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KALI WATSON
CHAIRMAN, HHC
Ka Luna Hoʻokele

KATIE L. DUCATT
DEPUTY TO THE CHAIRMAN
Ka Hope Luna Hoʻokele

DEPT. COMM. NO. 307

STATE OF HAWAII
DEPARTMENT OF HAWAIIAN HOME LANDS
Ka ʻOihana ʻĀina Hoʻopulapula Hawaiʻi

P. O. BOX 1879
HONOLULU, HAWAII 96805

January 3, 2024

The Honorable Ronald D. Kouchi,
President and Members of the Senate
32nd State Legislature
State Capitol, Room 409
Honolulu, Hawaii 96813

The Honorable Scott K. Saiki,
Speaker and Members of the House of Representatives
32nd State Legislature
State Capitol, Room 431
Honolulu, Hawaii 96813

Dear President Kouchi, Speaker Saiki, and Members of the Legislature:

For your information and consideration, I am transmitting a copy of the Report to the 2024 Legislature as required by HCR 153, HD 1 / HR 154 HD 1 (2023). In accordance with Section 93-16, Hawaii Revised Statutes, I am also informing you that the report may be viewed electronically at https://dhhl.hawaii.gov/reports/.

Sincerely,

Kali Watson, Chairman
Hawaiian Homes Commission

REPORT TO THE LEGISLATURE

RELATING TO
HCR153, HD1 / HR 154, HD1 (2023)

Prepared by

State of Hawaii
Department of Hawaiian Home Lands

January 3, 2024

HCR153, HD1 / HR 154, HD1 (2023)

REQUESTING THE DEPARTMENT OF HAWAIIAN HOME LANDS TO CONDUCT A STUDY THAT EVALUATES POSSIBLE METHODS OF FLOOD REMEDIATION AND FLOOD AVERSION FOR CERTAIN AREAS OF THE ISLAND OF MOLOKAI

The Department of Hawaiian Home Lands (DHHL) submits the following report to the Hawai'i State Legislature for HCR153, HD1/HR 154, HD1 which request that DHHL conduct a study that evaluates possible methods of flood remediation and flood aversion for certain areas of the island of Moloka'i including Kalama'ula, Kapa'akea, Kamiloloa, and Makakupa'ia.

In December 2022, the Hawaiian Homes Commission (HHC) approved the South Molokai Shoreline Erosion Management Plan (SM-SEMP). Please see the attached Item G-2 for the SM-SEMP. The approved SM-SEMP's recommendations and implementation will facilitate the planning process for the "Developing Community Resilience for Molokai Coastal Homesteads" project. This effort will result in preparation of a Community Resilience Plan for the ahupua'a of Kalama'ula, Kapa'akea, Kamiloloa and Makakupa'ia, and the DHHL-owned portion of Mālama Park in the ahupua'a of Kaunakakai. This next project is supported by funding from the National Fish and Wildlife Federation (NFWF). The project began in 2023 and will continue for the next two years.

While the SM-SEMP meets the definition of a shoreline erosion management plan, the document will be utilized in the near term as a technical background study that will provide best practices, site-specific data and recommendations for action to support the next phase of work, which will be preparation of a Community Resilience Plan for the project area's ahupua'a, including the mauka areas which contribute to flooding in low-lying coastal areas. One outcome of the SM-SEMP planning process has been identification of additional climate change-related impacts such as groundwater upwelling, flooding from stormwater runoff during heavy rain events, and cesspool failures.

<u>Collaboration and Coordination</u>

A more comprehensive, ahupua'a-based approach, in coordination with other landowners, governmental agencies at all levels, and Molokai-based nonprofits will be needed to adequately address erosion and flooding impacts affecting low-lying coastal homestead areas.

Now that the HHC has also approved the update of DHHL's General Plan, it is anticipated that the next update of the Molokai Island Plan will have an evaluation of projected sea level rise and other climate change-related impacts anticipated to occur within the twenty-year planning timeframe, with an emphasis on adaptation and mitigation measures and ways to increase community resilience in a more extreme climate.

DHHL also intends to initiate the following next steps:

- Bring a homestead-specific analysis of climate change-related risks and vulnerabilities, via GIS mapping, to the HHC.
- Continue to work on a more coordinated approach to DHHL representation and involvement in various disaster preparedness and community resilience planning processes, policies, and implementation activities at the federal, state and county levels.
- Continue to engage with organizations such as Sustʻāinable Molokaʻi and Molokaʻi Wetland Partnership to increase community resilience and implement nature-based solutions such as wetland restoration and enhancement.
- Work with Molokaʻi homestead associations and beneficiary-serving organizations to implement the "Restore natural shoreline function" core strategy via community projects supported with grant funding.

Molokaʻi people are the experts on their island home, and most if not all either grew up on the shoreline or spent many hours of their childhood there. Many still use the shoreline and nearshore waters regularly for subsistence. They have seen the changes that have occurred over time, and their participation in shoreline erosion mitigation, climate change adaptation, and coastal stewardship activities will be crucial to the success of DHHL's implementation efforts in the coming years.

DHHL appreciates the opportunity to provide this report to the State Legislature.

STATE OF HAWAII
DEPARTMENT OF HAWAIIAN HOME LANDS

December 21-22, 2022

To: Chairman and Members, Hawaiian Homes Commission

Thru: Andrew H. Choy, Planning Program Manager AC

From: Nancy M. McPherson, Planner NMM

Subject: Approval of South Molokai Shoreline Erosion Management Plan (SM-SEMP)

RECOMMENDED ACTION

That the Hawaiian Homes Commission:

1) Approve the South Molokai Shoreline Erosion Management Plan (SM-SEMP)(Exhibit A); and

2) Authorize dissemination of the South Molokai Shoreline Erosion Management Plan (SM-SEMP).

BACKGROUND

Context

The Planning Office (PO) last updated the Hawaiian Homes Commission (HHC) on the South Molokai Shoreline Erosion Management Plan (SM-SEMP) project at its January 2022 and March 2022 meetings. Acknowledging that the Community Engagement Program for the SM-SEMP had been significantly impacted by the COVID-19 pandemic restrictions, and after receiving additional feedback from the HHC and beneficiaries, a decision was made to allow for additional time to conduct community outreach with Molokai coastal homesteaders. A second focus group meeting was held on Tuesday April 5, 2022 with four beneficiaries participating, including the Molokai Hawaiian Homes Commissioner.

A larger Community Meeting to review the Draft Plan had been tentatively scheduled for summer 2022 as an in-person and virtual hybrid meeting, but due to conflicting schedules, the final meeting was delayed until an Open House could be held with the consultants in Kalama‘ula, Molokai on October 14, 2022.

After the Open House, Planning Office staff continued work on the project, incorporating additional beneficiary feedback into the SM-SEMP before requesting final approval by the Hawaiian Homes Commission. A Final SM-SEMP is now presented to the HHC for review and requested approval. See Exhibit A.

In spite of the delays and challenges, the SM-SEMP has incorporated a significant amount of information from the community that has guided the recommendations for DHHL policies and actions included in the plan. Molokai coastal homestead lessees shared their time, ‘ike and aloha, influencing recommendations for types of erosion responses and supporting a preference for nature-based solutions for shoreline restoration and stewardship grounded in cultural and subsistence practices.

DISCUSSION

Need for the Project

The HHC has been briefed regularly over the last several years on current and anticipated climate change impacts, both globally, nationally and here in our islands, as well as on the need for the project to address sea level rise and accelerated shoreline erosion on Molokai, as articulated in the last four updates on the SM-SEMP to the HHC (April 2019, April 2021, January 2022 and April 2022).

Climate Change and Sea Level Rise (SLR) Projections

The latest sea level rise models have been adjusted so that the high projections have now become the moderate projections, therefore putting the State of Hawai‘i and DHHL on notice that "Sea level is committed to rise for centuries to millennia due to continuing deep-ocean warming and ice-sheet melt and will remain elevated for thousands of years (high confidence)."[1] In order to avoid the worst impacts to our coastal homestead communities, sea level rise mitigation and adaptation measures must be put in place within the next 20 to 30 years.

[1] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. P. SPM-28. https://www.ipcc.ch/report/ar6/wg1/

Adjustments to Project Methodology and Timeline

- The planning team produced a Draft SM-SEMP for beneficiary review and comment and held a second focus group meeting in early April 2022. Feedback was incorporated into Chapter Five, Shoreline Erosion Management Options and Chapter Six, Implementation Strategy.
- Information on the Draft SM-SEMP was shared at the HHC Community Meeting held on Molokai on April 19, 2022.
- PO staff participated in Lā Pilina, a community outreach event held by SustʻĀinable Molokai to showcase community resilience and climate change adaptation efforts, on November 12, 2022. A display presented major components of the Draft Plan, and visitors to DHHL's table were given a copy of Sea Grant's Homeowner's Handbook to Prepare for Natural Hazards. Staff was on hand to answer questions and encourage participation in the upcoming Open House and future Community resilience Plan.
- DHHL PO staff and consultants held an in-person Open House for coastal homesteaders on Molokai on November 14, 2022 to share information and get feedback on the findings and recommendations of the Draft SM-SEMP and offer opportunities for beneficiary participation in the implementation phase. Attendees were given a copy of Sea Grant's Homeowner's Handbook to Prepare for Natural Hazards.
- Once the final SM-SEMP is approved by the HHC, PO staff will begin the planning process for the "Developing Community Resilience for Molokai Coastal Homesteads" project, to take place over the next two years.

