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3.11 GEOLOGY, SOILS, AND NATURAL HAZARDS

This section presents an overview of the geologic and soil characteristics of the project area and provides an assessment of natural hazards potentially affecting the Honoapiʻilani Highway Improvements Project (the Project), as well as the Project's consistency with federal, State, and local plans, and policies guiding infrastructure development relative to natural hazards. This section examines a comprehensive range of hazards, including earthquakes, hurricanes, tsunamis, coastal erosion, wildfires, and volcanic hazards. These natural hazards have some relationships with water resources, wetlands, and floodplains, and potential project effects on water resources, wetlands, and floodplains are presented in Section 3.9, Water Resources, Wetlands, and Floodplains. The same is true of climate change and sea level rise, which are mentioned in this section but more fully assessed in Section 3.13, Climate Change and Sea Level Rise. Coastal erosion hazards are discussed in this chapter, with a discussion in the context of sea level rise. Qualitative discussions on how climate change and sea level rise may affect the intensity, duration, spatial extent, and probability of related hazards are included in respective subsections.

Following publication of the Draft Environmental Impact Statement (EIS), the public was afforded an opportunity to review and comment on the effects of the Project with respect to geology, soils, and natural hazards. Based on those comments, or other information gathered after the publication of the Draft EIS, no revision to the analysis contained within this section was warranted and no further analysis is required as part of this Final EIS.

3.11.1 Regulatory Context

Regulatory frameworks at the federal, State, and local levels address natural hazards and require mitigation measures for potential impacts. TABLE 3.11-1 describes the various agencies, regulations, and guiding documents that pertain to natural hazards.

TABLE 3.11-1. **Natural Hazard Regulatory Context**

LEVEL	AGENCY, REGULATION, DOCUMENT RESPONSIBILITIES
Federal	At the federal level, agencies such as the Federal Emergency Management Agency (FEMA), the U.S. Geological Survey (USGS), and the U.S. Army Corp of Engineers provide guidance and regulations pertaining to natural hazards. The Coastal Zone Management Act, 16 United States Code [U.S.C.] 1451 et seq., administered by the Hawaiʻi Office of Planning and Sustainable Development, regulates development activities in the coastal zone to protect against coastal hazards, including coastal erosion, flooding, and sea level rise. The Coastal Zone Management Act guides land use planning, shoreline setbacks, and coastal development permits. Guidance for consideration of the Project's ability to plan for and mitigate the impacts of natural hazards fall under Title 44 Code of Federal Regulations [CFR] Part 201,[1] Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), 42 U.S.C. Sections 5121 through 5207; Homeland Security Act of 2002, 6 U.S.C. Section 101; National Flood Insurance Act of 1968, 42 U.S.C. Section 4104c, and the County of Maui Hazard Mitigation Plan.
State	At the State level, the *2018 State of Hawaiʻi Hazard Mitigation Plan* guides decision-making both for mitigation and for repairing State-owned infrastructure damage in federally declared disasters. To maintain State eligibility for federal assistance and funding, the 2018 Plan complies with the Stafford Act, the Disaster Mitigation Act of 2000 (P.L. 106-390), and Title 44 CFR Part 201. The Hawaiʻi Emergency Management Agency and the State Hazard Mitigation Officer, along with a multidisciplinary group of local, State, and federal stakeholders, developed the plan. There was also input from the public and a review by FEMA. The 2018 Plan serves as a "living document." It is updated every five years and County hazard mitigation plans use it as a technical reference. The 2023 update of the State Plan became available in August 2023.[2] The Hawaiʻi State Building Codes, enforced by the Department of Accounting and General Services, establish standards for construction and structural design to ensure buildings can withstand natural hazards such as hurricanes, earthquakes, and high winds. All assessments of natural hazard risk, particularly those of climate change and sea level rise are consistent with the Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report mandated by Act 83, Session Laws of Hawaiʻi 2014, and Act 32, Session Laws of Hawaiʻi 2017. The Hawaiʻi Department of Transportation (HDOT) is also guided by the *Hawaiʻi Highways Climate Adaptation Action Plan* (May 2021), which helps the agency better understand how changing climate conditions could impact the State highways and the exposure assessments of State highway facilities to rockfall and landslide, sea level rise, annual high-wave flooding, coastal erosion, storm surge, tsunami, wildfire, and lava flow.
Local	The County of Maui Emergency Management Agency is responsible for developing, implementing, and updating a local hazard mitigation plan in accordance with Title 44 CFR Section 201.6(c)(5). This plan, the *2020 Maui County Hazard Mitigation Plan*, is reviewed and approved on a semiannual basis by the Steering Committee, a County administered volunteer body of experts that oversees development and implementation of the hazard mitigation plan and following any major disasters. Updates are submitted for pre-adoption review to Hawaiʻi State Civil Defense, FEMA Region IX, and the Insurance Service Office prior to adoption.[3]

[1] 44 CFR Part 201: Mitigation Planning. https://www.ecfr.gov/current/title-44/chapter-I/subchapter-D/part-201. Accessed July 2023.

[2] Hawaiʻi Emergency Management Agency. (August 2023). State of Hawaiʻi 2023 Hazard Mitigation Plan. https://dod.hawaii.gov/hiema/final-2023-hazard-mitigation-plan/. Accessed February 2024.

[3] Maui Emergency Management Agency. (August 2020). 2020 Maui County Hazard Mitigation Plan. Multi-Hazard Mitigation Plan | Maui County, HI - Official Website. Accessed July 2023.

3.11.2 Methodology

This section identifies the natural hazards and risks posed by natural disasters, as well as a description of the geology and soils of the project area. Hazard mitigation actions and activities to reduce losses from such disasters are also identified. The No Build Alternative and the Build Alternatives are then evaluated for their susceptibility to natural hazards. The Project would be designed consistent with applicable construction codes to increase resilience to natural hazards to the extent practicable. These design considerations are described in the analysis of natural hazards.

3.11.3 Affected Environment

Maui, the second largest island in the Hawaiian group, was created by two volcanoes, Haleakalā in the east and Kahālāwai in the west. Kahālāwai, also known as the West Maui Mountains, is a deeply dissected volcano with an elevation of 5,788 feet. These features have helped shape the underlying geology and soils found within the project area, which in turn factor into the susceptibility of the project area to natural hazards. On Maui, the proposed stretch of existing highway sits within the West Maui Community Planning Area, an area characterized by its diverse topography comprising valleys, mountains, and coastal terrains. The project area is in the moku (traditional district) of Lāhainā and spans three ahupuaʻa: Ukumehame, Launiupoko, and Olowalu.

3.11.3.1 Geology

FIGURE 3.11-1 provides an overview map of the geologic characteristics of the project area. The oldest rocks on West Maui are the very permeable (where water can easily seep through) primitive Wailuku basalts. The sedimentary rocks comprise landslide debris, delta deposits, and valley fills, mostly of poorly permeable (where water cannot easily seep through) and bouldery alluvium (clays, silts, sand, and gravel).

3.11.3.2 Soils

The Natural Resource Conservation Service identifies and maps soil associations for the dominant soil types of an area. Soil associations are groups of related soils that occur in landscapes with characteristic topographic features, slopes, and parent materials, and give an overview of the soils present.[1]

TABLE 3.11-2 lists the soil associations and their primary characteristics in the project area. FIGURE 3.11-2 shows how these soil types are mapped throughout the project area. At the Pali end of the project area, the rock land formation is reflective of the rugged and rocky topography of the area and is notable for the presence of rock slides, as evidenced by rock fall protection along Honoapiʻilani Highway. In addition, along the immediate coastline in the area (and including) the existing highway, there is a potential for more erodible soil conditions.

1 U.S. Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI (2012). https://directives.sc.egov.usda.gov. Accessed July 2023.

TABLE 3.11-2. **Soil Associations**

ASSOCIATION NAME	CHARACTERISTICS[2]
Pulehu-Mala-Kealia-Ewa	Deep, nearly level to moderately sloping, well-drained and excessively drained soils that have a moderately fine textured to coarse-textured subsoil or underlying material; on alluvial fans and in basins
Waianee-Waiakoa	Deep, gently sloping to very steep, well-drained soils that have a moderately fine textured or medium-textured subsoil; on intermediate and high uplands
Ustorthents-Rock Outcrop-Lithic Ustorthents	Rough mountainous land association; very shallow, steep and very steep, rock land and rough mountain land

Cinder cone locations have been mapped, showing areas where underlying conditions may require design considerations. Cinder cones are conical hills formed by a buildup of glassy lava fragments that fall following an eruption.[3] The cinder cone in the northwest corner of Olowalu is unavoidable and would be crossed by all Build Alternatives.

2 U.S. Department of Agriculture Soil Conservation Service. (January 1971). General Soil Map Maui Island, Hawaiʻi. University of Hawaiʻi Agricultural Experiment Station. https://esdac.jrc.ec.europa.eu/content/general-soil-map-maui-island-Hawaii. Accessed July 2023.

3 US Geological Survey. (June 2015). Volcano Hazard Program. Glossary – Cinder Cone. https://volcanoes.usgs.gov/vsc/glossary/cinder_cone.html. Accessed November 2023.

