Multi-Hazard Mitigation and Resilience Plan

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Volume 1 of 2

TETRA TECH

County of Kaua‘i Multi-Hazard Mitigation and Resilience Plan

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NOTE:
This document uses spelling for Hawaiian geographic names, including diacritical marks (‘okina or kahakō), as currently included in spreadsheets developed by the Hawai‘i Board of Geographic Names. These are available online at https://planning.hawaii.gov/gis/hbgn/

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CONTENTS

Volume 1

Volume 2

TABLES (VOLUME 1 ONLY)

FIGURES (VOLUME 1 ONLY)

ABBREVIATIONS

Abbreviation	Definition	Abbreviation	Definition
%g	Percent force of gravity (a measure of acceleration)	H2O	Water vapor
44 CFR	Code of Federal Regulations, Title 44	HAR	Hawai'i Administrative Rules
ADC	Agribusiness Development Corporation	Hazus	Hazards U.S.
AFG	Assistance to Firefighters Grant	HDOT	Hawai'i Department of Transportation
BEACH Act	Beaches Environmental Assessment and Coastal Health Act of 2000	HHS	Health and Human Services
BRIC	Building Resilient Infrastructure and Communities	HMA	Hazard Mitigation Assistance
C&CB	Capability- and Capacity-Building Activities	HMP	Hazard Mitigation Plan
CARW	Communities at Risk from Wildfires	HSGP	Homeland Security Grant Program\
CDBG-DR	Community Development Block Grant Disaster Recovery	HUD	U.S. Department of Housing and Urban Development
CDBG-MIT	Community Development Block Grant Mitigation	HWH	Hanalei Watershed Hui
CDC	Centers for Disease Control and Prevention	IAL	Important Agricultural Lands
CIP	Capital Improvement Plan	IBC	International Building Code
CO2	Carbon dioxide	IRC	International Residential Code
CODEL	Congressional Delegation	KCC	Kaua'i Community College
CRS	Community Rating System	KEMA	Kaua'i Emergency Management Agency
CWPP	Community Wildfire Protection Plan	KFD	Kaua'i Fire Department
DAR	Division of Aquatic Resources	KIUC	Kaua'i Island Utility Cooperative
DFIRM	Digital Flood Insurance Rate Maps	LiMWA	Limit of Moderate Wave Action
DHS	U.S. Department of Homeland Security	NEHRP	National Earthquake Hazards Reduction Program
DLNR	Department of Land and Natural Resources	NFIP	National Flood Insurance Program
DMA	Disaster Mitigation Act of 2000	NOAA	National Oceanic and Atmospheric Administration
DOBOR	Division of Boating and Ocean Recreation	NRCS	Natural Resources Conservation Service
DOE	Department of Education	NWS	National Weather Service
DOFAW	Division of Forestry and Wildlife	PA	Public Assistance
DOH	Department of Health	PDI	Palmer Drought Index
DOPR	Department of Parks and Recreation	PGA	Peak Ground Acceleration
DPW	Department of Public Works	PIRCA	Pacific Islands Regional Climate Assessment
EAP	Emergency Action Plan	PMRF	Pacific Missile Range Facility Barking Sands
EMPG	Emergency Management Performance Grant	ppm	Parts per million
EPA	U.S. Environmental Protection Agency	SFHA	Special Flood Hazard Area
ESA	Endangered Species Act	SLOSH	Sea, lake, and overland surges from hurricane
FEMA	Federal Emergency Management Agency	SO2	Sulfur dioxide
FERC	Federal Energy Regulatory Commission	SPI	Standardized Precipitation Index
FIRM	Flood Insurance Rate Map	USACE	United States Army Corps of Engineers
FIS	Flood Insurance Study	USDA	U.S. Department of Agriculture
FMAG	Fire Management Assistance Grant	USGS	U.S. Geological Survey
GIS	Geographic Information System	WUI	Wildland urban interface

Part 1. PLANNING PROCESS AND COMMUNITY PROFILE

1. INTRODUCTION

1.1 THE VALUE OF HAZARD MITIGATION PLANNING

Hazard mitigation is defined as any action taken to reduce or alleviate the loss of life, personal injury and property damage that can result from a disaster. It involves long- and short-term actions implemented before, during and after disasters. Hazard mitigation activities include planning efforts, policy changes, programs, studies, improvement projects and other steps to reduce the impacts of hazards.

The federal Disaster Mitigation Act (DMA) of 2000 emphasizes planning for disasters before they occur. The DMA requires state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance. State plans allow access to all non-emergency FEMA assistance, PA (Public Assistance) and HMA (Hazard Mitigation Assistance) grants. Local plans allow access to HMA grants. Regulations developed to fulfill the DMA's requirements are included in Title 44 of the Code of Federal Regulations (44 CFR).

The responsibility for hazard mitigation lies with many, including private property owners, commercial interests, and local, state and federal governments. The DMA encourages cooperation among state and local authorities in pre-disaster planning. The enhanced planning network called for by the DMA helps local governments to articulate accurate needs for hazard mitigation, resulting in faster allocation of funding and more cost-effective risk-reduction projects.

The DMA also promotes sustainability in hazard mitigation. To be sustainable, hazard mitigation needs to incorporate sound management of natural resources and address hazards and mitigation in the largest possible social and economic context. That means going beyond an assessment of dollar-value losses that result from hazard events to consider a broad range of benefits and costs, including social equity, environmental impact, and ways to make people and places more resilient in the face of the risks that hazards pose.

All residents and businesses of the County of Kaua‘i are the ultimate beneficiaries of hazard mitigation planning. The County's hazard mitigation plan identifies strategies and actions to reduce risk for those who live in, work in, and visit the County. It provides a viable planning framework for all foreseeable natural hazards. Key stakeholders' participation in development of the plan helps ensure that outcomes will be mutually beneficial. The plan's goals and recommendations lay groundwork for the development and implementation of local hazard mitigation activities and partnerships.

1.2 PREVIOUS PLANNING FOR THE COUNTY OF KAUA‘I

The County of Kaua‘i prepared a hazard mitigation plan in compliance with the DMA in 2005 to help guide and coordinate mitigation and resilience activities throughout the county. That initial plan identified resources, information, and strategies for reducing risk from natural hazards. It was last updated in 2015, in compliance with federal requirements that communities update hazard mitigation plans every five years in order to remain eligible for certain federal hazard-related funding programs. The current status of mitigation actions recommended in the 2015 update is summarized in Appendix A.

1.3 THE UPDATED PLAN

1.3.1 Why Update?

The *County of Kaua'i Multi-Hazard Mitigation and Resilience Plan* is now undergoing its third comprehensive update in accordance with federal requirements. The 2020 hazard mitigation plan update was developed to achieve the following objectives:

- Meet or exceed requirements of the DMA.
- Enable the County to continue to access FEMA grant funding to reduce risk through mitigation.
- Meet the needs of the County as well as state and federal requirements.
- Create a risk assessment of local hazards of concern.
- Coordinate existing plans and programs so that high-priority projects to mitigate possible disaster impacts are funded and implemented.

KEY RESULTS OF THE 2015 COUNTY OF KAUA'I HAZARD MITIGATION PLAN (County of Kaua'i, 2015)

The 2015 plan identified the following key hazards of concern:

- Hurricanes and Strong Winds
- Floods
- Drought
- Wildfire
- Coastal Erosion
- Climate Variability and Change
- Earthquake
- Tsunami
- Landslide
- Dam Failure
- Hazardous Materials
- Homeland Security and Terrorism
- Health-related Hazards

Based on an assessment of risks, the 2015 plan identified 61 mitigation actions to address the identified hazards as follows:

- Multi-Hazard—18 actions
- Hurricane and Strong Winds—8 actions
- Floods—6 actions
- Drought—4 actions
- Wildfire—6 actions
- Climate Variability and Change—3 actions
- Earthquake—1 action
- Tsunami—6 actions
- Landslides/Mudslides—1 action
- Erosion—1 action
- Dam Safety—1 action
- Hazardous Materials—1 action
- Homeland Security and Human-Induced Hazards—4 actions
- Health-Related Disasters—1 action

Federal Eligibility

Title 44 of the Code of Federal Regulations (44 CFR) stipulates that hazard mitigation plans must present a schedule for monitoring, evaluating, and updating the plan. This provides an opportunity to reevaluate recommendations, monitor the impacts of actions that have been accomplished, and determine if there is a need to change the focus of mitigation strategies. The Robert T. Stafford Act requires that jurisdictions have current hazard mitigation plans to pursue and receive grant funding under the FEMA HMA grant programs.

Changes in Development

Hazard mitigation plan updates must be revised to reflect changes in development within the planning area during the previous performance period of the plan. The plan must describe changes in development in hazard-prone areas that increased or decreased vulnerability since the last plan was approved. If no changes in development impacted overall vulnerability, then plan updates may validate the information in the previously approved plan. The intent of this requirement is to ensure that the mitigation strategy continues to address the risk and vulnerability of existing and potential development and takes into consideration possible future conditions that could impact vulnerability.

A forecast of development trends that the County of Kaua'i prepared in 2018 estimated about 18 percent growth in housing units between 2020 and 2035 (County of Kaua'i, 2018). Between the time of the last hazard mitigation plan in 2015 and the most recent available estimates (for 2019), the County planning area experienced a 1.8 percent increase in population. This hazard mitigation plan update assumes that some new development triggered by population since the last plan would have occurred in hazard areas. Because all such new

development would have been regulated pursuant to local programs and codes, it is assumed that hazard vulnerability did not increase, although it is possible that an increase in hazard exposure has occurred.

New Analysis Capabilities

The risk assessment for this updated hazard mitigation plan provides more detailed information than the previous plan on exposed population and building counts for each hazard of concern. It focuses on all property and populations in the County, unlike the previous plan's focus on critical facilities and special populations. This update also expands the level of detail in the loss estimate modeling for tropical cyclone, flood, tsunami, and earthquake. Exposure and vulnerability estimates are presented at the community planning area level in addition to countywide findings. This enhanced risk assessment allows for a more detailed understanding of the County's risk associated with natural hazards.

1.3.2 What Is Different?

The County used the current update process to make significant changes to the format and content of the hazard mitigation plan. The plan was re-packaged in its entirety to improve readability and to more readily align with DMA and CRS requirements for hazard mitigation plans. A renewed effort was made to re-establish a plan maintenance and implementation protocol that clearly defines the County's commitment to the plan's ongoing success. Some of the major differences between the current and previous plans are as follows:

- New goals, objectives and mitigation initiatives were developed for the updated plan to more readily align with existing County plans and programs and identified state priorities.
- The list of evaluated hazards was updated based on the most current community experience and concerns.
- A new review was conducted of existing plans and programs that are relevant for hazard mitigation.
- The risk assessment was updated using the best available data, including updated general building stock and critical facility databases.
- Discussion on existing land uses was included for each hazard of concern that has defined extents and locations.
- A new risk ranking protocol was employed to assist in establishing mitigation priorities.
- The protocol for prioritizing actions was updated and included a qualitative benefit-cost review.
- The strategy for plan maintenance and implementation was revised and updated to encourage greater coordination and planning for hazard mitigation funding opportunities.

CONTENTS OF THIS UPDATED PLAN (2020)

This hazard mitigation plan is organized into three primary parts:

- Part 1—Planning Process and Community Profile
- Part 2—Risk Assessment
- Part 3—Mitigation Strategy.

Each part includes elements required under federal guidelines. DMA compliance requirements are cited at the beginning of subsections as appropriate to indicate compliance. Appendices at the end of the plan include information or explanations to support the main content of the plan.

Appendix B indicates the major changes between the two plans as they relate to 44 CFR planning requirements.

1.4 PLAN UPDATE METHODOLOGY

1.4.1 Developing the Plan

The process followed to develop this Kaua'i County Multi-Hazard Mitigation and Resilience Plan Update had the following primary objectives:

- Form a Core Planning Team to lead the process and write the updated hazard mitigation plan.

- Define the planning area that will be evaluated in the plan and for which hazard-related risks will be assessed.
- Establish a Steering Committee to provide community and stakeholder guidance for development of the plan.
- Coordinate with other agencies on issues of concern for local hazard mitigation planning.
- Review existing programs that are relevant to the updated plan's development.
- Engage the public in providing input needed to ensure that the updated plan addresses local priorities.

The Core Planning Team included staff from Kaua'i County's Emergency Management Agency and Planning Department, Hawai'i Sea Grant, and consulting firm Tetra Tech. The Steering Committee, consisting of 13 members (plus alternates) from County and State of Hawai'i departments, private businesses, educational institutions, and community organizations met nine times from May through December 2020. Public engagement activities included the following:

- Identify and involve planning area stakeholders.
- Include members of the public on the Steering Committee.
- Create a hazard mitigation website to inform the public about the development of this plan update.
- Invite public participation at virtual public meetings. Two meetings were held in September 2020, with total attendance by 23 members of the public.
- Use a survey to determine if the public's perception of risk and support of hazard mitigation has changed since the initial planning process. The survey was available through the website. A total of 534 respondents completed the online survey.
- Attempt to reach as many planning area citizens as possible using multiple media. Press releases were distributed over the course of the plan's development as key milestones were achieved and prior to each public meeting.

Further detail on all these activities, including Steering Committee meeting materials and results of the survey, are provided in Appendix C.

1.4.2 Assessing Risk

Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from natural hazards. It allows emergency management personnel to establish early response priorities, mitigation actions, and preparedness by identifying potential hazards and vulnerable assets. The process focuses on the following elements:

- **Hazard identification**—Use all available information to determine what types of disasters may affect a jurisdiction, how often they can occur, and their potential severity (see box at right).
- **Vulnerability identification**—Determine the impact of natural hazard

HAZARD PROFILES

In this hazard mitigation plan, hazard identification includes the following profile elements:

- **Past events**—A summary is provided of major episodes of the hazard that have previously occurred in the planning area
- **Location**—For hazards where the risk is not the same across the planning area, maps or descriptions are provided to indicate areas most at risk
- **Frequency**—Based on an assessment of previous hazard occurrences in the planning area, estimates are developed as to how often the hazard can be expected to occur in the future
- **Severity**—Based on an assessment of previous hazard occurrences in the planning area, a general discussion is provided of the types of damage and impact that can be expected in the planning area, along with numerical values of the scale of events in the planning area where such information is available
- **Warning time**—General descriptions are provided of how well hazard managers can predict a hazard event in advance and what systems are in place to notify the public of impending risk
- **Secondary hazards**—Other hazards are listed that have the potential to occur in response to each hazard evaluated

events on the people, property, environment, economy and lands of the region.
- **Cost evaluation**—Estimate the cost of potential damage or cost that can be avoided by mitigation.

The risk assessment for this hazard mitigation plan update evaluates the risk of natural hazards prevalent in the planning area. Detailed data and the qualitative and quantitative methods used for the assessment are described in Appendix D.

The assessment used FEMA's Hazus (Hazards U.S.-Multi-Hazard) simulation model to estimate losses caused by hazards and identify areas that face the highest risk and potential for loss. Hazus is a GIS-based software program used to support risk assessments, mitigation planning, and emergency planning and response. It provides a wide range of inventory data, such as demographics, building stock, critical facility, transportation and utility lifeline, and multiple models to estimate potential losses from natural disasters. The program maps and displays hazard data and the results of damage and economic loss estimates for buildings and infrastructure.

1.5 FOCUS ON EQUITY

1.5.1 Kaua‘i County Equity Goals

Social equity is critical in promoting healthy and diverse communities on Kaua‘i. It calls for expanding access to economic opportunity, quality education, affordable housing and health services, and ensuring that no racial or income group is unfairly disadvantaged. *Kaua‘i Kākou—Kaua‘i County General Plan*, a strategic roadmap for the County, outlines the following steps for equity (County of Kaua‘i, 2018):

- Celebrating Kaua‘i's diversity by addressing equity issues
- Caring for the most vulnerable
- Strengthening community networks
- Protecting Native Hawaiian rights

1.5.2 Addressing Equity in Hazard Mitigation

The planning process for this hazard mitigation and resilience plan was designed to stimulate better, more effective, sustainable and vital connections between stakeholders, toward the common objective of mitigating hazard risks to the community. The plan emphasizes equity in order to empower the County's most vulnerable people to play a role in building resilience. This is referred to as the application of an equity lens, which is defined as a critical thinking approach to undoing institutional and structural biases by evaluating burdens, benefits and outcomes on underserved communities. An equity lens was developed and applied throughout the public outreach process, in the evaluation of risk, and in the development of mitigation actions.

Through this broad engagement and focus on equity, the County seeks to reduce vulnerability to natural hazards for all communities so that the benefits of hazard mitigation, such as the following, can be shared by all:

- A faster recovery and return to normal life for neighborhoods after a hazard event
- Reduced stress on emergency responders and social services
- A faster return to work for workers after a hazard event, resulting in less economic disruption and fewer businesses closing
- Maintenance of the culture, diversity and distinct neighborhoods of the County

The planning process sought to identify specific needs for targeted mitigation actions that can overcome traditional barriers and challenges to equity. Such actions should achieve the following objectives:

- Minimize the impacts of hazard events so that they do not become disasters.

- Provide a better quality of life to all groups and members of the community.
- Build trust and networks that can be relied upon for other developmental activity.
- Promote overall sustainability and resilience.

The risk assessments and hazard mitigation action plan in this plan aimed for equity by considering the diversity of communities in the County and each community's access to resources (including information, knowledge, and technology), social networks and connections, beliefs and customs, age, gender, race, health, and physical ability.

2. KAUA‘I COUNTY PROFILE

2.1 GEOGRAPHIC OVERVIEW

The State of Hawai‘i consists of eight major islands (Kaua‘i, Ni‘ihau, O‘ahu, Maui, Moloka‘i, Lāna‘i, Kaho‘olawe, and Hawai‘i) and 124 small islands, reef, and shoals (the Northwest Hawaiian Islands). The islands are divided into five counties—Kaua‘i, City & County of Honolulu (O‘ahu), Maui, Kalawao, and Hawai‘i.

Kaua‘i is northwest of O‘ahu, separated by the Kaua‘i Channel. Known as the Garden Isle, Kaua‘i is the northernmost and geologically oldest of the major Hawaiian Islands. Kaua‘i County includes Ni‘ihau Island (nearly 70 square miles) and the tiny uninhabited islets of Ka‘ula and Lehua. These islands are volcanic in origin, although there are currently no active volcanoes in this county. The circular island of Kaua‘i rises 3 miles from the ocean floor and is roughly 550 square miles (County of Kaua‘i, 2015).

The Kaua‘i County seat is Līhu‘e. Other population centers are Hanalei, Kīlauea, Anahola, Kapa‘a Kapahi, Wailua, Hanamā‘ulu, Puhi, Kōloa, Po‘ipū, Kukui‘ula, Lāwa‘i, Kalāheo, Hanapēpē, ‘Ele‘ele, Waimea, and Kekaha. Pu‘uwai is the settlement on Ni‘ihau. The planning area for this hazard mitigation plan includes all of the island of Kaua‘i. For planning purposes and to assess potential losses from hazard events, the County’s six planning districts are used for analyses throughout this hazard mitigation plan. The Island of Ni‘ihau is also part of Kaua‘i County but, as in the Kaua‘i County General Plan, it is not analyzed in this hazard mitigation plan due to its predominantly private ownership and management. Figure 2-1 shows the planning area and the districts used for this plan.

2.2 HISTORICAL OVERVIEW

The first Polynesian settlers may have arrived around 600 A.D. with an influx of new settlers in about 1200 A.D. Manokalanipō, born at Wailua about 1350, is credited with building significant agricultural projects and bringing generations of prosperity to Kaua‘i and Ni‘ihau.

The arrival of Captain James Cook at Waimea in 1778 marked the first recorded encounter of Europeans with native Hawaiians. Other western explorers and settlers followed, and as a result, the island’s economy, land use system, form of government, population, culture, and lifestyle were forever changed.

Kaua‘i and Ni‘ihau were the last islands to join the Kingdom of Hawai‘i. Kamehameha I attempted twice to invade Kaua‘i. The first time in 1796 was thwarted by bad weather. In 1804 an outbreak of typhoid fever decimated the gathered forces on O‘ahu. Kaua‘i’s king, Kaumuali‘i, acknowledged Kamehameha as king of all of Hawai‘i in 1810 to avoid future bloodshed. When Kamehameha died in 1819, his successor, Kamehameha II (Liholiho), feared that Kaumuali‘i would sever Kaua‘i’s relationship with the Kingdom of Hawai‘i. In September 1821, Kamehameha II sailed to Kaua‘i and invited Kaumuali‘i to dine on his ship. Kamehameha then sailed back to O‘ahu with Kaumuali‘i under house arrest. Kaua‘i remained passive until Kaumuali‘i’s death on O‘ahu in 1824. His son George Kaumuali‘i Humehume attempted to re-establish Kaua‘i’s independence. After a brief and unsuccessful rebellion on the island’s west side was brutally repressed, Kamehameha II installed Kaikio‘ewa as Kaua‘i’s governor.

Source: County of Kauaʻi, 2018

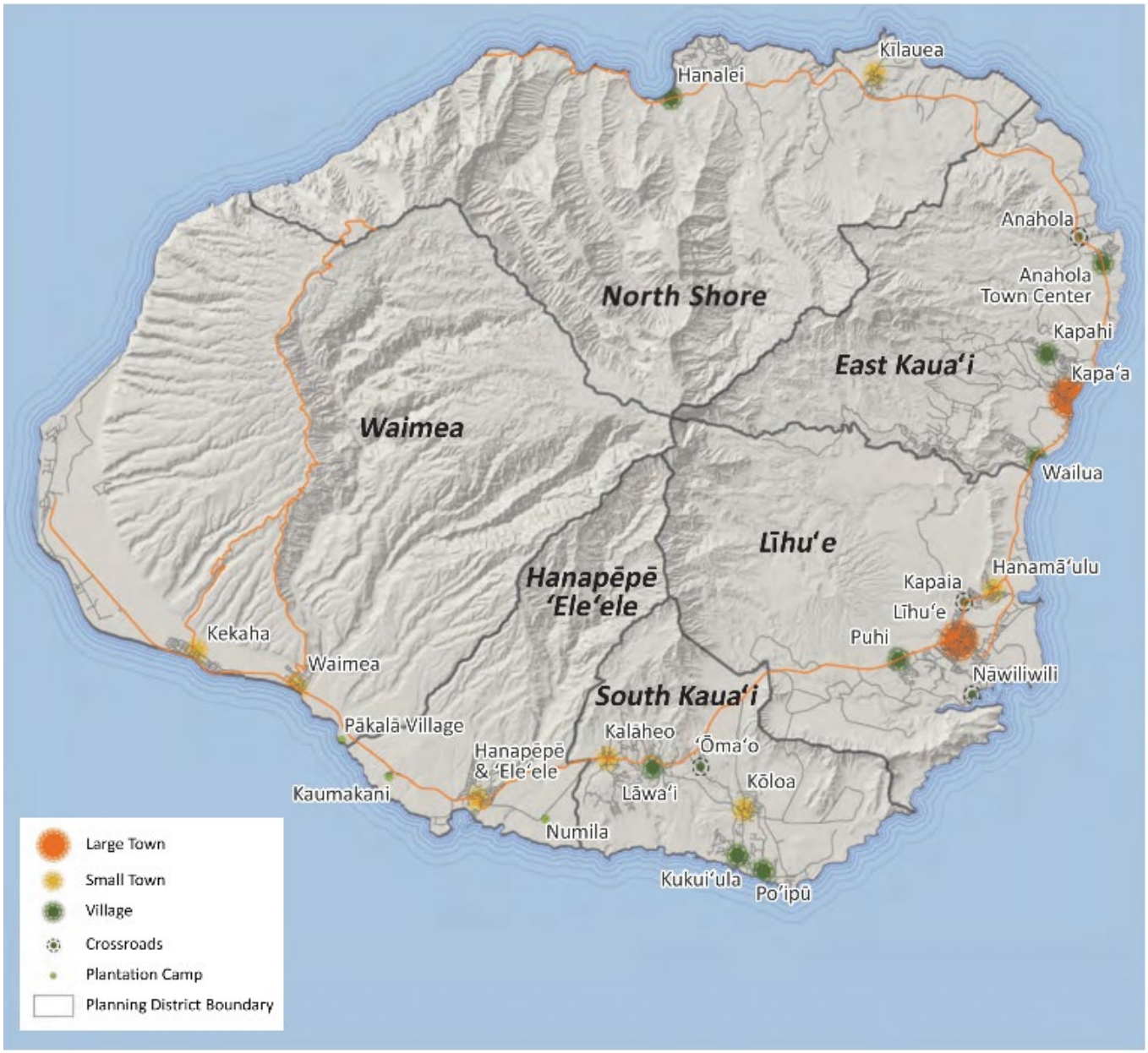


Figure 2-1. Planning Area Communities and Districts

Because of its location in the mid-Pacific, Hawaiʻi was an ideal stop for trade ships. Sandalwood trade dominated until 1830, when Kauaʻi's forests had been stripped of sandalwood. Whaling ships, stopping to reprovision at Waimea and Kōloa were common from 1820 to 1870. Kōloa Plantation was founded in 1835 with the setup of a simple sugar mill and became the first large-scale, commercial sugar plantation in Hawaiʻi. In the mid-1800s, coffee became the first successful new trade crop to be planted on Kauaʻi. Livestock production and rice and pineapple growing also changed the local economy, but sugar, especially after the 1875 Reciprocity Treaty removed all duties on Hawaiian sugar imported to the United States, dominated as the primary agricultural and industrial activity for more than 120 years and greatly boosted the plantation system. By 1910, plantation towns populated by immigrants from China, Japan, the Philippines, and Portugal, were common.

In July 1887 a group of primarily American and European businessmen forced a new constitution on King David Kalākaua, that among other things disenfranchised two thirds of native Hawaiians and all Asian immigrants. In January 1893 a similar group, the Committee of Safety, deposed Queen Lili'uokalani, and established the Provisional Government of Hawai'i. The Provisional Government placed Lili'oukalani under house arrest and established the Republic of Hawai'i in July 1894. The United States annexed Hawai'i in August 1898.

With a change of government following Hawai'i's annexation in 1898, Kaua'i's modern territorial era began. Roads were built for the first automobiles that arrived in 1907. Cross-island telephone service started in 1911. Electricity, which had previously only been used by the sugar mills, became available to consumers in Līhu'e, Kōloa, and Waimea. Airfields were built at Līhu'e and Hanapēpē, and regular flight service was established in the 1920s. Tourism began to increase in the 1950s with the arrival of passenger jet flights to the islands. By 1970, the number of workers in the tourism industry outnumbered those working on sugar plantations, and by the end of the 1980s, more than 80 percent of Kaua'i's income was dependent upon tourism (Kaua'i Historical Society, 2000). In recent years, diversified agriculture has experienced a generally upward trend, with seed corn being the island's number one crop and coffee from Kaua'i accounting for 60 percent of Hawai'i's total coffee output. Technology and defense also play important roles in the island's economy (Kaua'i Chamber of Commerce, 2020).

2.3 HAZARDS TO BE MITIGATED

2.3.1 Major Past Hazard Events

Presidential disaster declarations are typically issued for hazard events that cause more damage than state and local governments can respond to and recover from without assistance from the federal government, although no specific dollar loss threshold has been established for these declarations. A presidential disaster declaration puts federal response and recovery programs into motion to help disaster victims, businesses and public entities. Some of the programs are matched by state programs. Kaua'i County has experienced 20 events since 1955 for which presidential disaster declarations were issued. These events, taken from FEMA records, are listed in Table 2-1.

Table 2-1. Presidential Disaster Declarations for Hazard Events in Kaua'i County

Type of Event	Declaration #	Declaration Date
Tidal Wave[a]	DR-71	3/16/1957
Hurricane Dot[a]	DR-94	8/16/1959
Tidal Waves[a]	DR-101	5/25/1960
Heavy Rains and Flooding[a]	DR-152	4/24/1963
Heavy Rains and Flooding	DR-433	5/7/1974
Hurricane 'Iwa	DR-671	11/27/1982
Hurricane Iniki	DR-961	9/12/1992
Severe Storms, Flooding, Landslides, and Mudslides	DR-1640	5/2/2006
Severe Storms, High Surf, Flooding, and Mudslides	DR-1743	02/6/2008
Severe Storms and Flooding	DR-1814	1/5/2009
Severe Storms, Flooding, and Landslides	DR-4062	4/18/2012
Severe Storms, Flooding, Landslides, and Mudslides	DR-4365	5/8/2018
Hurricane Lane	DR-4395	9/27/2019
COVID-19 Pandemic	DR-4510	4/1/2020
Severe Storms and Flooding	DR-4549	7/9/2020

a. Prior to 1964, federal disaster declarations were not issued specific to counties; pre-1964 declarations listed in this table are for the entire state of Hawai'i, not Kaua'i County specifically

Source: fema.gov/disasters

Review of these events helps identify targets for risk reduction and ways to increase a community's capability to avoid large-scale events in the future. Still, many natural hazard events do not trigger federal disaster declaration protocol but have significant impacts on Kaua'i County's communities. These non-declared events are also important to consider in establishing recurrence intervals for hazards of concern.

2.3.2 Identifying and Ranking Hazards of Concern

For this plan, the Steering Committee considered the full range of natural hazards that could impact the planning area and then listed hazards that present the greatest concern. The process incorporated review of state and local hazard planning documents, as well as information on the frequency, magnitude and costs associated with hazards that have impacted or could impact the planning area. Anecdotal information regarding natural hazards and the perceived vulnerability of the planning area's assets to them was also used. Based on the review, this plan addresses 10 identified hazards of concern. Part 2 of this hazard mitigation plan presents risk assessments for the hazards of concern in order of risk (highest to lowest). In addition, a qualitative review, short of a full risk assessment, was conducted for health-related hazards. This qualitative overview is presented in Appendix E.

The risk assessments provided data that was used to rank the hazards based on probability of occurrence and potential impacts. The ranking methodology is described in Appendix F. Based on that methodology, the identified hazards of concern were assigned risk scores and categories as shown in Table 2-2.

Table 2-2. Hazard Risk Ranking

Risk Category	Hazard Event	Risk Score
High	Tropical Cyclone and Other High Winds	54
High	Wildfire	54
High	Climate Change	45
High	Inland Flood	33
High	High Surf, Coastal Flood and Erosion	33
Medium	Tsunami	22
Medium	Landslide	18
Low	Dam Failure	6
Low	Earthquake	6

2.4 PHYSICAL SETTING

The Hawaiian archipelago consists of 132 volcanic islands, atolls, reef, and shoals in the North Pacific Ocean. Although the Hawaiian Islands were all formed by volcanic eruptions, only the islands of Hawai'i and Maui still have active volcanoes.

2.4.1 Geology and Topography

In the center of the island of Kaua'i are Kawaikini Peak, rising 5,170 feet, and Mount Wai'ale'ale, rising 5,080 feet. Mount Wai'ale'ale is one of the rainiest spots on earth, with an average of 460 inches of rain a year. Many streams flow from these mountains to the sea through canyons in the volcanic rock. Waimea canyon has colorful rock walls that are 2,857 feet high. The Waimea River, at 20 miles, is the longest river in the state. The Wailua River is the state's only navigable waterway. Rugged cliffs along the northwestern coast make it impossible to build a road around the whole island. Along its 90 miles of shoreline, Kaua'i has more beaches per mile than any other island in the Hawaiian chain. Ni'ihau is a private island owned by the Robinson family of Kaua'i. It is the eroded remnant of a shield volcano. Ni'ihau is semi-arid with a dry climate, although several lakes provide fresh water (Smithsonian, 2013; County of Kaua'i, 2015; Summit Pacific, 2017).

2.4.2 Climate

Kauaʻi's climate is tropical, with generally humid and stable conditions year-round, although weather phenomena and infrequent storms have caused instances of extreme weather. An average of less than 20 inches of precipitation falls on the leeward side of the island, and up to 460 inches at Mount Waiʻaleʻale. Summertime high temperatures in Līhuʻe can range from 78 to 85 ºF, while the upper elevations of Kōkeʻe State Park can drop into the 30s and 40s (Wikipedia, 2020a). Niʻihau is relatively arid because it lies in the rain shadow of Kauaʻi and lacks the elevation needed to catch significant amounts of trade wind rainfall. It depends on winter Kona storms for rain, when more northerly weather systems intrude into the region. Therefore, Niʻihau is subject to long periods of drought (Wikipedia, 2020b)

The tropical conditions of the eastern Pacific—warm ocean water near the equator combined with cyclonic spin—are ideal for hurricane formation. Because of its western location in the state, Kauaʻi has a slightly lower probability of tropical cyclone landfall, but devastating events have occurred.

Table 2-3 summarizes normal monthly climate data at National Centers for Environmental Information (NCEI) weather stations across the planning area.

Table 2-3. Normal Monthly Kauaʻi County Precipitation and Temperatures

	Precipitation	Temperature (ºF)		
	(inches)	Minimum	Average	Maximum
Weather Station: Līhuʻe Weather Service Office Airport 1020.1, 1990-2019	2.77	70.2	76.0	81.7
Weather Station: Kōloa 936, 2010-2019	3.82	N/A	N/A	N/A
Weather Station: Waimea 947, 2010-2017	2.95	64.0	73.6	83.5
Weather Station: Princeville Ranch 1117, 2017-2019	6.48	65.3	72.3	79.3

2.5 SENSITIVE RESOURCES

2.5.1 Culturally Sensitive Resources

The Heritage Resources subsection of *Kauaʻi Kākou—Kauaʻi County General Plan* provides the following overview of heritage resources in the county (County of Kauaʻi, 2018):

> *Throughout Kauaʻi there is an abundance of archaeological, cultural, historic, and scenic resources. Together these resources document Kauaʻi's storied past, cultivate a unique sense of place, and educate new generations about their history.*
>
> *Historic buildings and structures are critical to preserving Kauaʻi's unique history, town character, and sense of place. It is our kuleana to ensure that each community's treasured structures are preserved and celebrated.*
>
> *Wahi Pana and the resources that support cultural practices are the foundation of Kauaʻi's identity. Culturally significant places and sites, once destroyed, cannot be replaced. These places and the stories behind them provide vital insight to how the ancient Hawaiians lived in harmony with the land and managed the use of natural resources in a sustainable manner.*

2.5.2 Beaches

While Kauaʻi has only 12 percent of the state's coastline, it has more than one-third of its beach sand, including the longest stretch of beach in Hawaiʻi. These beaches are heavily used and treasured by residents and visitors and

are a significant attraction for the tourism economy. However, approximately 70 percent of Kaua'i's beaches are eroding and Kaua'i has lost an estimated 4 miles of beach over the past century (Anderson et al., 2015). Although erosion is a naturally occurring force, the human contribution to beach erosion includes coastal development and coastal armoring, which exacerbate sand loss and the narrowing of beaches. Such structures cover approximately 10 percent of the shoreline. Sea level rise, which is accelerating worldwide due to global warming, is another human contribution to beach erosion (County of Kaua'i, 2018).

2.5.3 Forests

Kaua'i's upper watershed and its forests are critical to the health and integrity of the ecosystem. They provide the essential services of water quality protection, flood mitigation, and fire protection. These forests include the vestiges of Kaua'i's native forests and landscapes, which are the habitat for many endangered and at-risk species. The upper forests, which make up 50 percent of Kaua'i's land area, harbor rare and endangered plant and animal species, and include native ecosystems that are relatively intact. They have to date survived the fate of native lowland forests—destruction by invasive species, wildfires, and incompatible uses by humans (County of Kaua'i, 2018).

2.5.4 Freshwater Resources

Water is a public trust resource in Hawai'i. The rainclouds captured by Kaua'i's lofty peaks, such as Wai'ale'ale and Kawaikini, supply perennial streams and restore the island's underground aquifer. Kaua'i's aquifer supplies the vast majority of domestic water and is divided into three sectors that include 13 systems. Total well production on Kaua'i was 14.37 million gallons per day in 2014, compared to an estimated sustainable yield of 312 million gallons per day. On a remote island, there are no practical substitutes for groundwater as the primary source of domestic water. Kaua'i's aquifer depends on continual recharge by seepage of rainfall and stream water through permeable ground surfaces. The quality and quantity of Kaua'i's groundwater relies upon having a healthy watershed.

Kaua'i has 30 perennial streams (streams that consistently flow year round). Of these, 21 (70 percent) were impaired in 2014 according to the *State of Hawai'i Water Quality Monitoring and Assessment Report*. Historically, these streams provided pristine habitat for communities of native fish (o'opu), insects, and snails, but stream diversions and introduced species, such as guppies and swordtail, have led to the decline of many native species. Kaua'i's drainage system is mostly natural—consisting of its streams and rivers. This system is augmented by structures such as irrigation ditch systems and flood protection levees along certain streams. Due to development in the mid-watershed, poor land use practices, and natural sources, polluted runoff flows to drainage systems and ends up impairing streams and nearshore coastal waters (County of Kaua'i, 2018).

2.5.5 Scenic Resources

Kaua'i County features a broad range of scenic resources, including the coastline and Pacific Ocean, sand dunes, coral reefs, jagged mountains, deep canyons, rolling grasslands, native forests, heavily vegetated valleys, rivers and waterfalls, agricultural features, and distinctive rural communities. The island is home to flora, fauna and ecological communities that can be found nowhere else in the world. These natural resources face pressure from development, invasive species, natural hazards and climate change.

- **Coastal Views—** Kaua'i County's varied. extensive coastline offers a wide range of scenic vistas from roads and highways, and from beaches, county and state parks, coastal access points and heritage trails.
- **Forests—**Forestlands define much of the landscape of Kaua'i County. Nine State Forest Reserves are all significant protected forests in the county (Hawai'i Division of Forestry and Wildlife, 2020). Forestland is abundant well beyond these protected areas. The scenic value of these natural resources, viewed from within or from outside, is of great importance.

- **Scenic Roadways and Multi-use Paths—**Many roads and paths in Kauaʻi County have unique scenic qualities because of their natural setting. The federally recognized Holo Holo Kōloa Scenic Byway runs through Kōloa in South Kauaʻi (County of Kauaʻi, 2018). The Ke Ala Hele Makalae multi-use path follows the eastern shoreline and will eventually be lengthened to about 17 miles (kauai.com, 2020).

2.5.6 Endangered Species

The federal list of endangered species includes 48 species on the island of Kauaʻi—45 plant species and 3 animal species (U.S. Fish and Wildlife Service, 2012). These resources are an integral part of the economy, sense of place, and traditional culture of the island. They are impacted by natural hazards and can influence the way that hazards impact the built environment.

2.6 DEVELOPMENT PROFILE

In order to accurately evaluate ways to protect people and property from the potential impacts of natural and other hazards, hazard mitigation requires an understanding of how development has been spread across the planning area and how it is likely to change in the future. Appendix G provides a detailed review of planning area development. The key findings of the review are as follows:

- **Current state land use designations**—Hawaiʻi's State Land Use Commission defines four land use districts. The distribution of these districts in Kauaʻi County is shown in Table 2-4.
- **Current county land use designations**—Table 2-5 and Figure 2-2 summarize the area and location of current county-defined land uses in Kauaʻi County. More than 60 percent of the county's land area is designated as natural land, and nearly 28 percent (98,917 acres) is presently being used for agriculture.
- **Building counts, uses, and value**—Based on County tax parcel data, there are 34,695 buildings in the county, with an estimated total replacement value (for the building structure and contents) is $20.4 billion. Residential buildings make up 94 percent of the total.
- **Critical facilities**— Critical facilities are those that are essential to the health and welfare of the population. For this plan, the Steering Committee defined critical facilities as structures and infrastructure from which essential services and functions for victim survival, continuation of public safety actions, and disaster recovery are performed or provided. Table 2-6 summarizes the number of critical facilities by category. General locations of critical facilities and infrastructure in the planning area are shown in Figure 2-3 and Figure 2-4.

The development review also identified likely future trends in development, as follows:

- The County is expected to grow by an average of 1 percent each year to a population of 88,013 by 2035. Seniors will make up 20 percent of the population by 2035, compared to only 10 percent in 2015.
- According to the General Plan estimates, the rate of job growth is expected to be less than population growth, with an average annual growth rate of 0.66 percent between 2020 and 2030. However, this rate will likely change due to economic impacts from COVID-19.
- Housing units are forecasted to increase proportionally with the population at a rate of about 1.2 percent per year. Growth rates are expected to vary considerable by planning district. The Līhuʻe Planning District is likely to see a larger increase than other districts, with 47 percent of total growth between 2010-2035, followed by South Kauaʻi at 26 percent of total growth. Other planning districts are expected to grow more slowly, with a total growth of 13 percent in East Kauaʻi, 8 percent in Hanapēpē-ʻEleʻele, 4 percent in Waimea-Kekaha, and 2 percent in the North Shore.
- Visitor arrivals are projected to have an overall growth rate of 1 percent per year to 2035, with significant ups and downs based on the historical pattern of some form of disrupting event in the visitor industry every five to ten years. COVID-19 has proved to be one of those disrupting events.