The DHHL Planning Office will continue its coastal community outreach at every opportunity in order to reach the greatest number of homesteaders living in the coastal communities of Kalamaʻula, Kapaʻakea and Kamiloloa-One Aliʻi. It is important that lessees and their ʻohana learn more about the SM-SEMP's recommended mitigation and adaptation measures and the roles that DHHL, other state, federal and county agencies, and the lessees will need to play in successful implementation of the SM-SEMP recommendations.

This effort will be rolled into the subsequent preparation of a Community Resilience Plan for the ahupuaʻa of Kalamaʻula, Kapaʻakea, Kamiloloa and Makakupaʻia, and the DHHL-owned portion of Malama Park in the ahupuaʻa of

Kaunakakai. This next project is supported by funding from the National Fish and Wildlife Federation (NFWF). The project is scheduled to begin in the first quarter of 2023 and will continue for the next two years.

Organization of the Final SM-SEMP

The Final SM-SEMP is still organized into six chapters, with an Executive Summary, References and four Appendices. For an aerial map of the Project Area, see Figure 1, below.

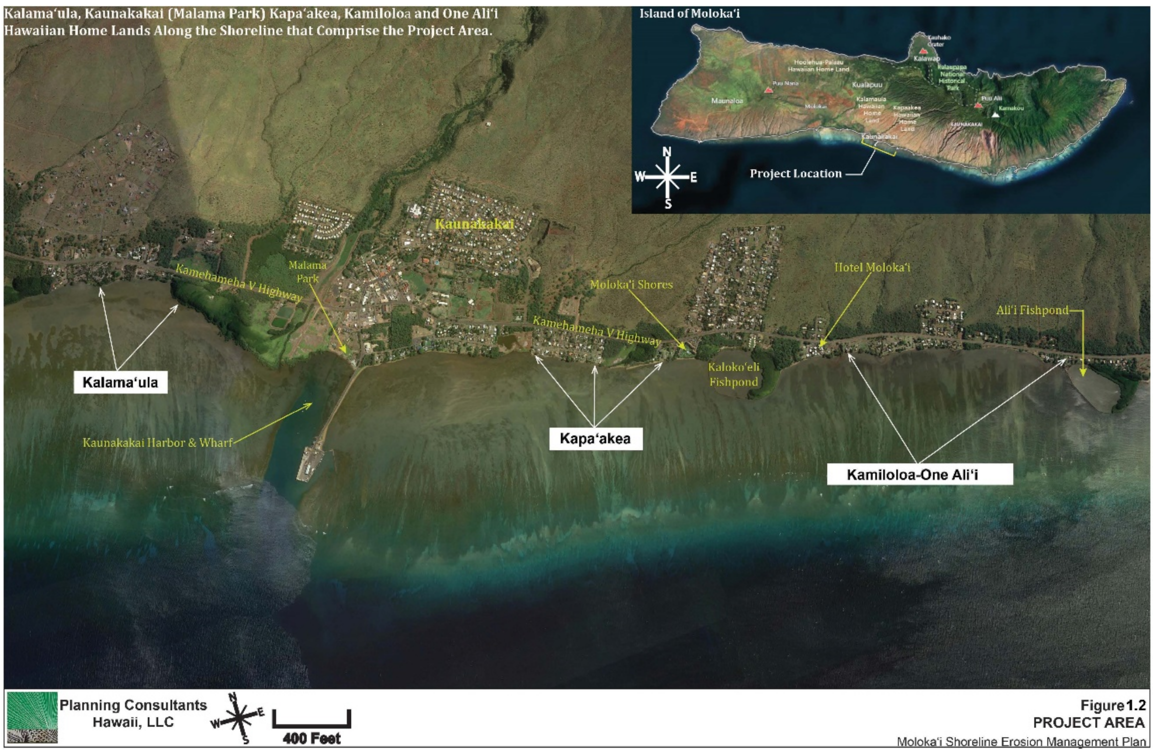


Figure 1, SM-SEMP Project Area

Synopsis of Plan Organization

Executive Summary

Chapter 1 Introduction

- Provides overview of project area's relationship to island as a whole and to coastline of south central Molokaʻi.
- Identifies SM-SEMP's purpose and objectives, discusses severity of the erosion problem, and identifies the cultural and ecological benefits of a healthy shoreline.

Chapter 2 SM-SEMP Planning Process

- Documents five-phase planning process used to prepare Draft SM-SEMP
    - Phase 1 - Desktop Research
    - Phase 2 - Field Surveys
    - Phase 3 - Stakeholder Outreach
    - Phase 4 - Stakeholder Vetting of Draft Recommendations
    - Phase 5 (Prepare Draft Final SM-SEMP)
        - Prepare HHC Review Draft, Draft for Community Review and Final SM-SEMP using information generated through Phases 1-4.

Chapter 3 Place and Context

- Analyzes project area spatially and temporally within context of Kona Moku and the five ahupuaʻa that have a direct influence on DHHL properties within SM-SEMP study area, with special emphasis on how human-induced change has affected coastal resources and shoreline processes.
- Describes socio-economic environment and planning and regulatory conditions that may influence appropriate responses to shoreline change.

Chapter 4 Coastal Hydrodynamics

- Identifies and describes factors that influence wave energy and physical form of coastline, e.g. wave conditions, currents, tidal changes, storm surge, bathymetry, sediment characteristics, and sources of sediment.
- Identifies four littoral (beach) cells fronting DHHL communities, defining hydrogeological and geographic areas needed to analyze forces affecting shoreline erosion, and prepare mitigation measures.

Chapter 5 Shoreline Erosion Management Options

- Discusses erosion management strategies and describes mitigation approaches ranging from soft, nature-based remedies to hard, man-made structures.
- Explores concept of adapting to shoreline change by realigning structures to reduce exposure to coastal hazards.

Chapter 6 Implementation Strategy *(This section received additional beneficiary input)*

- Offers strategies and actions designed to discourage building in harm’s way and encourage long-term sustainability and shoreline resiliency

- Provides more specific remedies for areas threatened by erosion within Littoral Cells A through D.

Appendices

- APPENDIX A: Stakeholder Outreach
- APPENDIX B: Five Molokai Land Divisions
- APPENDIX C: Flood Zones, Shoreline Setbacks, and State Certified Shoreline
- APPENDIX D: Shoreline Erosion Assessment (Severity and Risks)

Existing Conditions and Recommended Implementation Strategy

Table 1, below, lists the SM-SEMP's Core Strategies and some of the plan's highlighted actions.

CORE STRATEGIES	Action Highlights[1]
<u>Restore</u> natural shoreline function.	• Remove and replace invasive plants and trees with climate adapted, drought tolerant native grasses, shrubs, and trees such as ʻakiʻaki grass, pōhuehue, naupaka, and milo. • Develop a detailed vegetation management plan to guide shoreline and dune restoration within the SM-SEMP Area. • Remove man-made debris between the high and low water line including tires, appliances, vehicle parts, concrete and asphalt rubble, CMU blocks, pallets, steel and plastic drums, and other non-indigenous materials and dispose of it properly.
<u>Educate</u> beneficiaries on the causes and consequences of sea level rise and coastal erosion, including appropriate mitigation measures.	• Provide beneficiaries living in flood prone areas with the following information: ▪ "*Answers to Questions about Substantially Improved / Substantially Damaged Buildings*", FEMA publication 213, August 2018. ▪ "*Homeowners Handbook to Prepare for Natural Hazards*" 4th Edition, by Dennis Hwang and Darren Okimoto, Sea Grant, University of Hawaiʻi. ▪ Flood zone and sea level rise exposure maps.
<u>Strengthen</u> the <u>regulation and management</u> of shoreline resources.	• Recommend consistency with identified State of Hawaiʻi and Maui County regulations governing buildings and construction, the shoreline, and flood hazard areas. • Recommend consistency with Federal and State DLNR regulations regarding shoreline surveys, armoring, and coastal construction on submerged lands.

CORE STRATEGIES	Action Highlights[1]
<u>Adapt</u> structures and systems to better withstand coastal hazards.	• Require new dwellings to be elevated above flood hazard zones (base flood elevation, SLR inundation) by more than one foot in elevation (freeboard). • Encourage lessees to reconfigure dwellings by moving the kitchen mauka and elevating food preparation areas so that stove, refrigerator, and appliances are elevated or located at the highest, driest part of the property. • Convert cesspools to septic systems wherever feasible to reduce the risk of contaminated water and protect beneficiary health.
<u>Prepare</u> for the relocation or retirement of structures out of areas threatened by sea level rise and coastal erosion.	• Prepare a community-based plan for the relocation of vulnerable buildings, infrastructure, and public facilities away from areas threatened by sea level rise and/or coastal erosion. • Prepare and implement a planned obsolescence strategy for infrastructure at risk of damage from SLR, coastal erosion, and flooding including roads, drainages, wastewater treatment, and centralized utility systems and services.

[1] This table includes a sample of the SM-SEMP's highlighted actions. A complete list of the Plan's actions is in Chapter 6.

Table 1 (Table ES-1) Highlighted Actions

Results of Additional Community Outreach

DHHL received an invitation to share information about the Planning Office's climate adaptation and community resilience efforts on Molokai at the Lā Pilina community resilience event held by Sust‘ainable Molokai on November 12, 2022 at Mitchell Pau‘ole Center in Kaunakakai. Attendance was high, as the event offered live music and free food for participants. Approximately twenty beneficiaries stopped by DHHL's table and asked questions about the SM-SEMP and the Community Resilience Planning project. Approximately ten beneficiaries expressed interest in participating in either implementation of the SM-SEMP or development of the Community Resilience Plan, or both.