FIGURE 3.11-1. **Geologic Formations**

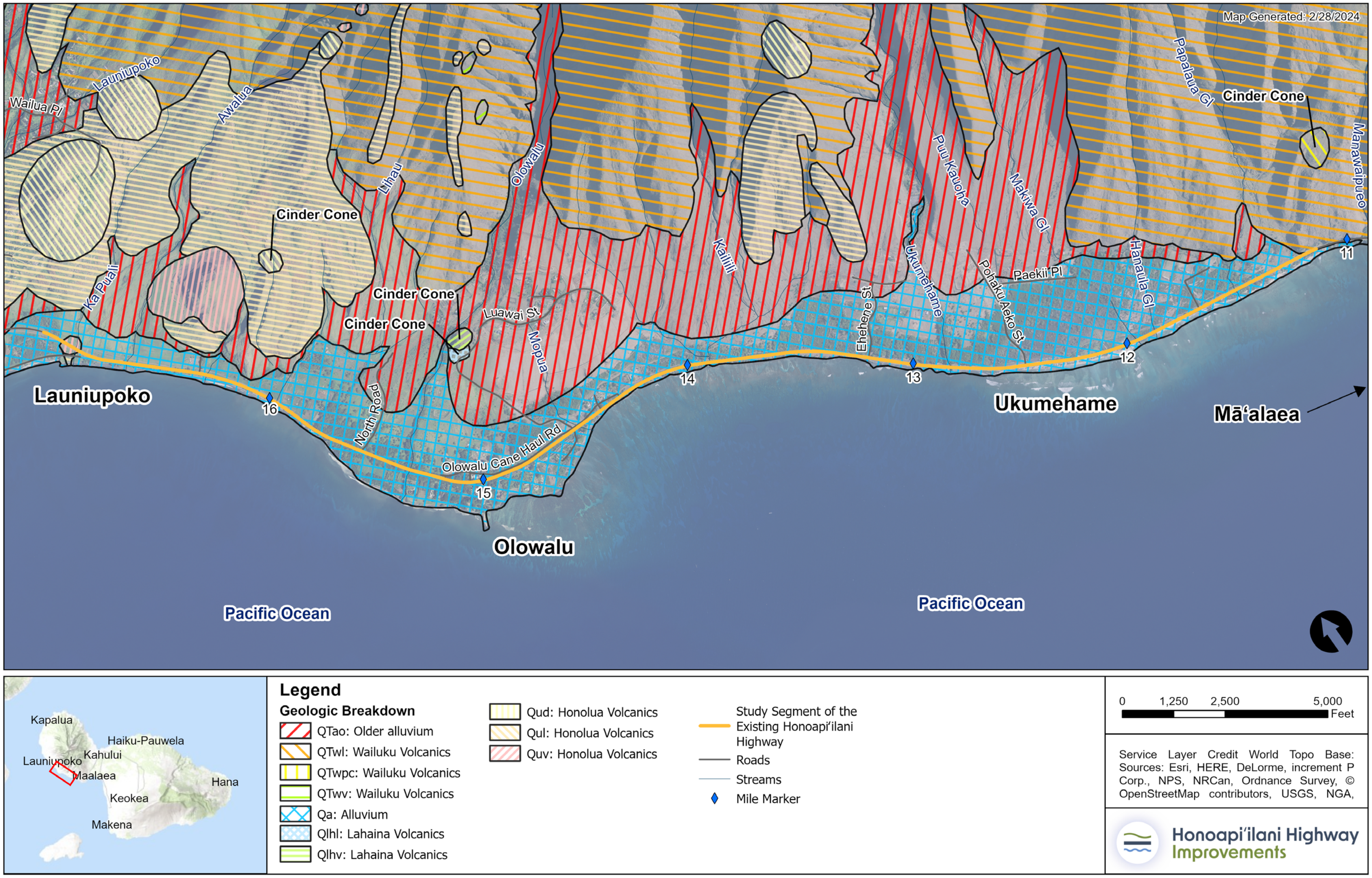
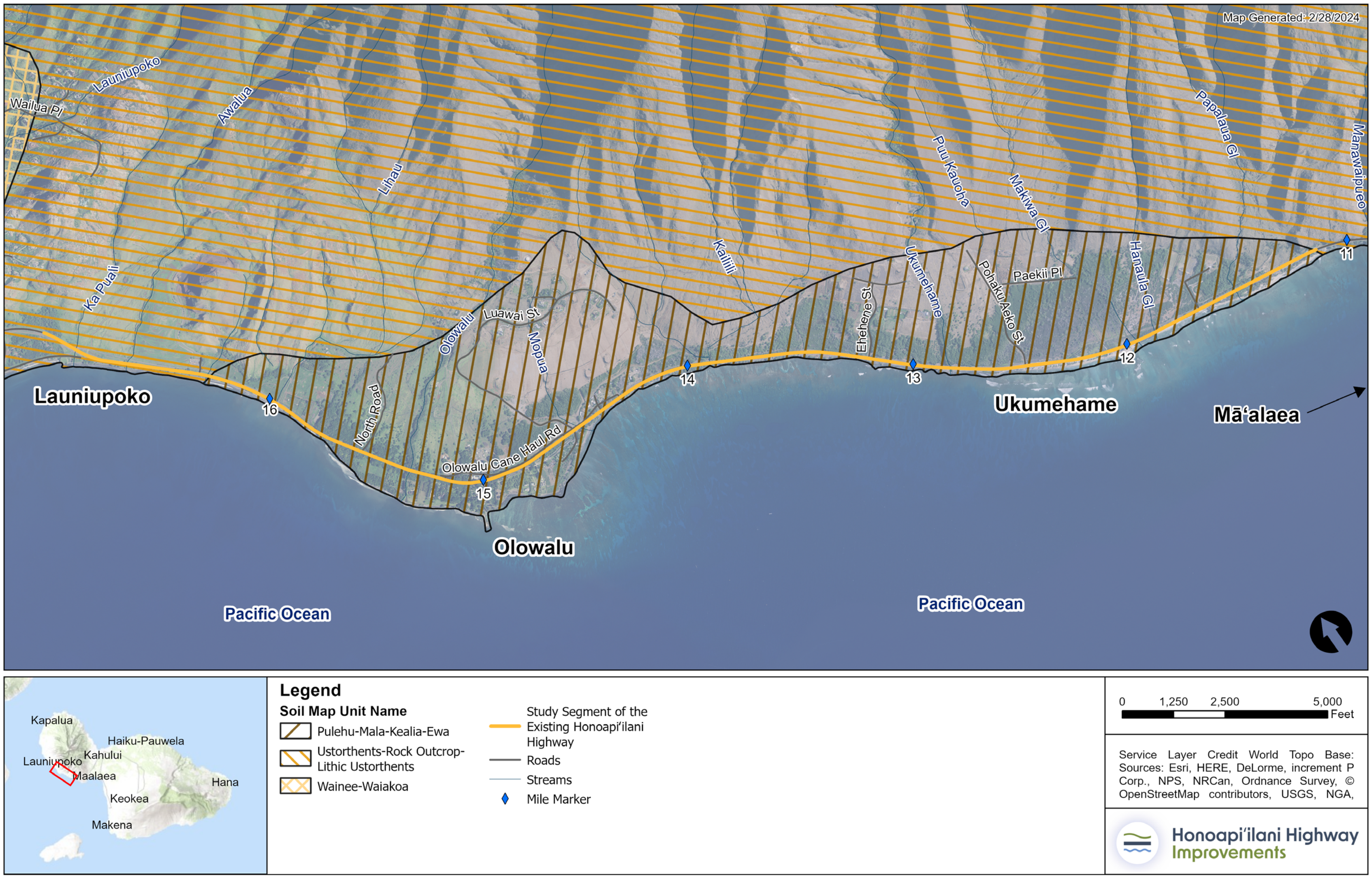


FIGURE 3.11-2. **Soil Associations**



3.11.3.3 Natural Hazards Overview

Maui is susceptible to natural hazards including earthquakes, hurricanes, tsunamis, coastal erosion, wildfires, and volcanic hazards. TABLE 3.11-3 provides a summary of the Priority Risk Index for natural hazards completed for West Maui by the Maui Emergency Management Agency. See the *2020 Maui County Hazard Mitigation Plan* for a full explanation of the Priority Risk Index. The Priority Risk Index results do not include climate change and sea level rise.

TABLE 3.11-3. **Priority Risk Index Results for West Maui**[4]

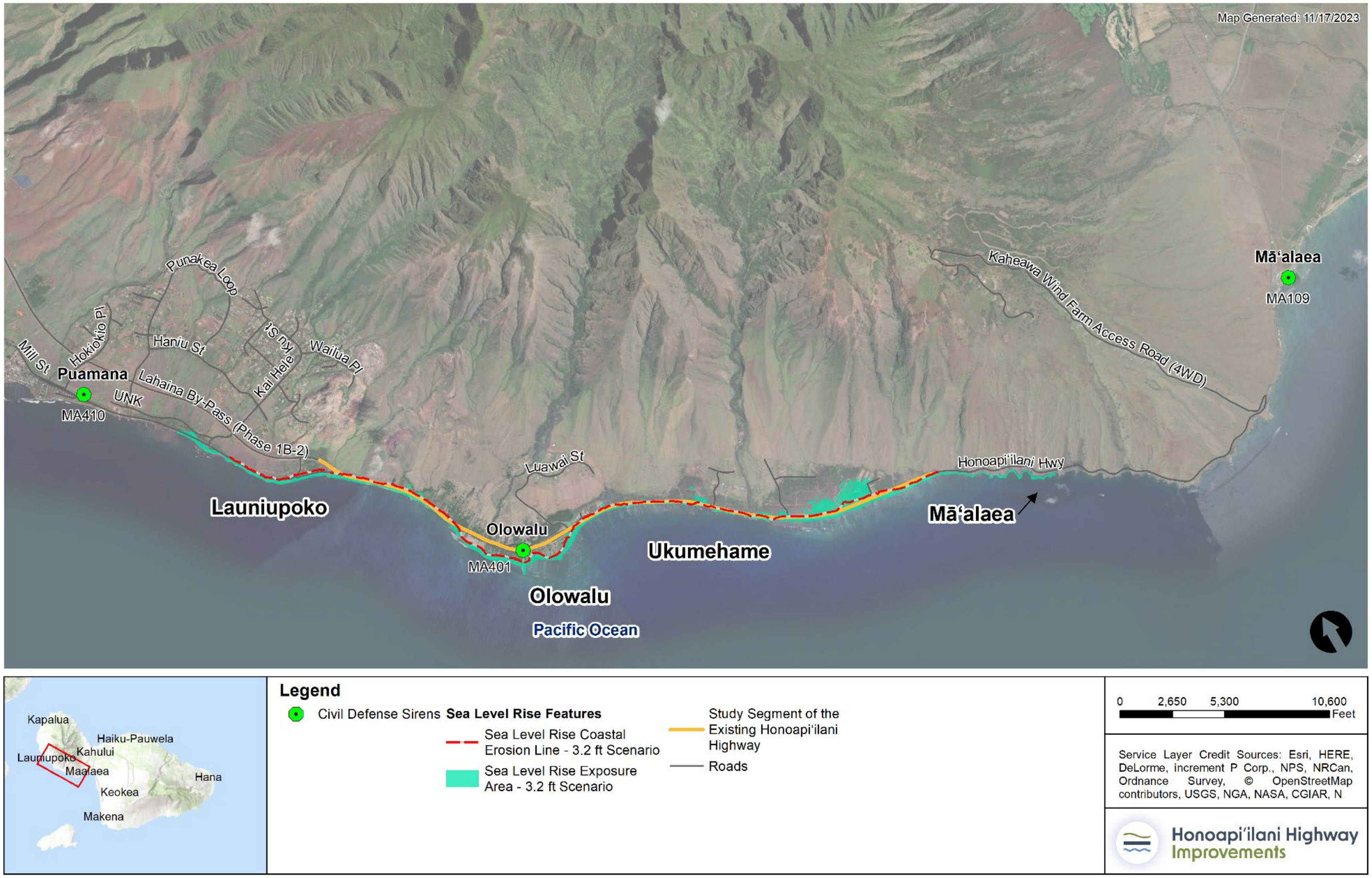
HAZARD	PROBABILITY	IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION
Earthquake	Possible	Critical	Moderate	Less than 6 hours	Less than 6 hours
Hurricanes	Possible	Catastrophic	Large	More than 24 hours	Less than 1 week
Tsunami	Likely	Critical	Moderate	Less than 6 hours	Less than 6 hours
Coastal Erosion	Highly Likely	Limited	Moderate	More than 24 hours	More than 1 week
Wildfires	Highly Likely	Critical	Moderate	12 to 24 hours	Less than 1 week
Volcanic Hazards	Possible	Minor	Small	More than 24 hours	Less than 1 week
Flooding	Highly Likely	Critical	Moderate	12 to 24 hours	Less than 24 hours

