.

The following diagram, taken from an EPA website, shows a diagram of how a heat island effect behaves in temperature.

*Figure 23: Heat Island Effect Diagram (EPA, 2025)*




### *4.12.1.3 Past Events (B1-D)*

Méndez Lázaro et al. (2015) identified several years in which extreme heat temperatures were recorded in the San Juan metropolitan area. According to their findings, periods of extreme heat occurred in 1983, 1995, 2012, and 2013. Notably, the summer of 2012 was the hottest in a century, with 42 days of extreme temperature values. During June, July, and August, the maximum heat index reached 98.06° F, 98.96° F, and 102.02° F, respectively (Méndez Lázaro et al., 2015).

### *4.12.1.4 Future Event Probabilities (B1-E)*

Official NOAA assessments in the 2018 Puerto Rico and U.S. Virgin Islands State Climate Summary report an increase in both average temperature (≈1.5°F since 1950) and the

frequency of extreme heat events (NOAA, 2022). Additionally, climate projections from CMIP6 (via the World Bank's Climate Change Knowledge Portal) show steady rises in summer and annual maximum temperatures for Puerto Rico, further indicating elevated future risk for heat waves (World Bank, n.d.).

### 4.12.2 Risk Analysis (B2-a, B2-b)

#### *4.12.2.1 Estimated Losses*

Extreme Heat primarily causes material and system stress rather than immediate structural failure. For example:

- Roads and Pavements: Asphalt can soften and deform under prolonged high temperatures, leading to rutting and surface damage (Highways Industry, n.d.) (EPA, 2012).
- Rail Systems: Steel tracks expand in extreme heat, which can cause buckling and derailment risks (USDOT - FRA, 2013).
- Power Infrastructure: Electrical grids experience higher loads from air conditioning demand, and transformers or cables can overheat, reducing efficiency or causing outages.
- Building Materials: Expansion and contraction of concrete, steel, and glass can lead to cracks or joint failures over time. Roofing materials may degrade faster under intense heat.
- Cooling Systems: HVAC systems work harder, increasing energy consumption and risk of failure, which can compromise indoor comfort and safety.

While heat waves rarely cause buildings to collapse, they accelerate wear and tear, increase maintenance costs, and can lead to system failures that disrupt essential services. As of now the municipality does not have a method to calculate losses from extreme heat events.

#### *4.12.2.2 Lifelines and Critical Infrastructure*

Extreme heat poses systemic risks across energy, transportation, and communications systems, creating compound failures precisely when demand for services peaks. In Energy Lifeline, high temperatures drive sharp increases in electricity demand for cooling while simultaneously decreasing generation and delivery efficiency. Thermoelectric plants may be forced to curtail output when cooling water is too warm, solar panels produce less electricity at elevated module temperatures, and transmission lines lose carrying capacity as conductors heat and sag—conditions

that heighten the likelihood of voltage drops and blackouts during heat waves (Jessen, 2025). The combination of record cooling loads and diminished supply underscores a growing "peak risk" problem for grids that were not designed for today's heat extremes (Jessen, 2025) (American Society of Civil Engineers, 2024).

Similarly, the Transportation Lifeline is similarly vulnerable. Prolonged high surface temperatures soften asphalt, accelerating rutting and deformation; steel rails thermally expand and can buckle, prompting heat-related slow orders that disrupt service; and catenary or other overhead lines can sag in the heat, further constraining operations. Airports face dual constraints: runway pavements can deform under extreme heat, and reduced air density on hot days impairs aircraft performance, affecting takeoff weight and scheduling. These effects are now commonly observed across U.S. systems during sustained heat events, requiring operational restrictions and emergency maintenance that ripple through supply chains and passenger mobility (American Society of Civil Engineers, 2024)

Communication Lifeline also faces mounting heat stress. Data centers, switching facilities, and network nodes rely on continuous cooling; overheating elevates outage risks and can degrade equipment lifespans. Heat-related disruptions to power supply and localized microclimate conditions compound these risks, with cascading impacts across other lifeline sectors that depend on connectivity for operations and emergency response. Federal assessments underscore that extreme weather—including extreme heat—can interrupt fiber networks, degrade wireless performance, and limit access to data centers, affecting each of the other critical infrastructure sectors and complicating disaster response coordination (Public-Private Analytic Exchange Program, 2025).

Overall, extreme heat acts as a stress multiplier: it pushes materials beyond design thresholds, reduces equipment efficiency, and narrows operational safety margins, all while increasing demand for services. The evidence from engineering organizations and energy market observers indicates that without targeted adaptation—such as heat-resilient design standards, strategic grid reinforcement, enhanced thermal management for digital infrastructure, and heat-aware operations—systems will face more frequent service disruptions and higher lifecycle costs as heat events intensify (American Society of Civil Engineers, 2024).

#### 4.12.2.3 Social Vulnerabilities

A recent academic study examines the relationship between heat stress and mortality in Puerto Rico (Méndez - Lázaro, et al., 2025). Researchers analyzed hourly 2-meter air temperature data from ERA5 reanalysis for 2015–2020 and derived daily minimum, maximum, and mean values to calculate two heat stress indices: the Heat Index (HI) and the Universal Thermal Climate Index (UTCI). Findings show that extreme heat conditions are common for eight months of the year, with August and September being the hottest months, and that urban heat island effects exacerbate exposure in metropolitan areas. (Méndez - Lázaro, et al., 2025) Mortality risk increased significantly on days with high heat stress: deaths were 23% higher in the highest HI tertile and 47% higher in the highest UTCI tertile compared to the lowest. Cardiovascular and cerebrovascular diseases, heart failure, and respiratory conditions were among the leading causes of death associated with heat stress. The study highlights Puerto Rico's socio-economic vulnerabilities, aging population, and limited infrastructure amplifying health risks during extreme heat events (Méndez - Lázaro, et al., 2025).

Further information about social vulnerabilities can be found in section 3.4.4.

#### 4.12.2.4 Natural and Cultural Resources

Extreme heat, specifically Urban Heat Islands can pose the following impacts on the natural resources:

- Increased Energy Consumption – Heat islands increase electricity demand for air conditioning and peak energy demand. Increased electricity demand for air conditioning ranges from 1–9% for each 2°F increase in temperature, with the highest increase in countries where most buildings have air conditioning, such as the United States[16].This increased demand contributes to higher electricity expenses. Peak demand generally occurs on exceptionally hot afternoons, when offices and homes are running air-conditioning systems, lights, and appliances. This increased demand can overload systems and require a utility to institute controlled brownouts or blackouts to avoid power outages.
- Elevated Emissions of Air Pollutants – To meet electricity needs, utility companies typically rely on fossil fuel power plants as a power source. Increased use of fossil fuels increases emissions of air-borne pollutants, such

[16] United States Environmental Protection Agency, What are Heat Islands? What Are Heat Islands? | US EPA

as carbon dioxide, which can have health concerns, especially in people living with respiratory diseases.

- Compromised Human Health and Comfort – Hot weather events contribute to heat-related deaths and heat-related illnesses. Areas experiencing heat islands further contribute to higher daytime temperatures and reduced nighttime cooling. Heat is of greatest concern for groups such as older adults, young children, populations with low-income, people who work outdoors, and people with chronic health conditions, disabilities, mobility constraints, or taking certain medications. From 2004 to 2018 the Centers for Disease Control and Prevention recorded an average of 702 heat deaths per year.

- Impaired Water Quality – High temperatures of pavement and rooftop surfaces can heat stormwater runoff, which drains into storm sewers. This runoff raises water temperatures as it is released into streams, rivers, ponds, and lakes. Water temperature affects the metabolism and reproduction of many aquatic species.

Rapid temperature changes can also be stressful, and even fatal, to aquatic life. One study found that urban streams have more frequent temperature surges than streams in forested areas. Temperature surges in urban streams were as much as 18°F higher due to heated runoff from urban areas, higher discharge volumes due to impervious surfaces, and warmer baseline stream temperatures (EPA, 2025).

#### *4.12.2.5 Future Conditions*

The approved construction permits map (Map 10) shows that many of the recent developments in Vega Alta are in the already built-up area of the city. This means that the urban heat island effect will continue to be present in the municipality in the near future.

## 4.13 Drought

### 4.13.1 Description (B1-a)

Drought is described as a temporary irregularity in rainfall or natural water flow, where a prolonged lack of precipitation leads to a significant hydrological imbalance. This condition may or may not result in interruptions to regular drinking water service, crop failures, and adverse effects on wildlife and vegetation. The severity of a drought is determined by the level of moisture deficiency, its duration, and the geographic extent of the affected area (Colón, 2009).

Drought represents one of the most complex climatological risks and one of the most severe events (DRNA, 2016). Drought is the result of a natural reduction in the expected amount of precipitation over a prolonged period, usually a season or longer. High temperatures, strong winds, and low humidity levels can exacerbate the effects of drought in areas where they are already prevalent. Likewise, drought can lead to severe wildfires (FEMA, 1997). Human actions and the demands they place on water resources can accelerate drought-related impacts. Droughts occur in different forms across the island, meaning that some regions may experience greater impact while others remain normal.

According to FEMA there are four types of droughts (FEMA, 1997):

*Table 33: Types of Droughts*

| | |
|---|---|
| **Meteorological Drought** | A period characterized by a significant deficiency in precipitation compared to normal conditions over a specific timeframe (e.g., monthly, seasonal, yearly) |
| **Agricultural Drought** | Occurs when soil moisture becomes insufficient to support crops or livestock needs, typically following meteorological drought. |
| **Hydrological Drought** | Defined by reduced water levels in streams, rivers, reservoirs, and groundwater systems, often lagging behind meteorological drought |
| **Socioeconomic Drought** | Reflects the impact on human systems and the economy, arising when water supply shortages—due to any form of drought—fail to meet societal demand for water and other resources |

In 1999, the Federal Drought Monitor program was implemented. This program is a tool that publishes data and maps on drought conditions in the United States, including Puerto Rico and Hawaii. This system integrates information from various agencies, such as NOAA, the United States Department of Agriculture (USDA), and the National Drought Mitigation Center at the University of Nebraska-Lincoln. In addition, the monitor has developed standardized indicators that allow drought categories to be classified at the national level, providing a uniform reference for risk assessment and management.

The short-term drought indicator focuses on precipitation over 1–3 months. The long-term drought indicator focuses on a period of 6–60 months. Additional indices used,

especially during the growing season, include the "USDA/NASS Topsoil Moisture," the Keetch-Byram Drought Index (KBDI), and NOAA/NESDIS satellite vegetation health indices. Other indicators include groundwater levels, reservoir capacity, and pasture conditions.

In Puerto Rico, the Puerto Rico Aqueduct and Sewer Authority (PRASA), the Puerto Rico Electric Power Authority (PREPA), and the Department of Natural and Environmental Resources (DNER) are responsible for constantly monitoring the dams and reservoirs used for potable water supply. Once critical levels are reached, the first strategy adopted at the supply system level is reducing water pressure. If adequate levels are not restored, water rationing begins. This is implemented in phases lasting 12 hours and, in extreme cases, up to 48 hours. The affected area is divided into sectors, and the different rationing phases of a given duration are initially implemented locally, usually in municipalities with the highest consumption. In extreme circumstances, several municipalities and entire regions may be affected.

#### 4.13.1.1 Affected Area

Vega Alta's administrative boundary is uniquely influenced by its topography, as it largely coincides with the natural limits of the watersheds formed by the surrounding mountainous terrain. The municipality's steep ridges and enclosed valleys define drainage patterns in such a way that most surface water flow originates and remains within its own territory, rather than receiving significant inflows from external watersheds. While this configuration helps contain runoff during rainfall events, it also creates heightened vulnerability during periods of drought. Because Vega Alta depends primarily on the precipitation that falls within its boundaries, prolonged dry conditions can significantly reduce water availability, with limited opportunity to offset shortages through inflows from neighboring regions. This makes localized droughts particularly critical, as water supply becomes directly tied to internal climatic conditions and the capacity of local watersheds to sustain demand.

#### 4.13.1.2 Risk Magnitude (B1-C)

Drought is a slow-onset hazard, but over time, it can have highly detrimental effects on crops, municipal water supplies, recreational uses, and wildlife. If drought conditions persist for several years, the direct and indirect economic impact can be significant. Drought can also potentially provide favorable conditions for another hazard to occur, wildfire.

The National Drought Monitoring Center uses the following categories to describe the magnitude of drought conditions (US Drought Monitor, 2025).

*Table 34: US Drought Monitor Categories*

| Category | Description | Typical Impacts |
|---|---|---|
| None | Normal/Wet Conditions | No drought impacts |
| D0 - Abnormally Dry | Early signs of dryness may slow planting, affect surface water | Short-term dryness; minor stress |
| D1 - Moderate Drought | Noticeable soil moisture depletion; low water; voluntary restrictions | Crop stress; reduced streamflow |
| D2 - Severe Drought | Common water shortages; likely crop/pasture losses | Mandatory restrictions possible |
| D3 - Extreme Drought | Major crop/pasture losses; widespread restrictions | Fire bans; severe water stress |
| D4 - Exceptional Drought | Exceptional and widespread losses; water emergencies | Emergency measures; critical impacts |

#### *4.13.1.3 Past Events (B1-D)*

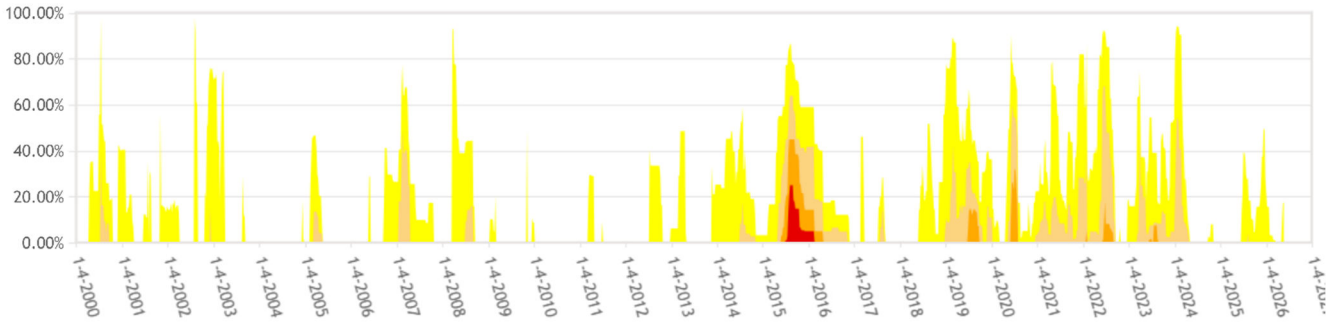
Puerto Rico has a humid tropical climate characterized by two well-defined seasons: a rainy season, which extends from May to November, and a dry season, which runs from December to April. The eastern and western interior regions record the highest annual rainfall, while the northern zone receives significantly more rain than the south.

USGS identified that major drought conditions have occur in 1967 – 1969, 1974, 1994, 1997, 2001-2002 and 2013 -2016 (USGS, 2014), (DNER, 2016). According to historical records the federal government has activated its resources to deal with drought conditions:

- Puerto Rico Extreme Drought Conditions (DR-170-PR) – Date of Declaration May 26, 1964
- Puerto Rico Impact of Drought (EM-3002-PR) - Date of Declaration August 29, 1974

During the rainy season, precipitation mainly comes from local convection processes, orographic effects, tropical waves, and cyclones. In contrast, rainfall during the dry season is mostly associated with the influence of cold fronts and troughs (CEACC, 2024).

Figure 25 shows the data captured by US Drought Monitor Categories for the period of January 2020 to January 2026 (US Drought Monitor, 2025) for Puerto Rico's entire territory. The graph measures the occurrence, duration, territorial extent and intensity of droughts in Puerto Rico. Intensity is measured with a color gradient ranging between yellow (D0 (abnormally Dry in the legend) as being the lowest intensity and the dark red (D4 Exceptional Drought) representing the highest level of drought. Duration is measured through the width of the data, expressed along the lower axis of the graph. Territorial extent is represented on the horizontal axis of the graph, the higher an event reaches the more Puerto Rico's territory it covers. Occurrence is measured by combining all of the other variables and locating them within the graph.



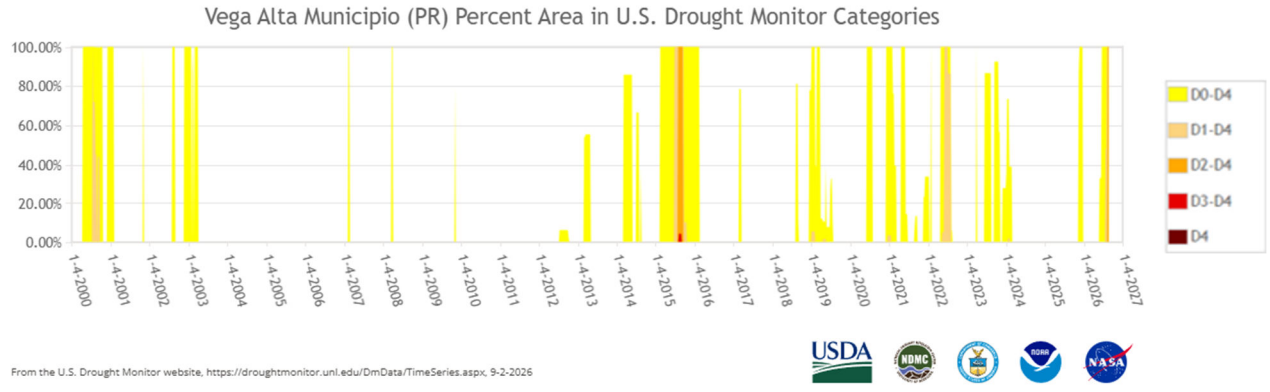

From the U.S. Drought Monitor website, https://droughtmonitor.unl.edu/DmData/TimeSeries.aspx, 5-29-2026

*Figure 24 Puerto Rico's Percent Area in U.S. Drought Monitor Categories*

From the graph we may appreciate a sustained trend of increased occurrence, duration and intensity of droughts in Puerto Rico that began as early as 2010 and solidified by 2014. Between 2015-2017, Puerto Rico experienced the most intense period of drought in recent years, with more than 80% of the Island's territory experiencing at least Abnormally Dry levels while at least 20% of the territory experienced Extreme Drought. The 2017 Hurricane season brough historic volume of precipitation, which explains the brief reduction in drought between 2017-2019. From 2019-2024, Puerto Rico experienced an extended period of drought in the vast majority of its territory.

Figure 26 shows the Municipality's Area in US Drought Monitor Categories for the period of January 2020 to January 2026 (US Drought Monitor, 2025). The series shows that in the period between 2015 and 2016 there was an occurrence where 100% of the municipality's territory was in the D3 – Extreme Drought category.

*Figure 25: Municipality's Percent Area in U.S. Drought Monitor Categories*[17]




### 4.13.1.4 Future event probabilities (B1-e)

[17] Source US Drought Monitor

USGS reports that in Puerto Rico, drought has an occurrence of 15 of 18 years (USGS, 2016), (USGS, 2014). Recent scientific data shows that the Caribbean region faces increased vulnerability to drought hazards. (USGCRP, 2018). The probability of drought occurrence is difficult to forecast or foresee in a long-term perspective. Though as figures 25 and 26 show, moderate droughts periods have become more prevalent since 2019.

### 4.13.2 Risk Analysis (B2-a, B2-b)

If drought results in potable water rationing, the municipality could experience economic losses to the extent that services are immediately affected by the partial or total closure of schools, businesses, industrial areas, and public and private offices.

The potential economic impact of a prolonged drought would arise from the need to mobilize the municipality to meet the basic needs of its population during the emergency period. This cost is associated with mobilizing resources such as personnel and equipment for the distribution of water to communities and municipal facilities. However, the municipality has not been able to quantify the economic impact of this expense, nor the impact on agriculture, due to a lack of information. Since drought is a hazard that does not directly affect structures, no dollar estimate of structural losses is generated.

Drought conditions in Vega Alta can significantly impact on the agricultural industry by reducing water availability for irrigation and stressing crops during critical growing periods. Prolonged dry conditions can quickly lead to soil moisture deficits, lower crop yields, and in severe cases, total crop failure. In addition, reduced water supply can affect livestock and increase production costs, as farmers may need to rely on alternative water sources. These combined effects threaten the economic stability of agricultural operations and the overall food supply within the municipality.

#### *4.13.2.1 Estimated Losses*

Documenting the fiscal impact of a drought is a complex process due to the wide range of ways this climate event affects society (DNER, 2015). For example, during the 2015 drought (see Figure 25) a potable water rationing plan was implemented for the San Juan Metropolitan Area (SJMA) of which Vega Alta is part of.

Another way to document the losses caused by drought period is by looking at the impact on the agricultural sector. The Puerto Rico Department of Agriculture reported that the 2015 drought had a net cost of $14,000,000.00 impact on the agricultural sectors.

#### 4.13.2.2 Critical Infrastructure and Lifelines

Drought can place significant strain on critical infrastructure by reducing water availability for municipal systems, often leading to rationing measures and service interruptions. Extended water shortages can disrupt essential operations in schools, hospitals, and businesses, resulting in economic losses and reduced access to public services. Energy infrastructure may also be affected, particularly where hydroelectric generation declines due to low reservoir levels, increasing reliance on more expensive or less sustainable energy sources. Transportation systems can experience indirect impacts, such as road damage caused by soil shrinkage and heightened wildfire risk along highways. Emergency response and communication services may face additional challenges when limited water supplies constrain cooling systems and firefighting capabilities. Collectively, drought conditions can trigger cascading impacts across interconnected infrastructure systems, increasing vulnerabilities and underscoring the need for coordinated mitigation and response strategies.

As noted above, drought events that require potable water rationing can lead to economic losses for the municipality by disrupting normal government operations. Partial or complete closures of schools, businesses, industrial zones, and public or private offices may occur when water availability is reduced. These impacts primarily affect the day-to-day functioning of municipal assets, as the services they provide are directly limited by water shortages or service interruptions. As droughts become more frequent or prolonged, their cumulative effects on operations are likely to intensify. However, while drought significantly affects service delivery and operational capacity, it does not directly damage the municipality's critical facilities and physical assets.

#### 4.13.2.3 Social Vulnerabilities

As mentioned in Section 3.4 the estimated vulnerable population of Vega Alta is 48.96% of total population. If the pattern that began in 2019 continues, the vulnerable population of Vega Alta will continue to face major challenges regarding access to potable water. Communities will experience a decrease in water availability, which is essential for industrial and agricultural production, as well as for personal use by

residents. It can also affect public health. This results in a reduction in quality of life, mental and physical stress, and social discomfort, with potential risks of malnutrition, dehydration, and disease. Since the effects of a drought period can have effects on the whole population (even drought periods that do not directly affect the municipality's territory, it is recommendable for the municipal administration to consider the whole population of Vega Alta as exposed to this hazard.

#### 4.13.2.4 Natural and Cultural Resources

When a region experiences prolonged and cumulative periods of little or no rainfall, a drought begins. This natural hazard has adverse effects on biodiversity and water supplies. For instance, a precipitation deficit lowers water levels in bodies of water, including mangroves, impacting the region's flora and fauna. Damage to vegetation directly affects animal habitats, creating an imbalance in food availability for wildlife.

Agriculture in the area is also severely affected due to the lack of water. When rainfall is significantly below normal levels, it causes severe hydrological imbalances that negatively affect land productivity systems. Similarly, crop growth and harvests decline, along with the availability and quality of drinking water. Drought can also lead to ecosystem degradation, loss of biodiversity and species, wind erosion, and increased wildfire risk.

#### 4.13.2.5 Future Conditions

Over the long term, drought-related challenges are expected to intensify as rainfall patterns continue to vary. These variations may result in droughts that are more severe, longer in duration, and wider in geographic extent than those experienced historically, thereby increasing vulnerability among affected populations.

Overall population trends in the Municipality of Vega Alta indicate a general decreasing trend at the neighborhood level. However, the population aged 65 and older has increased (see Section 3.4) This demographic trend requires consideration in drought planning, as aged-related health and mobility challenges may exacerbate the effects of water shortages and service disruptions for some residents.

Future land development also plays a critical role in drought vulnerability. Approving projects near sinkholes or developments that rely on septic systems increases the risk of groundwater contamination, which becomes especially problematic during

drought conditions when alternative water sources are limited. Additionally, soil surface impermeabilization and the obstruction or filling of sinkholes reduce natural aquifer recharge by increasing surface runoff. These factors further diminish groundwater availability, limiting its viability as a supplemental water source during drought events.

## 4.14 Wildfire (E1-a)

### 4.14.1 Description (B1-a)

Wildfires are uncontrolled fires that spread through vegetation, posing serious threats to structures, human health, and natural ecosystems. These events often begin unnoticed and can spread rapidly, producing dense smoke that affects nearby communities. While wildfires may occur at any time of year, they are most common during periods of low rainfall, when grasses, leaves, and other fine fuels become dry and highly combustible.

In 2021, the Puerto Rico Department of Natural and Environmental Resources published its Forest Action Plan (DNER, 2021). The Plan discusses overall trends, issues and objectives for the management of forest resources. Wildfires are among the challenges discussed in the document. The Plan argues that wildfire management is a pressing issue at both local and global levels due to the complex interactions among human activity, fire dynamics, and natural landscapes. While research has established that fire influences ecosystem structure and function, its effects on ecosystem services remain uncertain because of interrelated factors such as land cover changes, invasive species, and climate change (Gould, 2008).

A clear understanding of the ecological and social impacts of wildfires in Puerto Rico's natural ecosystems is essential for guiding effective conservation and management strategies. Prevention efforts must extend to private forest owners and the general public, as most fires on the island are human caused (Gould, 2008). Historically, fire monitoring and research in the region have received limited attention. Currently, fires occur predominantly in dry forest zones, where the risk is highest. However, climate change, prolonged droughts, and human-induced landscape fragmentation could expand fire-prone conditions into moist and wet tropical forests, as well as into areas traditionally unaffected by fire (Gould, 2008).

Increasing temperatures, more frequent droughts, and the spread of invasive species are making forests more susceptible to wildfires. This shift is already evident in Puerto

Rico, where fires are becoming more frequent and occurring in areas with no prior history of such events (Robbins, Eckelmann, & Quiñones, 2009).

#### 4.14.1.1 Risk Magnitude

The United States Forest Service main classification for fire types (USFS, n.d.) are;

- **Ground Fire** - Fire that burns within the organic material below the litter layer, mostly by smoldering combustion. It typically occurs in duff, peat, dead moss and lichens, and punky wood are typically ground fire. Ground fires mainly grow vegetation such as grasslands, shrubs, and tree bases. Depending on environmental factors (vegetation composition and density, slope orientation and steepness, wind speed, among others), these fires can vary in intensity but generally release less thermal energy than fires that spread through tree canopies.

- **Crown Fires** – A fire that burnt in the crowns of trees and shrubs usually ignited by a surface fire. Crown fires are common in coniferous forests and chaparral-type shrublands. In these types of fires, flames climb through lower branches until reaching the tree canopy. However, in some cases, its spread remains primarily surface-based, often because trees are sparse and their canopies are too far apart.

- **Surface Fire** – A fire that burnt through leaf litter and other live or dead fuels located at or just above the ground, mostly by flaming combustion.

While FEMA follows a four-classification typology (FEMA, 1997):

- **Wildfires** – Fueled almost exclusively by natural vegetation. They typically occur in forests and national parks, where federal agencies are responsible for fire management and suppression.

- **Interface or Intermixed Fires** – Fires that occur in urban and/or wildland areas where vegetation and integrated surroundings provide the fuel.

- **Firestorms** – Events of such extreme intensity that effective suppression is virtually impossible. Firestorms occur under severe weather conditions and generally burn until conditions change, or available fuel is exhausted.

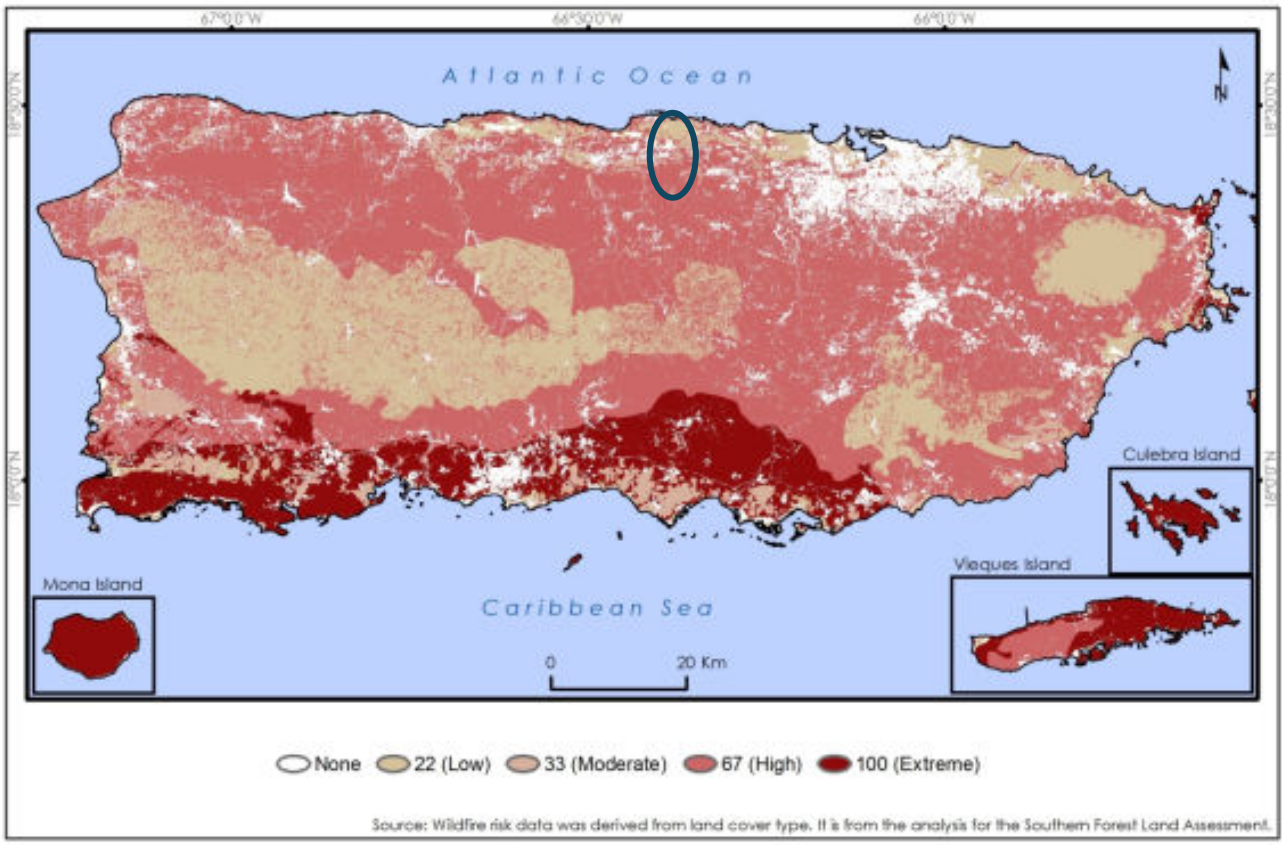
- **Intentional and Prescribed Burns** – Fires caused by human intervention and natural fires intentionally allowed to burn vegetation for management purposes.

Another typology is the distinction between wildfires and wildland-urban interface (WUI) fires. Wildfires occur in areas with minimal development, except for infrastructure such as roads or power lines. WUI fires, on the other hand, involve situations when fire spreads into areas with structures or other human developments. In WUI fires, flames feed on both vegetation and structural elements of urban areas. The US Fire Administration defines WUI as the zone or area where human structures and developments meet or intermingle with wildland vegetation and fuels (US Fire Administation, 2025).

#### *4.14.1.2 Affected Area (B1-b)*

Figure 27 (DNER, 2021) illustrates the distribution of wildfire incidence across Puerto Rico, Vieques, and Culebra, as defined by the Southern Federal Land Assessment (SFLA). The figure reflects the current understanding of areas identified as fire-prone landscapes. Elevated wildfire occurrence in the southern coastal plains is largely attributed to the combined influence of human activity, the presence of dry and combustible fuels, and prevailing climatic conditions. Vega Alta's territory (blue circle) is characterized by High risk in the mountainous area and a moderate risk in the valleys to wildfires.

*Figure 26: Levels of Wildfire incidence accounting to SFLA*




### *4.14.1.3 Risk Magnitude (B1-C)*

Wildfires tend to be associated with template climate areas, like California or Canada. However, the recent experience in the State of Hawai'i showed that rapid and deadly wildfire can occur even in tropical humid locations. The catastrophic Lahaina Fire of August 2023 sent swift, devastating flames through densely built neighborhoods, revealing severe vulnerabilities in early warning systems, evacuation planning, and community preparedness. Fueled by dry vegetation, strong winds, and record-setting drought conditions, the blaze rapidly ignited structures and overwhelmed emergency response efforts. Independent investigation by the Fire Safety Research Institute highlights that inadequate infrastructure resilience, insufficient communication networks, and a lack of coordinated interagency planning significantly amplified the disaster's impact.

As Puerto Rico faces similar wildfire threats, especially in southern coastal plains, this tragedy underscores the need to strengthen detection systems, bolster community evacuation routes, and elevate public education about fire safety. Building codes that emphasize fire-resistant materials and defensible space strategies around homes and critical facilities can reduce structural losses under extreme wildfire conditions.
The importance of integrated land management also emerges, encouraging Puerto Rico to limit development in WUI zones and maintain vegetation buffers. The Lahaina lessons highlight that rapid, well-coordinated suppression and resilient communications systems are vital to curbing wildfire escalation. Investing in cross-agency collaboration and emergency training at the local level will help Puerto Rican municipalities respond more effectively. Ultimately, Lahaina serves as a stark wake-up call, emphasizing that proactive planning, robust infrastructure, and community resilience are essential to preventing a similar wildfire catastrophe in Puerto Rico

#### *4.14.1.4 Past Events (B1-D)*

Citing data from the Puerto Rico Firefighters Bureau (PRFB), The Puerto Rico Forest Action Plan states that a total of 7,099 wildland fires were reported across Puerto Rico between 2018 and 2020. The highest number of incidents occurred in 2020, with 5,077 recorded fires. The regions most affected were Ponce, Guayama, and Mayagüez (DNER, 2021).

Within the Department of Natural and Environmental Resources (DNER) Protected Natural Areas, fire incidence increased in 2019 compared to 2018. Notable affected sites included Guánica State Forest, Boquerón Wildlife Refuge, Punta Cuchara Natural Reserve, Caño Tiburones Natural Reserve, and Tortuguero Lagoon Natural Reserve. Most of these fires were linked to human activities, such as unattended campfires, discarded cigarettes, intentional burning, improper waste burning, and poorly managed prescribed burns in pasturelands (DNER, 2021).

The high frequency of wildfires in Puerto Rico highlights the urgent need for targeted education and public outreach efforts to raise awareness. When combined with active land management and a landscape-scale conservation approach, these initiatives can help reduce the occurrence of fires and mitigate additional pressures on forest ecosystems.

During 2024 a total of 2 wildfires were reported by the Puerto Rico Fire Bureau. The following table shows the details of the wildfires reported in that year.

*Table 31: Registered Wildfires*

| Case Number | Discovery Date | Containment Date | Incident Coordinates[18] |
|---|---|---|---|
| PR040124-489 | 2024-04-01 11:25:54. | 2024-04-01 11:49:44. | -66.3135, 18.4162 |
| PR110724-102 | 2024-11-07 05:32:57. | 2024-11-07 06:44:14. | -66.34345, 18.401 |

*Source: Puerto Rico Fire Bureau*

#### *4.14.1.5 Future Event Probability (B1-e)*

Long-term trends in rain patterns, such as those caused by fluctuations in the El Niño–Southern Oscillation (ENSO), may lead to extended dry periods (CCOF, 2026), reduced soil moisture, and increased vegetation stress. When combined with rising temperatures, these conditions accelerate evapotranspiration and further dry out fuels, significantly increasing the likelihood of ignition and fire spread. As a result, areas that have not historically been prone to wildfires may become increasingly susceptible under these changing climate conditions.

### 4.14.2 Risk Analysis (B2-a, B2-b)

#### *4.14.2.1 Estimated Losses*

Wildfires can result from both natural conditions, such as the presence of flammable vegetation, and human activities, including the intentional use of fire. These factors strongly influence the potential scale and intensity of wildfire events. The level of potential loss increases with higher population concentrations, greater numbers of structures, and sensitive ecosystems located within the affected area. Climatic conditions, combined with patterns of human activity, largely determine the extent and severity of wildfire impacts.

At present, there is insufficient information to quantify monetary losses related to building damage from this hazard. Additionally, at the time of this Plan update, no official damage estimates were available for the municipality. To address this gap, the municipality will take a proactive approach by incorporating updated damage information in future Plan revisions as data become available

#### *4.14.2.2 Critical Infrastructure*

Wildfires pose a significant threat to critical infrastructure, creating cascading impacts across power systems, communications, water supply, transportation, and

[18] Coordinates are as per reported by PRFB

the built environment. The electric grid is particularly vulnerable. Research from Sandia National Laboratories (Sandia National Laboratories, n.d.) and other institutions shows that wildfires can both damage grid components and be ignited by them, as seen in the 2018 Camp Fire, which caused $9.3 billion in damages. To address this, the U.S. Department of Energy has invested $3.46 billion through its Grid Resilience and Innovation Partnerships program (DOE, 2023), funding projects that include undergrounding power lines, installing fire-resistant poles, and deploying advanced sensors.

Communications infrastructure faces similar risks A study by University of Wisconsin – Madison faculty found that while cell towers often survive fires physically, power outages lead to widespread service disruptions. (Anderson, Barford, & Barford, 2020) Water systems and watersheds are also heavily impacted. Post-fire conditions—such as vegetation loss and soil hydrophobicity—can trigger flooding and debris flows, introducing sediment, nutrients, and metals into water supplies.

Transportation networks suffer both direct and indirect damage. Roads, bridges, and drainage systems are often compromised by post-fire floods and debris flows buildings and other structures in the wildland–urban interface is increasingly at risk due to climate change and urban expansion.

In summary, wildfires create complex, interconnected risks for critical infrastructure, requiring a combination of engineering solutions, advanced modeling, policy reforms, and community engagement. Official and academic sources consistently call for proactive measures—such as infrastructure hardening, improved land management, and resilience planning—to reduce exposure and enhance recovery.

Wildfires occur regularly during periods of drought, primarily in the southern region of Puerto Rico. These events have significant social and economic impacts, mainly due to structural and property damage or loss caused by the fires. If the affected area served as an employment or industrial hub, many individuals could face unemployment. Additionally, insurance premiums tend to rise because of increased demand for coverage to mitigate economic losses associated with wildfire hazards. Collectively, these factors negatively affect the region's economy, wildlife, vegetation, and contribute to broader social decline.

#### *4.14.2.3 Social Vulnerability*

Social vulnerability plays a critical role in shaping how communities experience and recover from wildfire events. Research consistently shows that populations with higher

levels of poverty, older adults, individuals with disabilities, limited English proficiency, and households without reliable transportation face greater challenges preparing for, evacuating from, and recovering after wildfires. The CDC/ATSDR Social Vulnerability Index (SVI) identifies these demographic and socioeconomic conditions as key factors that increase susceptibility to disaster impacts, including wildfires, by constraining a community's adaptive and coping capacity before, during, and after an event. National scale studies further demonstrate that U.S. communities experiencing wildfire occurrence or exposure tend to have systematically higher levels of social vulnerability, including higher unemployment, lower educational attainment, and greater concentrations of medically or socially dependent populations (Schumann, III, et al., 2024).