While perhaps not the best venue to collect focused beneficiary input on the SM-SEMP, tabling at the event was an effective way to "get the word out" on DHHL's efforts to address shoreline erosion and climate change impacts on Molokai's southern coastline. It was also a good opportunity for DHHL to interact with other governmental agencies and nonprofits doing climate change-related work on the island.

DHHL Planning Office staff and project consultants, with assistance from the Molokai District Office, then held an Open House on November 14, 2022 to share the Draft SM-SEMP with Molokai coastal lessees. The Open House was held at the Hālau at Kūlana ʻŌiwi in Kalamaʻula. Nine beneficiaries attended. There were six stations arranged in a horseshoe shape, with 32 poster-sized displays taped to the tables due to the wind in the Hālau. Multiple copies of the Draft SM-SEMP were available for attendees to leaf through. The stations followed the general organizational structure of the Draft SM-SEMP, with the following focus areas:

I. Introduction / Project Overview
II. Project Area & Existing Conditions
III. Shoreline Erosion Management Options
IV. Draft Recommendations
V. Implementation and Next Steps
VI. Resource Table

While the turnout was small, as has been the case lately for in-person outreach events on Molokai, the feedback that was received was thoughtful and insightful. Major comments received supported the restoration of native coastal flora, requested more information and suggestions on specific plants for revegetation of the shoreline, and expressed support for allowing beneficiaries to conduct activities that will preserve and protect their shoreline lots from erosion.

Again, while the event didn't produce a lot of written comments, it was a good opportunity to talk story with shoreline lessees, answer their questions and discuss exhibits such as historical maps, the four littoral cells and the recommendations for shoreline erosion mitigation. As is usually the case, the planners learned a lot more from the beneficiaries than they probably learned from us.

Molokai people are the experts on their island home, and most if not all either grew up on the shoreline or spent many, many hours of their childhoods there. Many still use the shoreline and nearshore waters regularly for subsistence. They have seen the changes that have occurred over time, and their participation in shoreline erosion mitigation, climate change adaptation and coastal stewardship activities will be crucial to the success of DHHL's implementation efforts in the coming years.

Implementation Phase

While the SM-SEMP meets the definition of a shoreline erosion management plan, the document will be utilized in the near term as a technical background study that will provide best practices, site-specific data and recommendations for action to support the next phase of work, which will be preparation of a Community Resilience Plan for the project area's ahupuaʻa.

As discussed previously, DHHL has been awarded a National Coastal Resilience Fund (NCRF) grant from the National Fish and Wildlife Federation (NFWF) for a project titled "Developing Community Resilience for Molokai Coastal Homesteads". Grant funds will be used to procure a consultant who will work with Molokai coastal homestead lessees, the larger beneficiary community, DHHL staff and other governmental agencies and non-governmental organizations to prepare a Community Resilience Plan for the project area, which has been enlarged to include the entire subject ahupuaʻa, beginning in the first quarter of 2023.

One outcome of the SM-SEMP planning process has been identification of additional climate change-related impacts such as groundwater upwelling, cesspool failures, and flooding from stormwater runoff during heavy rain events. A more comprehensive, ahupuaʻa-based approach, in coordination with other landowners, governmental agencies at all levels, and Molokai-based nonprofits will be needed to adequately address erosion and flooding impacts affecting low-lying coastal homestead areas.

Now that the HHC has approved the update of DHHL's General Plan, it is anticipated that the next update of the Molokai Island Plan will have an evaluation of projected sea level rise and other climate change-related impacts anticipated to occur within the twenty-year planning timeframe, with an emphasis on adaptation and mitigation measures and ways to increase community resilience in a more extreme climate.

RECOMMENDED ACTION

Staff respectfully requests that the Hawaiian Homes Commission approve the action as requested.

South Moloka‘i Shoreline Erosion Management Plan

Prepared by:

Planning Consultants Hawai‘i, LLC

and

Coastal Planners, LLC

Prepared for:

State of Hawai‘i
Department of Hawaiian Home Lands

Approved by the Hawaiian Homes Commission

December 2022

Suggested citation:
DHHL, 2022. *South Moloka‘i Shoreline Erosion Management Plan*. State of Hawai‘i. Department of Hawaiian Home Lands. Prepared by Planning Consultants Hawai‘i, LLC and Coastal Planners, LLC. December 2022.

CONTENTS

EXECUTIVE SUMMARY

Project Background and Purpose

The overwhelming consensus of climate scientists is that "our planet's average temperature could be between 2 and 9.7°F (1.1 to 5.4°C) warmer in 2100 than it is today" (NOAA, 2012). As temperatures rise, Molokaʻi will see stronger and more frequent storms which will result in severe and dangerous floods, greater stress on mauka watersheds, and increased sediment discharge into coastal waters.

For Department of Hawaiian Home Lands (DHHL) communities living along the south shore of Molokaʻi, this means preparing for the impacts of increasing sea levels and shoreline erosion. Climate change will make low lying areas between Kalamaʻula and Kamiloloa-One Aliʻi more vulnerable to flooding. According to recent studies, "with 3.2 feet of sea level rise, low-lying coastal areas around the island...may become chronically flooded within the mid- to latter-half of this century" (Tetra Tech 2017, 115). Furthermore, as sea levels rise, more wave energy will be telegraphed further inland, above and over the offshore reef fronting the South Molokaʻi shoreline. As this happens, more and stronger waves will contact the area's beaches causing more frequent and severe shoreline erosion events and loss of sandy beach.

In recognition of the deleterious impact of this erosion on the Hawaiian Homestead communities of Kalamaʻula, Kapaʻakea, and Kamiloloa-One Aliʻi, the DHHL commissioned this South Molokaʻi Shoreline Erosion Management Plan (SM-SEMP). Its purpose is to provide a strategy to proactively manage shorelines that are vulnerable to erosion to make them more resilient to the effects of sea level rise.

This is to be achieved using: a. traditional ecological knowledge gathered from the project area's native Hawaiian homesteaders and lineal descendants; b. a scientific evaluation of coastal conditions; and c. published literature on the causal factors contributing to shoreline erosion. Recommendations are further informed by community input as well as thoughtful consideration of South Molokai's socioeconomic conditions and cultural, natural, and recreational resources.

The SM-SEMP team used the ahupuaʻa as a geographic construct to better understand the interconnected and interdependent relationship between South Molokai's land and ocean ecosystems, and the reciprocal relationship between DHHL homesteaders and the environment. SM-SEMP recommendations were designed within the context of how those recommendations could affect mauka and makai lands, waters, and communities. Within the SM-SEMP Area, emphasis was also placed on the littoral cell[1], rather than the individual parcel, as a means to more effectively study the causes and consequences of shoreline erosion and to devise appropriate recommendations to mitigate the effects of shoreline erosion.

The Planning Process

Preparing the SM-SEMP consisted of five phases as follows:

Phase 1 (Desktop Research)
Document the project area's moʻolelo, history, terrestrial environment, physical coastal processes, and erosion hotspots within the context of the project area's ahupuaʻa.

Phase 2 (Field Surveys)
Conduct field observations of shoreline conditions to gather valuable background data and photographs of past flooding, shore conditions, shore reference features, and shoreline change.

Phase 3 (Stakeholder Outreach)
Work with Hawaiian Homestead beneficiaries, lineal descendants, government, and community stakeholders to identify shoreline erosion threats and appropriate management responses.

Phase 4 (Stakeholder Vetting of Draft Recommendations)
Prepare conceptual draft recommendations for vetting by a diverse group of Hawaiian Homesteaders and other stakeholders.

PHASE 5 (Prepare the Draft and Final SM-SEMP)
Prepare the Draft and Final SM-SEMP using information generated through the first four phases.

> *"Over time, as sea level continues to rise, low-lying, populated coastal communities such as Kapaʻakea would experience increased frequency and severity of flooding ultimately leading to permanent inundation, making some areas of the coast impassable or uninhabitable" (*Tetra Tech 2017, 116*).*

Issues and Challenges

The SM-SEMP Area faces an unusual number of climate change-induced challenges in the future because of its location in a low-lying coastal area, environmental attributes, and the number of homesteaders residing in the area. Among the most important challenges caused by rising sea levels and coastal erosion are the following:

- Coastal flooding
- Damage to critical infrastructure such as Kamehameha V Highway and Kaunakakai Harbor and Wharf
- Loss of land and structures
- Damage to property
- Cesspool and septic system failure
- Impact on native flora and fauna
- Impact on cultural resources
- Access to and along the shoreline
- Diminished coastal water quality

Photo: *A panorama of the informal shoreline armoring along a portion of Kapaʻakea (Source: DHHL).*

[1] A littoral cell is a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks (Inman, 2005).

Key Recommendations for the SM-SEMP

The following six core strategies describe the broad strategic action that will be taken to make the SM-SEMP's shoreline more resilient to the effects of sea level rise and coastal erosion.

- Restore natural shoreline function.
- Educate beneficiaries on the causes and consequences of sea level rise and coastal erosion, including appropriate mitigation measures.
- Strengthen the regulation and management of shoreline resources.
- Adapt structures and systems to better withstand coastal hazards.
- Prepare for the relocation or retirement of structures out of areas threatened by sea level rise and coastal erosion.

Each strategy is further implemented through related actions. Table ES-1 highlights key SM-SEMP actions.

Next Steps

The 2020 – 2022 Covid-19 pandemic severely limited the ability of the planning team to carefully review the SM-SEMP's recommendations with affected beneficiaries. As such, the DHHL will conduct further outreach with the project area's beneficiaries in the second half of 2022 and update the SM-SEMP's recommendations accordingly.