The Hawaiʻi Emergency Management Agency utilizes a system of civil defense sirens throughout the state to alert the public of emergencies and natural hazards. Both natural and human-caused events can trigger the all-hazard siren, including tsunamis, hurricanes, dam breaches, flooding, wildfires, volcanic eruptions, terrorist threats, and hazardous material incidents. The only siren within the project area is just mauka of the Olowalu Landing.[5] The Olowalu siren serves as the most immediate response system to relevant natural hazards within the project area. The next closest sirens are to the north at Puamana and to the south at Māʻalaea (FIGURE 3.11-3).

4 Maui Emergency Management Agency. (August 2020). *2020 Maui County Hazard Mitigation Plan*. Multi-Hazard Mitigation Plan | Maui County, HI - Official Website. Accessed July 2023.

5 State of Hawaiʻi. 2019. Hawaiʻi Open Data. Department of Defense – State Civil Defense Emergency Siren Locations. Department of Defense - State Civil Defense Emergency Siren Locations - Department of Defense - State Civil Defense Emergency Siren Locations (CSV) - Hawaii Open Data. Accessed July 2023.

FIGURE 3.11-3. **Civil Defense Siren Locations**



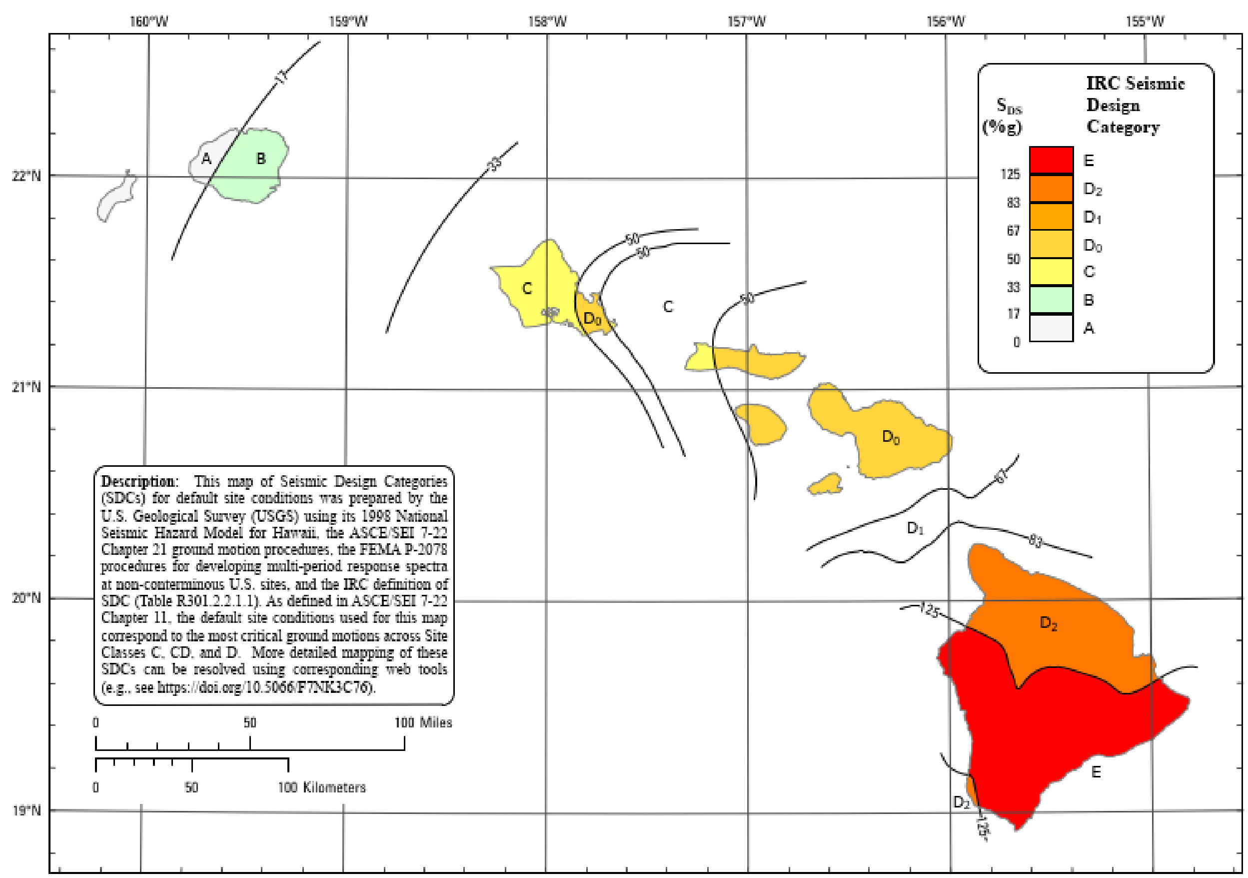
Source: State of Hawaiʻi (2019)

3.11.3.4 Earthquakes

Hazard Assessment

USGS peak ground acceleration is a method of measuring earthquake intensity appropriate for infrastructure and shorter buildings (FIGURE 3.11-4).[6] Peak ground acceleration values correspond with seismic design categories (SDC). SDCs indicate the level of seismic resistance required for new buildings and consider the soil type at the site.[7] TABLE 3.11-4 describes the hazard level associated with each SDC and the associated levels of shaking. The project area is in the D_0 category, indicating that the area could experience strong shaking but less than D_1 and D_2 areas (TABLE 3.11-4).

FIGURE 3.11-4. **Seismic Design Category Hazard Levels**



Source: 2020 NEHRP Recommended Seismic Provisions: Seismic Design Category Maps for 2024 International Residential Code (IRC) and International Building Code (IBC). (April 2023). Accessed on FEMA.gov July 2024.

6 Western Washington University. (n.d.). Geology Department. Peak Ground Acceleration. http://kula.geol.wwu.edu/rjmitch/pga_maps.pdf. Accessed July 2023.

7 Federal Emergency Management Agency. (2020). Risk Management: Earthquake Hazard Maps. Earthquake Hazard Maps | FEMA.gov. Accessed July 2023.

TABLE 3.11-4. **Seismic Design Category Hazard Levels**[8]

SDC/MAP COLOR	EARTHQUAKE HAZARD	POTENTIAL EFFECTS OF SHAKING
A/White	Very small probability of experiencing damaging earthquake effects	N/A
B/Gray	Could experience shaking of moderate intensity	Moderate shaking: felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
C/Yellow	Could experience strong shaking	Strong shaking: damage negligible in buildings of good design and construction; slight to moderate in well-built, ordinary structures; considerable damage in poorly built structures.
D_0/Light Orange D_1/Darker Orange D_2/Darkest Orange	Could experience very strong shaking (the darker the color, the stronger the shaking)	Very strong shaking: damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures.
E/Red	Near major active faults capable of producing the most intense shaking	Strongest shaking: damage considerable in specially designed structures; frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. Shaking intense enough to destroy buildings.

Earthquake damage can be intensified by soil factors. Saturated soils amplify earthquake motions and can result in mudflows on steep slopes.[9] Saturated soils also can be subject to soil liquefaction. Soil liquefaction is when "the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading."[10] When the ground shakes, liquefaction causes the soil to act like a fluid, resulting in ground failure.[11] All the soil associations in the project area (TABLE 3.11-2) are listed as National Earthquake Hazard Reduction Program Class D soils (that is, they are among the most susceptible to liquefaction).

Vulnerability

Maui County infrastructure is susceptible to earthquake hazards, including pipes, roads, bridges, dams, water and wastewater treatment facilities, and utility poles. Belowground infrastructure faces heightened vulnerability. The potential damage to roads can disrupt access to vital resources for specific populations. Infrastructure in areas with liquefaction-prone soils may experience sinking. Secondary impacts of earthquakes, such as rock falls or fires, can also damage infrastructure and present hazards to the surrounding community. A significant portion of Maui County's infrastructure

8 Federal Emergency Management Agency. (2020). Risk Management: Earthquake Hazard Maps. Earthquake Hazard Maps | FEMA.gov. Accessed July 2023.

9 U.S. Geological Survey. (n.d.). Damaging Earthquakes – A Common Hazard in Hawaiʻi. Hawaiian Volcano Observatory. https://www.usgs.gov/observatories/Hawaiian-volcano-observatory/damaging-earthquakes-common-hazard-Hawaii. Accessed July 2023.