Wildfires also exacerbate existing inequalities through indirect impacts such as prolonged displacement, loss of livelihoods, and health effects from smoke exposure. Peer reviewed studies show that socially vulnerable populations experience disproportionate health burdens from wildfire smoke, including higher rates of respiratory and cardiovascular illness and increased mortality risk, due to preexisting health conditions and limited access to medical care. FEMA and the U.S. Fire Administration emphasize that older adults, low-income households, people living in mobile homes, and individuals without access to private vehicles face heightened risk of injury or death during wildfire evacuations, underscoring the importance of incorporating social vulnerability into wildfire mitigation, evacuation planning, and recovery strategies (Dennin, Nock, Muller, Akindele, & Adams, 2025). A significant portion of Vega Alta's population is considered vulnerable (46.96%), and increased wildfire risk may disproportionately impact these residents by threatening homes, limiting access to essential services, and exacerbating health risks associated with heat and smoke exposure.

#### *4.14.2.4 Natural and Cultural Resources*

The severity, scale, and consequences of wildfire can be grouped into the following categories:

- Impact on Landscape - The most visible effect after a wildfire is the loss of scenic quality caused by the destruction of vegetation cover and its regression to earlier ecological stages.
- Impact on Wildlife - Wildfires immediately affect fauna, killing animals unable to escape—such as invertebrates, small vertebrates, young animals with limited mobility, and even large herbivores and carnivores trapped by flames and

fencing. Fires also lead to migration due to the loss of pastures, habitats, and endangered species.

- Impact on Soil - Wildfires alter soil structure and greatly increase its vulnerability to erosion. Organic matter is lost through combustion, destabilizing soil aggregates and causing progressive disintegration. Solid particles are then removed by rain or wind erosion. Hydrophobic layers often form, caused by water-repellent organic substances and changes in mineral composition, preventing water infiltration and accelerating erosion. Significant losses of soil and organic matter reduce nutrient levels, lowering fertility. Heat also kills many organisms, reducing biological activity and disrupting biogeochemical cycles. However, not all effects are negative. Naturally occurring fires (now increasingly rare) can benefit forest health by mobilizing nutrients and controlling pests. Low-intensity fires help retain carbon in the soil, preventing its release as carbon dioxide.
- Alteration of the Water Cycle - Soil loss drastically changes the hydrological cycle. Reduced infiltration lowers groundwater reserves that feed aquifers essential for agriculture and urban use. Surface runoff increases, intensifying erosion and contributing to flooding after heavy rain.
- Increase in Carbon Emissions - Combustion during wildfires releases carbon dioxide ($CO_2$), methane ($CH_4$), and suspended particles. These emissions cause significant environmental damage and negatively affect people with respiratory illness (Asthma, COPD, etc.).

Wildfires can lead to numerous environmental consequences, including the destruction of vegetation cover, the death or displacement of wildlife, the loss of fertile soil, and an increase in erosion events. They can also cause significant loss of life and property, resulting in substantial economic costs associated with firefighting and recovery efforts.

The impact of wildfires on ecosystems is severe and varies depending on the magnitude and frequency of these events. They cause extensive damage to vegetation, disrupt ecosystems, and lead to the loss of wildlife in affected areas. Additionally, wildfires contribute to increased soil erosion, alterations in the hydrological cycle, and higher emissions of carbon dioxide into the atmosphere. These factors collectively accelerate environmental and soil degradation.

As for cultural resources, Wildfires pose a serious threat to cultural resources, including historic buildings, and archaeological sites. Intense heat and flames can destroy irreplaceable structures, artifacts, and archives, erasing centuries of heritage in a

matter of hours. Smoke and water used in firefighting efforts can further damage delicate materials, while erosion and flooding after fires may expose or wash away archaeological remains. In addition, the loss of cultural landmarks disrupts community identity and traditions, impacting tourism and local economies. Protecting these resources requires proactive planning, fire-resistant measures, and collaboration between emergency agencies and cultural preservation experts.

#### *4.14.2.5 Future Conditions (E1-a)*

Puerto Rico already experiences a high annual probability of wildfire supporting conditions. According to the World Bank–supported ThinkHazard! platform, Puerto Rico's wildfire hazard is classified as High, meaning there is a greater than 50% probability in any given year of weather conditions capable of supporting a significant wildfire that could cause impacts to life or property. This assessment incorporates historical fire occurrence, climate variables, vegetation type, and drought conditions and is widely used in infrastructure and hazard mitigation planning worldwide (World Bank, n.d.).

Taken together, the best available scientific evidence indicates that Puerto Rico currently faces a probability exceeding 50% annually of wildfire supportive weather conditions, with future probability and severity expected to increase due to rising temperatures, expanded drylands, and longer seasonal droughts. While precise ignition probability percentages cannot be reliably projected at the municipal scale, confidence is high that wildfire occurrence, fire weather days, and burned area will increase by midcentury, particularly in southern, western, and interior regions of the island (World Bank, n.d.).

## 4.15 Long term Coastal Dynamics

### 4.15.1 Description

Long term coastal dynamics refer to the gradual, persistent processes that shape coastlines over extended periods of time, including shoreline movement, sediment transport, erosion, accretion, and changes in coastal water levels, which together influence coastal form, stability, and hazard exposure (USGS, 2018) (Mentaschi, Vousdoukas, Pekel, Voukouvalas, & Feyen, 2018). These dynamics differ from short term storm impacts in that they reflect persistent, incremental change rather than episodic disturbance. For Local Hazard Mitigation Plans, understanding long term coastal dynamics is critical because such changes influence shoreline position, coastal stability, and long-term exposure to coastal hazards (USGS, 2018).

Long term coastal dynamics are primarily driven by the interaction of coastal erosion, coastal accretion, and changes in the mean (base) sea level, all of which influence sediment distribution, natural protective features, and flood exposure along coastal areas (Bird, 2008; Davidson Arnott, 2010).

**Coastal Erosion**

Coastal erosion is the long-term landward movement of the shoreline resulting from a net loss of sediment from beaches, dunes, bluffs, or nearshore environments. While erosion may occur rapidly during storm events, long term erosion reflects sustained sediment imbalance operating over decades (Komar, 1998).

From a hazard mitigation perspective, chronic coastal erosion is important because it gradually reduces beach width and elevation, weakens dune systems, and exposes inland areas to increased wave action and flooding. Long term erosion is commonly measured as average annual shoreline retreat, integrating multiple historical shoreline positions and providing an indicator of sustained vulnerability rather than isolated event driven damage (Allan et al., 2003; USGS, 2018).

**Coastal Accretion**

Coastal accretion refers to the long-term accumulation of sediment that results in shoreline advancement or increases in beach width and elevation. Accretion can enhance coastal resilience by reinforcing natural protective features; however, it is often spatially variable and dependent on sediment availability and transport pathways (Davidson Arnott, 2010).

In many coastal systems, accretion in one location corresponds to erosion elsewhere, reflecting sediment redistribution rather than net sediment gain. As a result, accretion may be temporary and insufficient to offset long term erosional trends at a regional scale (Bird, 2008; Mentaschi et al., 2018).

**Variations in Mean (Base) Sea Level**

Mean sea level, often referenced using tidal datums such as mean sea level (MSL) or mean higher high water (MHHW), serves as a controlling baseline for coastal processes. Long term changes in mean sea level influence the elevation at which

waves interact with the shoreline, the frequency of tidal inundation, and the position of the coastal profile (USGS, 2018).

Gradual changes in mean sea level contribute to long term coastal dynamics by promoting landward adjustment of beaches and dunes, increasing inundation during routine tides, and enhancing erosion during moderate storm conditions. These impacts occur incrementally and contribute to persistent shoreline retreat over time (Bird, 2008; Mentaschi et al., 2018).

Long term coastal dynamics emerge from the interaction of erosion, accretion, and mean sea level position rather than from any single process acting independently. Coastal systems tend to adjust toward equilibrium conditions, which may involve shoreline migration, redistribution of sediment, and progressive loss of natural buffering capacity (Davidson Arnott, 2010).

As a result, localized accretion may slow erosion but may not reverse long term shoreline retreat where underlying sediment deficits or water level changes persist. These interactions explain why many coastlines experience sustained landward movement despite episodic periods of beach recovery (Komar, 1998; Allan et al., 2003).

For Local Hazard Mitigation Plans, long term coastal dynamics are a key consideration because they contribute to the gradual expansion of coastal hazard exposure beyond areas affected by single storm events. Persistent erosion, shifting shorelines, and changing base water levels can increase the vulnerability of infrastructure, reduce the effectiveness of fixed shoreline protection measures, and influence long term land use suitability (USGS, 2018).

Incorporating long term coastal dynamics into hazard mitigation planning supports proactive decision making related to land use, infrastructure siting, and mitigation strategy development by addressing the underlying physical processes shaping coastal risk.

Long term coastal dynamics, including ongoing erosion, accretion, and changes in mean sea level, contribute to gradual shoreline adjustment and increased exposure to coastal hazards over time. These processes represent a persistent source of coastal risk that should be considered in land use planning, infrastructure investment, and hazard mitigation strategies (Bird, 2008; USGS, 2018).

#### 4.15.1.1 Affected Area

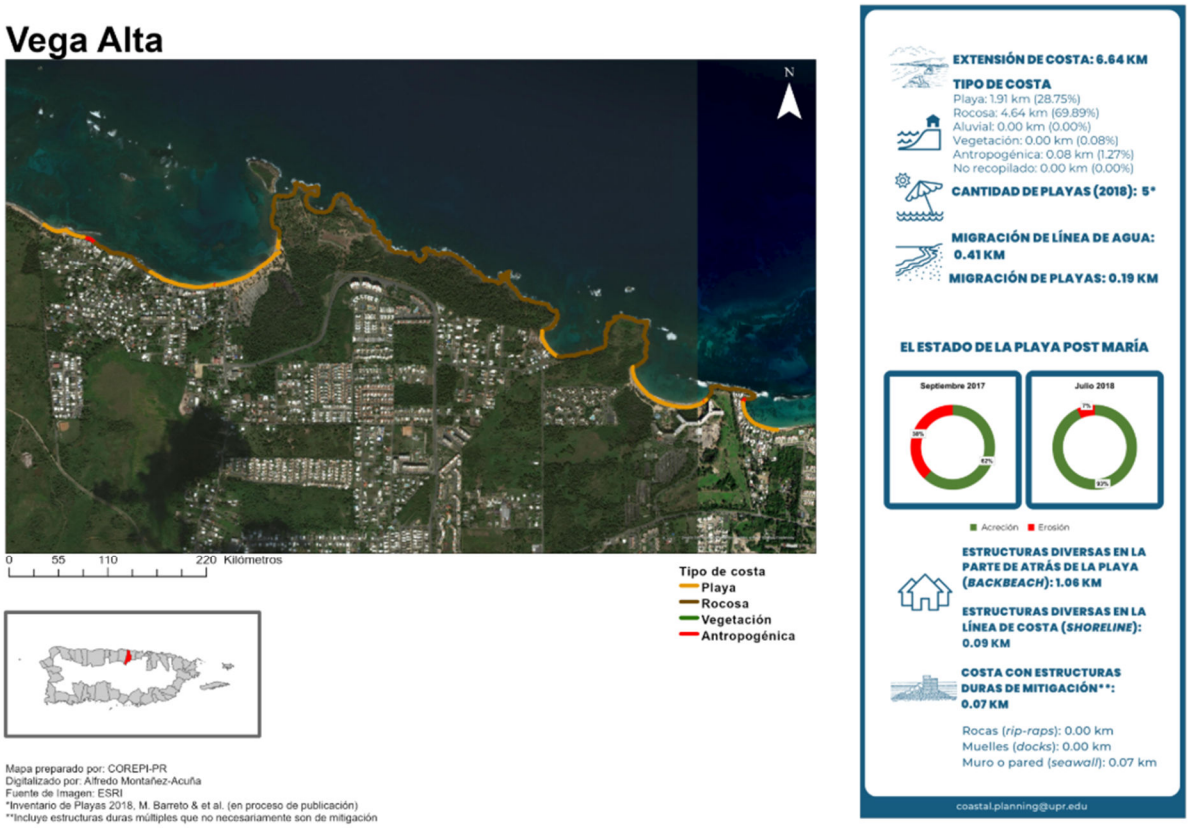
Under HMGP FEMA-4339-DR-PR Subgrantee Number 4339-0007P, a comprehensive post event coastal assessment was conducted to evaluate the geomorphic condition of Puerto Rico's beaches following Hurricane María (September 2017) and their subsequent recovery. This study was conducted by the University of Puerto Rico, Río Piedras' Coastal Research and Planning Institute of Puerto Rico (COREPI-PR).

The assessment analyzed beach conditions immediately after the hurricane and approximately ten months later (July 2018), covering a representative group of coastal municipalities across the north, west, east, and south coasts including Aguada, Aguadilla, Añasco, Arecibo, Arroyo, Barceloneta, Humacao, Loíza, Rincón, and San Juan (COREPI-PR, 2020).

The coastline of Vega Alta extends approximately 6.65 km, with rocky shores comprising 69% of the municipal coastline (Figure 28, only available in Spanish). Beaches account for 28% of the shoreline, with widths ranging from 2 to 50 meters as measured in 2018. Following the passage of Hurricane María in September 2017, most beach sectors experienced an increase in beach width. However, 38% of the beach coastline was affected by erosion. Notably, Vega Alta Beach and the western portion of Cerro Gordo Beach exhibited a reduction in beach width after the hurricane.

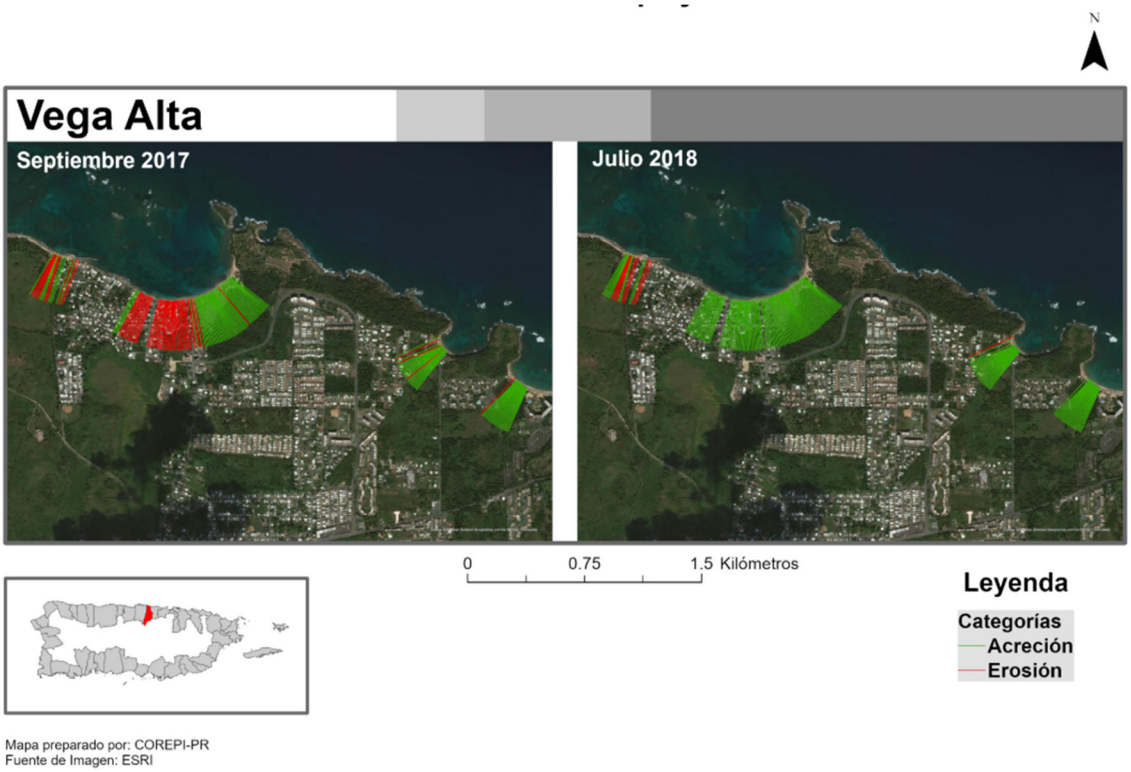
The next figures show the results of the State of the Beach study for the municipality of Vega Alta. Figure 28 shows the type of coast (beach, rocky, human-made). While figure 29 is a zoom in of the state of the beach in September 2017 (after María), and Julio 2018 (10 months after María). This figure also shows the difference of percentages between beaches that were in erosion versus those that were in accretion in the direct aftermath of Hurricane María (September 2017) and ten months after Hurricane María (July 2018) as shown in figure 29.

*Figure 27: Vega Alta - State of the Beach Study*



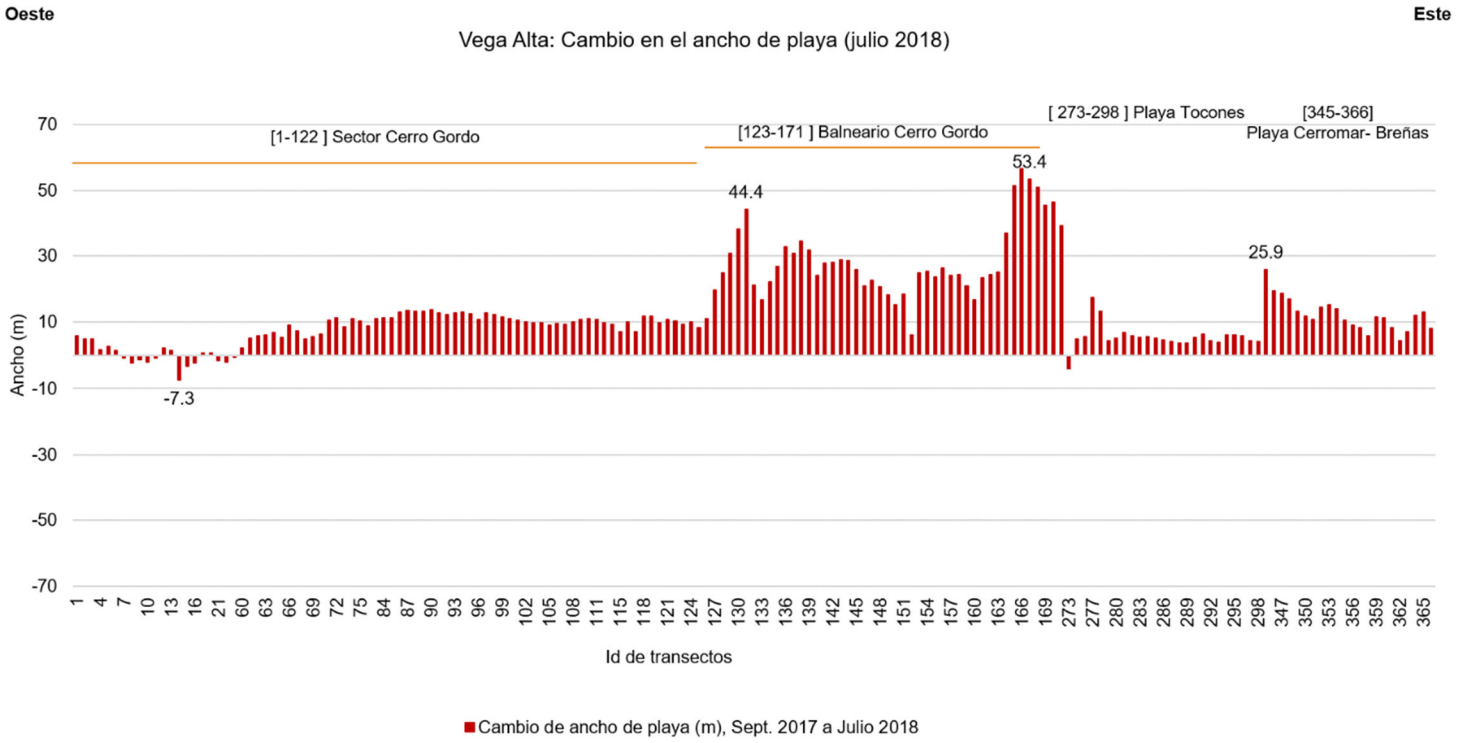

By July 2018, ten months after Hurricane María, approximately 93% of the beach coastline showed signs of accretion (Figure 29, only available in Spanish). Despite this overall recovery, Vega Alta Beach remained the only coastal sector experiencing erosion during this period. In 2018, shoreline migration was documented along approximately 1.9 km of the beach coastline. Areas where shoreline movement was observed included Vega Alta Beach, the western section of Balneario Cerro Gordo, and Tocones Beach. Two beach sectors were identified as experiencing inland shoreline migration in 2018: Vega Alta Beach and Cerromar Beach.

*Figure 28: Vega Alta - State of the Beach (Erosion vs. Accretion)*




Finally Figure 30 shows the specific changes in beach width for the period of September 2017 – July 2018 for the whole coastline of Vega Alta.

*Figure 29: Vega Alta - Change in Width of Beach (July 2018)*




### 4.15.1.2 Risk Magnitude

**Coastal Erosion**

Erosion is the process by which major storms, flooding, strong wave action, rising sea levels, and human activities wear away beaches and cliffs along coastlines (FEMA, 1997). Beaches are affected by storms and other natural events that cause coastal erosion; however, the extent and severity of the problem are not uniform, as they vary by location. Consequently, there is no single solution for mitigating erosion. Erosion processes and their impacts may be episodic or long term. These two (2) descriptors assign an important temporal component to erosion processes and their consequences.

Episodic erosion, also known as storm, induced erosion, primarily consists of the cross-shore movement of sand and sediments resulting from high intensity weather events and ocean storms. This type of response leads to coastal adjustment and occurs during a single storm or a sequence of storm events within a season. Changes in

beach and shoreline profiles during intense storms may result in dramatic erosion of beaches and dunes, including the reduction or removal of coastal dunes, as well as the retreat and collapse of coastal cliff formations. The consequences of this type of erosion may include increased inland wave penetration and ocean flooding in areas that were previously not exposed to water inundation.

Long term or chronic erosion, on the other hand, is associated with slower processes such as gradual shoreline change linked to:

- Increases in sea level,
- Land subsidence,
- Changes in sediment supply due to watershed modifications,
- Impacts on coral reefs resulting from rising water temperatures and ocean acidification,
- Coastal structures and development, and
- Decadal adjustments in rainfall, wind, and climate associated with global warming.

Erosion may also be caused by anthropogenic forces (Romeu Cotchett, 2012), including:

- Removal of coastal sediments, resulting in area erosion and the loss of dunes and beaches;
- Construction of developments, roadways, or agricultural activities, which increase sediment deposition and contamination in coastal waters, causing adverse effects on coral reefs. It should be noted that reefs function as natural barriers that protect beaches from wave impacts and, consequently, from erosion;
- Dam systems constructed to reduce the normal flow of sand delivered to the ocean by rivers; and
- Construction close to beaches, which allows the sea to advance further inland, thereby increasing erosion processes.

**Coastal Accretion**

Coastal accretion is a fundamental component of long-term coastal dynamics and represents the process by which sediment is deposited along the shoreline, resulting in the widening, elevation, or seaward movement of beaches, dunes, and other coastal landforms. Accretion occurs when sediment inputs exceed sediment losses

over time and plays a critical role in shaping shoreline configuration and influencing coastal hazard exposure (USGS, 2018).

For Mitigation planning coastal accretion is significant because it affects the capacity of beaches and dunes to function as natural protective features that reduce wave energy, coastal flooding, and erosion impacts. However, accretion is neither uniform nor permanent and must be evaluated in terms of its duration, spatial extent, and relationship to broader coastal processes (Bird, 2008).

Episodic coastal accretion refers to short term sediment deposition that occurs following discrete events or over limited periods, such as between storm seasons. This form of accretion is typically associated with the return of sediment from offshore bars or adjacent shoreline segments to the beach through cross shore or alongshore transport processes (Davidson Arnott, 2010).

Episodic accretion may result in temporary increases in:

- Beach width,
- Beach elevation, and
- Dune volume following storm related erosion.

These changes may occur rapidly, sometimes within weeks or months; however, episodic accretion represents temporary profile adjustment rather than sustained shoreline stabilization. Subsequent storms or shifts in hydrodynamic conditions may quickly redistribute or remove accreted sediments (Komar, 1998).
From a hazard mitigation perspective, episodic accretion may reduce short term exposure to wave action or tidal inundation but should not be assumed to provide long term protection unless supported by evidence of persistent sediment supply.

Long term coastal accretion occurs when sediment deposition persists over years to decades, resulting in stable or progressively advancing shorelines. This form of accretion reflects a positive sediment budget within the coastal system, often supported by consistent sediment delivery and favorable transport conditions (USGS, 2018).

Long term accretion is commonly associated with:

- Sustained sediment input from rivers or coastal ecosystems,

- Alongshore sediment transport that concentrates material in specific shoreline segments,
- Nearshore bathymetry that favors sediment retention, and
- Relatively stable mean sea level conditions relative to land elevation (Bird, 2008).

While long term accretion can enhance coastal resilience by reinforcing beaches and dunes, it is often spatially limited and may occur concurrently with erosion in adjacent areas. In many cases, accretion reflects sediment redistribution rather than net sediment gain across a regional coastline (Mentaschi et al., 2018).

Human activities can influence coastal accretion both directly and indirectly. In some cases, engineered interventions such as beach nourishment or coastal structures may promote localized sediment accumulation. In other cases, development and infrastructure interfere with natural sediment pathways, limiting accretion potential elsewhere (Komar, 1998).

Anthropogenic factors affecting accretion include:

- Beach nourishment and sediment placement projects,
- Coastal structures that trap sediment locally,
- Alterations to river systems that modify sediment delivery, and
- Shoreline development that restricts natural shoreline adjustment (NOAA, 2020).

While engineered accretion may provide short to medium term protective benefits, it typically requires long term maintenance and should be evaluated within the context of sustained coastal dynamics.

**Change in Base Sea Level Mean**

Changes in the mean (base) sea level, commonly referenced using tidal datums such as mean sea level (MSL) or mean higher high water (MHHW), represent an important component of long-term coastal dynamics and influence the frequency and extent of coastal inundation. Mean sea level serves as a baseline against which shoreline position, wave interaction, and tidal flooding are measured, and gradual shifts in this baseline affect how coastal systems respond over time (NOAA, 2026). Sustained increases in mean sea level relative to the land surface allow wave energy to act on higher portions of the coastal profile, increasing the frequency of tidal flooding and

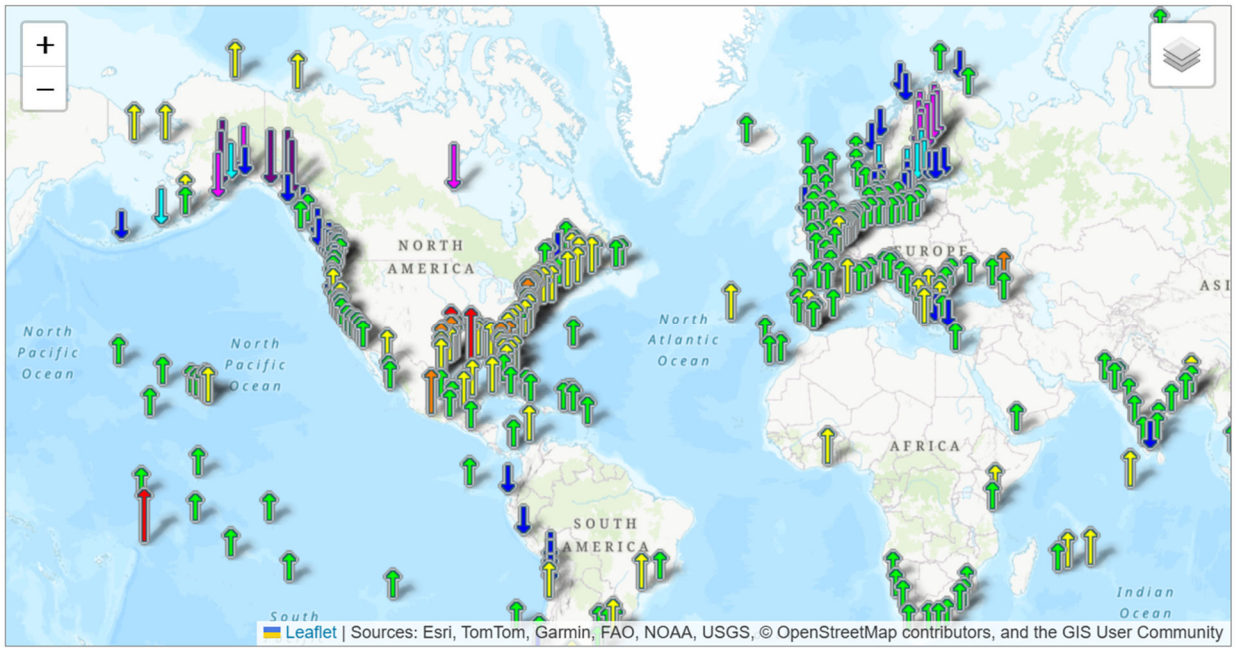
accelerating shoreline adjustment processes. These incremental changes can lead to landward migration of beaches and dunes, greater exposure of low-lying areas to coastal flooding, and reduced effectiveness of natural and engineered protective features, even in the absence of major storm events. From a hazard mitigation planning perspective, changes in mean sea level contribute to long term increases in coastal hazard exposure and should be considered when evaluating future risk, land use suitability, and infrastructure resilience along the coast (USGS, 2018) (NOAA, 2026).

Sea level fluctuates over both short - and long-term timeframes as a result of multiple interacting factors. Short term variations typically occur daily to event-based timescales and are influenced by processes such as waves, tides, and discrete flooding events, including those associated with seasonal snowmelt, hurricanes, or other coastal storms. In contrast, long-term sea-level variations occur over extended periods ranging from months to multiple years and may manifest as recurring cycles, gradual trends, or episodic departures from typical conditions. These longer-term changes are influenced by a combination of factors, including seasonal atmospheric patterns, variations in the Earth's declination, changes in coastal and ocean circulation, human activities such as dredging, vertical land motion, and large-scale climate–ocean oscillations such as the El Niño–Southern Oscillation.

When evaluating long-term sea-level trends, a minimum observational record of 30 years is commonly used to capture these underlying variations and minimize uncertainty associated with shorter term fluctuations in monthly mean sea level. Accounting for predictable and repeatable processes—such as tidal cycles, seasonal variability, and interannual oscillations—allows for a more accurate representation of long-term sea-level behavior (NOAA, 2026).

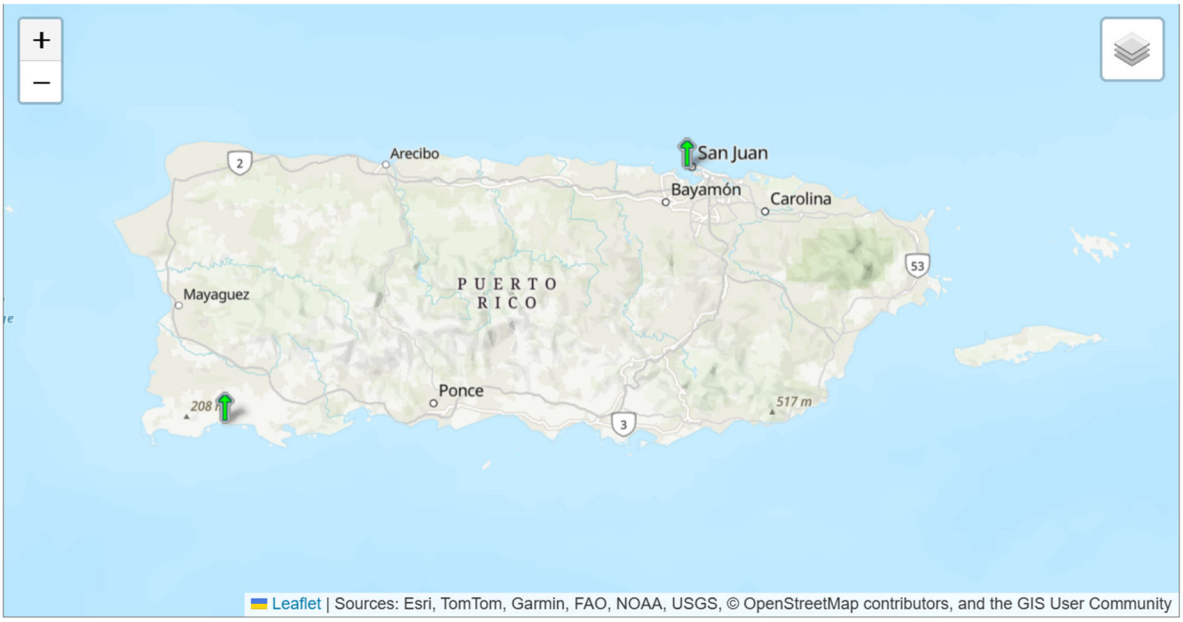
NOAA's Relative Sea Level Trends website provides the up-to-date trends for sea levels at a global scale. The global sea level trend has been measured using satellite altimetry since 1992, and the most recent global estimates, along with maps showing regional variations, are available from NOAA's Laboratory for Satellite Altimetry. The screen shot below shows the map provided by NOAA as of 4/29/2026 (NOAA, 2026).
As figure __ show, although there are various places where the sea level has decreased (specially to the south of Alaska, the west of British Columbia, Hudson Bay, the Nordic countries and among some parts of the South American western coast (Ecuador, Peru and northern Chile) the general trend is for an increasing sea level in varying degrees.

*Figure 30: NOAA's Relative Sea Level Trend Map*




In the case of Puerto Rico, according to this map there has been observed an increase in base sea levels.

*Figure 31; NOAA's Relative Sea Level Trend Map (Zoom to Puerto Rico)*




The gauges shown in the map present the following data:

*Table 32: Puerto Rico Sea Level Observations*

| Gauge Name | Trend | Period | Commentary |
|---|---|---|---|
| Magueyes Island, PR 9759110 | + 2.06 mm/year | 1955 - 2025 | The relative sea level trend is 2.06 mm/year with a 95% confidence interval of +/- 0.27 mm/year based on monthly mean sea level data from 1955 to 2025 which is equivalent to a change of 0.68 feet in 100 years. |
| San Juan, PR 9755371 | +2.16 mm/year | 1962 - 2025 | The relative sea level trend is 2.16 mm/year with a 95% confidence interval of +/- 0.32 mm/year based on monthly mean sea level data from 1962 to 2025 which is equivalent to a change of 0.71 feet in 100 years. |

Figures 33 and 34 are screen grabs from the Relative Sea Level Website. Figure 33 shows the trend for the Magueyes Island gauge if 2.06 mm/year, while figure 24 shows the trend in San Juan of 2.16 mm/year.

*Figure 32: Relative Sea Level Trend 9759110 Magueyes Island, PR*

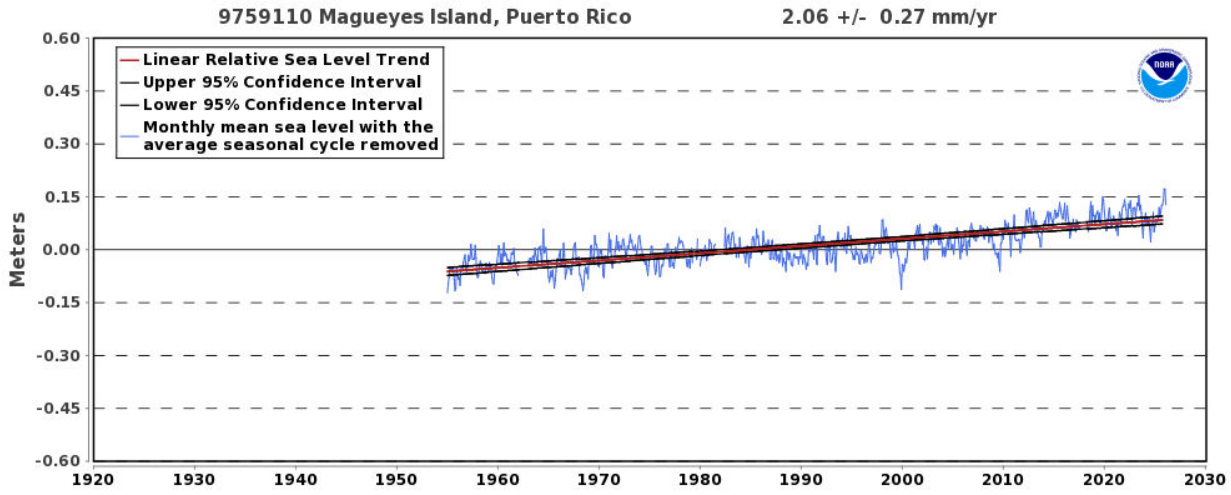
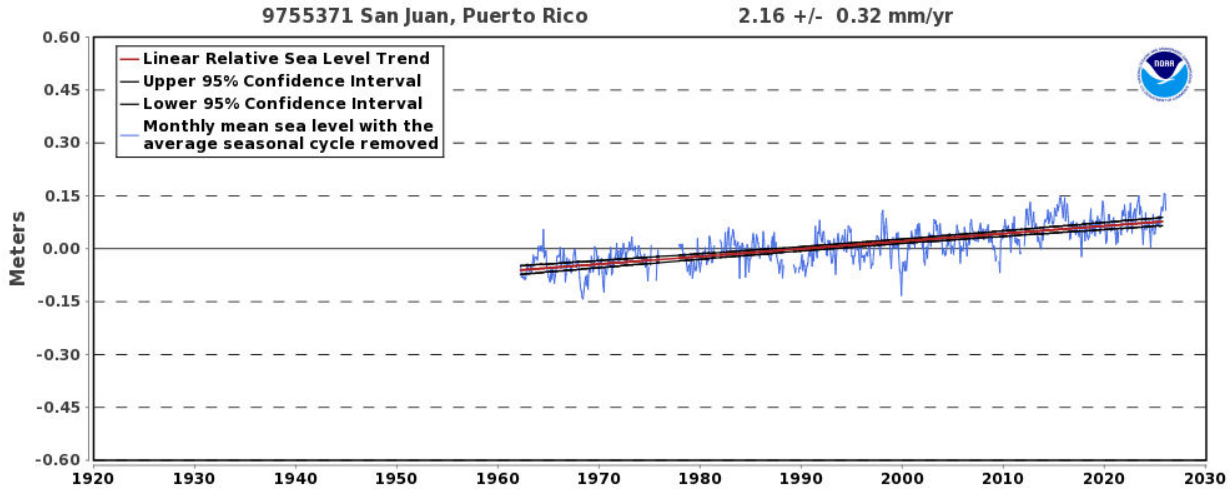


*Figure 33: Relative Sea Level Trend 9755371 San Juan, PR*




### *4.15.1.3 Past Events*

Section 4.15.1.1 above details the changes in beach erosion or accretion for the beaches in Vega Alta in the aftermath of Hurricane María as detailed in the COREPI-PR study.

This study brought forth the following key findings (COREPI-PR, 2020):

- Widespread Coastal Erosion: Significant erosion occurred along multiple beach segments following Hurricane María, particularly in Arroyo, Humacao, and Barceloneta, reducing beach width and elevation and increasing exposure to storm surge and flooding. https://storymaps.arcgis.com/stories/ac6e366a14d840e88a266d23b440ab0c
- Partial Natural Recovery: Ten months after the hurricane, many beaches exhibited sediment accretion and partial recovery; however, recovery was uneven and site specific, with some areas remaining highly vulnerable to future events.
- Beach Migration: The study documented permanent inland migration of beaches in several municipalities, including Añasco, Humacao, Arecibo, Aguada, and Rincón. This indicates a long-term shift of the shoreline landward, increasing risk to inland infrastructure and properties.
- Influence of Built Infrastructure: Erosion was frequently observed adjacent to rigid shoreline structures (e.g., seawalls, rip rap, coastal development),

suggesting that hardened shorelines may exacerbate erosion processes and reduce natural beach resilience.

- Loss of Protective Function: In several locations, the reduction of beach width and loss of sandbars diminished the beach's capacity to function as a natural protective barrier, resulting in greater susceptibility to storm surge damage during subsequent events (e.g., 2018 extra tropical storms).