The DHHL was awarded a National Fish and Wildlife Foundation (NFWF) grant to develop a Community Resilience Plan for Molokai's coastal homestead communities. Using the SM-SEMP as a foundation, the Resilience Plan will further expand scientific analyses and modeling of projected sea-level rise, flooding, groundwater upwelling and other increasing climate change-related hazards like hurricanes. The Resilience Plan will identify priorities for projects that will stabilize and restore shorelines, mitigate coastal flooding and sedimentation, and emphasize culturally grounded, nature-based solutions.

Subject to funding availability, the DHHL will also conduct the following SM-SEMP implementation activities:

1. Develop a detailed vegetation management and berm restoration plan with detailed topography and design renderings.
2. Prepare best management practices (BMP's) for shoreline hardening in Kapaʻakea to support dry stack walls, sills, and fishpond restoration.
3. Remove man-made debris along the shoreline, and where necessary, replace with native *pōhaku* using traditional Hawaiian techniques for the construction of dry stack walls, or *uhau humu pōhaku*.
4. Prepare an environmental assessment and pursue other governmental permits required for SM-SEMP implementation.

Plan Organization

The SM-SEMP is organized into the following six chapters:

Chapter 1 (Introduction) provides an overview of the project area's relationship to the island as a whole and more specifically to the coastline of south central Molokaʻi.

Chapter 2 (SM-SEMP Planning Process) documents the process the planning team used to prepare the SM-SEMP.

Chapter 3 (Place and Context) analyzes the project area within the context of the moku and the five ahupuaʻa that have a direct influence on the DHHL properties within the SM-SEMP study area, focusing on Kalamaʻula, Kaunakakai, Kapaʻakea, Kamiloloa, and Makakupaʻia.

Chapter 4 (Coastal Hydrodynamics) identifies and describes the factors that influence wave energy and the physical form of the coastline within the SM-SEMP study area, including: wave conditions, currents, tidal changes, storm surge, bathymetry, sediment characteristics, and sources of sediment. Chapter 4 then identifies four littoral cells fronting the DHHL communities. The planning team used the littoral cell boundaries to define the geographic area in which to analyze the forces affecting shoreline erosion, and to prepare mitigation measures.

Chapter 5 (Shoreline Erosion Management Options) explores erosion management strategies and describes mitigation approaches ranging from soft, nature-based remedies to hard, man-made structures. Chapter 5 also explores adapting to shoreline change by realigning structures to reduce their exposure to coastal hazards.

Chapter 6 (Implementation Strategy) offers strategies and actions for the overall SM-SEMP area to discourage building in harm's way and to encourage long-term sustainability and shoreline resiliency. Chapter 6 then provides more specific remedies for areas threatened by erosion within defined littoral cells A through D.

CORE STRATEGIES	Action Highlights[1]
Restore natural shoreline function.	• Remove and replace invasive plants and trees with climate adapted, drought tolerant native grasses, shrubs, and trees such as ʻakiʻaki grass, pōhuehue, naupaka, and milo. • Develop a detailed vegetation management plan to guide shoreline and dune restoration within the SM-SEMP Area. • Remove man-made debris between the high and low water line including tires, appliances, vehicle parts, concrete and asphalt rubble, CMU blocks, pallets, steel and plastic drums, and other non-indigenous materials and dispose of it properly.
Educate beneficiaries on the causes and consequences of sea level rise and coastal erosion, including appropriate mitigation measures.	• Provide beneficiaries living in flood prone areas with the following information: ▪ "*Answers to Questions about Substantially Improved / Substantially Damaged Buildings*", FEMA publication 213, August 2018. ▪ "*Homeowners Handbook to Prepare for Natural Hazards*" 4th Edition, by Dennis Hwang and Darren Okimoto, Sea Grant, University of Hawaiʻi. ▪ Flood zone and sea level rise exposure maps.
Strengthen the regulation and management of shoreline resources.	• Recommend consistency with identified State of Hawaiʻi and Maui County regulations governing buildings and construction, the shoreline, and flood hazard areas. • Recommend consistency with Federal and State DLNR regulations regarding shoreline surveys, armoring, and coastal construction on submerged lands.
Adapt structures and systems to better withstand coastal hazards.	• Require new dwellings to be elevated above flood hazard zones (base flood elevation, SLR inundation) by more than one foot in elevation (freeboard). • Encourage lessees to reconfigure dwellings by moving the kitchen mauka and elevating food preparation areas so that stove, refrigerator, and appliances are elevated or located at the highest, driest part of the property. • Convert cesspools to septic systems wherever feasible to reduce the risk of contaminated water and protect beneficiary health.
Prepare for the relocation or retirement of structures out of areas threatened by sea level rise and coastal erosion.	• Prepare a community-based plan for the relocation of vulnerable buildings, infrastructure, and public facilities away from areas threatened by sea level rise and/or coastal erosion. • Prepare and implement a planned obsolescence strategy for infrastructure at risk of damage from SLR, coastal erosion, and flooding including roads, drainages, wastewater treatment, and centralized utility systems and services.

[1] This table includes a sample of the SM-SEMP's highlighted actions. A complete list of the Plan's actions is in Chapter 6.

***Table ES-1**: Highlighted Actions.*

CHAPTER 1: INTRODUCTION

The complex interaction of coastal processes and generations of human-induced changes to the natural environment has had a profound impact on the South Molokaʻi shoreline. The interaction of these forces, along with rising sea levels, has resulted in significant erosion of some sections of the South Molokaʻi shoreline which is threatening private property, critical infrastructure, and natural, cultural, and recreational resources.

In recognition of the deleterious impact of this erosion on the Hawaiian Homestead communities of Kalamaʻula, Kapaʻakea, and Kamiloloa-One Aliʻi, the Department of Hawaiian Home Lands (DHHL) commissioned this South Molokaʻi Shoreline Erosion Management Plan (SM-SEMP). Its purpose is to develop a strategy to proactively manage shorelines that are vulnerable to erosion to make them more resilient to the effects of climate change.

This is to be achieved through a scientific evaluation of coastal conditions, the use of traditional ecological knowledge gathered from the project area's Hawaiian homesteaders and lineal descendants, and published literature on the causal factors contributing to shoreline erosion. Recommendations are further informed by community input as well as thoughtful consideration of South Molokaʻi's socio-economic conditions and cultural, natural, and recreational resources.

1.1 Regional and Local Setting

Molokaʻi is the fifth largest of the six developed southern Hawaiian Islands, being as much as ten miles wide and thirty-eight miles long. The island has approximately eighty-eight miles of shoreline that circumscribes the 260 square mile island. Molokaʻi has shorelines that are dynamic and can change rapidly in response to natural forces such as storms, high winds, and large surf.

On Molokai's West End, Pāpōhaku Beach is the longest, most intact coastal dune system in the southern Hawaiian Island chain. The East End of Molokaʻi, known as Manaʻe, is considerably more humid and lush owing to its exposure to the prevailing trade winds. The volcanic island rises some 4,961 feet above sea level and has some of the highest sea cliffs and waterfalls in Hawaiʻi along its north shore. In contrast, Molokai's south shore is not exposed to the prevailing northwest ocean swells and storms and forms a coastal plain. It is also somewhat protected from waves, storms, and swells from the south by the islands of Lānaʻi and Kahoʻolawe, as illustrated by Figure 1.1. Given this protection, Molokai's south shore has the longest continuous fringing reef in the United States, and it has sites with the best coral coverage in the developed Hawaiian Islands (Ogston and Field, 2010).

There are many ahupuaʻa incorporating watersheds or sub-basins within the Kona moku or division of land on the island of Molokaʻi. Of these, five ahupuaʻa have a direct influence on the DHHL properties within the SM-SEMP study area: Kalamaʻula, Kaunakakai, Kapaʻakea, Kamiloloa, and Makakupaʻia. The neighboring Kawela ahupuaʻa to the east also has considerable influence on sediment transport and stormwater influx to the coastline.

The DHHL subdivisions are adjacent to other residential developments along and within the coastal plains of Molokai's south shore and begin about one mile east of Kaunakakai Town, extending approximately 3.5 miles from town (Figure 1.2).