10 University of Washington. (n.d.). What is soil liquefaction? http://www.ce.washington.edu/~liquefaction/html/what/what1.html. Accessed July 2023.

11 Earthquake Basics: Liquefaction: Earthquake Engineering Research Institute. (n.d.). https://eeri.org/wp-content/uploads/store/Free%20PDF%20Downloads/LIQ1.pdf. Accessed July 2023.

was built in the 1970s and potentially lacks seismic construction or retrofitting to withstand earthquakes. The Project would be constructed to the American Association of State Highway and Transportation Officials (AASHTO) standards.

3.11.3.5 Tsunamis

Hazard Assessment

Tsunamis pose a significant natural hazard to coastal regions, including the project area. Strong currents, flooding, and the overall force of the water can destroy buildings and devastate coastal communities. Of all natural hazards facing the Hawaiian Islands, tsunamis have been the deadliest.[12]

West Maui has the greatest amount of tsunami exposure of any community planning area in Maui County, as development tends to occur along the coast.[13] If a tsunami were to come ashore, the coastal areas and parts of the existing highway could certainly be rendered impassable and transportation in and out of West Maui would be cut off, resulting in economic and physical damage for as long as it takes to make repairs.

The National Oceanic and Atmospheric Administration (NOAA) operates two tsunami warning centers (24 hours a day, 7 days a week) that monitor and forecast potential tsunami activity and coordinate warning and public outreach operations. More locally, the State of Hawaiʻi receives official tsunami warnings, watches, advisories, and information statements from the Pacific Tsunami Warning Center.[14] A description of the variety of tsunami warnings can be found in the *2023 State of Hawaiʻi Hazard Mitigation Plan*.[15]

Vulnerability

In Maui County, a tsunami resulting in damage or death occurs approximately every three and a half years, on average.[16] The *Maui County Hazard Mitigation Plan* lists West Maui as having a 1% to 10% annual chance of tsunami hazards. Unlike hurricanes and tropical storms, there is no tsunami season during which they occur with frequency. Because they are dependent on seismic activity, tsunamis can occur year-round and at any time.

NOAA collects data on and maps areas at risk of tsunamis, which are labeled tsunami evacuation zones and extreme tsunami evacuation zones. Tsunami evacuation zone maps detail where inundation and effect would be felt as well as tsunami safe zones.

There are no potentially at-risk critical facilities within the project area other than the existing highway, reducing the overall risk from tsunami damage. The existing highway does include three bridges, from

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12 *Maui Island Plan*. (2012). Chapter 3: Natural Hazards. https://www.mauicounty.gov/1503/Maui-Island-Plan.

13 Maui Emergency Management Agency. (August 2020). *2020 Maui County Hazard Mitigation Plan*. Multi-Hazard Mitigation Plan | Maui County, HI - Official Website. Accessed July 2023.

14 NOAA. (2020). U.S. Tsunami Warning System. National Weather Service. https://www.tsunami.gov/.

15 *State of Hawaiʻi Hazard Mitigation Plan Update (2023*). Chapter 4.13 OTIC Tsunami. https://dod.hawaii.gov/hiema/files/2023/01/2023_Hawaii_SHMP_Final_Approved_Adopted_508Compliant-10.27.23.pdf. Accessed February 2024.

16 Hawaiʻi Department of Transportation. (2023). HDOT Asset and Hazard Map, Hawaiʻi Highways Climate Insights for Infrastructure. https://climate-resilience.hidot.hawaii.gov/map/information/info. Accessed September 2023.

north to south: Bridge 009000300301971 (Olowalu B Stream Bridge), Bridge 009000300302100 (Olowalu Stream Bridge), and Bridge 009000300302351 (Ukumehame Stream Bridge), all of which are along potentially tsunami-inundated segments of the highway according to the HDOT Asset and Hazard Map (FIGURE 3.11-5).[17, 18] The Olowalu B Stream Bridge crosses an offshoot of the Olowalu Stream just after the Lahaina Bypass. The Olowalu Stream Bridge crosses the main branch of the Olowalu Stream just northwest of Olowalu town center. The Ukumehame Stream Bridge crosses the main branch of the Ukumehame Stream in between Ehehene Street and Pōhaku ʻAeko Street.

FIGURE 3.11-6 depicts the tsunami evacuation zone for the project area. Nearly the entire existing highway falls within the current tsunami evacuation zone in this section. This zone extends nearly 0.5-mile mauka from of the existing highway in some areas, with the largest coverage just north of Olowalu and just north of Pāpalaua Wayside Park.

Although the direct effect of climate change on tsunami sources such as earthquakes, landslides, and volcanoes are not yet fully understood, it is important to recognize that climate change could heighten the vulnerability of Maui County to tsunami impacts. Rising sea levels have the potential to extend the reach of tsunamis inland. Additionally, the warming of ocean waters contributes to coral bleaching events. Coral reefs act as natural barriers, safeguarding against tsunamis by dissipating wave energy offshore. Therefore, the implications of climate change on these protective coral reef ecosystems should be considered in the overall susceptibility of the project area to tsunamis.

3.11.3.6 Volcanic Hazards

Hazard Assessment

The only active volcano on Maui is Haleakalā, with its last eruption having occurred between 400 and 600 years ago.[19] Active volcanoes can produce several types of natural hazards: lava flows, volcanic ash and tephra fall, and volcanic gas or smog.[20]

Volcanic hazards on Maui are highly location dependent. Haleakalā sits in the southeastern portion of Maui; therefore, the project area is unlikely to face any hazards from lava flow. However, the project area may be affected by volcanic smog brought by storms or non-trade-wind conditions. The presence of acidic aerosols in volcanic smog increases the corrosion rate of exposed metals along the downwind path of the volcanic smog plume.[21] However, these effects are considered minor.

Vulnerability

Over the last 1,000 years, Haleakalā has erupted approximately 10 times, resulting in lava flow events every few hundred years. Volcanic gas or smog events, however, affect Maui every couple of years due

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17 Hawaiʻi Department of Transportation. (2023). HDOT Asset and Hazard Map, Hawaiʻi Highways Climate Insights for Infrastructure. https://climate-resilience.hidot.hawaii.gov/map/information/info. Accessed September 2023.

18 Hawaiʻi Department of Transportation. (2013). State Historic Bridge Inventory and Evaluation, Chapter 5 Maui. https://historichawaii.org/library/bridge/SHBIE2014_06_Ch5.pdf. Accessed October 2024.

19 U.S. Geological Survey. (2023). Active Volcanoes of Hawaiʻi. Hawaiian Volcano Observatory. https://www.usgs.gov/observatories/hvo/active-volcanoes-Hawaii. Accessed July 2023.

20 Fisher, R. (1997). Hazardous Volcanic Events. http://volcanology.geol.ucsb.edu/hazards.htm. Accessed July 2023.

21 Maui Emergency Management Agency. (August 2020). *2020 Maui County Hazard Mitigation Plan*. Multi-Hazard Mitigation Plan | Maui County, HI - Official Website. Accessed June 2023.

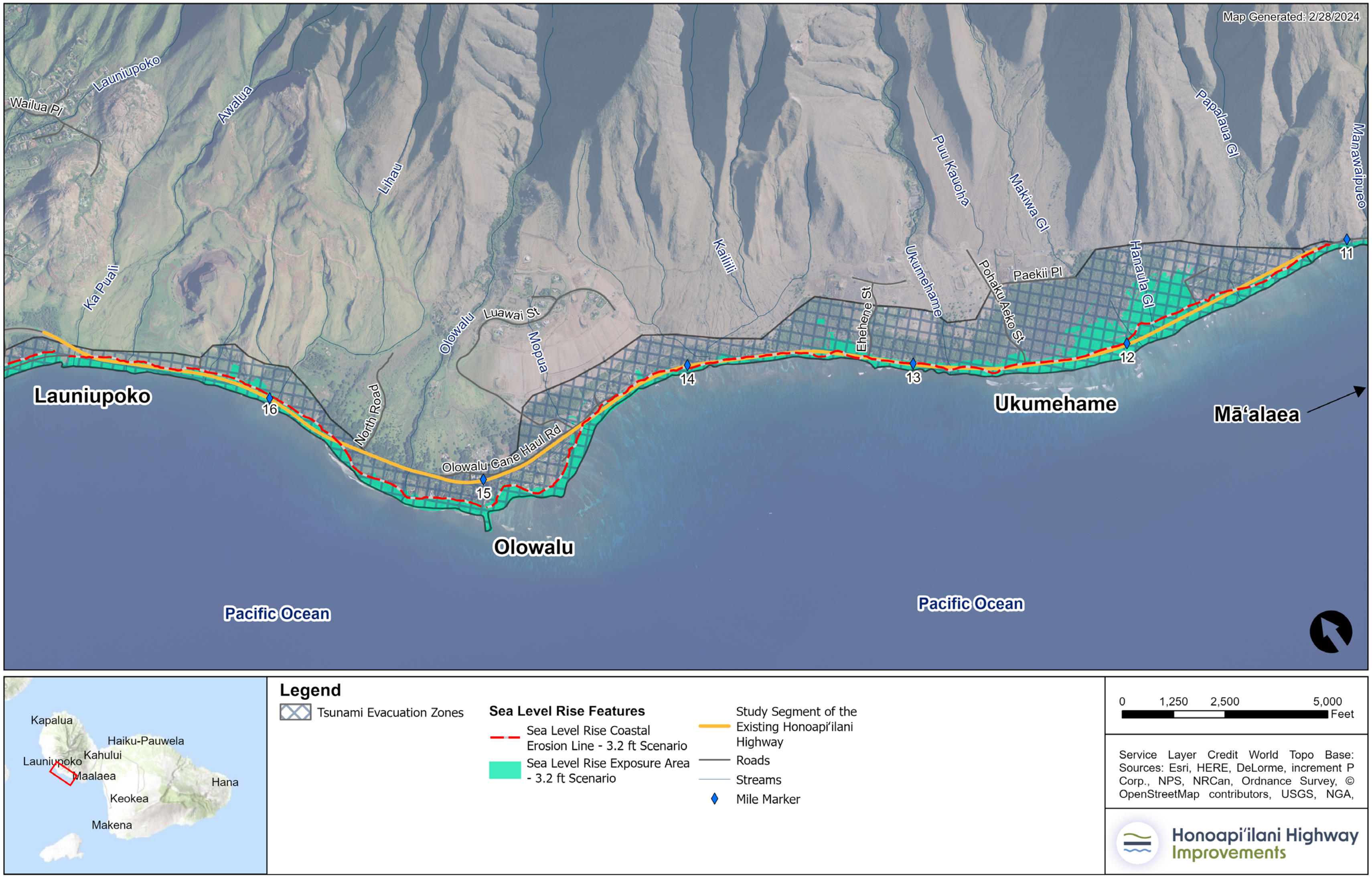
to eruptions on the Island of Hawaiʻi. The *Maui County Hazard Mitigation Plan* lists West Maui as having a 1% to 10% annual chance of volcanic hazards.[22]

[22] Maui Emergency Management Agency. (August 2020). *2020 Maui County Hazard Mitigation Plan*. Multi-Hazard Mitigation Plan | Maui County, HI - Official Website. Accessed July 2023.