Table 2-4. State-Designated Land Use in the Planning Area

Land Use District	Description	Area (acres)	% of Total County Land Areas
Urban	Lands in urban use with sufficient reserve to accommodate foreseeable growth	14,865	4.2%
Rural	Small farms mixed with low-density residential lots that have a minimum lot size of one-half acre	1,374	0.4%
Agriculture	Lands with capacity for intensive cultivation and minimum lot size of 1 acre	144,317	40.6%
Conservation	Lands in forest and water reserve zones	194,459	54.8%
Total		**355,015**	**100**

Source: Hawai'i Office of Planning, 2013

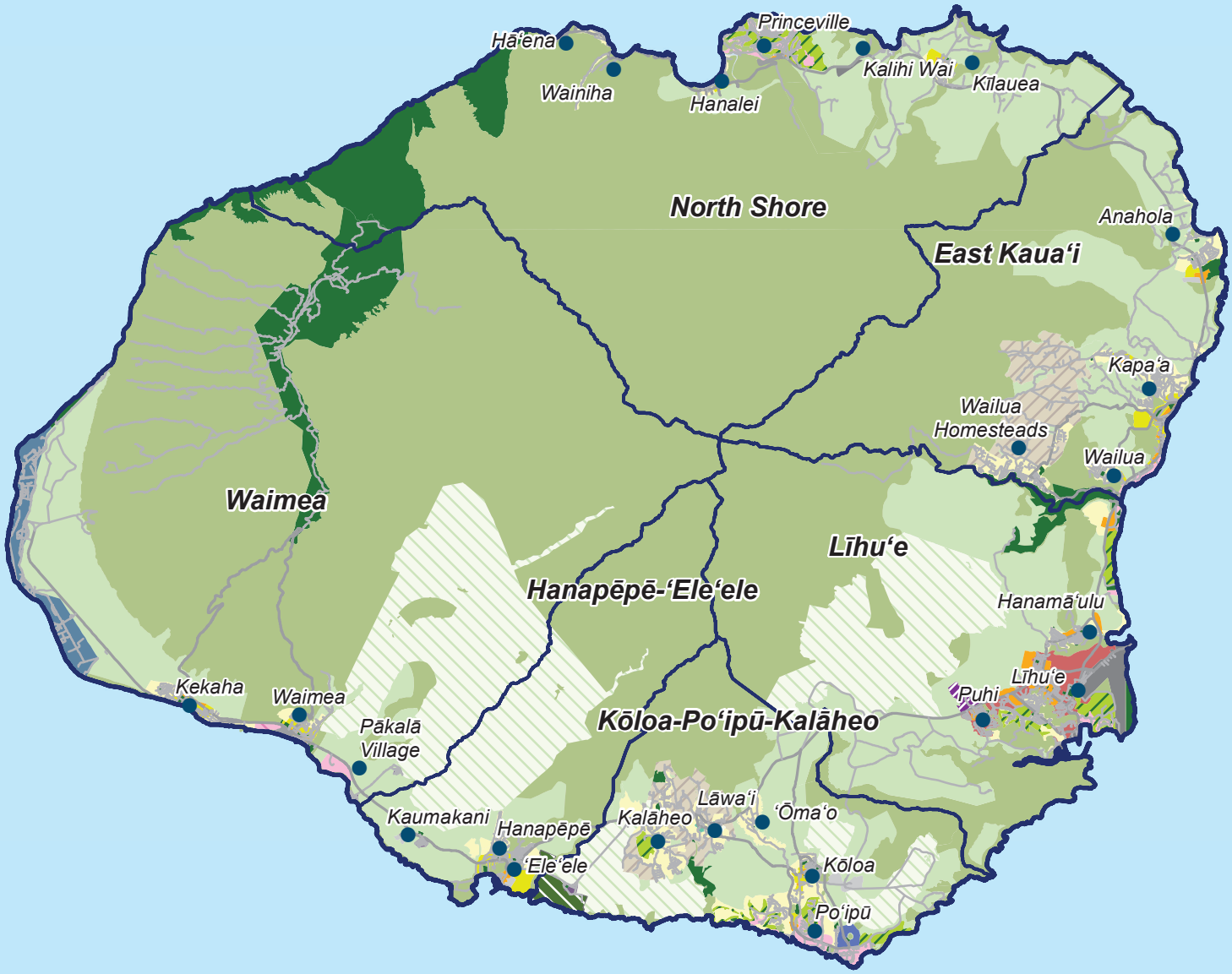
Table 2-5. County-Designated Land Use in the Planning Area

Land Use Category	Designated Area (acres)	Land Use Category	Designated Area (acres)
Agricultural	61,627	**Parks and Recreation**	14,882
Agricultural (IAL)	36,720	**Plantation Camp**	168
Golf Course	2,197	**Provisional Agriculture**[a]	570
Homestead	5,271	**Provisional Resort**[a]	94
Industrial	255	**Residential Community**	7,947
Large Town	177	**Resort**	1,833
Military	2,039	**Small Town**	18
Natural	215,414	**Transportation**	1,027
Neighborhood Center	1,156	**University Zone**	241
Neighborhood General	1,771	**Urban Center**	1,601
		Total	**355,010**

a. Areas reflect December 2020 amendment to the General Plan
Source: 2018 Kaua'i County General Plan

Table 2-6. Kaua'i County Critical Facilities

Type	Number	Type	Number
Safety & Security	100	**Communications**	17
Food, Water & Sheltering	565	**Transportation**	67
Health & Medical	30	**Hazardous Materials**	6
Energy	13	**Total**	798



Land Use Classifications in the Planning Area

- Agricultural
- Agricultural (IAL)
- Golf Course
- Homestead
- Industrial
- Large Town
- Military
- Natural
- Neighborhood Center
- Neighborhood General
- Parks and Recreation
- Plantation Camp
- Provisional Agriculture
- Provisional Resort
- Residential Community
- Resort
- Small Town
- Transportation
- University Zone
- Urban Center
- District Boundary

0 2.5 5 Miles

Figure 2-2.
Land Use Classifications in the Planning Area

Final draft will reflect December 2020 amendment to the General Plan

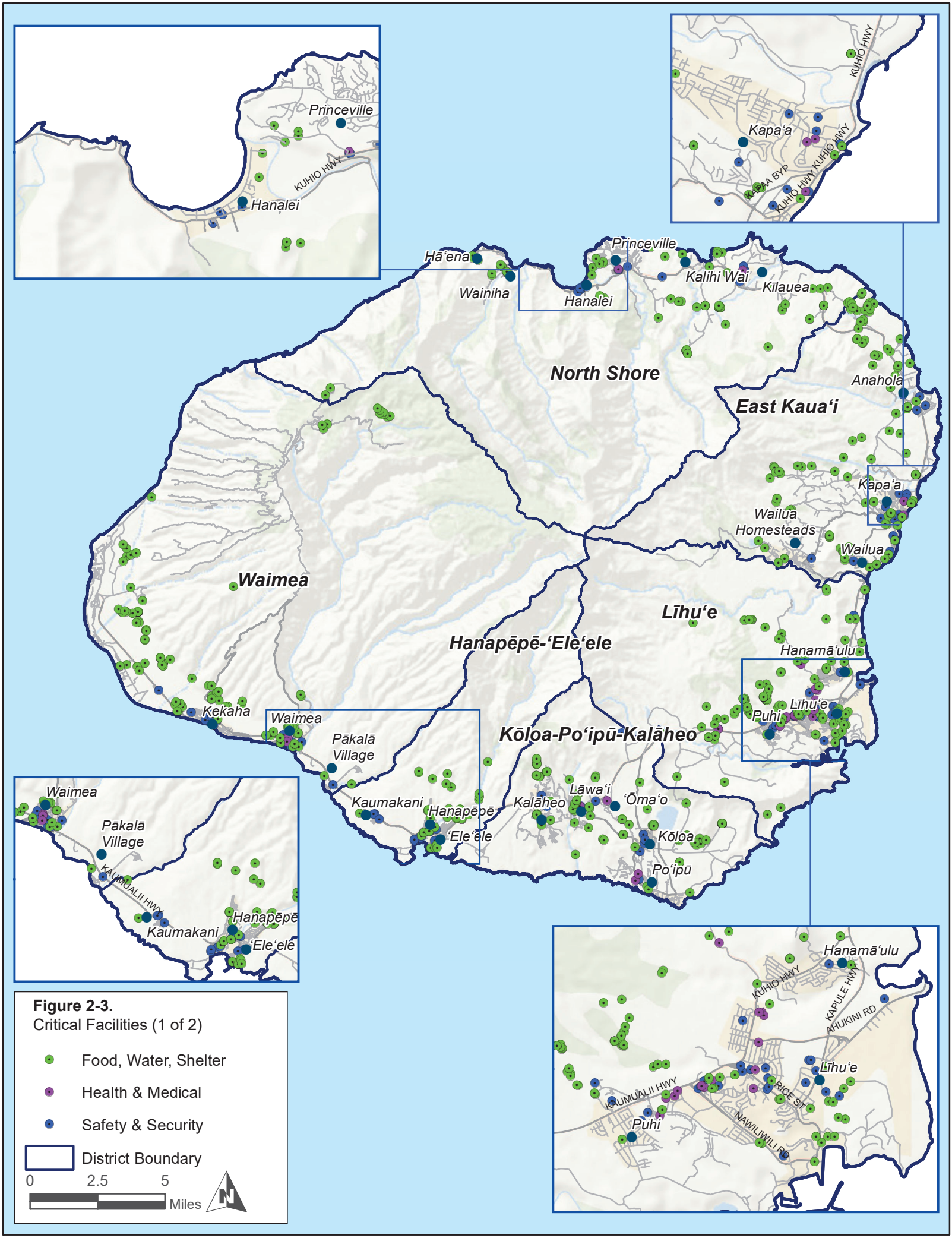


Figure 2-3.
Critical Facilities (1 of 2)

- Food, Water, Shelter
- Health & Medical
- Safety & Security
- District Boundary

0 2.5 5 Miles

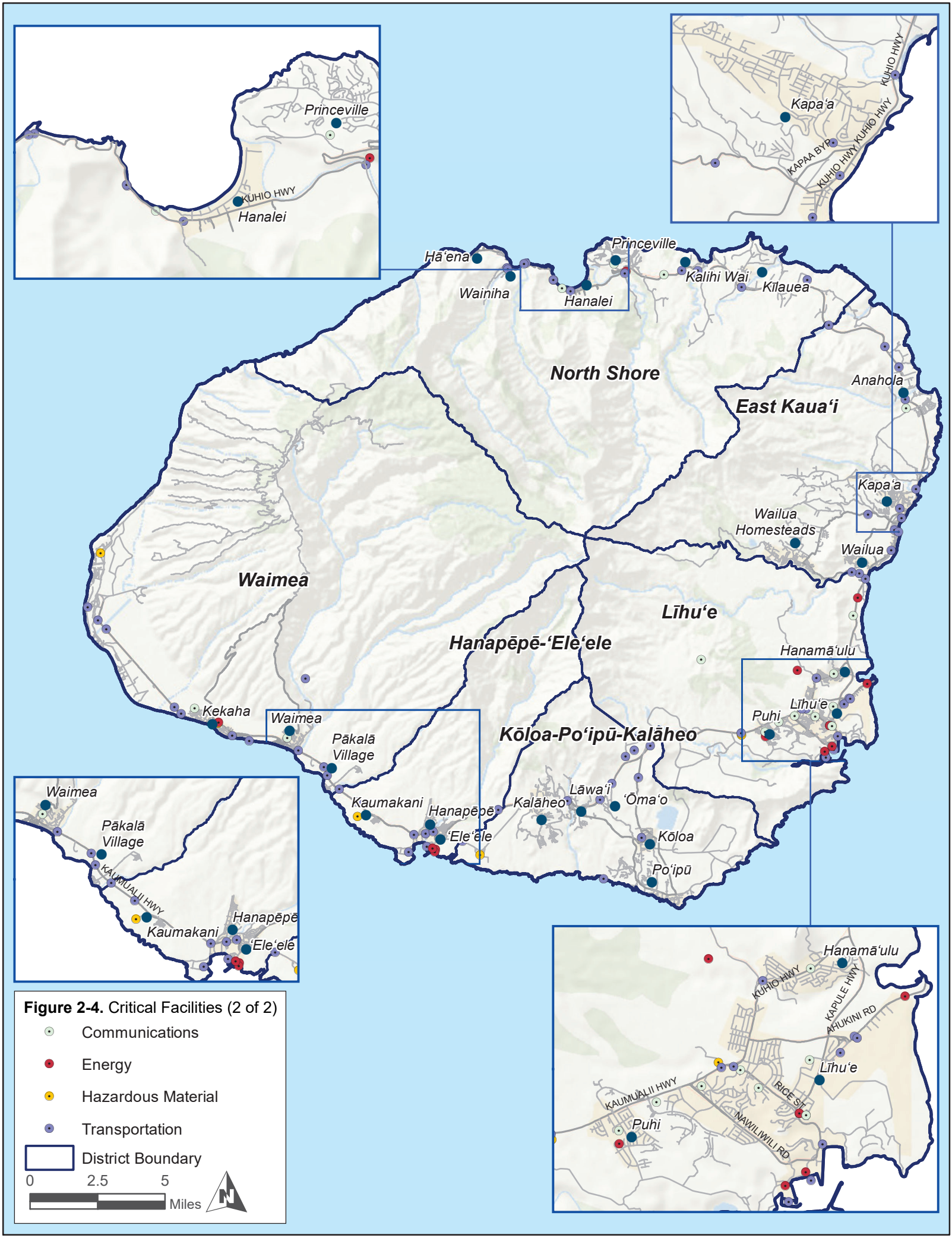


Figure 2-4. Critical Facilities (2 of 2)

- Communications
- Energy
- Hazardous Material
- Transportation
- District Boundary

0 2.5 5 Miles

2.7 DEMOGRAPHICS

Knowledge of the composition of the population and how it has changed in the past and how it may change in the future is needed for making informed decisions about hazard mitigation. Information about population is a critical part of planning because it directly relates to land needs such as housing, industry, stores, public facilities and services, and transportation. The U.S. Census Bureau estimates the County's total resident population at 72,293 as of July 2019. The average growth rate since 1980, for Kaua'i County and for the state, is shown on Figure 2-5. The 2018 Kaua'i County General Plan projects a population of 88,013 by 2035.

COUNTY POPULATION CHARACTERISTICS

The following are significant demographic characteristics of the County's current population:

- 20.1 percent of the County's population is 65 or older, higher than the state average of 18.4 percent.
- 32.2 percent of the over-65 population has disabilities of some kind.
- 6.7 percent of the over-65 population has income below the poverty line.
- 18.4 percent of the population is 14 or younger, about the same as the state average of 18.1 percent.
- Children under the age of 18 account for 21.6 percent of individuals who are below the poverty line.
- The racial composition of the County is predominantly Asian, at about 34 percent, and white, at about 33 percent.
- The largest minority populations are Hispanic or Latino, at nearly 11 percent, and Native Hawaiian or other Pacific Islander, at 9 percent.
- The planning area has a 17.3 percent foreign-born population.
- Other than English, the most commonly spoken languages in the planning area are Asian and Pacific Island languages.
- Persons with disabilities or with access and functional needs make up 9.9 percent of the total civilian non-institutionalized population.

Source: Hawai'i Department of Business, Economic Development & Tourism

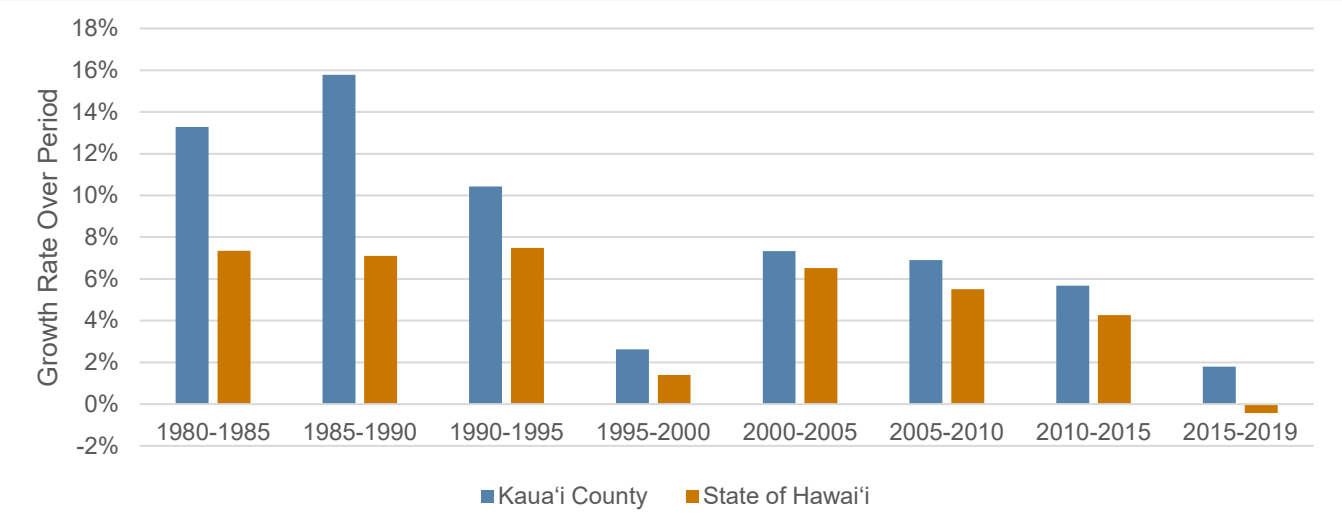


Figure 2-5. State of Hawai'i and Kaua'i County Population Growth

Some populations are at greater risk from hazard events because of decreased resources or physical abilities. People living near or below the poverty line, the elderly, individuals with disabilities, women, children, ethnic minorities, and renters all experience, to some degree, more severe effects from disasters than the general population. These vulnerable populations may vary from the general population in risk perception, living conditions, access to information before, during and after a hazard event, capabilities during an event, and access to resources for post-disaster recovery. Indicators of vulnerability—such as disability, age, poverty, and minority race and ethnicity—often overlap spatially and often in the geographically most vulnerable locations. The 2018 Kaua'i County General Plan identified "priority equity areas" with high populations of vulnerable and marginalized communities, as well as Census-designated places with high percentages of minority households and households experiencing poverty (see Figure 2-6).

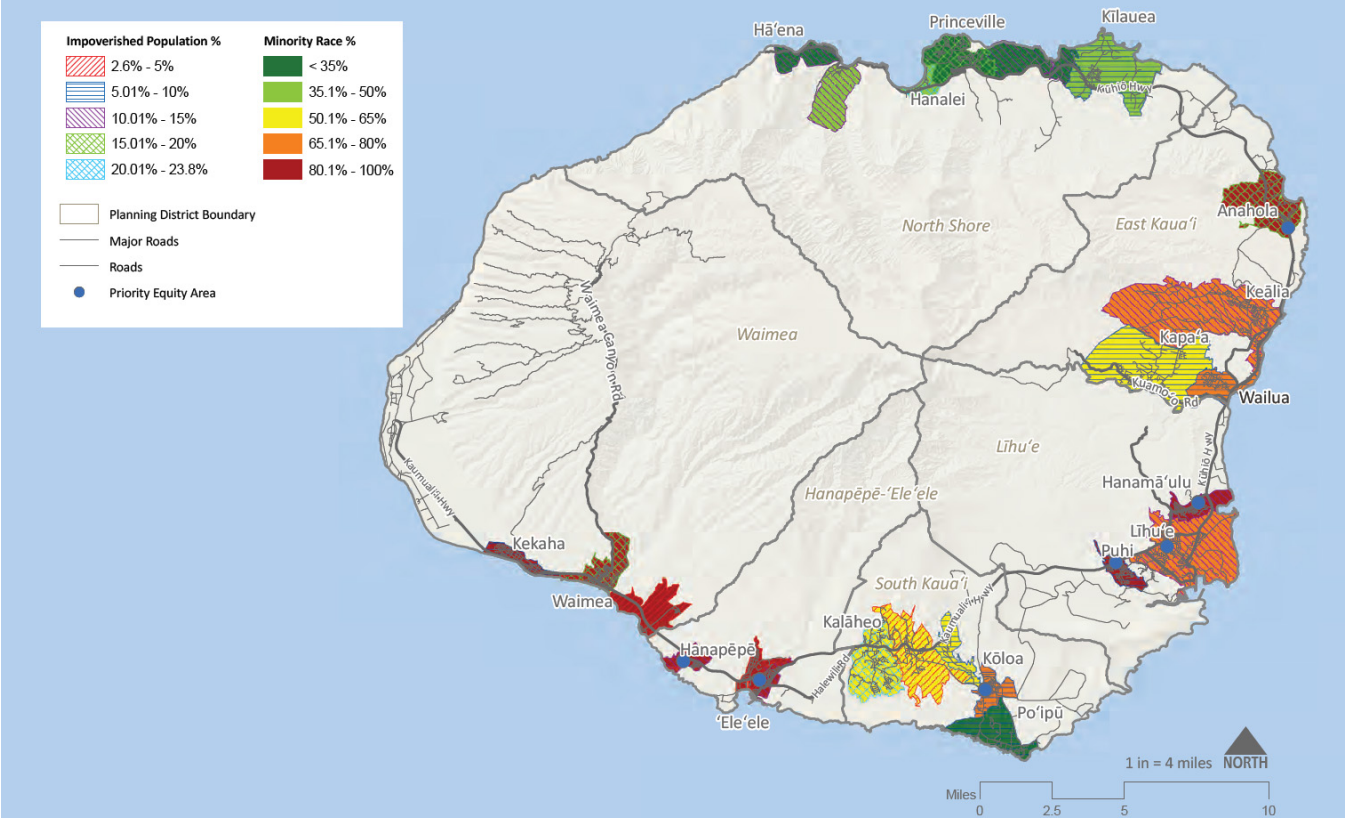


Figure 2-6. Kaua'i County Social Equity Map

Detailed demographic data for the planning area is provided in Appendix H.

2.8 ECONOMY

Kaua'i County is dependent on off-island sources for energy, food, construction materials, and common daily goods. The local community has expressed a desire for the County's agricultural economy to be more self-reliant (State of Hawai'i, 2012). This would include expanding agriculture, aquaculture, manufacturing, and renewable-energy sectors. By working toward self-sufficiency, Kaua'i County's economy could diversify and offer additional opportunities for employment and income (TakePart, 2015). The County of Kaua'i Office of Economic Development works in partnership with the community to create economic opportunities for balanced growth in the county (County of Kaua'i, 2020).

Over the long-term, the County has a projected annual job growth rate of 1.12 percent. Tourism has made up 30 percent of all employment, but current growth projections in this sector are unknown as this plan is being updated during the COVID-19 pandemic.

COUNTY ECONOMIC CHARACTERISTICS

The following are significant economic characteristics of the County as of 2018:

- Median household income was $78,482 in 2018
- 6.3 percent of all families and 19.7 percent of individuals had income that fell below the poverty line
- Based on U.S. Census data, the County's economy is strongly based in the accommodation and food service sector, followed by the health care and social assistance industry. Food and agriculture, sustainable technologies, sport and recreation, and arts and culture follow in number of private sector jobs.
- Service occupations, management/business/science/arts occupations, and sales/office occupations make up 31 percent, 28 percent and 21 percent of the jobs in the planning area, respectively.
- Hawai'i state data lists 15 employers in Kaua'i County with 250 or more employees as of July 2017.
- 66 percent of the County's population 16 and older is in the labor force.
- Since 2010, Kaua'i County's unemployment rate was highest in 2010, at 8.6 percent, dropped to a low of 2.4 percent in 2017, and then rose to 2.7 percent, in 2019.

Despite the projected job growth, the high cost of living in the County offsets economic opportunity. Kaua'i's median household income is typically less than the state average, so many residents work multiple jobs, supplement income with homegrown food or cottage industries, and have long work commutes from neighborhoods with affordable housing (County of Kaua'i, 2018).

Detailed economic data for the planning area is provided in Appendix I.

3. REGULATIONS AND PROGRAMS

Existing laws, ordinances and plans at the federal, state and local level can support or impact hazard mitigation initiatives identified in this plan. Hazard mitigation plans are required to include a review and incorporation, if appropriate, of existing plans, studies, reports, and technical information as part of the planning process. Pertinent federal, state, and local laws are described below.

3.1 RELEVANT AGENCIES, PROGRAMS AND REGULATIONS

Local, state and federal regulations and programs that need to be considered in hazard mitigation are constantly evolving. For this plan, a review was performed to determined which regulations and programs are currently most relevant to hazard mitigation planning. The findings are summarized in Table 3-1 through Table 3-3. Short descriptions of each program are provided in Appendix J.

Table 3-1. Summary of Relevant Local Programs and Regulations

Agency, Program or Regulation	Relevance
Kauaʻi Kākou—Kauaʻi County General Plan	The hazard mitigation plan will work together with programs established under the General Plan to support wise land use with vital information on the risk associated with natural hazards in the planning area.
Community Plans	Community plans serve as a forum for community input into land-use, delivery of government services, and any other matters relating to the planning area.
Kauaʻi County Code	The County Code establishes existing County capabilities and restrictions than can impact implementation of hazard mitigation actions.
Zoning Code	The zoning code draws upon information regarding location-specific hazards to establish guidelines for wise land use in the county.
Kauaʻi County Capital Improvement Program	The 2018 Kauaʻi County General Plan calls for hazard mitigation projects to be prioritized in the County's capital improvement program.

Table 3-2. Summary of Relevant State Agencies, Programs and Regulations

Agency, Program or Regulation	Relevance
Hawaiʻi Coastal Zone Management Program	Mitigation actions need to conform to the goals and policies of this plan
Hawaiʻi Hazards Awareness and Resilience Program	Provides a resource for hazard education measures
Hawaiʻi State Plan	Mitigation actions need to conform to the goals and policies of this plan
Hawaiʻi State Grants-in-Aid Capital Improvement Projects Program	This program provides a potential source of funding for implementing mitigation actions
Ocean Resources Management Plan	Mitigation actions need to conform to the goals and policies of this plan
State Building Code and Design Standards	Mitigation actions need to comply with all state building code requirements
State General Flood Control Plan	Mitigation actions need to conform to the goals and policies of this plan
State of Hawaiʻi Hazard Mitigation Plan	The state hazard mitigation plan provides information that is useful in developing local hazard mitigation plans
State of Hawaiʻi Land Use Law	Mitigation actions need to comply with all state land use requirements

Table 3-3. Summary of Relevant Federal Agencies, Programs and Regulations

Agency, Program or Regulation	Relevance
Americans with Disabilities Act	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Bureau of Land Management	The Bureau funds and coordinates wildfire management programs and structural fire management and prevention on BLM lands.
Civil Rights Act of 1964	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Clean Water Act	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Community Development Block Grant Disaster Resilience Program	This is a potential alternative source of funding for actions identified in this plan.
Community Rating System	This voluntary program encourages floodplain management activities that exceed the minimum National Flood Insurance Program requirements.
Disaster Mitigation Act	This is the current federal legislation addressing hazard mitigation planning.
Emergency Relief for Federally Owned Roads Program	This is a possible funding source for actions identified in this plan.
Emergency Watershed Program	This is a possible funding source for actions identified in this plan.
Endangered Species Act	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
Federal Energy Regulatory Commission Dam Safety Program	This program cooperates with a large number of federal and state agencies to ensure and promote dam safety.
Federal Wildfire Management Policy and Healthy Forests Restoration Act	These documents mandate community-based collaboration to reduce risks from wildfire.
Hazard Mitigation Assistance Grant Programs	These programs are potential sources of funding for the implementation of mitigation actions recommended in this plan
National Dam Safety Act	This act requires a periodic engineering analysis of most dams in the country
National Environmental Policy Act	FEMA hazard mitigation project grant applications require full compliance with applicable federal acts.
National Fire Plan (2001)	This plan calls for joint risk reduction planning and implementation by federal, state and local agencies.
National Flood Insurance Program	This program makes federally backed flood insurance available to property owners in exchange for communities enacting floodplain regulations
National Incident Management System	Adoption of this system for government, nongovernmental organizations, and the private sector to work together to manage incidents involving hazards is a prerequisite for federal preparedness grants and awards
Presidential Executive Order 11988, Floodplain Management	This order requires federal agencies to avoid long and short-term adverse impacts associated with modification of floodplains
Presidential Executive Order 11990 (Protection of Wetlands)	FEMA hazard mitigation project grant applications require full compliance with applicable presidential executive orders.
U.S. Army Corps of Engineers Dam Safety Program	This program is responsible for safety inspections of dams that meet size and storage limitations specified in the National Dam Safety Act.
U.S. Army Corps of Engineers Flood Hazard Management	The Corps of Engineers offers multiple funding and technical assistance programs available for flood hazard mitigation actions
U.S. Fire Administration	This agency provides leadership, advocacy, coordination, and support for fire agencies and organizations.
U.S. Fish and Wildlife Service	This service's fire management strategy employs prescribed fire throughout the National Wildlife Refuge System to maintain ecological communities.

3.2 CAPABILITY ASSESSMENT

The Core Planning Team performed an inventory and analysis of existing authorities and capabilities called a "capability assessment." A capability assessment creates an inventory of a jurisdiction's mission, programs and policies, and evaluates its capacity to carry them out. This assessment identifies potential gaps in the jurisdiction's capabilities. The full evaluation is provided in Appendix K. Table 3-4 summarizes key findings.

Table 3-4. Summary of Capability Assessment Findings

Category	Description	Key Findings
Legal and Regulatory	Jurisdictions have the ability to develop policies and programs and to implement rules and regulations to communities from natural hazards. Local policies are typically identified in community plans, implemented via local ordinance, and enforced by a government body.	Local capability is available for 20 out of 29 common capabilities assessed. Capabilities not available or unsure if available include: • Stormwater Management • Post-Disaster Recovery • Real Estate Disclosure • Floodplain or Watershed Plan • Stormwater Plan Master Plan • Urban Water Management Plan • Habitat Conservation Plan • Shoreline Management Plan • Community Wildfire Protection Plan
Development and Permitting	Jurisdictions regulate land use through zoning, subdivision and land development ordinances, building codes, building permit ordinances, and floodplain and stormwater management ordinances. These regulations can lead to hazard mitigation.	Local capability is available for all three common capabilities assessed, including a buildable lands inventory
Fiscal	Assessing a jurisdiction's fiscal capability provides an understanding of the ability to fulfill the financial needs associated with hazard mitigation projects.	Local capability is available for seven out of 11 common capabilities assessed. Capabilities not available include: • Private activity bonds • Withholding of public expenditures in hazard areas • Development impact fees • Land banking
Administrative and Technical	Administrative and technical capabilities focus on the availability of personnel to implement hazard mitigation.	Local capability is available for seven out of nine common capabilities assessed. Capabilities not available include: • Surveyors • Grant writers
National Flood Insurance Program Compliance	Community participation in the National Flood Insurance Program (NFIP) creates opportunity for additional grant funding associated with flooding. Assessment of current NFIP status and compliance provides an understanding of the local flood management program and available grant funding.	• Floodplain management program exceeds requirements • No outstanding compliance violations • Current flood maps are adequate • Training needed for new floodplain management staff
Public Outreach	Regular outreach on issues regarding hazard mitigation provides an opportunity to directly interface with community members. Assessing outreach capability opens a two-way dialogue that can result in a more resilient community through education and public engagement.	Local capability is available for all seven common capabilities assessed.

Category	Description	Key Findings
Participation in Other Programs	Other programs, such as the Community Rating System, StormReady/TsunamiReady, and Firewise USA, can enhance a jurisdiction's ability to mitigate, prepare for, and respond to natural hazards. These programs indicate a jurisdiction's desire to go beyond minimum requirements set forth by local, state and federal regulations in order to save lives and minimize the impact of natural hazards on a community.	Current participation in two of five common programs assessed. No participation in: • Community Rating System • Building Code Effectiveness Grading Schedule • Public Protection
Adaptive Capacity	All core capabilities must be fully adaptable to meet local needs. Every code can be amended, and every plan can be updated. Such adaptability is itself considered to be an overarching capability. An adaptive capacity assessment evaluates the ability to anticipate impacts from future conditions. By looking at public support, technical adaptive capacity, and other factors, jurisdictions identify their core capability for resilience against future changes.	Medium or high adaptive capacity rating for 11 of 18 common criteria assessed. Capacity low or unsure for: • Three technical criteria • Two implementation criteria • Two public criteria
Integration of Hazard Mitigation with Other Programs	For hazard mitigation planning, "integration" means that hazard mitigation information is used in other relevant planning mechanisms, such as general planning and capital facilities planning, and that relevant information from those sources is used in hazard mitigation. This part of the assessment identifies where such integration is already in place, and where there are opportunities for further integration in the future.	Hazard mitigation information currently integrated into General Plan, North Shore Plan, and West-Side Vulnerability Assessment. Potential for future integration into climate change adaptation plan and other community vulnerability assessments.

Part 2. RISK ASSESSMENT

4. TROPICAL CYCLONE AND OTHER HIGH WINDS

Three types of high winds affect the County of Kaua'i:

- **Trade winds**—Trade winds are the most common winds over Hawaiian waters, blowing 70 percent of the time from the northeast or east-northeast and generally ranging from 10 to 25 miles per hour. Occasional extreme events reach 40 to 50 miles per hour when a sub-tropical high-pressure cell north of the islands intensifies. Trade winds occur up to 90 percent of the time in summer (June through August) and 50 percent of the time in winter (December through January).
- **Kona winds**—Kona winds are rain-bearing winds that blow over the islands from the southwest or south-southwest. The western sides of the islands become windward during Kona winds, as the trade wind pattern is reversed. Kona winds are light and variable during winter when trade wind circulation diminishes, but strong, generally southerly, winds when storm systems move across Hawaiian waters. Strong Kona winds are most likely when a system with an unusually low pressure is within 500 miles northwest of the islands. Kona storms move erratically with a slow tendency toward the west.
- **Tropical cyclones—**The Central Pacific experiences four to five tropical cyclones most years, usually between June 1 and November 30. In the United States, forecast centers classify tropical cyclones according to their maximum sustained winds (measured over one minute or more) as listed in Table 4-1.

Table 4-1. Tropical Cyclone Classification Based on Wind Speed

Storm Classification	Maximum Sustained Wind Speed	Storm Classification	Maximum Sustained Wind Speed
Tropical Depression	< 39 miles per hour (mph)	**Category 3 Hurricane**	111 – 129 mph
Tropical Storm	39 – 73 mph	**Category 4 Hurricane**	130 – 156 mph
Category 1 Hurricane	74 – 95 mph	**Category 5 Hurricane**	> 156 mph
Category 2 Hurricane	96 – 110 mph		

Wind pressure, not wind speed, is the primary cause of damage. There are three types of wind pressure:

- Positive pressure (wind pushing inward against wall, doors, and widows)
- Negative pressure (pressure on the sides and roof of a building)
- Interior pressure (pushes up from inside a building when a door or window on the windward side is lost).

Windborne debris also can be a factor in causing damage. Debris includes flying objects, such as tree limbs, outdoor furniture, signs, roofs, gravel, and loose building components. Additional general information on the tropical cyclone / high windstorm hazard is provided in Appendix L.

Tropical cyclones pose two threats in addition to wind: storm surge (water that is pushed toward the shore by the force of the storm's winds); and rainfall-caused flooding. Storm surge levels are determined by modeling water depth, wind speed, vegetative cover and other factors to determine the "wave run-up" (how far inland waves will reach) and "wave setup" (the height, speed, and slope of waves and how they differ from the still-water elevation). Waves and storm surges normally hit coasts ahead of high winds, as waves move faster than a hurricane advances. Locally intense rainfall may occur as the hurricane makes landfall.

4.1 HAZARD PROFILE

Table 4-2 summarizes the key elements of the tropical cyclone / high windstorm hazard profile for Kaua'i County. Additional details are provided in Appendix L.

Table 4-2. Tropical Cyclone / High Windstorm Hazard Profile Summary

	Tropical Cyclone	Other High Windstorms
Past Events	Since 1950, eight hurricanes have affected the Hawaiian Islands. Figure 4-1 depicts storm tracks in the vicinity of Hawai'i from 1950 to 2020. Hurricane Iniki in 1992 was the most destructive hurricane to strike Hawai'i in the 20th century, with estimated peak winds over Kaua'i of between 130 and 160 miles per hour. Hurricane Lane in 2018 produced intense rainfall and caused severe flooding.	Since 2005, 14 high windstorm events have affected the planning area. The most notable in Kaua'i County was that of January 2005, which caused damage estimated at $100,000.
Location	• Tropical cyclones spin counter-clockwise in the northern hemisphere and most tropical cyclones have passed the Islands to the south, so east-facing Hawaiian coastlines usually receive the brunt of strong onshore winds. • South and west coastlines feel onshore winds as the storms pass to the west. • The highest wind speeds may occur on the side opposite the storm approach, as downdrafts accelerate downslope over mountainous terrain.	High windstorms can happen anywhere in the planning area, but topography plays a significant role in where the impacts of such events are most severe.
Frequency	• Category 1 hurricane about once every 50 years • Category 2 hurricane about once every 100 years • Category 5 hurricane about once every 500 years	Average of one event per year from 2005 through 2019.
Severity	Hurricane storm-tracks from 1950 to 2020 indicate that 17 storms of Category 1 or higher have come within 150 nautical miles of Hawai'i. Hurricane Iniki had winds equivalent to a Category 4 hurricane.	Windstorms in the planning area have been known to cause damage to utilities, trees, boats, homes, and other structures and buildings. Kaua'i County is located in FEMA's Wind Zone II, with speeds up to 160 miles per hour.
Warning Time	Accurate warnings up to days in advance of tropical cyclones are possible, with modeling offering possible storm movement up to a week prior. The National Oceanic and Atmospheric Administration (NOAA) offers the following tools: • **Tropical Cyclone Public Advisory**—A list of all current watches and warnings on a tropical or subtropical cyclone • **Tropical Cyclone Forecast/Advisory**—A list of all current watches and warnings on a tropical or subtropical cyclone, as well as the current latitude and longitude, intensity, and system motion • **Tropical Cyclone Discussion**—Explains the reasoning for the analysis and forecast of a tropical or subtropical cyclone	Meteorologists can often predict the likelihood of a severe storm. The National Weather Service Forecast Office in Honolulu issues the following watches, warnings, and advisories: • **High Wind Watch**—A high wind watch is issued when sustained winds exceeding 40 mph and/or frequent gusts over 60 mph are likely to develop in the next 24 to 48 hours. • **High Wind Warning**—A high wind warning is issued when sustained winds exceeding 40 mph and/or frequent gusts over 60 mph are occurring or imminent. • **Wind Advisory**—A wind advisory is issued when sustained winds of 30 to 39 mph and/or frequent gusts to 50 mph or greater are occurring or imminent. • **Small Craft Advisory**—A small craft advisory is issued for coastal waters when winds of 25 to 33 knots and seas 10 feet or higher are occurring or forecast. • **Gale Warning**—A gale warning is issued for coastal, offshore, and high seas areas when winds of 34 to 47 knots not associated with a tropical cyclone are occurring or forecast.
Secondary Hazards	Landslides, flooding, coastal erosion, storms, and high surf	High winds can contribute to strong surf, which in turn results in coastal erosion.

See Section 1.4.2 for a description of elements included in the hazard profile

Source: NOAA

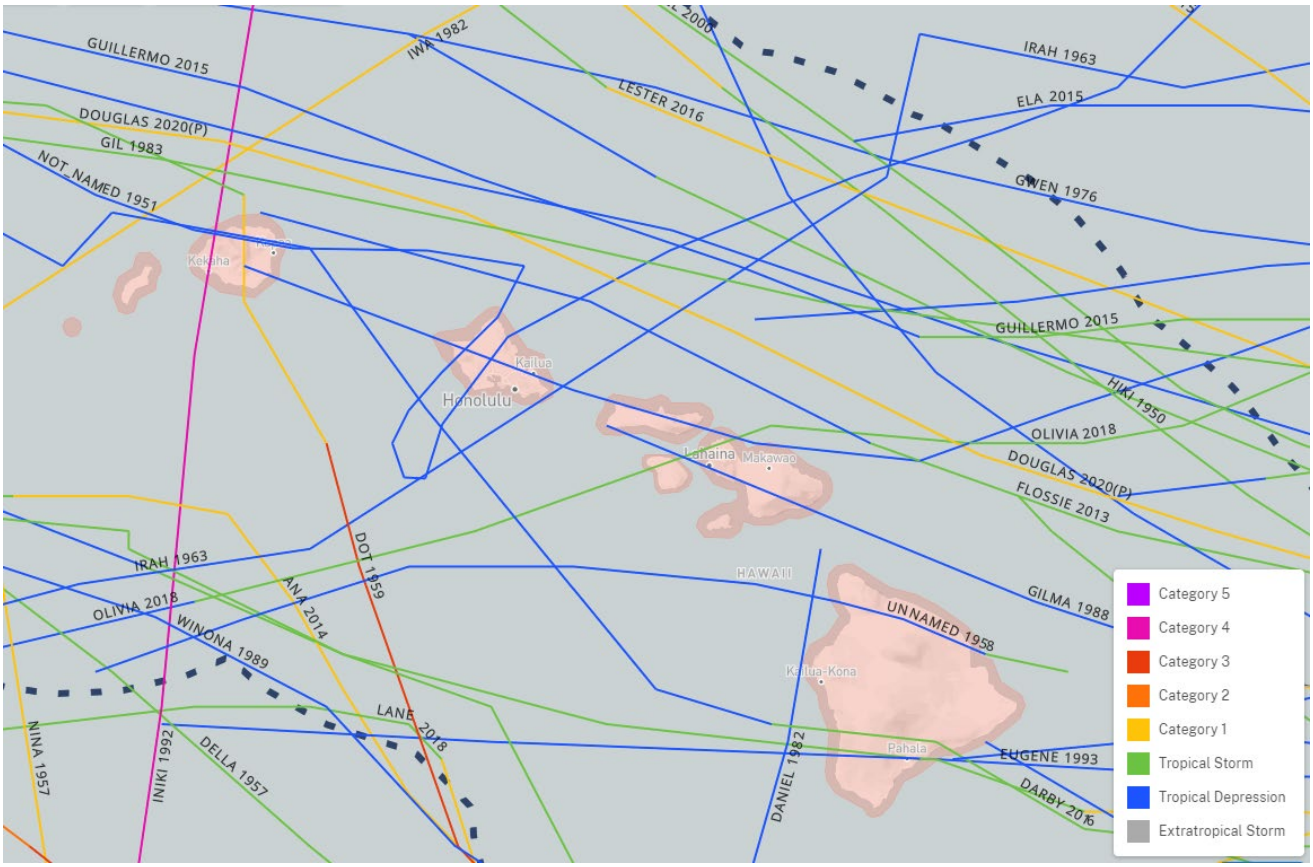


Figure 4-1. Historical Tropical Cyclones Within 150 Miles of Hawai'i, 1950 to 2020

4.2 RISK ASSESSMENT

4.2.1 Scenario

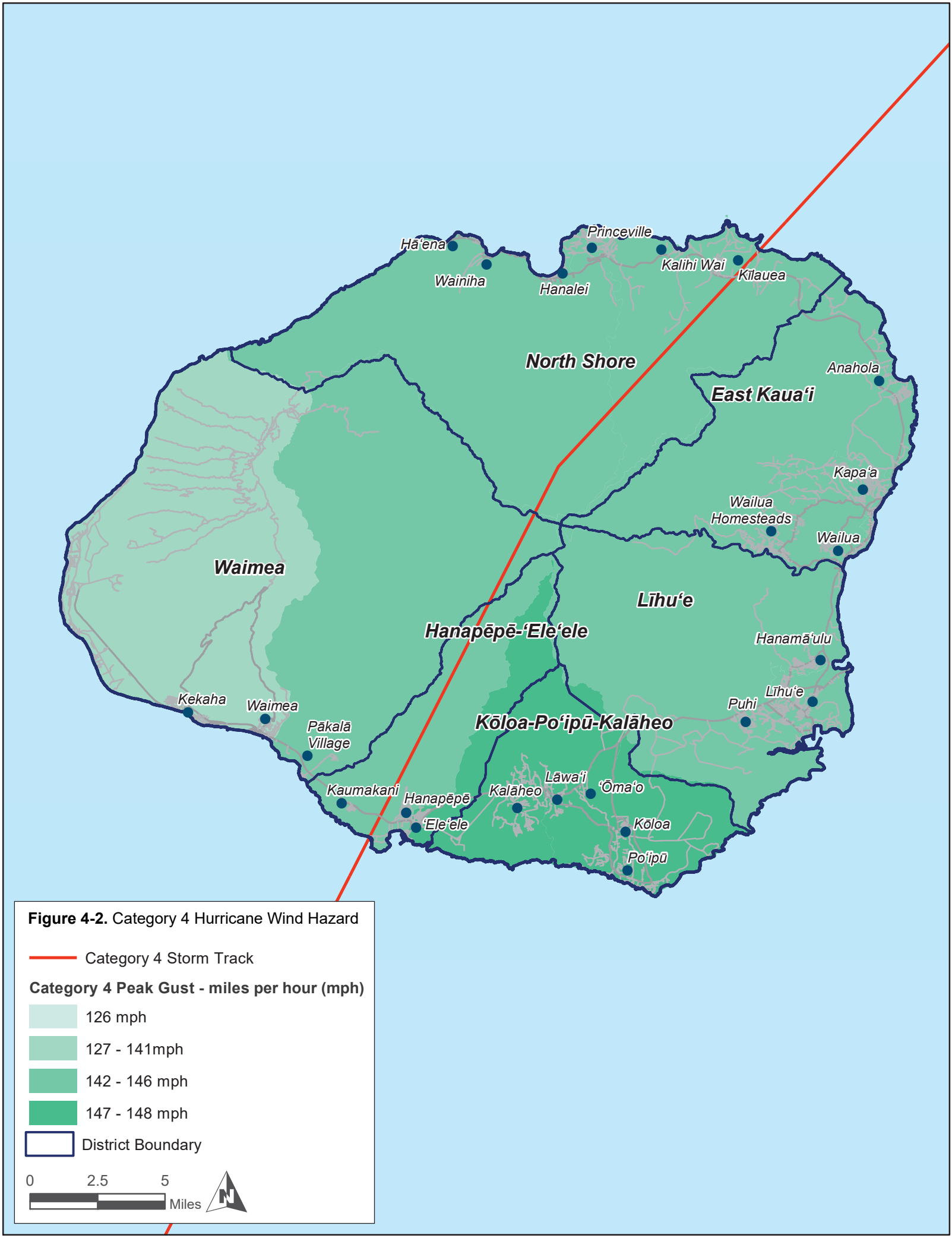
The tropical cyclone scenario used for the quantitative risk assessment is an "Iniki" Category 4 hurricane, tracking south-southwest by northeast across the planning area. Using Hazus, two types of impacts were modeled for the scenario event: wind and storm surge. Figure 4-2 and Figure 4-3 show the extent and location for these two parameters for the scenario event. The maximum wind gusts for the modeled scenario event range from 130 to 147 mph, correlating to a storm likely to occur about once every 180 years.

A worst-case high windstorm event would involve prolonged high winds. This event was not assessed quantitatively.

4.2.2 Exposure

The entire County's population, property, critical facilities and environment are considered to be exposed to the wind impacts of tropical cyclones and other high windstorms to some degree. Certain areas are more exposed due to geographic location and local weather patterns.

Tropical cyclone storm surge impacts were assessed using storm surge inundation mapping for a Category 4 hurricane, as determined using the NOAA National Hurricane Center's SLOSH (Sea, Lake and Overland Surges from Hurricanes) methodology.