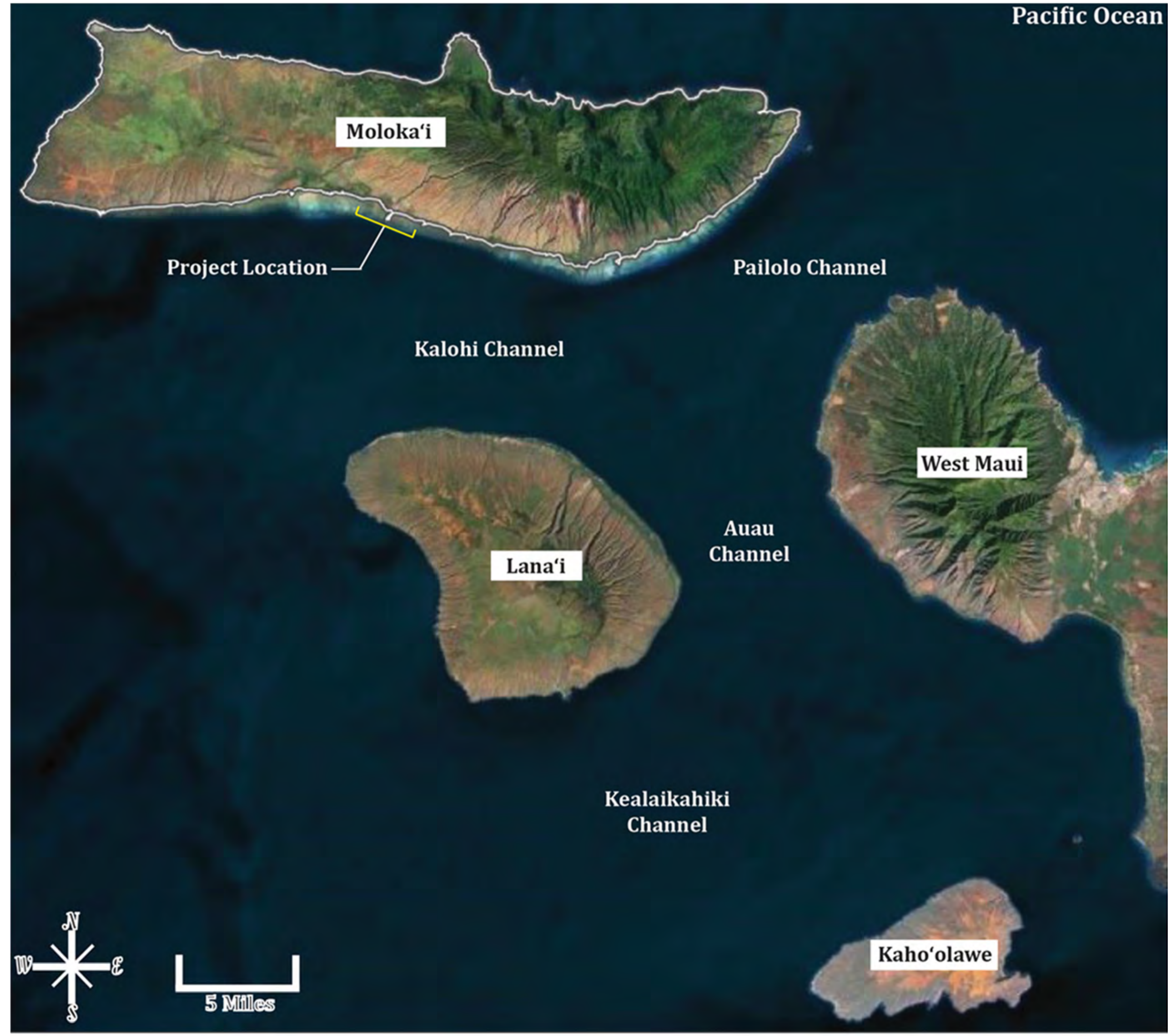


Figure 1.1: *Location of the study area in the context of neighboring islands.*

Planning Consultants Hawaii, LLC

400 Feet

Figure 1.2
PROJECT AREA
Moloka‘i Shoreline Erosion Management Plan

All of these communities are served by Kamehameha V Highway. There are fifteen homestead lots in the makai Kalamaʻula community, five of which are located along the shoreline. In Kapaʻakea there are forty-seven residential lots, seventeen of which are along the shoreline. The community is bordered by wetlands on either side and has concrete culvert drainages to divert heavy upland rainstorms to the ocean. Fourteen beneficiary lots within the Kamiloloa-One Aliʻi community are located along the shoreline to the east of Hotel Molokaʻi. In addition, thirteen residential lots within the community are located between the Kamehameha V Highway and the Aliʻi fishpond. In total, there are thirty-six oceanfront beneficiary lots within these DHHL communities (Table 1.1).

DHHL Homestead Lots Makai of Kamehameha V Highway			
DHHL Community	# of Oceanfront Homestead Lots	# of non-oceanfront Homestead Lots	Total Homestead Lots
Kalama'ula	5	10	15
Kapa'akea	17	30	47
Kamiloloa – One Ali'i	14	13[1]	27

[1]Thirteen residential lots within the subdivision are located between the Kamehameha V Highway and the Aliʻi fishpond.

***Table 1.1**: DHHL Homestead Lots within SM-SEMP Area Communities*.

1.2 The Erosion Problem

The three and one-half mile discontinuous stretch of coastline fronting the Hawaiian Homestead communities of Kalamaʻula, Kapaʻakea, and Kamiloloa-One Aliʻi has experienced substantial change over the years. Shoreline erosion has resulted in the loss of homestead property, limited shoreline access, and harmed cultural and environmental resources.

DHHL homesteaders living along this portion of Molokai's southern shore have observed changes to the shoreline over their lifetimes, and they have expressed concerns about how best to address these changes. Correspondingly, DHHL is studying what measures should be taken to respond to shoreline change and what actions would be prudent and appropriate to adapt to future states of the coastline, especially in light of sea level rise.

1.3 Purpose and Objectives of the SM-SEMP

In the future the effects of climate change, sea level rise, and more frequent extreme weather and king tide events are expected to increase coastal erosion and expose DHHL homesteads to coastal hazards such as flooding, storm surge, and beach and land loss. To address these risks, the DHHL contracted Planning Consultants Hawaiʻi, LLC, and Coastal Planners, LLC, to assist with the preparation of a shoreline erosion management plan for the coastal homestead communities of Kalamaʻula, Kapaʻakea, and Kamiloloa-One Aliʻi along Molokai's southern coast.

The purpose of this SM-SEMP is to provide DHHL and its lessees with a strategy to manage shoreline erosion in the project area. Specific objectives are to:

1. Enable DHHL to proactively plan for and manage shoreline erosion;
2. Investigate underlying causes of shoreline erosion, and likely future progression;
3. Identify effective and sustainable shoreline erosion management strategies that maintain natural processes and consider community needs; and
4. Educate the community as to the causes of shoreline erosion and appropriate management responses.

The intent is to offer a workable management plan that can be readily implemented by DHHL, homesteaders, and community members.

1.4 Structure of the SM-SEMP

The SM-SEMP describes the existing marine, terrestrial, and socioeconomic environment within the project area. Using available reports, peer reviewed studies, traditional ecological knowledge, and community input, this SM-SEMP provides a description of the physical coastal processes and geomorphology that affect shoreline function and health.

The SM-SEMP recommends actions that can help restore the natural function of the coastline fronting the project area. Where manmade actions have altered the shoreline and it is no longer feasible to restore the shoreline's natural function, the SM-SEMP provides construction and land use techniques to help prevent or mitigate the potential damage to land and coastal structures from shoreline erosion. While primarily focused on oceanfront properties, the suggestions and recommendations contained in the SM-SEMP could benefit mauka homes located in low-lying areas of Molokai's coastal plain.

The SM-SEMP also discusses ineffective shoreline management methods so that time, money, and energy are not spent on ideas that may appear to have merit, but usually are detrimental when compared to other methods of shoreline intervention. The SM-SEMP also provides recommendations that will build community resilience in the face of sea level rise.

1.5 Benefits of a Healthy Shoreline

A healthy Hawaiian shoreline is an extremely dynamic place. Natural forces sort out sediment into coarse and fine materials. Coarse materials such as rocks, cobbles, pebbles, and sand remain as waves, wind, and water affect the land-water interface. Finer materials such as silt and clay are washed away or diluted and dissolved into the water to be carried away by currents. The wind blows grains of sand, and waves push sand mauka where it can become entrained in the fine web of roots of native plants such as ʻakiʻaki grass, ʻākulikuli, pōhuehue, naupaka, beach heliotrope, and naio.

1.5.1 Flood Reduction

The native plants mentioned above help to build vegetated berms and sand dunes to support a healthy shoreline. Berms and dunes store sand aggregate for use during large storm events where waves can overtop the edge of the shoreline and spread out into rear yards resulting in flooding. During moderate storms, waves run up the beach but do not crest the berm, thereby avoiding the flooding of inland areas. However, large waves may overtop the berm and spread out over inland areas resulting in flooding, but with less force and depth of water than would occur without the berm.

Sand dunes and vegetated berms along the edge of the shoreline are nature's way of blocking and buffering incoming wave energy. The sand and aggregate contained within these natural features are released by having waves chew into them, which spreads the sand into the nearshore area making it shallower. This causes the wave to break sooner and further offshore. Naturally vegetated berms or dunes rise slightly higher than the coastal plain (or rear yard in many cases) offering a modicum of protection from seawater inundation into the mauka areas along the coastal plain. Berms and dunes are nature's way of buffering the dynamic forces along the shoreline.

1.5.2 Shoreline Access

A healthy, unobstructed shoreline can function as a pathway providing access to and along the coastline for community members to fish, glean, gather, and recreate. As shorelines erode and become narrow, the community's ability to access the coastline can be hindered. Access can be further diminished by human-made structures such as seawalls, rubble mounds, boulder piles, or other types of armoring placed on the coastline.

Excessive vegetative growth can form impenetrable thickets that also hinder access along the shoreline. Thick stands of non-native kiawe trees are a common hindrance to shoreline access that impedes lateral access along the shoreline in the project area. Additionally, kiawe tree roots can inhibit the free flow of sand and sediment causing erosion scarps to form. The trees also dry out the soil, reducing moisture needed for native plants to grow.

Photo: *Kiawe can impede access along the shoreline for subsistence gathering, particularly at high tide.*

1.5.3 The ‘Ice Box’

A healthy shoreline can contribute to a healthier reef, which in turn provides food for the people. For generations DHHL beneficiaries living in the SM-SEMP area have relied on the ocean and springs for their sustenance.