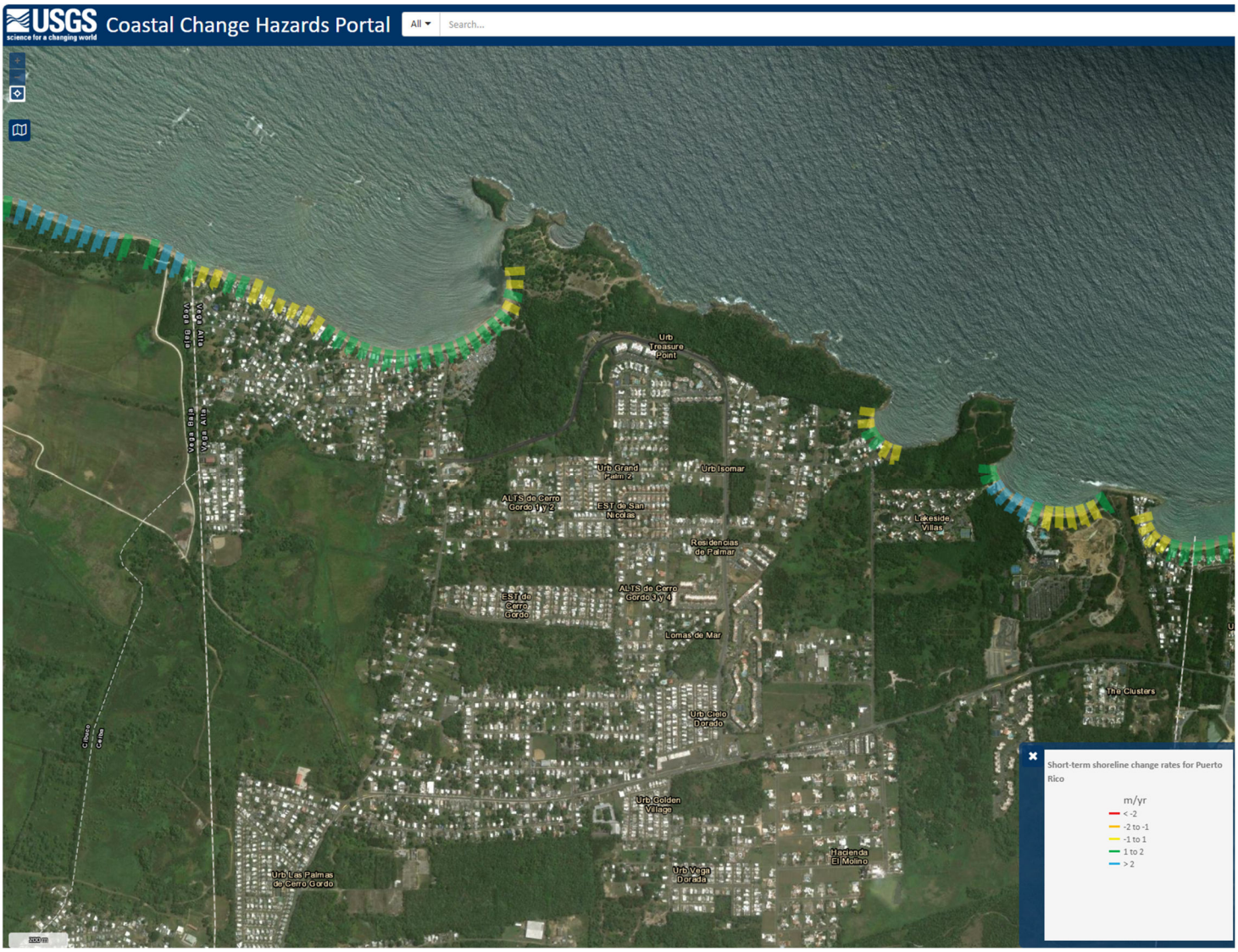
The findings of this study are important for hazard mitigation planning since beaches are a critical natural infrastructure that provide coastal protection by dissipating wave energy, reducing flooding extent, and protecting inland development. The documented erosion, beach migration, and reduced protective capacity highlight increased vulnerability to; coastal flooding, storm surge, wave action and progressive shoreline retreat.

These findings support the integration of coastal erosion monitoring, nature-based solutions, land use planning controls, and adaptive shoreline management strategies into local and regional hazard mitigation efforts. The assessment also provides a baseline for prioritizing mitigation projects and for validating requests for local, state, and federal mitigation funding.

In addition to the COREPI-PR study, the United States Geological Survey (USGS) Coastal Change Hazards Portal documents shoreline changes along the coasts of the United States, including Puerto Rico, using both historical sources, such as aerial photographs and topographic surveys, and contemporary datasets, including lidar point clouds and digital elevation models. These shoreline datasets are compiled and analyzed using the USGS Digital Shoreline Analysis System (DSAS) Version 5.1, which calculates historical rates of shoreline change.

Data available through the Coastal Change Hazards Portal indicates significant short-term shoreline changes along the coast of Vega Alta over an approximately 40-year period (1978-2018). The area surrounding Cerro Gordo Public Beach, near the Vista Alegre community, experienced shoreline retreat rates of approximately 1 to 2 meters per year. In contrast, Cerromar Beach experienced shoreline retreat exceeding 2 meters per year over the same period, highlighting the area's vulnerability to coastal erosion (Figure 35).

*Figure 34: – Short – Term Shoreline Changes*




### *4.15.1.4 Future Events Probability*

The Municipality of Vega Alta is subject to ongoing coastal processes, including shoreline erosion, coastal flooding, and sea level rise. As described before, historical shoreline changes analyses conducted by the U.S. Geological Survey (USGS) and findings from the Puerto Rico Coastal Resilience Master Plan (COREPI-PR) indicate that portions of the municipality's coastline have experienced long-term erosion and are vulnerable to future coastal changes.

The Fifth National Climate Assessment (NCA5) identifies sea level rise and changing storm patterns as key drivers of increasing coastal hazards, including flooding and erosion. The assessment concludes that these impacts are expected to increase over time as sea levels continue to rise and coastal ecosystems become increasingly stressed. (May, C.L., et al, 2023), (Méndez Lázaro, P.A, 2023)

Similarly, the 2022 Sea Level Rise Technical Report projects that sea level in the Caribbean region could rise approximately 8 to 10 inches (0.2 to 0.25 meters) by 2050 relative to 2020 conditions, contributing to more frequent coastal flooding and increased erosion hazards. (NOAA, 2022)

Given documented shoreline changes, observed sea level rise trends in Puerto Rico, and federal projections of future sea level rise, coastal erosion and associated coastal flooding are expected to remain significant long-term hazards for Vega Alta throughout the planning period.

## 4.15.2 Risk Analysis

### *4.15.2.1 Estimated Losses*

Monetary losses due to the expected coastal dynamics cannot be determined at this point

### *4.15.2.2 Lifelines and Critical Infrastructure*

**Coastal Erosion**

Coastal erosion is a long-term, progressive hazard that results in the loss of shoreline, land instability, and the degradation of natural protective features such as beaches, dunes, and wetlands. This hazard is driven by wave action, coastal storms, flooding, and long-term shoreline change processes, and it poses increasing risks to developed coastal areas and supporting infrastructure. In coastal communities, erosion directly affects the Community Lifelines that are essential to public safety, economic stability, and effective emergency response (FEMA, 2024).

- Safety and Security Lifeline is particularly vulnerable to coastal erosion. Law enforcement facilities, fire stations, emergency operations centers, and evacuation routes located near the shoreline may experience increasing exposure as erosion undermines foundations, access roads, and protective

buffers. Roadway narrowing or collapse caused by shoreline retreat can reduce emergency response times and limit evacuation capacity during hazard events, placing residents and responders at greater risk (FEMA, 2021)

- The Food, Water, and Shelter Lifeline is also impacted as erosion threatens utility infrastructure and housing stock. Water distribution lines, wastewater systems, and stormwater infrastructure may become exposed or damaged as coastal land erodes, increasing the risk of service disruptions and water quality concerns. In areas where erosion leads to the loss of residential structures, displaced households may require emergency shelter and housing assistance. Additionally, erosion affecting ports, coastal roads, and access points can disrupt food supply chains and the delivery of essential goods, particularly in geographically isolated or island communities (FEMA, 2024).

- Coastal erosion can adversely affect the Health and Medical Lifeline by limiting access to healthcare facilities and emergency medical services. Hospitals, clinics, and pharmacies located in erosion-prone areas may face increased structural risk or reduced accessibility. Transportation disruptions caused by erosion can delay emergency medical response and impede the delivery of medical supplies. Secondary public health concerns may arise when erosion damages water and wastewater infrastructure, potentially increasing exposure to contaminants or unsanitary conditions (USGS, 2025); (FEMA, 2021).

- The Energy Lifeline, including power generation, transmission, and fuel systems, is highly susceptible to erosion-related impacts. As shorelines retreat, erosion can expose underground electrical lines, pipelines, substations, and fuel storage facilities that were previously protected by coastal landforms. Damage to this infrastructure can result in power outages or fuel shortages, affecting residents, critical facilities, and emergency response operations that rely on consistent energy supply (USACE, 2013); (FEMA, 2021)

- Erosion also threatens the Communications Lifeline by damaging or destabilizing physical infrastructure such as cell towers, fiber-optic cables, and communications hubs located in coastal areas. Loss of communications systems can impair emergency notification, 911 services, and coordination among response agencies. Reduced system redundancy along eroding shorelines increases the likelihood that communications outages will occur during coastal hazard events (FEMA, 2024).

- The Transportation Lifeline experiences direct and cascading impacts from coastal erosion. Roads, bridges, ports, ferry terminals, and coastal airports may be undermined or rendered inoperable as erosion progresses. Transportation disruptions limit evacuation routes, restrict access for emergency responders, slow the delivery of supplies, and delay recovery operations. These impacts can have significant economic consequences and prolong community recovery following disaster events (USGS, 2023).

- Finally, coastal erosion may affect the Hazardous Materials Lifeline by exposing buried fuel tanks, contaminated soils, or legacy industrial sites located near the coast. Erosion can increase the risk of hazardous material releases, threatening environmental quality and public health, and complicating emergency response and cleanup efforts. Facilities handling hazardous materials lose natural protective buffers as shorelines retreat, increasing the likelihood of cascading impacts during severe weather events (USGS, 2023); (FEMA, 2021).

**Variations in Mean Base Sea-Level**

Sea level increase is a chronic and progressive coastal hazard that increases the frequency, depth, and duration of coastal flooding while accelerating erosion and shoreline instability. As relative sea levels rise, coastal communities experience more frequent high-tide flooding, expanded floodplains, and greater storm surge impacts. These changes place increasing stress on the Community Lifelines that support public safety, economic stability, and emergency response, even in the absence of major storm events (FEMA, 2024).

- The Safety and Security Lifeline is affected as sea level rise increases the exposure of emergency facilities and evacuation routes to recurrent flooding. Police stations, fire stations, and emergency operations centers located in low-lying coastal areas may experience reduced functionality or loss of access due to chronic inundation. Rising seas can also compromise evacuation routes, bridges, and ingress/egress corridors, limiting the ability to conduct timely evacuations and delaying emergency response during hazard events (FEMA, 2021); (USGS, 2025).

- Sea level increase presents significant challenges to the Food, Water, and Shelter Lifeline. Potable water systems, wastewater treatment plants, and stormwater infrastructure are increasingly vulnerable to tidal flooding and saltwater intrusion as sea levels rise. These impacts can disrupt service delivery,

degrade water quality, and increase maintenance and operational costs. In addition, repetitive flooding can damage residential structures, reduce housing availability, and increase demand for emergency shelter and long-term housing assistance, particularly in socially vulnerable communities (USGS, 2025).

- The Health and Medical Lifeline is impacted through both direct and indirect effects. Healthcare facilities located in flood-prone coastal zones may experience operational disruptions, equipment damage, or access constraints due to flood-impacted transportation networks. Frequent flooding can hinder patient movement, delay emergency medical services, and disrupt supply chains for pharmaceuticals and medical equipment. Public health concerns may also increase as rising groundwater and flooded sanitation systems elevate the risk of contamination and disease exposure (USGS, 2025; FEMA, 2024).

- Sea level increase also threatens the Energy Lifeline by increasing flood risk to power generation facilities, substations, fuel terminals, and transmission infrastructure located near the coast. Even minor but repeated flooding events can degrade electrical components and reduce system reliability, leading to power outages that affect residences, businesses, and critical facilities. Fuel distribution systems and ports may also experience operational interruptions, limiting fuel availability for generators, emergency vehicles, and recovery operations (FEMA, 2024).

- Communications Lifeline is vulnerable as increase in base sea level potentiates exposure of communications infrastructure, including cell towers, fiber-optic networks, and data facilities, to chronic flooding and corrosion. Disruptions to communications systems can impair emergency notification, 911 services, and interagency coordination. Repeated flood exposure without permanent mitigation measures may result in cumulative damage and decreased system reliability over time (FEMA, 2024).

- Transportation systems Lifeline are particularly sensitive to increase in base sea levels. Roads, bridges, ports, ferries, and coastal airports may experience more frequent closures or long-term service reductions due to flooding and infrastructure degradation. Transportation disruptions can isolate communities, delay emergency response, limit evacuation options, and impede the movement of goods, services, and recovery resources (USGS, 2025).

- Finally, increase in the mean base sea level can affect the Hazardous Materials Lifeline by increasing exposure of industrial sites, fuel storage areas, landfills, and wastewater facilities to flooding. Inundation of these sites raises the potential for releases of hazardous substances, posing risks to human health, ecosystems, and drinking water supplies. Managing these risks becomes more complex as flood frequencies increase and protective buffers are lost (FEMA, 2021); (USGS, 2025).

#### *4.15.2.3 Social Vulnerabilities*

Long-term coastal dynamics can be not only a physical hazard but also a social stressor that disproportionately affects certain populations due to preexisting social, economic, and environmental conditions.

Low-income households are among the most socially vulnerable to long-term coastal dynamics. These populations are more likely to reside in older or lower-cost housing located in high-risk coastal areas and may lack the financial resources needed to invest in mitigation measures, such as structural reinforcement or relocation. As erosion or inward changes in shoreline progresses, declining property values can further reduce household wealth and limit access to insurance, credit, and recovery assistance, thereby prolonging vulnerability and recovery timelines (FEMA, 2023).

Housing insecurity is a significant concern associated with long-term coastal dynamics. Gradual land loss can render homes unsafe or uninhabitable, leading to chronic displacement rather than sudden disaster-related relocation. Renters are particularly vulnerable, as they often have limited control over mitigation decisions and may be displaced without sufficient notice or long-term relocation support. In communities with limited affordable housing options, erosion-related housing loss can increase overcrowding, homelessness, or permanent out-migration (FEMA, 2023).

Elderly individuals, people with disabilities, and those with chronic health conditions face heightened risks as coastal erosion disrupts access to essential services and infrastructure. Eroded or flooded roadways and transportation networks can isolate neighborhoods from healthcare facilities, pharmacies, grocery stores, and social services. These populations may also experience limited mobility or depend on in-home medical equipment, increasing their sensitivity to infrastructure disruptions associated with erosion (FEMA, 2023).

Communities that rely on coastal and marine resources for their livelihoods are also socially vulnerable to erosion. Fishing communities, small tourism-dependent businesses, and subsistence users may experience economic losses as shorelines retreat, beaches narrow, and access to coastal infrastructure is reduced. These impacts can lead to job loss, reduced household income, and community-wide economic stress, particularly in rural and island settings where economic diversification is limited (USGS, 2023).

#### 4.15.2.4 Natural and Cultural Resources

Long-term coastal dynamics can significantly impact natural resources by altering shorelines, degrading habitats, and disrupting ecological processes. As beaches, dunes, wetlands, and mangroves erode or become permanently inundated, the natural systems that provide storm protection, water filtration, and wildlife habitats are reduced or lost. These changes can lead to declines in biodiversity as plant and animal species lose critical breeding, feeding, and nesting areas. Saltwater intrusion caused by rising sea levels can also degrade freshwater ecosystems, affecting groundwater, estuaries, and coastal forests. Increased erosion can mobilize sediments and pollutants, diminish water quality and harm coral reefs and seagrass beds. Over time, the loss of natural coastal features reduces ecosystem resilience and increases inland exposure to flooding and storm impacts. (USGS, 2023)

Long-term coastal dynamics can also pose serious threats to cultural resources, particularly those located near shorelines. Historic buildings, archaeological sites, cemeteries, and cultural landscapes may be damaged or permanently lost as shorelines retreat and soils are destabilized. Gradual erosion can undermine foundations and expose artifacts, making sites vulnerable to destruction, looting, or environmental decay. As these resources are often irreplaceable, coastal erosion and sea level rise represent not only physical loss but also the loss of cultural memory and heritage passed through generations (USGS, 2023).

#### 4.15.2.5 Future Conditions

As discussed in section 4.15.1 long-term coastal dynamics are understood to contribute to loss of shoreline, either due to coastal erosion or increases in mean base sea level. Specific mitigation actions to deal with expected future conditions will be included as part of Section 6.5.

## 4.16 Pandemic/Epidemic

### 4.16.1 Description (B1-a)

An epidemic occurs when the incidence of a disease or health-related event rises suddenly and significantly above what is expected in a specific community or region. According to the CDC, an epidemic represents a sudden increase in cases over the normal baseline in a population, and outbreaks—often used interchangeably—refer to such events in more limited geographic areas. (CDC, 2012)

A pandemic is essentially an epidemic that has expanded to span multiple countries or continents, affecting a large portion of the global population. The CDC describes it as an epidemic with broad geographic spread, while the World Health Organization defines it as the worldwide transmission of a new disease to which people generally have little or no immunity. (CDC, 2012)

These terms emphasize both the magnitude of cases and their geographical distribution: an epidemic is localized, but a pandemic reaches across international borders and impacts global public health systems. Emergency responses must therefore be scaled from regional interventions during epidemics to coordinated global action in pandemics.

#### *4.16.1.1 Affected Area (B1-b)*

This LHMP considers that all areas of the municipality are equally vulnerable to the Epidemic/Pandemic Hazard

#### *4.16.1.2 Risk Magnitude (B1-c)*

Though all can cause loss of life and economic disruption it is important to clarify terms:

- Epidemic refers to a sudden increase in the number of disease cases beyond what is normally expected within a specific population and geographic area.
- Outbreak shares the same definition as epidemic but is typically used for a more localized area.
- Cluster describes a grouping of cases in a particular place and time that appears to exceed the expected number, even if that expected number is unknown.
- Pandemic refers to an epidemic that has spread across multiple countries or continents, usually affecting a large population (CDC, 2012).

### 4.16.1.3 Past Events (B1-D)

The following table listing epidemics and pandemics in Puerto Rico has been collected from various sources. This list does not intend to be exhaustive:

*Table 33: Pandemics and Epidemic in Puerto Rico 1855 - 2020*

| Disease | Date | Classification | Description |
|---|---|---|---|
| Cholera Epidemic | 1855 - 1856 | Epidemic | Between 1855 and 1856, Puerto Rico suffered a major cholera outbreak that claimed over 25,820 lives, representing approximately 4–10% of the island's population at the time. (Vega Lugo, 2021) |
| Measles and Malnutrition | 1917 - 1918 | Epidemic | A severe measles outbreak occurred between 1917 and 1918, resulting in nearly 9,000 cases and approximately 2,000 deaths. High infant mortality—59% of deaths within six months were in children under two—was driven by malnutrition and poor living conditions (Rigau-Pérez & Vallejo - Calzada, 2020). |
| Spanish Flu (A/H1N1 influenza pandemic) | 1918 - 1919 | Pandemic | Puerto Rico was affected by the global A/H1N1 influenza pandemic, also known as the Spanish flu. Beginning around June 1918, community spread produced as many as 1,000 cases in four days in areas like Puerta de Tierra. Misdiagnosis as dengue initially obscured the true impact (Rosario Urrutia, 2021). |
| Poliomyelitis | 1960 | Epidemic | The 1960 polio epidemic in Puerto Rico was the most severe paralytic polio outbreak in the Western Hemisphere at the time. It impacted 68 of 76 municipalities, causing 495 cases of paralysis, |

| Disease | Date | Classification | Description |
|---|---|---|---|
| | | | predominantly among school-age children (Timothee, Morris, Filiberti, & Mainardi, 1963). |
| Dengue | 2013, 2024 | Outbreak | Dengue is endemic in Puerto Rico, with significant outbreaks occurring in 2013 and again in 2024. The 2024 outbreak triggered a public health emergency, with 6,291 confirmed cases, a 4.2% rate of severe dengue, and 11 deaths reported (Rodríguez, et al., 2024) (Ware-Gilmore, et al., 2025) |
| Chikungunya | 2014 | Epidemic | The first locally acquired chikungunya case in Puerto Rico was confirmed on May 5, 2014, triggering expanded surveillance efforts using Puerto Rico's dengue infrastructure. Between May 5 and August 12 of that year, 10,201 suspected cases (approximately 282 per 100,000 residents) were reported, of which 1,975 (68%) were laboratory-confirmed. During this period, four deaths were also recorded. (Sharp, et al., 2014) |
| Zika | 2015 - 2016 | Epidemic | The first locally transmitted Zika case in Puerto Rico was reported in December 2015. By April 2016, over 6,000 suspected cases had been evaluated, with 683 confirmed cases. Pregnant women and related neurological issues (e.g., Guillain-Barré syndrome) were of particular concern. (Thomas, et al., 2016) (Dirlikov, et al., 2016) |

| Disease | Date | Classification | Description |
|---|---|---|---|
| COVID - 19 | 2020 - 2022 | Pandemic | See narrative below |

**COVID Pandemic**

Puerto Rico confirmed its first COVID-19 case—a European tourist—on March 8, 2020, leading the governor to declare an emergency on March 12 and implement early measures including airport screening and mandatory isolation, as outlined in the Puerto Rico Department of Health's epidemic situation reports (PRDH, 2022), (COR3, n.d.). By April 6, 2022, official data reported 270,485 confirmed cases and 4,171 deaths due to COVID-19 in Puerto Rico, according to detailed government spreadsheets and dashboards maintained by the Puerto Rico Health Department (PRDH, 2022), (COR3, n.d.).

The territory experienced significant economic and social disruptions: a Bayesian analysis revealed a clear causal relationship between rising COVID-19 infections and increased unemployment, and engineering studies from the University of Puerto Rico–Mayagüez estimated that unemployment soared above 17%, also noting elevated operating costs for businesses due to PPE and safety measures (Hernández - Padilla & Méndez-Piñero, 2020).

Subsequent public health research revealed widespread mental health consequences: one study found that 31% of healthcare workers scored in the range of depressive symptomatology following combined stress from prior disasters (e.g., hurricanes) and the pandemic; another identified high levels of anxiety (26.9%) and stress (69.9%) among physicians during the second COVID-19 wave (Hernández - Torres, et al., 2023), (Sánchez - Plazas, García - De Jesús, Martínez - González, Amaya - Ardila, & Almodóvar - Rivera, 2024).

### *4.16.1.4 Future Events Probability (B1-e)*

Puerto Rico's susceptibility to future pandemics or epidemics is underscored by its subtropical climate, population distribution, and healthcare infrastructure. A university-developed emergency preparedness model—commissioned by Puerto Rico's Department of Health—simulated influenza pandemics and demonstrated how variations in disease transmissibility, healthcare capacity, and mitigation efforts can significantly influence outbreak trajectories and the likelihood of healthcare system overload. Furthermore, the U.S. Department of Health and Human Services' Hospital

Preparedness Program (HPP) in Puerto Rico operates under the Assistant Secretary for Preparedness and Response, with coordinated health care coalitions and special pathogen systems explicitly designed to reduce pandemic risk by strengthening surge capacity and infection-control readiness. These combined efforts reflect a data-driven recognition that, without sustained investment in public health infrastructure and preparedness modeling, Puerto Rico remains at an elevated probability for experiencing another epidemic or pandemic (Hirsh & Centeno - Marín, 2015), (ASPR, n.d.)

### 4.16.2 Risk Assessment (B2-a, B2-b)

#### *4.16.2.1 Estimated Losses*

The COVID-19 pandemic resulted in significant mortality across Puerto Rico, underscoring the importance of public health hazards in local mitigation planning. Official data from the Puerto Rico Department of Health indicate that COVID-19 mortality is tracked through an epidemiological surveillance system that compiles death certificate data and case investigations and is made publicly available through government data portals. At the territorial level, thousands of deaths have been attributed to COVID-19 since 2020, as reported in official datasets and federal summaries. However, cumulative mortality totals for individual municipalities, including Vega Alta, revision are not consistently published as single static figures in official reports. Instead, municipality-level death counts must be obtained by querying downloadable datasets provided by the Puerto Rico Department of Health, which allow users to filter results by municipality.

These datasets are considered provisional and subject to due to reporting delays and ongoing validation of death records, as acknowledged by public health authorities. Consequently, while Vega Alta-specific COVID-19 mortality was not recorded as fixed published figure. Based on the currently available data, the total number of COVID-19-related deaths in Vega Alta cannot be reliably determined.

#### *4.16.2.2 Critical Infrastructure and Lifelines*

The most affected lifeline in the case of a pandemic or epidemic is the healthcare and medicine lifeline. This is so because in response to a pandemic/epidemic hospitals, clinics and other healthcare facilities can be overwhelmed by the high demand of services. There are shortages of PPE, medical devices (ventilators in the case of COVID-19) and medical staff. Since the pandemic/epidemic is the priority there will be delays

in non-related medical care. Finally, there can be serious challenges in the management of mortality services.

However other lifelines can be affected such as the Food, Hydration and Shelter Lifeline, due to increase food insecurity from unemployment and economic shutdowns ort closed or reduced shelters due to infection control requirements. The Safety and Security Lifelines can be affected by high absenteeism due to illness, quarantine or caregiving responsibilities and increase levels of stress and burnout among first responders and law enforcement officers.

Other lifelines and critical infrastructures can be affected by increased demand, like increased residential water demand) or the lack of trained personnel to maintain existing operations.

#### *4.16.2.3 Social Vulnerability*

For this hazard, the whole population of Vega Alta is considered equally vulnerable. Nonetheless besides factors of age and poverty, the 2024 ACS shows that a total of 1,427 people in Vega Alta did not have health insurance coverage (US Census Bureau, 2025). This means that 4.1% of the total population of Vega Alta is uninsured.

Of those most of the uninsured group belonged to the 26-to-34-year cohort (455 persons) followed by the cohort of 45 to 54 years (245 persons).[19] The results given by the ACS shows that the young adult population is the most vulnerable in terms of uninsured in the face of a pandemic or epidemic.

Table 32 shows the breakdown of uninsured people in Vega Alta according to the 2024 ACS

*Table 34: Number of People in Vega Alta without Healthcare Coverage*

| Age Cohort | Number of people uninsured |
|---|---|
| Under 6 years | 35 |
| 6 to 18 years | 67 |
| 19 to 25 years | 216 |
| 26 to 34 years | 455 |

[19] US Census 2023 ACS Table S2701

| Age Cohort | Number of people uninsured |
|---|---|
| 35 to 44 years | 206 |
| 45 to 54 years | 245 |
| 55 to 64 years | 158 |
| 65 to 75 years | 24 |
| 75 years or older | 21 |

Source: US Census Bureau (ACS, 5 years estimates 2020-2024)

This would be considered population at risk in case of a pandemic or epidemic. Further information regarding social vulnerability can be found in Section 3.4.4

#### *4.16.2.4 Natural and Cultural Resources*

The scientific literature shows that the COVID-19 Pandemic was a mixed bag for the environment. On one hand the unprecedented pandemic-related lockdowns had negative effects on the physical environment. These impacts included increased pollution from the widespread use of personal protective equipment, deforestation, illegal poaching and logging, overfishing, and disruptions to conservation programs and projects. The findings also note that the spread of pandemics may be intensified by environmental pollution and rapid global population growth (Muche, Yemata, Molla, Muasya, & Tsegay, 2022), (Guo & Lee, 2021).

At the same time, despite these adverse impacts, the period of reduced human activity—often referred to as the *anthropause*—also produced several positive effects on natural resources. These included short-term reductions in indoor and outdoor air pollutants ($PM_{2.5}$, $PM_{10}$, $NO_2$, $SO_2$, CO, and $CO_2$) and decreases in noise pollution from ships, boats, vehicles, and aircraft. Collectively, these changes benefited aquatic ecosystems and water quality, influenced bird behavior, supported wildlife biodiversity, and contributed to temporary ecosystem recovery. (Muche, Yemata, Molla, Muasya, & Tsegay, 2022)

When it comes to cultural and heritage sites a report from UNESCO states that crisis has produced both negative and positive effects across different types of World Heritage properties (UNESCO, 2021). The sudden cessation of travel and tourism disrupted visitor flows and eliminated a critical source of revenue for many sites, where tourism income is essential to supporting conservation activities, routine

maintenance, and staff salaries. Local communities surrounding these properties were similarly affected, with widespread loss of employment and income.

Conversely, in some cases the reduced level of human activity enabled rehabilitation and restoration efforts to proceed more efficiently, while anthropogenic pressures were temporarily reduced across many natural areas. This contrast highlights the diverse and uneven impacts of the crisis on World Heritage properties. At the same time, it presents an opportunity to build on the benefits associated with the easing of specific pressures at certain sites, while advancing targeted research and strategic recovery planning (Guo & Lee, 2021) (Guibert & Hyde, 2021), (UNESCO, 2021).

#### 4.16.2.5 Future Conditions (E1-a)

Puerto Rico faces structural and environmental conditions that elevate its exposure and vulnerability to future pandemics relative to many mainland U.S. locations. As a tropical island with high population density in urban corridors, frequent international travel, and climatic conditions favorable to vectors and pathogens, Puerto Rico is particularly susceptible to emerging and re-emerging infectious diseases, especially those with zoonotic or vector-borne origins. The CDC and peer-reviewed research document ongoing transmission of diseases such as dengue and previous outbreaks of Zika and Chikungunya, demonstrating the island's continued exposure to pathogens with outbreak and epidemic potential. This exposure holds regardless of the development pattern of the municipality.

## 4.17 Hazard Prioritization

After receiving feedback from the public and stakeholders (see Section 2.3) along with their own expertise the planning committee has determined that the following is the prioritization for the hazard discussed in this LHMP.

*Table 35*

| Hazard | Priority |
|---|---|
| Earthquake | High Priority |
| Landslide | Mid Priority |
| Tsunami | Mid Priority |
| Flooding | High Priority |
| Tropical Cyclones/Extreme Winds | Mid Priority |
| Storm Surge | Low Priority |
| Extreme Heat | Low Priority |

| Hazard | Priority |
|---|---|
| Drought | Mid Priority |
| Wildfire | Low Priority |
| Long-Term Coastal Dynamics | Mid Priority |
| Pandemics/Epidemic | Low Priority |

## 4.18 Planning Mechanism

Understanding and recognizing regulatory and planning capacities enables more effective management of land use and economic growth. These capacities consist of the legal frameworks and public policy provisions that influence land use to guide sustainable development, while also supporting actions that mitigate the vulnerability of communities and their resources to natural hazards.

Besides the Public Policies already discussed in Section 1.1, what follows is a list in chronological order of the regulatory and planning mechanisms available to the municipality for the implementation of this LHMP.

### 4.18.1 Karst Special Planning Area Plan and Regulation (PRAPEC, by its Spanish Acronym) – 2014)

In compliance with Act 292-1999, this plan and regulation establish two overlayed districts in the karst zones of Puerto Rico. The Restricted Karst Special Planning Area (APE-RC) overlayed district aims to protect the land within the Restricted Karst Area. According to Act 292-1999, lands under this district cannot be used for the extraction of materials from the earth's crust, except in cases where such activities had already been recognized by the competent authorities at the time of the adoption of PRAPEC. Additionally, the APE-RC imposes other restrictions, such as prohibitions on subdivision in certain underlying districts.

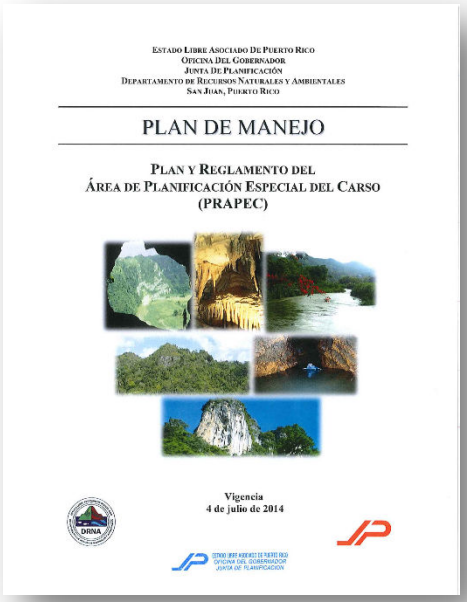



*Figure 35: PRAPEC Coversheet*

On the other hand, the Special Planning Area for the Karst Zone (APE-ZC) overlayed district includes lands within the karst physiography that are not part of the APE-RC.

Its purpose is to allow the extraction of materials from the earth's crust for commercial purposes under appropriate conditions, in areas of the karst zone that are not within the APE-RC, and to address lands that, although part of the karst physiography, are not included in the restricted area.

### 4.18.2 Joint Regulation for the Evaluation and Issuance of Permits Related to Development, Land Use, and Business Operations (2023)

The Joint Regulation for the Evaluation and Issuance of Permits Related to Development, Land Use, and Business Operations (*Reglamento Conjunto* in Spanish) is a regulatory instrument created by the Planning Board in compliance with Law No. 161, as amended. Its main purpose is to regulate land use, territorial planning, and the granting of permits related to development, construction, and business operations within a uniform and centralized framework.



*Figure 36: Joint Regulation Cover*

The Joint Regulation aims to harmonize public policy on land use planning with the principles of sustainable development, seeking a balance between economic growth, environmental protection, and social well-being. This regulation establishes the rules to classify land, define zoning districts, regulate zoning, and determine the permitted uses in each category. Additionally, it sets the procedures to evaluate projects, issue permits, and monitor compliance with the applicable provisions. Its purpose is to provide a uniform regulatory framework for the evaluation and issuance of permits, ensure the proper use of land, protect natural resources, and facilitate economic development under criteria of competitiveness and sustainability, integrating planning with permit management.

Of particular importance in the Joint Regulation is the zoning district Distrito de Riesgo para Espacios Abiertos – Open Space (RE-A). The RE-A zoning district was established to identify lands designated as open space in accordance with federal regulations (44 CFR Part 80) or another federal program, due to the presence of a risk condition resulting from a natural event. These spaces may include, but are not limited to, severe flooding and landslides. There are conditions in these areas that are unfavorable or

harmful to health, safety, or general welfare, and there may be a risk of loss of life and property. Land within this district may be susceptible to one or more of the identified hazards.

The purpose of the district is to preserve the open space condition established in perpetuity by federal regulation, which the government or the community must uphold, with the objective of protecting health, life, and property; preventing severe losses and repetitive use of affected properties; reducing the investment of public and federal funds in mitigation; and limiting rescue efforts, among other goals.

### 4.18.3 Special Flood Hazards Areas Regulation (2021)

The 2021 regulation was adopted by the Puerto Rico Planning Board under its authority from Public Law No. 75 of 1975 and Public Law No. 3 of 1961 to control development in flood prone zones. It aligns Puerto Rico's floodplain management requirements with the minimum standards of the National Flood Insurance Program (NFIP), administered by FEMA. The regulation establishes updated criteria for construction, land use, and development within Special Flood Hazard Areas (SFHAs), including requirements such as elevating structures above Base Flood Elevation and submitting technical certifications. It applies to new construction, substantial improvements, and land use changes across designated flood zones such as AE and VE, using FEMA Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FIS) for zone identification. The revision clarifies and expands regulatory provisions to enhance public safety and prevent harmful development in high-risk areas.

### 4.18.4 Puerto Rico 2023 Building Code

The Puerto Rico Building Code sets minimum requirements for the design, construction, modification, and upkeep of buildings to ensure the safety, health, and well-being of the public. It is derived from nationally and internationally recognized model codes and is updated periodically to incorporate improvements in construction practices and lessons learned from past hazard events. The code includes provisions addressing structural safety, fire protection, accessibility, energy conservation, and resistance to natural hazards such as earthquakes, hurricanes, floods, and strong winds. Adherence to the Building Code is mandatory for all new construction and substantial renovations throughout Puerto Rico. Enforcement is carried out through local permitting, planning review, and inspection processes to verify compliance with established standards. Overall, the Puerto Rico Building Code is a key instrument for advancing resilient, safe, and sustainable development across the island.

### 4.18.5 Regulation for the Design, Operation Criteria and Maintenance of Stormwater Systems in Puerto Rico




*Figure 37: Regulation 40 (Cover)*

Adopted in 2023 as Planning Regulation No. 40, this regulation updates and replaces the island's outdated 1975 standards to address current engineering practices, environmental considerations, and increased flood risk. The regulation is designed to provide developers, engineers, contractors, and municipalities with modern technical criteria for designing, operating, and maintaining public and private stormwater systems, incorporating updated scientific knowledge and methodologies necessary for managing stormwater infrastructure under present-day conditions. Its objectives include minimizing flood-related damage, improving the capture and management of runoff, reducing impacts to water resources and ecosystems, and supporting safer, more resilient community development. The regulation integrates risk management principles and aligns with Puerto Rico's climate adaptation policies, requiring consideration of urban flooding, karst hydrology, low impact development practices, and stormwater control structures such as retention and detention systems. It also establishes minimum design considerations for all land development projects and provides a comprehensive framework for planning, monitoring, and maintaining stormwater systems across the island.

### 4.18.6 Vega Alta Territorial Plan (2025)

As per the Municipal Code, the Municipality of Vega Alta updated their Territorial Plan as its First Integral Revision by December 2025. The Territorial Plan (PT, by its Spanish acronym) is a strategic and comprehensive tool for organizing land use within a municipality. This plan covers, at a minimum, the entire municipal area and aims to define the essential elements of such organization, as well as establish a program for its development and implementation, including its validity period.




*Figure 38: Territorial Plan Cover Page*

The 2025 version of Vega Alta's PT was updated to:

- Incorporate policies, strategies, and recommendations from land-use planning instruments approved by the Planning Board (JP) after the last review of the TP.
- Include provisions from recently approved or amended statutes.
- Review the municipal socioeconomic context based on recent population trends.
- Integrate information on policy and plan changes resulting from Hurricanes Irma and María in Puerto Rico.
- Include topics of mitigation, adaptation, and climate change resilience in public policy and state, sectoral, and municipal planning.
- Reflect the vision of the municipal administration and its citizens regarding the physical and socioeconomic development of Vega Alta.
- Adjust local land uses according to current and future context and needs (Autonomous Municipality of Vega Alta, 2025).

### 4.18.7 Vega Alta Emergency Operation Plan

This Emergency Operation Plan (EOP) describes how emergency operations are structured through the Incident Command System, enabling unified command and efficient allocation of resources. It details the activation levels of the Municipal Emergency Operations Center, which escalates from routine monitoring to full 24/7 multi agency disaster response. The municipality highlights the importance of interagency collaboration, including coordination with state and federal agencies

when local capabilities are exceeded. Community involvement, public information, and support for vulnerable populations—such as individuals with disabilities, children, and the elderly—are essential components woven into all phases of emergency management. Additionally, the plan incorporates long term recovery strategies, emphasizing damage assessments, restoration of critical services, and alignment with federal assistance processes. Ultimately, it presents a structured, community-centered approach to ensure Vega Alta can respond to, withstand, and recover from a wide range of emergencies.

### 4.18.8 National Flood Insurance Program

The National Flood Insurance Program falls within the category of planning mechanisms, as it imposes certain floodplain management requirements. FEMA provides flood insurance to communities that are following the NFIP criteria. This includes adopting and enforcing floodplain management practices that promote appropriate development in these flood-prone areas.