Hāʻena
Princeville
Kalihi Wai
Kīlauea
Wainiha
Hanalei
North Shore
Anahola
East Kauaʻi
Kapaʻa
Wailua Homesteads
Wailua
Waimea
Līhuʻe
Hanapēpē-ʻEleʻele
Hanamāʻulu
Kekaha
Waimea
Pākalā Village
Puhi
Līhuʻe
Kōloa-Poʻipū-Kalāheo
Kaumakani
Hanapēpē
Kalāheo
Lāwaʻi
ʻŌmaʻo
ʻEleʻele
Kōloa
Poʻipū
Figure 4-2. Category 4 Hurricane Wind Hazard
Category 4 Storm Track
Category 4 Peak Gust - miles per hour (mph)
126 mph
127 - 141mph
142 - 146 mph
147 - 148 mph
District Boundary
0
2.5
5
Miles
N

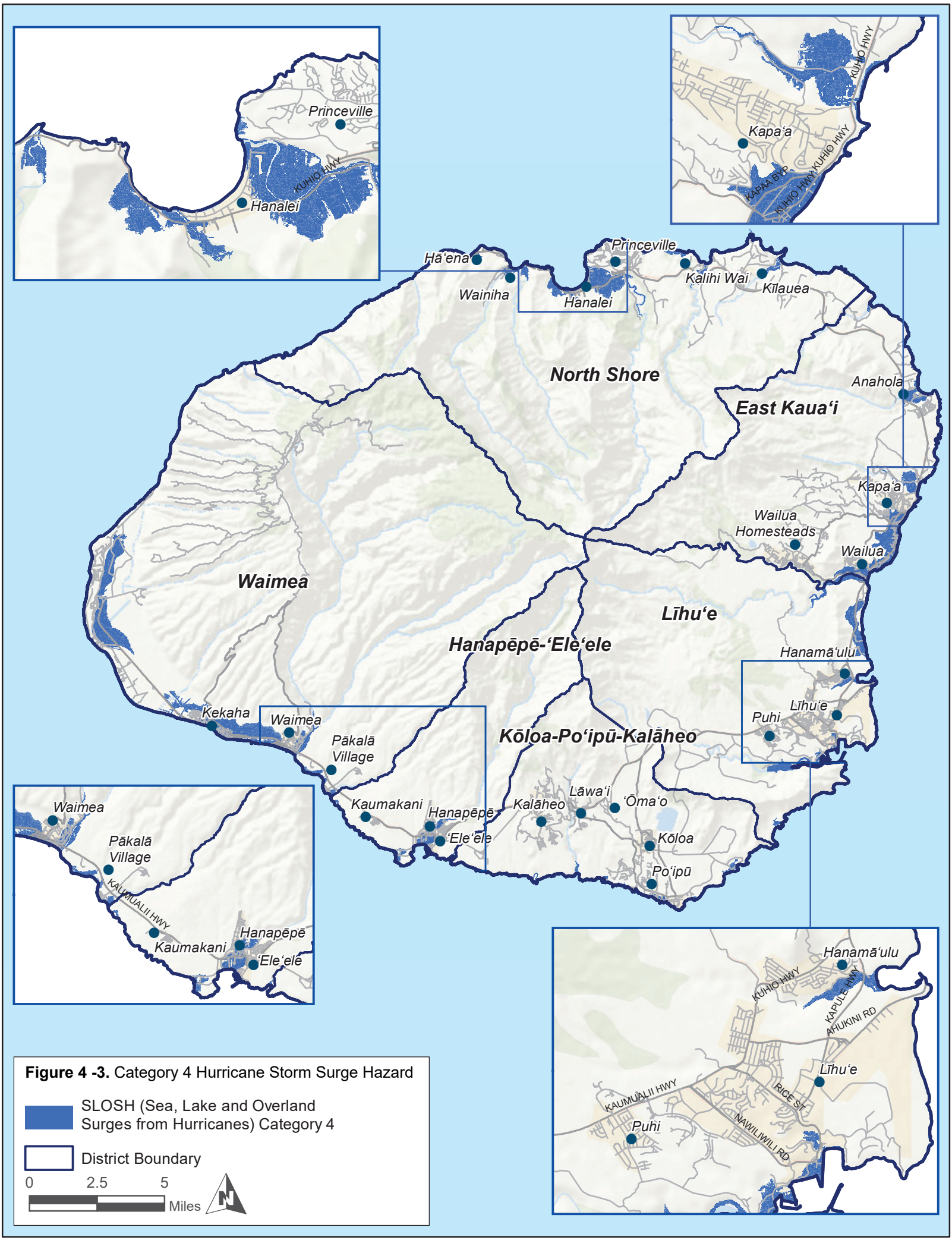


Figure 4 -3. Category 4 Hurricane Storm Surge Hazard

SLOSH (Sea, Lake and Overland Surges from Hurricanes) Category 4

District Boundary

0 2.5 5 Miles

People and Property

Table 4-3 summarizes the estimated population living in the mapped storm surge inundation area and the estimated property exposure.

Table 4-3. Exposed Population and Property in Category 4 Storm Surge Inundation Area

Population	
Population Exposed	8,081
% of Total Planning Area Population	11.6%
Property	
Number of Buildings Exposed	3,712
Value of Exposed Structures	$953,947,875
Value of Exposed Contents	$670,863,654
Total Exposed Property Value	$1,624,811,529
Total Exposed Value as % of Planning Area Total	7.96%

Critical Facilities

Figure 4-4 summarizes the critical facilities in the Category 4 storm surge inundation zones of the planning area. Critical facilities located just beyond the storm surge zones may be exposed if previous high surf or storm events destroyed the beach buffer. Coastal transportation routes also may be exposed. These routes are often located in areas where coastal erosion has gradually worn away the beach buffer, causing the potential for roadway inundation during high surf events.

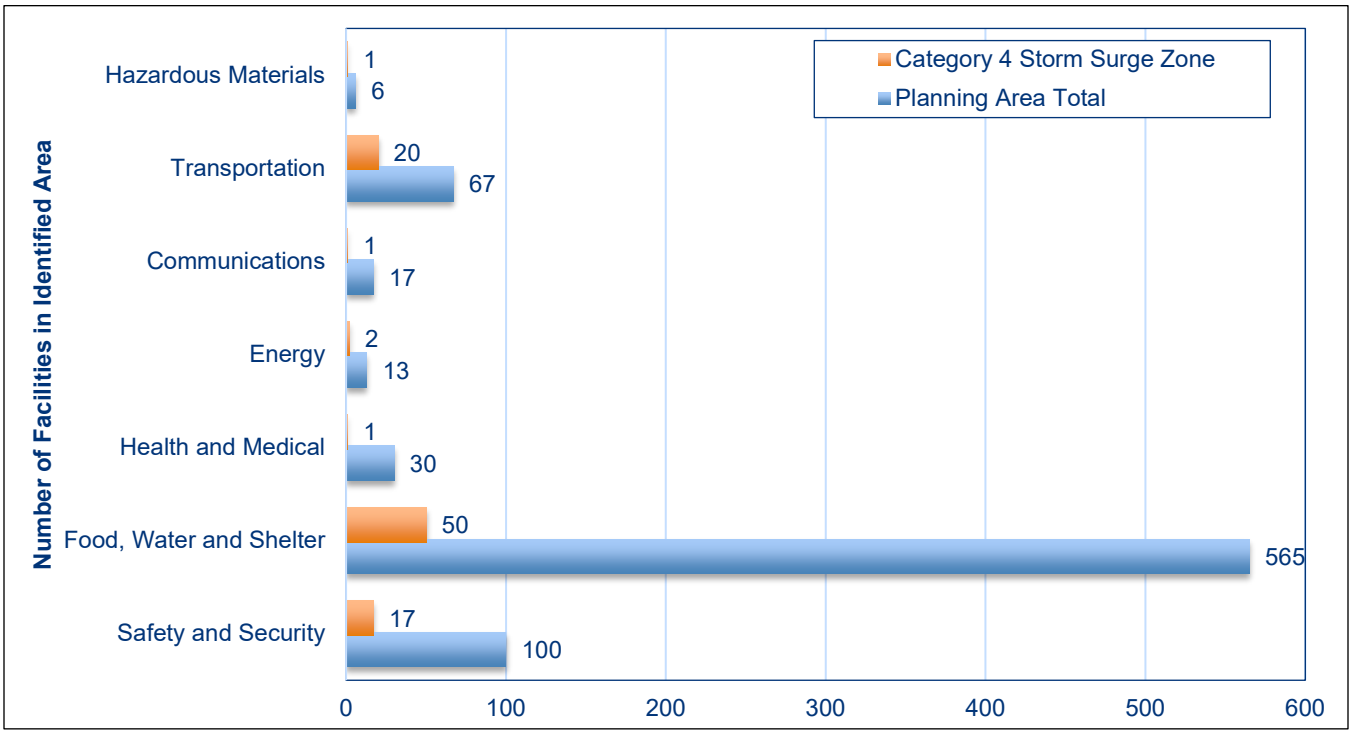


Figure 4-4. Critical Facilities in the Category 4 Storm Surge Inundation Zones

Environment

All beaches are exposed to the effects of storm surge.

4.2.3 Vulnerability

Population

The planning area is densely populated along its coastal shores and thus vulnerable to storm surge. Downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Residents may be displaced or require temporary sheltering. Populations living in areas with large stands of trees or power lines, especially at higher elevations, may be more susceptible to wind damage and power blackout. Loss of electricity and phone connection would leave certain populations isolated because residents would be unable to call for assistance.

Socially vulnerable populations are most susceptible to tropical cyclones and other high windstorms, based on their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Economically disadvantaged populations are vulnerable because they may not have funds to evacuate. The population over the age of 65 is more vulnerable because they may require extra time or outside assistance during evacuations and are more likely to seek or need medical attention that may not be available due to isolation during a storm event. Linguistically isolated populations and people with life-threatening illnesses face isolation during high wind events. Power outages can be life threatening to those dependent on electricity for life support.

The following impacts in the planning area were estimated for the Category 4 hurricane wind through the Level 2 Hazus analysis:

- Number of Displaced Households = 14,102
- Number of Persons Requiring Short-Term Shelter = 9,129

Property

All property is vulnerable during high windstorms, but properties in poor condition or in particularly vulnerable locations may risk the most damage. Structures that were built before the building code incorporated provisions for wind load are particularly vulnerable Those in higher elevations and on ridges may be more prone to wind damage. Buildings under or near overhead lines or near large trees may be vulnerable to falling lines or trees.

The following estimates of property damage were developed through the Level 2 Hazus analysis for the Category 4 hurricane wind:

- Losses to structures = $5,985,343,147
- Losses to contents = $3,124,593,928
- Total losses = $9,109,937,075
- Structure Debris to Be Removed = 685,682 tons (27,427 truckloads)

Detailed results for all districts are provided in Appendix M.

Critical Facilities

A hurricane event of the assumed scenario magnitude would result in widespread damage to private and public property, including critical facilities. Long-term power outages would be expected, with potential loss of utilities such as potable water and wastewater systems. Transportation lifelines are vulnerable to storm surge and cascading effects such as flooding, falling debris etc. Impacts on transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs. Loss of transportation facilities such as the harbor and airport would tax already limited resources and further isolate the island from response and recovery resources. Many facilities and structures would require months or years to

return to pre-event functionality. Long-terms impacts on tourism, supporting industries and the local tax base would be expected.

For the worst-case high windstorm event, temporary structures and structures unable to resist sustained wind speeds may collapse, posing an immediate threat to those within or around the structure. Long-term effects may include the removal of collapsed buildings and removal of debris from waterways. Downed power lines can cause blackouts, which can impact business operations and can impact heating or cooling provision to citizens (including the young and elderly, who are particularly vulnerable to temperature-related health impacts). Phone, water and sewer systems may not function. High winds and hurricane storm surge can block roads with debris, incapacitating transportation, isolating population, and disrupting ingress and egress. Of particular concern are roads providing access to isolated areas and to the elderly. Appendix R provides an analysis of roads in the category 4 hurricane storm surge hazard area.

High wind events pose a problem for facilities that house hazardous materials. Such facilities often depend on electricity and other utilities to maintain safe operations. While most of these facilities have a back-up power source to ensure continued operations, backup power can only be used for a finite time; prolonged power disruption could have dire consequences.

Hazus estimates the probability that critical facilities may sustain damage as a result of Category 4 hurricane winds. Table 4-4 summarizes the results.

Table 4-4. Damage to Critical Facilities from a Category 4 Hurricane Winds

Category	Number of Facilities Affected	Number of Facilities with 50% or Greater Probability of Achieving Damage Level				
		None	Minor	Moderate	Severe	Complete
Safety and Security	86	0	0	19	67	0
Food, Water and Sheltering	130	0	0	17	113	0
Health and Medical	30	0	0	6	24	0
Energy	13	0	0	3	10	0
Communications	17	0	0	1	16	0
Transportation	6	0	0	3	3	0
Hazardous Materials	6	0	0	0	6	0
Total	**288**	**0**	**0**	**49**	**239**	**0**

Note: The Hazus hurricane module does not analyze the following types of facilities: County Park, Boat Harbor, Bridge, Water Pump, Well.

Environment

A tropical cyclone's storm surge exacerbates the rate at which the coast erodes. A change in salinity and pH levels of the ocean after a tropical cyclone affects coral reefs (Tripp, 2013). Flooding caused by tropical cyclones has the potential to upset the natural balance of ecosystems. This is of particular concern when dealing with the compounding effects of multiple events in a single season.

Natural habitats such as streams and trees are exposed to the elements during a high windstorm and risk major damage and destruction including downed debris, uprooted trees, and debris-blocked rivers and streams. High winds affect natural vegetation across the planning area, including downed trees and blocked waterways.

4.3 ISSUES

4.3.1 Development in High-Hazard Areas

The distribution of general land use types in the Category 4 storm surge inundation areas is shown in Figure 4-5. Agricultural land and natural areas make up the greatest extent of exposed areas. Most homes and facilities are located areas designated urban center, neighborhood center, neighborhood general, or residential community. In all, 13.5 percent of the Category 4 storm surge inundation area is highly developed.

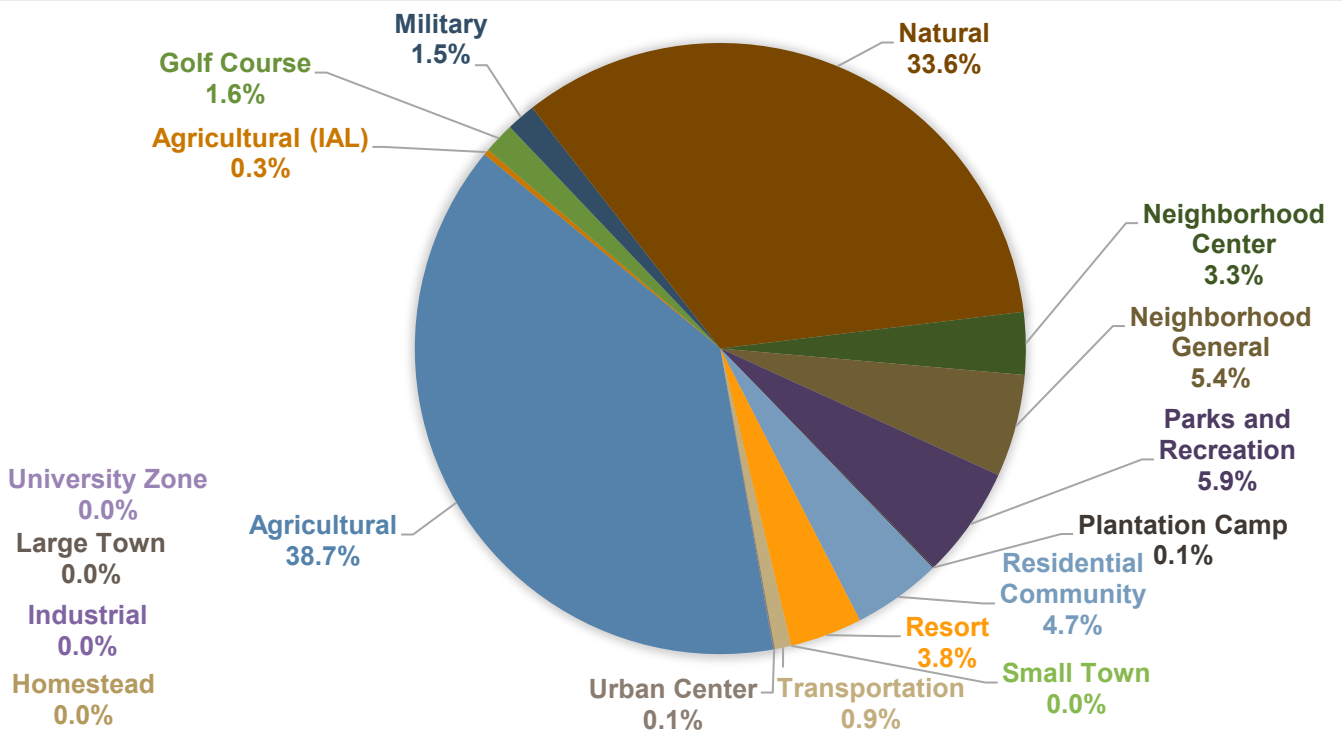


Figure 4-5. Land Use Distribution by Area in Category 4 Storm Surge Inundation Zone

All future development in the County will be affected by high windstorms. The ability to withstand impacts lies in sound land use practices and consistent enforcement of current codes and regulations for new construction. The State of Hawai'i design wind pressures have changed over the years with different editions of the Uniform Building Code (UBC) and International Building Code (IBC). Design wind pressures, typical construction type (single or double wall), and use of hurricane uplift resistance can all be determined by the year built based on the corresponding version of the UBC or IBC in effect at the time.

The current Kaua'i County building code includes specific provisions for current and future development regarding hurricane-resistant construction. Kaua'i County also has adopted the IBC and has developed county-specific wind load requirements. These codes are equipped to deal with the impacts of high windstorms. Land use policies identified in general plans within the planning area also address secondary impacts of high windstorms. With these tools, Kaua'i County is well-equipped to deal with future growth and the associated impacts of high windstorms.

4.3.2 Other Issues

The following issues have been identified related to the tropical cyclones/high windstorms hazard in the planning area:

- **Emergency Shelter Wind Speed Capability Assessment**—Because of the secondary hazards associated with tropical cyclones, emergency shelters are often needed to house residents displaced by collapsing houses or rising flood waters. The County should begin making efforts to test its emergency shelters to the design standard.
- **Vulnerable Trees—**There is significant tree exposure to hurricane wind forces within the planning area. The vulnerability of these trees to wind forces should be monitored by the County to pre-identify potential problem areas prior to pending storms.
- **Debris Management—**The scenario event modeled for this assessment estimated a significant amount of post-event debris accumulation. The ability to manage this amount of debris should be considered by the County prior to a pending event.
- **Power Interruption—** Long-term loss of power is likely to be a major impact from the scenario event modeled for this assessment. Energy assurance planning should be considered for the planning area.
- **Review of Building Stock**—Older building stock in the planning area is built to low code standards or none at all. These structures could be highly vulnerable to windstorms. The County could conduct a study within the planning area to identify at-risk buildings and investigate options for bringing them up to code.
- **Alternate Power Supply**—Redundancy of power supply must be evaluated to ensure continuity of power at critical facilities throughout the planning area.
- **Public Outreach for Isolated Population Centers**—Depending on the severity of the storm, isolated population centers could become stranded from the rest of the island. As such, community-based organization and training should be done to inform isolated population centers about what to do if they become stranded. This could include public information on sheltering in place, tips on developing a personal go-kit, and instructions on developing a personal emergency plan.

5. WILDFIRE

A wildfire is any uncontrolled fire on undeveloped land that requires fire suppression. Wildfires can be ignited by lightning or by human activity such as smoking, campfires, equipment use, and arson. The potential for significant damage to life and property exists in areas designated as "wildland urban interface (WUI) areas," where development is adjacent to densely vegetated areas. Fires in WUI areas tend to be more damaging than urban structural fires, are often more difficult to control, and behave differently from structural fires. When these fires erupt, people and structures must take priority, often at a devastating expense to natural resources. Homes and other structures are often built and maintained in a manner that leaves them and their occupants vulnerable. Thus, fire becomes a significant threat to both humans and natural resources. The Kauaʻi Fire Department responds to wildland fires, brush fires, and wildfires almost exclusively. Structure fires are rare on the island of Kauaʻi. Additional general information on the wildfire hazard is provided in Appendix L.

5.1 HAZARD PROFILE

Table 5-1 summarizes the key elements of the wildfire hazard profile for Kauaʻi County. Additional details are provided in Appendix L.

Table 5-1. Wildfire Hazard Profile Summary

Past Events	• In 2019, 500 acres of dry brush near Poʻipū burned, residents were evacuated, and roads were closed. • 50 acres behind Līhuʻe airport burned in 2015, requiring three flights to be diverted. • Near Anahola in 2014, 25 acres of dry brush burned, and residents were evacuated. • Near Kekaha in 2012, 3,000 acres of dry brush burned, and power poles were destroyed. • In Kōloa in 2011, 50 acres of dry brush and two homes burned, three homes were damaged, and eight people were left homeless.
Location	According to wildfire risk mapping prepared by the State of Hawaiʻi, communities on the north shores of Kauaʻi have the lowest wildfire risk and those on the west shore have the highest; the east and south shores have medium risk levels.
Frequency	15 wildfires were recorded in Kauaʻi County from 2011 through 2019; an average of one to two per year.
Severity	Each wildfire recorded in Kauaʻi County from 2011 through 2019 burned at least 25 acres, and the largest burned 3,000 acres.
Warning Time	Humans often cause wildfires, intentionally or accidentally. There is no way to predict when one might break out. If a fire does break out and spread rapidly, residents may need to evacuate within days or hours.
Secondary Hazards	Landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds and increased runoff due to increased imperviousness of the ground. Wildfires can cause direct economic losses in the reduction of harvestable crops and indirect economic losses in reduced tourism.

See Section 1.4.2 for a description of elements included in the hazard profile

5.2 RISK ASSESSMENT

5.2.1 Scenario

A major conflagration in the planning area might begin in the wet season, contributing to extensive growth of grasses and similar flash fuels. A dry season could follow, exacerbated by dry hot winds. Carelessness with combustible materials, a tossed lit cigarette, or a sudden lightning storm could trigger multiple small isolated fires.

The embers from these smaller fires could be carried by hot, dry winds into forests and WUI zones. New small fires there would eventually merge. Fires that start in flat areas move slower, but wind still pushes them. It is not unusual for a wildfire pushed by wind to burn the ground fuel and later climb into the crown and reverse its track. This is one of many ways that fires can escape containment, typically during periods when response capabilities are overwhelmed. Suppression resources would be redirected from protecting the natural resources to saving more remote subdivisions. The response to a major wildfire on the island would be exclusively local and state resources. The County does not have real-time access to federal firefighting resources.

To further complicate this scenario, heavy rains could follow, causing flooding and landslides and releasing tons of sediment into rivers, permanently changing floodplains and damaging sensitive habitat and riparian areas. Such a fire followed by rain could release millions of cubic yards of sediment into streams for years, creating new floodplains and changing existing ones. With forests removed from the watershed, stream flows could easily double. Floods that could be expected every 50 years may occur every couple of years. With the streambeds unable to carry the increased discharge because of increased sediment, the floodplains and floodplain elevations would increase.

5.2.2 Exposure

The Hawai'i Wildfire Management Organization has developed mapping of Communities at Risk from Wildfire (CARW), which was used for the wildfire risk assessment. CARW maps delineate communities that share similar environmental conditions, land use characteristics, fuel types, hazards, and general wildfire issues. They provide ratings to characterize generalized hazards in each area.

Population

Population was estimated using the residential building count in each mapped CARW hazard area and multiplying by the 2018 estimated average population per household (U.S. Census American Community Survey). Using this approach, the estimated population living in the high and medium CARW wildfire risk areas is 76.5 percent of the planning area population (53,329 people), as shown in Table 5-2. In addition to populations who reside in risk areas where fires may occur, hikers and campers may be exposed to wildfires. The entire population of the planning area has the potential to be exposed to smoke from nearby wildfires.

Table 5-2. Population Exposure to the Wildfire Hazard

CARW Zone	Population Exposed	% of Total Population
High	44,244	63.5%
Medium	9,085	13%
Total	**53,329**	**76.5%**

Property

Property damage from wildfires can significantly alter entire communities. Structures in WUI areas and those not designed with fire-smart principles in mind are particularly vulnerable. The total replacement value of property in the high and medium CARW wildfire risk areas is $13.3 billion—65.4 percent of the planning area total:

- High fire hazard: $11.9 billion
- Medium fire hazard: $1.4 billion

Critical Facilities

Critical facilities in the medium and high wildfire risk zones represent 41 percent of the total critical infrastructure and facilities in the planning area. The breakdown of exposure by facility type is shown in Figure 5-1.

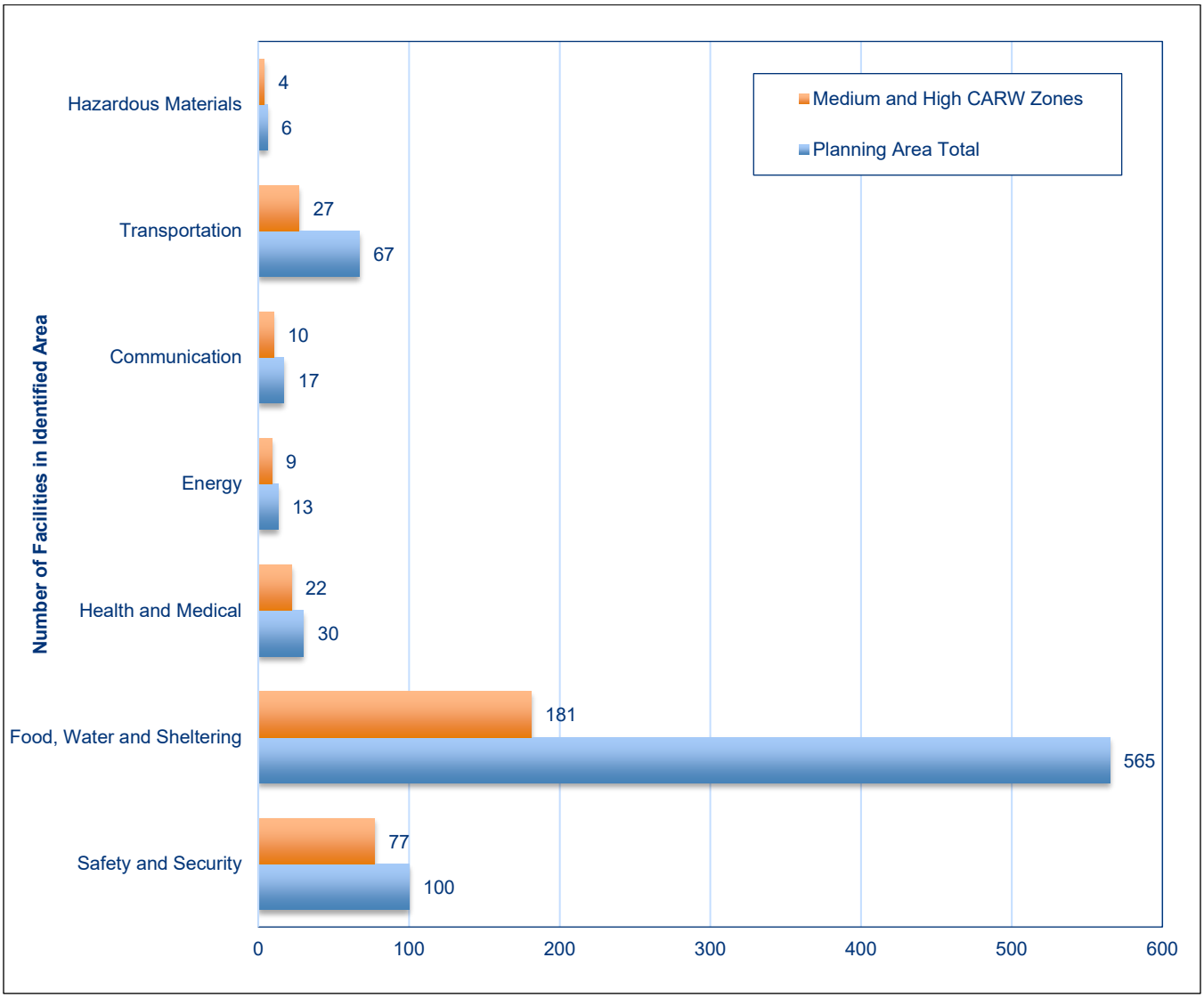


Figure 5-1. Critical Facilities in Medium and High CARW Zones and Countywide

In the event of wildfire, there would likely be little damage to the majority of infrastructure. Most roads would be without damage except in the worst scenarios. See Appendix R for an analysis of roads in the wildfire hazard area. Power lines are the most at risk to wildfire because most are made of wood and susceptible to burning.

There are likely to be several facilities containing hazardous materials exposed to the wildfire hazard. During a wildfire event, these materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading and escalating the fire to unmanageable levels. In addition, they could leak into surrounding areas, saturating soils and seeping into surface waters, and have a disastrous effect on the environment.

Environment

All natural areas within the mapped CARW higher-risk areas are exposed to the wildfire hazard.

5.2.3 Vulnerability

Population

All people exposed to the wildfire hazard are potentially vulnerable to wildfire impacts. Persons with access and functional needs, the elderly and very young may be especially vulnerable to a wildfire if there is not adequate warning time for them to evacuate if needed. In addition, people outside the mapped risk areas are susceptible to health hazards associated with smoke and air pollution from wildfires, especially sensitive populations including children, the elderly, and those with respiratory and cardiovascular diseases. In addition, wildfires threaten the health and safety of those fighting the fires.

Property

All property exposed to the wildfire hazard is vulnerable. Structures that were not constructed to standards designed to protect a building from a wildfire may be especially vulnerable. Loss estimations for the wildfire hazard are not based on damage functions, because no such damage functions have been generated. Instead, estimates of potential loss were developed representing 1 percent, 10 percent, 30 percent and 50 percent of the replacement value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 5-3 shows the general building stock loss potential estimates in the high and medium CARW wildfire risk areas.

Table 5-3. Loss Potential for High and Medium CARW Wildfire Risk Areas

	Exposed Value	Loss Value	Loss as % of Total Planning Area Replacement Value
Loss = 1% of Exposed Value	$13.3 billion	$133.4 million	Less than 1%
Loss = 10% of Exposed Value		$1.3 billion	6.5%
Loss = 30% of Exposed Value		$4.4 billion	21.6%
Loss = 50% of Exposed Value		$6.7 billion	32.7%

Critical Facilities

Critical facilities of wood frame construction are especially vulnerable during wildfire events. In the event of wildfire, there would likely be little damage to most infrastructure. Most roads would be without damage except in the worst scenarios. Power lines are the most at risk from wildfire because most poles are made of wood and susceptible to burning. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers. Wildfire typically does not have a major direct impact on bridges, but it can create conditions in which bridges are obstructed. Many bridges in areas of high to moderate fire risk are important because they provide the only ingress and egress to large areas and in some cases to isolated neighborhoods.

Hazardous materials sites located in proximity to wildfires are at particular risk for compounding issues. Hazardous materials facilities often contain large quantities of flammable materials. Should a wildfire reach one of these facilities, the result could be catastrophic.

Environment

Fire is a natural and critical ecosystem process in most terrestrial ecosystems, affecting the types, structure, and spatial extent of native vegetation. However, under a specific set of circumstances, it can also cause severe environmental impacts, such as the following:

- **Damaged Fisheries**—Critical fisheries can suffer from increased water temperatures, sedimentation, and changes in water quality.
- **Soil Erosion**—The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- **Spread of Invasive Plant Species**—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.
- **Disease and Insect Infestations**—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- **Destroyed Endangered Species Habitat—**Wildfire can have negative consequences for endangered species by degrading their habitat.
- **Soil Sterilization**—Some wildfires burn so hot that they can sterilize the soil. Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost.
- **Reduced Agricultural Resources**—Wildfire can have disastrous consequences on agricultural resources, removing them from production and necessitating lengthy restoration programs.
- **Damaged Cultural and Historical Resources**—The destruction of cultural and historic resources may occur, scenic vistas can be damaged, and access to recreational areas can be reduced.

5.3 ISSUES

5.3.1 Development in High-Hazard Areas

The highly urbanized portions of the planning area have little or no wildfire risk exposure. Urbanization tends to alter the natural fire regime and can create the potential for the expansion of urbanized areas into wildland areas. The expansion of WUI areas can be managed with strong land use and building codes. The planning area is well equipped with these tools. Land use is determined by the County's zoning code and zoning map, also known as the Comprehensive Zoning Ordinance. Zoning controls the density and intensity of development, and well as its form and character. Changes to the zoning code are guided by the General Plan, which is adopted by the Kauaʻi County Council. The General Plan includes community plans for West Kauaʻi, South Kauaʻi, Līhuʻe, East Kauaʻi, and North Shore. The General Plan and community plans establish policies to protect communities from hazards. Development in the planning area is also regulated by building standards and performance measures.

Figure 5-2 shows the land use distribution by area in high and medium CARW severity zones. Agricultural and natural uses make up about 34 percent of these zones. Most homes and facilities are in areas designated urban center, neighborhood center, neighborhood general, or residential community. Approximately 30 percent of the hazard area is highly developed.

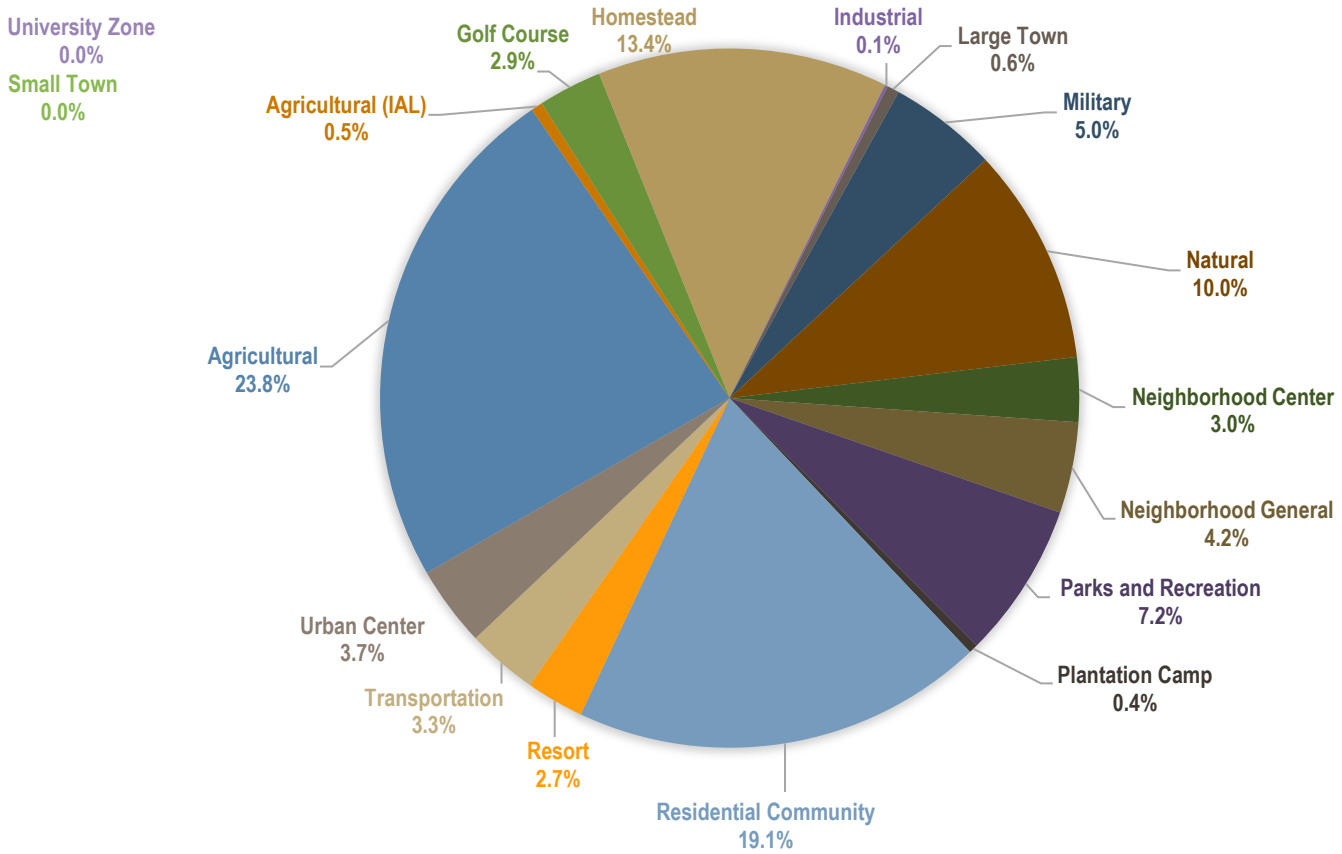


Figure 5-2. Land Use Distribution by Area in the High and Medium CARW Severity Zones

5.3.2 Other Issues

The following issues have been identified related to the wildfire hazard in the planning area:

- **WUI Public Information**—Public education and outreach to people living in or near the fire hazard zones should include information about and assistance with mitigation activities such as defensible space, and advance identification of evacuation routes and safe zones.
- **Management of Development**—Future growth into WUI areas should continue to be managed with special development considerations.
- **Continued Responder Training** —Area fire districts need to continue to train on WUI events.
- **Vegetation Management Activities**—Such activities would include enhancement through expansion of the target areas as well as additional resources. Controlled burns of former sugar cane fields would continue to be monitored to mitigate against potential major uncontrolled conflagrations
- **Responder Qualifications**—Expand certifications and qualifications for fire department personnel. Ensure that all firefighters are trained in basic wildfire behavior, basic fire weather, and that all company officers and chief level officers are trained in the wildland command and strike team leader level.

6. CLIMATE CHANGE

Climate, consisting of patterns of temperature, precipitation, humidity, wind and seasons, plays a fundamental role in shaping natural ecosystems and the human economies and cultures that depend on them. "Climate change" refers to changes over a long period of time.

The well-established worldwide warming trend of recent decades and its related impacts are caused by increasing concentrations of carbon dioxide and other greenhouse gases in the earth's atmosphere. Greenhouse gases are gases that trap heat in the atmosphere, resulting in a warming effect. Carbon dioxide is the most commonly known greenhouse gas; however, methane, nitrous oxide and fluorinated gases also contribute to warming. Emissions of these gases come from a variety of sources, such as the combustion of fossil fuels, agricultural production and changes in land use. According to the National Aeronautics and Space Administration (NASA), carbon dioxide concentrations measured about 280 parts per million (ppm) before the industrial era began in the late 1700s and have risen dramatically since then, surpassing 400 ppm in 2013 for the first time in recorded history (see Figure 6-1).

Additional general information on the climate change hazard is provided in Appendix L.

Source: NASA, 2020

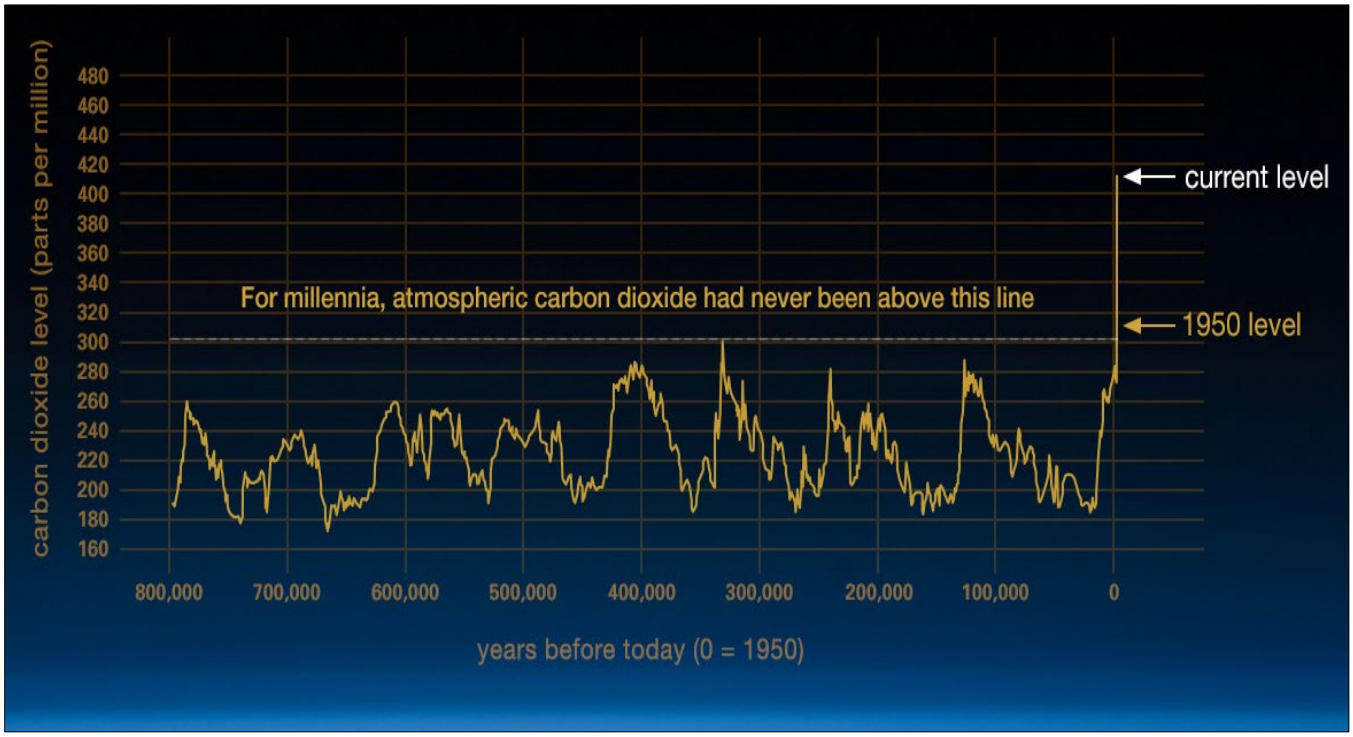


Figure 6-1. Global Carbon Dioxide Concentrations Over Time

6.1 SEA LEVEL RISE ESTIMATES

Changes in global temperatures, hydrologic cycles, coverage of glaciers and ice sheets, and storm frequency and intensity are captured in long-term sea level records. Sea levels provide a key to understanding the impact of climate change. Sea level rise increases the risks coastal communities face from coastal hazards (floods, storm surges, and coastal erosion).

The *Sea Level Rise Vulnerability and Adaptation Report* prepared by the Hawai'i Climate Change Mitigation and Adaptation Commission provides a statewide assessment of Hawai'i's vulnerability to sea level rise. The assessment is based on an aggregate of hazard data defining the "chronic sea level rise exposure area" (SLR-XA). The SLR-XA includes passive flooding, coastal erosion, and annual high wave runup with sea level rise (see Figure 6-2).

Source: Sea Level Rise Vulnerability and Adaptation Report

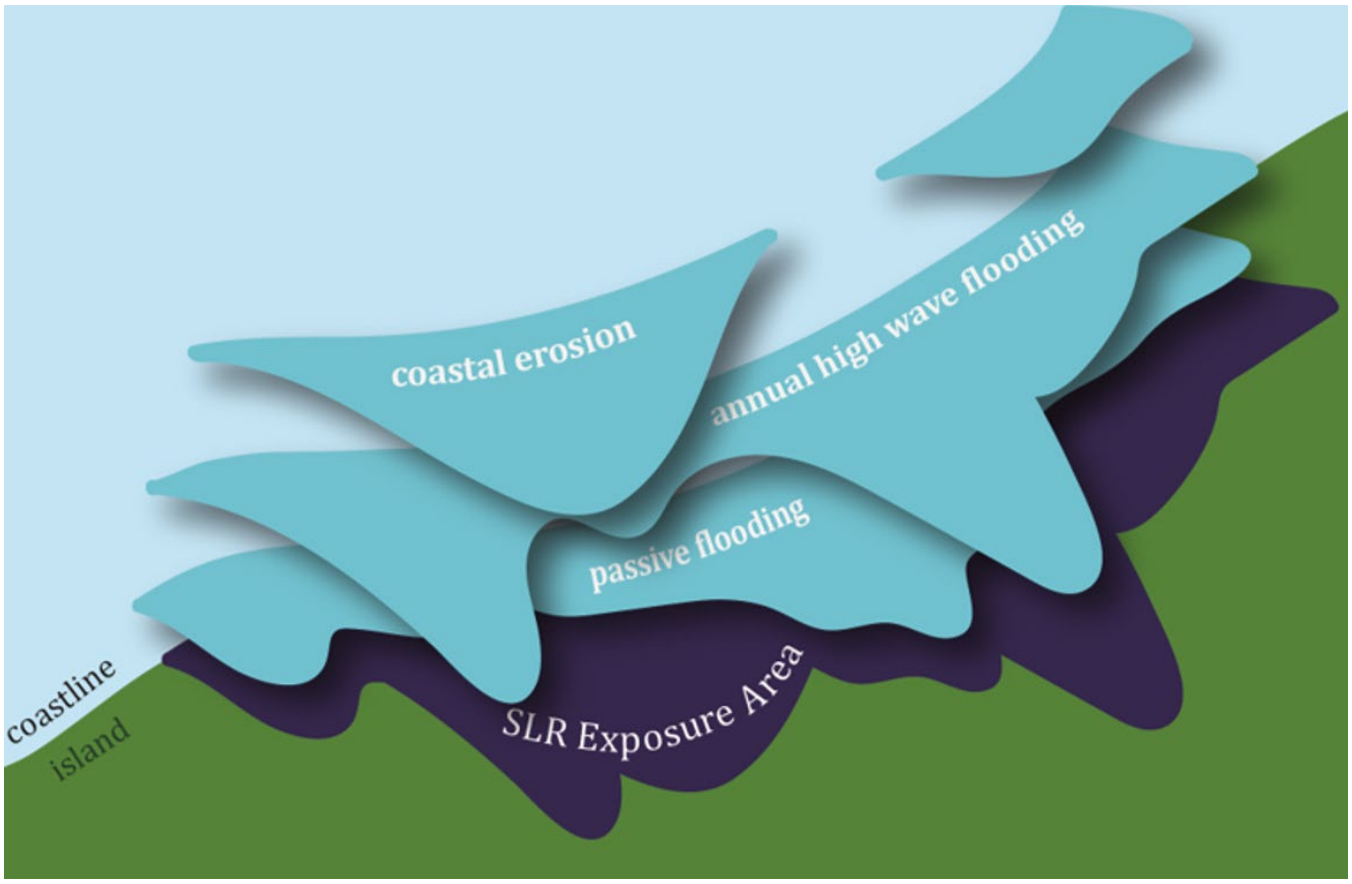


Figure 6-2. Hazard Data Used to Determine Chronic Sea Level Rise Exposure Area (SLR-XA)

The *Sea Level Rise Vulnerability and Adaptation Report* outlines recommendations to reduce exposure and sensitivity to sea level rise and increase capacity to adapt. The report's recommendations are based on emerging good practices and framed through extensive stakeholder consultations. A sea-level-rise risk assessment for this hazard mitigation plan used data from the report for Kaua'i County. The data provide a preliminary, generalized overview of the potential impacts of one facet of climate change for the planning area.