> *“Went crabbing, lay net before for the small fish – pua – small mullet. Her ‘ohana only took what they could eat. Mother gathered limu… She knew where the freshwater was coming out – all the way from Kimball’s place (now Penny’s) one… Our kupuna would tell us stories about all the sweet potato, vegetables being grown to feed the people of Kalama‘ula”.*
>
> **Kanani Negrillo, Kalama‘ula Lessee**

Fishing is more productive on a healthy coral reef with clean water than on a reef covered in sediment and having murky water. The pollution that harms coral reefs can also degrade nearshore and shoreline flora that is an important source of food and fiber for native Hawaiians. For instance, limu is a type of edible seaweed, of which at least eight species are popular in Polynesian and Hawaiian dishes (Preskitt, 2002). Some of these, like limu ogo (*Gracilaria parvisipora*) now occur in excess along Molokai’s southern shores, whereas other more preferred species of limu like ‘ele‘ele (*Enteromorpha prolifera*) are scarce or have become absent. Factors contributing to these changes may include species introductions, overharvesting, increased turbidity in the water column (i.e., murky water), degraded water quality along the shoreline and inner reef, and shoreline erosion and subsequent shoreline armoring.

1.5.4 Cultural and Recreational Practices

Access to and along the shoreline for cultural and subsistence purposes is vitally important to the well-being of native Hawaiians. The native Hawaiian people “access and use the shoreline area for many purposes, including fishing; gathering limu, 'opihi, and other ocean resources; and for recreation” (MacKenzie, M.K., 1991). Native Hawaiian traditional and customary rights are impeded when access to and along the shoreline is lost due to erosion and subsequent shoreline armoring activities. A healthy shoreline, backed by native plants and grasses, is important for the perptuation of the Hawaiian culture.

Boating can be a subsistence, commercial, or recreational activity. Small fishing boats, kayaks, and outriggers can easily be anchored near the shore along Molokai’s relatively calm, shallow, southern shoreline. However, access to mooring opportunities are diminishing along the project area’s eroding shoreline. On an eroding beach, boaters will frequently need to wade through shallow water along the shoreline to reach a mooring. If the nearshore is too silty, one may get stuck or lose footwear that becomes stuck in the silty muck. If the sand is scoured away, an outrigger or small boat’s hull can be damaged or leak as a result of being dashed against the rocks.

In addition, as coral reefs diminish in vitality, larger waves could penetrate further inland breaching the offshore fringing reef. Such large waves could overturn small boats and cause them to sink or cause them to break free of their moorings, resulting in lost or damaged watercraft.

Stand up paddling is one type of fitness and recreation that allows one to see through the water into the undersea menagerie. Kayaking is also a popular form of recreation with similar attributes. Both are more enjoyable in clean, rather than murky, ocean waters. Outrigger paddling, either solo or in a group, is a favorite pastime and traditional activity in Hawai‘i. It can be a competitive or social sport that improves mental and physical fitness and instills traditional Hawaiian values of collaboration and community, especially for youth. But the enjoyment of the experience may be diminished if the water is murky from silt, the sandy launch is scoured away, or if there is high wave reflection from shore armoring.

Photo: *Alluvial layers of red clay can pollute nearshore waters with fine silt and sediment that smothers coral reefs.*

CHAPTER 2: SM-SEMP PLANNING PROCESS

To proactively manage erosion and strengthen community resilience, the DHHL has conducted various integrated coastal zone management activities in recent years. These efforts, aimed at building resiliency, informed the SM-SEMP planning process. Two of these efforts are highlighted below.

2.1 Building Resiliency

In 2014, DHHL and select homestead residents were invited to a day-long workshop to develop post-disaster reconstruction guidelines and protocols sponsored by the Maui County Planning Department. The multiyear project resulted in nearly seventy recommendations, some of which were tailored from input received from DHHL homesteaders. For Molokaʻi, repair and reconstruction of homes are the community's highest priority, even with houses that are damaged by more than 50% of their replacement value. If Molokaʻi's residents have habitable accommodations it is less likely they would need to leave the island. Thus, a strong preference was expressed to focus limited resources and personnel on repairing and reconstructing habitable structures rather than constructing pools, carports, and other non-essential structures.

In 2015, DHHL sponsored a coastal resilience workshop for DHHL communities wherein the DHHL gathered input from the homestead communities of Kapaʻakea and Kamiloloa-One Aliʻi. In support of the project, the University of Hawaiʻi Department of Urban and Regional Planning prepared a coastal disaster resilience guidance manual. In coordination with community members, they identified areas and assigned levels of risk confronting the homestead communities from a wide range of coastal hazards. Among those hazards, the severity of the shoreline erosion was discussed and the need for further study and action identified.

2.2 The SM-SEMP Planning Process

The SM-SEMP team built upon recent planning efforts intended to build resiliency on Molokaʻi. Through desktop research the team gathered, reviewed, and documented existing relevant research and data. The team also gathered a wide variety of input from the community and stakeholders through multiple outreach techniques including agency meetings, community orientation meetings, stakeholder interviews, a focus group meeting, and a community workshop. The DHHL compared, analyzed, and synthesized the data from each outreach technique to capture a wide array of input and to assess the validity of the results.

In the plan preparation phase, the SM-SEMP team used the data collected through the desktop research, field survey, and outreach phases as a foundation to prepare the Preliminary and Final Draft SM-SEMP. The SM-SEMP planning process is depicted in Figure 2.1. The following subsections provide a more detailed description of the planning process.

2.2.1 Phase 1 - Desktop Research

The SM-SEMP Team started the project by conducting desktop research of publications, maps, and studies of Molokai's south shore. The team reviewed studies and articles about the project area's offshore coral reefs, sediment transport patterns, drainage, wind and currents, flooding, terrestrial environment, land use, and socioeconomic conditions. The team gave attention to studies of the areas between Kalamaʻula and One Aliʻi Park. The team undertook an analysis of coastal hazards and risk exposure using digital maps and resources as part of the desktop research. Team members also conferred with academics and researchers at the University of Hawaiʻi who have studied Molokai's south shore to gain feedback, test ideas, frame remedies, and narrow discussion.

2.2.2 Phase 2 - Field Surveys

The SM-SEMP team obtained observations of shoreline conditions during site visits held in February, October and November 2019. The February site visit was three consecutive days and involved traversing the project area's shoreline. The route was selected based on findings from the desktop assessment and by reviewing various sources of aerial imagery. Most areas were observed during low tide to maximize information capture about shore conditions. The site visits included a visual observation and assessment of the following shoreline features:

- Physical coastal processes;
- Shoreline access points;
- Drainage ditches and swales;
- Wetlands and stream mouths;
- Erosion hotspots;
- Flood prone areas;
- Proximity of buildings and accessory structures to the ocean both in terms of horizontal distance and elevation above the shoreline;
- Shoreline armoring;
- Parks and publicly used open space;
- Land, resources, physical infrastructure, and structures impacted by erosion; and
- Natural and man-made improvements to address erosion.

The February site visit began at the causeway to the Kaunakakai Wharf and extended to One Aliʻi Park. It was separated into a number of discrete segments that could be covered on foot. A few locations were not accessible, including the outer walls of fishponds and undeveloped wetland areas. Special site visits to the 22-acre Koheo Wetland adjacent to Kapaʻakea and the Kalokoʻeli and Aliʻi Fishponds were led by local experts familiar with these unique areas and their history.

Several oceanfront property owners hosted opportunities to see shoreline change firsthand and provided valuable background data and photographs of past flooding, shore conditions, shore reference features, and shoreline change. Site observations were supplemented with aerial and DHHL-authorized drone images, archival maps, and photographs.

The SM-SEMP team used the October and November 2019 site visits to ground truth observations made in February, revisit and reaffirm empirical findings at specific locations, such as taking measurements at erosion hot spots, and gather information and conduct interviews in the Kalamaʻula ahupuaʻa.

Photo: *Measuring shoreline change.*

2.2.3 Phase 3 - Stakeholder Outreach

The SM-SEMP team met with agency regulators and experts in the coastal management field to discuss DHHL land use and coastal issues. Discussions shed light on the difficulties of obtaining financing for home improvements for sites within flood hazard zones, emergency response and evacuation, fishpond creation and restoration, invasive species control, regulatory permitting and bifurcated jurisdictions, misconceptions about building permit processes, and a variety of other challenges that DHHL and beneficiaries may face in creating more resilient communities and shorelines.

‘A‘ohe hana nui ke alu ‘ia.
No task is too big when done together by all.
- Pukui, ‘Olelo No‘eau #142

DHHL staff provided updates to the community during regular Hawaiian Homes Commission meetings. In January/February 2019 the SM-SEMP team interviewed key stakeholders, conducted a resident survey, and hosted an orientation meeting on Moloka‘i to gather insight and perspective from residents, leaders, and stakeholders in the DHHL community. During the orientation meeting the SM-SEMP team presented the initial findings of the desktop research through PowerPoint presentations, handouts, and large format maps. Participants shared their knowledge of place by identifying erosion and flood prone areas and describing problematic locations on maps of the south shore. Discussion ensued about the project during an interactive question and answer period and in small groups and one-to-one discussion.

The SM-SEMP team distributed a survey at the meeting to help quantify issues that residents face in each homestead subdivision. The survey responses highlighted erosion-related concerns, themes, and problem areas and helped direct the SM-SEMP team to erosion hot spots and areas of concern.

Personal interviews were held with more than a dozen individual residents, families, and stakeholders that reside along the shoreline or had specific involvement in shoreline issues such as caretaking, stewardship, fishpond, or wetland restoration. The interviews followed the survey in format but were sufficiently open ended to allow for broad discussion and fluidity in conversation. The SM-SEMP team was privileged to meet a variety of knowledgeable people and kūpuna who were willing to share their ideas, generate remedies, and share their mana‘o in keeping with sound stewardship of the ‘āina. Appendix A provides a list of interviewees.