The National Flood Insurance Program of the Federal Emergency Management Agency allows homeowners, business owners, and renters in participating NFIP communities to purchase federally backed flood insurance. This insurance provides assistance to help cover the costs of repairing damage caused by flooding to buildings and their contents. This is an insurance program established to help property owners, renters, and businesses recover more easily and at a lower cost. Likewise, the program aims to reduce the impact of flooding on both public and private structures. These efforts help mitigate the effects of flooding on new and improved structures within each community.

The NFIP has several components, including:

- Floodplain management — for which the community must adopt and enforce measures for managing flood-prone lands in accordance with NFIP regulations;
- The preparation of Flood Insurance Rate Maps (FIRMs); and
- Flood insurance.

The Puerto Rico Planning Board has a collection of FIRM maps that can be consulted to determine whether your property is in a high-risk area or in a low- to moderate-risk zone. FIRMs refer to the official map developed and approved by FEMA and adopted by the Puerto Rico Planning Board to designate areas at risk of a 100-year flood (or a

1% annual chance of occurrence). In addition, these maps serve as a tool for managing special areas due to their susceptibility to flooding events.

While the Write Your Own Program (WYO) began in 1983 as a partnership between insurance companies and FEMA. This arrangement allows property and casualty insurance companies to underwrite and service federal flood insurance policies in their own company name. A key feature of this type of policy is that all companies participating in the WYO program provide the same coverage, and their rates must comply with NFIP rules and regulations.

Communities, for their part, adopt and require compliance with the NFIP's minimum standards for construction and development in designated Special Flood Hazard Areas. However, many communities seek to achieve a higher level of safety and protection for their residents beyond the NFIP minimum standards. For this purpose, communities have the option of participating in the NFIP's Community Rating System (CRS), which allows them to obtain reductions in flood insurance premiums.

This is because the CRS recognizes additional community efforts to: 1) Reduce flood damage to insurable property; 2) strengthen and support NFIP insurance provisions; and 3) encourage a comprehensive approach to floodplain management. These additional efforts provide residents with greater safety, reduce property damage, enhance community resilience, and promote a better quality of life. The municipality's participation in the NFIP will be discussed in Section 6.6

### 4.18.9 National Pollutant Discharge Elimination System (NPDES)

The NPDES is a program authorized under the United States Clean Water Act and administered by the Environmental Protection Agency (EPA). This program requires Municipal Separate Storm Sewer Systems (MS4s) to obtain a permit for the discharge of stormwater into water bodies. In the case of Puerto Rico, the EPA issued a general permit in 2016, under which municipalities can obtain coverage by submitting a Notice of Intent (NOI) and adopting a Stormwater Management Program (SWMP). If any of the mitigation measures listed in Section 6.5 modify the NOI or the SWMP, they will be properly amended.

### 4.18.10 Operational Guidelines for Determining Damages and Substantial Improvements in Puerto Rico (2025)

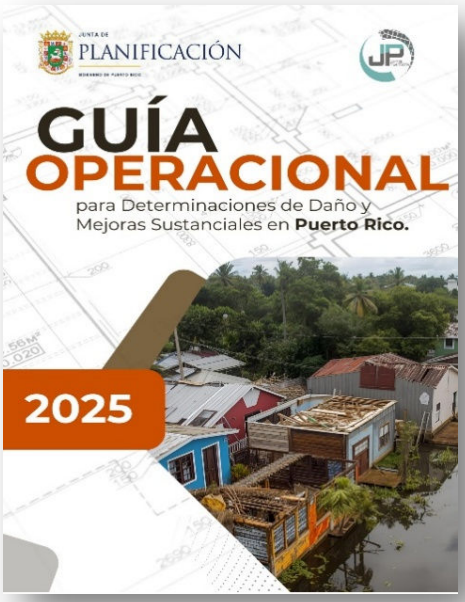



*Figure 39: Operational Guidelines Cover*

The Floodplain Administrator or the Participating Community may review, require, and audit permits in accordance with the provisions of Act No. 3 of September 27, 1961, known as the "Floodplain Building Control Act"; Act No. 75, the "Puerto Rico Planning Board Organic Act"; Act No. 161 of December 1, 2009, as amended, the "Puerto Rico Permit Process Reform Act"; and Act No. 38 of June 30, 2017, the "Uniform Administrative Procedure Act of the Government," as amended, and in compliance with the regulations of the National Flood Insurance Program (NFIP) of the Federal Emergency Management Agency (FEMA), Title 44 of the Code of Federal Regulations (CFR), Part 60.3 [d, e, and Subpart B], and its related sections.

As of the effective date of this guidance, an evaluation of substantial damage or substantial improvement will be required as part of the permitting requirements in Special Flood Hazard Areas. The Floodplain Administrator will require that both new structures and substantial improvements be constructed in a manner that minimizes or prevents damage during a regulatory flood.

### 4.18.11 Green Infrastructure and Nature Based Solutions

Section 502 of the United States Clean Water Act defines green infrastructure as the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvesting and reuse, or landscaping to store, infiltrate, or evapotranspiration stormwater and reduce flows to sewer systems or surface waters.

Green infrastructure is a cost-effective and resilient approach to managing wet weather impacts that provide many benefits to the community. While conventional

single-purpose gray stormwater infrastructure (such as pipe drainage and water treatment systems) is designed to move urban stormwater away from the built environment, green infrastructure reduces and treats stormwater at its source while providing environmental, social, and economic benefits.

Stormwater runoff is a major cause of water pollution in urban areas. When it rains on rooftops, streets, and parking lots in cities and suburbs, the water cannot soak into the ground as naturally would. Instead, stormwater drains through gutters, storm sewers, and other collection systems and is discharged into nearby water bodies. This runoff carries trash, bacteria, heavy metals, and other pollutants from the urban landscape. Higher flows resulting from heavy rainfall can also cause erosion and flooding in urban streams, damaging the environment, property, and infrastructure.

When rain falls in undeveloped natural areas, the water is absorbed and filtered by soil and vegetation. Stormwater runoff is cleaner and less problematic. Green infrastructure uses vegetation, soils, and other elements and practices to restore some of the natural processes needed to manage water and create healthier urban environments. At the municipal scale, green infrastructure is a network of natural areas that provide habitat, flood protection, cleaner air, and cleaner water. At the neighborhood, development, or sector scale, managing stormwater systems in a way that mimics natural processes help absorb and store runoff that can otherwise cause localized flooding (EPA, 2019).

Some green infrastructure measures that may be considered to mitigate flooding problems include:

- Rainwater harvesting
- Rain gardens (bio-retention/bio-infiltration)
- Urban rain gardens (“planter boxes”)
- Bioswales
- Porous pavements
- Green streets
- Green parking lots
- Green roofs
- Land conservation
- Creation or maintenance of urban tree canopy
- Wetland restoration
- Riparian area rehabilitation
- Sand dune restoration, among others.

The Municipality will consider green infrastructures measures when developing or championing flood control measures with the state or the federal government. In addition to flood control, green infrastructure provides benefits such as improved water quality, enhanced water supply, reduced stormwater management costs (public and private), improved habitat quality, increased spaces for recreation and physical activity, job creation in the maintenance of natural areas, and increased property values (EPA, 2019).

### 4.18.12 Four – Year Investment Program

The Four-Year Investment Program 2025–2026 to 2028–2029 (hereinafter, the PICA) is a short- and medium-term planning instrument designed to guide, coordinate, and direct public investments during the period it covers. Through this instrument, the Planning Board integrates the efforts of various government entities aimed at improving the quality of life of the people of Puerto Rico, in line with established public policies.

The Framework of Reference for the Four-Year Investment Program for the period 2022–2023 to 2025–2026 guides agencies and public corporations in preparing their investment and capital improvement programs. The framework includes a demographic and socioeconomic profile of Puerto Rico as a whole and by regional organization, a diagnosis of the recent performance of the economy, and information on development patterns and priority projects for the competitive Puerto Rico to which all aspire.

The full PICA document for the 2022–2023 to 2025–2026 period incorporates all information on capital improvement projects to be carried out by government entities. It includes a detailed analysis of the distribution of recommended resources by program areas and the origin of those resources. This analysis is the result of an integration process designed to guide budget recommendations formulated by the Office of Management and Budget regarding the Annual Capital Improvements Program included in Puerto Rico's budget.

This program serves as a short- and medium-term planning tool to guide, coordinate, and direct public investments during its period of effectiveness. It uses Puerto Rico's demographic and socioeconomic profile, along with a regional analysis as established by the Planning Board (JP, 2022).

With respect to the municipality's Hazard Mitigation Plan, the PICA is used to integrate information on the current performance of Puerto Rico's economy, including data on

public debt and development trends, as well as projects designated as priorities for implementation on the Island. Within this framework, the PICA provides municipalities with information from government entities regarding funding allocations and investments in improvements they are responsible for implementing, which contribute to municipal efforts to mitigate natural hazards.

As part of the projects influencing all Functional Areas of Puerto Rico, the review of municipal Mitigation Plans is included. The Planning Board was designated by the Government Authorized Representative (GAR) as the agency responsible for reviewing and developing Hazard Mitigation Plans in coordination with the 78 municipalities.

# 5. Municipal Capacities

## 5.1 Regulatory and Planning Mechanism (C1-a)

These capabilities refer to the legal provisions that influence land use to manage economic growth and that could support the municipality in its efforts to mitigate the vulnerability of its communities and resources to natural hazards. The municipality identified existing regulations and planning documents that could support its actions, as well as opportunities to promote the development of studies or plans for the same purpose of advancing its mitigation goals. These regulatory and planning tools are described in Section 4.18

## 5.2 Technical and Administrative Capacities (C1-a)

The Municipality of Vega Alta is staffed to implement this LHMP. The Municipality has an office of Planning, Development and Territorial Ordainment. Copy of this organigram can be found as part of Appendix E.

Table 36 shows the Municipality's Technical and Administrative Capacity

*Table 36: Municipal Technical and Administrative Human Resources*

| Personnel Team / Resources | Yes | No | Future Positions | Department or Agency | Opportunities to Integrate into LHMP | Comments |
|---|---|---|---|---|---|---|
| Planners with experience in land use and mitigation | X | | Internal resources | N/A | N/A | Currently the municipality does have a planning office with limited resources and planners. |

| Personnel Team / Resources | Yes | No | Future Positions | Department or Agency | Opportunities to Integrate into LHMP | Comments |
|---|---|---|---|---|---|---|
| Engineers or professionals trained in construction practices related to buildings and infrastructure | | X | Through contract services if needed | N/A | N/A | Currently the municipality does not have this staff. If the need arises this position will be procured by external professional services. |
| Planners or engineers with a broad understanding of natural hazards | X | | Internal limited resources and contracted | N/A | N/A | Currently the municipality have limited staff. If the need arises this position will be procured by external professional services. |
| Emergency Manager | X | | Director of the Municipal Emergency Management Office | Municipal Emergency Management Office, Department of Public Safety | The LHMP may be used to update the EOP | None |
| Scientist familiar with natural hazards | | X | Through contract services if needed | University of Puerto Rico, Puerto Rico Seismic Network, other universities in Puerto Rico | | Currently the municipality does not have this staff. If the need arises this position will be procured by external professional services. |

| Personnel Team / Resources | Yes | No | Future Positions | Department or Agency | Opportunities to Integrate into LHMP | Comments |
|---|---|---|---|---|---|---|
| Personnel with expertise or education regarding the vulnerabilities and natural hazards affecting the community | | X | Community Representative | N/A | N/A | Currently the municipality does not have this staff. If the need arises this position will be procured by external professional services. |
| Resource development staff or grant writers | | X | Director of Municipal Federal Programs, and contracted | Municipal Federal Programs Office | This staff may write and administer grants to cover the mitigation strategies mentioned below. | N/A |

## 5.3 Financial Capacity (C1-a)

The Municipality has successful track record administrating federal funds from various funding streams and has a dedicated office to administer and supervise the use of federal funds, and when any finding has been identified by grant – providers it has been addressed and corrected.

### 5.3.1 FEMA Funding Streams

For hazard mitigation projects the municipality has identified the following FEMA – administered possible funding streams which it could draw from.

**Stafford Act - Section 404**

Section 404 refers to Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, which authorizes the Hazard Mitigation Grant Program (HMGP), administered by FEMA. Its primary purpose is to reduce future disaster losses

by funding long-term mitigation projects after a major disaster is declared.
Under Section 404, funding is made available to states, territories, tribes, and local governments to implement mitigation measures that lessen the impacts of future hazards such as floods, earthquakes, hurricanes, wildfires, and droughts. Unlike Section 406, Section 404 projects do not have to be tied to facilities that were damaged by the declared disaster. This allows communities to take a proactive approach by investing in mitigation actions that address known risks before damage occurs.

Eligible projects under Section 404 may include activities such as elevation or acquisition of flood-prone structures, drainage improvements, seismic retrofits, safe rooms, wildfire mitigation measures, and hazard mitigation planning. Projects must be cost-effective, technically feasible, and consistent with an approved Hazard Mitigation Plan. The program typically provides up to 75 percent federal funding, with the remaining share provided by non-federal sources.

Under Section 404 is also the Hazard Mitigation Grant Program (HMGP) that can support plan development, data collection, risk assessments, and engagement activities required to maintain FEMA approval following a presidential disaster declaration.

**Stafford Act – Section 406**

Section 406 of the Stafford Act supports mitigation projects by allowing hazard-mitigation measures to be incorporated directly into the repair or replacement of public facilities damaged during a declared disaster. This provision enables communities to strengthen damaged infrastructure against future hazards, such as elevating flood-damaged buildings, reinforcing structures to withstand high winds, or improving drainage systems during repairs. Mitigation measures funded under Section 406 must be cost-effective and directly related to the damaged facility. By integrating mitigation into recovery activities, Section 406 helps reduce the likelihood of repetitive damage and future repair costs. Overall, it ensures that rebuilding efforts contribute to long-term resilience rather than simply restoring pre-disaster conditions.

**Stafford Act - Section 428**

Section 428 of the Stafford Act can support mitigation projects by allowing communities to integrate hazard-resilient and risk-reduction measures directly into

disaster recovery projects funded through FEMA's Public Assistance Program. Through its alternative procedures, Section 428 enables flexible project design, fixed-cost funding, and consolidation of damaged facilities, making it easier to incorporate mitigation improvements such as relocation, elevation, floodproofing, or structural hardening. Applicants may also reinvest cost savings from efficiently managed projects into additional mitigation features, as long as project objectives are met. By emphasizing outcomes rather than strict cost reimbursement, Section 428 encourages rebuilding that reduces future risk rather than simply restoring pre-disaster conditions. This approach allows mitigation to become an integral part of recovery, strengthening resilience and reducing the likelihood of repetitive losses.

**Flood Mitigation Assistance Program**

The Flood Mitigation Assistance (FMA) Program reduces flood hazards by providing funding to help communities identify and implement measures that lessen long-term flood risk to National Flood Insurance Program (NFIP)insured properties. The program focuses on projects such as elevating, acquiring, relocating, or floodproofing flood-prone structures, with particular priority given to repetitive loss and severe repetitive loss properties. By mitigating flood damage before disasters occur, FMA helps protect lives and property, reduces future flood insurance claims, and lowers the overall cost of disaster assistance. The program encourages proactive risk reduction by aligning mitigation investments with floodplain management and local hazard mitigation planning.

**Stafford Act – Section 203 (BRIC)**

The Building Resilient Infrastructure and Communities (BRIC) program supports mitigation projects by providing pre-disaster funding to help communities reduce risks from natural hazards before disasters occur. Administered by FEMA, BRIC focuses on long-term, cost-effective investments that enhance the resilience of critical infrastructure, lifelines, and communities. The program funds activities such as infrastructure retrofits, flood control projects, seismic upgrades, and nature-based solutions, as well as hazard mitigation planning and capacity building. BRIC emphasizes innovative, large-scale projects that address multiple hazards and provide measurable community benefits. By investing in mitigation prior to disasters, the BRIC program helps protect lives and property, reduce future disaster costs, and support more resilient and sustainable development.

### 5.3.2 Non-FEMA Federal Funding Streams

Non-FEMA federal Funding Streams can include:[20]

**CDBG-DR**

The Department of Housing and Urban Development's Community Development Block Grant–Disaster Recovery (CDBG-DR) program can fund hazard mitigation planning and projects by supporting activities that reduce long-term disaster risk and address unmet recovery needs following a major disaster. CDBG-DR funds may be used to develop or update hazard mitigation plans, conduct risk assessments, and support resilience and mitigation planning efforts that guide future investments. In addition, the program can finance mitigation projects such as drainage improvements, flood control infrastructure, elevation or acquisition of flood-prone properties, utility hardening, and other measures that reduce vulnerability to natural hazards. Unlike some recovery programs, CDBG-DR allows communities to target mitigation actions even if facilities were not damaged in the most recent disaster, as long as the activities address identified risks.

**CDBG-MIT**

The Department of Housing and Urban Development's Community Development Block Grant–Mitigation (CDBG-MIT) program supports hazard mitigation planning and projects by providing federal funding specifically dedicated to reducing future disaster risks in communities that have experienced major disasters. CDBG-MIT funds can be used for mitigation planning activities such as risk assessments, data analysis, and development of strategies that guide long-term resilience investments. The program also finances a wide range of mitigation projects, including flood risk reduction, stormwater management, wildfire mitigation, resilient infrastructure upgrades, and nature-based solutions. CDBG-MIT emphasizes addressing identified vulnerabilities and repetitive loss areas, even if they were not directly damaged in a recent disaster. By focusing on forward-looking risk reduction, the program helps communities proactively adapt to climate impacts and future hazards. Overall, CDBG-MIT integrates mitigation into long-term recovery and development efforts, strengthening community resilience and reducing future disaster losses.

It should be noted that CDBG-DR and CDBG-MIT differ primarily in their purpose and how they support hazard mitigation planning and projects. CDBG-DR focuses on

[20] Please note that the following list is not intended to be exhaustive.

post-disaster recovery, with mitigation activities integrated into rebuilding efforts to address unmet needs and reduce future risk as communities recover. Under CDBG-DR, mitigation planning and projects must be closely tied to disaster recovery goals and justified by disaster impacts or recovery assessments. In contrast, CDBG-MIT is specifically dedicated to hazard mitigation and long-term risk reduction, allowing communities to fund mitigation planning and projects even if areas or facilities were not damaged in the most recent disaster.

**Resilience and Emergency Relief Programs**

The Federal Highway Administration (FHWA) Resilience and Emergency Relief Programs support Hazard Mitigation Plans by promoting the identification and reduction of risks to transportation infrastructure from natural hazards. Through the Emergency Relief Program, FHWA allows mitigation and resilience measures—such as improved drainage, roadway elevation, and bridge reinforcement—to be incorporated into post-disaster repairs. FHWA resilience initiatives also encourage vulnerability assessments and risk-based planning that align with the risk assessment and mitigation strategy components of FEMA-approved HMPs. By integrating hazard mitigation and climate resilience into transportation planning, these programs help ensure that roads and bridges are addressed as critical lifelines. Overall, FHWA programs complement Hazard Mitigation Plans by supporting transportation-focused mitigation actions that reduce future disruption and repair costs.

**National Resource Conservation Service**

The Environmental Quality Incentives Program (EQIP) and the Watershed and Flood Prevention Operations (WFPO) program support hazard mitigation projects by addressing risks at the landscape and watershed scale through conservation and infrastructure improvements. EQIP, administered by the USDA Natural Resources Conservation Service (NRCS), provides financial and technical assistance to landowners to implement conservation practices that reduce erosion, manage runoff, improve soil health, and mitigate risks from flooding, drought, and wildfires. These practices—such as vegetation management, streambank stabilization, and water retention—help lessen downstream flood impacts and enhance resilience to climate variability. The Watershed and Flood Prevention Operations program support larger-scale mitigation through structural and non-structural measures, including small dams, floodwater retarding structures, channel improvements, and watershed planning. Together, these programs reduce hazard exposure upstream, protect communities and infrastructure downstream, and integrating natural resource

management into long-term flood and drought mitigation strategies.

### 5.3.3 Local Funds

The Municipality of Vega Alta, like other municipalities in Puerto Rico, receives revenue from the Municipal Revenue Collection Center (MRCC). Other funding sources include revenue from the Sales and Use Tax (IVU, by its Spanish acronym), legislative funds that might be assigned from time to time and other sources. Depending on the state of municipal finances, the municipality might determine that there are some funds that can be used to pay for or cover local funds match for mitigation projects.

However, most major capital improvement projects depend on federal funds transfers. The use of federal funds varies widely from year to year. In some cases, these funds are used to cover costs associated with the creation and monitoring of specific programs (for example, Section 8 or housing programs). In other cases, the funds are used to finance major capital improvement projects.

## 5.4 Outreach and Communications Capacity (C1-a)

Building robust outreach and communication capacity is essential to the successful implementation of a Hazard Mitigation Plan, as effective risk communication enables residents to recognize their risks, actively participate in planning processes, and make informed decisions to reduce potential impacts. FEMA guidance underscores the importance of early and thoughtfully designed engagement strategies to ensure that key stakeholders exchange information at the right time, promoting shared awareness of hazards and broad support for mitigation actions. Communication is a fundamental preparedness capability because it provides timely, practical information that helps individuals and communities act to limit harm. Research further demonstrates that outreach efforts are most successful when messages are clearly defined, customized for specific audiences, and conveyed through trusted sources. Communities that prioritize outreach—by collaborating with local leaders, leveraging a variety of communication channels, and tailoring messages to different population groups—tend to achieve higher public involvement and more effectively incorporate community feedback into hazard mitigation planning. These practices ultimately contribute to more effective plans and more resilient communities (FEMA, 2025).

The Municipality demonstrates adequate capacity to conduct effective outreach and communication activities. The Office of Planning, Development, and Territorial Ordainment is responsible for coordinating these efforts, and an organizational chart

for this office is provided in Appendix E. The Municipality utilizes both social media platforms for real-time communication and traditional methods to disseminate information to the public. In addition, the Planning Office administers the Community Board responsible for land-use decisions, which is largely composed of municipal residents. This board serves as an important forum for public engagement and provides an opportunity to further expand and strengthen the Municipality's outreach and communication capacity.

Table 41 details the communication tools available to the municipality.

*Table 37: Outreach and Communications Tools*

| Tool or resource | Present or not present | Description | Agency in Charge |
|---|---|---|---|
| Municipal Social Media | X | Facebook Page | Mayor's Office |
| Planning Board Print Material | X | Print Material regarding hazard mitigation, focused on flood hazard | Puerto Rico Planning Board |
| Community Meetings | X | Community Outreach Meeting to reach people that do not have access to social media | Various |

## 5.5 Capacity Development (C1-b)

Strengthening institutional and technical capacity is vital to the successful implementation of a Hazard Mitigation Plan, as communities must have the expertise, resources, and organizational frameworks needed to move from planning to sustained risk-reduction actions. FEMA guidance stresses that effective mitigation planning relies on well-coordinated teams, access to reliable technical data, and the ability to collaborate across agencies and stakeholders—all of which directly affect the execution of mitigation strategies. National evaluations have shown that local and state governments often face challenges in implementing mitigation projects not due to a lack of commitment, but because of limited technical assistance, constrained administrative capacity, and insufficient engagement with federal support programs. Studies focused on low-capacity communities further demonstrate that gaps in technical knowledge, training, and leadership involvement can significantly hinder mitigation outcomes. These findings highlight the importance of strengthening workforce skills, enhancing guidance and tools, and reinforcing institutional support to

achieve long-term resilience.

The Municipality continues to enhance its mitigation capacity by retaining qualified professionals as staff or contractors as needs arise. It also actively participates in training and continuing education opportunities offered through Commonwealth agencies and academic institutions to build and maintain the technical and institutional expertise necessary to support hazard mitigation efforts.

# 6. Mitigation Action Plan

The goals, objectives, and mitigation actions outlined in this Plan are based on discussions held by the designated Mitigation Plan Committee, as well as the public-participation activities conducted to date.

## 6.1 Mitigation Goals and Objectives(C3-a)

### 6.1.1 Municipal Goals and Objectives

The Municipality of Vega Alta adopts the following goals and objectives as part of their mitigation efforts. These Mitigation goals and objectives express the Municipality of Vega Alta's commitment to protecting its residents and infrastructure, reducing response and recovery costs in the event of a disaster, and minimizing disruptions to normal daily activities afterward.

**Goal 1:** Minimize the loss of life and reduce public exposure to natural and human-caused hazards.

- **Objective 1.1** Improve disaster warning and public information systems.
- **Objective 1.2** Enhance emergency preparedness and response planning.
- **Objective 1.3** Strengthen interagency and community partnerships.
- **Objective 1.4** Pursue funding and resources for mitigation efforts.
- **Objective 1.5** Protect natural and environmental resources.
- **Objective 1.6** Reduce risk in vulnerable hazard-prone areas.

**Goal 2:** Continue reducing and preventing damage to and loss of public and private property.

- **Objective 2.1:** Increase insurance coverage in hazard-prone areas.
- **Objective 2.2:** Protect critical buildings and infrastructure.
- **Objective 2.3:** Reduce repetitive losses through targeted mitigation projects.
- **Objective 2.4:** Identify and assess at-risk properties.

**Goal 3**: Reduce economic losses and disruptions resulting from natural and human caused hazard events.

**Objective 3.1:** Protect businesses from disaster-related losses.

**Objective 3.2:** Promote business preparedness and continuity planning.

**Objective 3.3:** Support access to disaster recovery assistance and resources.

**Goal 4**: Enhance the effectiveness of emergency plans and services through the continued operation of essential facilities before, during, and after disaster events.

**Objective 4.1:** Enhance the resilience and protection of essential facilities and emergency services.

**Objective 4.2**: Strengthen local emergency response capabilities through the acquisition of critical equipment and resources.

**Objective 4.3:** Improve and expand emergency evacuation route signage.

**Objective 4.4**: Enhance training and professional development for emergency management personnel.

**Objective 4.5:** Maintain and expand infrastructure that supports emergency services and operations.

**Goal 5**: Continue promoting sustainable and resilient community development.

**Objective 5.1:** Integrate hazard mitigation strategies into municipal planning and development processes.

**Objective 5.2:** Prevent development in hazard-prone areas through effective land use regulations and enforcement.

**Objective 5.3:** Promote compliance with building codes to enhance structural resilience.

**Objective 5.4:** Expand public participation in local planning and decision-making processes.

**Goal 6**: Enhance public awareness and community engagement in hazard mitigation.

**Objective 6.1:** Increase public outreach and education on hazards and mitigation activities.

**Objective 6.2:** Strengthen collaboration with local media to support hazard communication and public awareness.

### 6.1.2 National Mitigation Investment Strategy

The Municipality also adopts the National Mitigation Investment Strategy and the following goals.

- Goal 1: Show How Mitigation Investments Reduce Risk - The whole community will build a shared understanding of mitigation investment and its value. Specifically, the whole community will understand how effective mitigation investments can protect people, homes, neighborhoods, cultural and historic resources, ecosystems and lifelines (for example, communications, energy, transportation and water). The federal government and its non-federal partners will create a shared vocabulary and common measures to communicate information about risk and find opportunities to educate, hire, train and develop a base of qualified mitigation professionals.
- Goal 2: Coordinate Mitigation Investments to Reduce Risk - The whole community will coordinate mitigation investments through shared risk information, reinforced strategies for risk reduction, and easier access to existing funding. Such coordination will help the whole community justify mitigation investments and choose the most cost-effective and reasonable actions.
- Goal 3: Make Mitigation Investment Standard Practice The whole community will factor mitigation into investment decisions, especially for buildings and infrastructure. The federal government and its non-federal partners will use and expand financial products and approaches for mitigation investment, including funding, incentives and financial risk transfer opportunities. The federal government and its non-federal partners also will make mitigation standard professional practice critical to safeguarding lifelines, services, and national safety and security.

## 6.2 Mitigation Strategy Selection Criteria

The following methodologies were used to select the mitigation actions:

- The Planning Committee reviewed mitigation actions from the previous Mitigation Plan.
- The Committee evaluated those actions and determined which ones were appropriate to include in the current Plan. Actions were excluded if:

    - The measure had already been implemented during the previous plan's period and was not a recurring or ongoing action.
    - The measure was no longer necessary or useful based on new information. This applies to mitigation actions linked to identified hazards, risks, and vulnerabilities.

- The Committee considered the Letters of Intent (LOIs) submitted by the municipality to COR3 in 2019 to participate in the Hazard Mitigation Grant Program. These projects were incorporated into the current Plan, ensuring no duplication of projects included in the previous Plan.
- The Planning Committee revised the Puerto Rico 2026 State Hazard Mitigation Plan during the preparation of this LHMP update. Risk profiles, state capabilities, mitigation goals, and relevant state actions were considered during the risk assessment, capacity assessment, and development of the municipal mitigation strategy.
- Committee members evaluated and added new measures. These new actions were proposed based on the Committee members' professional experience and suggestions received from community members.

The mitigation strategies of the Municipality of Vega Alta were evaluated by the Committee using the STAPLEE tool. This tool provides the selection criteria used to assess the projects included in the preceding section. The technique applies to seven evaluation criteria:

- S – Social: The proposed action must be socially acceptable.
- T – Technical: The proposed action must be technically feasible.
- A – Administrative: The community must have the capacity to implement the action (for example, determining whether the responsible agency is capable of supervising the mitigation project).
- P – Political: Mitigation actions must be politically acceptable.
- L – Legal: The community must have the authority to implement the proposed action.
- E – Economic: Economic considerations must include the current economic base, projected growth, and opportunity costs.
- E – Environmental: The environmental impact must be considered, given statutory requirements and the public's interest in maintaining sustainable and environmentally healthy communities.

## 6.3 Mitigation Strategy Categorization

The 2025 Local Hazard Mitigation Planning Handbook established the following categorization:

- Local Planning and Regulations – These activities aim to keep hazards from creating or worsening problems. These actions are typically carried out through government programs or regulatory measures that guide land-use development and building practices. Prevention is especially effective for reducing future vulnerability in areas that have not yet been developed. Examples include:
  - Planning and zoning
  - Building codes
  - Open-space preservation
  - Floodplain regulations
  - Stormwater management regulations
  - Maintenance of drainage systems
  - Capital improvement programming
  - Riverbank realignment
  - Projects addressing fault zones

  In the tables below, this category will be identified with the code LP

- Structure and Infrastructure Projects – These actions involve modifying existing structures and infrastructures to protect them from a hazard or remove them from a hazard area. This could also apply to public or private structures as well as critical facilities and infrastructure. Since these are the bulk of the strategies presented in this LHMP, the municipality has made the decision to subdivide these types of projects into two subcategories:

  - Property Protection – Those that will harden and strengthen existing facilities. In the tables below, this category will be identified with the code PP

- Structural Improvements – Those that entail new construction efforts. In the tables below, this category will be identified with the code SI.

- Natural resource protection – activities reduce the impact of natural disasters by preserving or restoring natural areas that offer protective benefits. These areas include flood plains, wetlands, steep slopes, and sand dunes. Parks, recreational agencies, and conservation organizations commonly implement measures such as:

  - Flood protection
  - Watershed management
  - Riparian buffers
  - Forest and vegetation management (including wildfire and fuel-load control)
  - Erosion and sediment control
  - Wetland preservation and restoration
  - Habitat preservation
  - Slope stabilization

  In the tables below, this category will be identified with the code NR

- Education and awareness programs- Efforts to help inform residents, elected officials, business owners, homebuyers, and visitors about hazard-prone areas and mitigation techniques they can use to protect themselves and their property. Examples include:

  - Outreach projects
  - Demonstration events and guest presentations
  - Hazard information materials
  - Property-specific risk information
  - Library materials
  - Educational programs for children
  - Exposure to risk-related information

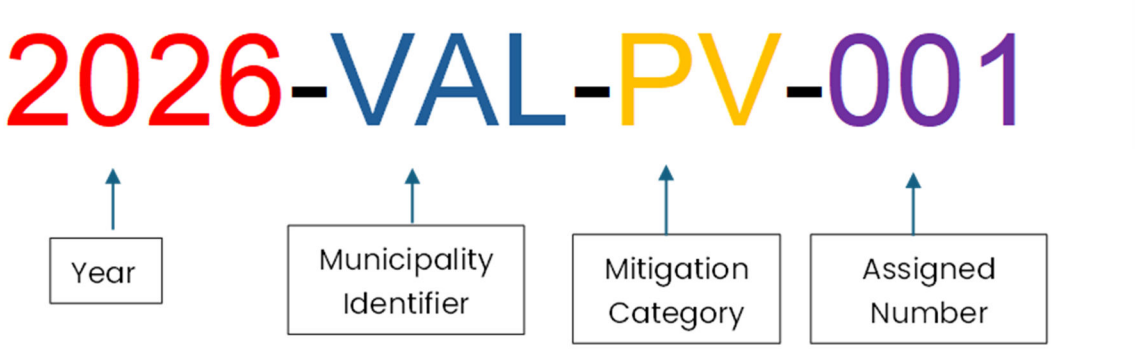
  In the tables below, this category will be identified with the code EA

Though not hazard mitigation actions per se, the municipality deems it necessary to also record those projects that are related to emergency services in this LHMP. In this sense the interaction between the LHMP and the yearly updated EOP is streamlined and cross-referenced.

## 6.4 Mitigation Strategies (C4-a, C4-b, C5-a, C5-b, E2.b)

To improve tracking and updating each mitigation strategy has been giving a unique id. The following figure shows the meaning of the nomenclature.

*Figure 42: Unique Id Nomenclature*




Each identified mitigation strategy shall include:

- New 2026 Mitigation ID
- Old 2020 ID if applicable
- Description
- Mitigated hazard(s): If a mitigation action is applicable to all hazards it will be identified by the word "all"
- Priority of the strategy according to the planning committee
- Assigned FEMA Lifelines
- Municipal Office in charge of execution
- Possible funding sources
- Estimated budget
- Implementation Horizon: For this LHMP horizon time frames are as follows:
    - Immediate: Any action that will be executed in a period of one year or

less.
    - Short – Term: Any action that will be executed in a period of two to three years.
    - Mid – Term: Any action that will be executed in a period of four to five years.
    - Long – Term: Any action that will be executed in a period beyond five years.
    - Note: Should funding for a specific strategy become available, the municipality may execute it even if it is not in the assigned time horizon.

- Current status and expected benefits

Strategies from the 2020 LHMP that are no longer needed will be identified by "Supressed from this LHMP" in order to flag them to be not included in the 2031 LHMP update.

Tables 50-54 have the details of the mitigation strategies adopted by this LHMP.