Two areas of risk were identified for this analysis:

- Chronic Sea Level Rise Exposure Area (SLR-XA)—The chronic sea level rise exposure area is the area predicted to be inundated under ongoing normal conditions in the future, for various scenarios of sea level rise. The previous report assessed four possible scenarios. For this risk assessment, only the 3.2-foot rise was evaluated. The area of future chronic inundation for this estimate is shown on Figure 6-3.
- Event-Based Sea Level Rise Inundation Area—The event-based inundation area is the area that would be inundated under the 3.2-foot chronic sea-level-rise scenario if a 1 percent annual chance coastal flood event occurs (Coastal Flood + SLR). This area is shown in Figure 6-4.

The Core Planning Team overlaid this data on the population, land use, general building stock and critical facility and asset data developed for the hazard risk assessment for this plan. Detailed results by district are provided in Appendix M; results for the total planning area are presented in Table 6-1, and Figure 6-5 and Figure 6-6. The analysis of sea level rise on roads in the planning area can be found in Appendix R. This assessment assumes that these sea level rise impacts occur on present day Kaua'i County rather than occurring gradually over years or decades.

Table 6-1. Estimated Exposure for Coastal Flood + Sea Level Rise and Sea Level Rise Chronic Flooding

	Coastal Flood + SLR	SLR-XA
Population		
Population Exposed	17,221	2,690
% of Total Planning Area Population	24.7%	3.86%
Property		
Number of Buildings Exposed	8,448	1,255
Value of Exposed Structures	$3.259 billion	$308.4 million
Value of Exposed Contents	$2.045 billion	$186.3 million
Total Exposed Property Value	$5.304 billion	$494.7 million
Total Exposed Value as % of Planning Area Total	26.0%	2.43%

6.2 POTENTIAL CLIMATE CHANGE IMPACT ON HAZARDS

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches, the more subject to changing dynamics it becomes. Although quantitative estimates are subject to concerns about changing conditions, qualitative assessments can be made of potential impacts on hazard-related risks. Discussions of the potential impacts of climate change on each hazard are provided below.

6.2.1 Tropical Cyclone and Other High Winds

A tropical cyclone's strong winds and intense low pressure can generate storm surge along coastal communities. While not all tropical cyclones have devastating impacts or create significant levels of storm surge, the surge index record shows a significant positive trend between warmer years and extreme events (i.e., Katrina-level events). One study found that Category 4 and 5 hurricanes could increase up to 81 percent in frequency with a temperature increase of only 2.5 ºC. While surge levels will vary because of situational factors, projected changes in hurricane surge levels above the mean sea level in Hawai'i are more likely to increase than decrease with global warming (results range from a 10 percent reduction to 50 percent increase with a 2.8 ºC temperature increase).

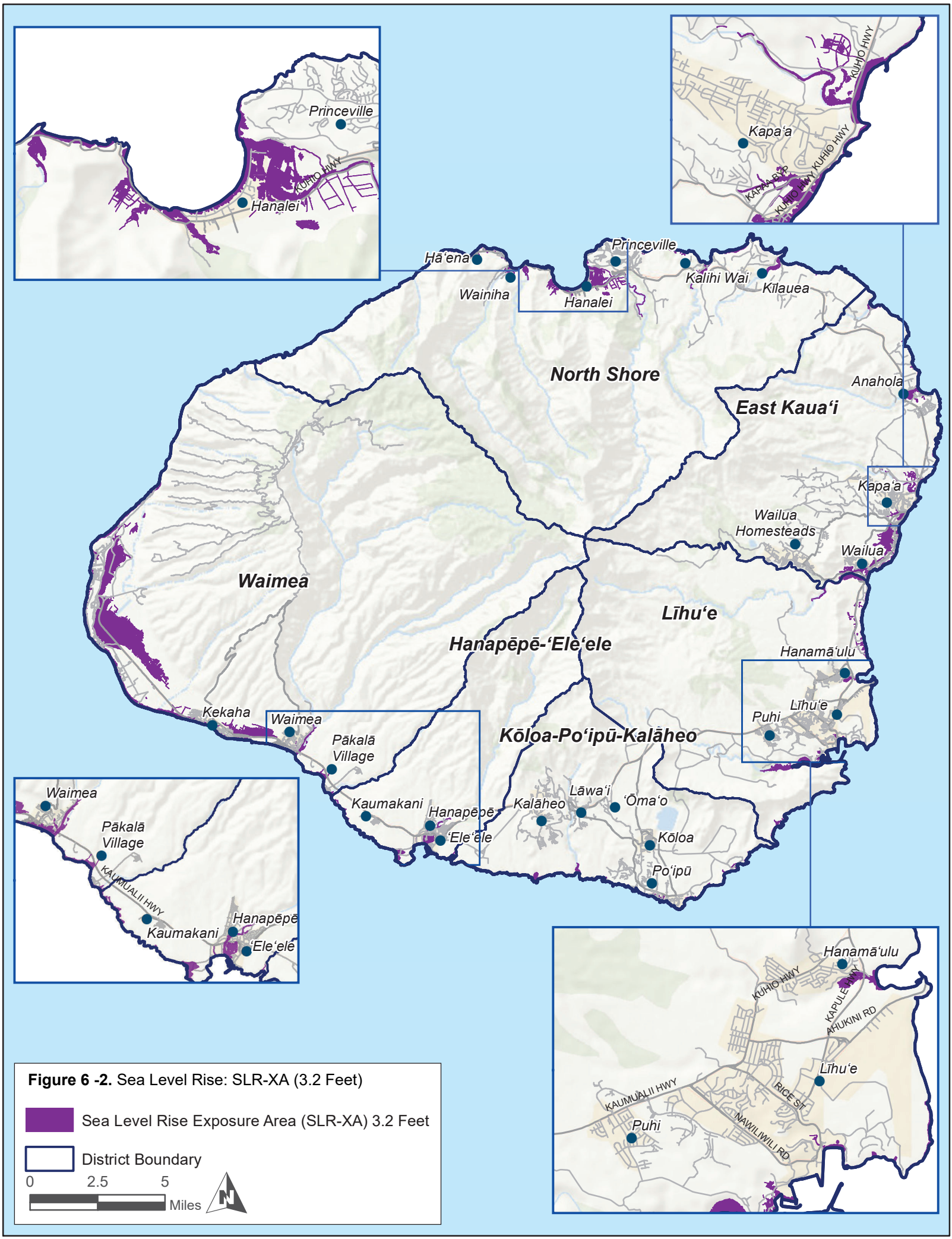
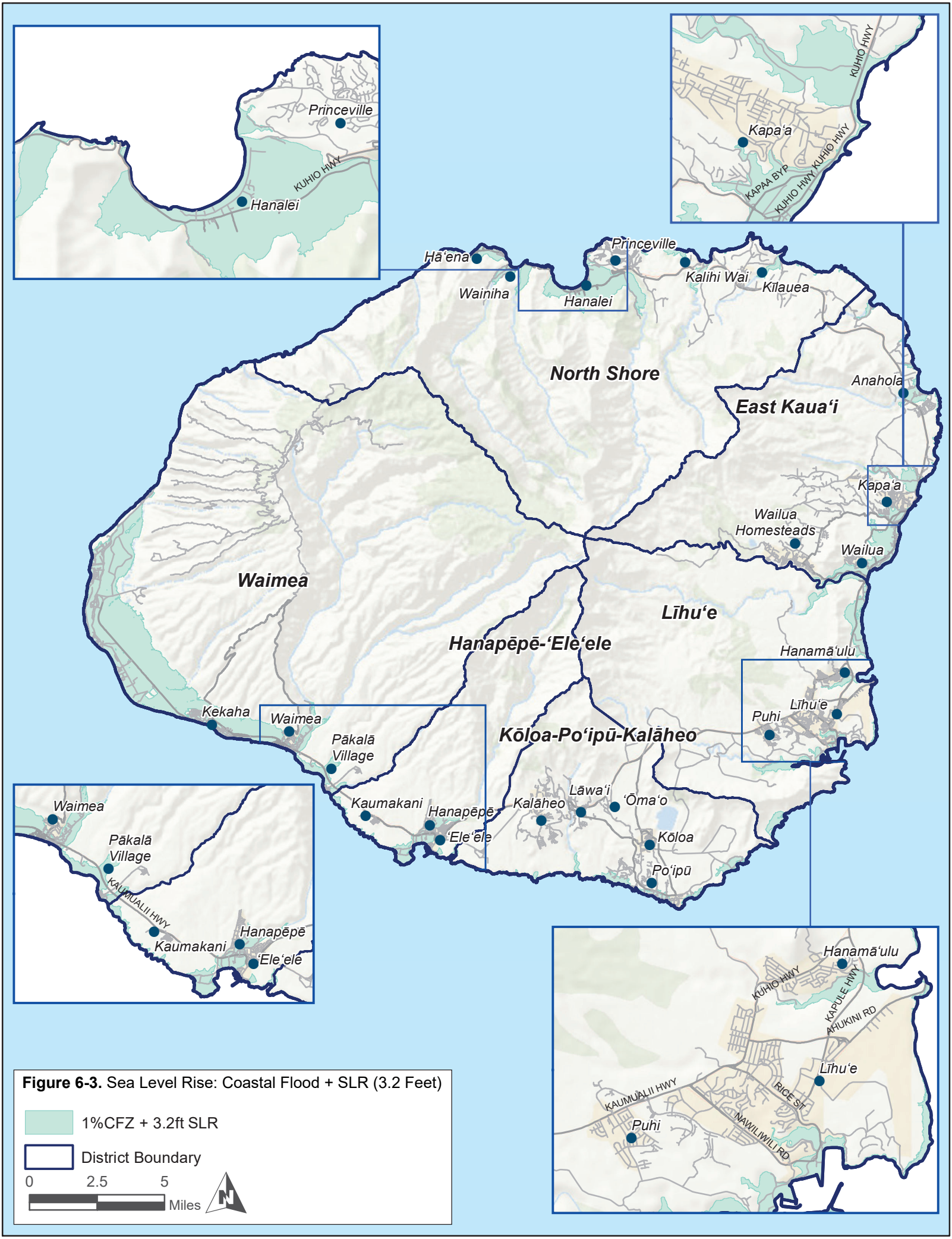


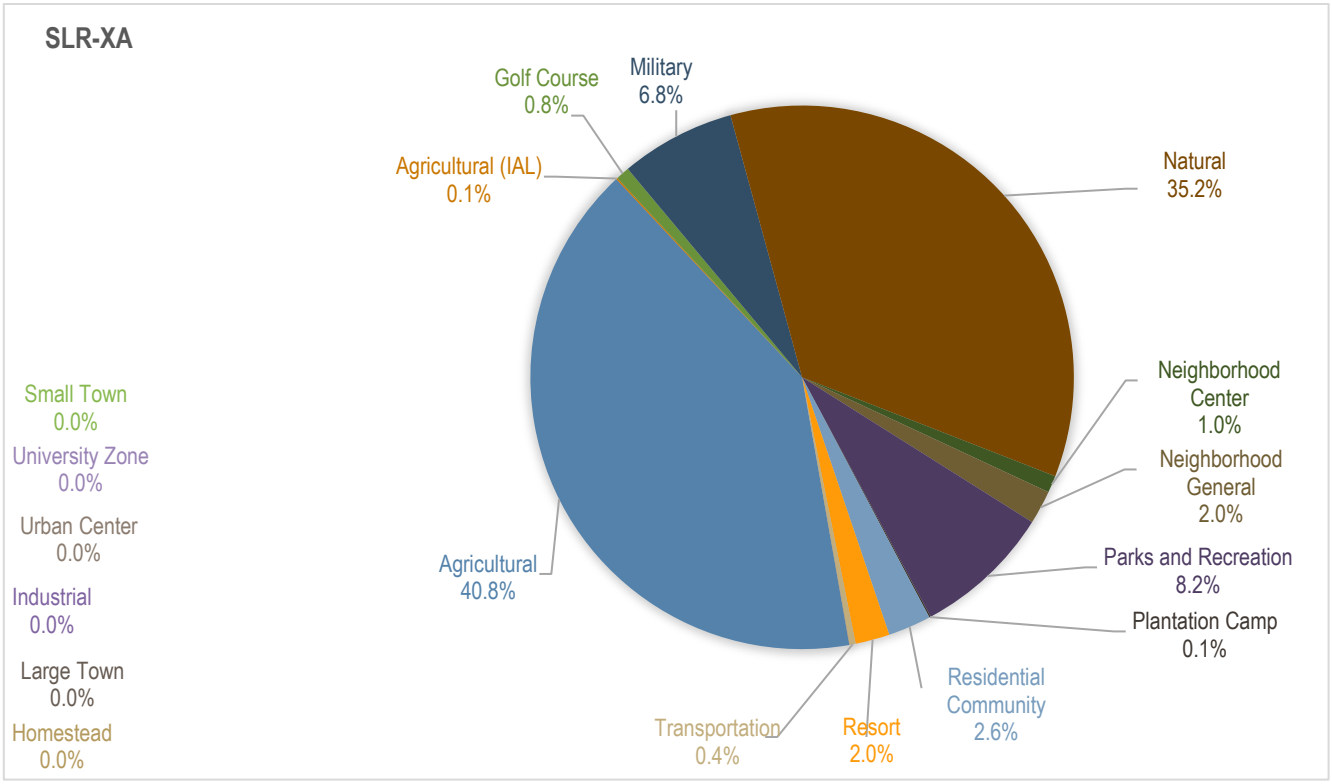
Figure 6 -2. Sea Level Rise: SLR-XA (3.2 Feet)

Sea Level Rise Exposure Area (SLR-XA) 3.2 Feet

District Boundary

0 2.5 5 Miles


Princeville
KUHIO HWY
Hanalei
KUHIO HWY
Kapa'a
KAPAA BYP
KUHIO HWY KUHIO HWY
Hā'ena
Princeville
Kalihi Wai
Kīlauea
Wainiha
Hanalei
North Shore
Anahola
East Kaua'i
Kapa'a
Wailua Homesteads
Wailua
Waimea
Līhu'e
Hanapēpē-'Elē'ele
Hanamā'ulu
Līhu'e
Puhi
Kekaha
Waimea
Pākalā Village
Kōloa-Po'ipū-Kalāheo
Kaumakani
Hanapēpē
'Ele'ele
Kalāheo
Lāwa'i
'Ōma'o
Kōloa
Po'ipū
Waimea
Pākalā Village
KAUMUALII HWY
Kaumakani
Hanapēpē
'Ele'ele
Hanamā'ulu
KUHIO HWY
KAPULE HWY
AHUKINI RD
Līhu'e
KAUMUALII HWY
RICE ST
NAWILIWILI RD
Puhi
Figure 6-3. Sea Level Rise: Coastal Flood + SLR (3.2 Feet)
1%CFZ + 3.2ft SLR
District Boundary
0
2.5
5
Miles
N



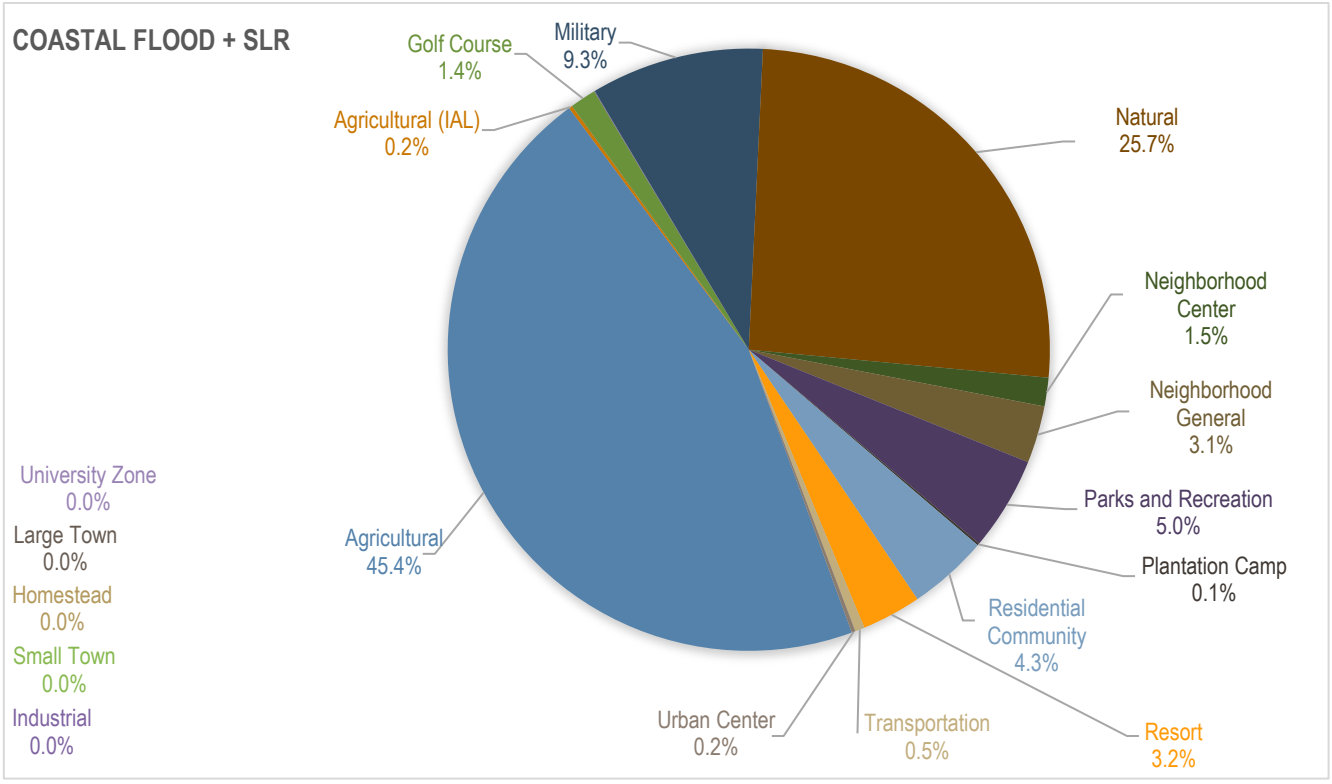


Figure 6-5. Land Use Distribution by Area in Sea Level Rise Inundation Areas

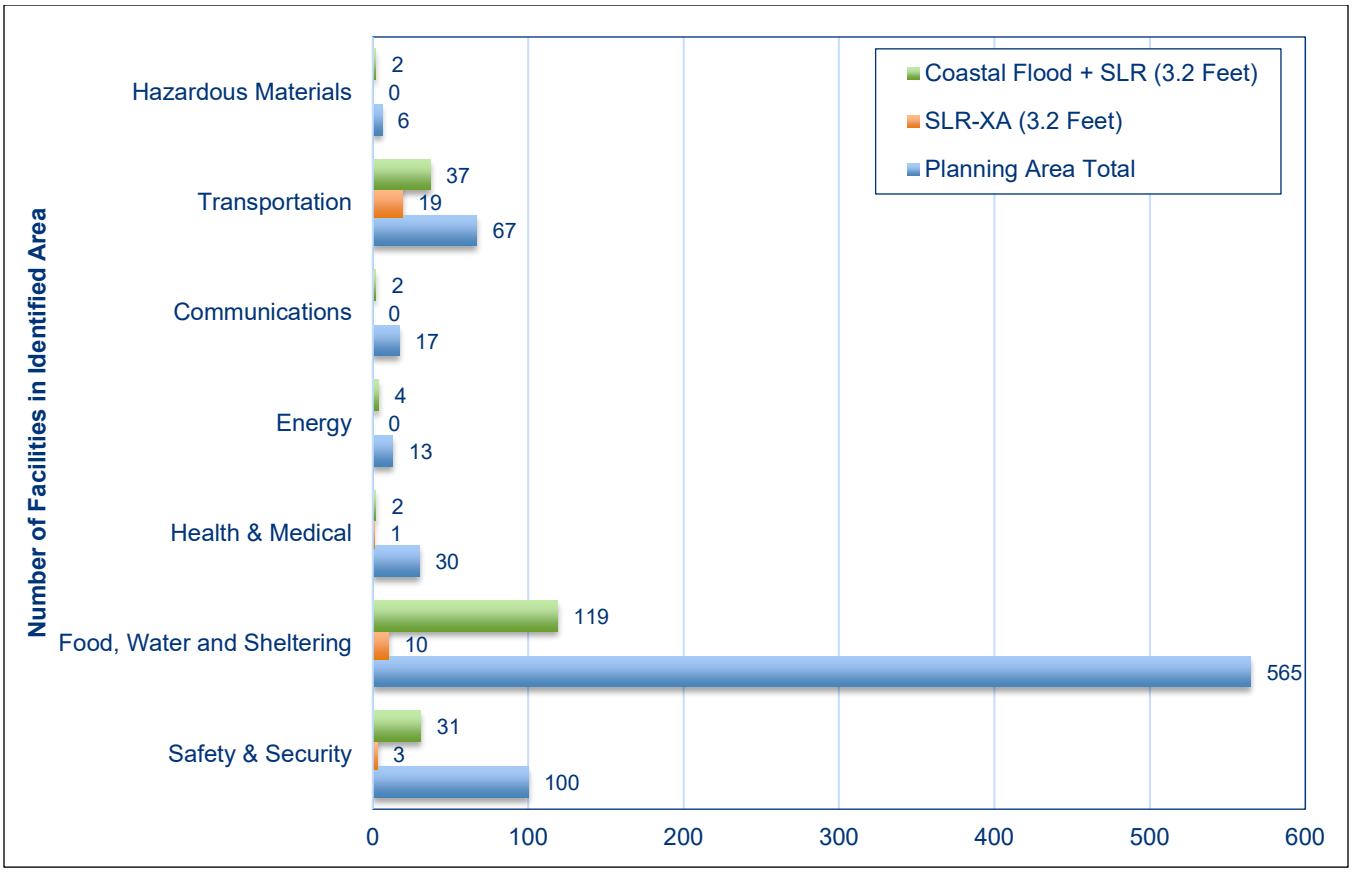


Figure 6-6. Critical Facilities in SLR-XA and Coastal Flood + SLR

Figure 6-7 provides a visual representation of the number of Katrina-magnitude surge events per decade in the past and projected changes. Each line shows the results based off different modeling techniques and data contributions. Although there is some variation depending on the model, the results show an overall positive correlation between temperature increase and storm surge frequency (Grinsted et al., 2013). Although this study focused on hurricanes and the Atlantic Ocean, which are not exactly comparable to the tropical cyclone events that impact Hawai'i, the results still highlight how a small temperature change can significantly increase damage and vulnerability. Hawai'i is expected to see an additional increase in tropical cyclone events unrelated to the increase from warmer temperatures, as the storm track may shift north toward the Central North Pacific (University of Hawai'i, 2014).

The projected increase in sea level rise has the potential to increase risk of storm surge-related flooding along the coast; expand areas at-risk of coastal flooding; increase vulnerability of energy facilities located in coastal areas; flood transportation and telecommunication facilities; and cause saltwater intrusion into some freshwater supplies near the coasts. High water levels, strong winds, and heavy precipitation resulting from severe coastal storms already cause billions of dollars in damage and disrupt transportation and utility distribution systems. Sea level rise will lead to more frequent and extensive coastal flooding. Warming ocean waters raise sea level through thermal expansion and have the potential to strengthen the most powerful tropical cyclones.

Source: Grinsted et al., 2013

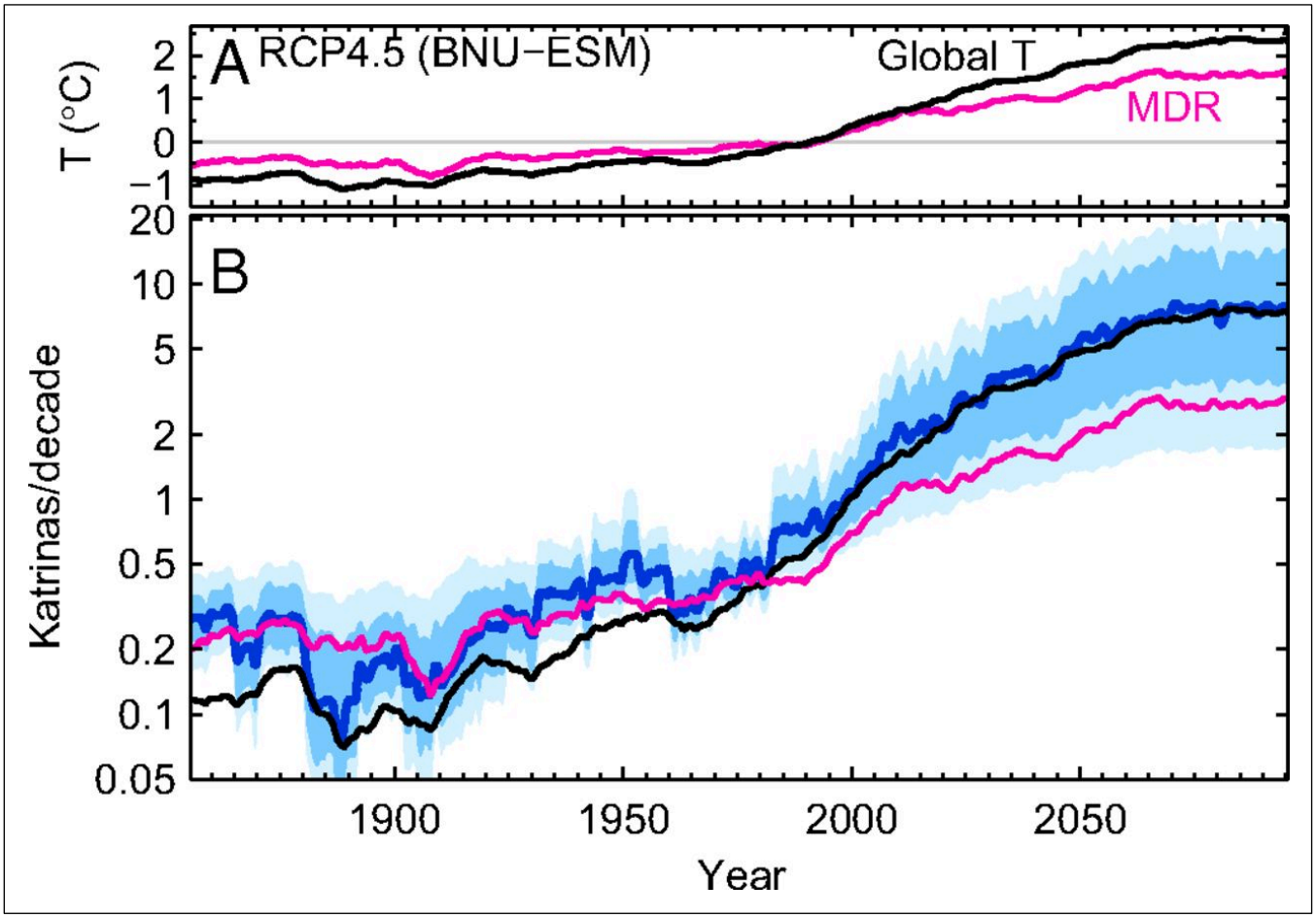


Figure 6-7. Surge Event Frequency over Time and Climate Changes

6.2.2 Wildfire

Wildfire is determined by climate variability, local topography, and human intervention. Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, ignitions, fire management, and vegetation fuels. An increase in temperature coupled with a noticeable decrease in precipitation exacerbates droughts and has the potential to contribute to an increased frequency of wildfire. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

6.2.3 Inland Flood

Use of historical hydrologic data has long been the standard of practice for designing and operating water supply and flood protection projects. For example, historical data are used for flood forecasting models and to forecast runoff for water supply. This method of forecasting assumes that the climate of the future will be similar to that of the period of historical record. However, the hydrologic record cannot be used to predict changes in frequency and severity of extreme climate events such as floods. Going forward, model calibration or statistical relation development must happen more frequently, new forecast-based tools must be developed, and a standard of

practice that explicitly considers climate change must be adopted. Climate change is already impacting water resources, and resource managers have observed the following:

- Historical hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management and ecosystem functions.
- Extreme climatic events will become more frequent, necessitating improvement in flood protection, drought preparedness and emergency response.

High frequency flood events (e.g. 10-year floods) in particular will likely increase with a changing climate. Scientists project greater storm intensity, resulting in more direct runoff and flooding. Changes in watershed vegetation and soil moisture conditions will likewise change runoff and recharge patterns. As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which increase sediment loads and water quality impacts.

As hydrology changes, what is currently considered a 100-year flood may strike more often, leaving many communities at greater risk. Planners will need to factor a new level of safety into the design, operation, and regulation of flood protection facilities such as dams, bypass channels and levees, as well as the design of local sewers and storm drains. Additionally, rising sea levels, coupled with high water levels caused by tropical and extra-tropical storms, will incrementally increase coastal flooding and erosion, damaging coastal ecosystems, infrastructure, and agriculture, and negatively affecting tourism (Leong et al., 2014).

6.2.4 High Surf, Coastal Flood and Erosion

Coastal areas are sensitive to sea-level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures. According to NASA, warmer temperatures may lead to an increase in frequency of storms, thus leading to more weather events that cause coastal erosion. A study on increased storm wave heights from climate change indicated that coastal erosion and flooding may occur twice as fast from sea level rise alone and up to four times as fast as a doubling of the frequency of major El Niño events occurring. Should all these potential subsequent events from climate change occur simultaneously, there could be up to an order of magnitude increase in coastal erosion and flood frequency compared to current rates (Ruggiero, 2008).

The *Sea Level Rise Vulnerability and Adaptation Report* has annual high wave runup data for sea level rise scenarios of 1 to 3 feet as part of SLR-XA, but high surf data can be analyzed separately.

As an island, Kaua'i County is particularly sensitive to the impacts of climate change on coastal erosion. According to the Intergovernmental Panel on Climate Change, small islands can anticipate the following effects of climate change:

- Inundated and displaced wetlands and lowlands
- Eroded shorelines
- Exacerbated coastal storm flooding
- Increase in salinity of estuaries, threatening freshwater aquifers and otherwise impair water quality
- Alteration of tidal ranges in rivers and bays
- Alteration of sediment depositional patterns.

As sea levels rise, so will the increase in pressure and strength of wave action against Kaua'i County's coastlines. Additionally, sewage and siltation are among the most significant contributions to human-caused degradation of coral-reef and other natural coastal systems in Hawai'i (Bijlsma et al., 1996).

Sea level rise, coupled with overall global warming and other climate change impacts, can lead to more frequent high surf events. It could result in currently high surf levels of 10 to 20 feet becoming normal. This change can create several secondary, negative impacts and vulnerabilities, including:

- Loss of important coastal habitats
- Increased beach and coastal erosion
- Increased life safety and property risks
- More frequent coastal flood events and greater damage from all coastal flood-related hazards.

Sea level has risen over the last century on each island in Hawai'i at rates of 0.5 to 1.3 inches per decade. Globally, rates of sea-level rise have are projected to continue to accelerate, resulting in a 3.2-foot rise by the end of the century, or as early as 2060. Sea-level rise will exacerbate coastal inundation, erosion and hazards (Hawai'i Climate Change Mitigation and Adaptation Commission, 2017).

6.2.5 Tsunami

Any rise in sea level resulting from climate change could increase the risk to coastal communities exposed to the tsunami hazard. Oceanic waves and surge could reach further inland, resulting in more damage to infrastructure and increased life safety concerns.

6.2.6 Landslide

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Warming temperatures also could increase the occurrence and duration of droughts, which would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for landslide occurrences.

6.2.7 Dam Failure

Dams are designed partly based on assumptions about a stream's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some of its designed margin of safety, also known as freeboard. If freeboard is reduced, dam operators may be forced to release increased volumes earlier in a storm cycle in order to maintain the required margins of safety. Such early releases of increased volumes can increase flood potential downstream.

Dams are constructed with safety features known as "spillways," which provide a safety measure in the event of the reservoir filling too quickly. Spillway overflow events, often referred to as "design failures," result in increased discharges downstream and increased flooding potential. Although climate change will not increase the probability of catastrophic dam failure, it may increase the probability of design failures.

6.2.8 Earthquake

The impacts of global climate change on Kaua'i's earthquake probability are unknown. Secondary impacts of earthquakes could be magnified by climate change. Soils saturated by repetitive storms could experience liquefaction or an increased propensity for slides during seismic activity due to the increased saturation. Dams storing increased volumes of water due to changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts.

6.2.9 Heat and Drought

As parts of the world get hotter and drier, the amount and quality of water available will decrease, impacting people's health and food supplies. With a warmer climate, droughts could become more frequent, more severe, and longer-lasting. Heat-related illnesses could increase the strain on healthcare facilities. More frequent extreme heat and drought events could result in decreased stream flows in local rivers, affecting water supplies for domestic and agricultural uses.

Between 2000 and 2009, approximately 30 to 60 percent of the United States experienced drought conditions at any one time (NRDC, n.d.). Hawai'i has experienced longer droughts on all the populated islands, as indicated by a comparison of the length of dry periods from 1980 to 2011 against 1950 to 1970 (University of Hawai'i, 2014).

From 1999 through 2009, extreme heat exposure caused or contributed to more than 7,800 deaths in the United States. Extreme heat is a real danger to human health, with events projected to become more frequent, longer lasting, and more severe. Average temperatures on Kaua'i have increased by approximately 1 degree since the early 20th century, whereas the entire U.S. average temperature has risen more than 2 degrees over the past 50 years (CDC, n.d.)

An option for water resource managers regarding climate change is to start addressing current stresses on water supplies and build flexibility and robustness into any system. Flexibility helps to ensure a quick response to changing conditions, and robustness helps people prepare for and survive the worst conditions. With this approach to planning, water system managers will be better able to adapt to the impacts of climate change.

7. INLAND FLOOD

This hazard mitigation plan distinguishes inland flooding—caused by overflowing rivers and streams or extreme rainfall that causes inundation of urban areas—from coastal flooding that results from high surf and storm surge. This chapter provides a risk assessment for the inland flood hazard; the risk assessment for coastal flooding is included in Chapter 8.

Floods are one of the most common natural hazards in the U.S. They can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, coastlines and multiple counties or states).

A floodplain is as the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that becomes inundated with water during a flood.

Additional general information on the inland flood hazard is provided in Appendix L.

FLOOD PROBABILITIES AND FLOOD MAPS

River flooding is measured based on the probability that a certain river flow will be equaled or exceeded in a given year. The area that is flooded by a river flow that has a **1-percent annual chance** of occurrence (also called the **base flood**) is called the **special flood hazard area**.

This area is commonly used to assess risk, and many communities have maps that show the extent and likely depth of flooding for the base flood. These maps, developed by FEMA, are called **flood insurance rate maps (FIRMs)** because the rates that property owners pay for flood insurance under the National Flood Insurance Program (NFIP) depend on the property's location relative to the mapped special flood hazard areas. A structure located within a 1-percent annual chance floodplain has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage.

FIRMs also show areas flooded by 0.2-percent annual chance river flows. They also indicate regulatory **floodways**, which are areas where development is restricted or prohibited because of the immediate flood risk and because of the potential impact of development in these zones on flooding in surrounding areas.

7.1 HAZARD PROFILE

Kaua'i County is generally susceptible to the following types of inland flooding:

- **Riverine Floods**—Small rivers and streams, such as those found in Kaua'i County, are susceptible to flooding from long-lasting or short intense rainfall. When a river or stream receives too much water, the excess water flows over its banks and inundates adjoining low-lying areas.
- **Flash Floods**—Intense rainfall may trigger flash floods, which provide little warning (less than 6 hours) before an area experiences flood conditions.
- **Rain Bombs**—Microbursts caused by a sudden concentrated downburst of wind and rain can result in flash flooding.
- **Overland Sheet Flow**—Poorly drained low-lying areas are a problem when flooding occurs even when rainfall is not heavy. Overland sheet flow occurs primarily in areas with undefined drainage ways.
- **Dam Failure Floods**—See Chapter 11 for additional information.

REPETITIVE LOSS PROPERTIES AND AREAS

A repetitive loss property is defined by FEMA as an NFIP-insured property that has experienced any of the following since 1978, regardless of any changes in ownership:

- Four or more paid losses in excess of $1,000
- Two paid losses in excess of $1,000 within any rolling 10-year period
- Three or more paid losses that equal or exceed the current value of the insured property.

Table 7-1 summarizes the key elements of the inland flood hazard profile for Kaua'i County. Additional details are provided in Appendix L.

Table 7-1. Inland Flood Hazard Profile Summary

Federal Flood Program Participation	• Kaua'i County participates in the National Flood Insurance Program and is in good standing with NFIP requirements (See Appendix J). Table 7-2 lists flood insurance statistics for Kaua'i County.
Repetitive Loss Status	• Kauai County has 45 FEMA-identified repetitive loss properties and is classified as a "Category B" repetitive loss community (1-49 properties) under FEMA's CRS program. See Appendix L for more information.
Past Events	The National Climatic Data Center's Storm Events Database lists 81 flood events in the planning area between 2005 and 2020. Notable recent floods are as follows: • December 1991—Flash floods resulting from a storm that dropped over 20 inches of rain in 12 hours over Anahola, caused five deaths, intense flooding, bank failures, erosion, and slides, totaling more than $5 million in property damage. • October/November 2006—Two systems caused heavy rainfall, especially along windward sections, which received over 15 inches of rain. Some locations received over 3 inches in 1 or 2 hours. The excessive rain produced flooding over windward portions of Kaua'i. • April 2018—Heavy rain generated historic flash flooding conditions. A 24-hour rainfall total of 50 inches was recorded near Hanalei. The deluge, mainly over northern Kaua'i but also affecting east O'ahu, damaged or destroyed farms and structures, including 532 homes. The storm downed trees and power lines, flooded homes, businesses and vehicles, and closed and damaged numerous roadways. Highway and road repairs were estimated at $35 million. The Hawai'i state legislature approved $125 million in relief aid. A major disaster declaration (DR-4365) was issued, with over $11 million in Public Assistance and $1.6 million for Individual Assistance. • March 2020—Heavy rainfall led to severe flooding. Kūhiō Highway was closed near the Hanalei Bridge as the Hanalei River overflowed along the roadway. Kūhiō Highway was also closed in Wailua as debris piled up against the Wailua River Bridge. A major disaster declaration (DR-4549) was issued to assist with recovery.
Location	The mapped 1 percent annual chance floodplain covers 3 percent of the entire County (7,358 acres). The districts with the greatest area of mapped floodplain are Waimea (4,375 acres), North Shore (2,063 acres), and East Kaua'i (1,538 acres). FEMA has identified 45 repetitive loss and severe repetitive loss properties that are within repetitive loss areas. Figure 7-1 shows the repetitive loss areas.
Frequency	The planning area can expect an average of one episode of minor river flooding each winter. Large, damaging floods typically occur every 10 years.
Severity	Floods that cause millions of dollars in damage are not uncommon in the planning area. At least three such events have been recorded since 2000, as described in the "past events" listing above.
Warning Time	Due to the sequential pattern of weather conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Warning times for floods can be between 24 and 48 hours. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flooding danger.
Secondary Hazards	Bank erosion, landslides, hazardous material spills

See Section 1.4.2 for a description of elements included in the hazard profile

Table 7-2. Flood Insurance Statistics

Date of Entry Initial FIRM Effective Date	11/04/1981
# of Flood Insurance Policies as of 07/21/2020	4,792
Insurance In Force	$1,019,373,800
Total Annual Premium	$4,387,457
Claims, as of February 29, 2020	1,312
Value of Claims Paid, as of February 29, 2020	$38,416,601
Average Payment per Claim, as of February 29, 2020	$29,281

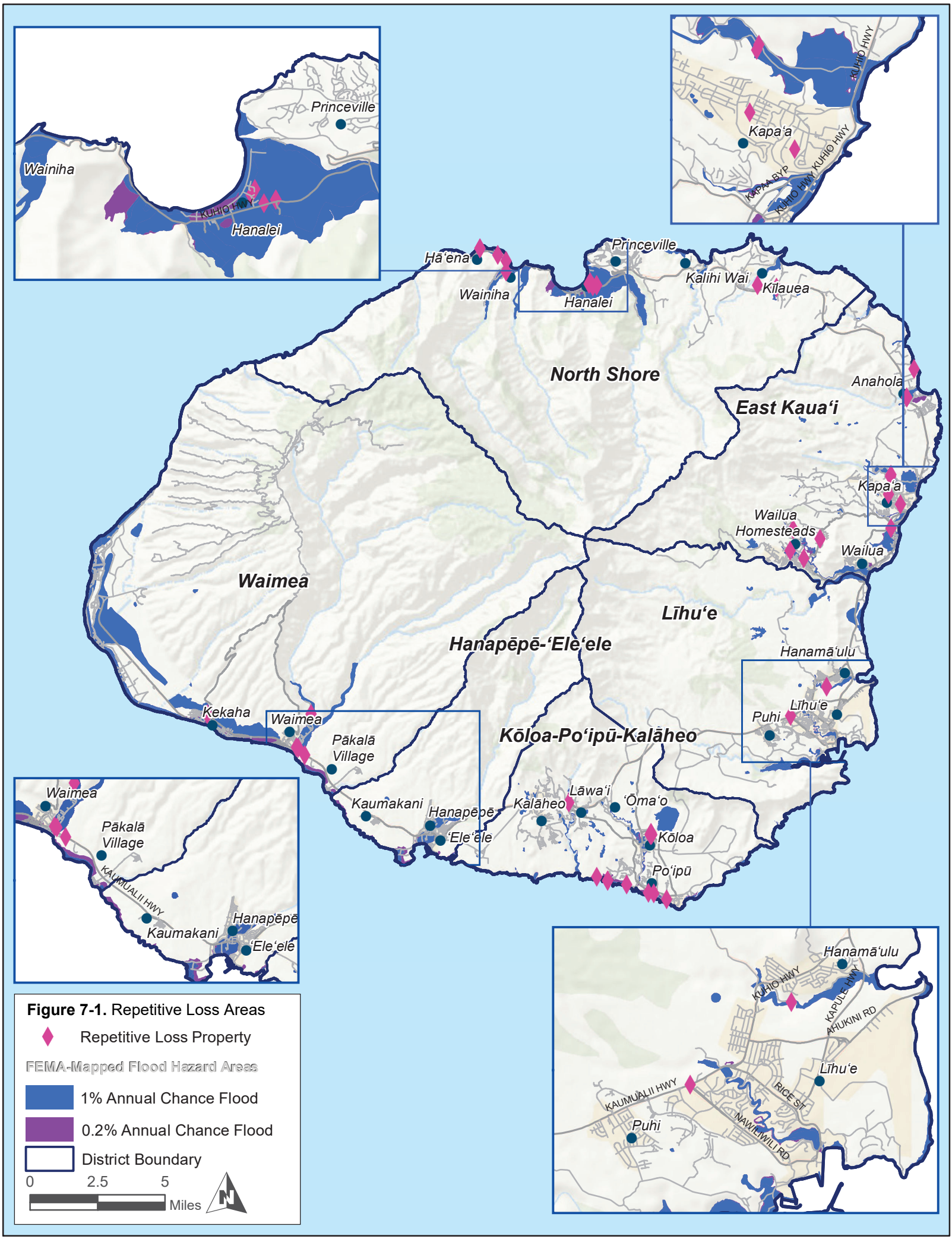


Figure 7-1. Repetitive Loss Areas

Repetitive Loss Property

FEMA-Mapped Flood Hazard Areas

1% Annual Chance Flood

0.2% Annual Chance Flood

District Boundary

0 2.5 5 Miles

7.2 RISK ASSESSMENT

7.2.1 Scenario

The quantitative risk assessment for the inland flood hazard was conducted for a 1 percent annual chance riverine flood (see Figure 7-2), using the asset inventory developed for this plan. Most of the flood zones used for the quantitative risk assessment are from the effective DFIRM dated November 26, 2010. However, selected flood zones from the preliminary DFIRM (PFIRM), dated May 24, 2019 were combined with the effective DFIRM data. The PFIRM, which is expected to become effective in the spring of 2021, accounts for de-certified levees on the Waimea River, the Hanapēpē River, and Moloaʻa Stream (County of Kauaʻi, 2020a).