FIGURE 3.11-5. **Existing Honoapiʻilani Highway Potentially Tsunami-Inundated Bridges**

Source: Hawaiʻi Department of Transportation (2022).

FIGURE 3.11-6. **Tsunami Evacuation Zone**



3.11.3.7 Wildfires

Hazard Assessment

Hawaiian wildfires are most common during the dry months from April to October.[23] Leeward sides of the islands tend to be drier, increasing the risk for fire. More than 1,000 fires occur annually in Hawaiʻi, burning more than 20,000 acres.[24] Intensifying development and travel to the islands have resulted in increased frequency and intensity of wildfires in the state. Human actions such as improperly extinguished campfires or cigarettes, intensifying land use, and sparks and heat from vehicles most often provide the ignition. It is estimated that 87% of wildfires are ignited by human activity.[25] TABLE 3.11-5 lists contributing factors to wildfire intensity and frequency in Hawaiʻi.

Wildfires can cause significant damage to buildings and infrastructure, as well as death and serious injury to people. The extreme heat and smoke risks are coupled with aftereffects such as soil destabilization, aggradation, dust storms, and landslides and rockfalls.[26]

In 2023, Lāhainā, just north of the project area, experienced a devastating wildfire that resulted in significant human and economic impacts. The 2023 Lāhainā wildfire marked one of Hawaiʻi's worst natural disasters and the deadliest in the United States since 1918. TABLE 3.11-6 includes information on recent wildfires.

TABLE 3.11-5. **Contributing Factors to Wildfire Intensity and Frequency in Hawaiʻi**

FACTOR	CONTRIBUTION
Invasive and Nonnative Vegetation	Invasive species and nonnative grasses and shrubs provide large amounts of fuel for fires, as they are now the predominant vegetation in the state.
Climate Change[1]	• Climate change leads to greater dryness and elevated temperatures, both of which are significant factors contributing to the heightened intensity of wildfire conditions. • Longer draughts and high rainfall variability create conditions for non-fire-resistant vegetation to ignite.
El Niño-Southern Oscillation	Warm El Niño years provide long growth periods for vegetation (fuel) followed by drought, increasing high-risk fire conditions.[2]

1 Section 3.13, Climate Change and Sea Level Rise.

2 State of Hawaiʻi. (August 6, 2018). Hazard Mitigation Plan. https://dod.Hawaii.gov/hiema/files/2018/11/State-of-Hawaii-2018-Mitigation-Plan.pdf. Accessed July 2023.

Changing conditions in Hawaiʻi are increasing the risk of wildfires. Climate change is anticipated to bring more intense precipitation to certain regions while increasing the risk of drier conditions in others, heightening the susceptibility to both natural and human-induced wildfires. Areas experiencing

23 State of Hawaiʻi. (August 6, 2018). Hazard Mitigation Plan. https://dod.Hawaii.gov/hiema/files/2018/11/State-of-Hawaii-2018-Mitigation-Plan.pdf. Accessed July 2023.

24 Trauernicht, C., and M. P. Lucas. (September 2016). “Wildfire ignition density maps for Hawaiʻi.” Forest and Natural Resource Management Series RM-21, University of Hawaiʻi Cooperative Extension Service.

25 National Interagency Fire Center. (2023). Human-caused and lightning-caused wildfire summary. Statistics. https://www.nifc.gov/fire-information/statistics. Accessed September 2023.

26 U.S. Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI (2012). https://directives.sc.egov.usda.gov. Accessed July 2023.

heavier precipitation may witness amplified vegetation growth, potentially serving as future wildfire fuel. In 2018, Hawaiʻi recorded 627 wildfires that scorched 32,386 acres of land. These fires primarily ignited in the drier, leeward island areas—often near population centers, roads, and vehicles—which are common sources of fire ignition.[27]

Concerns loom over escalating wildfire risks in the coming decades. This stems from the ongoing expansion of grasslands and shrublands, population growth, increasing arid conditions in lowland areas, and heightened year-to-year rainfall variability, which includes more frequent droughts. While arid lowlands may eventually become less flammable due to reduced vegetation growth in extremely dry conditions, wildfires on Maui are becoming more frequent, and this trend is anticipated to escalate with the warming of the climate.[28]

Vulnerability

West Maui has a probability of "Highly Likely" (greater than 90% annual chance) of experiencing a wildfire in a given year. The HDOT Climate Insights for Infrastructure platform includes a variety of resources, including the 2021 *Hawaiʻi Highways Climate Adaptation Action Plan* and the Climate Insights for Infrastructure mapping tool, to analyze and assess hazard impacts, such as wildfires. Previous data and work from the 2021 plan include concerns that wildfire risk would increase over the coming decade, partially due to expansions of grass and shrublands, climate change-related temperature and precipitation variability, and population growth.[29] The mapping tool indicates that from 2013 to 2020, all wildfire ignitions within the project area were within 400 feet of an existing roadway.[30]

The areas of Olowalu and Ukumehame have historically been among the most wildfire-prone areas in West Maui. From 2016 to 2019, four wildfires in these areas burned 1,955 acres. Honoapiʻilani Highway itself was within a 2016 fire that burned 203 acres.[31] Firebreaks have been installed between Olowalu and Ukumehame, as well as on the plateau on the southern flank of Pāpalaua stream. TABLE 3.11-6 lists recent fires in and overlapping the project area.

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27 Pacific Fire Exchange. 2019. 2018 Wildfires in Hawaiʻi | PFX Annual Summary. Accessed April 6, 2020, from: https://www.pacificfireexchange.org/research-publications/category/2018-annual-wildfire-summary-hawaii-pefkz.

28 Rezaie, F., Panahi, M., Bateni, S. M., Lee, S., Jun, C., Trauernicht, C., & Neale, C. M. U. (2023). Development of novel optimized deep learning algorithms for wildfire modeling: A case study of Maui, Hawaiʻi. *Engineering Applications of Artificial Intelligence*, *125*, 106699-. https://doi.org/10.1016/j.engappai.2023.106699.

29 Hawaiʻi Department of Transportation. (April 2021). Wildfire Exposure Assessment. *Hawaiʻi Highways Climate Adaptation Action Plan*. Accessed September 2023.

30 Hawaiʻi Department of Transportation. (2022). Climate Insights for Infrastructure Tool. https://climate-resilience.hidot.hawaii.gov/map/information/info. Accessed September 2023.

31 Hawaii Wildfire Management Organization. (2019). Hawaiʻi State Wildfire History Data Set. University of Hawaiʻi College of Tropical Agriculture and Human Resources. http://gis.ctahr.hawaii.edu/WildfireHistory#acks. Accessed July 2023.

TABLE 3.11-6. **2023 Fires in and Around Project Area**

YEAR	ACRES BURNED	IMPACT
June 2023	120	In June 2023, a wildfire burned in Olowalu mauka of the highway. Smoke and fire conditions threatened homes and properties in the area of the Olowalu Stream and created roadway closures for this important link to West Maui. **FIGURE 3.11-7. June 2023 Olowalu Fire** 
August 2023	2,170	The 2023 Lāhainā wildfire marked one of Hawaiʻi's worst natural disasters and the deadliest in the United States since 1918. The County of Maui estimates the wildfire burned 2,170 acres.[1] The cause of the fire remains debated, with possibilities including fallen power lines and worsening drought conditions.[2] Climate change was cited as a long-term concern for wildfires, as Hawaiʻi has experienced an increase in acreage burned by wildfires due to invasive grasses and worsening dry conditions, symptoms attributed to climate change. Heavy winds from Hurricane Dora moving across the Pacific Ocean south of the Island fanned flames and propelled the fire's movement. The wildfires caused significant road closures and evacuations that impacted project efforts to access the project area for field surveys and data collection. No portions of the proposed 6-mile stretch of the existing Honoapiʻilani Highway were damaged.

1 Maui County. (August 21, 2023). County of Maui Wildfire Disaster Update. Press Releases. https://www.mauicounty.gov/CivicAlerts.aspx?AID=12744. Accessed September 2023.

2 Trauernicht, Clay, & Elizabeth Pickett (2016) Pre-fire planning guide for resource managers and landowners in Hawaiʻi and Pacific Islands, Forest and Natural Resource Management, College of Tropical Agriculture and Human Resources, https://www.ctahr.hawaii.edu/oc/freepubs/pdf/RM-20.pdf. Accessed September 2023.

FIGURE 3.11-8 shows ignition density or number of ignitions per square mile per year across the state. The University of Hawaiʻi at Mānoa's Pacific Fire Exchange, in conjunction with the Hawaiʻi Wildfire Management Organization, provide and update datasets on wildfires in the islands. Within the project area, the greatest densities occur in Olowalu, though pockets of ignitions can be seen along the coastline spanning the whole project area.