*Table 42: Mitigation Strategies-Prevention*

| 2026 ID | 2020 ID | Description | Danger | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-LP-001 | P-1 | Cerro Gordo: Cleaning of the channel that borders part of the Cerro Gordo Community. Implement a flood risk reduction program in the Cerro Gordo community by monitoring the channel, identifying points of recurrent obstruction, removing hydraulic restrictions, improvements to the drainage system, and scheduled preventive maintenance to reduce the recurrence of flooding and protect adjacent properties. | Flooding | High | Water Systems | Office of Planning, Municipal Office of Emergency Management, Municipal Office of Public Works Department of Natural Resources | State and Federal | Medium Term | Current Status: In Continuous Execution – This periodic cleaning strategy has been carried out about 5 times from 2022 to the present. MAVA maintains constant monitoring of the Caño particularly during flood or rainfall events to avoid adverse impact on these communities. This strategy will provide the following qualitative benefits: It reduces the risk of flooding, improves storm drainage, decreases public health risks and protects nearby properties. Prevention: 1- Remove sediments, garbage, invasive vegetation and any obstructions that reduce the hydraulic capacity of the channel. 2-Establish an inspection and maintenance program after heavy rain events.3-Hydraulic evaluation to determine if the channel has the capacity to handle rain events by design. Mitigation:<br>1- Stabilization of slopes and margins for erosion control by means of geotextiles, erosion blankets or vegetation.<br>2- Meteorological monitoring of the forecasts of the National Weather Service to detect any severe event. The description of this strategy in relation to the 2020 Plan was prepared to improve its implementation. |

| 2026 ID | 2020 ID | Description | Danger | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-LP-002 | P-2 | PR2 State Highway. Provide maintenance to the storm sewer to prevent flooding due to low-intensity rainfall. | Flooding | High | Transportation | Office of Planning, Office of Emergency Management, Office of Public Works.<br><br>DTOP and PRHTA | State and Municipal | Short Term | Current Status: In Continuous Execution – This strategy is carried out every 6 months. MAVA continues constant monitoring of flood or rainfall events to avoid adverse impact on these communities and on this main road to facilitate access. This strategy will provide the following qualitative benefits: It decreases the occurrence of flooding, maintains the adequate flow of runoff, and improves road safety. Prevention 1. Perform inspections and scheduled cleaning of storm sewer systems, removing sediment, garbage, leaves, and other materials that may obstruct the flow of water.2. Implement a periodic monitoring and evaluation program of the rainwater infrastructure, identifying and correcting deterioration, cracks, or faulty connections before they affect its operation. Mitigation: 1. Immediately address obstructions or damages identified during inspections, using specialized equipment to restore the hydraulic capacity of the system. 2. Establish rainfall response procedures, including emergency cleanup, flood hotspot monitoring, and coordination with municipal agencies to minimize impacts on affected areas. |

| 2026 ID | 2020 ID | Description | Danger | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-LP-003 | P-3 | Urb. Santa Ana Extension - Commission a Hydrological-Hydraulic (HH) study to determine the flow that runs towards the road. | Flooding | Medium | Transportation | Planning Office | Municipal | Long Term | Current Status: Completed – This strategy was fully implemented in 2022 and 2023. This strategy will provide the following qualitative benefits: It decreases the occurrence of flooding, maintains adequate runoff flow, and improves road safety. This strategy will not be included in the next Plan 2031 update process. |
| 2026-VAL-LP-004 | P-4 | Morán Community Sector, and Breñas Sector: Cleaning and improvements to drains in these sectors. In addition, it is considered to develop an HH Study to determine possible improvements. | Flooding | Medium | Water Systems | Municipal Planning Office, Public Works | State and Federal | Short Term | Current Status: Completed – This strategy was carried out in 2024 for both the study and cleaning of the drains. This strategy will provide the following qualitative benefits: It reduces the risk of flooding, improves the capacity of the rainwater system and protects affected communities. This strategy will not be included in the next update process of the 2031 Plan. |
| 2026-VAL-LP-005 | P-5 | Creation of a strategic planning unit on mitigation of multiple natural risks as part of the Office of Planning and Territorial Ordering. | All | High | Security | Planning Office | Municipal | Short Term | Current Status: Running – The municipality assigned staff to establish the strategic planning unit that is still in progress. This strategy will provide the following qualitative benefits: providing better services to the communities. |

| 2026 ID | 2020 ID | Description | Danger | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-LP-006 | P-6 | Prepare an Inventory of Places Susceptible to Landslides in order to estimate the level of risk of the contiguous sectors. | Landslide | High | Security | Office of Emergency Management | State and Federal | Long Term | Current Status: Continuous Execution. MAVA continues to monitor communities such as Pámpanos, Maricao, Mavilla, Candelaria, Cieneguetas, and Bajuras susceptible to landslides during heavy rains. This strategy will provide the following qualitative benefits: identify susceptible areas. Prevention: 1. Conduct periodic geotechnical inspections and field assessments to identify areas with unstable slopes, active erosion, or conditions that may lead to landslides. 2. Develop and update a geographic information system (GIS) and inventory of susceptible areas, incorporating historical data, topographic features, and changes in land use. Mitigation: 1. Implement continuous monitoring in areas identified as high risk, including observation of cracks, ground movements, and effects of heavy rainfall to trigger early warnings. 2. Prioritize and execute corrective measures in the sectors of greatest risk, such as slope stabilization, storm drainage improvements, and erosion controls to reduce the probability of landslides and their impacts on nearby communities. |

| 2026 ID | 2020 ID | Description | Danger | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-LP-007 | P-7 | Formulate a Plan for the evaluation of all residences located in areas under recurrent risks and include strategies for the acquisition and relocation of families. | All | High | Food, Hydration and Shelter | Planning Office Municipal Emergency Management Office | Municipal | Long Term | Current Status: Ongoing Implementation – The relocation of families to the Communities of Ponderosa, Calle 8 has been managed. OMME continues to monitor to identify affected families. : Reduces the exposure of families to natural hazards and strengthens community resilience through permanent solutions. |
| 2026-VAL-LP-008 | P-8 | To guide citizens on the importance of acquiring insurance against floods and landslides. | Flooding/Landslide | High | Security | Planning Office Municipal Emergency Management Office | State and Federal | Long Term | Current Status: Ongoing Implementation – This strategy is carried out in coordination with the Planning Office and OMME in affected communities. This is particularly reinforced in emergency declarations. This information is also disseminated during service fairs. This strategy will provide the following qualitative benefits: reduction of risk to the resident's life and property and that they are protected in the event of a natural disaster associated with floods or landslides. |

| 2026 ID | 2020 ID | Description | Danger | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-LP-009 | P-9 | Prohibit or restrict construction in areas identified as storm surge, EVs, and areas identified as tsunami-susceptible, unless an effective mitigation measure has been implemented and is strictly necessary. | Coastal Modification; Tropical Cyclone; Tsunami | High | Security | Planning Office OMME, Committee on Coastal Erosion (COREPI-PR) DRNA | State/Federal Locals | Immediate | Current Status: In Execution – The MAVA updated the Land Use Plan in December 2025 where some provisions to regulate or reduce risks to life and property in coastal areas are addressed. MAVA continues to monitor communities and municipal infrastructure. This strategy is executed to prevent construction in areas identified as susceptible to storm surge and tsunami. This strategy will provide the following qualitative benefits: It prevents new construction in vulnerable areas, reduces future losses, and promotes safe and resilient development. |

| 2026 ID | 2020 ID | Description | Danger | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-LP-010 | P-10 | Maintain an inventory in the Municipal Office of Emergency Management of fire events in the municipality. | Vegetative Fire | Medium | Security | Office of Emergency Management | Municipal | Long Term | Current Status: In Continuous Execution – This strategy is fed with constant information. MAVA maintains an inventory of fire events that is then submitted to the Emergency Management Bureau (NME). A monthly incident report is prepared in order to identify susceptible areas for future prevention. This strategy will provide the following qualitative benefits: Maintaining a fire incident inventory and producing monthly reports supports the identification of fire-prone areas, enables targeted mitigation actions, and improves resource allocation, ultimately reducing future fire-related losses and enhancing community resilience. |

| 2026 ID | 2020 ID | Description | Danger | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-LP-011 | P-11 | Installation of storm shutters and generators in the Government and Municipal OMME Centre. | Tropical Cyclone | High | Energy | Planning Office City Office of Emergency Management | State/Federal Locals | Short Term | Current Status: Funding – The funds were approved by FEMA for generators. It is close to auction process. Funds for storm shutters are still pending. This strategy will provide the following qualitative benefits: It guarantees the continuity of essential services and improves the municipality's response capacity during emergencies. . Prevention: 1. Install certified storm shutters resistant to hurricane winds on doors, windows, and other critical openings to reduce the vulnerability of facilities to severe weather events.2. Perform periodic inspections and preventive maintenance of generators and backup electrical systems, ensuring their operability before hurricane season and other emergency events. Mitigation: 1. Keep fuel, replacement parts, and service contracts available for generators, ensuring continuity of operations during prolonged interruptions of electrical service. 2. Develop and implement emergency protocols for the activation of storm shutters and generators, including personnel training and periodic operational tests to minimize interruptions in the municipality's essential services. |

*Table 43: Mitigation Strategies – Property Protection*

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-PP-001 | PP-1 | Creation of a Housing Improvement Program in sectors of the Maricao and Candelaria neighborhoods: Maricao: Morán, Boquerón, El Nueve, Chinea, Capilla, Pachanga, and Cruz sectors. Candelaria: Villa del Río sector.<br><br>Conduct a technical study to evaluate the risk of landslides affecting homes located in the Morán, Boquerón, El Nueve, Chinea, Capilla, Pachanga, and Cruz sectors of the Maricao neighborhood, as well as in the Villa del Río sector of the Candelaria neighborhood. The study will include geotechnical evaluations, slope stability analysis, identification of drainage problems, documentation of existing damage, and determination of the level of risk to life and property. As a result, a georeferenced inventory of vulnerable structures and a prioritized portfolio of mitigation projects will be developed, which may include drainage improvements, slope stabilization, erosion control, revegetation, structural measures, and, when necessary, alternatives for properties with high risk. | Tropical Cyclone/Landslides | High | Safety Food, Hydration & Shelter | Office of Planning and Engineering, Municipal Office of Emergency Management, Municipal Office of Public Works | Municipal, State (COR3, JPPR), Federal (FEMA HMGP, FEMA BRIC, HUD CDBG-MIT) | Medium Term | Current Status: In Continuous Execution – Although MAVA maintains frequent monitoring of these communities in heavy rainfall events, this strategy was modified in relation to the PP-1 Strategy of the 2020 Plan to better define the scope and facilitate its implementation. The Municipality has identified residential sectors with a history of land instability and susceptibility to landslides associated with heavy rainfall, hurricanes, and slope erosion. As a first step to reduce the exposure of the population, a technical study will be developed to characterize the existing risk and establish mitigation priorities. The results will serve as the basis for future requests for state and federal funds for risk reduction. Benefits: 1. Reduces the exposure of people and homes to the risk of landslides; 2. Decreases the potential for loss of life during extreme rainfall events. 3. Reduces recurrent damage to homes and community infrastructure. 4. Improves the resilience of communities located in sloped areas. |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-PP-002 | PP-2 | Housing Improvement Program in sectors of the Maricao and Candelaria neighborhoods: Maricao: Morán, Boquerón, El Nueve, Chinea, Capilla, Pachanga, and Cruz sectors. Candelaria: Villa del Río Sector. Design and prioritization of Mitigation Projects or Measures for Homes Vulnerable to Landslides in Priority Sectors located in the Morán, Boquerón, El Nueve, Chinea, Capilla, Pachanga and Cruz sectors of the Maricao neighborhood, as well as in the Villa del Río sector of the Candelaria neighborhood. The measures to be implemented or project designs will be determined through the geotechnical studies and risk assessments developed under the Landslide Risk Assessment Strategy (PP-1). Projects may include surface and underground drainage improvements, slope stabilization, construction of retaining walls, erosion control measures, revegetation with deep-rooted species, runoff management, access infrastructure improvements, and other structural or nature-based actions that reduce risk to life and property. | Tropical Cyclone/Landslides | High | Food, Hydration and Shelter | Planning Office | Municipal, State (COR3, JPPR), Federal (FEMA HMGP, FEMA BRIC, HUD CDBG-MIT) | Medium Term | Current Status: NEW – This strategy will be implemented after completion of the geotechnical assessments and risk prioritization process identified in the Landslide Risk Assessment Strategy (PP-1). The technical results will be used to identify the most cost-effective interventions and develop funding requests for the execution of mitigation projects. Benefits: 1. Reduces risk to life and property. 2. Decreases the likelihood of structural damage during extreme rainfall events. 3. Reduces disruptions to roads and community infrastructure. 4. Protects vulnerable communities located in unstable terrain.5. Reduces future recovery and response costs. |

*Table 44: Mitigation Strategies – Natural Resources Protection*

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-RN-001 | PRN-1 | Erosion and sedimentation control in the Quebrada Honda. See PE-6 strategy | Flooding | High | Water Systems | Office of Planning and Engineering, Municipal Office of Emergency Management, Municipal Office of Public Works | State and Federal Federal Department of Agriculture (USDA) | Short Term | Current Status: In Execution – Several cleanups have been carried out and there is a USDA-approved project. The municipality required qualifications to carry out studies in the Ponderosa area. This strategy will provide the following qualitative benefits: prevention of overflow of water bodies. Prevention: 1. Implement permanent erosion control practices on the banks of the stream, through revegetation with native species, planting vegetation cover and slope stabilization to reduce soil loss. 2. Carry out periodic inspections and preventive maintenance of the channel and its banks, identifying areas with active erosion or sediment accumulation to address them before they evolve into major problems. Mitigation: 1. There is currently a project in the Municipality to repair the retaining wall and the channeling of runoff water in the Ponderosa sector. 2. Install sedimentation control and energy dissipation structures, such as sediment barriers, gabions, stone linings or retention dikes in the most vulnerable sectors. 3. Remove accumulated sediments and repair eroded areas in a timely manner, restoring the hydraulic capacity of the creek and reducing the risk of overflows, damage to infrastructure and damage to nearby properties. |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-RN-002 | PRN-2 | Carry out an Inventory of Sinkholes and Caverns in the MAVA. The reason is that Vega Alta is located in Northern Karst, which is characterized by the large number of these systems. The Inventory would include georeferenced location, maps, size, flood potential, nearby communities, and state of the system, among others. After the Inventory is completed, a Sinkhole and Cavern Management Plan would be formulated. | Flooding | High | Security | Office of Public Works Department of Natural Resources | State and Federal | Short Term | Current Status: In Continuous Execution –: The inventory of caverns and sinkholes was carried out and documented in the First Comprehensive Review of the Land Use Plan approved in December 2025. The cleaning and monitoring of the same is carried out by the Municipal Public Works Office. The drains are concentrated in: Maricao Morán sector, Hoyo Morán in Cieneguetas, Arenas sector, Espinosa (Bajuras). For the hurricane season, Public Works carry out monitoring and cleaning. This strategy will provide the following qualitative benefits: Have an inventory database and location, status and mitigation in case of extreme rain or cyclone event. |
| 2026-VAL-RN-003 | PRN-3 | Reinforce, through municipal ordinances, the imposition of fines for the illegal disposal of materials that tend to reduce the natural flow and quality of water. It should be noted that the illegal practice of disposing of materials near bodies of water, areas of protected natural resources, sewers and/or drains, increases or causes severe flooding in urban areas. | Flooding | Medium | Water Systems | Municipal Public Works Office, Municipal Police, Emergency Management Office | Municipal | Short Term | Current Status: In Continuous Execution – Placement of signs indicating the imposition of fines for illegal disposal of materials. Public Works has inventoried clandestine landfills where prohibition signs are placed. The imposition of fines for illegal disposal of materials is expressed in the Public Order Code of the Autonomous Municipality of Vega Alta, approved on September 24, 2025 (legal basis Law 107, approved on August 13, 2020). These fines are expressed in the Public Order Code Chapter VI – Environmental Quality, in its Articles 6.02, 6.04, 6.07 to Article 6.16. This strategy will provide the following qualitative benefits: Significantly reduce the illegal |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | disposal of materials; Provide a healthy flow and quality of water; Reduce severe flooding in urban areas. |

*Table 45: Mitigation Strategies – Structural Improvements*

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-SI-001 | PE-1 | Flood and pollutant control in various sectors identified by the MAVA. This initiative seeks to identify and prioritize the areas of the municipality most affected by recurrent flooding and pollution caused by storm runoff, to develop and implement mitigation projects that include drainage improvements, channel restoration, margin stabilization, green infrastructure, and pollutant control measures. The objective is to reduce public health risks, minimize property damage, and improve the resilience of vulnerable communities.<br>The main affected areas include sections of the PR-647, PR-620, PR-675, PR-676, PR-690, PR-693 and PR-2 highways, mainly due to the overflow of the Cibuco River, the Quebrada Honda, the Quebrada Corea and the Caño Matamba, as well as deficiencies in the drainage systems. Among the most vulnerable communities and sectors are Espinosa, Ponderosa, Machuchal, Candungo, Cachete, Cerro Gordo, Sabana Breñas and Sabana Hoyos, where flooding causes road closures, damage to homes and recurrent runoff problems during heavy rain events and severe storms. | Flooding | High | Water Systems | Municipal Office for Emergency Management, Municipal Public Works, Department of Natural and Environmental Resources; Highway and Transportation Authority | State and Municipal | Short Term | Current Status: Funding – This project is in the pipeline for funding to design wastewater disposal in the sectors most vulnerable to flooding as outlined in the strategy. This strategy will provide the following qualitative benefits: Reduces flooding, improves water quality, and protects critical infrastructure and communities. |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-Si-002 | PE-2 | Highway 690 at the height of Estancias de Cerro Gordo: Elevation of the Bridge and the road and improvements to the canal. | Flooding | High | Transportation | Planning Office | State and Federal | Short Term | Current Status: In Continuous Execution – Channel cleaning was performed but not the bridge elevation. MAVA does not contemplate bridge elevation since it is a state highway. We are in coordination with state agencies to mitigate. MAVA continues to monitor this area for periodic cleanups as needed. This strategy will provide the following qualitative benefits: Reduces flood risk and improves safe access to communities during heavy rain events. |
| 2026-VAL-SI-003 | PE-3 | El Corozo/Carmelita: Construction of rainwater works to connect the canal and direct the waters to the Ciénaga Prieta. | Flooding | High | Transportation | Office of Planning and Engineering, Municipal Office for Emergency Management, Municipal Public Works, Department of Natural and Environmental Resources; Highway and Transportation Authority | State and Federal | Short Term | Current Status: In Continuous Execution – The MAVA continues to monitor this area to perform periodic cleanups as necessary. This strategy will provide the following qualitative benefits: Improves runoff management, decreases recurrent flooding, and protects road infrastructure. |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-Si-004 | PE-4 | El Corozo/Carmelita: Build a storm pipe in the Carmelita.<br><br>In the Carmelita area there is a canal where the runoff from all the streets of the community arrives. One of the streets most affected by the flooding is 7th Street. This canal runs along the west side of PR-690 in front of the Corozo Hardware Store and then crosses east under the PR-690 towards the ponds that are located behind the hardware store and in turn inland to the canal that crosses again next to the Finca La Solución. It is recommended to lengthen this drainage channel so that, instead of crossing east, it runs parallel to the PR-690 to the canal next to the Finca La Solución. The major cost would be to pass the pipe under the intersection that gives access to the nearby pharmaceutical company (intersection 690). | Flooding | High | Transportation | Office of Planning and Engineering, Municipal Office of Emergency Management, Municipal Public Works, Department of Natural and Environmental Resources; Highway and Transportation Authority | State and Federal | Short Term | Current Status: In Continuous Execution – MAVA continues to monitor this area for periodic cleanups as needed. This strategy will provide the following qualitative benefits: Increases drainage system capacity, reduces flood damage, and improves community mobility. |
| 2026-VAL-SI-005 | PE-5 | Develop a Management Plan to Improve the Channel and Banks of the Quebrada Honda from its source in the Fortuna Sector of the Espinosa Neighborhood, to its mouth in the Cibuco River in the Bajura Neighborhood. The goal of the Plan would be to reduce the impact on the communities caused by the flooding of the Quebrada. The channeling of the Quebrada faces several challenges since the problem places (because of its difficulty and cost) are where it passes under the PR 2 | Flooding | High | Water Systems | Municipal Public Works and Office for Emergency Management | State and Federal | Short Term | Current Status: In Continuous Execution – On three occasions before 2024, the dredging of the Quebrada Honda was carried out along the segment starting from the Ponderosa basketball court to PR 690. These projects were carried out with municipal funds and funds from the Department of Natural Resources (DNER). In March 2026, the dredging of the Quebrada Honda was carried out from the Ponderosa basketball court to |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| | | (twice) and under the PR690. I consider that structural projects such as the channeling of the channel and the construction of gabions are technically difficult and extremely expensive. On the other hand, the Plan should propose non-structural projects, which are more technically feasible and less expensive. Some examples of these projects would be: 1. cleaning of debris within, and along the entire length of, the channel, including the areas under the PR2 and PR690 2. guidance to the communities on the disposal of garbage in the Quebrada 3. cleaning of its banks 4. control of erosion and sedimentation along the channel small modifications of the channel where strictly necessary and the environmental impact is minimal. | | | | | | | the PR 690 highway and the funds for these projects were provided by the municipality and by the Department of Transportation and Public Works (DTOP). MAVA continues to monitor this area to carry out periodic cleanups as necessary. This strategy will provide the following qualitative benefits: It reduces the risk of flooding through sustainable measures and improves the environmental conditions of the channel. |
| 2026-VAL-SI-006 | PE-6 | Nevelio Dávila Sector Inshore. Develop an HH Study to determine the level of the flood in order to develop mitigation measures. | Flooding | Medium | Transportation | Public Works, Office of Emergency Management | Municipal, State (COR3, PREMB, JPPR), Federal (FEMA HMGP, FEMA BRIC, HUD CDBG-MIT) | Immediate | Current Status: In Continuous Execution – Cleanup was performed from PR 676 to PR 2 in May 2026. MAVA maintains continuous monitoring of this area to perform periodic cleanups as needed. This strategy will provide the following qualitative benefits: Identifies mitigation solutions based on technical data to reduce flood risk. |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-SI-007 | PE-7 | El Batey and Abra Williams: Sewer Cleanup | Flooding | High | Transportation | Municipal Public Works Office, Municipal Emergency Management Office | State and Federal | Short Term | Current Status: In Continuous Execution – This strategy is carried out every 3 to 4 months in coordination between Public Works and the OMME. This strategy will provide the following qualitative benefits: It maintains the operation of the rainwater system, reduces flooding and protects access roads. |
| 2026-VAL-Si-008 | PE-8 | Los Pitirres Creek-Korea and Machuchal. Structural projects such as the piping of this creek are technically difficult, if not impossible, as well as very expensive. The strategy to be implemented in this case is to develop non-structural projects, which are more technically feasible and less expensive. Some examples of these projects would be cleaning of debris within, and along the entire length of the channel; 2. orientation to related communities on the consequences of dumping garbage in the Quebrada; 3. cleaning of its banks where feasible; 4. small modifications of the channel where strictly necessary and the environmental impact is minimal; 5. evaluate the possibility of relocating some houses located on the channel. | Flooding | High | Water Systems | Planning Office | State & Federal (HMGP) | Short Term | Current Status: In Permits – The phase I project was approved in 2024, only for the Machuchal Creek: IMPROVEMENTS TO THE EXISTING CHANNEL – MACHUCHAL SECTOR HMGP NO. 4339-0294 in the permitting process. The purpose of the project is to restore the hydraulic functionality of the existing channel, reduce erosive processes, stabilize the adjacent terrain and protect the nearby infrastructure. These improvements seek to increase the resilience of the drainage system to heavy rain events and extend the useful life of the associated structures. In addition, MAVA maintains continuous monitoring. During 2024, the dredging of the Machuchal creek was carried out and covered with municipal funds. This strategy will provide the following qualitative benefits: It reduces the risk of flooding, improves the flow of the channel and |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | strengthens the protection of the surrounding communities. |
| 2026-VAL-Si-009 | PE-9 | Ojo de Agua Sector: Raise the Level of Highway 647 along 2 kilometers. This strategy is modified to improve its implementation to: Evaluate and implement hydraulic improvements to reduce recurrent flooding in the Ojo de Agua Sector through structural and non-structural alternatives, including improvements to existing drainage, widening of canals and other measures identified through engineering studies. The 2020 Plan stated that: This strategy comes from the Vega Alta Mitigation Plan 2012. Consideration: This proposal to raise the level of PR647 along two kilometers is extremely expensive. Consider for this plan a better alternative (less expensive and less inconvenient) to excavate an outlet under PR647 to direct the flow of water to a channel that connects with the Cibuco River. The Project would also include the widening of the channel. | Flooding | High | Transportation | Office of Planning and Engineering, Municipal Office for Emergency Management, Municipal Public Works, DTOP and DNER | Municipal, State (COR3, PREMB, JPPR), Federal (FEMA HMGP, FEMA BRIC, HUD CDBG-MIT) | Short Term | Current Status: In Continuous Execution – The canal was cleaned in 2024. MAVA continues to monitor this area for periodic cleanups as needed. This strategy is modified to improve its implementation. This strategy will provide the following qualitative benefits: Reduces recurrent flooding, improves drainage, and protects road infrastructure and nearby properties. |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-Si-010 | PE-10 | Moran Sector: Construction of retaining wall and repair of water tank. | Flooding/Landslide | Medium | Security | Planning Office | State and Federal | | Current Status: Retired – The Aqueduct and Sewer Authority reports that the water tank is still in operation. There is no additional project from the municipality, but additional information has been requested from PRASA to establish if there is a possibility of an improvement project on their part, and PRASA's response is still awaited. This strategy will provide the following qualitative benefits: It reduces the risk of landslides and flooding, stabilizes the land, and protects existing infrastructure. |
| 2026-VAL-SI-011 | PE-11 | Remodeling of the Twin Building (Municipal Security Complex) that houses the OMME-AD and the Vega Alta Municipal Police), located along a strategic corridor of less than one kilometer on State Highway PR-2, which together provide the three essential capabilities for emergency management: Preparedness and Response Capacity — Public Safety Center that integrates the Municipal Office for Emergency Management (OMME), the Municipal Police and the Emergency Operations Center (COE). Permanent structure of 17,750 square feet. Humanitarian Services Capacity — Rehabilitation of the Municipal Reception Center to function as a distribution center for supplies (UA is duly certified as a Distribution Center), (Certified Shelters are Schools) and | All | High | Security, | Planning Office | Federal | Short Term | Current Status: NEW Funding – This strategy is 90% designed. A proposal has been submitted to the federal BRIC program, and we are awaiting approval. (Upcoming to Auction). This strategy will provide the following qualitative benefits: The strategy strengthens the City's capacity to prepare for, respond to, and recover from emergencies through resilient facilities that improve interagency coordination, streamline response, protect City resources, and ensure continuity of essential services to the community |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| | | point of provision of primary emergency medical services. Permanent structure of 30,500 square feet. (Whenever an Emergency is declared or the COE is Activated, a space is set up to move an Outpatient Emergency Room and attend to emergencies that occur. Operational Resilience — Construction of a new building for the Municipal Public Works Department with protected facilities for the vehicle fleet, maintenance shops, and field response teams. 7,000 square foot permanent structure. | | | | | | | |

*Table 46: Mitigation Strategies – Education and Awareness*

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-EA-001 | EPC-01 | Strengthen citizen participation in the formulation of plans, creation of programs and design of projects related to mitigation of natural disasters. | All | High | Security | Office of Planning, Municipal Office of Emergency Management, Office of Citizen Assistance | Federal, State, and Local | Short Term | Current Status: In Continuous Execution – The Community Boards created to prepare the First Comprehensive Review of the TEP (approved in December 2025), have provided feedback on information from the communities for the processes related to mitigation and the TEP. This strategy will provide the following qualitative benefits: It strengthens collaboration between the municipality and the community, promoting more effective decisions for risk reduction, |
| 2026-VAL-EA-002 | EPC-02 | Expand the Education and Orientation Program on natural disasters in all neighborhoods and sectors of the MAVA. | All | High | Security | Office of Planning, Municipal Office of Emergency Management, Office of Citizen Assistance | Federal, State, and Local | Immediate | Current Status: Ongoing – Talks are being offered in schools and churches. The Citizen Assistance Office and OMME, in conjunction with other state agencies, will be conducting discussions and hearings with communities to guide them and provide informational documents. This strategy will provide the following qualitative benefits: It increases the preparedness of the population, encourages a timely response, and reduces community vulnerability. |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-EA-003 | EPC-03 | To guide citizens on the importance of acquiring insurance against floods and landslides. | All | Medium | Security | Office of Planning, Municipal Office of Emergency Management, Office of Citizen Assistance | Federal, State, and Local | Short Term | Current Status: Running – The Citizen Assistance Office and OMME, in conjunction with other state agencies, will be conducting discussions and hearings with communities to guide them and provide informational documents. This strategy will provide the following qualitative benefits: Increases residents' financial resilience and facilitates faster recovery after a disaster. |
| 2026-VAL-EA-004 | EPC-04 | Educate businesses, stakeholders and the general public, through workshops, talks, publications, external resources, on how to avoid fires due to spontaneous combustion of pastures in Vega Alta. | Vegetative Fire | High | Security | Office of Planning, Municipal Office of Emergency Management, Office of Citizen Assistance | Federal, State, and Local | Immediate | Current Status: Ongoing Execution – This work is performed by the fire department with the support of the Citizen Assistance and Emergency Management Offices in conjunction with other state agencies. Discussions and hearings are held with communities to guide them. and provide informational documents. This strategy will provide the following qualitative benefits: Increases residents' financial resilience and facilitates faster recovery after a disaster. |

| 2026 ID | 2020 ID | Description | Hazard | Priority | Lifeline | Municipal Office in Charge | Possible Sources of Funds | Implementation term | Status |
|---|---|---|---|---|---|---|---|---|---|
| 2026-VAL-EA-005 | EPC-05 | Develop an awareness and education program, through workshops, talks and/or publications, for traders, stakeholders and the general public about the importance of water and alternatives for its conservation, storage and protection. | Drought | Medium | Water Systems | Office of Planning, Municipal Office of Emergency Management, Office of Citizen Assistance | Federal, State, and Local | Short Term | Current Status: In Execution – This work is carried out by the Citizen Assistance and Emergency Management Offices in conjunction with other state agencies and will be conducting discussions and hearings with communities to guide them and provide informative documents. This strategy will provide the following qualitative benefits: It promotes the efficient use of the resource, strengthens drought preparedness, and encourages sustainable practices. |

## 6.5 Participation in NFIP (C2-a)

Covered under the PRPB, the Municipality maintains continuous participation in the National Flood Insurance Program (NFIP) and remains committed to meeting all program requirements to reduce flood risk and protect life and property. Ongoing participation in the NFIP enables residents and businesses to access federally backed flood insurance while promoting sound floodplain management practices. The PRPB, on the municipality's behalf, enforces floodplain management regulations consistent with FEMA requirements, including the adoption and use of Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FIS) for development decisions. Local permitting, inspection, and enforcement activities help ensure that new construction and substantial improvements in Special Flood Hazard Areas comply with applicable elevation and floodproofing standards. The Municipality also supports public awareness and education activities related to flood risk, insurance requirements, and mitigation measures. Continued compliance with the NFIP strengthens eligibility for federal hazard mitigation funding and supports the long-term reduction of flood-related damages.

# 7. Plan Maintenance

This chapter outlines the actions required to ensure that the Plan's activities are effectively implemented, kept up to date, and aligned with the mitigation goals and objectives. In some cases, updating the Plan may involve amending proposed activities due to changes in on-site conditions that could increase or decrease the level of risk to which certain areas are exposed.

According to federal requirements the review process of LHMPs must include:[21]

- A section describing the method and schedule for monitoring, evaluating, and updating the Mitigation Plan within a five-year period.
- A process for integrating the Mitigation Plan's requirements into other local planning mechanisms, such as comprehensive plans or capital improvement plans, when appropriate.
- A discussion of how the community will continue to participate in the Plan's review process.

## 7.1 Point of Contact

The designated point of contact responsible for the monitoring, revision, and update of the Choose an item. LHMP is as follows:

| | |
|---|---|
| **Name** | Elsie J. Rosario Nieves |
| **Position** | Administrator |
| **Office** | Planning, Development , and Territorial Ordainment Office |
| **Telephone Number** | 787.883.5900 X-1245 |
| **Email** | erosario@vegaalta.pr.gov |

[21] 44 C.F.R. § 201.6(c)(4)

## 7.2 Public Participation Continuation (D1-a)

The Municipality of Vega Alta will ensure continuous public participation by promoting the following:

- Public education and awareness initiatives
- Surveys
- Workshops and meetings with communities throughout the municipality

Accordingly, the municipality commits to fostering public participation and community education. This commitment is reflected in several mitigation strategies described in this Plan. The public is encouraged to provide comments and take part in the LHMP's updates at any time, including requesting a copy of the LHMP—both during its development and throughout its monitoring and maintenance phases.

Additionally, each time a progress report is completed for this Plan, a copy will be made available for public review. Progress will also be periodically discussed in public meetings and shared through various social media and communication channels. The municipality will ensure that public participation notices are disseminated throughout the Plan's monitoring and oversight stages.

The municipality will also provide regular presentations to community groups regarding the LHMP's content and the progress of mitigation strategy implementation. These groups may include elected officials, schools, and other community organizations. Furthermore, the municipality will continue to promote civic engagement and community education by offering courses and workshops—such as CERT—focused on preparedness and response to hazardous events, as well as informing residents about components of the NFIP and other relevant programs.

These natural hazard-mitigation efforts must be adapted to the specific vulnerabilities and needs of each community. This approach will help build a more prepared and resilient population. This principle underpins the municipality's commitment to ensuring that the community remains engaged throughout the Plan's update cycle, its effective period, and subsequent processes following the Plan's adoption

## 7.3 LHMP Oversight (D2-a)

The municipality's review strategy for implementation, monitoring, and evaluation provides a framework that encourages collaboration, information-sharing, and innovation. Through multiple implementation methods, the municipality—acting through its Planning Committee, which is composed of representatives from various

municipal agencies and departments—will work with its partners and residents to apply a localized approach to loss reduction while addressing community needs through coordinated efforts. This strategy aims to break the cycle of disasters and strengthen the municipality's ability to withstand future events.

The Plan will be monitored for several related purposes:

- To maintain accurate information regarding hazards and risks
- To ensure that mitigation strategies reflect the priorities of participating communities and stakeholders
- To comply with federal and Puerto Rico government requirements for LHMP review
- To maintain eligibility for mitigation funding
- To ensure that the Plan remains aligned with other planning efforts

To ensure efficient and effective implementation, the municipality will make use of its existing capabilities and infrastructure planning processes. The municipality intends to carry out the mitigation strategies identified as immediate or short – term in the LHMP over the next five (5) years, or for as long as funding and resources allow.

## 7.4 LHMP Evaluation and Monitoring (D2-b)

The evaluation of the LHMP will be continuous. In addition to the five-year review required by FEMA, the municipality will conduct an annual review of the LHMP, or more frequently if circumstances require it. A meeting of the Planning Committee will be held after each annual review to approve a yearly progress report. Each year, a progress report will be prepared and submitted to the Office of the Mayor, documenting any updates to its information as well as any progress made toward achieving the mitigation goals and objectives. This report will be available to the public

A preliminary schedule to hold the Planning Committee meeting is outlined below:

*Table 43: Preliminary Planning Committee Meeting Schedule*

| Time Period | Participants | Purpose of the Meeting |
|---|---|---|
| **Annual Meeting (2027)** | Planning Committee<br><br>(Can be open to the public if deemed necessary) | The Committee members will hold the first annual meeting to identify the funding needed to implement the mitigation measures included in this LHMP, reassess the municipality's priorities regarding natural hazards or risk areas, and develop a strategy for submitting proposals to various state and federal programs. In addition, site visits will be conducted to review at-risk areas, monitor project progress, and establish direct communication with the communities. |
| **Annual Meeting (2028)** | Planning Committee<br><br>(Can be open to the public if deemed necessary) | The Committee will hold the annual meeting during the second year of the LHMP's approval to review the status of mitigation strategy implementation, identify emerging risks, and assess community needs. Site visits to at-risk areas will also be conducted, as needed, to track project progress and maintain direct engagement with the communities. |
| **Annual Meeting (2029)** | Planning Committee<br><br>(Can be open to the public if deemed necessary) | The Committee will meet to confirm the status of mitigation action implementation and determine whether additional funding is required to continue progress. |
| **Annual Meeting (2030)** | Planning Committee<br><br>(Can be open to the public if deemed necessary) | The Committee will hold its final meeting before the next LHMP review/update to verify the implementation status of mitigation actions, which will be documented in the upcoming Plan revision. |

## 7.5 LHMP Update and Revision (D2-C, D3-A)

### 7.5.1 Revision after a major disaster declaration

If a major emergency or disaster declaration affecting the Municipality occurs during

the Plan's five-year term, the Planning Committee—along with stakeholders, community representatives, and nonprofit organizations—will convene to identify newly affected areas, revise mitigation priorities, and incorporate lessons learned. This meeting will replace the annual review scheduled for that year.

### 7.5.2 Five – year comprehensive update

In accordance with federal guidance, the LHMP will be comprehensively updated five (5) years after approval and submitted to the State Hazard Mitigation Officer and FEMA for review and approval. Approximately eighteen (18) months prior to the Plan's expiration, the review process will begin, including a full evaluation of the municipal profile, risk assessment, and mitigation strategies, with attention to updated guidance and requirements.

## 7.6 Integration with Other Planning Mechanisms (D3-A)

The following public policies and planning documents were considered in the development of this LHMP:

Commonwealth Level:

- Puerto Rico Land Use Plan (PUT-PR)
- Choose an item. Territorial Plan (PT)
- Karst Special Planning Area Plan and Regulation
- Joint Regulation for the Evaluation and Issuance of Permits
- Special Flood Hazard Areas Regulation (2021)
- Stormwater System Design, Operation, and Maintenance Regulation
- Choose an item. Emergency Operations Plan

Following adoption, the LHMP will guide updates to the Territorial Plan, special area plans, and urban expansion plans, and will inform municipal budget priorities. Once FEMA approval is received, a digital copy of the Plan will be submitted to the Puerto Rico Planning Board to support updates to the PUT-PR and other relevant Commonwealth planning documents.

# 8. Adoption and Approval (F1-a, F1-b)

## 8.1 LHMP Adoption

Federal policy establishes LHMPs must include "Documentation that the LHMP has been formally adopted by the governing body of the jurisdiction requesting approval of the Plan. The municipality has one (1) year to adopt the Plan once it receives an *Approval Pending Adoption (APA)."*[22]

This LHMP was adopted by the Municipality of Vega Alta on **XXXXXX**. A copy of **Resolution**, titled *"To Adopt the 2026 Natural Hazard Mitigation Plan of the Municipality of Vega Alta and for Other Related Purposes,"* is included as part of **Appendix A**.

## 8.2 LHMP Approval

This LHMP was approved by FEMA and the SHMO on **XXXXX**. A copy of the Approval Letter, titled *"Approval of the Local Hazard Mitigation Plan, Municipality of Vega Alta,"* is included in **Appendix A**. FEMA's approval of the Plan is valid for a period of **five (5) years**, through **XXXXXX**

[22] 44 C.F.R. §201.6(c)(5)

# Selected References


American Society of Civil Engineers. (2024, August 20). *Civil Engineering Source*. Retrieved December 17, 2025, from Rising heat is scorching Americans - and our infrastructure: https://www.asce.org/publications-and-news/civil-engineering-source/article/2024/08/20/rising-heat-is-scorching-americans-and-our-infrastructure

Anderson, S., Barford, C., & Barford, P. (2020). *Five Alarms: Assessing the Vulnerabilities of US Cellular Communication Infrastructure to Wildfires*. Association for Computing Machinery.

Aqilah, S., Karmilla, K., Tamanna, K., Ali, Z., & Mat, N. (2024). Assesing Socio-Economic and Environmental Losses of Dam Failure Flood Risk: A Review on Sustainable Framework. *Journal of Sustainability Sceince and Management, 19*(1), 171 - 195.

ASDSO. (2022). *Dam Safety Performance Report 2022*. Lexington, KY. Retrieved January 4, 2026, from https://damsafety-dev.s3.amazonaws.com/s3fs-public/files/Puerto%20Rico%20Dam%20Safety%20Performance%20Report%202022.pdf

ASPR. (n.d.). *ASPR Health Care Readiness State Highlights*. Retrieved January 5, 2026, from https://aspr.hhs.gov/HealthCareReadiness/HealthCareReadinessNearYou/Pages/Puerto-Rico.aspx

AtkinsRéalis. (2024). *Hazard Mitigation Plan: Dam Annex Template for Puerto Rico*.

Autonomous Municipality of Bayamón. (2018). *Plan de Mitigación Multi-Riesgos 2018 (All Hazard Local Mitigation Plan*. Bayamón, PR: Oficina de Planificación y Ordenamiento Territorial.

Autonomous Municipality of Bayamón. (2024). *Plan Territorial Municipio, Fase 1 - Enunciacion de Metas y Objetivos, Plan de Trabajo, Memorial y Programa (Borrador)*. Oficina de Planificación.

Autonomous Municipality of Bayamón. (2025). *Emergency Operation Plan*. Bayamón PR: Municipal Agency for Emergency Mangement and Disaster Administration.

Baker, C., Cohen, S., Coulson, G., Durden, S., & Rossman, E. (n.d.). *Identification and Engagement of Socially Vulnerable Populations in the USACE Decision Making Process*. The Institute for Water Resources.

Bates, R., & Jackson, J. A. (1980). In *Glossary of geology*. Falls Church, Va.: American Geological Institute.

Benitez-Jaime, CPA-PSC. (2025). *SINGLE AUDIT REPORT-Independent Auditors' Report on Basic Financial Statements and Supplementary Schedule of* .

Bonano, V. e. (2020). *Perfil de Riesgo: Fallas y Fisuras*. Retrieved from https://storymaps.arcgis.com/stories/142062e6d5ec4bfca832c1a7f97dfa3f

Buckeye Partners, L.P. . (2010). *BUCKEYE PARTNERS, L.P. ANNOUNCES AGREEMENT TO PURCHASE REFINED PETROLEUM PRODUCTS TERMINAL IN PUERTO RICO*.

Retrieved from https://www.buckeye.com/wp-content/uploads/2021/08/Yabucoa-Agreement-Announcement-FINAL.pdf

Byrne, M. (2019). *Monitoring Storm Tide, Flooding, and Precipitation from Hurricane Maria in Puerto Rico and the U.S. Virgin Islands, September 2017*. USGS.

Caricoos. (n.d.). *Marejada Ciclónica*. Retrieved Noviembre 18, 2025, from http://www.caricoos.org/mao/strorm-surge

Castro Rivera, A. (n.d.). *Proyecto 1867*. Retrieved December 27, 2025, from La triple condena de 1867: https://www.proyecto1867.com/la-triple-condena-de-1867.html

Castro Rivera, A., & López Marrero, T. (2018). *Cartilla de los Ciclones*. Mayagüez, PR: Sea Grant - Universidad de Puerto Rico, Mayagüez.

CBO. (2024). *Federal Spending for Flood Adaptations*. Retrieved from www.cbo.gov/publication/59971

CCOF. (2026, March). *Caribbean Climate Outlook Newsletter - April to June 2026*. Caribbean Institute for Meteorology and Hydrology. Caribbean Climate Outlook Forum. Retrieved from https://rcc.cimh.edu.bb/files/2026/03/caricofamjjas.pdf

CDC. (2012, May 18). *CDC Archive*. Retrieved December 29, 2025, from https://archive.cdc.gov/www_cdc_gov/csels/dsepd/ss1978/lesson1/section11.html

CDC. (2014, December 5). *Morbidity and Mortality Weekly Report*. Retrieved December 29, 2025, from Chikungunya Cases Identified Through Passie Surveillance and Household Investigations - Puerto Rico, May 5 - August 12, 2014: https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6348a1.htm

CDC. (2024, Junio 25). *Heat Health*. Retrieved Noviembre 12, 2025, from Heat and Older Adults (Aged 65+): https://www.cdc.gov/heat-health/risk-factors/heat-and-older-adults-aged-65.html

CEACC. (2024). *Borrador del plan de mitigación, adaptación y resilencia al cambio climático en Puerto Rico*. San Juan, PR: Gobierno de Puerto Rico.

Center for Disaster Resilient Communities. (n.d.). *The Health Effects of Landslides*. Retrieved December 28, 2025, from https://edge.deohs.washington.edu/sites/edge/files/2025-07/Landslides%20Fact%20Sheet.pdf

Chowdhury, A., Zzaman, R. U., Hasan, H., Tarin, N. J., Islam, S., Ansenk, O., . . . Leya, R. (2025). Interacting Social and Environmental drivers of gendered resilience to storm surge disasters. *Discover Geoscience, 3*(190). doi:https://doi.org/10.1007/s44288-025-00297-1

Colón, J. A. (2009). *Climatología*. San Juan, PR: La Editorial Universidad de Puerto Rico.