7.2.2 Exposure

Population and Property

Detailed results for exposed populations and properties are provided by district in Appendix M; Table 7-3 summarizes the results for the entire planning area. Population exposure was estimated by calculating the number of buildings in the FEMA-mapped floodplain as a percent of total planning area buildings, and then applying this percentage to the estimated planning area population.

Table 7-3. Exposed Population and Property in Mapped 1% Annual Chance Riverine Flood Zone

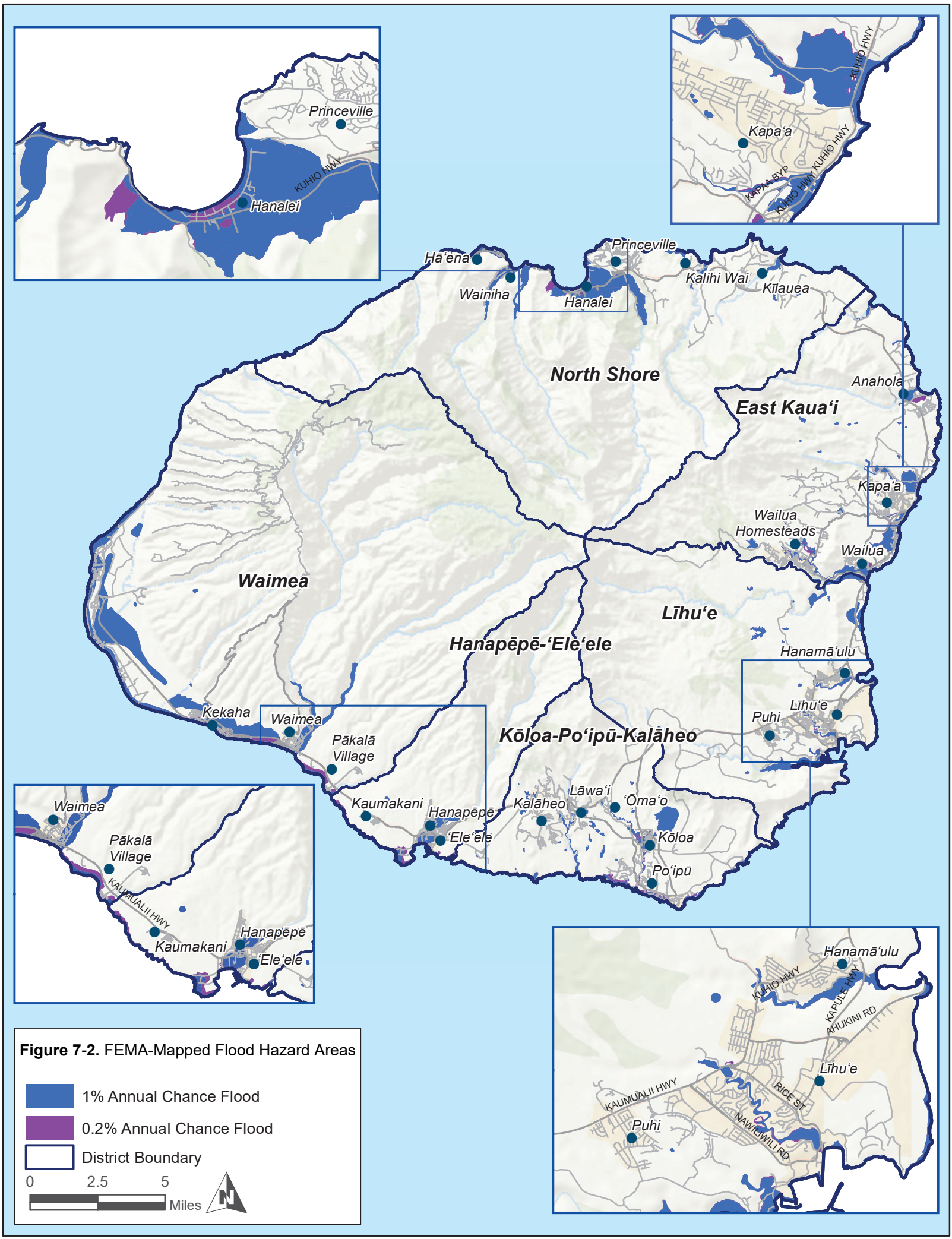
Population	
Population Exposed	6,796
% of Total Planning Area Population	9.8%
Property	
Number of Buildings Exposed	3,608
Value of Exposed Structures	$1,180,911,317
Value of Exposed Contents	$795,647,779
Total Exposed Property Value	$1,976,559,096
Total Exposed Value as % of Planning Area Total	9.7%

Critical Facilities

Critical facilities exposed to the 1-percent-annual-chance flood hazard represent 11.9 percent (95 facilities) of the total critical facilities in the planning area. The breakdown of exposure by facility type is shown in Figure 7-3.

The exposure of specific types of critical facilities has been quantified as follows:

- **Roads**—A complete analysis of roads in the inland (riverine) flood area can be found in Appendix R. The following major roads in the planning area pass through the 1-percent-annual-chance flood zone and thus are exposed to flooding:
  - Ahukini Road
  - Ala Kinoiki Road
  - Alae Road
  - Kamalu Road
  - Kapaʻa Bypass
  - Kapule Highway
  - Kaumualiʻi Highway
  - Kekaha Road
  - Kōkeʻe Road
  - Kōloa Road
  - Kuamoʻo Road
  - Kūhiō Highway
  - Maluhia Road
  - Poʻipū Road
  - Rice Street


Princeville
KUHIO HWY
Hanalei
Kapa'a
KUHIO HWY
KAPAA BYP
KUHIO HWY
Hā'ena
Princeville
Kalihi Wai
Kīlauea
Wainiha
Hanalei
North Shore
Anahola
East Kaua'i
Kapa'a
Wailua Homesteads
Wailua
Waimea
Līhu'e
Hanapēpē-'Elē'ele
Hanamā'ulu
Līhu'e
Puhi
Kekaha
Waimea
Pākalā Village
Kōloa-Po'ipū-Kalāheo
Kaumakani
Hanapēpē
'Ele'ele
Kālāheo
Lāwa'i
'Ōma'o
Kōloa
Po'ipū
Waimea
Pākalā Village
KAUMUALII HWY
Kaumakani
Hanapēpē
'Ele'ele
Hanamā'ulu
KUHIO HWY
KAPULE HWY
AHUKINI RD
Līhu'e
KAUMUALII HWY
RICE ST
NAWILIWILI RD
Puhi
Figure 7-2. FEMA-Mapped Flood Hazard Areas
1% Annual Chance Flood
0.2% Annual Chance Flood
District Boundary
0
2.5
5
Miles
N

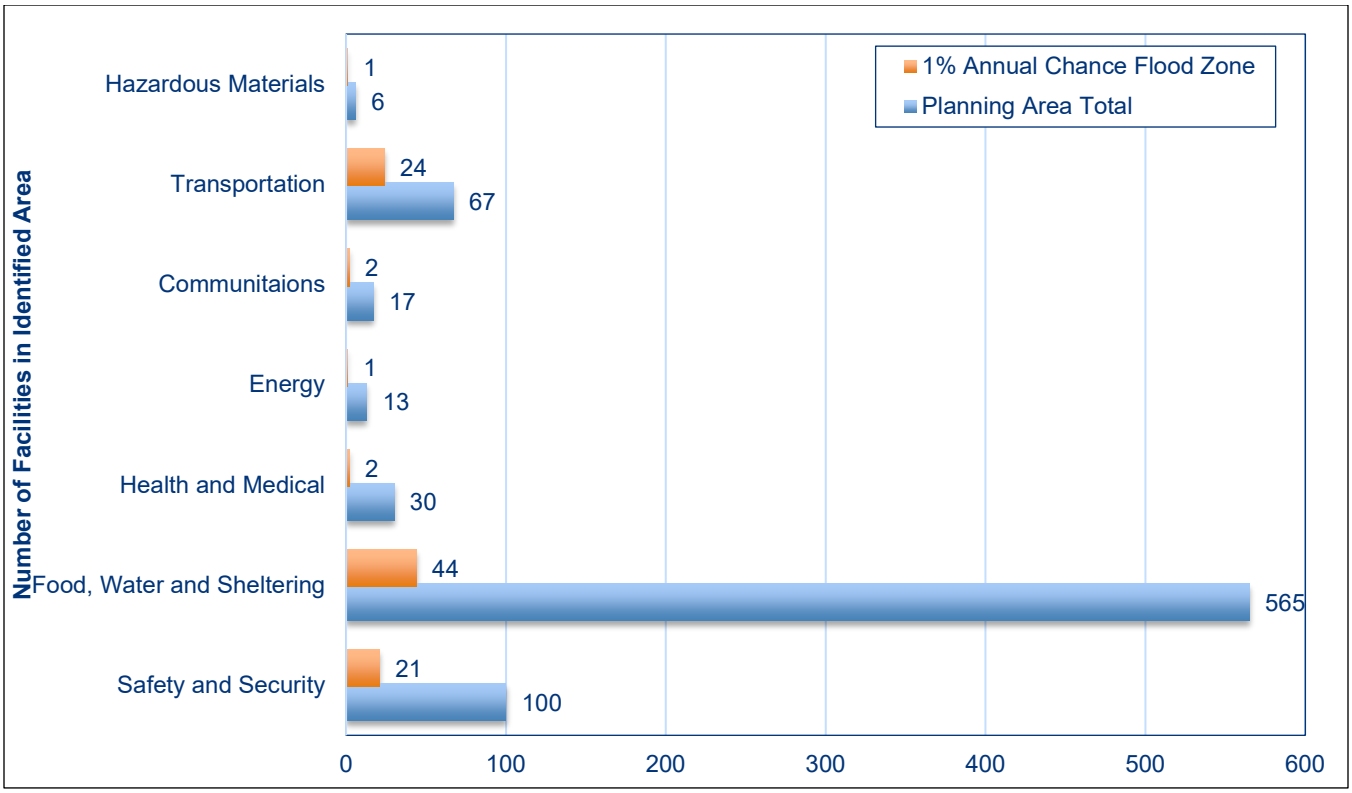


Figure 7-3. Critical Facilities in Mapped Flood Hazard Areas and Countywide

- **Bridges**—Flooding events can significantly impact road bridges. The risk assessment identified 19 bridges that are in or cross over the 1-percent-annual-chance flood zone.
- **Toxic Release Inventory Reporting Facilities**—Toxic Release Inventory facilities are known facilities that use certain chemicals above minimum thresholds. During a flood event, containers holding these materials can rupture and leak. One Toxic Release Inventory facility has been identified as being within the 1-percent-annual-chance flood zone.

Environment

All environment within the mapped floodplain is exposed to the hazard from a 1 percent annual chance flood.

7.2.3 Vulnerability

This section describes vulnerabilities for the total planning area in terms of population, property, critical facilities, and the environment. Detailed results by district are provided in Appendix M.

Population

Vulnerable Populations

The following populations living in the floodplain are particularly vulnerable to the flood hazard:

- Economically Disadvantaged Population (defined as having household incomes of $20,000 or less)
- Population over 65 Years Old
- Population under 16 Years Old

Impacts on Persons and Households

The Hazus analysis of impacts on persons and households in the planning area estimated that 2,463 people could be displaced by the 1-percent-annual-chance event and that 133 people would need short-term sheltering following the event.

PUBLIC HEALTH AND SAFETY

Floods and their aftermath present the following threats to public health and safety:

- **Unsafe food—**Floodwaters contain disease-causing bacteria, dirt, oil, human and animal waste, and farm and industrial chemicals. Their contact with food items, including food crops in agricultural lands, can make that food unsafe to eat.
- **Contaminated drinking and washing water and poor sanitation—**Flooding impairs clean water sources with pollutants. The pollutants also saturate into the groundwater. Flooded wastewater treatment plants can be overloaded, resulting in backflows of raw sewage.
- **Mosquitoes and animals—**Floods provide new breeding grounds for mosquitoes in wet areas and stagnant pools. The public should dispose of dead animals that can carry viruses and diseases only in accordance with guidelines issued by local animal control authorities.
- **Mold and mildew—**Excessive exposure to mold and mildew can cause flood victims—especially those with allergies and asthma—to contract upper respiratory diseases.
- **Carbon monoxide poisoning—**In the event of power outages following floods, some people use small gasoline engines, stoves, generators, lanterns, gas ranges, charcoal or wood for heating or cooking in enclosed or partly enclosed spaces. Carbon monoxide from these sources can poison people and animals.
- **Hazards when reentering and cleaning flooded homes and buildings—**Flooded buildings can pose significant health hazards to people entering them. Electrical power systems can become hazardous. Gas leaks can trigger fire and explosion. Flood debris may cause injuries.
- **Mental stress and fatigue—**People who live through a devastating flood can experience long-term psychological impact. The expense and effort required to repair flood-damaged homes places severe financial and psychological burdens on the people affected.

Property

Table 7-4 summarizes Hazus estimates of flood damage in the planning area. The debris estimate includes only structural debris and building finishes; it does not include additional debris that may result from a flood event, such as from trees, sediment, building contents, bridges or utility lines.

Table 7-4. Estimated Impact of a 1 Percent-Annual-Chance Flood Event in the Planning Area

Structure Debris Generated (Tons)	74,273 (2,971 25-ton truckloads)
Buildings Impacted	3,091
Total Value (Structure + Contents) Damaged	$248 Million
Damage as % of Total Value	1.2%

Critical Facilities

Hazus was used to estimate the loss potential to critical facilities exposed to the flood risk, using depth/damage function curves to estimate the percent of damage to the building and contents of critical facilities. Table 7-5 shows the results for the 1 percent-annual-chance flood event.

Table 7-5. Estimated Impact of a 1 Percent-Annual-Chance Flood Event on Critical Facilities

	Number of Facilities Affected	Average % of Total Value Damaged	
		Structure	Contents
Safety and Security	18	8.95%	49.11%
Food, Water and Sheltering	17	25.19%	27.57%
Health and Medical	2	6.64%	11.72%
Energy	1	0.92%	1.84%
Communications	2	9.23%	52.55%
Transportation	20	1.28%	0.10%
Hazardous Materials	1	10.33%	16.46%
All Facilities	**61**	**8.93%**	**22.76%**

A major storm during the rainy season that occurs during high tide could flood numerous areas in a short time, overwhelming the response and floodplain management capability within the planning area. Major roads could be blocked, preventing critical access for many residents and critical functions. High in-channel flows could cause water courses to scour, possibly washing out roads and creating more isolation problems. In the case of multi-basin flooding, Kaua'i County would not be able to make repairs quickly enough to restore critical facilities.

Environment

Flooding can harm the environment. Pollution from roads can wash into rivers and streams. Flooding-caused stream bank erosion can cause rivers and streams to migrate into non-natural courses. Fish can wash into roads or flooded fields. Loss estimation platforms such as Hazus are not equipped to measure environmental impacts of flood hazards. Loss data that segregates damage to the environment was not available at the time of this plan. Capturing such data from future events could aid future assessments of the environment's vulnerability.

7.3 ISSUES

7.3.1 Development in High-Hazard Areas

Some land uses are more vulnerable to flooding, such as single-family homes, while others are less vulnerable, such as agricultural land. Figure 7-4 shows the distribution of land use types in the flood zones. The dominant land uses are open areas and agricultural uses, which are considered to be lower-risk uses for the floodplain. Most homes and facilities are in areas designated urban center, neighborhood center, neighborhood general, or residential community. In all, 11.2 percent of the inland flood hazard area is highly developed.

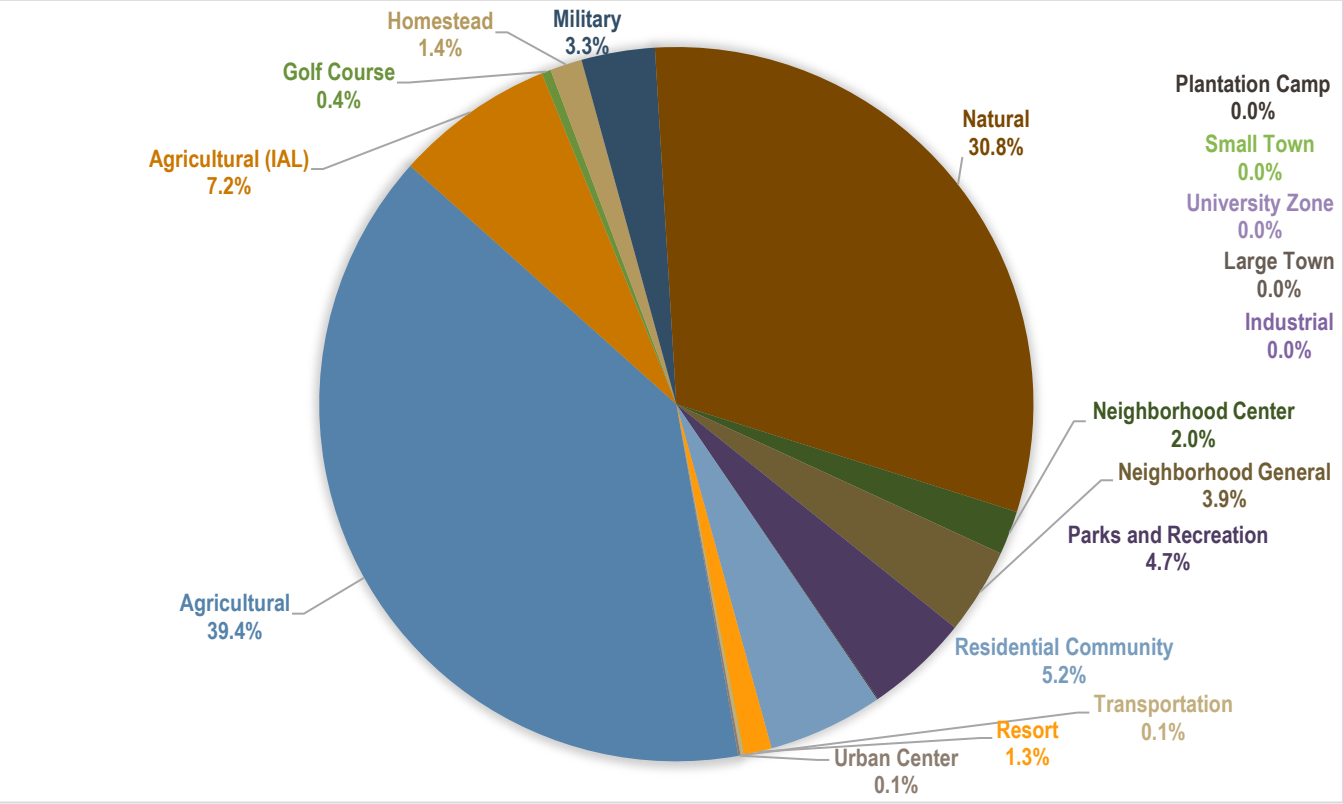


Figure 7-4. Land Use Distribution by Area in the 1-Percent-Annual-Chance Riverine Flood Hazard Area

The U.S. Census Bureau estimates that the County of Kaua'i had a population of 72,293 as of July 2019, and the population is slated to grow to 88,013 by 2035—nearly a 22 percent increase in 16 years (County of Kaua'i, 2018). Kaua'i County is equipped to handle future growth within flood hazard areas. The County participates in the NFIP and has adopted a flood damage prevention ordinance in response to its requirements. Kaua'i County has committed to maintaining its good standing under the NFIP through initiatives identified in this plan. Linking the County's general plan and community plans to this hazard mitigation plan update will create an opportunity for wise land use decisions as future growth impacts flood hazard areas.

7.3.2 Other Issues

The following issues have been identified related to the flood hazard in the planning area:

- **Visitor Awareness for Flooding**—Visitors are often unaware of the flooding dangers in the areas of their accommodations and activities. Public awareness campaigns could target visitor accommodations to inform visitors of the flood risks.
- **Hiker Outreach for Flash Flooding**—Tourists hiking Kaua'i County's numerous trails are not always cognizant of issues associated with flash flooding. The County could develop a tourism outreach program specifically designed to inform hikers about the danger and potential for flash flooding.
- **Climate Change Future Impacts**—Climate change has the potential to drastically alter the severity, location, and extent of flooding in Kaua'i County. The County must remain vigilant and be prepared to address anticipated and new issues as they occur as a direct result of climate change.
- **Levee Renovation**—Older levees are subject to failure or do not meet current building practices for flood protection. The County should discuss and investigate the resources needed to bring these levees up to date and reaccredited.
- **Multi-hazard Mitigation Techniques**—The risk associated with the flood hazard overlaps the risk associated with other hazards such as hurricane and landslide. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- **Risk Based Analysis**—Collect more information on flood risk to support the concept of risk-based analysis of capital projects.
- **Historical Data Collection**—There needs to be a sustained effort to gather historical damage data, such as high water marks on structures and damage reports, to measure the effectiveness of future mitigation.
- **Funding Identification**—Ongoing flood hazard mitigation will require funding from multiple sources.
- **Resident Education**—Floodplain residents need to continue to be educated about flood preparedness and the resources available during and after floods.
- **Residual Risk**—Residual risk (the risk that remains after all mitigation actions and risk reduction actions have been completed) associated with the flooding hazard is high due to the topography and nature of flooding in Kaua'i County. The concept of residual risk should be considered in the design of future capital flood control projects and should be communicated with residents living in the floodplain.
- **Continue Emphasizing the Value of Flood Insurance**—As a flood-prone area, Kaua'i County understands the importance and power of educated residents. The County should continue the promotion of flood insurance as a means of protecting private property owners from the economic impacts of frequent flood events.
- **Upholding Land-Use Regulations**—Existing floodplain-compatible uses such as agricultural and open space need to be maintained. There is constant pressure to convert these existing uses to more intense uses within the planning area during times of moderate to high growth.
- **Proactive Floodplain Management**—The economy affects a jurisdiction's ability to manage its floodplains. Budget cuts and personnel losses can strain resources needed to support floodplain management. The County should proactively manage current and future floodplains during affluent times to ensure self-sustainment of floodplains during budget cuts and personal losses.

- **Repetitive Loss Properties**—Several repetitive loss properties are located outside of FEMA mapped flood zones. Additional investigation and outreach should be conducted to determine likely sources of flood damage for these properties.

8. HIGH SURF, COASTAL FLOOD AND EROSION

The greatest number of deaths, injuries and rescues in the Hawaiian Islands are from high waves breaking at the shoreline. High surf, resulting from dangerous and damaging waves, is typically described as waves ranging in height from 10 feet to 20 feet or more. The hazards associated with high surf include debris overwash, flooding, erosion, high wave energy and turbulence in the near shore zone, and strong currents.

Coastal floods are characterized by inundation of normally dry lands by ocean waters. This flooding is often caused by storm surge that occurs during severe storms, tsunamis, or extreme high tide events (sometimes called king tides) that result in shallow flooding of low-lying coastal areas. Coastal floods typically result in coastal erosion, salinization of freshwater sources, and contamination of water supplies. These floods are also responsible for significant agricultural losses, loss of life and damage to public and private structures and infrastructure.

Coastal erosion occurs when strong wave action, coastal floods, and local sea level rise wear away rocks, soil, and sand along a coastline. In the United States, coastal erosion causes roughly $500 million in coastal property loss each year. In Hawai‘i, 70 percent of beaches are eroding and 13 miles of beaches have been lost, with 3.7 miles lost on Kaua‘i. Beaches serve as a buffer between wave action and the land and are the lifeline of Hawai‘i’s economy. Shoreline resources and the ocean-based economy in Hawai‘i are worth over $9 billion annually (U.S. Army Corps of Engineers, 2018). Coastal erosion affects all shorelines but erosion rates and potential impacts are highly localized (U.S. Climate Resilience Toolkit, 2020). Coastal erosion has the potential to exacerbate high surf or tsunami/run-up incidents along coast flood zones subject to wave action.

Additional general information on the high surf, coastal flood and erosion hazard is provided in Appendix L.

8.1 HAZARD PROFILE

Table 8-1 summarizes the key elements of the high surf, coastal flood and erosion hazard profile for Kaua‘i County. The frequency and severity of flooding for coastal systems are measured using wave heights. Additional details are provided in Appendix L.

8.2 RISK ASSESSMENT

8.2.1 Scenario

The worst-case scenario would be high wave events from tropical cyclones coinciding with high tide. During a scenario of this magnitude, individuals and properties alike are potentially impacted by high surf, coastal flooding and erosion.

Table 8-1. High Surf, Coastal Flood and Erosion and Erosion Hazard Profile Summary

Past Events	February 2016, high surf of 55 feet, beach erosion, damage to roadways, one death; November 2016, surf of 25 to 40 feet, one death; January 2017, swells of 15 to 30 feet, one death.
Location	North-facing shores frequently between October and March. East-facing shores from trade wind swell-induced waves. South-facing shores are exposed to Kona storms and southern swells. Long-term erosion of sandy beaches affects 78 percent of east beaches and 76 percent of north beaches. South beaches (63 percent) and west beaches (64 percent) are also significantly affected by erosion.
Frequency	95 high surf events from January 2018 through April 2020 on all coasts of the County of Kaua'i, an average of more than three per month.
Severity	The highest hazard occurs in most cases for north-facing shorelines where north Pacific swells arrive in the winter with regularity in heights exceeding 12 feet. Sets of these large waves are characterized by rapid onset so that within a few seconds they can double in size, often catching unaware swimmers, fishermen, and hikers walking along the shoreline. The water level on the coast increases with these large waves, and rip currents are generated as excess water surges seaward.
Warning Time	The timing of individual waves cannot be predicted, however general forecasting can be made about surf conditions. High surf warnings and high surf advisories are issued by the National Weather Service.
Secondary Hazards	Debris overwash, flooding, high wave energy and turbulence in the nearshore zone, and strong currents. Loss of beaches due to erosion can have negative impacts on ecosystems, native species, cultural and historical sites, recreation, subsistence practices and tourism.

See Section 1.4.2 for a description of elements included in the hazard profile

8.2.2 Exposure

Although FEMA's coastal flood zones were not developed exclusively to address the impacts of high surf, they do provide an approximate delineation of areas that may be at risk. FEMA-mapped coastal flood zones thus form the basis of the high surf hazard exposure and vulnerability assessment. A quantitative assessment was made of exposure in these zones. Detailed results by district are provided in Appendix M; results for the total planning area are presented below. The coastal zones in Hawai'i also include tsunami inundation risk in some areas, so these zones are likely to overestimate the risk from high surf impacts alone.

Population and Property

Table 8-2 summarizes the estimated population living in the mapped coastal flood zone and the estimated property exposure. The population at greatest risk for exposure to the high surf hazard is individuals along the affected beachfront areas. Surfers are potentially most at risk, as they will pursue their sporting activity during times when surf conditions are high.

Table 8-2. Exposed Population and Property in the 100-Year Coastal Flood Zone

Population	
Population Exposed	872
% of Total Planning Area Population	1.3%
Property	
Number of Buildings Exposed	593
Value of Exposed Structures	$199,486,350
Value of Exposed Contents	$106,392,757
Total Exposed Property Value	$305,879,108
Total Exposed Value as % of Planning Area Total	1.5%

Critical Facilities

Figure 8-1 summarizes the critical facilities in the coastal flood zones of the planning area. Critical facilities located just beyond the coastal flood zones may be exposed if previous high surf or storm events destroyed the beach buffer. In addition to facilities that may be exposed to high surf, coastal transportation routes may be exposed. These routes are often located in areas in which coastal erosion has gradually worn away the beach buffer, causing the potential for roadway inundation during high surf events. See Appendix R for a detailed analysis of roads in the coastal flood hazard area.

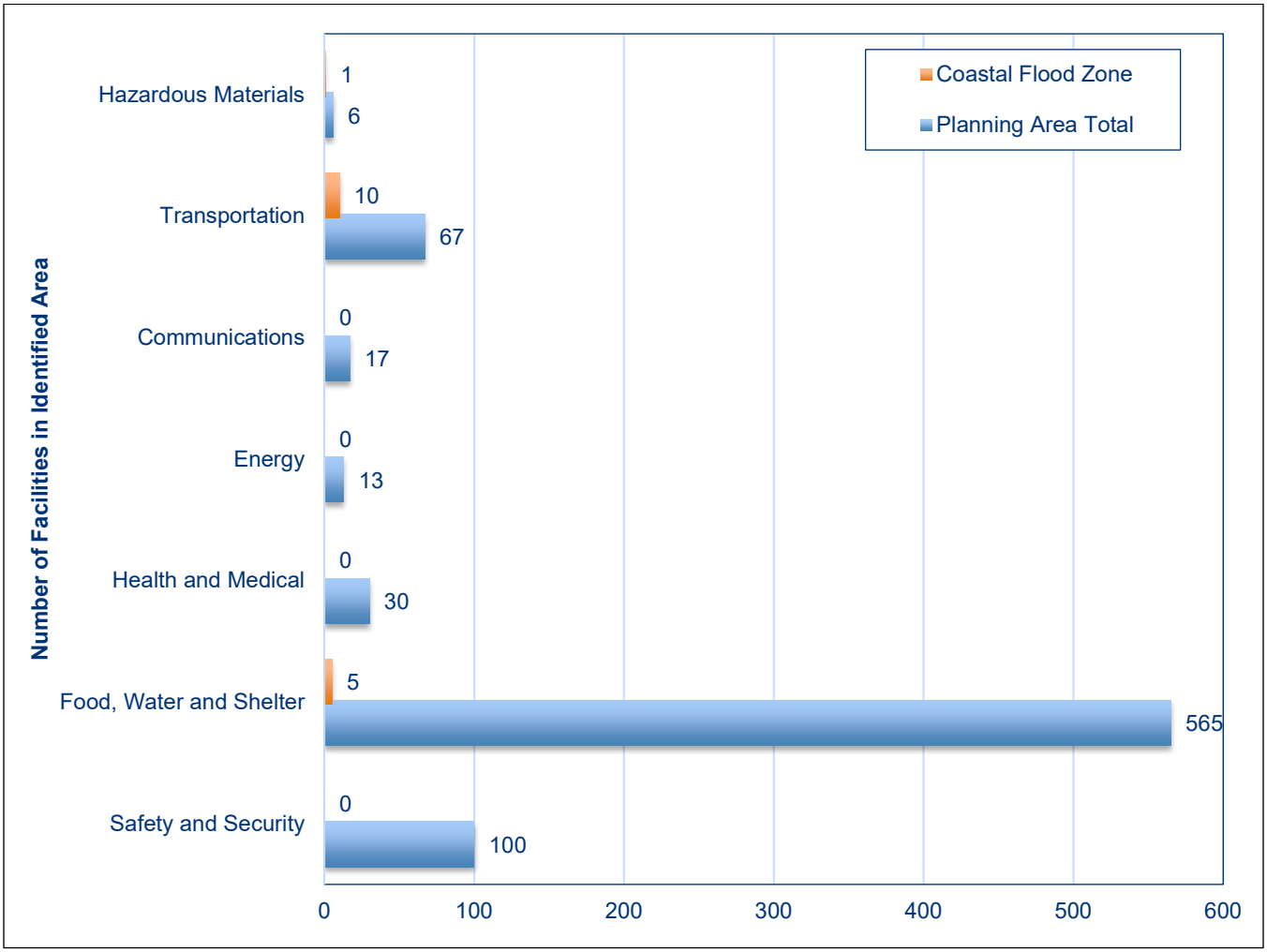


Figure 8-1. Critical Facilities in Mapped Coastal Flood Zone

Environment

All beaches are vulnerable to the effects of high surf events and chronic erosion. Beaches provide important habitat for sea birds, shore birds, sea turtles, monk seals, native dune vegetation, insects, and invertebrates. In 2014, a study published in the journal *Nature Communications* indicated that coral reefs play an extremely large role in the dissipation of wave energy that affects high surf on beach areas. This study indicated that wave energy is reduced by an average of 97 percent, with reef crests alone dissipating most of the energy. This study further explores and asserts that natural reef formations can provide comparable wave attenuation benefits to those provided by artificial means, such as breakwaters (Ferrario et al., 2014). Coral reefs not only provide protection from wave energy but also are a source of sand for beaches (U. S. Army Corps of Engineers, 2018).

8.2.3 Vulnerability

Population

The population most vulnerable to high surf events and strong currents are beach goers, swimmers, fisherman, and hikers along the shoreline. The homeless population that gathers in beach parks is especially vulnerable to high surf and coastal flood. A particular population vulnerable to the high surf hazard is surfers. High surf indicates larger waves, which many amateur and professional surfers actively seek. As a result, warnings and advisories may cause an opposite effect for these populations. This requires beach patrols and first responders to remain on alert during days when surfers may ignore warnings and advisories in an effort to catch large waves.

Property

Loss estimations for the high surf hazard are not based on modeling utilizing damage functions, because the available modeling includes impacts from other hazards such as hurricanes and tsunami, not exclusively high surf. Instead, loss estimates were developed representing 1 percent, 10 percent, 30 percent and 50 percent of the replacement value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 8-3 shows the general building stock loss estimates in FEMA mapped coastal zones.

Table 8-3. Loss Potential for Coastal Flood Zones

Damage Type	1% Annual Chance Coastal Flood
Structure Debris (Tons)	35,469
Buildings Impacted	535
Total Value (Structure + Contents) Damaged	$40.4 million
Damage as % of Total Value	Less than 1%

Critical Facilities

Hazus was used to estimate the loss potential to critical facilities exposed to the coastal flood risk, using depth/damage function curves to estimate the percent of damage to the building and contents of critical facilities. This helps to gauge how long the planning area could have limited usage of facilities deemed critical to flood response and recovery. Table 8-4 shows the results for the 1 percent-annual-chance coastal flood event.

Table 8-4. Estimated Impact of a 1 Percent-Annual-Chance Coastal Flood Event on Critical Facilities

	Number of Facilities Affected	Average % of Total Value Damaged	
		Building	Contents
Safety and Security	0	N/A	N/A
Food, Water and Sheltering	4	30%	N/A
Health and Medical	0	N/A	N/A
Energy	0	N/A	N/A
Communications	0	N/A	N/A
Transportation	5	1.25%	N/A
Hazardous Materials	0	N/A	N/A
All Facilities	**9**	**15.63%**	**N/A**

Areas important for tourism and commerce, lying between Wailua and Kapa'a and along the North Shore, are situated on low coastal plains, and so experience periodic wave over-wash, which causes rapid erosion and temporarily disrupts transportation.

Environment

Erosion and secondary hazards associated with high surf events will likely have some of the most damaging effects on the environment. A combination of wave height and a long duration of swells impacting the shoreline can increase beach erosion, damage homes and infrastructure, as well as blocking coastal highways with sand, debris, and water (Meiers, 2014). Coastal habitats are critical to the natural environment, society, and economy of Hawai'i, and their loss has compounding effects on the vulnerability of the community at large.

A 2014 study indicated that coral reefs play a large role in the dissipation of wave energy that affects beach areas. This study indicated that wave energy is reduced by an average of 97 percent, with reef crests alone dissipating most of the energy. This study asserts that natural reef formations can provide comparable wave attenuation benefits to those provided by artificial means, such as breakwaters (Ferrario et al., 2014).

8.3 ISSUES

8.3.1 Development in High-Hazard Areas

Development in Kaua'i County is guided by the General Plan, community plans and the Kaua'i County Code. This guidance includes requirements pertaining to development in coastal hazard areas, which would include areas that are susceptible to high surf and erosion.

Some land uses are more vulnerable to high surf and coastal erosion, such as single-family homes, while others are less vulnerable, such as agricultural land or recreation areas. Figure 8-2 shows the distribution of land use by area in the FEMA coastal zones. Natural and agricultural lands make up nearly half of these zones. Most homes and facilities are in areas designated urban center, neighborhood center, neighborhood general, or residential community. In all, 6.3 percent of the coastal hazard zones are highly developed.

8.3.2 Other Issues

The following issues have been identified related to the high surf, coastal flood and erosion hazard:

- **High Surf Public Information**—Those most prone to high surf are individuals who choose to be in areas that are impacted by high surf, whether for recreation or because they are unfamiliar with their surroundings. Develop pamphlets and other messaging about the dangers of high surf. Distribute in hotels, tourist venues, and high schools.
- **Future Development Impact Studies**—High surf events are particularly destructive when natural processes are unable to replenish beaches due to development, causing high surf to impact infrastructure. Building on eroding coasts increases vulnerability to shoreline hazards. Ensure that future development does not contribute to coastal erosion, and subsequently, harmful high surf events.
- **Coastal AE Zone Building Standards**—Coastal AE zones, which are landward of coastal high hazard zones (VE zones), have the potential to become affected by waves spilling over from the coastal high hazard zones. Such flooding results in greater stressors for current and future development. Additional building standards should be investigated regarding the effect of wave action that may spill over to AE zones during 100-year flood events.
- **Potential Impacts from Sea Level Rise—**Rising sea levels are very likely to have significant impacts on the frequency and severity of high surf events. Areas not typically exposed to this type of event may become exposed, increasing vulnerability to this hazard of concern. Studies indicate that chronic coastal erosion rates will have doubled by 2050 due to sea level rise (Anderson et al., 2015).

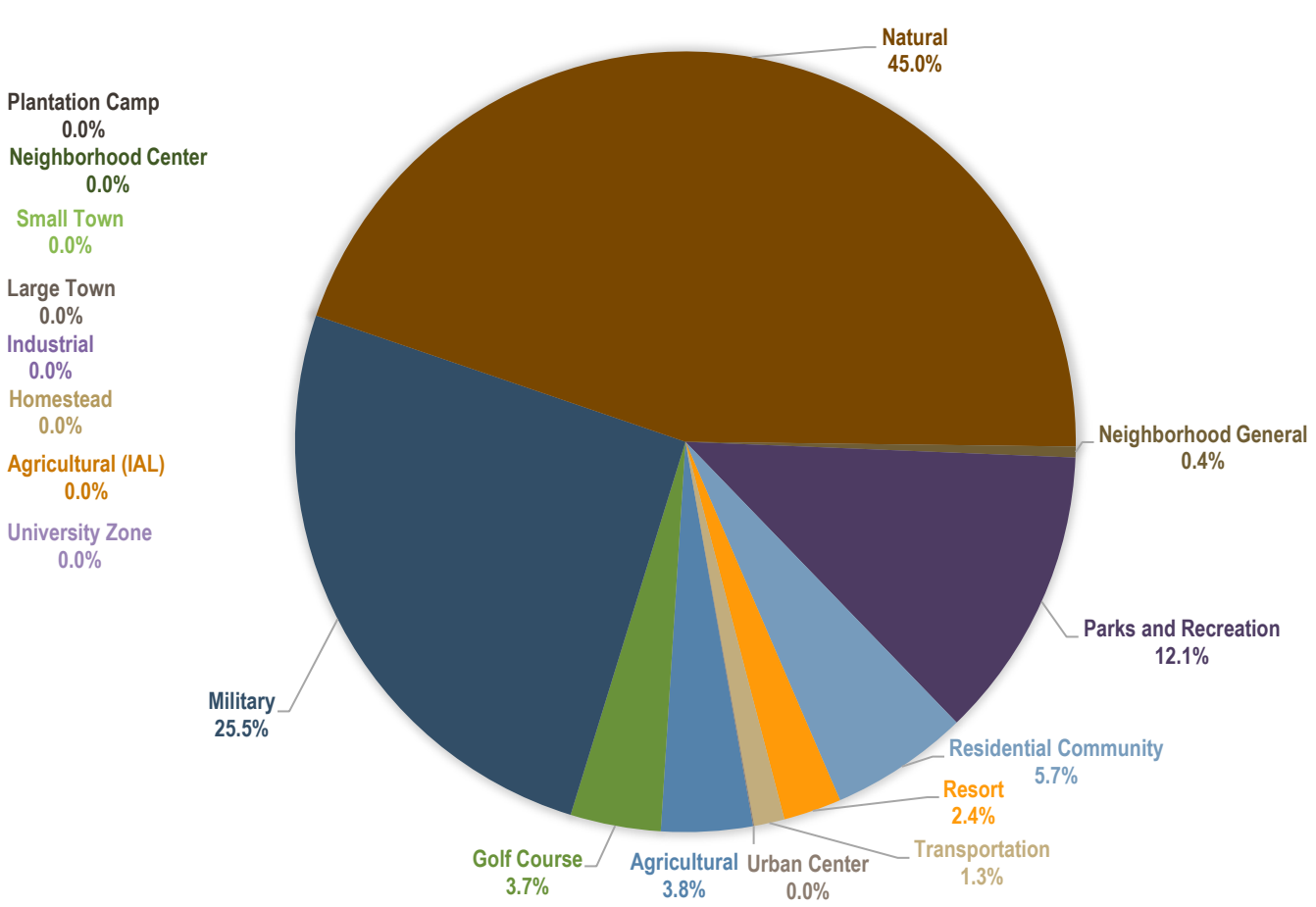


Figure 8-2. Land Use Distribution by Area in the 100-Year Coastal Flood Zone

9. TSUNAMI

A tsunami consists of a series of high-energy waves that radiate outward like pond ripples from an area where a generating event occurs, such as an earthquake, landslide, or submarine volcanic explosion. The waves arrive at shorelines over an extended period. Tsunamis are typically classified as local or distant, based on the proximity of the generating event. Locally generated tsunamis have minimal warning times, leaving little time for response. Distant tsunamis may travel for hours before striking a coastline, giving a community a chance to implement more detailed evacuation plans.

The first visible indication of a tsunami may be a rapid rise or fall in water level (NOAA, 2020b). The advancing tsunami can resemble a strong surge increasing the sea level like the rising tide, but the tsunami surge rises faster and often does not break as a normal wave. Additionally, this surge of water does not stop at the shoreline and pushes above normal sea level tidal reach. This phenomenon is called "run-up". Even if the run-up appears to be small—3 to 6 feet for example—the strength of the accompanying surge can be deadly and cause much damage to infrastructure and the surrounding environment.

According to the National Tsunami Hazard Mitigation Program's *National Tsunami Hazard Assessment*, Hawai'i as a whole is classified as a "high hazard" area for tsunamis. The state has experienced the highest number of tsunami-associated deaths in the country (Dunbar and Weaver, 2008). Additional general information on the tsunami hazard is provided in Appendix L.

9.1 HAZARD PROFILE

Table 9-1 summarizes the key elements of the tsunami hazard profile for Kaua'i County. Additional details are provided in Appendix L.

Table 9-1. Tsunami Hazard Profile Summary

Past Events	April 1, 1946, 13.7 meters, 17 deaths, destroyed homes, trees, boat launch, shifted buoys, washed tug against breakwater; March 9, 1957, 16.2 meters, destroyed bridges, flooded highways, homes destroyed or badly damaged, sampans disabled
Location	FEMA has mapped tsunami inundation zones along the coastline for the entire State of Hawai'i.
Frequency	Eight tsunami events with run-up of 3 feet or more occurred in Kaua'i between 1819 and 1975; an average of one event about every 20 years
Severity	Tsunamis have been recorded on Kaua'i with run-up heights up to 45 feet (in 1946 at Hā'ena).
Warning Time	The Pacific Tsunami Warning System begins to function when a Pacific basin earthquake of magnitude 6.5 or greater triggers an earthquake alarm. This system is not considered to be effective for communities close to the tsunami-generating source because the first wave would arrive before the data were analyzed. In this case, strong ground shaking would provide the first warning of a potential tsunami.
Secondary Hazards	Port facilities, naval facilities, fishing fleets and public utilities are often the backbone of the economy of the affected areas, and these are the resources that generally receive the most severe damage. Until debris can be cleared, wharves and piers rebuilt, utilities restored, and fishing fleets reconstituted, communities may find themselves without fuel, food and employment. Wherever water transport is a vital means of supply, disruption of coastal systems caused by tsunamis can have far-reaching economic effects.

See Section 1.4.2 for a description of elements included in the hazard profile

9.2 RISK ASSESSMENT

9.2.1 Scenario

A tsunami in Hawai'i can be generated by a nearby or distant landslide, earthquake or volcanic explosion. Several scenarios could create large tsunami events and impact Kaua'i County. The scenario used for the risk assessment of this plan was based on the aggregate 2009 Hawai'i Tsunami Mapping Project data, which includes the 1946 Aleutian, 1952 Kamchatka, 1957 Aleutian, 1960 Chile and 1964 Alaskan tsunami events simulated at both mean-sea-level and high -tide conditions.