The HDOT Asset and Hazard Assessment tool indicates that the project area faces a less than or equal to one wildfire ignition event per square mile per year.[32] Several small breaks in the coverage exist along the existing highway, including a small break at Ukumehame Beach Park. Regardless of these breaks, the existing highway faces annual threats of wildfire exposure. Additionally, the HDOT Climate Insights for Infrastructure mapping tool presents Wildfire Risk Zone and wildfire events per square mile, per year data.

The project area is on the leeward side of the island with steep slopes nearby and a history of wildfires. Mauka streams in Olowalu and Ukumehame present the added risk of sedimentation and water pollution associated with the aftereffects of wildfires.[33]

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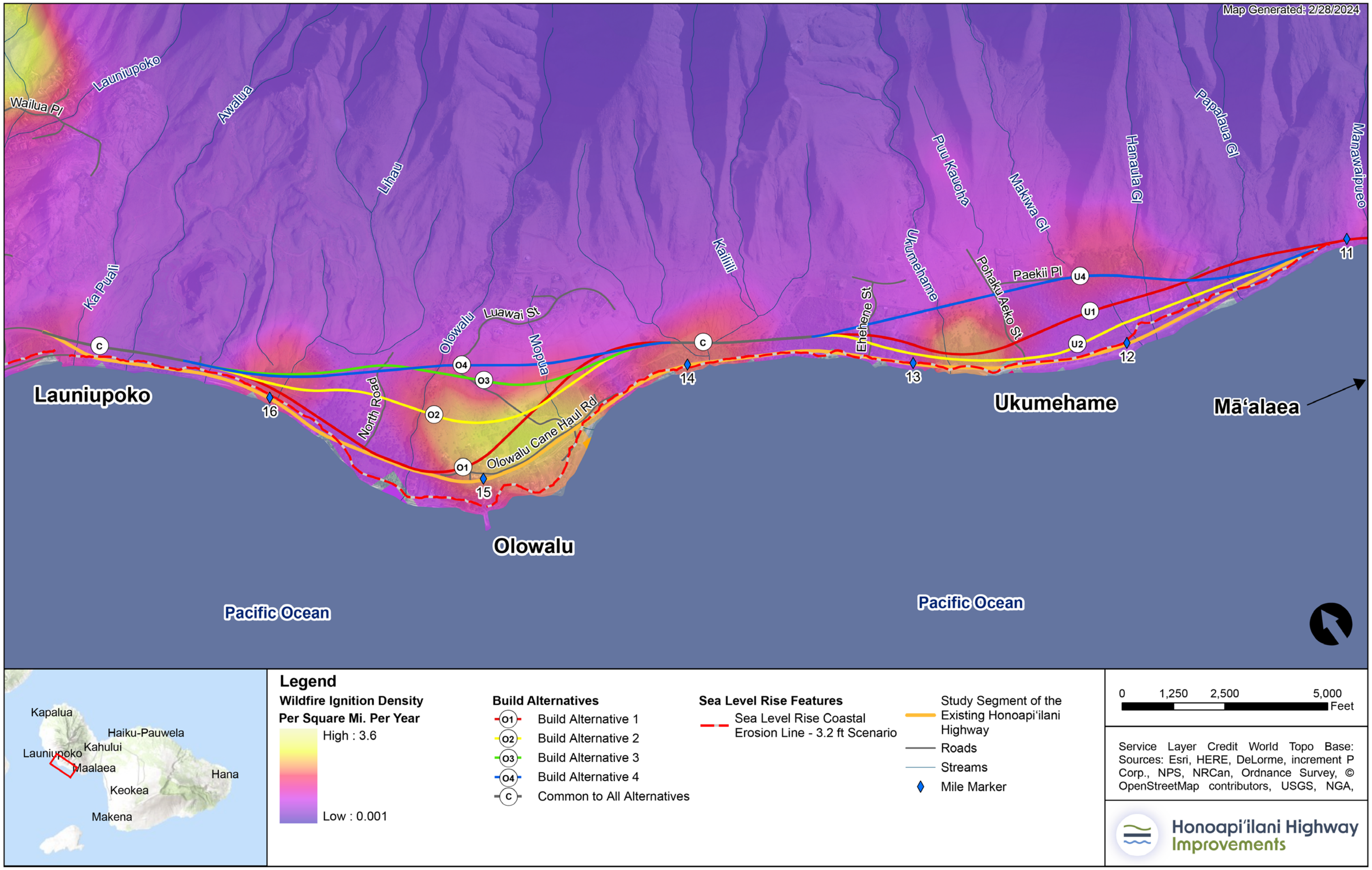
32 Hawaiʻi Department of Transportation. (April 27, 2021). Wildfire Exposure Assessment. HDOT Asset and Hazard Assessment. https://histategis.maps.arcgis.com/apps/MapSeries/index.html?appid=fb60bffa652c453d96b89d9f4aa9f756. Accessed July 2023.

33 Hawaiʻi Wildfire Management Organization. (2017). Prevent Wildfires to Protect Oceans. https://www.Hawaiiwildfire.org/home. Accessed July 2023.

FIGURE 3.11-8. **Maui County Wildfire Ignitions**



Source: Pacific Fire Exchange. (n.d.) Wildfire Ignition Density Map for Hawaiʻi. Hawaiʻi Wildfire Management Organization and University of Hawaiʻi at Mānoa. https://pacificfireexchange.org/map_tool_topic/wildfire-ignition-density-maps-for-hawaii/. Accessed September 2023.

3.11.3.8 Hurricanes and Tropical Storms

Hazard Assessment

Hurricanes are classified from one to five on the Saffir-Simpson Scale, based on the speed of sustained wind and subsequent damage level. Category 1 storms are the weakest, with minimal damage. Category 5 storms are the strongest, with catastrophic damage.[34]

The majority of hurricanes and tropical storms form between June 1 and November 30, commonly referred to as hurricane season. August to October is particularly notable as the peak period for hurricane development. To ensure effective monitoring and response, the Central Pacific Hurricane Center takes charge of monitoring hurricanes specifically in Hawaiʻi.[35]

In the central Pacific region, climate warming scenarios indicate a projected increase in both the frequency and intensity of hurricanes and tropical storms. These changes are potentially driven by warmer ocean waters, which contribute to the development of tropical cyclones. Furthermore, the occurrence of hurricanes and tropical storms in Maui County exhibits significant variability based on El Niño-Southern Oscillation patterns. El Niño years tend to have a higher likelihood of hurricanes affecting Hawaiʻi. Although the exact changes in the timing and intensity of El Niño-Southern Oscillation patterns in the future remain uncertain, climate models suggest a doubling of El Niño and La Niña extremes in the 21st century compared to the 20th century. Consequently, projected sea level rise, in combination with storm surges, could lead to the inland expansion of hurricane impacts over time, exacerbating the impacts on coastal communities.[36]

Vulnerability

Coastal areas face the greatest effect because hurricanes weaken the longer they are over land. Roads are particularly vulnerable to hurricanes and tropical storms because surges combined with heavy rainfall led to flooding, erosion, or undermining of coastal highways. Heavy rains combined with winds may trigger landslides that can damage roadways. Strong winds can create conditions for additional hazards, such as spreading wildfires (in 2023, Hurricane Dora produced winds that contributed to the Lāhainā wildfire).

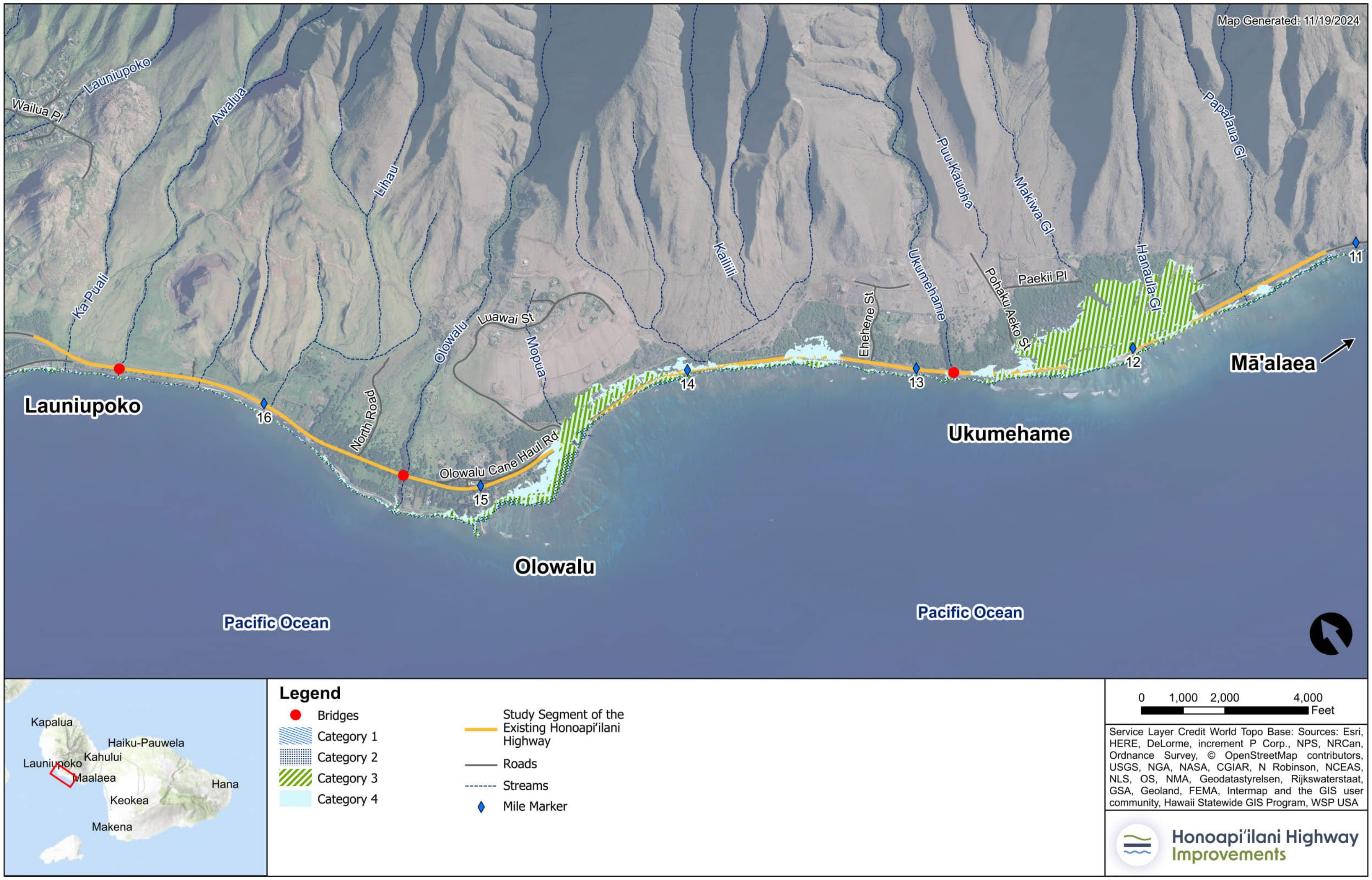
Estimates of storm surge heights and inundation areas come from the NOAA Sea, Lake, and Overland Surges from Hurricanes model. Per the model, the southern portion of the project area from Olowalu to Pāpalaua Wayside Park is within a designated Area of Potential Effects for storm surge inundation by Category 3 hurricanes. FIGURE 3.11-9 shows estimated inundation areas by hurricane category within the project area, based on the Saffir-Simpson Scale.