2.2.4 Phase 4 - Stakeholder Vetting of Draft Recommendations

Using the data collected through the first three phases, the vetting phase included DHHL preparation of draft recommendations for review by a diverse group of stakeholders. The DHHL hosted focus group meetings with stakeholders and will hold a community open house to gather input on the draft recommendations and to discuss and resolve outstanding issues through this and/or subsequent planning processes.

2.2.5 Phase 5 - Prepare the Draft and Final SM-SEMP

Using the input collected during the previous phases, DHHL will prepare the Draft SM-SEMP for review and final approval by the Hawaiian Homes Commission.

Photos: *Community stakeholders identify erosion-related problems, details, and concerns through facilitated group discussion.*

PHASE 1 Desktop Research	PHASE 2 Field Surveys	PHASE 3 Stakeholder Outreach	PHASE 4 Stakeholder Vetting of Draft Recommendations	PHASE 5 Prepare the Draft and Final SM-SEMP
Document the project area's moʻolelo, history, terrestrial environment, physical coastal processes, and erosion hotspots within the context of the project area's ahupuaʻa.	Conduct field observations of shoreline conditions to gather valuable background data and photographs of past flooding, shore conditions, shore reference features, and shoreline change.	Work with Hawaiian Homestead beneficiaries, lineal descendants, government, and community stakeholders to identify shoreline erosion threats and appropriate management responses.	Prepare conceptual draft recommendations for vetting by a diverse group of Hawaiian Homesteaders and other stakeholders.	Prepare the Draft and Final SM-SEMP using information generated through the first four phases.

Figure 2.1: *SM-SEMP Planning Process.*

CHAPTER 3: PLACE AND CONTEXT

The island of Molokaʻi is elongated with its highest point being Kamakou, a high volcanic peak that rises 4,961 feet in the east. The island's central and eastern terrain forms steep mountain slopes with deeply eroded gulches and valleys, especially on the wetter east side of the island. The West End of Molokaʻi has much lower tablelands and is barren owing to its arid state. Its people have long recognized the important connection between the land and the sea.

The poetic name Molokai Nui a Hina and its legendary origin establishes kuleana (duty, responsibility, privilege) to care for the island's resources (Halealoha Consulting, 2021, 5):

> … the island of Molokaʻi, like a child, is small and fragile – unlike a large continent. The resources of an island are finite, and these finite resources need to be nurtured by the island's "family" if the people are to grow strong, healthy and prosper. Many of the families of Molokaʻi trace their roots on the island back to antiquity, making the island an integral part of their ancestral family. Molokaʻi's modern-day stewards have a special responsibility to care for the island as they would care for a member of their own family – a responsibility bequeathed to them by Hina, birth mother of this island (Molokaʻi Community Service Council, 2020).

Traditional poetic names of the island include *Molokai ʻāina momona* (fat, fertile lands of Molokai), which refers to verdant lands that produce an abundance of food from loʻi kalo (taro patches), loko iʻa (fishponds), kai (near-shore) and moana (deep-sea) fishing grounds. Another name, *Molokai nō ka heke* (Molokai is greatest, foremost) refers to the celebrated athletes of the Makahiki competitions held at Naʻiwa and Kainalu. One of the most famous is *Molokai pule oʻo* (Molokaʻi of powerful prayer), a reference to the powerful kahuna trained at Puʻu Anoano and ʻIliʻiliʻopae Heiau, in particular the ones who practiced ʻanāʻanā (black magic, evil sorcery). The other well-known name is *Molokai nui a Hina* (Great Molokai, Child of Hina) (Halealoha Consulting, 2021, 5).

3.1 Ancient Molokaʻi Land Divisions

Ancient Hawaiians subdivided the mokupuni (island) of Molokaʻi into subareas to enhance the stewardship of the island's resources (Figure 3.2). The initial land divisions were the Koʻolau (windward) and the Kona (leeward) districts, or moku-o-loko (Summers, 1971). In 1859 the Kona and Koʻolau districts were dropped, and the island was made into just one district, called Molokaʻi district. In 1909, the present division into Molokaʻi and Kalawao districts was made (ibid.).

Each of Molokaʻi's moku is further divided into ahupuaʻa which incorporate watersheds or sub-basins (Figure 3.1). Of these, five have a direct influence on DHHL properties within the SM-SEMP study area including Kalamaʻula, Kaunakakai, Kapaʻakea, Kamiloloa, and Makakupaʻia (Figure 3.3). Each of these ahupuaʻa is briefly described below. Please see Appendix B for more detailed insights into the origins of Molokaʻi, its place names, and its ancient land divisions.

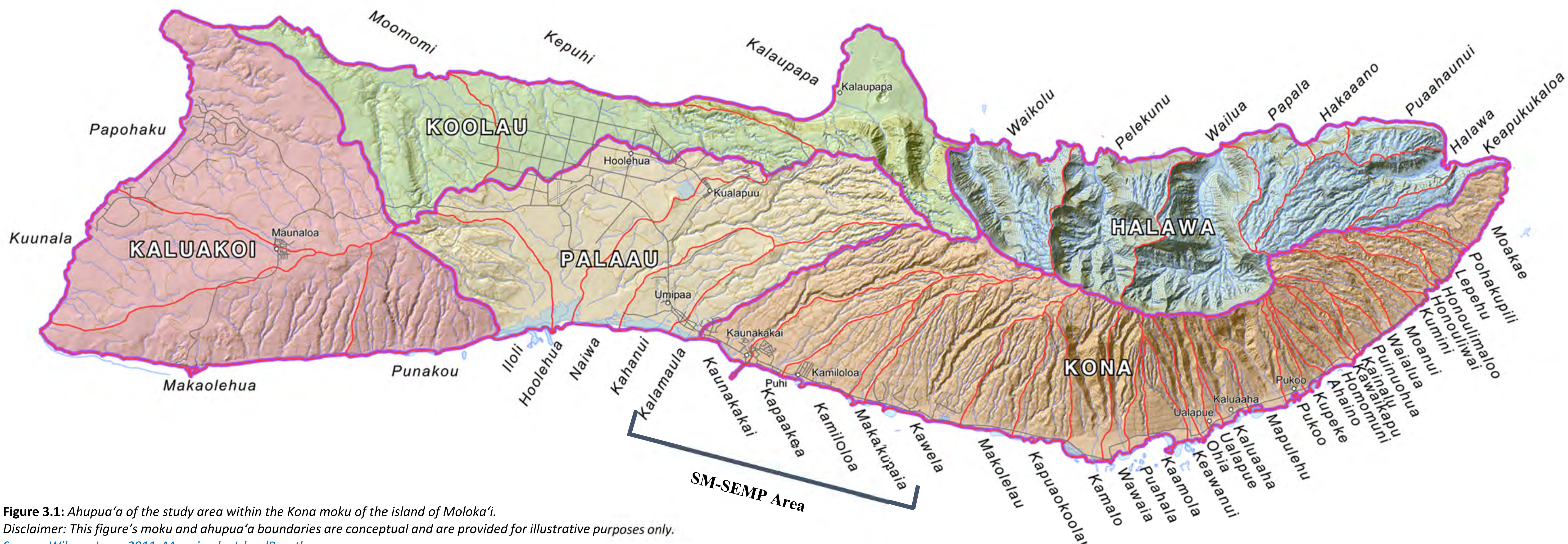


Figure 3.1: *Ahupuaʻa of the study area within the Kona moku of the island of Molokaʻi.*
Disclaimer: This figure's moku and ahupuaʻa boundaries are conceptual and are provided for illustrative purposes only.
Source: Wilson, Juan. 2011. Mapping by IslandBreath.org.

3.1.1 Kalamaʻula Ahupuaʻa

Kalamaʻula translates to mean "the red torch or red lama tree." The Kalamaʻula ahupuaʻa is located west of Kaunakakai (Pukui, 1974, 74). The ahupuaʻa rises gradually from sea level upland to Puʻu Luahine before ascending to 1,800 feet above sea level (ADS 2013, 21). Kalamaʻula is one of three watershed areas in the Pālāʻau region comprising 5,838 acres with no perennial streams (CRAMP, 2008). Known water names include ʻOloʻolo (pool/spring), Waianui (spring) and Makehe Stream (Halealoha Consulting 2021, 10).

In 1925 Kalamaʻula became the first Hawaiian Homestead community in the Hawaiian islands. Today Kalamaʻula has a "growing homestead residential community in the coastal lowlands and kula (upland) region, wetlands in the southwestern corridor, pastoral use, Kapuāiwa Grove, Church Row, and Kūlana ʻŌiwi Multi-Service Center (Kūlana ʻŌiwi), which houses the offices of DHHL, Office of Hawaiian Affairs, Queen Liliʻuokalani Children's Center, Kamehameha Schools, Alu Like and Na Puuwai. The area acts as a rural transition between industrial and agricultural uses to the northwest, and the more urban uses of Kaunakakai, Molokaʻi's country town, to the east" (ADS 2013, 21).