Colorado State University. (2026). *Tropical Cyclones, Radar, Atmospheric Modeling, and Software Team*. Retrieved April 28, 2026, from CSU Tropical Cyclone Impact Probabilities: https://tropical.colostate.edu/TC_impact.html

Columbia University/Mailman School of Public Health. (2021, February 19). *Epidemic, Endemic, Pandemic: What are the Differences?* Retrieved from https://www.publichealth.columbia.edu/news/epidemic-endemic-pandemic-what-are-differences

COR3. (n.d.). *Coronavirus (COVID-19*. Retrieved January 4, 2026, from https://recovery.pr.gov/en/coronavirus

COREPI-PR. (2020). *The State of the beaches of Puerto Rico post Maria (G-1) ArcGIS Story Maps*. Retrieved April 29, 2026, from https://storymaps.arcgis.com/stories/ac6e366a14d840e88a266d23b440ab0c

Cutter, S., Boruff, B., & Shirley, W. (2003). Social Vulnerability to Envirnmental Hazards. *Social Science Quaterly, 84*(2), 244 - 261.

Cutter, S., Emrich, C., Morath, D., & Dunning, C. (2013). Integrating Social Vulnerability into Federal Flood Risk Management Planning. *Journal of Flood RIsk Management, 6*, 332 - 344.

Dennin, L., Nock, D., Muller, N., Akindele, M., & Adams, P. (2025). Social Vulnerable Communities Face Disproportionate Exposure and Suceptibility to US wildfire and prescribed burn smoke. *Communications Earth & Environment, 6*(190). doi:https://doi.org/10.1038/s43247-025-02100-y

DHS. (n.d.). *Ready.gov*. Retrieved enero 16, 2020, from https://www.ready.gov/heat

Dirlikov, E., Ryff, K. R., Torres -Aponte, J., Thomas, D. L., Pérez - Padilla, J., Muñoz-Jordán, J., Rivera - García, B. (2016, May 6). Update: Ongoing Zika Virus Transmission - Puerto Rico, November 1, 2015 - April 14, 2016. *Morbidity and Mortality Weekly Report, 65*(17), 451-455. Retrieved December 29, 2025, from https://www.cdc.gov/mmwr/volumes/65/wr/pdfs/mm6517.pdf

DNER. (2006, Marzo). Incendios Forestales en Puerto Rico. *Hojas de Nuesto Ambiente*, pp. 1 - 2.

DNER. (2015). *Informe sobre la sequía de 2014-2016 en Puerto Rico*. San Juan, PR: Division de Monitoreo del Plan de Aguas.

DNER. (2016). *Informe sobre la sequía 2014 - 16 en Puerto Rico*. San Juan, PR: Departamento de Recursos Naturales y Ambientales.

DNER. (2021). *Puerto Rico Forest Action Plan, 2021*. San Juan, PR: DNER.

DNER. (2021). *The Puerto Rico Forest Action Plan*. The Puerto Rico Department of Natural and Environmental Resources. Retrieved from https://www.drna.pr.gov/documentos/planes-de-manejo/puerto-rico-forest-action-plan-2021/

DOE. (2023, October 25). *Protecting our Electric Grid from Wildfire*. Retrieved December 16, 2025, from https://www.energy.gov/gdo/articles/protecting-our-electric-grid-wildfire

Ecoexploratorio. (2000). *¿Qué son las inundaciones?*

Eliot, J. W., Cloyd, T. E., & Philbin, M. (1994). Impacts of Landslides on an Ecosystem. *ASAE International Winter Meeting*. Atlanta, GA.

EPA. (2012). Cool Pavements. In *Reducing Urban Heat Islands: Compendium of Strategies*.

EPA. (2025, September 2). *Heat Island*. Retrieved December 17, 2025, from What are Heat Islands?: https://www.epa.gov/heatislands/what-are-heat-islands

EPA. (2026). *Hazardous Waste Cleanup: Buckeye Caribbean Terminals Incorporated in Yabucoa, Puerto Rico*. Environmental Protection Agency. Retrieved from https://www.epa.gov/hwcorrectiveactioncleanups/hazardous-waste-cleanup-buckeye-caribbean-terminals-incorporated-yabucoa

FBI & DHS. (2023). *Strategic Intelligences Assessment and Data on Domestic Terrorism*.

FEMA. (1997). *Multi - Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy*. Federal Emergency Management Administration.

FEMA. (1997). *Multi- Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy*.
FEMA. (1997). *Multi-Hazard Identification and RIsk Assessment: A Cornerstone of the National Mitigation Strategy*.
FEMA. (2013). *Federal Guidelines for Inundation Mapping of Floood Risk Associated with Dam Incidents and Failures - FEMA P-946*.
FEMA. (2018). *Threat and Hazard Identification and Risk Assessment (THIRA) and Stakeholder Preparedness Review (SPR) Guide*.
FEMA. (2021). *Coastal Flood Risk*. Retrieved April 28, 2026, from https://www.fema.gov/flood-maps/coastal
FEMA. (2021). *National Incident Management System*.
FEMA. (2023, July). *fema.gov*. Retrieved November 24, 2025, from Community Lifelines Implementation Toolkit: https://www.fema.gov/sites/default/files/documents/fema_lifelines-toolkit-v2.1_2023.pdf
FEMA. (2024, February 20). *2.7 Community Lifelines: The HAZMAT Lifeline*. Retrieved December 28, 2025, from https://www.fema.gov/oet-tools/chemical-incident-consequence-management/2/7
FEMA. (2024). *Federal Guidelines for Dam Safety*. DHS.
FEMA. (2024). *Hazus Earthquake Model User Guidance*.
FEMA. (2024). *Natural and Nature-based Solutions Job Aid for Stormwater Management in Puerto Rico*.
FEMA. (2025). *Local Mitigation Planning Handbook*.
FEMA. (2025). *Local Mitigation Planning Policy Guide*.
FEMA. (2025, May 9). *National Dam Safety Program*. Retrieved April 20, 2026, from Resources for the General Public: https://www.fema.gov/grants/mitigation/learn/dam-safety/resources-general-public
FEMA. (2025). *National Risk Index Data - Technical Documentation*.
FEMA. (2025). *Reducing Damage from Localized Flooding*.
FEMA. (2026, January 7). *National Risk Index for Natural Hazards*. Retrieved June 17, 2026, from https://www.fema.gov/flood-maps/products-tools/national-risk-index
FEMA. (n.d.). *Puerto Rico Earthquakes DR-4473-PR*. Retrieved December 15, 2025, from https://www.fema.gov/disaster/4473
Fox, S., Agyemang, F., Hawker, L., & Neal, J. (2024). Integrating social vulnerability into high-resolution global flood risk mapping. *Nature Communication, 15*. doi:ttps://doi.org/10.1038/s41467-024-47394-2
Ganz, S., Duan, C., & Ji, C. (2023). Socioeconomic Vulnerability and Differential Impact of Severe Weather - Induced Power Outages. *PNAS NEXUS, 2*, 1-10. doi:https://doi.org/10.1093/pnasnexus/pgad295
Gill, J. C., & Malamud, B. D. (2017). Anthropogenic processes, natural hazards, and interactions in a multi-hazard framework. *Earth-Science Reviews*, 246 - 269.
Gould, W. (2008). Editorial. *AMBIO: A Journal of the Human Environment 37(7)*, 521. doi:https://doi.org/10.1579/0044-7447-37.7.521

Guibert, G., & Hyde, I. (2021). *Analysis: COVID-19's impact on Arts and Culture*. Argone National Laboratory.

Guiney, J. (1999). *Preliminary Report Hurricane Georges 15 September - 01 October 1998*. NHC.

Guo, Q., & Lee, D. C. (2021). The Ecology of COVID-19 and Related Environmental and Sustainability Issues. *Ambio*.

Guzmán-Colon, B., Guido, Z., Amaya-Ardilla, C. P., Cabrera-Rivera, L. T., & Méndez-Lázaro, P. A. (2025). Heat Risk Perception and Vulnerability in Puerto Rico: Insights for Climate Adaptation in the Caribbean. *International Journal of Environmental Research and Public Health, 22*(1197). doi:https://doi.org/10.3390/ijerph22081197

Hernández - Padilla, J. A., & Méndez-Piñero, M. I. (2020). Economic Impact of the COVID-19 Pandemic in Puerto Rico. *Proceedings of the 9th Annual World Conference of the Society for Industrial and Systems Engineering 2020 SISE Virtual Conference*, (pp. 90-95). Retrieved January 5, 2026, from https://ieworldconference.org/content/SISE2020/Papers/Hernandez-Padilla.pdf

Hernández - Torres, R., Martínez - Lozano, M., Torres, I., Rosario - Hernández, E., Ramos - Pibernus, A., Soto, A., Rivera - Segarra, E. (2023). The impact of the Covid-19 pandemic and previous natural disasters on the mental health of healthcare workers in Puerto Rico. *PLOS Global Public Health, 3*(5). Retrieved January 5, 2026, from file:///C:/Users/PITR4955/Downloads/journal.pgph.0001784.pdf

Highland, L. M., & Bobrowsky, P. (2008). *The Lanslide Handbook - A Guide to Understanding Landslides*. Reston, VA: USGS.

Highways Industry. (n.d.). *Highways Industry.com*. Retrieved January 2, 2026, from https://www.highwaysindustry.com/impact-extreme-heat-roads/

Hirsh, G. B., & Centeno - Marín, H. (2015). The Puerto Rico Emergency Prepara=edness Model. *Proceedings of the System Dymanics Society*. Retrieved January 4, 2026, from https://proceedings.systemdynamics.org/2015/papers/P1186.pdf

Hughes, K., Bayouth García, D., Martínez Milian, G., Schulz, W., & Baum, R. (2019). *Map of slope-failure locations in Puerto Rico after Hurricane María: U.S. Geological Survey data release*. doi:https://doi.org/10.5066/P9BVMD74

IFRC. (2023, August 8). *Landslides*. Retrieved December 28, 2025, from https://epidemics.ifrc.org/manager/disaster/landslides

Institute for Environmental Research and Education. (2025). *How Do Tsunamis Impact the Environment*. Retrieved December 28, 2025, from https://iere.org/how-do-tsunamis-impact-the-environment/

Jessen, J. (2025, June 30). *Energy Digital*. Retrieved December 17, 2025, from https://energydigital.com/news/climate-change-how-heatwaves-are-affecting-power-grids

Kerber, S., & Alkoins, D. (2024). *Lahaina Fire Incident Analysis Report*. Columbia, MD: Fire Safery Research Institute.

Lander, J. F., Whiteside, L. S., & Lockridge, P. A. (2002). A Brief History of Tsunamis in the Caribbean Sea. *Science of Tsunami Hazards, 20*(1). Retrieved December 27, 2025, from

https://www.proyecto1867.com/uploads/8/6/3/9/86396506/lander_et_al.__2002_.pdf

Larsen , M., & Torres-Sanchez, A. (1998). The frequency and distribution of recent landslides in three montane tropical regions of Puerto Rico. *Geomorphology*, 309-331.

Larsen, M., & Park, J. (1997). How wide is a road? The association of roads and mass-wasting in a forested montane environment. *Earth Surface Processes and Landforms*, 835-848.

López Marrero, T. (2010, June). An Integrative Approach to Study and Promote Natural Ahzards Adaptive Capacity: A Case Study of Two Flood-Prone Communities in Puerto Rico. *The Geograhical Journal, 176*(2), 150-163.

López-Vega, CPA, PSC. (2024). *Report on the Audit of the Financial Statements of the Autonomous Municipality of Yabucoa*.

Lugo, A. E., Miranda Castro, L., Abel, V., López, T., Hernández Prieto, E., García Martinó, A., Helmer, E. (2021). *Puerto Rican Karst - A Vital Resource*. Forest Service, United States Department of Agriculture. USFS.

Méndez - Lázaro, P. A., Di Napoli, C., Rivas - Tumanyan, S., Pérez Ríos, N., González Sepulveda, L., Rodríguez, E., Milán, L. (2025). Too hot and too humid in the Caribbean: Impacts of extreme heat events and non-accidental mortality in the tropical island of Puerto Rico. *The Journal of CLimate and Healt*.

Mentaschi, L., Vousdoukas, M., Pekel, J.-F., Voukouvalas, E., & Feyen, L. (2018). Global - long-Term Observations of Coastal Erosion and Accretion. *Scientific Reports, 8*(12876), Scientific Reports. doi:10.1038/s41598-018-30904-w

Muche, M., Yemata, G., Molla, E., Muasya, A., & Tsegay, B. (2022). COVID-19 Lockdown and Natural Resources: A Global Assessment on the Cahllenges, Opportunities and the Way Forward. *Bulleting of the National Research Centre, 46*(20).

Municipality of Vega Alt. (2018). *Plan de MitigaciónContra Peligros Naturales 2020*. San Juan, PR: Junta de Planificación.

Municipality of Vega Alta. (2025). *Emergency Operation Plan*. Vega Alta: Municipal Agency for Emergency Mangement and Disaster Administration.

Municipality of Vega Alta. (2024). *Municipal Recovery Plan: San Juan, PR, Puerto Rico Department of Housing*

National Institute of Building Sciences. (2020). *2020 NEHRP Recommended Seismic Provisions: Design Examples, Training Materials; and Design Flow Chart*. FEMA. Retrieved April 28, 2026, from https://www.fema.gov/sites/default/files/documents/fema_nehrp_design-examples-training-materials_volume-1.pdf

National Integrated Heat Health Information System. (n.d.). *Heat.gov*. Retrieved noviembre 12, 2025, from Urban Heat Islands: https://heat.gov/urban-heat-islands/

National Oceanic and Atmospheric Administration. (2026). *Historical Hurricane Tracks*. Retrieved from https://coast.noaa.gov/hurricanes/#map=8.57/18.2704/-66.2032&search=eyJzZWFyY2hTdHJpbmciOiJQdWVydG8gUmljbywgVVNBIiwic2VhcmNoVHlwZSI6Imdlb2NvZGVkIiwib3NtSUQiOiI0NDIyNjA0IiwiY2F0ZWdvcmllcyI6WyJINSIsIkg0IiwiSDMiLCJIMiIsIkgxIiwiVFMiLCJURCIsIkVUIl0sInllYXJzIjp

NIST. (n.d.). Retrieved November 26, 2024, from Infrastructure: https://www.nist.gov/infrastructure

NMEAD. (2021). *Plan Estatal de Mitigación de Peligros Naturales de Puerto Rico*. San Juan, PR: Negociado de Manejo de Emergencias y Administracion de Desastres.

NOAA. (2022). *Centers for Environmental Information*. Retrieved January 2, 2026, from State Climate Summaries: Puerto Rico and the US Virgin Islands: https://statesummaries.ncics.org/chapter/pr/

NOAA. (2025). *National Centers for Environmental Information*. Retrieved December 28, 2025, from https://www.ncei.noaa.gov/stormevents/choosedates.jsp?statefips=99%2CPUERTO+RICO

NOAA. (2026). *Relative Sea Level Trends*. Retrieved April 28, 2026, from https://tidesandcurrents.noaa.gov/sltrends/

NOAA. (n.d). *National Hurricane Center and Central Pacific Hurricane Center*. Retrieved April 20, 2026, from Storm Surge Overview: https://www.nhc.noaa.gov/surge/

NOAA. (n.d.). *NCEI*. Retrieved May 27, 2026, from Tsunamis: https://www.ncei.noaa.gov/products/natural-hazards/tsunamis-earthquakes-volcanoes/tsunamis

Norris, F., Stevens, S., Pfefferbaum, B., Wyche, K., & Pfefferbaum, R. (2007). Community Resilience as a Methaphor, Theory, Set of Capabilities and Strategy for Disaster Readiness. *American Jounral of Community Psychology, 47*, 127 - 150. Retrieved April 28, 2026, from https://www.researchgate.net/publication/5691020_Community_Resilience_as_a_Metaphor_Theory_Set_of_Capacities_and_Strategy_for_Disaster_Readiness

Okamura, K., Fujisawa, A., Kondo, Y., Fujimoto, Y., Uozu, T., Kaner, S., & Mizoguchi, K. (2013). The Great East Japan Earthquake and cultural heritage: towards an archeology of disaster. *Antiquity, 87*, 258-269.

Pasch, R., Penny, A., & Berg, R. (2023). *Hurricane Maria*. NHC. Retrieved April 28, 2024, from https://www.nhc.noaa.gov/data/tcr/AL152017_Maria.pdf

Pasch, R., Reinhart, B., & Alaka, L. (2023). *Hurricane Fiona*. NHC.

Peek, L., & Stough, L. (2010). Children with Disabilities in the Context of Disaster: A Social Vulnerability Perspective. *Child Development, 81*(4), 1260 - 1270. Retrieved April 20, 2026, from https://hazards.colorado.edu/uploads/publications/36_2010_Peek_Stough.pdf

PRDH. (2022). *Resumen ejecutivo: Situación de la epidemia del COVID-19 en Puerto Rico año 2021*. Retrieved January 5, 2026, from https://www.salud.pr.gov/CMS/DOWNLOAD/8708

PRDOH. (2025). *Puerto RIco Mitigation Action Plan, CDBG-MIT*. San Juan, PR: Puerto Rico Department of Housing.

PREMB. (2021). *2021 Puerto RIco State Natural Hazards Mitigation Plan*.

PRPB. (2014). *Plan de Manejo del Area de Planificación Especial del Carso*.

PRPB. (2015). *Plan de Uso de Terrenos, Guías de Ordenación del Territorio*. San Juan, PR: Junta de Planificación.

PRPB. (2020). *Hazard Mitigation Plan agains Natural Hazards - Municipality of Yabucoa*. Puerto Rico Planning Board. Retrieved from https://docs.pr.gov/files/JP-Junta%20de%20Planificacion/Planes%20de%20Mitigaci%C3%B3n%20Aprobados/Resumen%20Ejecutivo/Yabu-Approved-HMP-1.pdf

PRPB. (2020). *Hazard Mitigation Plan against Natural Hazards - Muicipality of Jayuya*. Puerto Rico Planning Board. Retrieved from https://docs.pr.gov/files/JP-Junta%20de%20Planificacion/Planes%20de%20Mitigaci%C3%B3n%20Aprobados/Actualizados%20por%20los%20municipios/Jayuya-Approved-HMP-200622.pdf

PRPB. (2021). *Special Flood Hazard Areas Regulation*.

PRPB. (2023). *Reglamento para la evaluación y expedición de permisos relacionados al desarrollo, uso de terrenos y operación de permisos*. San Juan, PR: Junta de Planificación.

PRSN. (n.d.). Retrieved December 27, 2025, from http://www.prsn.uprm.edu/Spanish/tsunami/historia.php

PRSN. (2019). *Red Sísmica de Puerto Rico*. Retrieved enero 13, 2020, from http://redsismica.uprm.edu/Spanish/educacion/terremotos/

PRSN. (2025). *Puerto Rico Seismic Network*. Retrieved December 15, 2025, from https://redsismica.uprm.edu/english/education/prediction.php

PRSN. (2025). *Red Sísmica de Puerto Rico*. Retrieved December 15, 2025, from Resumen Preliminar de actividad sísmica anual para el 2024: https://redsismica.uprm.edu/spanish/sismicidad/reportes/anuales/Informe_Anual_2024.pdf

PRSN. (2025). *Seismic Information*. Retrieved December 26, 2025, from Earthquake of 1918: http://www.prsn.uprm.edu/English/information/quake1918.php

PRSN. (n.d.). *Red Sísmica de Puerto Rico*. Retrieved December 15, 2025, from Reporte de Sismicidad: https://redsismica.uprm.edu/spanish/sismicidad/reportes/

Public-Private Analytic Exchange Program. (2025). *Implications of Extreme Weather Events on U.S. Telecommunications Infrastructure*. DHS.

Rigau-Pérez, J., & Vallejo - Calzada, E. D. (2020, march). Measles, Malnutrition and Mortality. *Puerto Rico Health Science Journal, 39*(1), 20 - 27. Retrieved December 29, 2025, from https://issuu.com/coleccionpuertorriquena/docs/rigau__vallejo_measles_in_pr_1917-1918_prhsj_2020

Robbins, A., Eckelmann, C., & Quiñones, M. (2009). Forest Fires in the Insular. *Ambio: A Journal of the Human Environment*, 37:528-534.

Rodríguez, D. M., Madwell, Z. J., Torres, J. M., Rivera, A., Wong, J. M., Santiago, G. A., . . . Adams, L. E. (2024, December 12). Epidemiology of Dengue - Puerto RIco, 2010 - 2024. *Morbidity and Mortality Weekly Report*. Retrieved December 29, 2025, from https://www.cdc.gov/mmwr/volumes/73/wr/pdfs/mm7349a1-H.pdf

Rosario Urrutia, M. (2021, February 12). *Puerto Rican Endowment for the Humanities - Encyclopedia of Puerto Rico*. Retrieved December 29, 2025, from From the forgotten Flu Pandemic in Puerto Rico, 1918-1919, to the beginning of Covid-19 in 2020: https://en.enciclopediapr.org/content/from-flu-pandemic-1918-to-covid19-puerto-rico/

Sánchez - Plazas, L. C., García - De Jesús, R., Martínez - González, K. G., Amaya - Ardila, C. P., & Almodóvar - Rivera, I. A. (2024). The psychological impact of the COVID-19 pandemic on physicians in Puerto Rico: a cross-sectional study after the second wave in 2021. *Psychiatry, 14*. Retrieved January 5, 2026

Sandia National Laboratories. (n.d.). *Wildfire Electric Grid Resilience*. Retrieved December 16, 2025, from https://energy.sandia.gov/programs/electric-grid/wildfire-electric-grid-resilience/

Schumann, III, R., Emrich, C., Bustic, V., Mockrin, M., Zhou, Y., Johnson - Gaither, C., . . . Aksha, S. (2024). The Geography of Social Vulnerability and Wildfire Ocurrebce (1984 - 2018) in the Contermonous USA. *Natural Hazards, 120*, 4297 - 4327. doi:https://doi.org/10.1007/s11069-023-06367-2

Seadex. (n.d.). *Yabucoa Port (Small) — Puerto Rico Maritime Hub*. Retrieved from https://seadex.ai/en/port/pryab

Sharp, T. M., Roth, N. M., Torres, J., Ryff, K., Pérez Rodríguez, N., Mercado, C., . . . Rivera García, B. (2014, December 5). Chikungunya Cases Identified Through Passive Surveillance and Household. *Morbidity and Mortality Weekly Report*. Retrieved December 29, 2025, from https://www.cdc.gov/mmwr/pdf/wk/mm6348.pdf

Shipnext. (Accessed 2026). *Yabucoa, Puerto Rico (PRYAB)*. Retrieved from https://shipnext.com/port/yabucoa-pryab-pri

SNOFLO. (2026). *Carite Dam Report*. Retrieved January 4, 2026

SNOFLO. (2026). *Cidra Dam Reservoir Report*. Retrieved January 2, 2026, from https://snoflo.org/reservoir/puerto-rico/pr00020-cidra-dam

Soler - López, L. R. (2010). *Sedimentation Survey of Lago de Cidra, Puerto Rico*. Retrieved January 2, 2026, from https://pubs.usgs.gov/sim/3118/

Stein, S. M., Comas, S. J., Menakis, J. P., Carr, M. A., Steward, S. I., Cleveland, H., . . . Radeloff, V. (2013). *Wildfire, Wildlands and People: Undertaking and preparing for Wildfire in the Wildland-Urban Interface - a Forest on the Edge Report*. Fort Collins, CO: US Department of Agriculture - Forest Service, Rocky Mountain Resewarch Station.

Thomas, D. L., Sharp, T. M., Torres, J., Armstrong, P. A., Muñoz-Jordán, J., Ryff, K. R., . . . Rivera - García, B. (2016, February 19). Local Transmission of Zika Virus — Puerto Rico,. *Morbidity and Mortality Weekly Report, 65*(6). Retrieved December 29, 2025, from https://www.cdc.gov/mmwr/volumes/65/wr/pdfs/mm6506e2.pdf

Timothee, R. A., Morris, L., Filiberti, M., & Mainardi, L. E. (1963). Epidemic of Poliomyelitis in Puerto Rico, 1960. *Public Health Reports, 78*(1), 65 - 76.

UNESCO. (2021). *World Heritage in the Face of COVID-19*.

US Census Bureau. (2024, September 26). *Resource Library*. Retrieved February 10, 2025, from Tools for Vulnerable Populations in Puerto Rico: https://www.census.gov/library/stories/2024/09/cre-pr-tools.html

US Census Bureau. (2025). *Census Data*. Retrieved November 21, 2025, from https://data.census.gov/table/ACSST5Y2023.S1701?g=050XX00US72021

US Census Bureau. (2025). *Census Data*. Retrieved November 21, 2025, from https://data.census.gov/table/ACSST5Y2023.S0101?g=050XX00US72021

US Census Bureau. (2025). *Census Data*. Retrieved November 30 30, 2025, from S1810 Disability Characteristics: https://data.census.gov/table/ACSST5Y2023.S1810?g=050XX00US72021

US Census Bureau. (2025). *Data Census*. Retrieved November 21, 2025, from https://data.census.gov/table?g=050XX00US72021

US Census Bureau. (2025). *Data Census*. Retrieved November 30, 2025, from S1810 Disability Characteristics: https://data.census.gov/table/ACSST5Y2018.S1810?g=050XX00US72021

US Census Bureau. (2025). *Data.Census*. Retrieved November 30, 2025, from S2201: Food Stamps/Supplemental Nutrition Assistance Program: https://data.census.gov/table/ACSST5Y2023.S2201?g=050XX00US72021

US Drought Monitor. (2025). *Data*. Retrieved December 16, 2025, from Time Series: https://droughtmonitor.unl.edu/DmData/TimeSeries.aspx

US Fire Administation. (2025, December 16). *What is the WUI?* Retrieved from https://www.usfa.fema.gov/wui/what-is-the-wui/

USACE. (2013). *Coastal Risk Reduction and Resiliency: Using the Full Array of Measures*. Retrieved April 28, 2026, from https://cdm16021.contentdm.oclc.org/utils/getfile/collection/p266001coll1/id/5270

USACE. (2019). *LifeSim: Flood life-loss estimation model - Technical reference manual*.

USACE. (2020). *Safety of Dams- Policy and Procedures* .

USACE. (2021). *HEC-RAS river analysis system user's manual*.

USACE. (2022, May 11). *National Inventory of Dams*. Retrieved January 4, 2026, from Cidra Dam: https://nid.sec.usace.army.mil/nid/#/dams/system/PR00020/inspections

USACE. (2022, May 11). *National Inventory of Dams*. Retrieved January 4, 2026, from Carite Dam: https://nid.sec.usace.army.mil/nid/#/dams/system/PR00021/inspections

USACE. (2022, May 11). *National Inventory of Dams*. Retrieved January 4, 2026, from https://nid.sec.usace.army.mil/nid/#/dams/system/PR00018/inspections

USACE. (2022, May 11). *National Inventory of Dams*. Retrieved January 4, 2026, from https://nid.sec.usace.army.mil/nid/#/dams/system/PR00019/summary

USACE. (2023, May). *Congresional Fact Sheets 2025*. Retrieved December 29, 2025, from Guajataca Dam Repairs: https://www.saj.usace.army.mil/About/Congressional-Fact-Sheets-2025/Guajataca-Dam-Repairs-PR-C/

USACE. (2024). *Public Notice Archive*. Retrieved from SAJ-1987-01095(SP-CGR): https://www.saj.usace.army.mil/Missions/Regulatory/Public-Notices/Article/3875333/saj-1987-01095sp-cgr/

USACE. (n.d.). *Publications*. Retrieved April 20, 2026, from Risk - Informed safety Program: https://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_360-1-31.pdf

USACE. (n.d.). *Value to the Nation*. Retrieved December 22, 2025, from Flood Risk Mgmt: Ecomomic Impaxct: https://www.iwr.usace.army.mil/Missions/Value-to-the-Nation/Flood-Risk-Mgmt/Flood-Risk-Economic-Impact/

USDA. (2001, 07). *MAUNABO SERIES*. Retrieved from Soil Series: https://soilseries.sc.egov.usda.gov/OSD_Docs/M/MAUNABO.html

USDA. (2002, 06). *TALANTE SERIES*. Retrieved from Soil Series: https://soilseries.sc.egov.usda.gov/OSD_Docs/T/TALANTE.html
USDA. (2004, 06). *TEJA SERIES*. Retrieved from Soil Series: https://soilseries.sc.egov.usda.gov/OSD_Docs/T/TEJA.html
USDA. (2023, 10). *PANDURA SERIES*. Retrieved from SoilSeries: https://soilseries.sc.egov.usda.gov/OSD_Docs/P/PANDURA.html
USDOT - FRA. (2013). *Track Buckling Prevention: Theory, Safety Concepts, and Applications*. Washington DC: Office of Research and Development.
USFS. (n.d.). *Fire Effects Information System*. Retrieved December 16, 2025, from https://www.fs.usda.gov/database/feis/glossary.html#SCATTER-HOARD:
USGS. (2014). *Puerto Rico's Rainfall Deficit Indicates Drought*. Retrieved December 23, 2025, from https://www.usgs.gov/news/state-news-release/puerto-ricos-rainfall-deficit-indicates-drought
USGS. (2016). *Caribbean - Florida Water Science Center*. Retrieved December 23, 2025, from Drought Conditions in Puerto Rico: https://www.usgs.gov/centers/caribbean-florida-water-science-center-%28cfwsc%29/science/drought-conditions-puerto-rico
USGS. (2018). *Long-Term Coastal Change*. Retrieved April 28, 2026, from https://www.usgs.gov/programs/cmhrp/science/long-term-coastal-change#overview
USGS. (2019, August 6). *Earthquake Hazards 201 Technical Q&A*. Retrieved April 28, 2026, from https://www.usgs.gov/programs/earthquake-hazards/science/earthquake-hazards-201-technical-qa
USGS. (2020). *La duración potencial de las réplicas del terremoto 2020 del suroeste de Puerto Rico*. Reston Virginia: Servicio Geológico de EE. UU.
USGS. (2023). *Coastal Hazards and Resilience*. Retrieved April 28, 2026, from https://www.usgs.gov/science/science-explorer/coasts/coastal-hazards-and-resilience
USGS. (2024, September 10). Retrieved December 15, 2025, from Moment magnitude, Richter scale- what are the different magnitudes scales, and why are there so many?: https://www.usgs.gov/faqs/moment-magnitude-richter-scale-what-are-different-magnitude-scales-and-why-are-there-so-many
USGS. (2025). *Deep Dive: Protecting Critical Infrastructure*. Retrieved April 29, 2026, from https://www.usgs.gov/programs/climate-adaptation-science-centers/science/deep-dive-protecting-critical-infrastructure
USGS. (2026). *Granodiorite–Quartz Diorite of San Lorenzo, Puerto Rico (Geologic Unit Ksl). Mineral Resources Online Spatial Data*. Retrieved from https://mrdata.usgs.gov/geology/pr/prgeo-unit.php?unit=Ksl
USGS. (2026). *Granodiorite–Quartz Diorite of San Lorenzo, Puerto Rico (Geologic Unit Ksl). Mineral Resources Online Spatial Data*. Retrieved from https://mrdata.usgs.gov/geology/pr/prgeo-unit.php?unit=Ksl
USGS. (2026). *State Geologic Map Compilation (SGMC) Lithology Classification—Metavolcanic Rock (Lithology Code 5.3). Mineral Resources Online Spatial Data*.

Retrieved from Available at: https://mrdata.usgs.gov/geology/state/sgmc-lith.php?code=5.3

USGS. (n.d.). *Earthquake Hazard Program*. Retrieved December 15, 2025, from Earthquake Hazards ProgramM 6.4 - 4 km SSE of Indios, Puerto Rico: https://earthquake.usgs.gov/earthquakes/eventpage/us70006vll/executive#d

USGS. (n.d.). *Topoview*. Retrieved Noviembre 12, 2025, from http://ngmdb.usgs.gov/topoview/#13/18.3925/-661240

Vega Lugo, R. (2021, February 21). *Enciclopedia de Puerto Rico*. Retrieved December 29, 2025, from El cólera morno en Puerto Rico, 1855 a 1856: https://enciclopediapr.org/content/el-colera-morbo-en-puerto-rico-1855-a-1856/

Ware-Gilmore, F., Rodríguez, D. M., Ryff, K., Torres, J. M., Pérez Vélez, M., Torres - Toro, C. T., Marzán-Rodríguez, M. (2025, February 20). Dengue Outbreak and Response — Puerto Rico, 2024. *Morbidity and Mortality Weekly Report, 74*(5). Retrieved December 29, 2025, from https://www.cdc.gov/mmwr/volumes/74/wr/pdfs/mm7405-H.pdf

Weilert, L., & Laó-Dávila, D. (2023, August). Fault structure and segmentation of the Punta Moltalva Fault in sourhwestern Puerto Rico using high-resolution digital elevantion models. *Tectonophysics*.

West, J., Rodríguez Cruz, L. A., & Hughes, K. (2023). Assessing Social Vulnerability to Landslides in Rural Puerto Rico. *Natural Hazards Center Public Health Disaster Research Report Series*. Retrieved February 10, 2025, from https://hazards.colorado.edu/public-health-disaster-research/steep-risks

WHO. (2025). *Floods*. Retrieved December 22, 2025, from https://www.who.int/health-topics/floods/#tab=tab_1

World Bank. (n.d.). *Climate Knowledge Portal*.

World Bank. (n.d.). *Think Hazard*. Retrieved from https://www.thinkhazard.org/en/report/200-puerto-rico-u-s/WF

Zhang, R., Ji, H., Pang, Y., & Suo, L. (2022). The Impact of COVID-19 on Cultural Industries: An Empirical Research Based on Stock Market Returns. *Frontiers in Public Health*.

# Appendix A: Adoption and Approval

## Adoption

To be included in the FEMA Approved Document

## Approval by FEMA

To be included in the FEMA Approved Document

## FEMA APA Letter

To be included in the FEMA Approved Document

## FEMA Review Tool

To be included in the FEMA Approved Document

# Appendix B: Planning Committee

JUNTA DE
PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

## Carta de Compromiso sobre el Plan de Mitigación Municipal

El Municipio de Vega Alta, representado en este acto por su alcaldesa, Hon. María Vega Pagán, mediante el presente documento denominado carta de compromiso se compromete en conjunto con la Junta de Planificación de Puerto Rico (JPPR) trabajar en la revisión y actualización del plan de mitigación contra peligros naturales municipal (Plan). El mismo tiene el objetivo de identificar actividades y medidas dirigidas a la mitigación de peligros naturales tales como huracanes, inundaciones, sequías, terremotos, deslizamientos, tsunami entre otros que apliquen. El Plan tiene dentro de sus prioridades la reducción de pérdidas de vida y propiedad asociado a los diferentes peligros naturales e identificar medidas para atender las necesidades del municipio y sus residentes de manera planificada y ordenada, promoviendo así el desarrollo sostenido mediante la preservación de la función natural y los beneficios de la conservación de los recursos naturales y la infraestructura.

Observando los planes que se han vencido, y están próximos a vencer, la *Oficina Central de Recuperación, Reconstrucción y Resiliencia* (COR3 por sus siglas en inglés) procedió asignar presupuesto a la JPPR para atender la revisión y actualización de los Planes de Mitigación Contra Peligros Naturales de los municipios. Es importante destacar que los planes de mitigación deberán estar aprobados por la Agencia Federal para el Manejo de Emergencias (FEMA por sus siglas en inglés) para evitar que los municipios pierdan los fondos asignados para la ejecución de los proyectos. Por lo tanto, recae sobre el municipio la responsabilidad de gestionar adecuadamente su plan, ya que la falta de vigencia conllevaría la pérdida de dichos fondos.

La JPPR está facultada para asistir a los municipios, conforme a la Ley Orgánica de la Junta de Planificación de Puerto Rico, Ley Núm. 75 del 24 de junio de 1975, según enmendada, 23 LPRA., sección 62 (k). Asimismo, la JPPR podrá hacer uso de recursos externos para la elaboración del plan de mitigación.

A su vez el Municipio está facultado a realizar acuerdos con cualquier agencia del Gobierno Central para que este desarrolle o lleve a cabo, en beneficio del Municipio, cualquier estudio, trabajo, obra o mejora pública municipal conforme a lo establecido en la ley Código Municipal de Puerto Rico, Ley Núm. 107 del 13 de agosto de 2020, según enmendada.

Es esencial que este plan cumpla con los requisitos del Acta de Mitigación de Desastre, la cual establece que los gobiernos municipales y estatales que hayan adoptado sus planes de mitigación contra peligros naturales serán elegibles para fondos de mitigación pre-desastre (Pre-disaster Mitigation Act) y post desastre a través del Programa de Subvención para la Mitigación de Riesgos (HMGP), el Predisaster Mitigation (PDM) y el Flood Mitigation Assistance Program (FMAP).

Por lo tanto, el municipio reconoce que la JPPR se comprometerá a coordinar junto al municipio la aprobación del Plan; coordinar la evaluación del Plan por parte del COR3 y FEMA; y efectuar la entrega del Plan aprobado por COR3 y FEMA al municipio.

P.O. Box 41119, San Juan PR, 00940-1119 • 787.723.6200 • jp.pr.gov

El Municipio asignará una persona contacto o empleado municipal designado por el alcalde que será el contacto oficial (POC) del municipio para la coordinación, ejecución y la elaboración de la actualización del plan de mitigación. Esta persona trabajará directamente con el personal designado por la Junta de Planificación en este proyecto.

Asimismo, el Municipio agilizará y tramitará la adopción del plan mediante Orden Ejecutiva o a través de la Legislatura Municipal mediante Ordenanza Municipal. También coordinará en conjunto con la JPPR o el personal autorizado, el proceso de participación ciudadana.

Se coordinará por parte del municipio la recopilación de información necesaria que sea requerida, incluyendo:

- Identificación de todos los Riesgos locales – Descripción de los diferentes eventos ocurridos en el Municipio y los impactos que han tenido en la comunidad.
- Identificación de inventario de activos del Municipio, de considerarse el activo como uno crítico favor de identificar el mismo como activo-crítico.
- Información necesaria para complementar la Tabla de análisis de capacidad.
- Identificación e Implantación de las Medidas / actividades de Mitigación: Lista de proyectos y Plan de Acción describiendo cómo los proyectos serán implantados por prioridades, cómo serán administrados, si son costo-beneficiosos.
- Evaluación del Plan Preliminar.
- Evaluación del Borrador del Plan.
- Evaluación del Borrador Final del Plan.
- Implementación del Plan de Mitigación - Monitoreo, Evaluación y Actualización.
- Realizar los esfuerzos educativos y comunicación necesarios a los diferentes sectores de la ciudadanía de este proceso de actualización del plan.
- La JPPR coordinará con el municipio respecto a cualquier otra información que se requiera.