9.2.2 Exposure

Exposure and vulnerability estimates are based on tsunami inundation maps that were created for the 2009 Hawai'i Tsunami Mapping Project. The maximum flow depth area was computed from historical (distant) tsunami events in 1946, 1952, 1957, 1960, and 1964 and simulated at mean-sea-level and high tide conditions. The value of exposed buildings in the tsunami inundation zone within the planning area was generated by overlaying the inundation areas on the general building stock. The population living in tsunami hazard zones was estimated using the percent of buildings within the tsunami inundation areas and applying this percent to the estimated planning area population. Detailed results by district are provided in Appendix M; results for the total planning area are presented below.

Population and Property

Table 9-2 summarizes the estimated population living in the evaluated tsunami inundation areas and the estimated property exposure. The populations that would be most exposed to this type of hazard are those along beaches, low-lying coastal areas, tidal flats and stream deltas that empty into ocean-going waters. People recreating in these areas would also be exposed.

Table 9-2. Exposed Population and Property in the Tsunami Inundation Zone

Population	
Population Exposed	10,411
% of Total Planning Area Population	14.9%
Property	
Number of Buildings Exposed	5,139
Value of Exposed Structures	$1,752,803,669
Value of Exposed Contents	$1,131,470,328
Total Exposed Property Value	$2,884,273,996
Total Exposed Value as % of Planning Area Total	14.1%

Critical Facilities

Figure 9-1 provides an estimate of the number and types of critical facilities exposed to the tsunami hazard. The sections below summarize exposure of specific types of critical facilities.

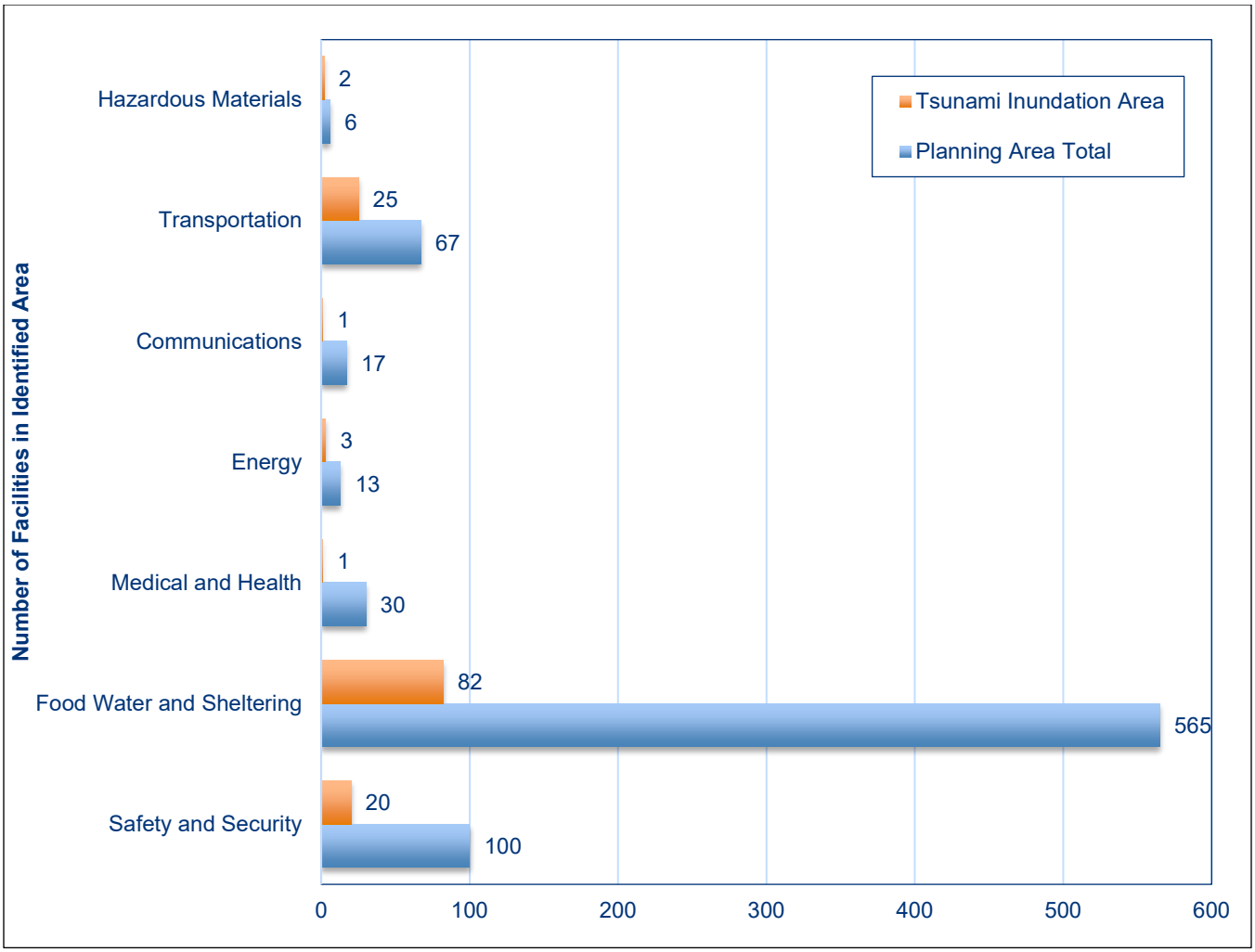


Figure 9-1. Critical Facilities in Tsunami Inundation Areas

Roads

Appendix R contains the detailed analysis of roads in tsunami inundation areas. Hazus indicated that the following major roads may be impacted by tsunami events:

- Ahukini Road
- Alae Road
- Kapa'a Bypass
- Kapule Highway
- Kaumuali'i Highway
- Kekaha Road
- Kōke'e Road
- Kuamo'o Road
- Kūhiō Highway
- Kukui Street
- Malu Road
- Nāwiliwili Road
- Olohena Road
- Rice Street
- Wa'apa Road

This list of roads should not be misinterpreted as possible evacuation routes for tsunami events. Evacuation routes are identified in emergency response plans.

Bridges

Hazus identified 23 bridges that would be exposed to the tsunami scenario event.

Ports / Fuel Farms

In general, due to their locations, all ports and fuel farms within Kaua'i County are exposed to the tsunami hazard.

Water/Sewer/Utilities

All water, sewer, stormwater, power, and communications facilities within the limits of the tsunami inundations zone, whether above ground or below, are exposed to the tsunami hazard.

Toxic Release Inventory Reporting Facilities

Toxic Release Inventory facilities are known facilities that manufacture, process, store or otherwise use certain chemicals above minimum thresholds. One facility in the tsunami inundation area is a Toxic Release Inventory Reporting facility.

Environment

All waterways would be exposed to the effects of a tsunami. All wildlife inhabiting the area also is exposed. Depending on the size and associated force of a tsunami event, Kaua'i County's coral reefs may be exposed to increased pressure caused by an incoming tsunami or to hazardous materials washed offshore into the ocean as the tsunami recedes.

The aquatic habit and associated ecosystems would be most exposed in low-lying areas close to the coastline. Areas near gas stations, industrial areas and hazardous material containing facilities would be vulnerable due to potential contamination from hazardous materials.

9.2.3 Vulnerability

Population

The populations most vulnerable to the tsunami hazard are the elderly, the disabled, the very young and the homeless who reside or recreate near beaches, low-lying coastal areas, tidal flats and stream or river deltas that empty into ocean-going waters. Visitors recreating in or around inundation areas would also be vulnerable as they may not be as familiar with residents on appropriate responses to a tsunami or ways to reach higher ground. In the event of a local tsunami generated in or near the planning area, there would be little warning time, so more of the population would be vulnerable. The degree of vulnerability of the population exposed to the tsunami hazard event is based on a number of factors:

- Is there a warning system?
- What is the lead time of the warning?
- What is the method of warning dissemination?
- Will the people evacuate when warned?

For this assessment, the population vulnerable to possible tsunami inundation is considered to be the same as the exposed population.

Property

All structures along beaches, low-lying coastal areas, tidal flats and stream or river deltas would be vulnerable to a tsunami, especially in an event with little or no warning time. The impact of the waves and the scouring

associated with debris that may be carried in the water could be damaging to structures in the tsunami's path. Those that would be most vulnerable are those located in the front line of tsunami impact and those that are structurally unsound. Table 9-3 shows the general building stock loss in the tsunami inundation areas.

Table 9-3. Loss Impact for Tsunami in the Planning Area

Structure Debris Generated (tons)	525
Buildings Impacted	3,983
Total Value Damaged (Structure + Contents)	$845.7 Million
Damage as % of Total Value	4.1%

Critical Facilities

A more in-depth analysis of the mitigation measures taken by critical facilities in the tsunami inundation area to prevent damage from tsunami events should be done to determine if they could withstand impacts of a tsunami. Vulnerability of specific types of critical facilities is generally as follows:

- **Roads**—Roads are the primary resource for evacuation to higher ground before and during a tsunami event. Roads that are blocked or damaged can isolate residents and prevent access for emergency service providers. Roads often act as flood control facilities in low depth, low velocity flood events by acting as levees or berms and diverting or containing flood flows.
- **Bridges**—Bridges washed out or blocked by tsunami inundation or debris also cause isolation. Bridges can be extremely vulnerable due to forces transmitted by wave run-up and by the impact of debris carried by waves.
- **Ports and Fuel Farms**—Depending on the strength and location of the tsunami, ports and fuel farms could sustain damage from water and debris that would render them out of commission for months, exacerbating the disaster.
- **Utilities**—Water and sewer systems can be flooded or backed up, causing further health problems. Floodwaters can back up drainage systems, causing localized flooding. Culverts can be blocked by flood debris, also causing localized urban flooding. Floodwaters can get into drinking water supplies, causing contamination. Sewer systems can be backed up, causing wastes to spill into homes, neighborhoods, rivers and streams. The forces of tsunami waves can impact above-ground utilities by knocking down power lines and radio/cellular communication towers. Power generation facilities can be severely impacted by both the impact of the wave action and the inundation of floodwaters. Underground utilities can also be damaged during flood events.
- **Hazardous Materials Sites**—If damaged by a tsunami, a Toxic Release Inventory facility could release chemicals that cause cancer or other significant adverse human health effects, as well as significant adverse environmental effects (U.S. EPA, 2016). During a tsunami event, containers holding these materials can rupture and leak into the surrounding area, having a disastrous effect on the environment and people.

Environment

Inundation of natural surface waters and introduction of foreign debris could be hazardous to the environment. Coral reefs may be vulnerable to increased pressure caused by an incoming tsunami or to hazardous waste and other materials pulled into the ocean by retreating waters. Millions of dollars spent on habitat restoration and conservation in the planning area could be wiped out by a significant tsunami. There are currently no tools available to measure these impacts. However, it is conceivable that the potential financial impact of a tsunami event on the environment could equal or exceed the impact on property. Community planners and emergency managers should take this into account when preparing for the tsunami hazard.

9.3 ISSUES

9.3.1 Development in High-Hazard Areas

Figure 9-2 shows the land use distribution by area within the tsunami inundation areas. About 71 percent of the lands in these areas are agricultural lands or natural areas. Most homes and facilities are in areas designated urban center, neighborhood center, neighborhood general, or residential community. In all, 9.2 percent of the tsunami inundation area is highly developed.

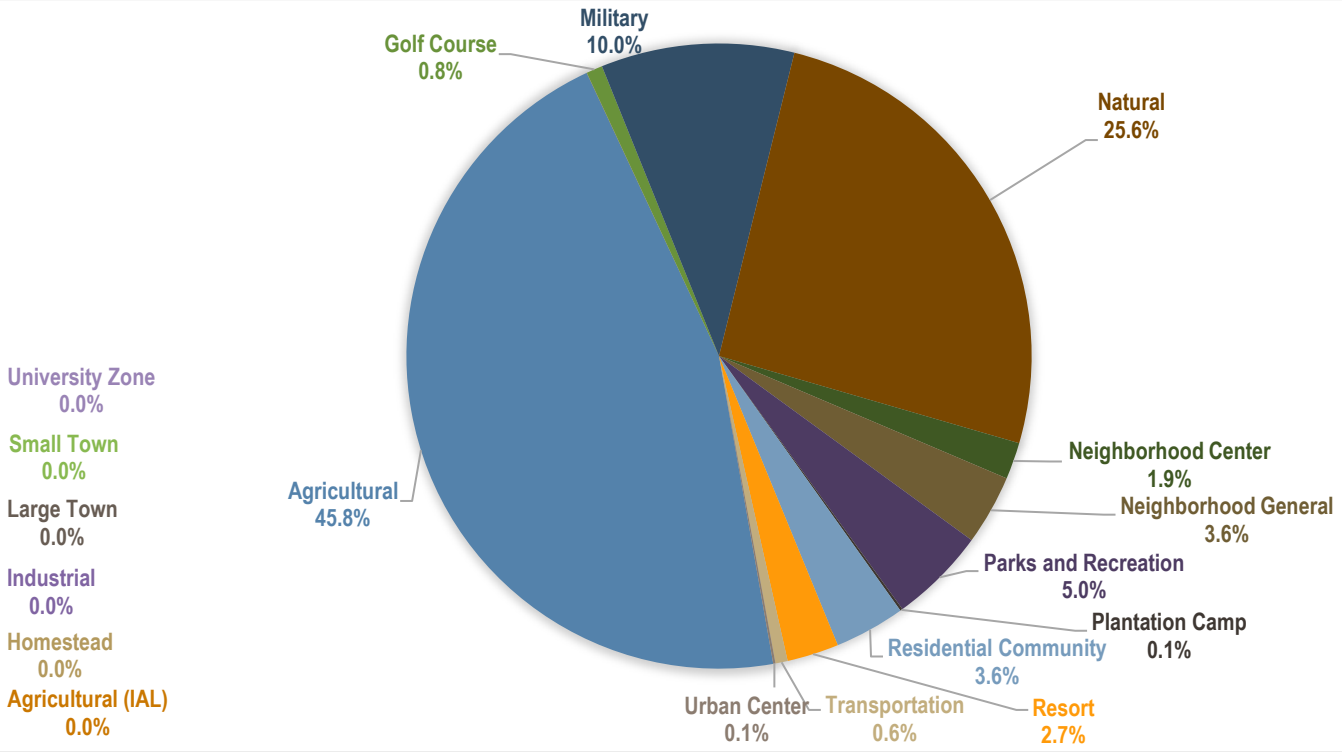


Figure 9-2. Land Use Distribution by Area in the Tsunami Inundation Area

The County does not currently have regulatory provisions for identified tsunami hazard areas. There is some overlap between the County's regulated floodplains and the tsunami impact areas assessed by this plan. However, with historical run-up levels on the island of Kaua'i reaching as much as 45 feet, standard floodplain development regulation may not provide adequate risk protection for new development. Once deterministic data and science can be applied to official mapping with assigned probabilities of occurrence, Kaua'i County may want to consider higher regulatory provisions for new development in high risk tsunami inundation areas.

9.3.2 Other Issues

The following issues have been identified related to the tsunami hazard in the planning area:

- **Hazard Identification**—To best evaluate the probable impacts of tsunamis on the planning area, new hazard mapping needs to be created based on likely probabilistic scenarios. The science and technology in this field are emerging.
- **Building Code Revisions**—Present building codes and guidelines do not adequately address the impacts of tsunamis on structures, and current tsunami hazard mapping is not adequate for code enforcement.

- **Enhancement of Current Capabilities**—As tsunami warning technologies evolve, the tsunami warning capability within the planning area will need to be enhanced to provide the highest degree of warning.
- **Vulnerable Populations Planning**—Special attention must be paid to vulnerable communities in the tsunami zone and to public hazard mitigation education and outreach. This may be especially true for visitors to Kaua'i County.
- **Debris Accumulation**— Significant debris would be produced as a result of a major tsunami impacting the planning area and could be exacerbated by damage caused by the earthquake that preceded it.
- **Climate Change Impacts**—With future climate change, sea level rise may become an important consideration for future studies to identify probable tsunami inundation areas.

10. LANDSLIDE

A landslide is a mass of rock, earth or debris moving down a slope, caused by a combination of geological and climate conditions, as well as the encroaching influence of urbanization. Landslides can be initiated by storms, earthquakes, fires, or volcanic eruptions and may be affected by human residential, agricultural, commercial and industrial development and the infrastructure that supports it. In general, geologists look for the following land characteristics to identify landslide hazard areas with higher risk of downhill movement of material:

- A slope greater than 33 percent
- A history of landslide activity or movement during the last 10,000 years
- Stream or wave activity that has caused erosion or cut into a bank to make the surrounding land unstable
- The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments
- The presence of impermeable soils, such as silt or clay, mixed with granular soils such as sand and gravel.

Landslides can be influenced by any the following factors, whether natural or human-caused: change in slope of the terrain, increased load on the land, shocks and vibrations, change in water content, groundwater movement, weathering of rocks, and changing the amount or type of vegetation on slopes. Additional general information on the landslide hazard is provided in Appendix L.

10.1 HAZARD PROFILE

Table 10-1 summarizes the key elements of the landslide hazard profile for Kaua‘i County. Additional details are provided in Appendix L.

Table 10-1. Landslide Hazard Profile Summary

Past Events	A recent significant landslide event began with torrential rainfall and severe flooding in April 2018, resulting in numerous landslides over north Kaua‘i west of Hanalei that cut off access to Wainiha and Hā‘ena for more than two weeks.
Location	Areas generally more prone to landslides are those located at: • Previous landslides areas • Base of slopes • Base of minor drainage hollows • Base or top of an old, filled slope • Base or top of a steep, cut slope • Developed hillsides with leach-field septic systems.
Frequency	Between 2007 and 2020, NASA’s Global Landslide Catalog recorded landslide events in Kauai on nine dates; an average of one event every year or two.
Severity	Recent landslides in Kaua‘i have been rated as small or medium by NASA, indicating few or no fatalities and minimal or moderate damage to infrastructure.
Warning Time	Assessing the geology, vegetation and amount of predicted precipitation for an area can help in identifying susceptibility to landslides. However, there is no practical warning system for individual landslides.
Secondary Hazards	Potential flooding if landslide materials block the natural flow of a stream.

See Section 1.4.2 for a description of elements included in the hazard profile

10.2 RISK ASSESSMENT

10.2.1 Scenario

Landslides in the planning area occur as a result of soil conditions that have been affected by severe storms, groundwater, or human development. After heavy rains, soils become saturated with water. A short intense storm could cause saturated soil to move, resulting in landslides. As rains continue, the groundwater table rises, adding to the weakening of the slope. Gravity, poor drainage, a rising groundwater table, poor soil, and ground shaking exacerbate hazardous conditions.

Private and public property, including infrastructure, would likely be affected. A landslide could affect bridges that pass over ravines and knock out transportation routes through the planning area. Road obstructions caused by the landslide would create isolation problems for residents and businesses in sparsely developed areas. Property owners exposed to steep slopes may suffer damage to property or structures. Landslides carrying vegetation such as shrubs and trees may cause a break in utility lines, cutting off power and communication access to residents.

Continued heavy rains and flooding would complicate the problem further. As emergency response resources are applied to problems with flooding, it is possible they will be unavailable to assist with landslides occurring all over the planning area.

10.2.2 Exposure

Population and Property

A quantitative assessment of exposure to the landslide hazard was conducted using slope analysis and the asset inventory developed for this plan, with an emphasis on the zones with the highest degree of susceptibility (high susceptibility: greater than 40 percent slope; and moderate susceptibility: 20 to 40 percent slope). Population exposure was estimated by calculating the number of buildings in each hazard area as a percent of total planning area buildings, and then applying this percentage to the estimated planning area population. Table 10-2 summarizes the estimated population living in the mapped landslide risk areas and the estimated property exposure. Detailed results by district are provided in Appendix M.

Table 10-2. Exposed Population and Property in Mapped Landslide Hazard Zones

	High Landslide Susceptibility Zone	Moderate Landslide Susceptibility Zone
Population		
Population Exposed	355	2,562
% of Total Planning Area Population	Less than 1%	3.7%
Property		
Number of Buildings Exposed	175	1,295
Value of Exposed Structures	$43,218,906	$324,226,405
Value of Exposed Contents	$21,609,453	$178,825,536
Total Exposed Property Value	$64,828,359	$503,051,941
Total Exposed Value as % of Planning Area Total	Less than 1%	2.5%

Critical Facilities

Figure 10-1 summarizes the critical facilities within the high and moderate landslide susceptibility zones.

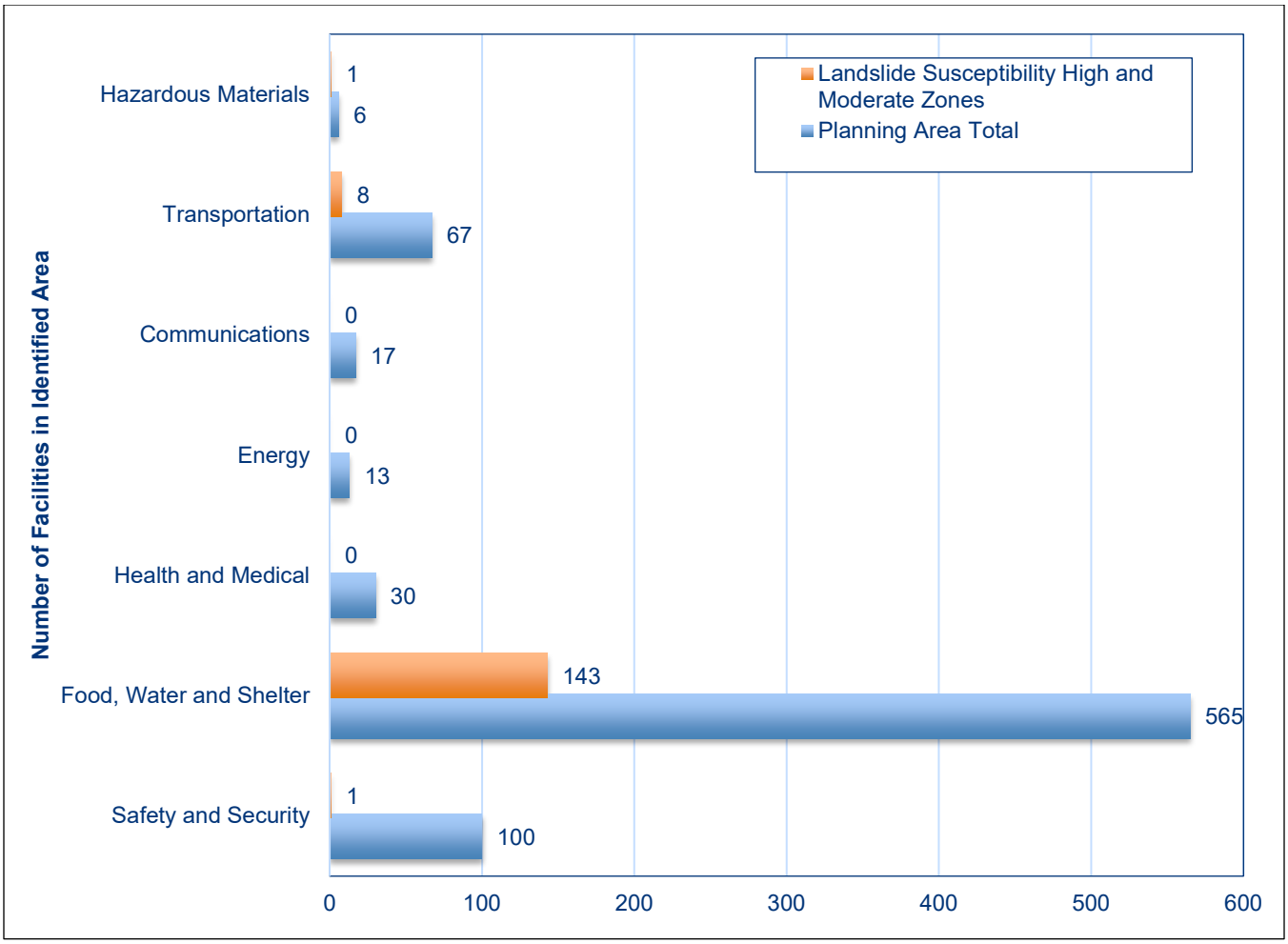


Figure 10-1. Critical Facilities in Mapped Landslide Susceptibility High and Moderate Zones

A significant amount of infrastructure can be exposed to mass movements:

- **Roads**—Access to major roads is crucial after a disaster event for response and recovery operations. Landslides can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems and delays for public and private transportation. This can result in economic losses for businesses.
- **Bridges**—Landslides can significantly impact road bridges. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use.
- **Power Lines**—Power lines are generally elevated above steep slopes; but the towers supporting them can be subject to landslides. A landslide could trigger failure of the soil underneath a tower, causing it to collapse and ripping down the lines. Power and communication failures due to landslides can create problems for vulnerable populations and businesses.

Environment

All natural areas within the high and moderate susceptibility zones for landslide are considered to be exposed to the hazard.

10.2.3 Vulnerability

Population

In general, all persons exposed to high-risk landslide areas are considered to be vulnerable to the hazard.

Property

Loss estimations for the landslide hazard are not based on modeling utilizing damage functions, because no such damage functions have been generated. Instead, loss estimates were developed representing 10 percent, 30 percent and 50 percent of the replacement value of exposed structures. This allows emergency managers to select a range of economic impact based on an estimate of the percent of damage to the general building stock. Damage in excess of 50 percent is considered to be substantial by most building codes and typically requires total reconstruction of the structure. Table 10-3 shows potential losses in the areas with the highest degree of landslide susceptibility (high and moderate zones).

Table 10-3. Loss Estimation for Landslide (High and Moderate Susceptibility Zones)

	Exposed Value	Loss Value	Loss as % of Total Planning Area Replacement Value
Loss = 1% of Exposed Value	$567.9 Million	$5.7 Million	Less than 1%
Loss = 10% of Exposed Value		$56.8 Million	Less than 1%
Loss = 30% of Exposed Value		$187.4 Million	Less than 1%
Loss = 50% of Exposed Value		$283.9 Million	1.4%

Critical Facilities

No loss estimation of critical facilities was performed due to the lack of established damage functions for the landslide hazard.

Several types of infrastructure are exposed to mass movements, including transportation, water and sewer and power infrastructure. Highly susceptible areas of the planning area include mountain and coastal roads and transportation infrastructure. Many roads in the planning area are single lane highways that if blocked would cause a significant impact to the areas they serve. Highways blocked by a landslide could isolate communities for a significant amount of time. All infrastructure and transportation corridors identified as exposed to the landslide hazard are considered vulnerable. See Appendix R for a detailed analysis of roads in the landslide hazard area.

Environment

Environmental problems as a result of landslides can be numerous. Landslides that fall into streams may significantly impact fish and wildlife habitat, as well as affecting water quality. Hillsides that provide wildlife habitat can be lost for prolonged periods of time due to landslides.

Landslides that occur along coastal areas pose a particular threat to Kaua'i County's coastal coral reefs. As massive amounts of land falls into surrounding ocean waters, tides and waves may draw the earthen sediment to the reef area, choking the natural habitat. Natural cyclical processes normally remove earthen sediment and clean the coral reef area; however a large landslide may produce too much sediment to be removed by the natural processes (Piniak, 2004).

10.3 ISSUES

10.3.1 Development in High-Hazard Areas

Land use is determined by the County's zoning code and zoning map, also known as the Comprehensive Zoning Ordinance. The General Plan and community plans establish policies to protect communities from hazards. Development in the planning area is also regulated by building standards and performance measures. The distribution of general land use types in the landslide hazard areas is shown in Figure 10-2. Agricultural and conservation land make up the greatest extent of exposed areas.

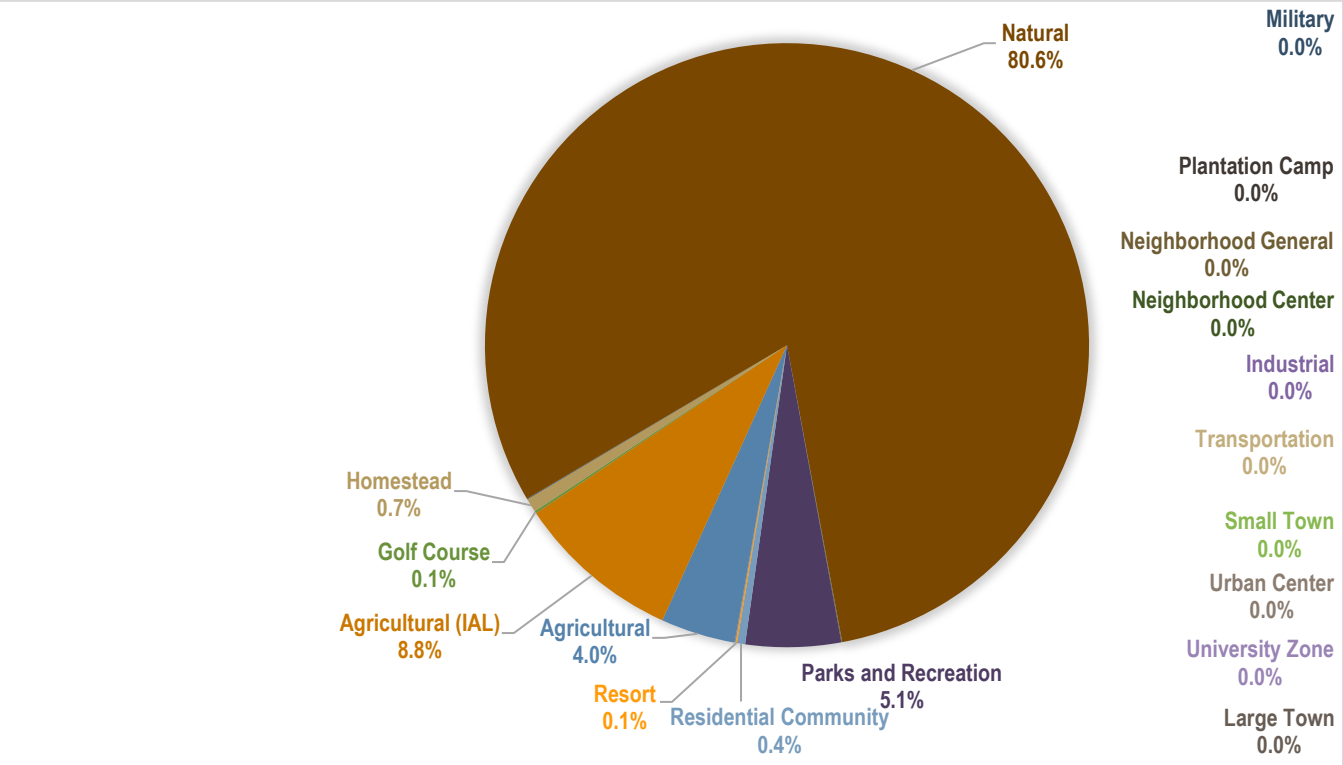


Figure 10-2. Land Use Distribution by Area in Landslide Susceptibility High and Moderate Zones

10.3.2 Other Issues

The following issues have been identified related to the landslide hazard in the planning area:

- **Identification and Development of Geospatial Landslide Hazard Layers**—Data for determining landslide areas is currently only based on slope analysis. Better data is needed to determine landslide hazards and risks.
- **Use of Best Available Data and Scientific Studies for Stabilization**—Methods of hillside stabilization along roadways should be improved for effective project implementation.
- **Native Species Introduction**—Native species planting and care along with invasive species removal could have a stabilizing effect on soils in landslide areas.
- **Collection of Detailed Information**—Existing homes and transportation corridors are situated in landslide risk areas throughout the planning area. The degree of vulnerability of these structures depends on the codes and standards the structures were constructed to. Information to this level of detail is not currently available.

- **Monitoring of Future Development**—Future development could lead to more homes in landslide risk or potentially isolated areas. By continuing to monitor land use and development, Kaua'i County could play an integral part in minimizing development in known landslide risk areas or areas prone to isolation due to blocked transportation corridors by landslides.
- **Water Quality Degradation**—Landslides may cause negative environmental consequences, including water quality degradation. The County must continue to monitor water quality during potentially impactful landslide events.
- **Multi-Hazard Mitigation Measures**—The risk associated with the landslide hazard overlaps the risk associated with other hazards such as earthquake, flood and wildfire. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.
- **State Transportation Projects**—The State Department of Transportation tries to address landslide and rock fall problems through its maintenance budget. The more chronic problem areas require capital improvement project funding that has not been provided to date, although data is available regarding the frequency and severity of landslide events.

11. DAM FAILURE

Hawai‘i Administrative Rules (Chapter 190.1) define a state-regulated dam as any artificial barrier that impounds or diverts water and has one of the following characteristics:

- Is 25 feet or more high from the natural bed of the stream or from the lowest elevation of the outside limit of the barrier if it is not across a stream
- Has an impounding capacity at maximum water storage elevation of 50 acre-feet or more
- Has two or more reservoirs that operate or function as a single facility or are connected together with an uncontrolled conduit
- Is a natural structure that retains water and has been altered by the addition of an outlet works and has a maximum storage volume greater than 50 acre-feet

Many dam failures in the United States have been secondary results of other disasters. Potential causes include earthquakes, landslides, extreme storms, equipment malfunction, structural damage, foundation failures, and sabotage. Poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable by a program of regular inspections. Sabotage is a serious concern that all operators of public facilities must plan for.

Unusually heavy rainfall contributed to the March 14, 2006, Ka Loko Dam failure. Almost 400 million gallons of water came crashing down from the reservoir into Kilauea Bay, wiping out everything in its path and taking the lives of seven people (Godbey, 2007). The event was part of FEMA Major Disaster Declaration DR-1640.

While the probability of dam failure is very low, the probability of flooding associated with changes to dam operational parameters in response to climate change is higher. Dam designs and operations are developed based on hydrographs with historical record. If these hydrographs experience significant changes over time due to the impacts of climate change, the dam design and operations may no longer be valid for the changed condition. This could have significant impacts on dams that provide flood control. Specified release rates and impound thresholds may need to be changed. This could result in increased discharges downstream of these facilities, thus increasing the probability and severity of flooding.

Regulatory oversight for dam safety includes the following:

- U.S. Army Corps of Engineers—Safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act.
- Federal Energy Regulatory Commission—Cooperates with a large number of federal and state agencies to ensure and promote dam safety.
- State and federal initiatives—Established to reduce the potential of full or partial failures. Initiatives include the State of Hawai‘i’s 2010 Dam Safety Act (HAR, Title 13, Subtitle 7, Chapter 190.1), which is administered by the Department of Land and Natural Resources.

Additional general information on the dam failure hazard is provided in Appendix L.

11.1 HAZARD PROFILE

Table 11-1 summarizes the key elements of the dam failure hazard profile for Kauaʻi County. Additional details are provided in Appendix L.

Table 11-1. Dam Failure Hazard Profile Summary

Past Events	On March 14, 2006, the Ka Loko Dam broke on the North Shore of Kauaʻi, sending millions of gallons of water downstream. Seven people were killed, and dozens of homes and properties were damaged.
Location	Kauaʻi County has 48 high-hazard dams; the mapped inundation zones for these dams represent the location of greatest risk for the dam failure hazard in the planning area.
Frequency	A major dam failure is a rare event for which there is no defined recurrence interval. However, failure potential does exist during an extreme rainfall event or major earthquake at any unmaintained or under-maintained location.
Severity	Kauaʻi County has 48 high-hazard dams, which are dams whose failure would probably cause loss of human life.
Warning Time	Warning time for dam failure depends on the cause of the failure. In events of extreme precipitation, evacuations can be planned with sufficient time. In the event of a structural failure due to earthquake, there may be little warning time.
Secondary Hazards	Severe downstream flooding, landslides around the reservoir perimeter, potential contribution to drought by releasing water that might have been used as a potable water source.

See Section 1.4.2 for a description of elements included in the hazard profile

11.2 RISK ASSESSMENT

11.2.1 Scenario

Based on available data and probable impacts, the Kapaia, Huinawai, and Waita dams were selected for an exposure and vulnerability analysis as representative samples that have the potential to affect densely populated areas. A quantitative assessment of exposure to the dam failure hazard was conducted using inundation mapping for these dams (see Figure 11-1) and the asset inventory developed for this plan. The mapping assumes complete failure of each dam on a day with low flow in the downstream water course and the dam's reservoir full. Results were developed for the two County districts that would be affected by dam failure:

- Kōloa-Poʻipū-Kalāheo, the district that would experience inundation from failure of the Huinawai and Waita dams
- Līhuʻe, the district that would experience inundation from failure of the Kapaia dam

Appendix M provides results by district; results for the total planning area are presented below.

11.2.2 Exposure

Population and Property

Table 11-2 summarizes the estimated population living in the evaluated dam failure inundation zones and the estimated property exposure.

Critical Facilities

Figure 11-2 shows critical facilities located in the dam failure inundation zones by facility type.

Environment

All areas of the environment within the boundaries of the mapped dam failure inundation zones are considered to be exposed to the dam failure hazard.

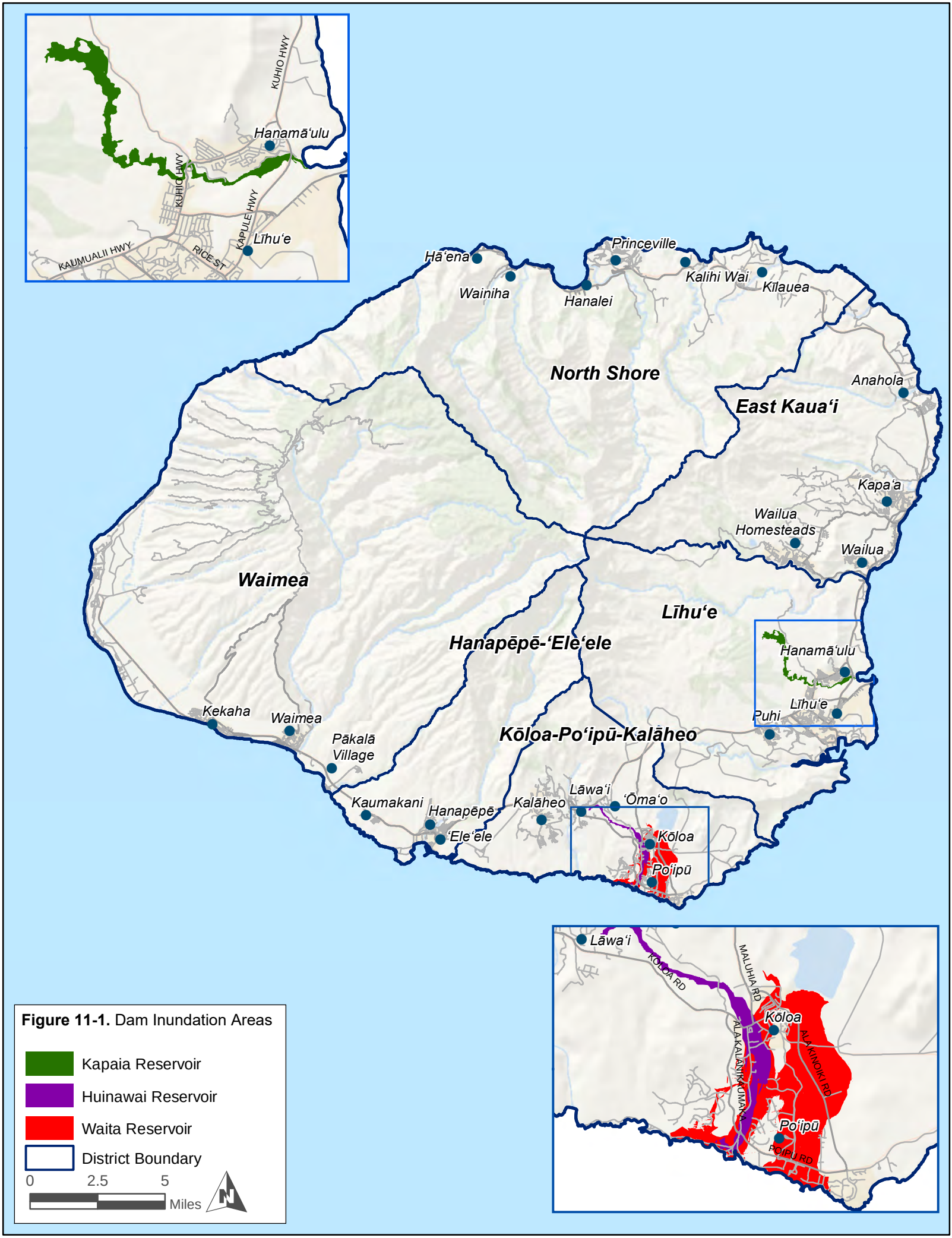

KUHIO HWY
Hanamā'ulu
KUHIO HWY
KAPULE HWY
KAUMUALII HWY
RICE ST
Līhu'e
Hā'ena
Wainiha
Hanalei
Princeville
Kalihi Wai
Kīlauea
North Shore
Anahola
East Kaua'i
Kapa'a
Wailua Homesteads
Wailua
Waimea
Līhu'e
Hanapēpē-'Ele'ele
Hanamā'ulu
Līhu'e
Puhi
Kekaha
Waimea
Pākalā Village
Kōloa-Po'ipū-Kalāheo
Kaumakani
Hanapēpē
'Ele'ele
Kalāheo
Lāwa'i
'Ōma'o
Kōloa
Po'ipū
Lāwa'i
KOLOA RD
MALUHIA RD
Kōloa
ALAKALANIKAUMAKA
ALAKINOKI RD
Po'ipū
POIPU RD
Figure 11-1. Dam Inundation Areas
Kapaia Reservoir
Huinawai Reservoir
Waita Reservoir
District Boundary
0
2.5
5
Miles
N

Table 11-2. Exposed Population and Property in Evaluated Dam Failure Inundation Zones

	Huinawai & Waita (Kōloa-Poʻipū-Kalāheo)	Kapaia (Līhuʻe)
Population		
Population Exposed	3,174	58
% of Total Planning Area Population	4.6%	Less than 1%
Property		
Number of Buildings Exposed	2,173	32
Value of Exposed Structures	$693.1 million	$6.7 million
Value of Exposed Contents	$394.5 million	$6.6 million
Total Exposed Property Value	$1.1 billion	$13.3 million
Total Exposed Value as % of Planning Area Total	5.33%	Less than 1%

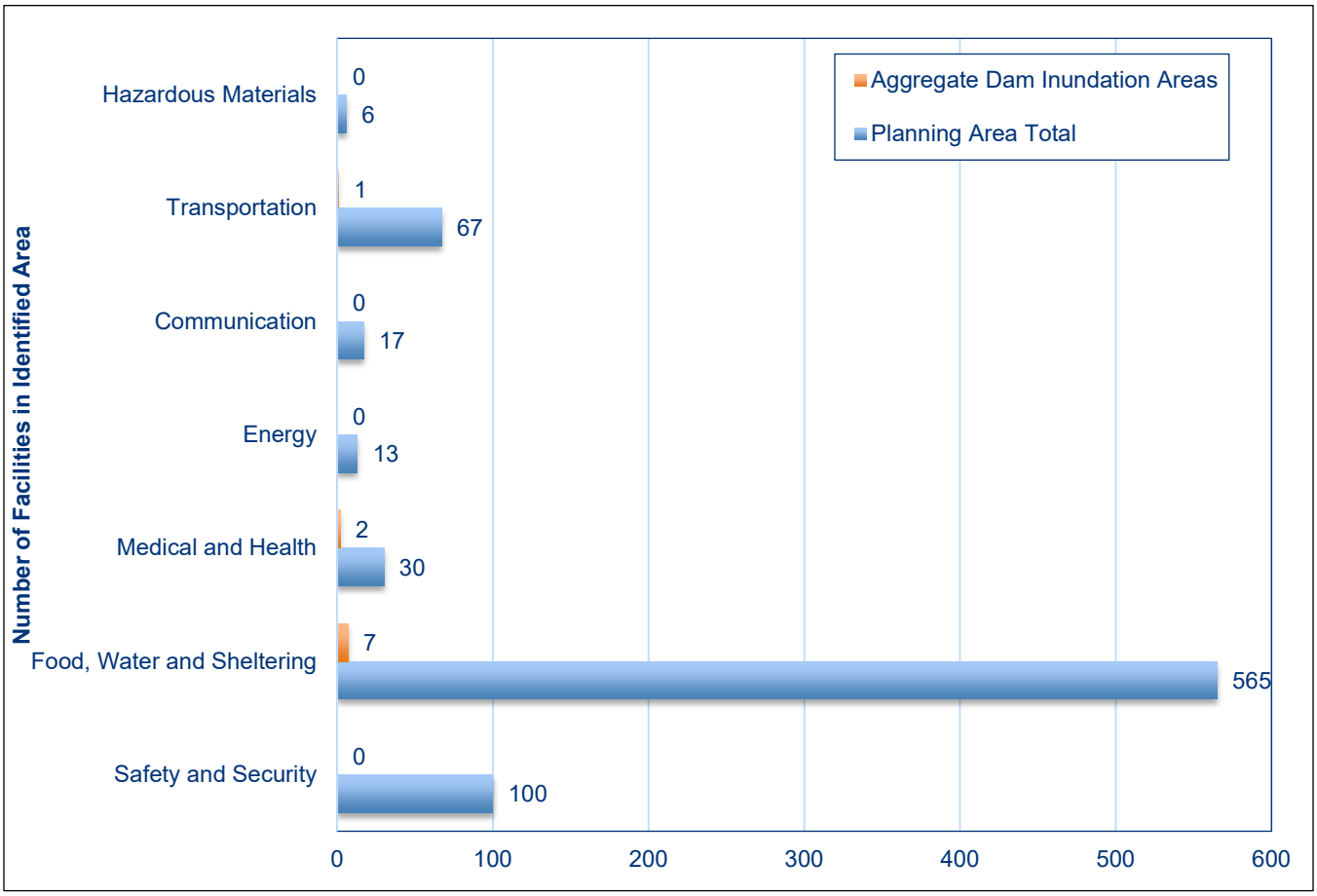


Figure 11-2. Critical Facilities in the Aggregate Dam Inundation Areas and Countywide

11.2.3 Vulnerability

Population

Quantitative impacts on persons and households for the three dams chosen for analysis were estimated through the Level 2 Hazus analysis. Table 11-3 summarizes the results.