34 National Hurricane Center. (n.d.). Saffir-Simpson Hurricane Wind Scale. NOAA Central Pacific Hurricane Center. https://www.nhc.noaa.gov/aboutsshws.php. Accessed July 2023.

35 Hawaiʻi Department of Health. (2023). Hurricane Season. Issues and Advisories. Office of Public Health Preparedness | Hurricane Season (Hawaii.gov). Accessed July 2023.

36 U.S. Global Change Research Program (2018). Fourth National Climate Assessment. Chapter 27: Hawaiʻi and U.S.-Affiliated Pacific Islands. https://nca2018.globalchange.gov/chapter/27/. Accessed July 2023.

FIGURE 3.11-9. **Estimated Storm Surge Inundation for the Island of Maui**



3.11.3.9 Coastal Erosion

Hazard Assessment

Coastal erosion occurs due to a combination of natural processes such as wave action, sediment transport, and sea level changes. Factors such as wave energy, shoreline dynamics, sediment availability, and the influence of storms and climate change work to wear away coastal rocks, soils, and sands. While shorelines can naturally recover from erosion, it takes a long time to do so. This is the case in shorelines with heavy development, causing damage to infrastructure and the environment by a receding coast.[37]

While a natural process, some human activities can exacerbate coastal erosion. One such activity is shoreline hardening. Also known as coastal armoring, this process can provide immediate protection against coastal erosion by shielding the land behind them from wave energy. But the process can also disrupt natural sand movement and deposition processes, hastening erosion on the seaward side. Notably, the protective benefits of hardening structures often come at the expense of losing beaches and impacting coastal habitats.[38]

Coral reefs play a major role in controlling coastal erosion. They protect coastlines by providing a natural buffer but expose coastlines when degraded. Warming oceans, water pollution, and increases in turbidity all constitute human impacts that degrade coral reefs.[39]

Vulnerability

The project area sits along the western coast of West Maui, exposing it to year-round natural erosion factors. The *Maui County Hazard Mitigation Plan* lists the probability for coastal erosion in West Maui as "Highly Likely" (greater than 90% annual chance).[40] Transportation infrastructure faces risk of undermining, structural failure, and flooding resulting from coastal erosion. To protect the existing roadway, the State of Hawaiʻi has taken measures to harden the shoreline at several locations, such as in early 2003, when HDOT realigned the highway mauka north of Olowalu.

The 2019 HDOT Statewide Coastal Highway Program Report evaluated over 300 discrete coastal highway sites across the state that are threatened by coastal hazards and climate change and prioritized them using a ranking system called the Coastal Road Erosion Susceptibility Index. The report ranked a section of Olowalu (known as Mōpua) as second in priority statewide with the recommendation to harden or relocate the highway. Ukumehame is ranked 11th in priority with a recommendation to elevate or relocate that section of road.[41]

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37 U.S. Global Change Research Program. (April 1, 2021). Coastal Erosion. U.S. Climate Resilience Toolkit. https://toolkit.climate.gov/topics/coastal-flood-risk/coastal-erosion. Accessed July 2023.

38 U.S. Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI (2012). https://directives.sc.egov.usda.gov. Accessed July 2023.

39 NOAA. (2019). How do coral reefs protect lives and property? https://oceanservice.noaa.gov/facts/coral_protect.html. Accessed July 2023.

40 Maui Emergency Management Agency. (August 2020). *2020 Maui County Hazard Mitigation Plan*. Multi-Hazard Mitigation Plan | Maui County, HI - Official Website. Accessed July 2023.

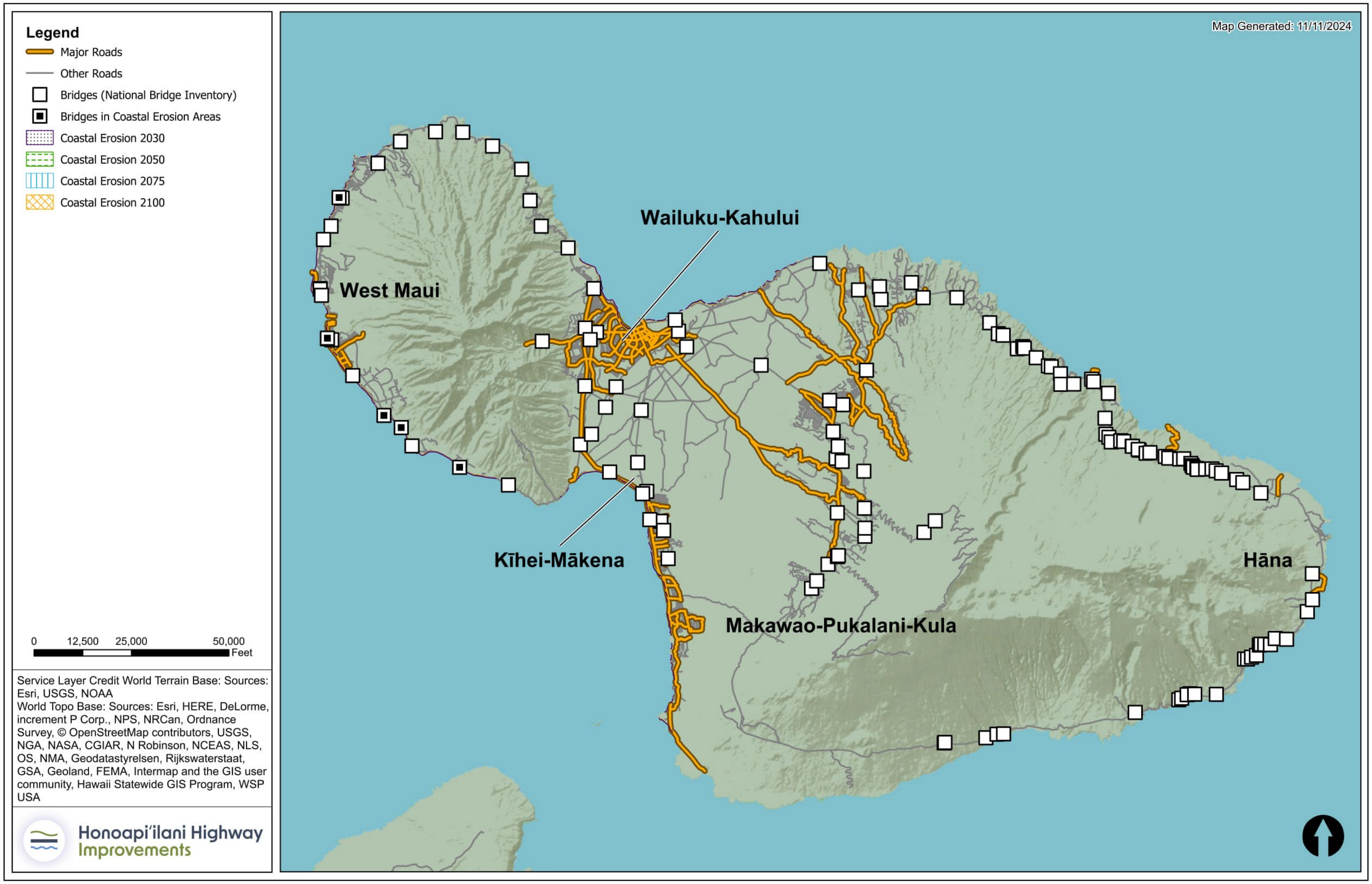
41 Francis, O., Horst, B., Zhang, G., Ma, D. (August 21, 2019). State of Hawaiʻi Statewide Coastal Highway Program Report. Hawaiʻi Department of Transportation Highways Division. Accessed July 2023.

The University of Hawaiʻi School of Ocean and Earth Science and Technology Coastal Geology Group has studied shoreline erosion trends across the state by evaluating mosaics of aerial photography that date back to 1912. In general, portions of the shoreline areas abutting the highway near Launiupoko and between Ukumehame Park and Pāpalaua Wayside Park are experiencing significant rates of erosion at an average of -1.4 feet/year and -1.9 feet/year, respectively. For comparison, adjacent transects within the same study areas lose roughly -0.3 feet/year and -0.7 feet/year.[42]

Two of the three bridges in the project area are within coastal erosion areas (FIGURE 3.11-10). Should coastal erosion continue or increase in intensity, impacts to these bridges could render this stretch of highway impassible. The first affected bridge lies just north of Awalua Beach, and the second is just northwest of Ukumehame Park.

42 University of Hawaiʻi (July 2021). Historical Mosaics. School of Earth Science and Technology. Coastal Geology Group. http://www.soest.Hawaii.edu/crc/index.php/resources-2/historical-mosaics/. Accessed July 2023.