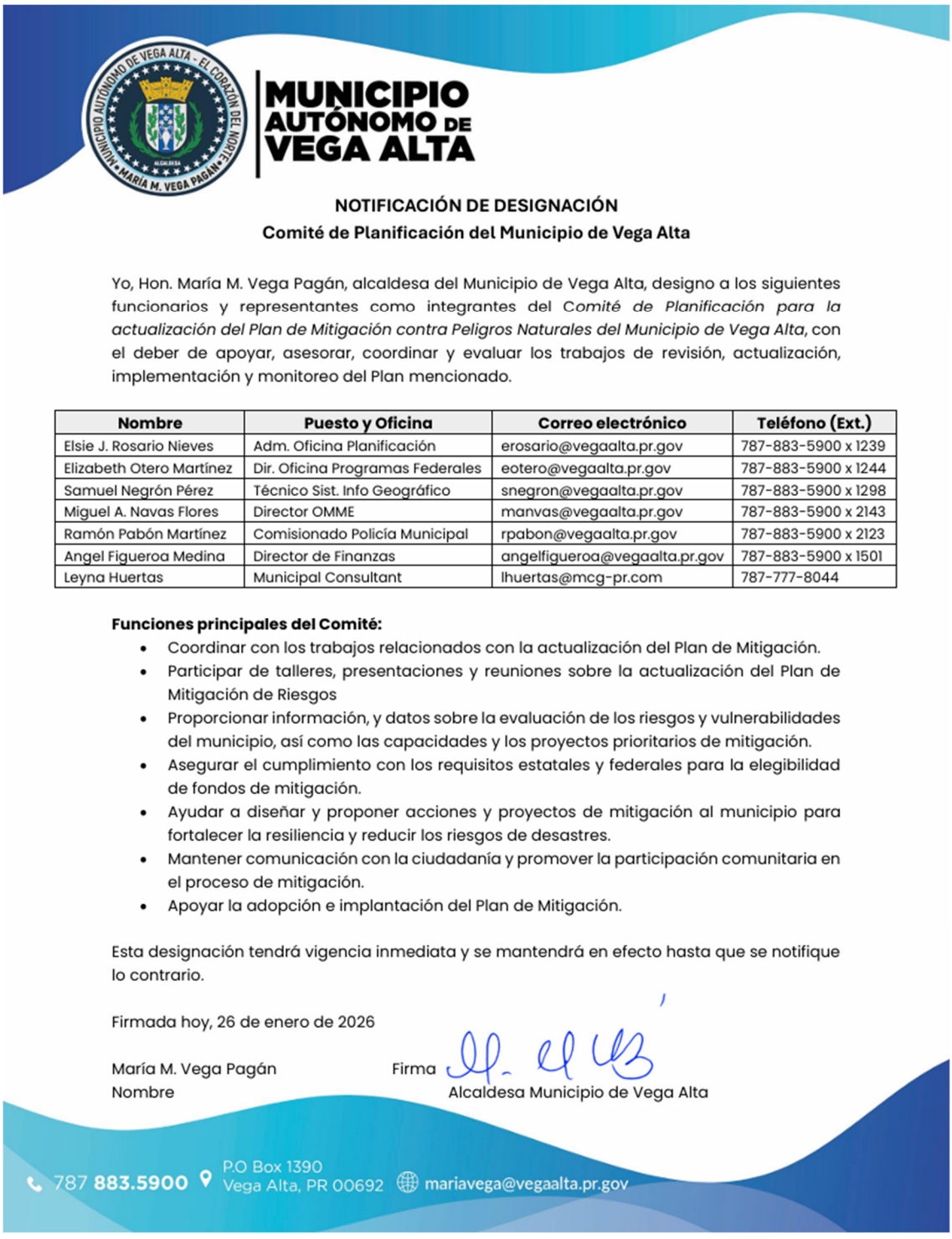
Este compromiso no implica la erogación de fondos públicos por parte del municipio ni de la JPPR. A su vez, podrá ser terminado por la JPPR o por el Municipio, mediante comunicación escrita dirigida al presidente de la JPPR o a la alcaldesa, según corresponda.

Por lo que, de acuerdo con este compromiso, yo, María Vega Pagán lo firmo conforme a los mejores intereses del pueblo de Vega Alta.

En San Juan, Puerto Rico, hoy 16 de diciembre de 2025.

Alcalde

# Planning Committee Appointments



MUNICIPIO AUTÓNOMO DE VEGA ALTA

**NOTIFICACIÓN DE DESIGNACIÓN**

**Comité de Planificación del Municipio de Vega Alta**

Yo, Hon. María M. Vega Pagán, alcaldesa del Municipio de Vega Alta, designo a los siguientes funcionarios y representantes como integrantes del *Comité de Planificación para la actualización del Plan de Mitigación contra Peligros Naturales del Municipio de Vega Alta*, con el deber de apoyar, asesorar, coordinar y evaluar los trabajos de revisión, actualización, implementación y monitoreo del Plan mencionado.

| Nombre | Puesto y Oficina | Correo electrónico | Teléfono (Ext.) |
|---|---|---|---|
| Elsie J. Rosario Nieves | Adm. Oficina Planificación | erosario@vegaalta.pr.gov | 787-883-5900 x 1239 |
| Elizabeth Otero Martínez | Dir. Oficina Programas Federales | eotero@vegaalta.pr.gov | 787-883-5900 x 1244 |
| Samuel Negrón Pérez | Técnico Sist. Info Geográfico | snegron@vegaalta.pr.gov | 787-883-5900 x 1298 |
| Miguel A. Navas Flores | Director OMME | manvas@vegaalta.pr.gov | 787-883-5900 x 2143 |
| Ramón Pabón Martínez | Comisionado Policía Municipal | rpabon@vegaalta.pr.gov | 787-883-5900 x 2123 |
| Angel Figueroa Medina | Director de Finanzas | angelfigueroa@vegaalta.pr.gov | 787-883-5900 x 1501 |
| Leyna Huertas | Municipal Consultant | lhuertas@mcg-pr.com | 787-777-8044 |

**Funciones principales del Comité:**

- Coordinar con los trabajos relacionados con la actualización del Plan de Mitigación.
- Participar de talleres, presentaciones y reuniones sobre la actualización del Plan de Mitigación de Riesgos
- Proporcionar información, y datos sobre la evaluación de los riesgos y vulnerabilidades del municipio, así como las capacidades y los proyectos prioritarios de mitigación.
- Asegurar el cumplimiento con los requisitos estatales y federales para la elegibilidad de fondos de mitigación.
- Ayudar a diseñar y proponer acciones y proyectos de mitigación al municipio para fortalecer la resiliencia y reducir los riesgos de desastres.
- Mantener comunicación con la ciudadanía y promover la participación comunitaria en el proceso de mitigación.
- Apoyar la adopción e implantación del Plan de Mitigación.

Esta designación tendrá vigencia inmediata y se mantendrá en efecto hasta que se notifique lo contrario.

Firmada hoy, 26 de enero de 2026

María M. Vega Pagán — Nombre

Firma — Alcaldesa Municipio de Vega Alta

787 883.5900 | P.O Box 1390 Vega Alta, PR 00692 | mariavega@vegaalta.pr.gov

JUNTA DE
PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

FORMULARIO PARA DESIGNAR PERSONA(S) CONTACTO(S)
PLAN DE MITIGACIÓN CONTRA PELIGROS NATURALES

Municipio: Vega Alta

| | Nombre | Teléfono | Correo electrónico |
|---|---|---|---|
| Personal Designado | Elsie Rosario | 787-883-5900 | erosario2 vegaalta pr gov |
| Personal Alterno | Miguel A. Nieves | 787-883-5900 | mnavas2 vegaaltapr gov |
| | | | |
| | | | |
| | | | |

Hon. María Vega Pagán
Nombre (letra de molde)
Alcalde

Firma
Alcalde

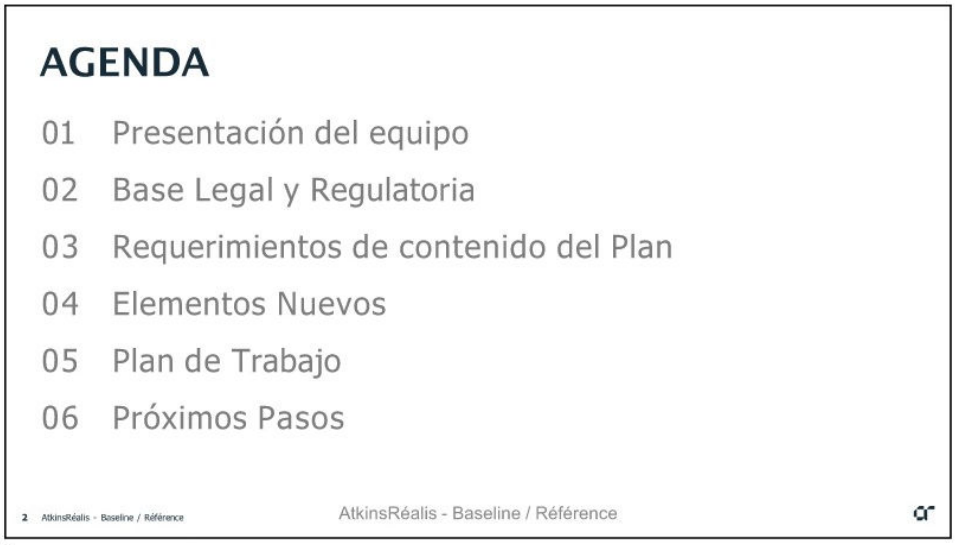
Fecha: 16/12/2025

# First Planning Committee Meeting

## Presentation

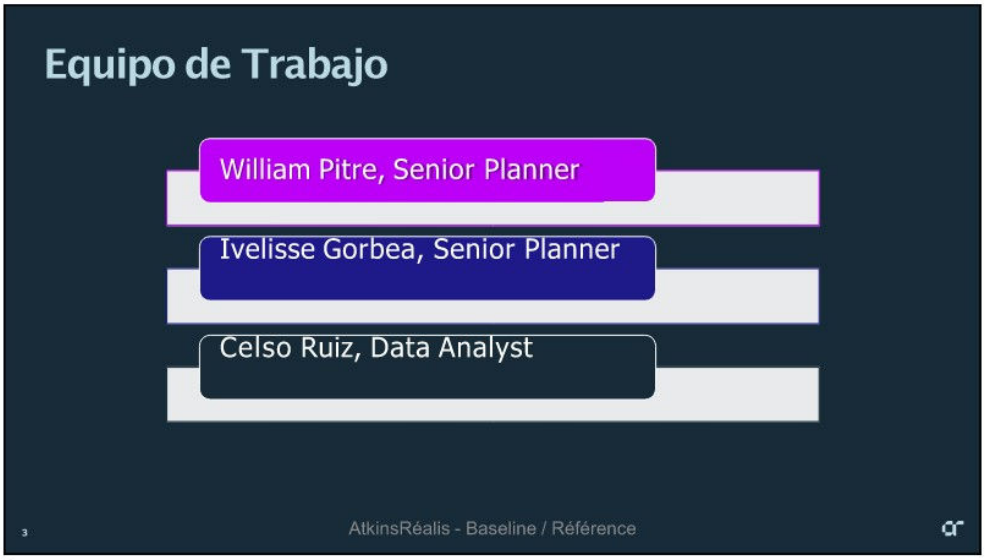



1

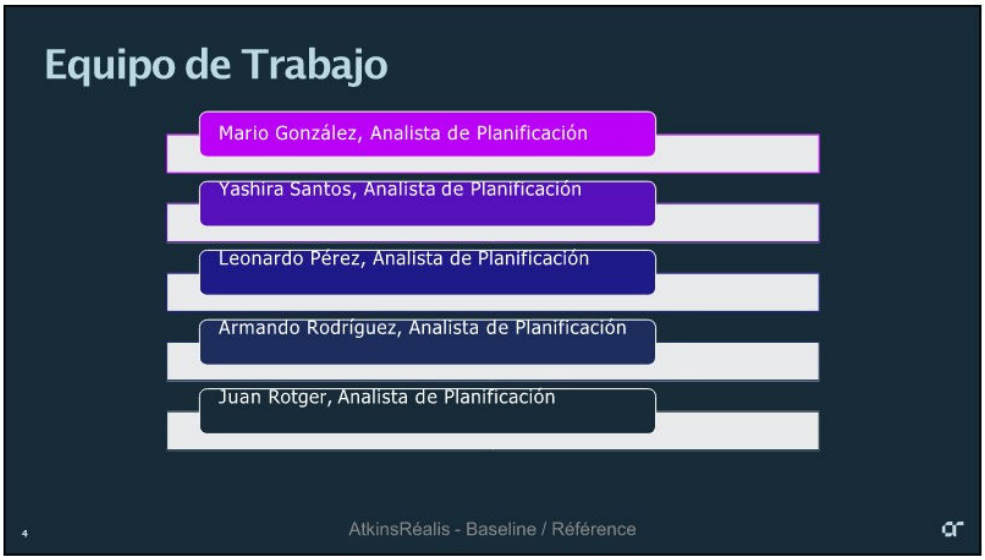



1

2


Equipo de Trabajo
William Pitre, Senior Planner
Ivelisse Gorbea, Senior Planner
Celso Ruiz, Data Analyst
3
AtkinsRéalis - Baseline / Référence

3


Equipo de Trabajo
Mario González, Analista de Planificación
Yashira Santos, Analista de Planificación
Leonardo Pérez, Analista de Planificación
Armando Rodríguez, Analista de Planificación
Juan Rotger, Analista de Planificación
4
AtkinsRéalis - Baseline / Référence

4

2

# Base Legal y Regulatoria

- **Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended**

- PL 100-707, signed into law November 23, 1988; amended the Disaster Relief Act of 1974, PL 93-288.
- National Flood Insurance Act of 1968, as amended.
- National Dam Safety Program Act (Pub. L. 92-367), as amended.
- Regulation: 44 CFR Part 201 Mitigation Planning.

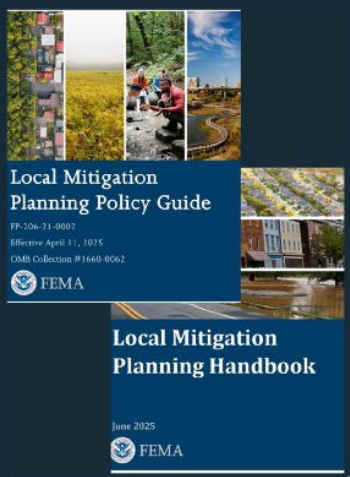





9

# Requerimientos del Plfn de Mitigfción

- Elemento A: Proceso de Planificación
- Elemento B: Identificación de Peligros y Evaluación de riesgos
- Elemento C: Estrategias de Mitigación
- Elemento D: Plan de Seguimiento e Implementación
- Elemento E: Actualización del Plan
- Elemento F: Adopción del Plan
- Elemento G: Peligros Potenciales ante fallos en Represas (opcional)
- Elemento H: Requisitos Estatales Adicionales






AtkinsRéalis - Baseline / Référence

10

5

# Elementos nuevos del Plan

1. **Identificación y evaluación de riesgos**
   - Se clasifica la infraestructura crítica por servicio vital o línea de vida
   - Se analiza su exposición y vulnerabilidad
   - Se prioriza por línea de vida
2. **Evaluación de capacidades**
   - Se evalúa la capacidad local para proteger servicios vitales
   - Se identifican brechas y se proponen acciones
3. **Estrategia de Mitigación**
   - Se incluyen acciones específicas para proteger, estabilizar y restaurar servicios vitales
4. **Participación de Partes Interesadas**
   - Se invita a agencias responsables o representantes de servicios vitales y se documenta su participación
   - Se comunica al público y recopila retroalimentación sobre los servicios vitales

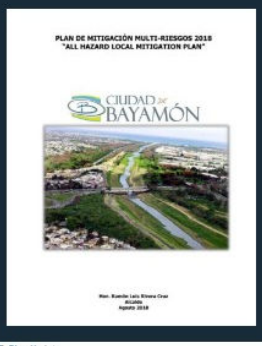





11

# Elementos nuevos del Plan

- **Actualización del Plan:**
  **"Review Tool" especifica los elementos que se deben documentar para reflejar los cambios**
  - El Plan describe los cambios en las áreas propensas a peligros (ha incrementado o disminuido la vulnerabilidad o peligro)
  - Deberá reflejar los cambios en prioridades y progreso de los esfuerzos locales de mitigación.


PLAN DE MITIGACIÓN MULTI-RIESGOS 2018
"ALL HAZARD LOCAL MITIGATION PLAN"

CIUDAD DE BAYAMÓN


Element E: Plan Update

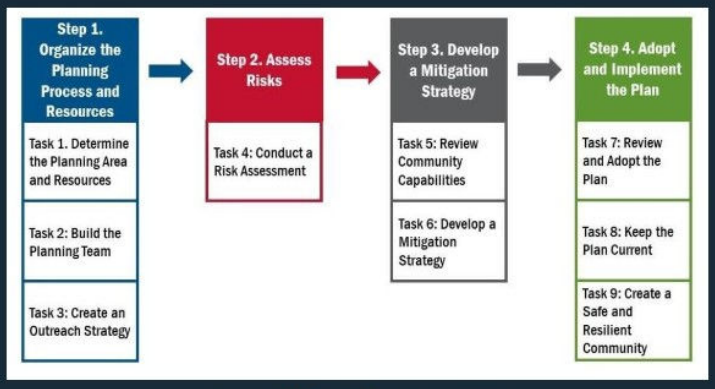
| Element E Requirements | Location in Plan (section and/or page number) | Met / Not Met |
|---|---|---|
| E1. Was the plan revised to reflect changes in development? (Requirement 44 CFR § 201.6(d)(3)) | | |
| E1-a. Does the plan describe the changes in development that have occurred in hazard-prone areas that have increased or decreased each community's vulnerability since the previous plan was approved? | Click or tap here to enter text. | Choose a |



12

6

## Proceso del Plfn de Mitigfción




13 AtkinsRéalis - Baseline / Référence

AtkinsRéalis - Baseline / Référence

13

## Peligros a considerer para los cinco municipios

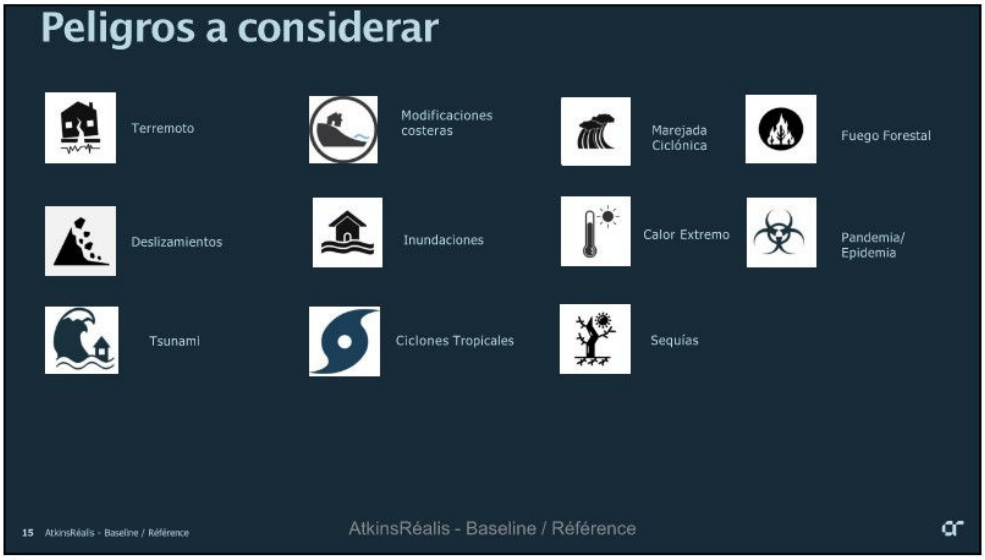



7

14 AtkinsRéalis - Baseline / Référence

AtkinsRéalis - Baseline / Référence

14

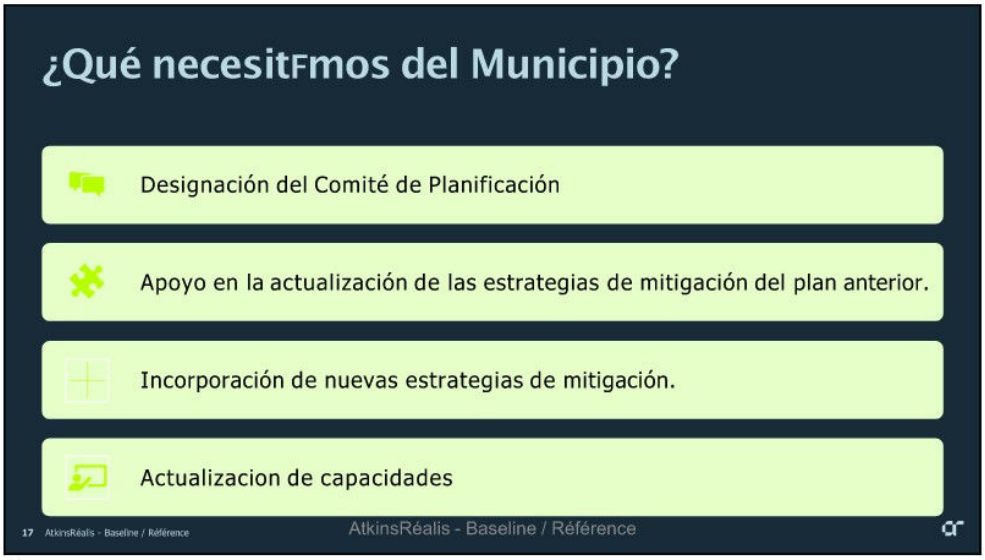

Peligros a considerar
Terremoto
Modificaciones costeras
Marejada Ciclónica
Fuego Forestal
Deslizamientos
Inundaciones
Calor Extremo
Pandemia/ Epidemia
Tsunami
Ciclones Tropicales
Sequías
15 AtkinsRéalis - Baseline / Référence
AtkinsRéalis - Baseline / Référence

15

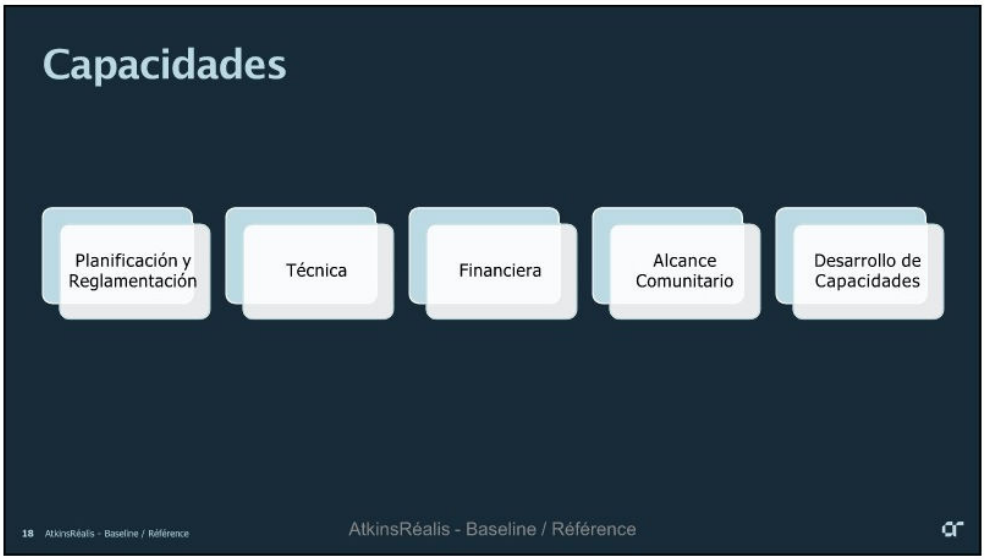

PeÉuelfs
Modificaciones costeras
Marejada Ciclónica
Tsunami
EN DIOS CONFIAMOS
16 AtkinsRéalis - Baseline / Référence
AtkinsRéalis - Baseline / Référence

16

8


¿Qué necesitFmos del Municipio?
Designación del Comité de Planificación
Apoyo en la actualización de las estrategias de mitigación del plan anterior.
Incorporación de nuevas estrategias de mitigación.
Actualizacion de capacidades
17 AtkinsRéalis - Baseline / Référence
AtkinsRéalis - Baseline / Référence

17


Capacidades
Planificación y Reglamentación
Técnica
Financiera
Alcance Comunitario
Desarrollo de Capacidades
18 AtkinsRéalis - Baseline / Référence
AtkinsRéalis - Baseline / Référence

9

18

## PFrticipFCión Ciudadana

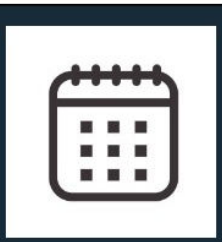
- Dos reuniones de participación ciudadana.
- Notificación sera publicada por Junta de Planificación.
- Publicar 15 días antes de la reunión
- Se otorga 15 días para comentarios
- Para la Segunda reunion se discute el primer borrador.
- El primer borrador sera comentado por el publico, el municipio y la Junta de Planificación





19

## Ventana para la primera actividad de participacion ciudadana



26 de febrero al 6 de marzo.

Debe informar su fecha de reunion en o antes del lunes 9.

De varias fechas para que su analista de Planificación pueda estar.

Si no da sus posibles fechas en o antes del miércoles, no puedo asegurar que pueda atenderlo hasta que hayan pasado los demás municipios.



20

10


JUNTA DE
PLANIFICACIÓN
Información de Contacto
Programa
Plan. Ivette Colón
Plan. William Pitre
Junta de Planificación
Junta de Planificación
AtkinsRéalsi Caribe
prpb.lhmp@atkinsrealis.com
colon_i@jp.pr.gov
William.Pitre@atkinsrealis.com
/+19392051336
Pedimos que el titulo de todo correo debe comience con el nombre del municipio unicamente.
e.j.: "San Germán – Tablas de Mitigación Actualizadas"
Solicitamos que en todo correo electrónico sobre el programa siempre copie al correo del programa:
"prpb.lhmp@atkinsrealis.com"
hayan pasado los demás municipios
AtkinsRéalis - Baseline / Référence

21


Grupos de Trabajo
AtkinsRéalis - Baseline / Référence
AtkinsRéalis - Baseline / Référence

11

22

### 8.2.1 Sign – In Sheets

JUNTA DE PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

**HOJA DE ASISTENCIA**

Fecha: 2 de febrero de 2026 Hora: 9:00am Asunto: 1era Reunión -Revisión Plan de Mitigación contra Peligros Naturales

| Nombre y dos apellidos | Teléfono | Municipio | Firma | Correo Electrónico |
|---|---|---|---|---|
| Elsie J. Rosario Nieves | 787-226-6347 | Vega Alta | Blocked for PII Protection | |
| Samuel H Najwin Perez | 787-378-1515 | Vega Alta | | |
| RAMÓN RAFAEL MARTÍNEZ | 787-544-1309 | VEGA ALTA | | |
| Miguel Rafael Rivera | 787-883-[illegible] | Vega Alta | | |

**Meeting Minutes**

# MINUTA

| | | | |
|---|---|---|---|
| **PROYECTO:** | PRPB 25 LHMP Update | | |
| **TITULO:** | First Committee Meeting | | |
| **LUGAR DE LA REUNIÓN:** | Junta de Planificación Salón B | **# REUNIÓN:** | 1 |
| **FECHA Y HORA:** | 2/2/2026 @ 9:00am | **MINUTA POR:** | Armando E. Rodriguez Aponte |

## Lista de Asistencia:

| NOMBRE | INICIALES | COMPAÑÍA |
|---|---|---|
| Elsie Rosario Nieves | ER | Municipio de Vega Alta |
| Miguel Navas | MN | Municipio de Vega Alta |
| Samuel Negrón Pérez | SN | Municipio de Vega Alta |
| Ramón Pabón Martínez | RP | Municipio de Vega Alta |
| Armando E. Rodriguez Aponte | AER | AtkinsRéalis |

## Asuntos Discutidos:

| ID | ASUNTOS DISCUTIDOS |
|---|---|
| AD-1 | Aprobación de Minuta Reunión Anterior:<br>• N/A |
| AD-2 | Asunto Relacionado con Alcance de Servicio Contratado y Entregables<br>• N/A |
| AD-3 | Plan de Trabajo Propuesta (Two Weeks Ahead / Four Week Ahead)<br>• N/A |
| AD-4 | Asuntos Nuevos<br>• Se comenzó la reunión con una presentación que brindó el planificador William Pitre, de AtkinsRéalis, explicando en que consiste el proyecto, actividades, requisitos y como la Junta de Planificación y AtkinsRéalis van a estar preparando el Plan de Mitigación para los municipios. |

**NOTA A LOS DESTINATARIOS:**
Estas notas de la reunión reflejan la interpretación de AtkinsRéalis sobre la reunión y las acciones previstas que se derivan de la misma. Se asumirá su conformidad en que estas notas constituyen un registro fiel de lo discutido, a menos que se reciban comentarios adversos por escrito dentro de los cinco (5) días posteriores a su recepción.

| ID | ASUNTOS DISCUTIDOS |
|---|---|
| | • Luego de la presentación, se dió inicio a la mesa de trabajo con el municipio de Vega Alta.<br>• AER se presentó y brindóun breve trasfondo de su experiencia con el Programa de HMGP.<br>• AER solicitó que el municipio confirmara los Puntos de Contacto (POC). A lo cual ER indicó que los puntos de contactos designados por el alcalde son: Elsie Rosario Nieves, Miguel Navas, Samuel Negrón Pérez y Ramón Pabón Martínez.<br>• Se repasó la lista del "Local Hazard Mitigation Plan" (LHMP) anterior, para que el municipio identificara si alguno de esos proyectos se había completado, se encontraba en diseño, en subasta o si ya no se estaría realizando por parte del municipio.<br>○ El equipo de Vega Alta indicó que Quebrada Machuchal se encuentra en diseño.<br>○ La Quebrada Onda fue limpiada desde la PR-2 hasta la PR-690.<br>○ El personal del municipio identificó que el P-1 se realizó en su totalidad, al igual que el P-2. El P-4 aún requiere la realización del estudio H&H; el PE-2 no se ha completado y el PE-3 solo incluyó trabajos de limpieza.<br>• AER preguntó si, luego de revisar la lista, el municipio identificó algún proyecto que no estuviera incluido y que furea necesario añadir.<br>○ Se mencionó la adquisición de una residencia en el barrio Korea para canalizar las aguas y mitigar inundaciones en el área.<br>○ También se mencionó la mitigación del cauce del río Cibuco en la PR-647, ya que el mismo se encuentra a cinco (5) pies de la carretera y está socavándola.<br>• AER realizó una dinámica con el municipio llamada "Planning Poker"<br>○ Se le preguntó al municipio que si recibieran fondos ilimitados para realizar un solo proyecto de mitigación, cual sería y por qué.<br>▪ De las cuatro (4) personas participantes, tres (3) indicaron la canalización del cauce de la Quebrada Onda en la urbanización Ponderosa, calle diecisiete (17), así como la mejora del puente, para mitigar las inundaciones que provoca dicha quebrada.<br>▪ Un (1) miembro del equipo indicó que el proyecto que trabajaría sería la creación de una base de datos con toda la información del municipio en 3D y GIS, para mitigar y responder con más rapidez ante eventos atmosféricos o desastres.<br>• AER realizó otra pregunta,<br>• en esta ocasión se les indicó que ahora tienen nuevamente fondos ilimitados y que adicional al proyecto mencionado, cual el municipio escogería como segundo proyecto de mitigación.<br>○ En esta ocasión el equipo del municipio contestó con cuatro (4) proyectos distintos:<br>▪ Limpieza y restauración de acuíferos y aguas subterráneas para mejorar la agricultura y mitigar la contaminación.<br>▪ Canalización de la ciénaga de Cerro Gordo.<br>▪ Canalización de la Quebrada Carmelitas en la PR-690.<br>▪ Canalización de la Quebrada Onda.<br>• AER preguntó, del uno (1) al tres (3), cuáles peligros representan un mayor impacto para el municipio, siendo el tres (3) el de mayor impacto. |

**NOTA A LOS DESTINATARIOS:**
Estas notas de la reunión reflejan la interpretación de AtkinsRéalis sobre la reunión y las acciones previstas que se derivan de la misma. Se asumirá su conformidad en que estas notas constituyen un registro fiel de lo discutido, a menos que se reciban comentarios adversos por escrito dentro de los cinco (5) días posteriores a su recepción.

| ID | ASUNTOS DISCUTIDOS |
|---|---|
| | ○ El municipio indicó inundaciones con un tres (3) y terremotos con un tres (3).<br>• AER dio por culminada la dinámica e indicó que el correo electrónico para enviar o solicitar información es prpb.lhmp@atkinsrealis.com. También informó que es importante que, cada vez que envíen un correo electrónico, el título comience con el nombre del municipio, en este caso Vega Alta, seguido de una breve descripción del contenido, con el fin de archivar y atender las comunicaciones de manera más eficiente.<br>• AER indicó que el analista asignado al municipio es el Sr. Leonardo Pérez y que su correo electrónico es leonardo.perez@atkinsrealis.com.<br>• AER solicitó al municipio que envío del LOGO oficial.<br>• ER indicó que, de manera tentativa, se seleccionaron las fechas de febrero veintiséis (26) y veintisiete (27) para la reunión comunitaria. No obstante, el día de 2/3/2026 estarán enviando un correo electrónico para confirmar la fecha, hora y lugar. |
| AD-5 | Discusión de Acciones por Tomar<br>• Tabla Inferior |
| AD-6 | Coordinación Próxima Reunión<br>• |

## Acciones Por Tomar:

| ID | ACCIONES POR TOMAR | FECHA LÍMITE | ENTIDAD RESPONSABLE |
|---|---|---|---|
| AT-1 | Confirmación de Fecha, hora y lugar para reunión comunitaria. | 2/3/2026 | Mun. Vega Alta |
| AT-2 | Envío de LOGO el municipio. | 2/3/2026 | Mun. Vega Alta |

## Acuerdos/Aclaraciones:

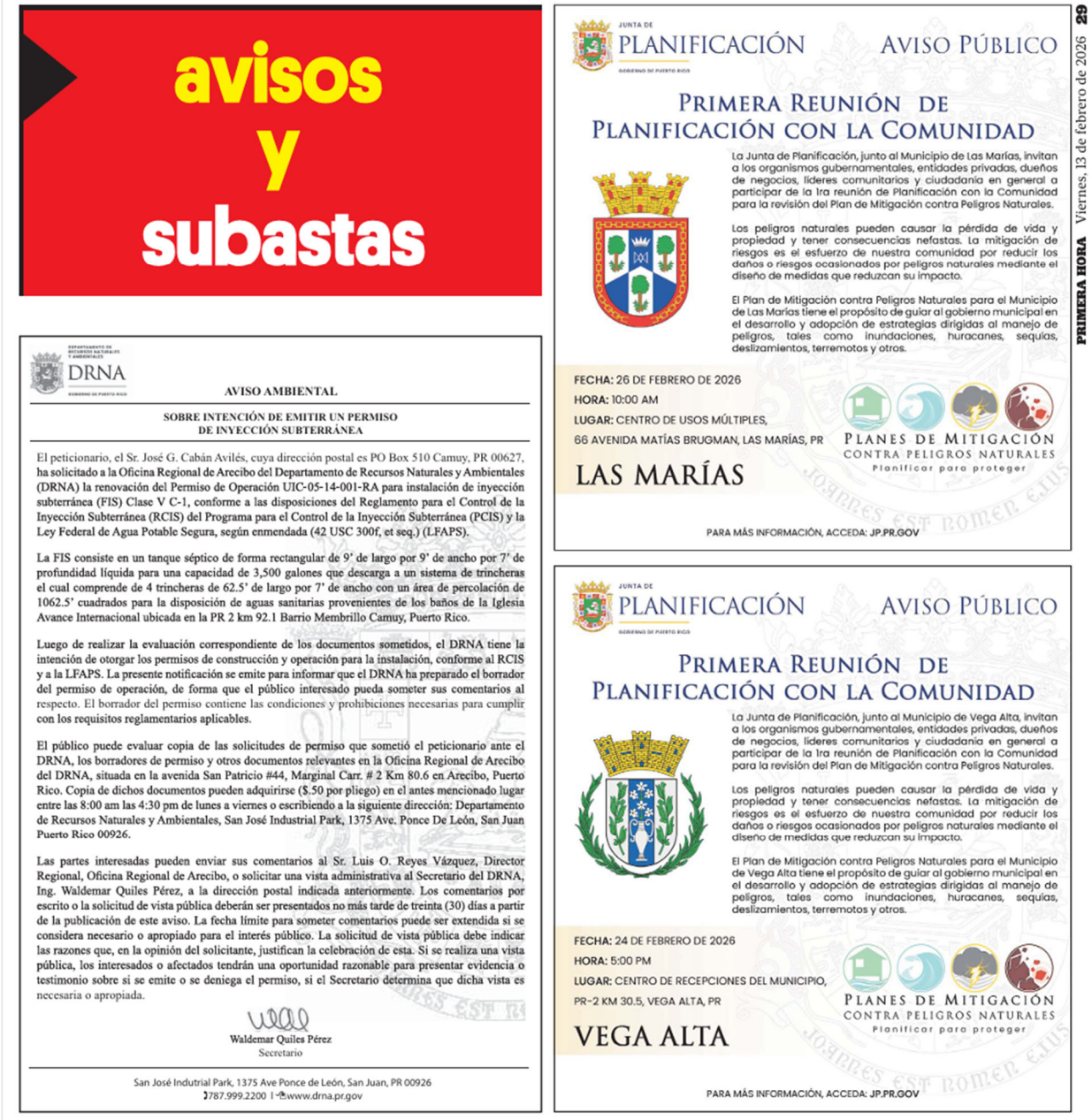
| ID | DESCRIPCIÓN |
|---|---|
| AC-1 | N/A |

## Anejos:

**NOTA A LOS DESTINATARIOS:**
Estas notas de la reunión reflejan la interpretación de AtkinsRéalis sobre la reunión y las acciones previstas que se derivan de la misma. Se asumirá su conformidad en que estas notas constituyen un registro fiel de lo discutido, a menos que se reciban comentarios adversos por escrito dentro de los cinco (5) días posteriores a su recepción.

# Appendix C – Public Participation and Outreach

## First Community Meeting: February 24th, 2026



avisos
y
subastas

DRNA

**AVISO AMBIENTAL**

**SOBRE INTENCIÓN DE EMITIR UN PERMISO DE INYECCIÓN SUBTERRÁNEA**

El peticionario, el Sr. José G. Cabán Avilés, cuya dirección postal es PO Box 510 Camuy, PR 00627, ha solicitado a la Oficina Regional de Arecibo del Departamento de Recursos Naturales y Ambientales (DRNA) la renovación del Permiso de Operación UIC-05-14-001-RA para instalación de inyección subterránea (FIS) Clase V C-1, conforme a las disposiciones del Reglamento para el Control de la Inyección Subterránea (RCIS) del Programa para el Control de la Inyección Subterránea (PCIS) y la Ley Federal de Agua Potable Segura, según enmendada (42 USC 300f, et seq.) (LFAPS).

La FIS consiste en un tanque séptico de forma rectangular de 9' de largo por 9' de ancho por 7' de profundidad líquida para una capacidad de 3,500 galones que descarga a un sistema de trincheras el cual comprende de 4 trincheras de 62.5' de largo por 7' de ancho con un área de percolación de 1062.5' cuadrados para la disposición de aguas sanitarias provenientes de los baños de la Iglesia Avance Internacional ubicada en la PR 2 km 92.1 Barrio Membrillo Camuy, Puerto Rico.

Luego de realizar la evaluación correspondiente de los documentos sometidos, el DRNA tiene la intención de otorgar los permisos de construcción y operación para la instalación, conforme al RCIS y a la LFAPS. La presente notificación se emite para informar que el DRNA ha preparado el borrador del permiso de operación, de forma que el público interesado pueda someter sus comentarios al respecto. El borrador del permiso contiene las condiciones y prohibiciones necesarias para cumplir con los requisitos reglamentarios aplicables.

El público puede evaluar copia de las solicitudes de permiso que sometió el peticionario ante el DRNA, los borradores de permiso y otros documentos relevantes en la Oficina Regional de Arecibo del DRNA, situada en la avenida San Patricio #44, Marginal Carr. # 2 Km 80.6 en Arecibo, Puerto Rico. Copia de dichos documentos pueden adquirirse ($.50 por pliego) en el antes mencionado lugar entre las 8:00 am las 4:30 pm de lunes a viernes o escribiendo a la siguiente dirección: Departamento de Recursos Naturales y Ambientales, San José Industrial Park, 1375 Ave. Ponce De León, San Juan Puerto Rico 00926.