Table 11-3. Estimated Dam failure Impacts on Persons and Households

	Displaced Population	People Requiring Short-Term Shelter
Kapaia (Līhu'e)	3	0
Huinawai & Waita (Kōloa-Po'ipū-Kalāheo)	1,720	108

Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area quickly. This population includes the elderly, the young, and individuals with disabilities, access or functional needs. The vulnerable population also includes those who would not have adequate warning from a television or radio emergency warning system. The potential for loss of life is affected by the capacity and number of evacuation routes available to populations living in areas of potential inundation. Population adversely affected by a dam failure may also include those beyond the disaster area who rely on the dam for providing potable water.

Property

Vulnerable properties are those closest to the dam inundation area. These properties would experience the largest, most destructive surge of water. Low-lying areas are also vulnerable since they are where the dam waters would collect. Table 11-4 shows the Hazus loss estimates for the dam failure scenario evaluated.

Table 11-4. Loss Estimates for Dam Failure

	Structures Impacted[a]	Estimated Loss			
		Structures	Contents	Total	Estimated Loss as % of Total Replacement Value
Kapaia (Līhu'e)	25	$ 2,035,815	$ 3,928,281	$5,964,095	Less than 1%
Huinawai & Waita (Kōloa-Po'ipū-Kalāheo)	1,653	$65,397,324	$45,059,957	$110,457,280	2.5%

a. Calculated using a user-defined analysis in Hazus 4.2 SP03.

Critical Facilities

Hazus estimated damage to critical facilities in the dam failure inundation zone as summarized in Table 11-5. General impacts on critical facilities include the following:

- Transportation routes could be wiped out, creating isolation issues. This includes all roads and bridges in the path of the dam inundation. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand a large water surge. Appendix R contains the analysis of roads in the combined dam failure hazard area.
- Utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

Table 11-5. Estimated Damage to Critical Facilities from Dam Failure

	Number of Facilities Affected	Average % of Total Value Damaged	
		Building	Contents
Safety and Security	5	8.21%	34.99%
Food, Water and Sheltering	3	14.05%	0.00%
Health and Medical	2	0.00%	0.00%
Energy	0	N/A	N/A
Communications	0	N/A	N/A
Transportation	1	1.25%	N/A
Hazardous Materials	0	N/A	N/A
Total	**11**	**5.88%**	**11.66%**

Environment

The environment would be vulnerable to a number of risks in the event of dam failure. The inundation could introduce foreign elements into local waterways, resulting in destruction of downstream habitat and detrimental effects on many species of animals, especially endangered species and delicate coral ecosystems.

11.3 ISSUES

11.3.1 Development in High-Hazard Areas

Land use is determined by the County's zoning code and zoning map, also known as the Comprehensive Zoning Ordinance. The General Plan and community plans establish policies to protect communities from hazards. Development in the planning area is also regulated by building standards and performance measures. The distribution of general land use types in the dam inundation areas is shown in Figure 11-3. Agricultural lands make up most of the area (about 38 percent), followed by residential community (21.5 percent) and resort (14 percent).

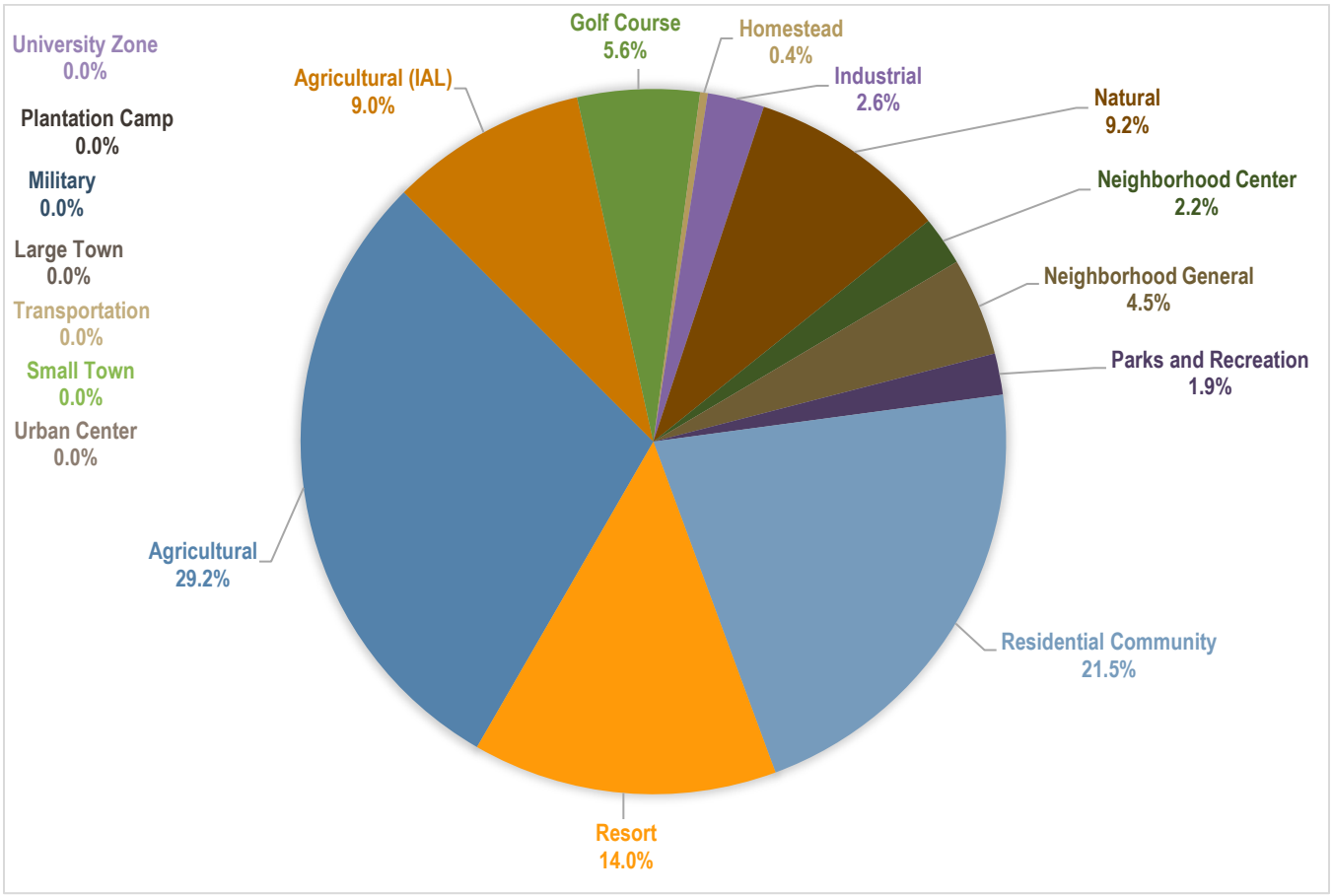


Figure 11-3. Land Use Distribution by Area in the Aggregate Dam Inundation Areas

The "Public Safety & Hazards Resiliency" sector of the General Plan establishes standards and policies for the protection of the community from hazards. Dam failure is currently not explicitly addressed in the countywide policy plan or many of the older community plans. Many of these plans are currently in the update process and the results and recommendations of this hazard mitigation plan will be incorporated into updated policies and planning actions.

11.3.2 Other Issues

The following issues have been identified related to the dam failure hazard in the planning area:

- **Warning time**—There is often limited warning time for dam failure. Failures are frequently associated with other natural hazard events such as earthquakes, landslides or tropical cyclones, which limits their predictability and compounds the hazard.
- **Residual risk**—The concept of residual risk associated with structural flood control projects should be considered in the design of capital projects and the application of land-use regulations.
- **Security**—Addressing dam security concerns while keeping the public informed of the risk associated with dam failure is a challenge for public officials.
- **Climate change impacts**—Dam infrastructure may require improvement to withstand climate change impacts, such as changes in the timing and intensity of rain events.
- **Flood insurance coverage**—A significant number of the structures located in the dam inundation zone are outside of special flood hazard areas, meaning that they are not constructed to withstand floodwaters and are less likely to be covered by flood insurance. Even structures that have been designed with flood hazards in mind may not be able to withstand the height and velocity of flow from a dam failure event.

12. EARTHQUAKE

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust, a volcanic eruption, or a volcano mass settling on the ocean floor. Dislocations of the crust cause more destructive quakes than does volcanic activity. Proximity of the built environment to the epicenter results in the most damage. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. In the process of breaking, vibrations called "seismic waves" are generated. These waves travel outward from the source of the earthquake at varying speeds.

An earthquake's magnitude is a measure of the energy released at the source of the earthquake. Magnitude is commonly expressed by ratings on the moment magnitude scale (M_w), the most common scale used today (USGS, 2017). This scale is based on the total moment release of the earthquake (the product of the distance a fault moved and the force required to move it). The scale is as follows:

- Great—Mw > 7.9
- Major—Mw = 7.0 – 7.9
- Strong—Mw = 6.0 – 6.9
- Moderate—Mw = 5.0 – 5.9
- Light—Mw = 4.0 – 4.9
- Minor—Mw = 3.0 – 3.9
- Micro—Mw < 3

The USGS Earthquake Hazards Program produces maps called ShakeMaps that map ground motion and shaking intensity following significant earthquakes. ShakeMaps focus on the ground shaking caused by the earthquake, rather than on characteristics of the earthquake source, such as magnitude and epicenter. An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region, depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth's crust. Additional general information on the earthquake hazard is provided in Appendix L.

12.1 HAZARD PROFILE

Table 12-1 summarizes the key elements of the earthquake hazard profile for Kaua‘i County. Additional details are provided in Appendix L.

12.2 RISK ASSESSMENT

12.2.1 Scenario

Any seismic activity of 6.0 or greater felt within the planning area would have significant impacts throughout the planning area. While this level of seismicity is unlikely, substantial shaking may occur as a result of a large earthquake on the islands of Maui or Hawai‘i. Potential warning systems could give approximately 40 seconds notice that a major earthquake is about to occur. This would not provide adequate time for preparation.

Table 12-1. Earthquake Hazard Profile Summary

Past Events	No large earthquakes have occurred in Kaua'i, however, the island of Hawai'i has experienced numerous earthquakes of magnitude 5 or greater.
Location	No mapping of fault lines or earthquake-sensitive soil classifications has been done for the island of Kaua'i. Exposure areas are based on floodplains, which typically contain soft soils.
Frequency	Due to a lack of volcanic activity and historical occurrence of earthquakes, Kaua'i County can expect earthquake activity to be minimal. However, the USGS estimates a 50-percent probability of a 6.5 magnitude or greater earthquake occurring in the Hawaiian Islands in the next 10 years.
Severity	The USGS-estimated peak ground acceleration in Kaua'i County with a 2 percent chance of occurrence in 50 years is between 0.05 g and 0.17 g. (Fractions of g represent the acceleration due to Earth's gravity, equivalent to g-force. Objects become airborne at 1 g.)
Warning Time	There is currently no reliable way to predict when an earthquake will occur at any given location. Potential warning systems could give approximately 40 seconds notice that a major earthquake is about to occur.
Secondary Hazards	Landslides, unsecured hazardous materials released causing significant damage to the environment and people, earthen dams and levees fail, fires start from broken gas lines or downed electric wires, tsunamis, leading to potential coastal flooding and erosion.

See Section 1.4.2 for a description of elements included in the hazard profile

Power outages lasting hours from tripped circuits or days from downed lines could occur. Levees and revetments built on poor soils would likely fail, representing a loss of critical infrastructure. These events could cause secondary hazards, including landslides that would further damage structures.

12.2.2 Exposure

Population

The entire population of the planning area is potentially exposed to direct and indirect impacts from earthquakes and will have to deal with the consequences of earthquakes to some degree. Populations that suffer no direct damage from an event itself could be affected by business interruption that keep people from working, road closures that isolate populations, and loss of functions of utilities.

Property

There are 34,695 buildings in the earthquake exposure area. These structures are estimated to have a total replacement value of $20.4 billion.

Critical Facilities

Critical facilities constructed on floodplain soils, which are typically soft soils, are particularly at risk from seismic events. Figure 12-1 shows the number of critical facilities built on these soils in the planning area, by type of facility.

Hazardous materials releases can occur during an earthquake from fixed facilities or transportation-related incidents. Transportation corridors can be disrupted during an earthquake, leading to the release of materials to the surrounding environment. Facilities holding hazardous materials are of particular concern because of possible isolation of neighborhoods surrounding them. During an earthquake, structures storing these materials could rupture and leak into the surrounding area or an adjacent waterway, having a disastrous effect on the environment.

Environment

All natural areas with floodplain soils are exposed to the earthquake hazard.

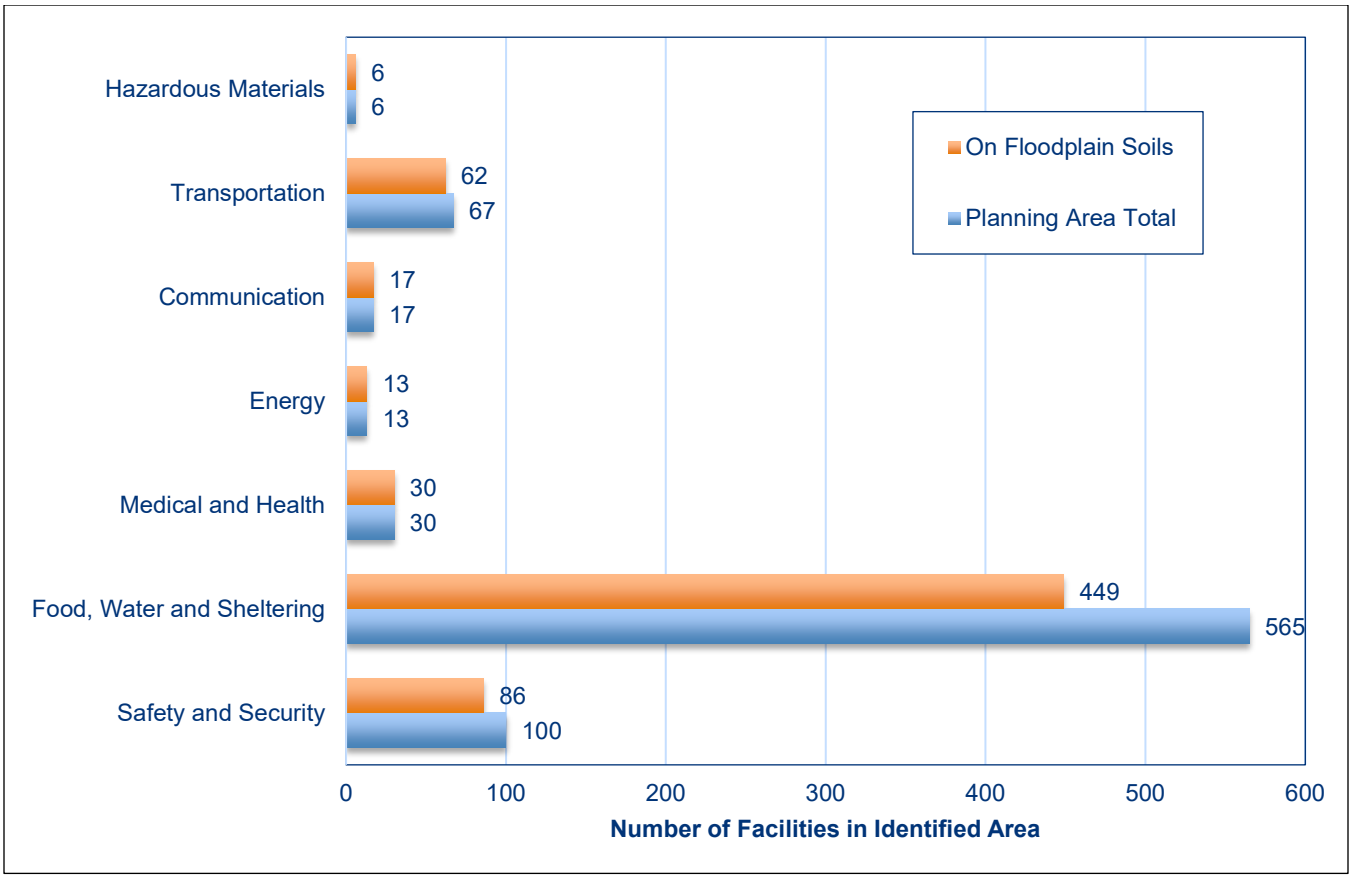


Figure 12-1. Critical Facilities Constructed on Floodplain Soils, and Countywide

12.2.3 Vulnerability

Earthquake vulnerability data for the risk assessment was generated using a Hazus Level 2, user-defined analysis for the structures built on floodplain soils. Hazus estimates the intensity of the ground shaking, the number of buildings damaged, the number of casualties, the damage to transportation systems and utilities, the number of people displaced from their homes, and the estimated cost of repair and clean up. The analysis results are summarized in the sections below, and more detailed information, broken down by district, can be found in Appendix M.

Population

High-Risk Populations

Three groups are identified as being particularly vulnerable to the earthquake hazard:

- **Population Below Poverty Level**—Households listed as earning less than $20,000 in annual income. These households may lack the financial resources to improve their homes to prevent or mitigate earthquake damage. Poorer residents are also less likely to have insurance to compensate for losses in earthquakes.
- **Population Over 65 Years Old**—This population group is vulnerable because they are more likely to need special medical attention, which may not be available due to isolation caused by earthquakes. Elderly residents also have more difficulty leaving their homes during earthquake events and could be stranded in dangerous situations.

Estimated Impacts on Persons and Households

The degree of vulnerability of people in the planning area is dependent on many factors, including the age and construction type of the structures they live in, the soil types their homes are constructed on, the intensity of the earthquake, etc. A Level 2 Hazus analysis for the 500-year probabilistic earthquake event showed that no residents would be displaced or require short-term shelter. Effects on the population were not conducted for seismic activity originating on neighboring islands.

Property

Structures built on the typically soft soils in floodplains are vulnerable to seismic activity. Loss estimates summarized in Table 12-2 are based on those structures.

Table 12-2. Estimated Impact of 500-Year Probabilistic Earthquake Event in the Planning Area

Damage Type	500-year Probabilistic Event
Structure Debris (Tons)	1,670
Total Value (Structure + Contents) Damaged	$1.5 million
Damage as % of Total Value	Less than 1%

Critical Facilities

Hazus classifies the vulnerability of critical facilities to earthquake damage in five categories: no damage, slight damage, moderate damage, extensive damage, or complete damage. The model was used to assign a vulnerability category to each critical facility in the planning area except hazardous material facilities and "other infrastructure" facilities, for which there are no established damage functions. Table 12-3 summarizes the results.

Table 12-3. Estimated Damage to Critical Facilities from 500-Year Probabilistic Earthquake Event

Category	# of Critical Facilities	Number of Buildings with 50% or Greater Probability of Achieving Damage Level				
		None	Slight	Moderate	Extensive	Complete
Safety and Security	86	86	0	0	0	0
Food, Water and Sheltering	449	449	0	0	0	0
Health and Medical	30	30	0	0	0	0
Energy	13	13	0	0	0	0
Communications	17	17	0	0	0	0
Transportation	62	62	0	0	0	0
Hazardous Materials	6	6	0	0	0	0
Total	**663**	**663**	**0**	**0**	**0**	**0**

Environment

Secondary hazards associated with earthquakes will likely have some of the most damaging effects on the environment. Earthquake-induced landslides can significantly impact surrounding habitat including coral reefs. Earthquakes can result in underwater avalanches, which can potentially damage the reefs surrounding the island. It is also possible for streams to be rerouted after an earthquake. This can change the water quality, possibly damaging habitat and feeding areas. There is a possibility of streams fed by groundwater drying up because of changes in underlying geology.

12.3 ISSUES

12.3.1 Development in High-Hazard Areas

Land use is determined by the County's zoning code and zoning map, also known as the Comprehensive Zoning Ordinance. Zoning controls the density and intensity of development, and well as its form and character. Changes to the zoning code are guided by the General Plan, which is adopted by the Kaua'i County Council. The General Plan includes community plans for West Kaua'i, South Kaua'i, Līhu'e, East Kaua'i, and North Shore. The General Plan and community plans establish policies to protect communities from hazards. Development in the planning area is also regulated by building standards and performance measures. Kaua'i has very low seismic hazard, much lower than O'ahu. Wind hazard considerations will always govern over seismic hazard on Kaua'i.

12.3.2 Other Issues

The following issues have been identified related to the earthquake hazard in the planning area:

- **Continuity of Operations**—Critical facility owners should be encouraged to include earthquake considerations in their continuity of operations plans, using the information on risk and vulnerability contained in this plan.
- **Standardization of Future Development**—Current building codes and standards (International Building and Residential Codes) are sufficient to account for the probable impacts from earthquakes in the design and construction of new or enhanced facilities. For existing buildings and critical facilities, the emphasis should be on addressing the hurricane and flood hazards.
- **Continued Public Education**—The State of Hawai'i Emergency Management Agency recommends that citizens be self-sufficient up to 14 days following a major disaster without government response agencies, utilities, private sector services and infrastructure components. Education programs are currently in place to facilitate the development of individual, family, neighborhood, and business disaster preparedness. Government alone can never make this region fully prepared. It takes individuals, families, and communities working in concert with one another to truly be prepared for disaster.

13. HEAT AND DROUGHT

Periods of high temperature and low precipitations do not generally pose risks to structures, but they can have significant impacts on the people and economy of the affected area.

Extreme heat can be defined as temperatures that hover 10 ºF or more above the average high temperature for the region, last for prolonged periods of time, and are often accompanied by high humidity. Extreme heat can pose a significant risk to human health, diminishing the body's ability to maintain a normal temperature. Studies have shown that a significant rise in heat-related illness occurs when excessive heat persists for more than two days.

A drought is a period of abnormally dry weather. Drought can lead to water use restrictions, water quality problems, and inadequate water supplies for fire suppression. There may also be conflicts between agricultural uses of surface water and in-stream uses, or between new water demand and traditional and cultural uses of water. The U.S. Drought Monitor (USDM) map is updated weekly and shows the location and intensity of drought. The USDM uses a five-category system:

- D0—Abnormally Dry
- D1—Moderate Drought
- D2—Severe Drought
- D3—Extreme Drought
- D4—Exceptional Drought

Additional general information on the heat and drought hazard is provided in Appendix L.

13.1 HAZARD PROFILE

Table 13-1 summarizes the key elements of the hazard profile for heat and drought in Kaua‘i County. Additional details are provided in Appendix L.

13.2 RISK ASSESSMENT

13.2.1 Scenario

An extreme drought with a combination of low precipitation and unusually high temperatures could occur over several consecutive years. Intensified by such conditions, extreme wildfires could break out throughout the planning area, increasing the need for water. If such conditions persisted for years, the economy of Kaua‘i County could experience setbacks, especially in water dependent industries such as agriculture.

A heat wave can cause significant health problems for the population including heat exhaustion, heat stroke, or dehydration. Extensive use of air conditioners puts a strain on the power grid and can lead to blackouts. Many residential properties do not have air conditioning so crowds may form in air-conditioned public buildings as community members try to escape the heat. Extended heat events may affect water supplies as needs are increased to support people, crops, and livestock.

Table 13-1. Heat and Drought Hazard Profile Summary

	Extreme Heat	Drought
Past Events	• 2014: High temperatures recorded at the Līhuʻe airport broke a record five out of the seven days starting October 10. • 2019: Every day between August 24 and September 12, high record temperatures were set or surpassed in Līhuʻe. Sixteen nights stayed above 80 degrees. • 2020: In Līhuʻe, 83 days between July 1 – October 18 exceeded normal high temperatures.	• D0 to D2 conditions in 2019 • D2 conditions in March through June 2016 • 2012-2013 Primary Natural Disaster Area declared • February to December 2010, and November 2011, windward Kauaʻi County, Primary Natural Disaster Area • D0 to D3 covered the entire state.
Location	All areas of Kauaʻi County are susceptible to extreme heat. The effects of heat may be exacerbated in cities, due to the urban heat island effect, but the non-urban communities can also be disrupted during periods of unusually hot weather.	All areas of Kauaʻi County are susceptible to drought. The extent and severity depend on the variance of rainfall across the planning area. A small belt in the southeastern corner of the island appears to be more vulnerable to some drought levels.
Frequency	Between 2014 and 2020, three multi-day extreme heat events occurred that exceeded previous records.	From 1972 to 2001, the 3-month SPI severe drought occurred 0 to 4 percent of the time and the 12-month SPI severe drought occurred 4 to 12 percent of the time.
Severity	Kauaʻi has experience record highs surpassing 90º F.	Kauai has experienced drought up to D3 (extreme drought) on the USDM drought scale.
Warning Time	The National Weather Service issues Excessive Heat Warnings within 12 hours of the onset of extremely dangerous heat conditions. Heat Watches are issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours. A Heat Advisory is issued within 12 hours of the onset of extremely dangerous heat conditions. Excessive Heat Outlooks are issued when the potential exists for an excessive heat event in the next 3 to 7 days.	Scientists may be able to predict El Niño/Southern Oscillation (ENSO) events more than a year in advance. Since El Niño events are closely linked to drought conditions in Hawaiʻi, this may help produce more reliable forecasts that can reduce risks in economic sectors most sensitive to drought.
Secondary Hazards	Heatwaves can burden health and emergency services and increase strains on water, energy and transportation, resulting in power outages. Food and livelihood security may be strained if people lose their crops or livestock due to extreme heat.	Areas that have experienced long-term drought may be more susceptible to wildfire.

See Section 1.4.2 for a description of elements included in the hazard profile

13.2.2 Exposure

All people, property and environments in the planning area would be exposed to some degree to the impacts of extreme heat and drought.

13.2.3 Vulnerability

Population

The most common impacts of specific weather event types on people are as follows:

- **Drought**—Kauaʻi County has the ability to minimize the impacts on residents and water consumers should several consecutive dry years occur. No significant life or health impacts are anticipated as a result of drought within the planning area.
- **Extreme Heat**—Individuals with physical or mobility constraints, cognitive impairments, economic constraints, or social isolation are typically at greater risk to the adverse effects of excessive heat events.

Certain medical conditions, such as heat stroke, can be directly attributable to excessive heat, while others may be exacerbated by excessive heat, resulting in medical emergencies. The homeless population is particularly vulnerable to extreme heat.

Property and Critical Facilities

Extreme heat events are not known for causing direct damage to buildings, but may damage building systems such as heating, ventilation and cooling systems or infrastructure. No structures will be directly affected by drought conditions, though some structures may become vulnerable to wildfires, which are more likely following years of drought. Droughts can also have significant impacts on landscapes, which could cause a financial burden to property owners. However, these impacts are not considered critical in planning for impacts from the drought hazard.

Environment

Extended periods of extreme heat can impact crops and agriculture. Environmental losses from drought are associated with damage to plants, animals, wildlife habitat, and air and water quality; forest and range fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity.

13.3 ISSUES

13.3.1 Development in High-Hazard Areas

The core capability assessment for this plan identified the County's strong commitment to adoption of uniform codes and standards that will position the planning area well to manage risk for future development. The *2017 Hawai'i Drought Plan Update*, the *2015 Kaua'i County Water Use and Development Plan Update*, and *Water Plan 2020* provide the capability at the state and local level to respond to and develop long- and short-term mitigation strategies from the impacts of drought.

13.3.2 Other Issues

The following issues have been identified related to the heat and drought hazard in the planning area:

- **Drought-tolerant landscape designs are not adequately encouraged**—Incorporating drought tolerant or xeriscaping practices into landscape ordinances, providing incentives for xeriscaping, and encouraging permeable driveways and surfaces will reduce dependence on irrigation.
- **Groundwater recharge techniques are not utilized**—During non-drought period, recharging groundwater to stabilize the groundwater supply should be a regular practice. By ensuring groundwater remain stable, impacts of future drought occurrences will be minimized.
- **Active water conservation even during non-drought periods needs to be promoted**—Active conservation during non-drought periods serves as a tool to anticipate how entities will use water during drought periods. If conservation is practiced during non-drought periods, needed conservation during drought periods will minimize the impact on the County and mitigate against overuse of minimal water supply. The con associated with this particular initiative is encouraging residents to adhere to water conservation. Public outreach initiatives regarding this issue must emphasize the need for water conservation during non-drought periods.
- **Cooling centers are not accessible**— During periods of extreme heat, cooling centers located in strategic areas around the island may be an effective strategy to protect the public from high temperatures.

Part 3. THE ACTION PLAN

14. HAZARD MITIGATION ACTION PLAN

14.1 MITIGATION BEST PRACTICES

Catalogs were developed that present a broad range of hazard mitigation best practices to consider for use in the planning area. One catalog was developed for each hazard of concern evaluated in this plan. The catalogs are included in Appendix N. Recommended hazard mitigation actions in this plan were selected from among the best practices presented in the catalogs. The selected alternatives provide a baseline of actions that are backed by a planning process, are consistent with the established goals and objectives, and are within the capabilities of Kauaʻi County to implement.

The purpose of the catalogs was to provide a list of what could be considered to reduce risk of the natural hazards in the planning area. Some practices in the catalogs are not feasible for this plan. Those that are not included for the action plan were not selected for one or more of the following reasons:

- The action is not feasible.
- The action is already being implemented.
- There is an apparently more cost-effective alternative.
- The action does not have public or political support.
- There is very little development in the planning area that is exposed to the hazard the action addresses.

Appendix N also identifies potential actions to create, keep or enhance adaptive capacity, which is defined as "the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC, 2014). The identified adaptive capacity actions are general alternatives that the County considered to build capacity for adapting to both current and future risks.

14.2 GOALS AND OBJECTIVES

Hazard mitigation plans must identify goals for reducing long-term vulnerabilities to identified hazards. As part of the plan update process, the Steering Committee reviewed the goals and objectives of the 2015 plan and revised them to more fully align with other community objectives and priorities. The following are the updated mitigation goals for this plan:

1. Reduce the long-term vulnerability of the County of Kauaʻi's people, communities and property—including government-owned or operated buildings, lifelines, and infrastructure—to hazards, while conserving the County's natural, historical, and cultural assets. This includes high risk properties such as repetitive loss and severe repetitive loss properties.
2. Promote the County of Kauaʻi's long-term resilience, the capacity to adapt to and thrive with changing conditions and acute shocks.
3. Strengthen public and private partnerships and leverage existing resources and capabilities to identify, assess, and reduce the impact of hazards and increase resilience.
4. Utilize local knowledge and state-of-the-art methods and technology to identify and analyze hazards and assess the County's capabilities to reduce the impact of those hazards and increase resilience.

5. Promote public awareness of hazard risks and public actions that can reduce the long-term risks and increase resilience.
6. Provide a framework for robust community hazard mitigation and resilience planning and strategy implementation in alignment with this plan.
7. Increase the County of Kaua'i's capabilities and capacity to prepare for, respond to, recover from, and mitigate the impacts of hazards that can impact the County.

The updated objectives are as follows:

1. Engage the whole community, including visitors, to develop a shared science-based understanding of hazard and climate change risks and vulnerabilities to inform risk-reduction measures, preparedness response, and adaptation strategies.
2. Reduce repetitive property losses due to floods, erosion, high winds, tsunamis, fire and sea level rise through acquisition, retrofitting, design, and updated construction and land use regulations.
3. Incorporate mitigation measures into repairs, major alterations, new development, and redevelopment, especially in areas with substantial hazard risk and those known to have repetitive loss.
4. Consider climate change impacts—including greenhouse gas emissions—in all repairs, major alterations, new development, and redevelopment.
5. Enhance community capacity to develop community-based disaster resilience plans that incorporate education and risk -reduction measures, including visitors; and integrate them into county planning documents.
6. Align the hazard mitigation plan with state mitigation plans; county general, community, and capital improvement plans; and climate action, resilience, and adaptation plans.
7. Reduce risk to and increase the resilience of vulnerable infrastructure and community lifelines.
8. Leverage limited financial and human resources by prioritizing projects that provide multiple benefits addressing social equity, disaster mitigation, and greenhouse gas reduction.
9. Establish and maintain public-private partnerships among all levels of government, community groups, the private sector, and institutions of higher learning to promote hazard mitigation, disaster preparedness, and recovery programs.
10. Create financial and regulatory incentives for development and land use techniques to motivate homeowners, private sector businesses, and nonprofit community organizations to mitigate hazards and risk.
11. Improve systems that provide warning and emergency communications.
12. Proactively manage and care for natural infrastructure and resources such as mountain slopes, stream channels, beaches, and reefs to enhance their ability to withstand natural disasters and minimize public safety risks.
13. Recognize and support the disaster resilience inherent in host culture traditions and practices including holistic watershed management, community connectivity, and local, ahupua'a based decision-making.
14. Prioritize investment and support efforts to improve resilience of community lifelines in socially vulnerable communities.
15. Create supply chain diversity and improved resilience by supporting local food and energy production and increased multi-modal transportation.
16. Develop a disaster recovery framework to guide streamlined, resilient, decision-making post-disaster.

14.3 RECOMMENDED MITIGATION ACTIONS

The Steering Committee reviewed the catalogs of hazard mitigation alternatives and selected actions to be included in a hazard mitigation action plan. The selection of actions was based on the risk assessment of identified

hazards of concern, the defined hazard mitigation goals and objectives, and considerations of equity in project selection and implementation. Table 14-1 lists the recommended hazard mitigation actions that make up the action plan. The timeframe indicated in the table is defined as follows:

- Short Term = to be completed in 1 to 5 years
- Long Term = to be completed in greater than 5 years
- Ongoing = currently being funded and implemented under existing programs.

Appendix O provides additional information on the detailed steps included in each recommended action. This includes a specific emphasis on integrating nature-based solutions to address hazard risk reduction and resiliency building. Nature-based solutions weave natural features and processes into a community's landscape through planning, design, and engineering. While nature-based solutions have many hazard mitigation benefits, they can also help a community meet its social, environmental, and economic goals. Communities across the country are finding nature-based solutions to be a highly effective way to provide public services that were traditionally met with structural or "gray" infrastructure.

Table 14-1. Hazard Mitigation Action Plan Matrix

Applies to New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Cost Rating	Sources of Funding	Timeline[a]
Action KC1— Adopt the most current International Building Code and standards.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	2, 3, 4, 7, 10	DPW		Low	County Funds	Short-term
Action KC2— Implement the most current International Building Code and standards. Identification of specific infrastructure that will be impacted by the adoption of the IBC. Identification of relocation options.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	2, 3, 4, 7, 10	DPW		TBD	FEMA BRIC (C&CB) with General Funds, NOAA Programs	Short-term
Action KC3— Assess Kaua'i War Memorial Convention Hall Exhibition Hall for high wind retrofit. Implement actions to allow use of the exhibit hall as a disaster shelter during natural disasters.						
Hazards Mitigated: Tropical Cyclone and Other High Winds						
Existing	1, 2, 3, 7, 8	DOPR	KEMA	Low	FEMA HMA, County Funds	Short-term
Action KC4— Harden State DLNR radio repeater sites and base station on Kaua'i.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Tsunami, Landslide, Dam Failure						
Existing	2, 3, 4, 7, 11, 14	DLNR DOFAW		Medium	State Funds	Short-term
Action KC5— Install a 500-kW DC photovoltaic ground mount and canopy renewable power generation system ("PV") and renewable energy storage system ("RESS") at KCC.						
Hazards Mitigated: Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami						
Existing	3, 4, 9	KCC		Medium	State Funds	Short-term
Action KC6— Procure new 4,000-gallon capacity water truck to assist in providing the public with potable water and to assist other state and county agencies efforts in disaster management activities.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure, Drought and Heat						
New and Existing	8, 14	DLNR DOFAW		Medium	State Funds	Short-term

Applies to New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Cost Rating	Sources of Funding	Timeline[a]
Action KC7— Provide alternate distribution feed to the Līhu'e Airport with the installation of auto transfer switchgear and underground conduits and cables.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Tsunami, Landslide, Dam Failure						
Existing	2, 3, 4, 7	KIUC		Low	FEMA HMA, KIUC Funding	Short-term
Action KC8— Assess hardening needs and develop implementation plans for critical infrastructure.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	2, 3, 4, 7, 8, 9, 11, 13, 14	DOT, DPW		TBD	FEMA BRIC, FEMA HMGP, FEMA FMA (flood only), USGS, NOAA, HUD CDBG-DR, HUD CDBG-MIT: Local Match - CIP and General Fund	Long-term
Action KC9— Protect and restore the integrity of native habitats, especially Kaua'i's last remaining pristine native habitats in the upper watershed.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	1, 5, 7, 8, 9, 10, 12, 13, 15	TBD		TBD	NOAA, EPA, FEMA BRIC, STATE FUNDING	DOF
Action KC10— Develop and implement mitigation strategies to address impacts of invasive species that increase vulnerability to natural hazards						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	1, 2, 3, 5, 7, 8, 9, 12, 13, 14, 15	TBD, HWH		TBD	Disaster Recovery Funding - Act 35, FEMA HMA (hazardous fuel reduction, landslide stabilization)	Short-term
Action KC11— Conduct an island-wide shelter needs assessment in coordination with community, faith-based, and government entities to identify shelter locations in new buildings and to ensure existing shelters are ready for use.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	1, 2, 3, 4, 5, 7, 8, 9, 10, 13, 14	KEMA		Medium	EMPG, DHS HSGP State High Wind Shelter Program	Ongoing
Action KC12— Conduct alternative analyses of identified vulnerable lifelines of critical facilities; 'Ele'ele, Waimea, Līhu'e & Wailua Wastewater Facilities						
Hazards Mitigated: Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Tsunami, Dam Failure						
Existing	5, 7, 14	DPW		TBD	FEMA HMA Programs	Long-term
Action KC13— Conduct alternative analyses of identified vulnerable lifelines.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
Existing	5, 7, 14	DPW		TBD	FEMA HMA, General Funds, NOAA, U.S. Fish and Wildlife, EPA	Long-term

Applies to New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Cost Rating	Sources of Funding	Timeline[a]
Action KC14— Continue assessing the vulnerability of critical assets using the best available science, and support the development of vulnerability assessments specific to wastewater, roads, and other critical assets.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
Existing	5, 7, 14	DPW		TBD	FEMA HMA, General Funds, NOAA, U.S. Fish and Wildlife, EPA	Long-term
Action KC15— Conduct a public awareness and education campaign to promote public health preparedness during hurricane season.						
Hazards Mitigated: Health-related Hazards, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Tsunami, Landslide, Dam Failure						
New and Existing	1, 5, 9	DOH	KEMA	Medium	State DOH, General County Funds, CDC, HHS	Ongoing
Action KC16—Develop a Public Health emergency action plan and implementation strategy to determine which medications, equipment & staff will be needed post-event, where they should be staged, how and by whom they will be administered, and when and where to set up vaccine clinics; develop guidance for public awareness campaign.						
Hazards Mitigated: Health-related Hazards, Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure, Drought and Heat						
New and Existing	1, 5, 9, 13	DOH	KEMA	Medium	State DOH, FEMA EMPG, CDC, HHS	Short-term
Action KC17— Develop an Island-wide Climate Adaptation and Resiliency Plan to incorporate impacts of climate change in land use planning, relocation of critical infrastructure, and County operations.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Tsunami, Landslide, Dam Failure						
New and Existing	1, 2, 3, 4, 5, 6, 7	Planning Department	County Agencies	Medium	County General Funds	Short-term
Action KC18— Reduce impacts from climate change risks through the implementation of mitigation actions, including those already identified in regional community plans and assessments, such as the West Kaua'i Community Plan and West Kaua'i Community Vulnerability Assessment						
Hazards Mitigated: Climate Change, Tropical Cyclone and Other High Winds, High Surf, Coastal Flood and Erosion, Tsunami, Landslide, Dam Failure						
New and Existing	1, 2, 3, 4, 5, 7, 8, 9, 12, 13, 14	Planning Department	DLNR, DOBOR, County Public Access, Open Space & Natural Resources Fund; Legacy Lands; KEMA; DPW; Wastewater Division; Department of Water	TBD	NOAA Programs, FEMA HMA, CDBG-MIT, EPA, State General Funds, Non-Profit Agencies	Long-term
Action KC19—— Distribute University of Hawai'i Sea Grant publications and Homeowner's Handbook to support education and outreach for hazard awareness. Target audience to include island youth (i.e. CSAV example), tourist populations and other vulnerable populations.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	1, 9, 13	Sea Grant	KEMA	High	NOAA, FEMA HMA, CDBG-MIT, EPA, State General Funds, Non-Profit Agencies	Short-term

Applies to New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Cost Rating	Sources of Funding	Timeline[a]
Action KC20— Develop and maintain public awareness of hazards, vulnerability, mitigation and adaptation strategies.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure, Drought and Heat						
New and Existing	1, 9, 12, 13	Planning Department	DLNR, DOPR, KEMA, DOE, Kaua'i Visitor Bureau	TBD	NOAA, FEMA HMA, CDBG-MIT, EPA, State General Funds, Non-Profit Agencies	Long-term
Action KC21— Develop tools to identify socially vulnerable populations (and vulnerable geographic areas) in Kaua'i County to determine and prioritize hazard risk reduction projects.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure, Drought and Heat						
New and Existing	1, 2, 3, 4, 5, 7, 8, 9, 12, 13, 14	Planning Department	DLNR, DOPR, KEMA, DOE	TBD	FEMA HMA, NOAA, EPA, HUD, State & County General Funds, Non-Profits	Long-term
Action KC22—Identify and implement enhanced cyber security measures across county government agencies.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure, Drought and Heat						
New and Existing	6, 7, 11	KEMA		Medium	HSGP, EMPG, County General Funds	Ongoing
Action KC23—Implement U.S. Army Corps of Engineers plan to raise the height of the Hanapēpē levee to re-establish the 100-year flood protection. Coordinate with CODEL & Corps of Engineers.						
Hazards Mitigated: Inland Flood						
Existing	2, 3, 7, 14	DPW	KEMA	Low	ACT-35 Funds	Short-term
Action KC24—Implement U.S. Army Corps of Engineers plan to raise the height of the Waimea levee and repair the broken sluice gate to re-establish the 100-year flood protection. Coordinate with CODEL & Corps of Engineers.						
Hazards Mitigated: Inland Flood						
Existing	2, 3, 7, 14	KPW	KEMA	Low	ACT-35 Funds	Short-term
Action KC25—Inspect, repair, and maintain levees and county dams to reduce and/or prevent impacts from potential disasters.						
Hazards Mitigated: Inland Flood						
Existing	1, 2, 3, 4, 7, 14	DPW	KEMA	Low	ACT-35 Funds	Long-term
Action KC26—Integrate community-based disaster resilience plans into future community plan updates.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure, Drought and Heat						
New and Existing	1, 5, 6, 9, 13	Planning Department	Department of Elderly Affairs, HWH	Medium	FEMA HMA, NOAA, CDBG-MIT, EPA, ACT-35	Long-term
Action KC27—Identify county and local resources to build capacity for preparedness, response, recovery and mitigation.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure, Drought and Heat						
New and Existing	5, 6, 9, 13	TBD	KEMA	High	EMPG, HSGP, County Funds	Ongoing
Action KC28—Conduct training and exercise for multi-hazard events						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure, Drought and Heat						
New and Existing	1, 9, 13, 15, 16	KEMA		Medium	EMPG, HSGP, County Funds	Ongoing

Applies to New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Cost Rating	Sources of Funding	Timeline[a]
Action KC29—Establish resilience hubs and decentralized command and supply centers.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure, Drought and Heat						
New and Existing	1, 8, 9, 13, 14, 16	TBD	KEMA	Medium	ACT-35, FEMA HMA, NOAA HUD, EPA	Long-term
Action KC30—Organize and coordinate local resources to prepare, respond to and recover from disaster events.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure, Drought and Heat						
New and Existing	1, 8, 9, 13, 14, 15, 16	KEMA		Medium	FEMA PA & HMA, County Funds	Ongoing
Action KC31— Pursue beach and dune restoration to mitigate impact from coastal hazards and sea level rise.						
Hazards Mitigated: Climate Change, Tropical Cyclone and Other High Winds, High Surf, Coastal Flood and Erosion, Tsunami						
Existing	1, 2, 7, 12, 13, 14	DOPR	DPW	High	NOAA Programs, U.S. Fish and Wildlife, FEMA HMA	Long-term
Action KC32— Establish five repeater sites to enable better emergency response communications among DOFAW baseyard, DOFAW office, DSP office and DOCARE offices.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	3, 4, 7, 11, 14	DLNR		Medium	State Funds	Short-term
Action KC33— Integrate new equipment to increase wildfire fighting capability.						
Hazards Mitigated: Wildfire						
New and Existing	7, 14	DLNR, KFD		Medium	State Funds	Short-term
Action KC34— Reduce wildfire risk through the implementation of mitigation projects.						
Hazards Mitigated: Wildfire						
New and Existing	1, 2, 3, 7, 9, 12, 14	DLNR, KFD		High	U.S. Forest Service, U.S. Fish and Wildlife, FEMA HMA, FEMA AFG, FEMA FMAG	Long-term
Action KC35— Continue to maintain signage and sirens that were installed as part of the updated scenarios for tsunami evacuation zones.						
Hazards Mitigated: Inland Flood, High Surf, Coastal Flood and Erosion, Tsunami, Landslide, Dam Failure						
New and Existing	1, 11	KEMA		Medium	NOAA, FEMA HMA, EPA	Ongoing
Action KC36— Develop and employ an Early Warning System for flood events on the north shore of Kaua'i.						
Hazards Mitigated: Inland Flood, High Surf, Coastal Flood and Erosion, Tsunami, Landslide, Dam Failure						
New and Existing	1, 11	HWH		Low	ACT-35	Short-term
Action KC37— Encourage development of local preparedness plans in cooperation with local communities to include the designation of evacuation routes, critical facility access routes, public shelters and storage of food and water.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	1, 5, 6, 9, 13, 14, 15	HWH		Low	ACT-35	Short-term
Action KC38— Install a KEMA outdoor warning siren on Ni'ihau.						
Hazards Mitigated: Tsunami						
New and Existing	1, 11	KEMA		Medium	State Funds	Short-term

Applies to New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Cost Rating	Sources of Funding	Timeline[a]
Action KC39— Install public address system to ensure effective emergency communications to the KCC campus and surrounding areas.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	1, 11	KCC		Medium	State Funds	Long-term
Action KC40— Update, maintain, and enhance the use of the County's GIS and database to improve decision-making and ensure consistency in planning, permitting, and construction regulations to reduce disaster risk.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	2, 4, 6, 14	TBD		TBD	NOAA, State Funds	DOF
Action KC41— Review and update County Emergency Management Plans.						
Hazards Mitigated: Wildfire, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	6, 16	KEMA		Medium	EMPG, HSGP, County General Funds	Short-term
Action KC42— Continue to update and implement the shoreline setback ordinance taking into account the best available science with respect to erosion and sea level rise.						
Hazards Mitigated: Climate Change, Tropical Cyclone and Other High Winds, High Surf, Coastal Flood and Erosion, Tsunami						
New and Existing	2, 4, 6, 14	Planning Department		High	County General Funds	DOF
Action KC43— Review, update and implement codes and regulations to incorporate adaptation strategies, green infrastructure and low impact development strategies.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Earthquake, Tsunami, Landslide, Dam Failure						
New and Existing	2, 4, 6, 14	Planning Department, DPW		High	USDA, USDA-NRCS, EPA, FEMA BRIC	Long-term
Action KC44— Conduct a hydraulic/hydrologic study of the North Shore, Waimea, and Wailua, which will produce a project list that can be turned into proposals for funding.						
Hazards Mitigated: Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Landslide, Dam Failure						
New and Existing	1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14	HWH		Low	ACT-35	Short-term
Action KC45— Utilize best available data and scientific studies to assess the vulnerability of agricultural properties and develop public outreach and mitigation strategies.						
Hazards Mitigated: Wildfire, Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, Drought and Heat						
New and Existing	1, 6, 9, 12, 13, 15	TBD	USDA-NRCS, Office of Hawaiian Affairs, Community Groups	TBD	USDA, USDA-NRCS, EPA	DOF
Action KC46— Utilize best available data and scientific studies to assess watershed and community flood drainage problems.						
Hazards Mitigated: Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Tsunami, Dam Failure						
New and Existing	1, 6, 7, 9, 12, 13	TBD	ADC, Kaua'i Agriculture Association, DPW, PMRFTBD	TBD	FEMA HMA. NOAA, EPA, USACE, USGS	DOF

Applies to New or Existing Assets	Objectives Met	Lead Agency	Support Agency	Cost Rating	Sources of Funding	Timeline[a]
Action KC47— Maintain NFIP Compliance. Continue to maintain good standing and compliance under the NFIP through implementation of floodplain management programs that, at a minimum, meet the NFIP requirements: • Enforce the flood damage prevention ordinance. • Participate in floodplain identification and mapping updates. • Provide public assistance/information on floodplain requirements and impacts. *Hazards Mitigated:* Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Tsunami, Dam Failure						
New and Existing	2, 6, 7, 9, 10	DPW	KEMA	Low	County Funds	Ongoing
Action KC48— Work with the State NFIP coordinator to develop the program for participation in the Community Rating System. *Hazards Mitigated:* Climate Change, Tropical Cyclone and Other High Winds, Inland Flood, High Surf, Coastal Flood and Erosion, Tsunami, Dam Failure						
New and Existing	2, 6, 7, 9, 10	DPW	KEMA, Sea Grant	Medium	ACT-35, County Funds	Short-term
Action KC49— Utilize best available data and scientific studies to identify landslide risk, geospatial data needs and mitigation strategies. *Hazards Mitigated:* Landslide						
New and Existing	1, 6, 7, 9, 12, 13	DLNR		High	USGS, FEMA HMA, DOT	DOF

a. Short-term = Completion within 5 years; Long-term = Completion within 10 years; Ongoing= Continuing new or existing program with no completion date, DOF = Depending upon funding

See the introduction to this volume for list of acronyms used in this table.