FIGURE 3.11-10. **Bridges in Coastal Erosion Areas on Maui Island**



3.11.4 Environmental Consequences

Implementation of the Project would not increase the incidence or likelihood of earthquakes, tsunamis, volcanic hazards, hurricanes and tropical storms, or broader consequences of coastal erosion. Nonetheless, the Project's design would adhere to applicable regulations and best practices to manage and minimize risk to the roadway and the surrounding environment associated with these hazards.

3.11.4.1 No Build Alternative

The No Build Alternative reflects future conditions assuming the existing Honoapiʻilani Highway remains in its current configuration and would remain vulnerable to the natural hazards discussed in this section. The existing highway was constructed prior to current design standards in terms of bridges, culverts, stormwater management infrastructure, and seismic stability, and may not be seismically constructed or retrofitted to withstand strong earthquakes.[43]

While the underlying geology and soil characteristics would remain unchanged, the No Build Alternative would continue to be subject to coastal storms and erosion (combined with sea level rise as discussed in Section 3.13, Climate Change and Sea Level Rise) that have already created unstable conditions and resulted in multiple breaches and washouts. Nature-based solutions, revetments, and seawalls, or a combination of these protections combined with elevating the road are short- to mid-term fixes. But the long-term effects of coastal storms and erosion would continue to diminish the reliability and resiliency of the transportation corridor—both temporary and permanent closures of sections of the roadway would be a potential outcome of the No Build Alternative.

The No Build Alternative would remain susceptible to earthquakes, tsunamis, volcanic hazards, wildfires, hurricanes, and tropical storms. The No Build Alternative has the greatest percentage of alignment within the tsunami evacuation zone, making it the most susceptible to impact.

3.11.4.2 Build Alternatives

The Build Alternatives have potential environmental benefits and adverse effects regarding geology, soils, and natural hazards. This section summarizes this information for each of the alternatives.

<u>Common to All Build Alternatives in Olowalu and Ukumehame</u>

The Build Alternatives would provide an opportunity to construct a new roadway that would minimize potential damage and disruption from natural hazards. Roadway design and construction would adhere to applicable local ordinances and statutes regarding the movement of sand and unintended consequences of protective measures, such as shoreline hardening (Section 3.13, Climate Change and Sea Level Rise, includes further discussion on coastal erosion). While the Project would be constructed to satisfy the applicable AASHTO standards, floodplains may be affected. This effect, along with the potential for the Project to result in impacts to coastal ecosystems, including coral reefs, is

43 Hawaiʻi Department of Transportation. (2023). HDOT Asset and Hazard Map, Hawaiʻi Highways Climate Insights for Infrastructure. https://climate-resilience.hidot.hawaii.gov/map/information/info. Accessed September 2023.

evaluated separately in Section 3.9, Water Resources, Wetlands, and Floodplains, and Section 3.10, Flora and Fauna, and Endangered Species.

Regarding geology and soils, the Build Alternatives would generally be constructed on alluvium and old alluvium, with some areas of various alignments consisting of outcrops of basalt rock formations and clinkers (jagged volcanic rocks). The far west portion of the alignments cross a cinder cone and the far east portion of the alignments cross through Wailuku Volcanics, which would require stabilization considerations by the contractor during design-build. In the vicinity of the termini of the alignments to the far east and far west, basalt outcrops exist. Based upon existing available geotechnical information, it is anticipated that construction requirements for the various alignments would be essentially similar, with the exception of the southeast end of Build Alternative 1 in Ukumehame, which consists of significantly more excavation in basalt than the other Build Alternatives. Rock outcroppings are known in the project area, as identified by the USGS geologic maps, and would be confirmed as part of final design for the Preferred Alternative.

The Project would be designed consistent with applicable construction codes to increase resilience to natural hazards to the extent practicable. New bridges would be designed in accordance with AASHTO Load and Resistance Factor Design Bridge Design Specifications, which include seismic provisions. Roadway design and construction would adhere to applicable local ordinances and statutes regarding coastal erosion (that is, the movement of sand and unintended consequences of protective measures).

Based on this information, while portions of each Build Alternatives may be susceptible to natural hazards, the Project would represent an improvement in susceptibility to natural hazards as compared to the No Build Alternative.

Olowalu

Build Alternatives 1 and 2

These alignments pass through the area of high wildfire ignition density in Olowalu near mile marker 15, presenting opportunities to act as potential firebreaks (FIGURE 3.11-8).

Build Alternatives 3 and 4

Neither of these alignments pass through the high wildfire ignition density area in Olowalu near mile marker 15, offering relatively minimal benefit as potential firebreaks (FIGURE 3.11-8).

Ukumehame

Common to All Build Alternatives

All these alignments pass through areas of high wildfire ignition density, presenting opportunities to act as potential firebreaks (FIGURE 3.11-8).

At the connection point with the existing Honoapiʻilani Highway at the Pali, the existing roadway is very close to the water and overlaps with erosion hazard areas and erodible soil conditions. Therefore, it is assumed that shoreline protection would be required at the point of the Pali connection. To avoid encroachment beyond existing highway's paved area, a design commitment would be to use cutoff walls constructed within the highway's makai shoulder.

Build Alternative 1

In Ukumehame, geology and soils at the Pali connection would cut into steeper and rockier areas, which would require more grading and/or retaining walls to ensure the soil is stable and to minimize rock falls.

3.11.5 Construction Effects

Construction activities can pose a fire risk during highway construction. Several factors contribute to this risk. Construction sites often involve the use of heavy machinery and equipment that can generate heat, sparks, or friction, leading to potential ignition sources. Similarly, on-site flammable materials increase the risk of fire hazards.

3.11.6 Indirect Effects

The only natural hazard that the Project may have reasonably foreseeable indirect effects on is wildfire. Improvements to the Honoapiʻilani Highway have implications for increased number of trips and miles traveled on the roadway. As described in Section 3.11.3.7, interaction between humans and fuel sources can trigger wildfires. Relocating portions of the highway to new areas may create new wildfire hazards (sparks and heat from vehicles, new trash, and still burning cigarettes and matches) based on proximity of relocated roadway traffic, particularly where alignments are in more arid environments compared to the existing coastal highway alignment. Wildfire mitigation is described below.

3.11.7 Mitigation

Mitigation to keep soil from eroding in the project area is imperative to prevent sediment from reaching the ocean. Accordingly, during construction of the Project, plants would be preserved to the greatest extent possible, and fire prevention would be emphasized. Construction best management practices would be defined in a National Pollutant Discharge Elimination System permit.

Erosion mitigation measures include preserving plants to the greatest extent possible and adhering to National Pollutant Discharge Elimination System best management practices.

The new highway could potentially be used as a belowground utility corridor for Maui Electric Company and offers the opportunity to upgrade utility infrastructure to minimize wildfire risks associated with power lines and other electric transmission. Maui Electric Company would be involved in the design, and all applicable rules and regulations would be followed.

To mitigate potential effects of wildfires, the Project would represent an opportunity to provide a fire break based on the width of the right-of-way, with discontinuous vegetated areas and through the routine clearing of debris and vegetation within High Wildfire Risk Areas. Fire-resistant vegetation may also be incorporated to further reduce wildfire risk, as recommended in the HDOT *Hawaiʻi Highways Climate Adaptation Action Plan* (2021) <u>and was used in the evaluation of the Preferred Alternative</u>. ~~Input from the Hawaiʻi Wildfire Management Organization and local authorities, including fire departments, would be integrated as part of the Final EIS evaluation of the proposed Preferred Alternative as well as into the final design and wildfire mitigation activities of the Project.~~

The 2021 HDOT *Hawaiʻi Highways Climate Adaptation Action Plan* includes several recommended actions for highways to improve resilience to wildfires, as does the City of Honolulu Climate Change Commission. Additionally, throughout the scoping process, public input identified several mitigation measures that the Project can take to reduce wildfire impacts (TABLE 3.11-7).

TABLE 3.11-7. **Wildfire Impact Mitigation Measures**

MEASURES
Increase shoulder areas to increase the distance between road users and roadside vegetation.
Routinely clear debris and vegetation along roads to reduce wildfire fuel sources.
Strengthen partnerships with the Hawaiʻi Wildfire Management Organization and local authorities to support wildfire education, particularly risk along roadways.
Use new alignments as a firebreak through wildfire hotspots.
Utilize fire-resistant vegetation and place a greater emphasis on native vegetation along roadways.
Require the contractor to have a fire extinguisher within every vehicle, including large construction equipment. The fire department phone number will be on every supervisor's contact list and fire prevention and control methods will be discussed at site safety meetings.

3.11.8 Build Alternatives Comparative Assessment

TABLE 3.11-8 and TABLE 3.11-9 summarize the comparison of potential environmental effects for the Build Alternatives in Olowalu and Ukumehame, respectively.

TABLE 3.11-8. **Build Alternatives Comparison - Olowalu**

HAZARD AREA	BUILD ALTERNATIVE 1	BUILD ALTERNATIVE 2	BUILD ALTERNATIVE 3	BUILD ALTERNATIVE 4
Geologic or Soils Constraints	None	None	None	None
Built to Current Seismic Standards	Yes	Yes	Yes	Yes
Percentage within Tsunami Evacuation Zone	89%	53%	52%	37%
Volcanic Hazards	No increase in susceptibility	No increase in susceptibility	No increase in susceptibility	No increase in susceptibility
Wildfires	Potential firebreak benefit	Potential firebreak benefit	Minimal benefit	Minimal benefit
Hurricane and Tropical Storms	Improved reliability	Improved reliability	Improved reliability	Improved reliability

TABLE 3.11-9. **Build Alternatives Comparison - Ukumehame**

HAZARD AREA	BUILD ALTERNATIVE 1	BUILD ALTERNATIVES 2 AND 3	BUILD ALTERNATIVE 4
Geologic or Soils Constraints	Requires more slope stabilization in Pali	None	None
Built to Current Seismic Standards	Yes	Yes	Yes
Percentage within Tsunami Evacuation Zone	95%	100%	87%
Volcanic Hazards	No increase in susceptibility	No increase in susceptibility	No increase in susceptibility
Wildfires	Potential firebreak benefit	Potential firebreak benefit	Potential firebreak benefit
Hurricane and Tropical Storms	Improved reliability	Improved reliability	Improved reliability