Las partes interesadas pueden enviar sus comentarios al Sr. Luis O. Reyes Vázquez, Director Regional, Oficina Regional de Arecibo, o solicitar una vista administrativa al Secretario del DRNA, Ing. Waldemar Quiles Pérez, a la dirección postal indicada anteriormente. Los comentarios por escrito o la solicitud de vista pública deberán ser presentados no más tarde de treinta (30) días a partir de la publicación de este aviso. La fecha límite para someter comentarios puede ser extendida si se considera necesario o apropiado para el interés público. La solicitud de vista pública debe indicar las razones que, en la opinión del solicitante, justifican la celebración de esta. Si se realiza una vista pública, los interesados o afectados tendrán una oportunidad razonable para presentar evidencia o testimonio sobre si se emite o se deniega el permiso, si el Secretario determina que dicha vista es necesaria o apropiada.

Waldemar Quiles Pérez
Secretario

San José Indutrial Park, 1375 Ave Ponce de León, San Juan, PR 00926
787.999.2200 | www.drna.pr.gov

JUNTA DE PLANIFICACIÓN — AVISO PÚBLICO

**PRIMERA REUNIÓN DE PLANIFICACIÓN CON LA COMUNIDAD**

La Junta de Planificación, junto al Municipio de Las Marías, invitan a los organismos gubernamentales, entidades privadas, dueños de negocios, líderes comunitarios y ciudadanía en general a participar de la 1ra reunión de Planificación con la Comunidad para la revisión del Plan de Mitigación contra Peligros Naturales.

Los peligros naturales pueden causar la pérdida de vida y propiedad y tener consecuencias nefastas. La mitigación de riesgos es el esfuerzo de nuestra comunidad por reducir los daños o riesgos ocasionados por peligros naturales mediante el diseño de medidas que reduzcan su impacto.

El Plan de Mitigación contra Peligros Naturales para el Municipio de Las Marías tiene el propósito de guiar al gobierno municipal en el desarrollo y adopción de estrategias dirigidas al manejo de peligros, tales como inundaciones, huracanes, sequías, deslizamientos, terremotos y otros.

**FECHA:** 26 DE FEBRERO DE 2026
**HORA:** 10:00 AM
**LUGAR:** CENTRO DE USOS MÚLTIPLES, 66 AVENIDA MATÍAS BRUGMAN, LAS MARÍAS, PR

**LAS MARÍAS**

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
Planificar para proteger

PARA MÁS INFORMACIÓN, ACCEDA: JP.PR.GOV

PRIMERA HORA Viernes, 13 de febrero de 2026 29

JUNTA DE PLANIFICACIÓN — AVISO PÚBLICO

**PRIMERA REUNIÓN DE PLANIFICACIÓN CON LA COMUNIDAD**

La Junta de Planificación, junto al Municipio de Vega Alta, invitan a los organismos gubernamentales, entidades privadas, dueños de negocios, líderes comunitarios y ciudadanía en general a participar de la 1ra reunión de Planificación con la Comunidad para la revisión del Plan de Mitigación contra Peligros Naturales.

Los peligros naturales pueden causar la pérdida de vida y propiedad y tener consecuencias nefastas. La mitigación de riesgos es el esfuerzo de nuestra comunidad por reducir los daños o riesgos ocasionados por peligros naturales mediante el diseño de medidas que reduzcan su impacto.

El Plan de Mitigación contra Peligros Naturales para el Municipio de Vega Alta tiene el propósito de guiar al gobierno municipal en el desarrollo y adopción de estrategias dirigidas al manejo de peligros, tales como inundaciones, huracanes, sequías, deslizamientos, terremotos y otros.

**FECHA:** 24 DE FEBRERO DE 2026
**HORA:** 5:00 PM
**LUGAR:** CENTRO DE RECEPCIONES DEL MUNICIPIO, PR-2 KM 30.5, VEGA ALTA, PR

**VEGA ALTA**

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
Planificar para proteger

PARA MÁS INFORMACIÓN, ACCEDA: JP.PR.GOV

# Presentation



## Estrategias de Mitigación

- Describir las metas y objetivos específicos para minimizar el impacto en el municipio.
- Identificar acciones de mitigación específicas y proyectos.
- Estas pueden incluir:
  - **Prevención-** actividades tales como planificación usos terrenos, regulaciones, mantenimientos, etc.
  - **Protección de propiedades-** mejoras de diseños, relocalización, adquisición, etc.
  - **Proyectos de estructura-** ej. Diques, muros de contención, alcantarillado pluvial, etc.
  - **Servicios de emergencia-** alertas, sistemas de advertencias, manejo y planes de desalojo, ejercicios de respuesta a emergencias, etc.
  - **Educación y concientización pública.**

## Mantenimiento y Documentación del Plan

- **Monitoreo:** Identificar frecuencia para verificar el progreso de las acciones en el plan.
- **Evaluación:** Determinar si el plan sigue siendo viable, si las acciones aún tienen sentido, etc.
- **Actualización:** Si se determina que algo debe cambiarse en el proceso de evaluación, identificar persona a cargo (comité de planificación) para la actualización cada 5 años.
- **Adopción del Plan por el municipio:** ordenanza de la legislatura municipal u orden ejecutiva del alcalde.
- **Revisión, certificación y aprobación de FEMA.**

## Proyecto Actualización de los Planes de Mitigación



## Alcance del Trabajo

1. Revisar y actualizar los planes de mitigación contra peligros naturales de acuerdo con las nuevas guías y regulaciones.
2. Coordinar las actividades y trabajos en conjunto con el municipio y la Junta de Planificación.
3. Promover la participación ciudadana.
   - Reuniones de planificación con la comunidad
   - Página cibernética JP (www.jp.pr.gov)




plandemitigación@jp.pr.gov

## Actividades del Proyecto




## Encuesta de la Comunidad

## Identificar Áreas de Riesgo



## ¡Gracias!

## Información de Contacto

Lcdo. Héctor Morales Martínez
Presidente

Plan. Rebecca Rivera Torres
Directora Ejecutiva Auxiliar Interina
Miembro Alterno
Rivera_rt@jp.pr.gov

Plan. Ivette Colón Meléndez
Planificadora de Ordenación Territorial Senior
colon_ig@jp.pr.gov

Plan. Erika Rivera Felicié
Planificadora de Ordenación Territorial Senior
rivera_el@jp.pr.gov

Plan. Vanessa I. Marrero Santiago
Planificadora de Ordenación Territorial
marrero_v@jp.pr.gov

Plan. Onix Concepción Rodríguez
Planificador de Ordenación Territorial
Concepcion_o@jp.pr.gov

plandemitigacion@jp.pr.gov
*Incluir nombre del municipio en el asunto.

787-723-6200 ext. 16623 y 16681

JUNTA DE PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
Planificar para proteger

## 1ra Reunión de Planificación con la Comunidad
## Municipio de Vega Alta

| | |
|---|---|
| **Asunto:** | **Actualización del Plan de Mitigación contra Peligros Naturales** |
| **Lugar:** | **Centro de Recepciones del municipio, PR-2 km 30.5, Vega Alta** |
| **Fecha:** | **24 de febrero de 2026** |
| **Hora:** | **5:00 pm** |

### Notas:

- Representante de la Junta de Planificación:
  - Plan. Ivette Colón y Plan. Vanessa I. Marrero Santiago
- Personal enlace del Municipio de Vega Alta:
  - Elsie Rosario Nieves, administración Oficina de Planificación
- La reunión comenzó aproximadamente a las 5:15 pm.
- La Sra. Elsie Rosario brindó el mensaje de bienvenida e introducción a la 1ra Reunión de Planificación con la Comunidad (1ra RPC). Además, presentó a los miembros del Comité de Planificación del municipio que estaban presentes en la reunión, y excusó a los que no pudieron asistir.
- La Plan. Ivette Colón ofreció un resumen sobre los trabajos a realizarse en la 1ra RPC, los cuales incluían la presentación sobre el proyecto, la encuesta a la comunidad y el ejercicio de identificación de los peligros naturales en su comunidad mediante los mapas impresos.
- Se procedió a brindar la presentación sobre el proceso de actualización del Plan de Mitigación contra Peligros Naturales del Municipio de Vega Alta. Entre los asuntos discutidos, se encuentran, pero no se limitan a los siguientes:
  - Identificación de fondos por la JP para realizar una extensión del Proyecto para la actualización de los planes de mitigación, el cual tuvo su inicio en el 2018-19. A estos efectos, se identificaron aquellos planes con 5 años o más desde su aprobación, los cuales perdieron su vigencia y ahora forman parte de este proyecto de actualización.
  - Se mencionó el trasfondo normativo federal y los conceptos básicos de mitigación.
  - Se explicó el ciclo de manejo de emergencias (mitigación, preparación, respuesta y recuperación).
  - Se orientó sobre el proceso de planificacion para la mitigación.
  - Se mencionó como se identificarán las estrategias de mitigación, esto mediante la evaluación de riesgos y evaluación de capacidades del Municipio.
  - Se identificaron los riesgos naturales que se estarán evaluando a la luz de la realidad del Municipio. Además, se indicó que en reunión previa con el Comité de Planificación se solicitó a la JP que se incluyera el peligro por tornados.
  - Se ilustró mapa con los 25 municipios cuyos planes de mitigacion se están actualizando con la JP.

  - Se discutió flujograma de las actividades que comprenden el proyecto de actualización de los planes de mitigacion. Se identificaron las actividades realizadas y aquellas en el pipeline para realizar.
  - Se administró una encuesta comunitaria mediante un código QR, lo que permitió a los participantes responder preguntas sobre los peligros identificados en su comunidad.
  - Se exhortó a los asistentes a colaborar en un ejercicio de identificación de riesgos utilizando los mapas impresos provistos durante la actividad.
  - El personal del Municipio y de la JP brindó asistencia a los participantes durante ambos ejercicios, ofreciendo orientación tanto en el uso de la encuesta como en la marcación de peligros en los mapas.
- En el ejercicio con los mapas se identificaron varias áreas de riesgo (ver mapas)
  - Sector Machuchal: Se inunda y no está en los mapas de inundación.
  - Carr 630 intersección con la 677 el deslizamiento es alto y deja incomunicados a comunidades adyacentes. Cuevas y Sumideros en la norte del Barrio Bajura- marcado en mapa de deslizamiento.
  - Cerro Gordo: Preocupación por posibles nuevos proyectos planificados para el área que impactan recursos naturales y pueden afectar hidrología del área.
- Al concluir la presentación, se mostró la información de contacto de los enlaces de la JP relacionados con el Proyecto de actualización de los planes de mitigación, así como el correo electrónico oficial para canalizar comentarios (plandemitigacion@jp.pr.gov).
- La reunión comunitaria finalizó aproximadamente a las 6:30 pm.

## Sign-in Sheets

JUNTA DE PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

PLANES DE MITIGACIÓN
CONTRA PELIGROS NATURALES
Planificar para proteger

**HOJA DE ASISTENCIA**

Asunto: 1era Reunión de Planificación con la Comunidad- Municipio de Vega Alta
Fecha: 24 de febrero de 2026
Lugar: Centro de Recepciones del Municipio, PR-2 Km 30.5, Vega Alta
Hora: 5:00 pm

| Nombre completo (en letra de molde) | Municipio/Barrio/ Comunidad | Teléfono | Correo electrónico | Firma |
|---|---|---|---|---|
| José Rivera Rodz | Barahona | | | |
| Herminia Reymundi | Carmelita | | | |
| Sixta Martínez | Mavilla | | | |
| Magdalena López | Villa Linares | | | |
| Elizabeth Otero Martínez | Buena | | | |
| Samir Rosario Rosario | Vega Baja (Municipio) | | | |
| Marisol Rodz | V. Alta | | | |
| Samuel H Negrón Pérez | Vega Alta | | | |
| [illegible] | Ducuemos | | | |
| [illegible] Rodríguez | Bo: Arenas | | | |
| [illegible] | Vega Alta | | | |

Blocked for PII Protection

JUNTA DE PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

PLANES DE MITIGACIÓN
CONTRA PELIGROS NATURALES
Planificar para proteger

**HOJA DE ASISTENCIA**

Asunto: 1era Reunión de Planificación con la Comunidad- Municipio de Vega Alta
Fecha: 24 de febrero de 2026
Lugar: Centro de Recepciones del Municipio, PR-2 Km 30.5, Vega Alta
Hora: 5:00 pm

| Nombre completo (en letra de molde) | Municipio/Barrio/ Comunidad | Teléfono | Correo electrónico | Firma |
|---|---|---|---|---|
| Dasmin Burgos Henriquez | Mun. Vega Alta | | | |
| José A Medina | Centro Gardo | | | |
| Vanessa Marrero Santiago | agencia Junta de Planificación | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Blocked for PII Protection


ACTUALIZACION
PLAN DE
MITIGACION
VEGA ALTA
PLANIFICACIÓN


CICLO PARA EL MANEJO DE
EMERGENCIAS

# Appendix D: Stakeholder Involvement

JUNTA DE
PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

18 de mayo de 2026

Hon. Waldemar Quiles Pérez
Secretario
Departamento de Recursos Naturales y Ambientales
San José Industrial Park 1375
Avenida Ponce de León
San Juan, PR 00926

Vía correo electrónico:
waldemar.quiles@drna.pr.gov; brendaliz.gonzalez@drna.pr.gov

**RE: SOLICITUD DE INFORMACIÓN PARA LA ACTUALIZACIÓN DE LOS PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES MUNICIPALES**

Estimado señor secretario:

¡Reciba un cordial saludo! La Junta de Planificación (JP) se encuentra en proceso de apoyar a veinticinco municipios en el proceso de actualización de los planes locales de mitigación ante peligros naturales (LHMP, por sus siglas en inglés). Los municipios que son parte de esta iniciativa son; 1) Adjuntas, 2) Aguada, 3) Aguas Buenas, 4) Añasco, 5) Arecibo, 6) Arroyo, 7) Barranquitas, 8) Cataño, 9) Ceiba, 10) Comerío, 11) Dorado, 12) Hatillo, 13) Isabela, 14) Jayuya, 15) Las Marías, 16) Patillas, 17) Peñuelas, 18) Rincón, 19) Salinas, 20) San Germán, 21) Santa Isabel, 22) Utuado, 23) Vega Alta, 24) Vieques y 25) Yabucoa. Estos planes son de gran importancia para los municipios, ya que brindan la oportunidad de fortalecer estrategias de mitigación ante los eventos naturales a los cuales sus residentes son vulnerables. Además de tener estos planes actualizados es un requisito federal para que el municipio sea elegible para recibir fondos para proyectos de mitigación de parte de Agencia Federal para el Manejo de Desastre (FEMA, por sus siglas en ingles).

Por tal razón, solicitamos su colaboración dentro del ámbito pericial de su agencia para poder contar con la información más reciente para la actualización de estos planes. Dentro de la información que necesitamos está:

P.O. Box 41119, San Juan PR, 00940-1119 • 787.723.6200 • jp.pr.gov

- Capas de información geográfica actualizadas relacionadas a estos municipios, incluyendo la localización de las instalaciones que opere o áreas que administre en estos municipios. Ejemplos: casas bombas, represas, etc.
- Datos sobre las instalaciones que considere críticas localizadas en estos municipios.
- Planes de continuidad de operación (si alguno) para las instalaciones que su agencia administra en estos municipios.
- Planes operacionales de emergencia (si alguno) para las instalaciones que administre en estos municipios. Ejemplo: casas bombas, represas, etc.
- Lista y descripción de proyectos subvencionados por fondos de FEMA que incluyan componentes de mitigación bajo las secciones 404, 406 o 428 de la *Stafford Act*.
- Lista y descripción de proyectos subvencionados por fondos CDBG-DR o CDBG-MIT propuestos o gerenciados por su agencia, si alguno.

Agradecemos su cooperación en este esfuerzo de planificar las mejores estrategias para salvaguardar vida y propiedad en estos municipios. Toda información que tenga disponible favor tramitarla a través del correo electrónico plandemitigacion@jp.pr.gov. De tener cualquier duda puede comunicarse con la planificadora Ivette Colón Meléndez al correo electrónico colon_i@jp.pr.gov o al teléfono 787-723-6200 ext. 16681.

Cordialmente,

Lcdo. Héctor Morales Martínez
Presidente

Cc: Edwin.malavet@drna.pr.gov; mdmartes@drna.pr.gov;

JUNTA DE
# PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

18 de mayo de 2026

Vía correo electrónico:
ivrodriguez@agricultura.pr.gov

Hon. Irving Y. Rodríguez Torres
Secretario
Departamento de Agricultura
Box 10163
San Juan, PR 00908-1163

**RE: SOLICITUD DE INFORMACIÓN PARA LA ACTUALIZACIÓN DE LOS PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES MUNICIPALES**

Estimado señor secretario:

¡Reciba un cordial saludo! La Junta de Planificación (JP) se encuentra en proceso de apoyar a veinticinco municipios en el proceso de actualización de los planes locales de mitigación ante peligros naturales (LHMP, por sus siglas en inglés). Los municipios que son parte de esta iniciativa son; 1) Adjuntas, 2) Aguada, 3) Aguas Buenas, 4) Añasco, 5) Arecibo, 6) Arroyo, 7) Barranquitas, 8) Cataño, 9) Ceiba, 10) Comerío, 11) Dorado, 12) Hatillo, 13) Isabela, 14) Jayuya, 15) Las Marías, 16) Patillas, 17) Peñuelas, 18) Rincón, 19) Salinas, 20) San Germán, 21) Santa Isabel, 22) Utuado, 23) Vega Alta, 24) Vieques y 25) Yabucoa. Estos planes son de gran importancia para los municipios, ya que brindan la oportunidad de fortalecer estrategias de mitigación ante los eventos naturales a los cuales sus residentes son vulnerables. Además de tener estos planes actualizados es un requisito federal para que el municipio sea elegible para recibir fondos para proyectos de mitigación de parte de Agencia Federal para el Manejo de Desastre (FEMA, por sus siglas en ingles).

Por tal razón, solicitamos su colaboración dentro del ámbito pericial de su agencia para poder contar con la información más reciente para la actualización de estos planes. Dentro de la información que necesitamos está:

- Capas de información geográfica actualizadas relacionadas a estos municipios, incluyendo la localización de las instalaciones que opere o áreas que administre en estos municipios.
- Datos sobre las instalaciones que considere críticas localizadas en estos municipios.
- Planes de continuidad de operación (si alguno) para las instalaciones que su agencia administra en estos municipios.
- Planes operacionales de emergencia (si alguno) para las instalaciones que administre en estos municipios.
- Lista y descripción de proyectos subvencionados por fondos de FEMA que incluyan componentes de mitigación bajo las secciones 404, 406 o 428 de la *Stafford Act*.
- Lista y descripción de proyectos subvencionados por fondos CDBG-DR o CDBG-MIT propuestos o gerenciados por su agencia, si alguno.
- Inventarios de fincas agrícolas activas e inactivas.

Agradecemos su cooperación en este esfuerzo de planificar las mejores estrategias para salvaguardar vida y propiedad en estos municipios. Toda información que tenga disponible favor tramitarla a través del correo electrónico plandemitigacion@jp.pr.gov. De tener cualquier duda puede comunicarse con la planificadora Ivette Colón Meléndez al correo electrónico colon_i@jp.pr.gov o al teléfono 787-723-6200 ext. 16681.

Cordialmente,

Lcdo. Héctor Morales Martínez
Presidente

Cc: hmendez@agricultura.pr.gov
yflores@agricultura.pr.gov

JUNTA DE
PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

21 de mayo de 2026

Ing. Luis González Delgado, P.E
Presidente Ejecutivo
Autoridad de Acueductos y Alcantarillados
P.O. Box 7066
San Juan, PR 00916-7066

**Actualización de Veinticinco (25) Plan Locales de Mitigación Contra Peligros Naturales**

Estimado ingeniero González:

Reciba un cordial saludo. La Junta de Planificación (JP) está apoyando a veinticinco municipios en el proceso de actualización de sus planes locales de mitigación ante peligros naturales (LHMP, por sus siglas en inglés). Los municipios que son parte de esta iniciativa son; 1) Adjuntas, 2) Aguada, 3) Aguas Buenas, 4) Añasco, 5) Arecibo, 6) Arroyo, 7) Barranquitas, 8) Cataño, 9) Ceiba, 10) Comerío, 11) Dorado, 12) Hatillo, 13) Isabela, 14) Jayuya, 15) Las Marías, 16) Patillas, 17) Peñuelas, 18) Rincón, 19) Salinas, 20) San Germán, 21) Santa Isabel, 22) Utuado, 23) Vega Alta, 24) Vieques y, 25) Yabucoa. Estos planes son de gran importancia para los municipios, ya que brindan la oportunidad de fortalecer estrategias de mitigación ante los eventos naturales a los cuales sus residentes son vulnerables. Además, tener estos planes actualizados es un requisito federal para que el municipio sea elegible para recibir fondos para proyectos de mitigación de parte de Agencia Federal para el Manejo de Desastre (FEMA, por sus siglas en ingles).

Por tal razón, solicitamos su colaboración dentro del ámbito pericial de la Autoridad para poder contar con la información más reciente para la actualización de estos planes. Dentro de la información que necesitamos está:

- Capas de información geográfica actualizadas relacionadas a estos municipios, incluyendo la localización de las facilidades que la Autoridad opere o áreas que administre en estos municipios.

P.O. Box 41119, San Juan PR, 00940-1119 • 787.723.6200 • jp.pr.gov

- Datos sobre las facilidades que la Autoridad considere criticas localizadas en estos municipios.
- Planes de continuidad de operación (si alguno) para las facilidades que la Autoridad administre en estos municipios
- Planes operacionales de emergencia (si alguno) para las facilidades que la Autoridad administre en estos municipios.
- Lista y descripción de proyectos subvencionados por fondos de FEMA que incluyan componentes de mitigación bajo las secciones 404, 406 o 428 de la *Stafford Act* propuestos o gerenciados por la Autoridad
- Lista y descripción de proyectos subvencionados por fondos CDBG-DR o CDBG-MIT propuestos o gerenciados por la Autoridad.
- De particular importancia para nosotros es cualquier información que pueda brindar relacionada a las siguientes represas administradas por la Autoridad.
  - Cidra
  - La Plata

Para las represas estamos solicitando copia del Plan Operacional de Emergencias, así como documentación de los esfuerzos de alcance comunitario y diseminación que haya hecho la Autoridad en los pasados cinco años.

Agradecemos su cooperación en este esfuerzo de planificar las mejores formas de salvar vida y propiedad en estos municipios. Por favor preferimos que toda información sea enviada a través del correo electrónico plandemitigacion@jp.pr.gov. De tener cualquier duda puede comunicarse con la planificadora Ivette Colón Meléndez al correo electrónico colon_i@jp.pr.gov o al teléfono 787-723-6200 ext. 16681.

Cordialmente,

Lcdo. Héctor Morales Martínez
Presidente

Cc: rogelio.gonzalez@acueductospr.com

GOBIERNO DE
PUERTO RICO

PRESIDENCIA I AUTORIDAD DE ACUEDUCTOS Y ALCANTARILLADOS
Ing. Luis R. González Delgado I Presidente Ejecutivo I luis.gonzalez@acueductospr.com

26 de mayo de 2026

**Lcdo. Héctor Morales Martínez**
Presidente
Junta de Planificación
Gobierno de Puerto Rico
P.O. Box 41119
San Juan, PR 00940-1119

Estimado licenciado Morales:

En respuesta a su solicitud de información a la Autoridad de Acueductos y Alcantarillados en referencia al proceso de ***Actualización de Veinticinco (25) Planes Locales de Mitigación Contra Peligros Naturales***, por este medio remitimos la información correspondiente a nuestra agencia respecto a la infraestructura de agua potable y alcantarillado sanitario conforme a lo requerido, por lo que se adjunta:

- Base de Datos Infraestructura Sanitaria y Potable en formato *shapefile* (GDB)
  - Capas Junta Planificacion 2026
- Enlace a mapa interactivo de los proyectos de la AAA
  - Mapa Interactivo Proyectos AAA (acueductos.pr.gov)

Certificamos que la información suministrada es correcta y está actualizada a la fecha de esta comunicación. Debido a la naturaleza de los datos contenidos en esta solicitud para la cual estamos proveyendo la información, es nuestro interés que los mismos se utilicen estrictamente para fines de su análisis y no sean publicados, esto en virtud de la Ley de la Infraestructura de Agua de los Estados Unidos (AWIA, siglas en inglés), la Directriz de Política Presidencial 21 (PPD-21) bajo el Departamento de Seguridad Nacional (DHS, siglas en inglés) y la Ley de Agua Potable Segura (SDWA).

Quedamos a su disposición para cualquier información adicional que estime necesaria.

Cordialmente,

Ing. Luis R. González Delgado
Presidente Ejecutivo

AUTORIDAD DE ENERGÍA ELÉCTRICA

AEE

GOBIERNO DE PUERTO RICO

23 de junio de 2026

VÍA CORREO ELECTRÓNICO (colon_i@jp.pr.gov)

Lcdo. Héctor Morales Martínez
Presidente
Junta de Planificación
PO Box 41119
Guayama, PR 00940-1119

Estimado señor Presidente:

**Re: Actualización de Veinticinco (25) Plan Locales de Mitigación Ante Peligros Naturales**

La Autoridad de Energía Eléctrica (AEE) recibió su carta con fecha del 5 de junio de 2026, donde solicita información para la actualización de veinticinco (25) plan de local de mitigación ante peligros naturales.

Nuestra agencia administra las hidroeléctrica y canales de riego en Puerto Rico. Acompañamos la información concerniente a los sistemas que administra la Autoridad de Energía Eléctrica: Datos de las Hidroeléctricas y Canales de Riego (Anejo 1) y Planes de Emergencia (Anejo 2).

Los activos de transmisión y distribución están bajo la responsabilidad de LUMA Energy, y Genera PR administra el sistema de generación. Recomendamos para solicitud de información, que incluya a LUMA Energy y Genera PR, favor de solicitarla a las personas contactos:

Sr. Alejandro Figueroa Ramírez
(E-mail: Alejandro.Figueroa@lumapr.com)
Principal Oficial Regulatorio de LUMA
LUMA Energy, LLC
PO Box 363508
San Juan, PR 00936-3508

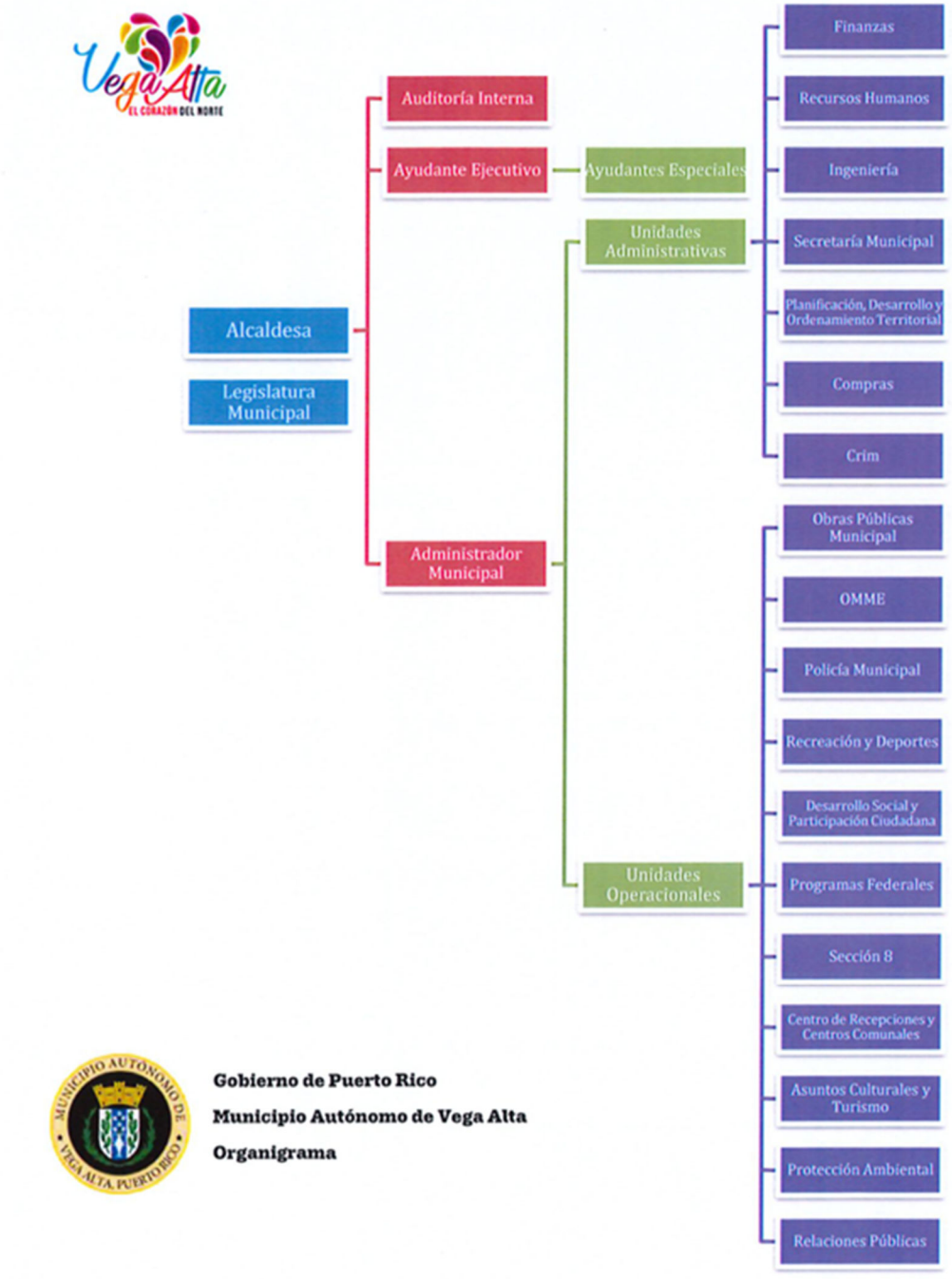
Sr. Winnie Irizarry Velázquez
(Email:winnie@genera-pr.com)
Presidente y CEO
Genera PR, LLC
954 Avenida Ponce de León, Suite 400
San Juan, PR 00907

Agradeceremos la atención prestada a este asunto. Para información adicional, puede comunicarse con el Sra. Yaritza Acevedo Correa (yaritza.acevedo@prepa.pr.gov), Oficial de Programa, División de Protección Ambiental y Confiabilidad de Calidad por el 787-521-4565.

Cordialmente,

Ruth Dones Ramos, Jefa
División de Protección Ambiental y
Confiabilidad de Calidad
(Email: ruth.dones@prepa.pr.gov)

# Appendix E: Municipal Organizational



# Appendix F: Critical Infrastructure by Lifeline

| # | FACILITY NAME | COORD Y | COORD X | TYPE | CATEGORY | SUBCATEGORY |
|---|---|---|---|---|---|---|
| 1 | (Generador) Dorado Club | 18.468445 | -66.331214 | Lifeline: Water Systems | Water Supply | AAA |
| 2 | (Generador) General Electric | 18.416534 | -66.329652 | Lifeline: Water Systems | Water Supply | AAA |
| 3 | (Generador) Vega Doradoada | 18.462645 | -66.331697 | Lifeline: Water Systems | Water Supply | AAA |
| 4 | Calle 17 | 18.418586 | -66.326889 | Lifeline: Transportation | Transportation Systems | Puente |
| 5 | CDT | 18.421092 | -66.335966 | Lifeline: Health and Medical | Medical Care | CDT |
| 6 | Centro de Gobierno Irmo Figueroa Concepción | 18.413997 | -66.330137 | Lifeline: Safety and Security | Government Service | Gobierno |
| 7 | Centro de Recepciones | 18.414379 | -66.328289 | Other Facilities | Recreational Facilities | Centros Comunales |
| 8 | Colegio Discípulos de Cristo | 18.412732 | -66.314914 | Other facilities | Educational Institutions | Colegio |
| 9 | Cuartel de la Policía Estatal | 18.412502 | -66.324723 | Lifeline: Safety and Security | Law Enforcement | Estaciones De Policía |
| 10 | Cuartel de la Policía Municipal Bo. Sabana | 18.466359 | -66.334792 | Lifeline: Safety and Security | Law Enforcement | Estaciones De Policía |
| 11 | EBAS ABB Vega Alta | 18.44152 | -66.3298 | Lifeline: Water Systems | Water Supply | Sanitary System |

| # | FACILITY NAME | COORD Y | COORD X | TYPE | CATEGORY | SUBCATEGORY |
|---|---|---|---|---|---|---|
| 12 | EBAS Barriada Correa Vega Alta | 18.4098 | -66.333 | Lifeline: Water Systems | Water Supply | Sanitary System |
| 13 | EBAS Esc. Ileana De Gracia | 18.41922 | -66.3353 | Lifeline: Water Systems | Water Supply | Sanitary System |
| 14 | EBAS Maricao | 18.3823 | -66.3322 | Lifeline: Water Systems | Water Supply | Sanitary System |
| 15 | EBAS Sabana Hoyos II | 18.4509 | -66.3434 | Lifeline: Water Systems | Water Supply | Sanitary System |
| 16 | EBAS Urb. Santa Ana Vega Alta | 18.417453 | -66.307622 | Lifeline: Water Systems | Water Supply | Sanitary System |
| 17 | Edificio de Obras Públicas / Ornato y Reciclaje | 18.416015 | -66.331305 | Lifeline: Safety and Security | Government Service | Manejo de Emergencias |
| 18 | Esc. Antonio Paoli | 18.41179 | -66.31669 | Other facilities | Educational Institutions | Escuela |
| 19 | Esc. Apolo San Antonio | 18.41254 | -66.33316 | Other facilities | Educational Institutions | Escuela |
| 20 | Esc. Apolo San Antonio | 18.41254 | -66.33316 | Other facilities | Educational Institutions | Escuela |
| 21 | Esc. Elemental Urbana | 18.41309 | -66.3293 | Other facilities | Educational Institutions | Escuela |
| 22 | Esc. Elisa Dávila Vázquez | 18.400507 | -66.306078 | Other facilities | Educational Institutions | Escuela |
| 23 | Esc. Francisco Felicié Martínez | 18.465883 | -66.335594 | Other facilities | Educational Institutions | Escuela |
| 24 | Esc. Ignacio Miranda | 18.41052 | -66.32616 | Other facilities | Educational Institutions | Escuela |
| 25 | Esc. Ileana De Gracia | 18.419784 | -66.335273 | Other facilities | Educational Institutions | Escuela |

| # | FACILITY NAME | COORD Y | COORD X | TYPE | CATEGORY | SUBCATEGORY |
|---|---|---|---|---|---|---|
| 26 | Esc. José M. Pagan De Jesús | 18.44004 | -66.33508 | Other facilities | Educational Institutions | Escuela |
| 27 | Esc. José M. Pagan De Jesús | 18.44004 | -66.33508 | Other facilities | Educational Institutions | Escuela |
| 28 | Esc. Ladislao Martínez | 18.409426 | -66.324793 | Other facilities | Educational Institutions | Escuela |
| 29 | Esc. Rafael Hernández | 18.41734 | -66.30981 | Other facilities | Educational Institutions | Escuela |
| 30 | Estación de Bombas AAA Pica El Peje Frances Bajura Vega Alta | 18.423165 | -66.341968 | Lifeline: Water Systems | Water Supply | Potable Water Systems |
| 31 | Estación de Bomberos | 18.414837 | -66.329089 | Lifeline: Safety and Security | Fire Station Facilities | Estaciones De Bomberos |
| 32 | FMC Vega Alta | 18.4152 | -66.3299 | Lifeline: Health and Medical | Medical Care | Centro de Diálisis |
| 33 | Fresenius Kidney Care | 18.414854 | -66.329917 | Lifeline: Health and Medical | Medical Care | Clínica |
| 34 | IPA 307 | 18.412977 | -66.326376 | Lifeline: Health and Medical | Medical Care | CDT |
| 35 | NW Bilingual Academy | 18.416082 | -66.309658 | Other facilities | Educational Institutions | Colegio |
| 36 | Oficina de Manejo de Emergencias / Policía Municipal | 18.414585 | -66.328753 | Lifeline: Safety and Security | Government Service | Manejo de Emergencias |
| 37 | PAS Vega Alta | 18.4175 | -66.3383 | Lifeline: Water Systems | Water Supply | Sanitary System |
| 38 | Planta de Tratamiento de | 18.417524 | -66.338568 | Lifeline: Water Systems | Water Supply | Sanitary System |

| # | FACILITY NAME | COORD Y | COORD X | TYPE | CATEGORY | SUBCATEGORY |
|---|---|---|---|---|---|---|
| | Aguas Servidas Vega Alta | | | | | |
| 39 | PR 22 Eastbound | 18.428444 | -66.3393 | Lifeline: Transportation | Transportation Systems | Puente |
| 40 | PR 22 Eastbound | 18.428342 | -66.343486 | Lifeline: Transportation | Transportation Systems | Puente |
| 41 | PR 22 Eastbound | 18.424503 | -66.301336 | Lifeline: Transportation | Transportation Systems | Puente |
| 42 | PR 22 Etbd Km. 29.1 | 18.425358 | -66.309617 | Lifeline: Transportation | Transportation Systems | Puente |
| 43 | PR 22 Etbd Km. 30.6 | 18.427075 | -66.319894 | Lifeline: Transportation | Transportation Systems | Puente |
| 44 | PR 22 PR 2 Km. 32.4 | 18.432075 | -66.340642 | Lifeline: Transportation | Transportation Systems | Puente |
| 45 | PR 22 Webd Km. 30.6 | 18.427264 | -66.319842 | Lifeline: Transportation | Transportation Systems | Puente |
| 46 | PR 22 Westbound | 18.428494 | -66.343625 | Lifeline: Transportation | Transportation Systems | Puente |
| 47 | PR 22 Westbound | 18.428283 | -66.339486 | Lifeline: Transportation | Transportation Systems | Puente |
| 48 | PR 22 Westbound | 18.425536 | -66.309503 | Lifeline: Transportation | Transportation Systems | Puente |
| 49 | PR 620 | 18.400297 | -66.343908 | Lifeline: Transportation | Transportation Systems | Puente |
| 50 | PR 647 Km. 8.3 | 18.383161 | -66.349931 | Lifeline: Transportation | Transportation Systems | Puente |
| 51 | PR 647 Km. 8.3 | 18.383069 | -66.34945 | Lifeline: Transportation | Transportation Systems | Puente |
| 52 | PR 675 Km. 0.3 | 18.422003 | -66.3436 | Lifeline: Transportation | Transportation Systems | Puente |

| # | FACILITY NAME | COORD Y | COORD X | TYPE | CATEGORY | SUBCATEGORY |
|---|---|---|---|---|---|---|
| 53 | PR 690 | 18.428094 | -66.347303 | Lifeline: Transportation | Transportation Systems | Puente |
| 54 | PR 690 | 18.421317 | -66.347272 | Lifeline: Transportation | Transportation Systems | Puente |
| 55 | PR 694 Km. 1.0 | 18.424347 | -66.301539 | Lifeline: Transportation | Transportation Systems | Puente |
| 56 | Ramp PR 2 To PR 22 | 18.429722 | -66.342778 | Lifeline: Transportation | Transportation Systems | Puente |
| 57 | Subestación #9101 Vega Alta Pueblo | 18.41458 | -66.331239 | Lifeline: Energy | Energy Generation And Distribution | AEE, LUMA |
| 58 | Subestación #9103 Santa Ana | 18.414279 | -66.307185 | Lifeline: Energy | Energy Generation And Distribution | AEE, LUMA |
| 59 | Subestación #9105 Vega Alta 13kv | 18.414534 | -66.331221 | Lifeline: Energy | Energy Generation And Distribution | AEE, LUMA |
| 60 | Subestación #9201 Bo. Breñas | 18.467832 | -66.315723 | Lifeline: Energy | Energy Generation And Distribution | AEE, LUMA |
| 61 | Vega Alta Community Health | 18.42072 | -66.3356 | Lifeline: Health and Medical | Medical Care | Clínica |
| 62 | Vega Alta Community Health | 18.42072 | -66.33614 | Lifeline: Health and Medical | Medical Care | CDT |