14.4 BENEFIT-COST REVIEW

The action plan must be prioritized according to a benefit/cost analysis of the proposed actions (44 CFR, Section 201.6(c)(3)(iii)). The benefits of proposed actions were weighed against estimated costs as part of the action prioritization process. The benefit/cost analysis was not of the detailed variety required by FEMA for project grant eligibility under the Hazard Mitigation Grant Program (HMGP) and Pre-Disaster Mitigation (PDM) grant program. A less formal approach was used because some actions may not be implemented for up to 10 years, and associated costs and benefits could change dramatically in that time. Therefore, a review of the apparent benefits versus the apparent cost of each action was performed. Parameters were established for assigning subjective ratings (high, medium, and low) to the costs and benefits of these actions. Figure 14-1 shows how actions are prioritized when cost and benefit ratings are combined.

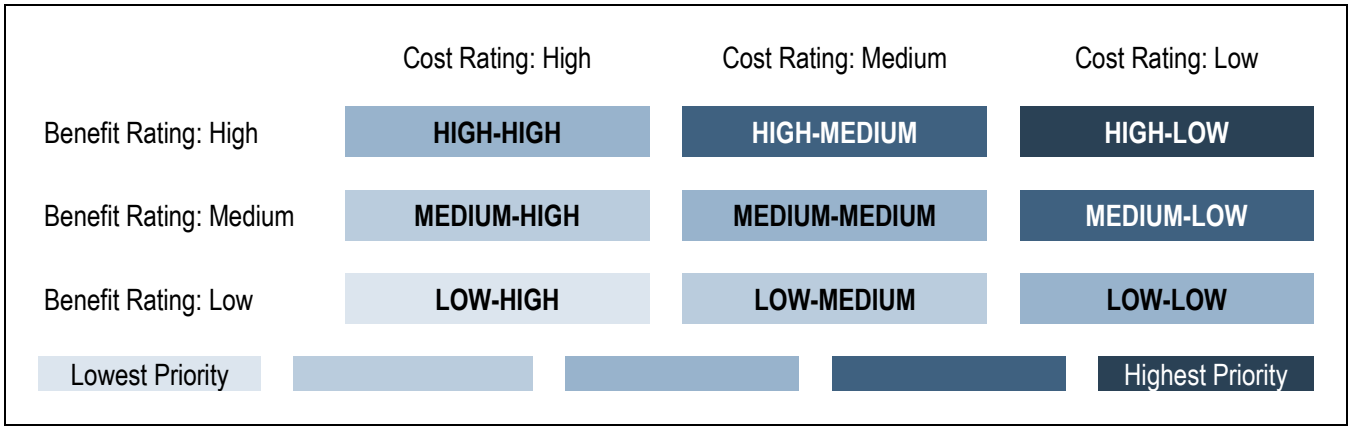


Figure 14-1. Action Prioritization by Benefit/Cost Analysis

Cost ratings were defined as follows:

- **High**—Existing funding will not cover the cost of the action; implementation would require new revenue through an alternative source (for example, bonds, grants, and fee increases).
- **Medium**—The action could be implemented with existing funding but would require a re-apportionment of the budget or a budget amendment, or the cost of the action would have to be spread over multiple years.
- **Low**—The action could be funded under the existing budget. The action is part of or can be part of an ongoing existing program.

Benefit ratings were defined as follows:

- **High—**Action will provide an immediate reduction of risk exposure for life and property.
- **Medium—**Action will have a long-term impact on the reduction of risk exposure for life and property, or action will provide an immediate reduction in the risk exposure for property.
- **Low—**Long-term benefits of the action are difficult to quantify in the short term.

Using this approach, actions with positive benefit versus cost ratios (such as high over high, high over medium, medium over low, etc.) are considered cost-beneficial and are prioritized accordingly. According to this analysis, the following mitigation actions are considered the highest priority:

- **Action KC1**—Adopt the most current International Building Code and standards.
- **Action KC3**—Assess Kaua'i War Memorial Convention Hall Exhibition Hall for high wind retrofit. Implement actions to allow use of the exhibit hall as a disaster shelter during natural disasters.
- **Action KC7**—Provide alternate distribution feed to the Līhu'e Airport with the installation of auto transfer switchgear and underground conduits and cables.
- **Action KC23**—Implement U.S. Army Corps of Engineers plan to raise the height of the Hanapēpē levee to re-establish the 100-year flood protection. Coordinate with CODEL and Corps of Engineers.
- **Action KC24**—Implement U.S. Army Corps of Engineers plan to raise the height of the Waimea levee and repair the broken sluice gate to re-establish the 100-year flood protection. Coordinate with CODEL and Corps of Engineers.
- **Action KC47**—Maintain NFIP compliance. Continue to maintain good standing and compliance under the NFIP through implementation of floodplain management programs that, at a minimum, meet the NFIP requirements.

For many of the strategies identified in this action plan, financial assistance may be available through the HMGP or PDM programs, both of which require detailed benefit/cost analyses. These analyses will be performed on projects at the time of application using the FEMA benefit-cost model. For actions not seeking financial assistance from grant programs that require detailed analysis, "benefits" can be defined according to parameters that meet the goals and objectives of this plan.

14.5 ACTION PLAN PRIORITIZATION

Table 14-2 lists the priority of each action. A qualitative benefit-cost review was performed for each action.

Table 14-2. Prioritization of Mitigation Actions

Action #	# of Objectives Met	Benefit Rating	Cost Rating	Do Benefits Equal or Exceed Costs?	Is Action Grant Eligible?	Can Action be Funded under Existing Programs/ Budgets?	Implementation Priority	Grant Pursuit Priority
KC1	5	High	Low	Yes	TBD	Yes	High	
KC2	5	Medium	TBD	TBD	Yes	No	Medium	High
KC3	5	High	Low	Yes	TBD	Yes	High	
KC4	6	High	Medium	Yes	TBD	Yes	High	
KC5	3	High	Medium	Yes	TBD	Yes	High	
KC6	2	High	Medium	Yes	TBD	Yes	High	
KC7	4	High	Low	Yes	TBD	Yes	High	
KC8	9	Low	TBD	TBD	Yes	No	Medium	High
KC9	9	Low	TBD	TBD	TBD	Yes	High	
KC10	11	Low	TBD	TBD	Yes	No	Medium	High
KC11	11	Medium	Medium	Yes	Yes	Yes	High	
KC12	3	Low	TBD	TBD	Yes	Yes	High	
KC13	3	Low	TBD	TBD	Yes	No	Medium	High
KC14	3	Low	TBD	TBD	Yes	No	Medium	High
KC15	3	High	Medium	Yes	TBD	Yes	High	
KC16	4	Medium	Medium	Yes	Yes	No	Medium	High
KC17	7	Medium	Medium	Yes	TBD	Yes	High	
KC18	11	Low	TBD	TBD	Yes	No	Medium	High
KC19	3	High	High	Yes	Yes	Yes	High	
KC20	4	Low	TBD	TBD	TBD	No	Medium	High
KC21	11	Low	TBD	TBD	Yes	No	Medium	High
KC22	3	High	Medium	Yes	Yes	No	Medium	High
KC23	4	High	Low	Yes	Yes	Yes	High	
KC24	4	High	Low	Yes	Yes	Yes	High	
KC25	6	Medium	Low	Yes	Yes	No	Medium	High
KC26	5	Medium	Medium	Yes	Yes	No	Medium	High
KC27	4	Medium	High	No	TBD	Yes	High	
KC28	5	High	Medium	Yes	TBD	Yes	High	
KC29	6	Medium	Medium	Yes	TBD	Yes	High	
KC30	7	High	Medium	Yes	TBD	No	Medium	High
KC31	6	Medium	High	No	Yes	No	Medium	High
KC32	5	High	Medium	Yes	TBD	Yes	High	
KC33	2	High	Medium	Yes	TBD	Yes	High	
KC34	7	Medium	High	No	Yes	No	Medium	High
KC35	2	High	Medium	Yes	TBD	Yes	High	
KC36	2	Medium	Low	Yes	TBD			
KC37	7	Medium	Low	Yes	TBD	Yes	High	
KC38	2	High	Medium	Yes	TBD	Yes	High	
KC39	2	Medium	Medium	Yes	TBD	Yes	High	
KC40	4	High	TBD	TBD	TBD	Yes	High	
KC41	2	High	Medium	Yes	TBD	Yes	High	
KC42	4	Medium	High	No	Yes	No	High	
KC43	4	Medium	High	No	Yes	No	Medium	High
KC44	12	Medium	Low	Yes	TBD	Yes	High	

Action #	# of Objectives Met	Benefit Rating	Cost Rating	Do Benefits Equal or Exceed Costs?	Is Action Grant Eligible?	Can Action be Funded under Existing Programs/ Budgets?	Implementation Priority	Grant Pursuit Priority
KC45	6	Low	TBD	TBD	Yes	No	Medium	High
KC46	6	Low	TBD	TBD	Yes	No	Medium	High
KC47	5	High	Low	Yes	Yes	Yes	High	
KC48	5	High	Medium	Yes	Yes	No	Medium	High
KC49	6	Low	High	No	Yes	No	Medium	High

The priorities are defined as follows:

- **Implementation Priority**
  - **High Priority**—An action that meets multiple objectives, has benefits that exceed costs, and has a secured source of funding. Action can be completed in the short term (1 to 5 years).
  - **Medium Priority**—An action that meets multiple objectives, has benefits that exceed costs, and is eligible for funding though no funding has yet been secured for it. Action can be completed in the short term (1 to 5 years), once funding is secured. Medium-priority actions become high-priority actions once funding is secured.
  - **Low Priority**—An action that will mitigate the risk of a hazard, has benefits that do not exceed the costs or are difficult to quantify, has no secured source of funding, and is not eligible for any known grant funding. Action can be completed in the long term (1 to 10 years). Low-priority actions are generally "wish-list" actions. They may be eligible for grant funding from programs that have not yet been identified.
- **Grant Pursuit Priority**
  - **High Priority**—An action that meets identified grant eligibility requirements, has high benefits, and is listed as high or medium implementation priority; local funding options are unavailable or available local funds could be used instead for actions that are not eligible for grant funding.
  - **Medium Priority**—An action that meets identified grant eligibility requirements, has medium or low benefits, and is listed as medium or low implementation priority; local funding options are unavailable.
  - **Low Priority**—An action that has not been identified as meeting any grant eligibility requirements.

14.6 CLASSIFICATION OF MITIGATION ACTIONS

Each recommended action was classified based on the hazard it addresses and the type of mitigation it involves. Table 14-3 shows these classifications. Mitigation types used for this categorization are as follows:

- **Prevention**—Government, administrative or regulatory actions that influence the way land and buildings are developed to reduce hazard losses. Includes planning and zoning, floodplain laws, capital improvement programs, open space preservation, and stormwater management regulations.
- **Property Protection**—Modification of buildings or structures to protect them from a hazard or removal of structures from a hazard area. Includes acquisition, elevation, relocation, structural retrofit, storm shutters, and shatter-resistant glass.
- **Public Education and Awareness**—Actions to inform residents and elected officials about hazards and ways to mitigate them. Includes outreach projects, real estate disclosure, hazard information centers, and school-age and adult education.

Table 14-3. Analysis of Mitigation Actions

Hazard	Actions That Address the Hazard, by Mitigation Type[a]						
	Prevention	Property Protection	Public Education & Awareness	Natural Resource Protection	Emergency Services	Structural Projects	Community Capacity Building
Wildfire	9, 10, 34	1, 2, 8, 13, 14, 17, 21, 33, 41, 43, 45	19, 20, 30, 37	9, 10, 21, 33, 34, 41	4, 6, 11, 16, 22, 28, 29, 30, 33, 39, 41	4, 7, 8, 11, 29, 32, 40	26, 27, 28, 30, 37
Climate Change		1, 2, 8, 14, 17, 18, 21, 31, 42, 43, 44, 45, 46, 47	15, 19, 20	9, 10, 18, 21, 31, 44, 45, 46		8, 29, 40	26, 27, 28, 30
Tropical Cyclone and Other High Winds		1, 2, 12, 13, 14, 17, 18, 21, 31, 42, 43, 44, 45, 46, 47	15, 19, 20, 30, 37	9, 10, 18, 21, 31, 44, 45, 46	4, 6, 11, 16, 22, 28, 29, 30, 39, 41	3, 4, 5, 7, 8, 11, 29, 32, 40	26, 27, 28, 30, 37
Inland Flood	9, 10	1, 2 12, 13, 14, 17, 21, 43, 44, 45, 46, 47	15, 19, 20, 30, 37	9, 10, 21, 44, 45, 46	4, 6, 11, 16, 22, 28, 29, 30, 39, 41	4, 5, 7, 8, 11, 23, 24, 25, 29, 32, 36, 40	26, 27, 28, 30, 37
High Surf, Coastal Flood and Erosion	9, 10	1, 2 12, 13, 14, 17, 18, 21, 31, 42, 43, 44, 45, 46, 47	15, 19, 20, 30, 37	9, 10, 18, 21, 31, 44, 45, 46	4, 6, 11, 16, 22, 28, 29, 30, 41	4, 5, 7, 8, 11, 29, 32, 40	26, 27, 28, 30, 37
Tsunami		1, 2 12, 13, 14, 17, 18, 21, 31, 42, 43, 44, 45, 46, 47	19, 20, 30, 37	9, 10, 18, 21, 31, 44, 45, 46	4, 6, 11, 16, 22, 28, 29, 30, 39, 41	4, 5, 7, 8, 11, 29, 32, 40	26, 27, 28, 30, 37
Landslide	9, 10	1, 2, 8, 13, 14, 21, 42, 44, 48	19, 20, 30, 37	9, 10, 21, 44, 45	4, 6, 11, 28, 29, 30, 41	4, 7, 8, 11, 23, 24, 25, 29, 32, 40	26, 27, 28, 30, 37
Dam Failure		1, 2, 8, 12, 13, 14, 46, 47, 48	19, 20, 30, 37	9, 10, 21	4, 6, 16, 22, 29, 30, 41	4, 7, 11, 23, 24, 25, 29, 32, 40	26, 27, 28, 30, 37
Earthquake		1, 2, 8, 13, 14, 21, 48	19, 20, 30, 37	21	4, 6, 11, 16, 28, 29, 30, 41	4, 7, 8, 11, 29, 32	26, 27, 28, 30, 37
Heat and Drought		21, 45	20	21, 45	6, 16, 22, 28, 29, 30	29	26, 27, 28, 30

- **Natural Resource Protection**—Actions that minimize hazard loss and preserve or restore the functions of natural systems. Includes sediment and erosion control, stream corridor restoration, watershed management, forest and vegetation management, wetland restoration and preservation, and green infrastructure.
- **Emergency Services**—Actions that protect people and property during and immediately after a hazard event. Includes warning systems, emergency response services, and the protection of essential facilities.
- **Structural Projects**—Actions that involve the construction of structures to reduce the impact of a hazard. Includes dams, setback levees, floodwalls, retaining walls, and safe rooms.
- **Community Capacity Building**—Actions that increase or enhance local capabilities to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. Includes staff training, memorandums of understanding, development of plans and studies, and monitoring programs.

14.7 PLAN ADOPTION AND IMPLEMENTATION

The action plan presents a range of action items for reducing loss from hazard events. The County has prioritized actions and can begin to implement the highest-priority actions over the next five years. The effectiveness of the hazard mitigation plan depends on its effective implementation and incorporation of the outlined action items into

existing County plans, policies, and programs. Some action items do not need to be implemented through regulation but can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation. KEMA (Kaua'i Emergency Management Agency) will have lead responsibility for overseeing the plan implementation and maintenance strategy.

14.7.1 Plan Adoption

A hazard mitigation plan must document that it has been formally adopted by the governing body of the jurisdiction requesting federal approval of the plan. This plan was submitted for a pre-adoption review to HI-EMA (Hawai'i Emergency Management Agency) and FEMA Region IX prior to adoption. Once pre-adoption approval was provided, the County formally adopted the plan. A copy of the FEMA approval and County resolution adopting this plan can be found in Appendix P.

14.7.2 Plan Maintenance Strategy

Plan maintenance is the formal process for achieving the following:

- Ensuring that the hazard mitigation plan remains an active and relevant document and that the County maintains its eligibility for applicable funding sources
- Monitoring and evaluating the plan annually and producing an updated plan every five years
- Integrating public participation throughout the plan maintenance and implementation process
- Incorporating the mitigation strategies outlined in this plan into existing planning mechanisms and programs, such as any relevant comprehensive land-use planning process, capital improvement planning process, and building code enforcement and implementation.

Table 14-4 summarizes the plan maintenance strategy. Appendix Q further describes each element.

Table 14-4. Plan Maintenance Matrix

Plan Element	Approach	Timeline
Plan Monitoring	• Track the implementation of actions over the performance period of the plan	Continuous over the 5-year performance period of the plan
Plan Evaluation	• Review the status of previous actions • Assess changes in risk • Evaluate success of integration	Upon initiation of hazard mitigation plan update, comprehensive general plan update, or major disaster
Integration into Other Planning Mechanisms	• Create a linkage between the hazard mitigation plan and the County's general plan and similar plans identified in the core capability assessment	Continuous over the 5-year performance period of the plan
Grant Monitoring and Coordination	• As grant opportunities present themselves, consider options to pursue grants to fund actions identified in this plan	As grants become available
Plan Update	• At least every 5 years, the County will guide a comprehensive update of the plan.	Every 5 years or upon comprehensive update to General Plan or major disaster; funding and organizing for plan update will begin in FY 2021/2022
Continuing Public Participation	• Maintain the hazard mitigation website over the course of the plan. • Review status of projects, update strategy, etc. • Receive comments through the website. • Maintain the comments over the course of the plan.	Continuous over the 5-year performance period of the plan

REFERENCES

American Society of Civil Engineers (ASCE). 2010. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction. Ka Loko Dam Break. Accessed at: https://ascelibrary.org/doi/10.1061/%28ASCE%29LA.1943-4170.0000036#:~:text=On%20March%2014%2C%202006%2C%20the,homes%20and%20properties%20were%20damaged.

Anderson, Tiffany R., Charles H. Fletcher, Matthew M. Barbee, L. Neil Frazer & Bradley M. Romine. 2015. Doubling of coastal erosion under rising sea level by mid-century in Hawaii. Accessed at: https://www.soest.hawaii.edu/coasts/publications/Anderson_et_al_2015_NaturalHazards.pdf

Bijlsma, L., C.N. Ehler, R.J.T. Klein, S.M. Kulshrestha, R.F. McLean, N. Mimura, and R.A. Warrick. 1996. Coastal zones and small islands. Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change, 289-324.

Brittanica.com 2020. "Kamehameha I". Web page accessed at https://www.britannica.com/biography/Kamehameha-I

Brown, W. et al. 2001. U.S. Geological Survey (USGS). "Hazard Maps Help Save Lives and Property." 2001. Accessed 2017. http://pubs.usgs.gov/fs/1996/fs183-96/fs183-96.pdf

Centers for Disease Control and Prevention (CDC). No date. Accessed 2020. climatechangeandextremeheatevents.pdf (cdc.gov)

Commission on Water Resource Management (CWRM). 2003. Drought Risk and Vulnerability Assessment and GIS Mapping Project. Prepared for State of Hawai'i Department of Land and Natural Resources by the University of Hawai'i School of Ocean, Earth Science and Technology and the Social Science Research Institute. September 2003. Accessed at: https://files.hawaii.gov/dlnr/cwrm/planning/drva2003.pdf

County of Kaua'i. 2015. County of Kaua'i Multi-Hazard Mitigation and Resiliency Plan, 2015 Update.

County of Kaua'i. 2018. Kaua'i Kākou—Kaua'i County General Plan. Adopted March 12, 2018. Accessed at: https://www.dropbox.com/s/ptm72sqtikcn5kb/Kauai%20Kakou%20General%20Plan%202018%20Online.pdf?dl=0

County of Kaua'i. 2020. Office of Economic Development, Department Mission. Accessed at: https://www.kauai.gov/OED

County of Kaua'i. 2020a. Kaua'i County Multi-Hazard Mitigation and Resilience Plan - 2020 Update StoryMAP. Accessed at: https://kauaigis.maps.arcgis.com/apps/MapSeries/index.html?appid=9283c6b4f9fe447689f707e42303ce4f

County of Maui. 2015. Hazard Mitigation Plan Update. Prepared for Maui County Civil Defense Agency by Tetra Tech, Inc. August 2015.

Dunbar, P. K., and C.S. Weaver. August 2008. U.S. States and Territories National Tsunami Hazard Assessment: Historical Record and Sources for Waves. Washington, DC: U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Available online at: http://nws.weather.gov/nthmp/documents/Tsunami_Assessment_Final.pdf

Federal Emergency Management Agency (FEMA). 1997. "Other Natural Hazards." A webpage of the FEMA website. Last accessed February 2015. Available online at: http://www.fema.gov/media-library-data/20130726-1545-20490-4031/mhira_n5.txt

Federal Emergency Management Agency (FEMA). 2010. Flood Insurance Study; Kaua'i County, Hawai'i. Revised November 26, 2010. Flood Insurance Study No. 150002V001C. Accessed at: http://dlnreng.hawaii.gov/nfip/wp-content/uploads/sites/11/2018/01/150002V001C-11262010.pdf

Federal Emergency Management Agency (FEMA). 2014. "Taking Shelter from the Storm; Building a Safe Room for Your Home or Small Business." FEMA L-233. December 2014. Accessed at: https://www.fema.gov/media-library-data/1418917310499-890993170f74d917b872dcbe83d7a688/FEMA_L233_TakingShelter_2014_508.pdf

Federal Emergency Management Agency (FEMA). 2014a. Flood Zones. A webpage of the FEMA website. Last accessed in March 2014. Available online at: https://www.fema.gov/flood-zones

Federal Emergency Management Agency (FEMA). 2015. "Why Dams Fail." Webpage of the Federal Emergency Management Agency Website. Last updated April 7, 2015. Available online at: https://www.fema.gov/why-dams-fail

Ferrario, F. Beck, M., Storlazzi, C., Micheli, F., Shepard, C., Airoldi, L. 2014. The effectiveness of coral reefs for coastal hazard risk reduction and adaptation. Nat. Commun. 5:3794 doi: 10.1038/ncomms4794 (2014). Available online at: http://www.nature.com/ncomms/2014/140513/ncomms4794/full/ncomms4794.html

Fletcher, Charles, Eric Grossman, Bruce Richmond, and Ann Gibbs. 2002. Atlas of Natural Hazards in the Hawaiian Coastal Zone. U.S. Department of the Interior and United States Geological Survey. Available online at: http://pubs.usgs.gov/imap/i2761/

Fletcher, C.H. 2010. Hawai'i's Changing Climate, Briefing Sheet, 2010. Honolulu: Center for Island Climate Adaptation and Policy. University of Hawai'i Sea Grant College Program.

Godbey, Robert Carson. 2007. Report of the Independent Civil Investigation of the March 14, 2006, Breach of Ka Loko Dam. Accessed at: http://the.honoluluadvertiser.com/pdf/kaloko/Kaloko-Report.pdf

Grinsted, A., J.C. Moore, and S. Jevrejeva. 2013. Projected Atlantic hurricane surge threat from rising temperatures. Proceedings of the National Academy of Sciences, 110(14), 5369-5373.

Hawai'i Climate Change Mitigation and Adaptation Commission. 2017. Hawai'i Sea Level Rise Vulnerability and Adaptation Report. Prepared by Tetra Tech, Inc. and the State of Hawai'i Department of Land and Natural Resources, Office of Conservation and Coastal Lands, under the State of Hawai'i Department of Land and Natural Resources Contract No: 64064. Accessed at: https://climateadaptation.hawaii.gov/wp-content/uploads/2017/12/SLR-Report_Dec2017.pdf

Hawai'i Department of Business, Economic Development & Tourism. 2018. "Self-Sufficiency Income Standard" web page. Accessed at: https://dbedt.hawaii.gov/economic/reports_studies/self-sufficiency-income-study/

Hawai'i Department of Land and Natural Resources (DLNR). 2020. "Dam Inventory System." Accessed at: http://132.160.239.52/daminventory/Default.aspx

Hawai'i Division of Forestry and Wildlife. 2020. Forestry Programs; Hawai'i Island Forest Reserves. Accessed at: https://dlnr.hawaii.gov/forestry/frs/reserves/kauai/

Hawai'i Drought Monitor. 2020. Drought Forecast web page. Accessed at: https://dlnr.Hawai'i.gov/drought/forecast/

Hawai'i News Now (HNN). 2014. Kaua'i has record-breaking heat wave. Accessed at: https://www.hawaiinewsnow.com/story/26831845/kauai-has-record-breaking-heat-wave/

Hawai'i Office of Planning. 2013. State Land Use District Map. Produced by Hawai'i Statewide GIS Program. Map No. 20130402-01-OK. April 2, 2013. Accessed at: https://www.slideshare.net/jessesouki/future-of-agriculture-in-Hawai'i

Hawai'i Wildfire Management Organization (HWMO). 2016. Community Wildfire Protection Plan. Kaua'i Update 2016. Accessed at: https://dlnr.hawaii.gov/forestry/files/2018/04/2016_12_26_KauaiCWPPUpdate_HWMO.pdf

Hawaiian Electric Company. 2020. "Wind Speed Map of Hawaii at 50 Meters." Map accessed online at: https://www.hawaiianelectric.com/documents/clean_energy_hawaii/renewable_energy_sources/hawaii_final_SPD_50m_26_july_04.pdf

History.com. 2020. Hawai'i history page. Accessed at: https://www.history.com/topics/us-states/Hawai'i

Intergovernmental Panel on Climate Change (IPCC). 2014. Fifth Assessment Report Synthesis Report.

Kauai.com. 2020. Explore Kauai's East Side on the Kapa'a Bike Path" Accessed at: https://www.kauai.com/blog/kapaa-bike-path

Kaua'i Chamber of Commerce. 2020. "Kaua'i Industries" web page. Accessed at: http://www.kauaichamber.org/pages/KauaiIndustries1

Kaua'i Historical Society. 2000. Kaua'i in History. A Guide to the Resources. Accessed at: https://sfca.hawaii.gov/wp-content/uploads/2013/08/Kauai2000_SFCA.pdf

Keener, V. W., J.J. Marra, M.L. Finucane, D. Spooner, and Smith, M. H. (Eds.). 2012. Climate Change and Pacific Islands: Indicators and Impacts. Report for The 2012 Pacific Islands Regional Climate Assessment. Washington, DC: Island Press.

Leong, J.-A., J. J. Marra, M. L. Finucane, T. Giambelluca, M. Merrifield, S. E. Miller, J. Polovina, E. Shea, M. Burkett, J. Campbell, P. Lefale, F. Lipschultz, L. Loope, D. Spooner, and B. Wang. 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. Ch. 23: Hawai'i and U.S. Affiliated Pacific Islands. J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 537-556. doi:10.7930/J0W66HPM.

Main, Douglas. 2014. "How Hurricane Forecasts Have Improved." Posted on the website of livescience.com on September 5, 2014. Available online at: http://www.livescience.com/21850-hurricane-forecast-improvements.html

Meiers, Rich. 2014. "Largest swell in decades hits Hawaiian shores, 40-50 foot waves roll in." Posted on the website of Hawaii News Now on January 21, 2014 and updated January 24, 2014. Available online at: http://www.hawaiinewsnow.com/story/24509382/forecasters-issue-high-surf-warning-predict-40-50-foot-waves

National Academies of Sciences, Engineering, and Medicine. 2017. *Volcanic Eruptions and Their Repose, Unrest, Precursors, and Timing*. Washington, DC: The National Academies Press. https://doi.org/10.17226/24650.

National Aeronautics and Space Administration (NASA). 2004. NASA Earth Observatory News Website Item. Dated August 2, 2004. Available online at: http://earthobservatory.nasa.gov/Newsroom/view.php?id=25145

National Aeronautics and Space Agency (NASA). 2020. NASA Global Climate Change web page "The relentless rise of carbon dioxide." Accessed at: https://climate.nasa.gov/climate_resources/24/graphic-the-relentless-rise-of-carbon-dioxide/

National Aeronautics and Space Agency (NASA). 2020a. NASA Global Climate Change web page "Climate Change: How Do We Know?" Accessed at: https://climate.nasa.gov/evidence/

National Aeronautics and Space Agency (NASA). 2020b. Global Landslide Catalog Downloadable Products Gallery. Accessed at: https://maps.nccs.nasa.gov/arcgis/apps/MapAndAppGallery/index.html?appid=574f26408683485799d02e857e5d9521

National Centers for Environmental Information (NCEI). 2020. Storm Events Database search results. Accessed at: https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=15%2CHAWAII

National Integrated Drought Information System (NIDIS). 2020. Drought.gov U.S. Drought Portal web page "U.S. Drought Monitor." Accessed at https://www.drought.gov/drought/data-gallery/us-drought-monitor

National Oceanic and Atmospheric Administration (NOAA). 1989. United States Tsunamis. 1690-1988. Accessed at: https://www.ngdc.noaa.gov/hazard/data/publications/pub41-2.pdf

National Oceanic and Atmospheric Administration (NOAA). 2012. National Weather Service Glossary; Including Phrases, Abbreviations, and Acronyms.

National Oceanic and Atmospheric Administration (NOAA). 2020. "What are El Niño and La Niña?" NOAA website accessed at https://oceanservice.noaa.gov/facts/ninonina.html

National Oceanic and Atmospheric Administration (NOAA). 2020a. Global Historical Tsunami Database. Accessed at: doi:10.7289/V5PN93H7

National Oceanic and Atmospheric Administration (NOAA). 2020b. Ocean Today. Tsunami Awareness. Accessed at: https://oceantoday.noaa.gov/tsunamiawareness/#:~:text=The%20first%20one%20may%20not,coast%3B%20a%20load%20ocean%20roar.

National Research Council (NRC). 2011. Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia. National Research Council. The National Academies Press, Washington, DC, USA.

NWS. 2013. "National Hurricane Center: Saffir-Simpson Hurricane Wind Scale." A webpage of the NWS website. Last updated May 24, 2013. Available online at: http://www.nhc.noaa.gov/aboutsshws.php

National Weather Service (NWS). 2018. "Final Rain Totals from Lane Flood Event on Kauai and Oahu". Accessed at: https://web.archive.org/web/20180901215918/http://www.prh.noaa.gov/hnl/Products/PNSHFO/PNSHFO.1808290955.txt

National Weather Service (NWS). 2020. Hawai'i Forecast Office Standardized Precipitation Index web page. Accessed at: https://www.weather.gov/hfo/spi_info

National Weather Service (NWS). 2020a. "Coastal Warning Display Program" web page of the National Weather Service. Accessed at: https://www.weather.gov/marine/cwd

National Weather Service (NWS). 2020b. "Honolulu, HI, Weather Forecast Office; Standardized Precipitation Index - Early version." Website accessed at https://www.weather.gov/hfo/quickspi

National Weather Service (NWS). 2020c. "This Day in Weather History: November 24th" Accessed at: https://www.weather.gov/abr/This_Day_in_Weather_History_Nov_24

National Weather Service (NWS). 2020d. "Jan 8-9, 2005 Severe Storms on Kauai and Oahu" Accessed at: https://www.weather.gov/hfo/jan9storms#:~:text=Severe%20Thunderstorms%20roll%20across%20Kauai%20and%20Oahu%20January,wind%20gusts%2C%20wind%20damage%20and%20a%20small%20tornado.

National Weather Service (NWS). 2020e. "Record Kauai and Oahu Rainfall and Flooding – April 2018" Accessed at: https://www.weather.gov/hfo/RecordKauaiandOahuRainfallAndFlooding-April2018

National Weather Service (NWS). 2020f. "Temperature and Rainfall Graphs" webpage. Accessed at: Temperature and Rainfall Graphs (weather.gov)

Oskin, Becky. 2012. "Landslide-Driven Megatsunamis Threaten Hawaii." Article on LiveScience.com. December 6, 2012. Accessed at https://www.livescience.com/25293-hawaii-giant-tsunami-landslides.html

Piniak, Greg. 2004. "Sediment Impacts on Reef Corals in Maui, Hawai'i." A webpage of the USGS website. Available online at: http://soundwaves.usgs.gov/2004/11/

Reuters. 2018. "Global temperatures on track for 3-5 degree [Celsius] rise by 2100: U.N." Accessed at https://www.reuters.com/article/us-climate-change-un/global-temperatures-on-track-for-3-5-degree-rise-by-2100-u-n-idUSKCN1NY186

RSMeans. 2019. 2019 Square Foot Costs Book with RSMeans data. Published by Gordian. Rockland, MA.

Ruggiero, Peter. 2008. Impacts of Climate Change on Coastal Erosion and Flood Probability in the U.S. Pacific Northwest. Accessed at: http://geo.science.oregonstate.edu/files/geo/Ruggiero_Coastal%20Disasters_2008.pdf

Smithsonian. 2013. Niihau. Accessed at: https://volcano.si.edu/volcano.cfm?vn=332810

State of Hawai'i. 2012. Increased Food Security and Food Self-Sufficiency Strategy. Accessed at: https://files.hawaii.gov/dbedt/op/spb/INCREASED_FOOD_SECURITY_AND_FOOD_SELF_SUFFICIENCY_STRATEGY.pdf

State of Hawai'i. 2013. State of Hawai'i 2013 Hazard Mitigation Plan. Accessed at: https://dod.Hawai'i.gov/hiema/files/2017/03/2013-Hawai'i-State-Mitigation-Plan-FEMA-Review-COMPLETE.pdf

State of Hawai'i. 2017. Hawai'i Drought Plan. 2017 Update. Prepared for State of Hawai'i Department of Land and Natural Resources by One World One Water, LLC. May 2017.

State of Hawai'i. 2018. State of Hawai'i 2018 Hazard Mitigation Plan. Prepared for the Hawai'i Emergency Management Agency by Tetra Tech, Inc.

State of Hawai'i. 2020a. COVID-10 State of Hawai'i Portal. Everyday Prevention. Accessed at: https://hawaiicovid19.com/everyday-prevention/

State of Hawai'i. 2020b. Top 50 Employers – Kauai County. Accessed at: https://data.hawaii.gov/Employment/Top-50-Employers-Kauai-County/metr-canm/data

Summit Pacific. 2017. "Kauai Map Information" web page. Accessed at: http://www.summitpacificinc.com/kauai_map.html

Sweet, W.V., R.E. Kopp, C.P. Weaver, J. Obeysekera, R.M. Horton, E.R. Thieler, and C. Zervas. 2017. Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report NOS CO-OPS 083. NOAA/NOS Center for Operational Oceanographic Products and Services. Accessed at: https://tidesandcurrents.noaa.gov/pub.html

TakePart. 2015. "Food Independence Could Be a Matter of Survival for the U.S.' Most Isolated State." Article in TakePart magazine. June 29, 2015. Accessed at: http://www.takepart.com/article/2015/06/29/Hawai'i-local-food

The Washington Post. 2019. Inside Hawaii's wild summer of broken high-temperature records. Accessed at: Hawaii likely saw its warmest summer on record. The records broken are wild. - The Washington Post

Tilden, Charles E. 1959. "1959 Annual Typhoon Report" Accessed at: https://www.usno.navy.mil/NOOC/nmfc-ph/RSS/jtwc/atcr/1959atcr.pdf

Tripp, Tom. 2013. "Tropical Cyclones Cause Significant Damage to Coral Reefs." Posted to the MarineScience.com website. Last accessed on June 23, 2015. Available online at: http://marinesciencetoday.com/2013/10/21/tropical-cyclones-cause-significant-damage-to-coral-reefs/

U.S. Army Corps of Engineers. 1997. Hydrologic Engineering Requirements for Reservoirs. Engineer Manual 1110-2-1420, Washington, D.C.

U. S. Army Corps of Engineers. 2018. Hawaiian Islands Shoreline Management Study. Accessed at: https://www.iwr.usace.army.mil/Media/News-Stories/Article/1677869/usace-releases-hawaiian-islands-shoreline-management-regional-assessment-report/

U.S. Climate Resilience Toolkit. 2020. Coastal Erosion. Accessed December 23, 2020 at: https://toolkit.climate.gov/topics/coastal-flood-risk/coastal-erosion

U.S. Department of Commerce. 1993. Natural Disaster Survey Report. Hurricane Iniki. September 6-13, 1992. Accessed at: https://www.weather.gov/media/publications/assessments/iniki1.pdf

U.S. Drought Monitor (USDM). 2020b. U.S. Drought Monitor Time Series for Kaua'i County. Accessed July 27, 2020 at https://droughtmonitor.unl.edu/Data/Timeseries.aspx

U.S. Environmental Protection Agency (EPA). 2016. "Toxics Release Inventory (TRI) Program." https://www.epa.gov/toxics-release-inventory-tri-program/learn-about-toxics-release-inventory.

U.S. Fish and Wildlife Service. 2012. 48 Kaua'i Species Protected Under the Endangered Species Act. Accessed at: https://www.fws.gov/pacificislands/CH_Rules/Kauai48.pdf

U.S. Geological Survey (USGS). 2002. Atlas of Natural Hazards in the Hawaiian Coastal Zone. Accessed at: https://pubs.usgs.gov/imap/i2761/sections/2_Kauai.pdf

U.S. Geological Survey (USGS). 2020a. Search Earthquake Catalog web page of the USGS Earthquake Hazards Program. Accessed at: https://earthquake.usgs.gov/earthquakes/search/. Results at: This link.

United Nations Educational, Scientific, and Cultural Organization (UNESCO). No date. Retrieved from "Tsunami." A webpage of the Different Directions website. Last accessed June 2015. Available online at: http://go2add.com/paleo/Tsunamis.php

University of Hawai'i. 2014. Climate Change Impacts in Hawai'i - A summary of climate change and its impacts to Hawai'i's ecosystems and communities. Manoa Sea Grant College Program. June 2014. Accessed at: https://seagrant.soest.hawaii.edu/climate-change-impacts-in-hawaii/

Western Regional Climate Center (WRCC). 1998. Monthly Precipitation Summary. State of Hawai'i portion of Honolulu HSA. Accessed at: https://wrcc.dri.edu/monitor/hawaii.9801

Western Regional Climate Center (WRCC). 2020. "Climate of Hawai'i." Accessed at: https://wrcc.dri.edu/Climate/narrative_hi.php

Wikipedia. 2020a. "Kaua'i" web page. Accessed at: https://en.wikipedia.org/wiki/Kauai

Wikipedia. 2020b. "Ni'ihau" web page. Accessed at: https://en.wikipedia.org/wiki/Ni%CA%BBihau