Catherine Summers identifies the special places in Kalamaʻula including ponds, a fishpond, heiau, a pool, kahua maika (stone rolling fields), petroglyphs, a spring, and house sites (Halealoha Consulting 2021, 6). Some of Kalamaʻula's special places include:

1. Kahua Maika near Puʻu Luahine. (The only one of old left in all the islands.)
2. Childhood home of Keōpūolani, sacred wife of Kamehameha the Great.
3. "Kapuāiwa," coconut grove planted by Kamehameha V.
4. Kamaloko Fishpond, with all kinds of fish. *(awa, āholehole,* large *ʻoʻopu,* and *ʻalamihi* crab)
5. Kahokai/Kakokahi Fishpond: "mess up the work." (now filled)
6. ʻŌhiʻapilo Fishpond: "smelly *ʻōhiʻa* tree." (now filled)
7. ʻUmipaʻa Fishpond: "stifle firmly." (now a dry land section)

The area was also known for its food cultivation on land and the abundance of fish and other ocean foods gathered in the nearshore area. The entire shoreline was called Hīlīa, "an off-shore area extending eastward from Pakanaka Pond through Kalamaʻula, it is now covered with mud, but formerly the shores had sandy beaches. Fish were very numerous here especially small mullet which often came in great schools near the shore. At times they were so numerous that 'This little fish darkened all of the beaches" (Tomonari-Tuggle, 1983 and Tomonari-Tuggle, 1990).

The ʻōlelo noʻeau for this shoreline area is:

Ka iʻa kā wawae o Hīlīa
The fish of Hīlīa, kicked by the feet (Summers, 1971).

There was extensive cultivation of ʻuala (sweet potato) in the kula (upland) areas (Halealoha Consulting 2021, 7).

3.1.2 Kaunakakai Ahupuaʻa

"The old name for Kaunakakai was Kaunakahakai, "Resting-(on) -the beach." It was the place for the canoes to come, for here there were plenty of fish (Pukui, personal communication)." (Summers, 1971)

The Kaunakakai ahupuaʻa gradually rises from sea level to approximately 1,300 feet where it enters the Molokaʻi Forest Reserve before terminating at Kahanui Apana 3. The ahupuaʻa is bound by the Koheo Wetland and Puʻu Maninikolo to the east and the western extent of the Kalanianaole Colony to the west. The makai portion of the ahupuaʻa is nearly 6,400 feet wide, but the ahupuaʻa gradually narrows before reaching its uppermost elevation. The Kaunakakai Stream transects the ahupuaʻa and flows continuously. The upper portions of the ahupuaʻa are mostly forested while the dry uplands and lowlands mauka of the coastal plain are mostly comprised of shrubland or bare earth. The small country town of Kaunakakai lies at the foot of the ahupuaʻa and serves as Molokaʻi's commercial, educational, and government center.

West of the approach to the Kaunakakai Wharf is a platform that was part of Kamehameha V's home, "'Malama'... The beach in front of this site was used exclusively by the *aliʻi* for sun bathing" (Halealoha Consulting 2021, 15). The coastal flats along Kaunakakai's shoreline were rich in salt pans. It is said that the salt pans were made "something like a taro patch" and the salt was "not too sour..." (Summers, 1971).

3.1.3 Kapaʻakea Ahupuaʻa

The literal meaning of Kapaʻakea is "the coral or limestone surface" (Pukui, 1974, 86). The Kapaʻakea ahupuaʻa is pie shaped and ascends gradually from the seashore to the South Fork of Kaunakakai Gulch where it becomes very steep. The ahupuaʻa is bound on the west by Koheo Wetland and Puʻu Maninikolo, and bordered on the east by Molokai Shores and Kamiloloa Heights. Along its makai side the ahupuaʻa is roughly 3,000 feet wide and extends from Kamiloloa in the east to Koheo Wetland in the west. There are no perennial streams in the ahupuaʻa. Two intermittent streams run during heavy rains and were diverted around the west and east boundaries of the Kapaʻakea Cemetery. The first stream is named Kamiloloa, and the name of the second stream is unknown (Halealoha Consulting 2021, 18). The upper portion of the ahupuaʻa is mostly forested while the dry uplands and lowlands mauka of the coastal plain are mostly comprised of shrubland or bare earth. The ahupuaʻa includes the homestead community of Kapaʻakea.

The Kapaʻakea ahupuaʻa is also adjacent to the Kōheo Wetlands, Ka Laʻi o Ke Kioea Bird Sanctuary, which is a 10-acre coastal salt marsh (Halealoha Consulting 2021, 18). *Ka laʻi o kioea*, "The tranquil spot of the kioea" was the name of a place where the homesteads are now located in Kapaʻakea. "Here there were numerous plover and curlews. The curlews are said to have called to the canoes to go out to sea to fish. Hence the saying, 'Molokai i ke kioea hoʻolale ka waʻa (Molokai where the kioea urge on the canoes)'" (Halealoha Consulting 2021, 18).

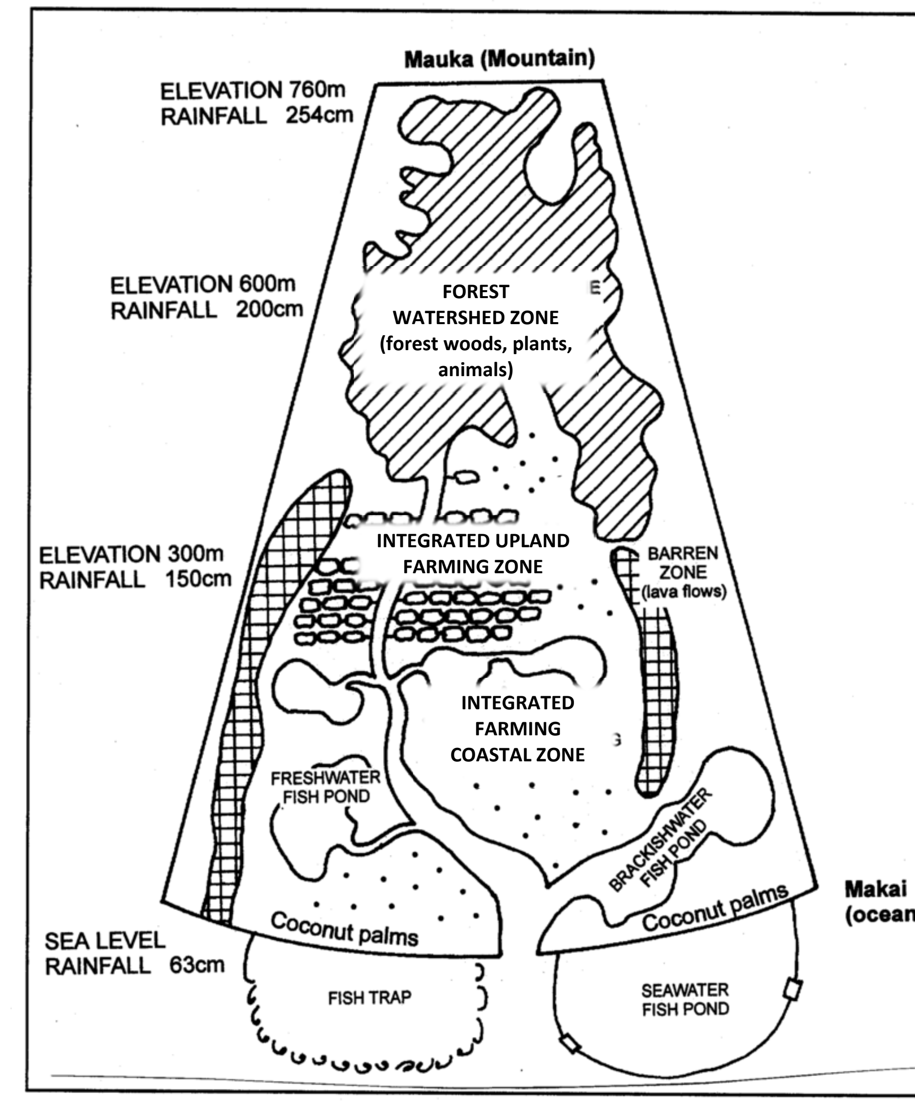


Figure 3.2: The Ahupuaa System of Ancient Hawaiʻi (Source: adapted from Costa-Pierce 1987, Pg. 324).

In ancient Hawaiʻi land was divided into units called ahupuaʻa. Ahupuaʻa boundaries typically spanned the valley between two ridgelines and extended from the uplands to the sea. Ahupuaʻa often included a variety of resources, available within different ecological zones, to sustain human life. As shown in Figure 3.2, the mauka forested areas provide a variety of plants and animals for food, clothing, medicinal, and cultural purposes. In the mid-to-lower elevations streamwater is diverted to support farming and aquaculture. Coconut trees and other coastal plants and animals provide an additional source of food for the community. Coastal fishponds and coral reefs provide important resources from the sea. In ancient days the Kanaka Maoli carefully managed their ahupuaʻa and gave special consideration to the relationship of mauka and makai resources when making resource management decisions.

3.1.4 Kamiloloa Ahupuaʻa

Two adjoining land sections comprise the Kamiloloa ahupuaʻa. The section to the west is referred to as “Government” while the section to the east is known as “Konohiki.” Kamiloloa literally means “the tall milo tree” (Pukui, 1974, 82)

The ahupuaʻa is pie shaped and rises gently from the seashore to about the 1,000 foot elevation before it gradually becomes steeper and is hemmed in by the Makakupaʻia ahupuaʻa to the east and the Kapaʻakea ahupuaʻa to the west. The ahupuaʻa includes the community of Kamiloloa in the west and the community of One Aliʻi and the Aliʻi fishpond in the east. The intermittent Kamiloloa stream runs through the ahupuaʻa. The dry uplands and lowlands mauka of the coastal plain are mostly comprised of shrubland or bare earth.

The Kamiloloa ahupuaʻa is also the home of Kalokoʻeli Pond which is known as “The dug up pond,” it was a loko kuapa having an area of 27.6 acres in 1901 (Summers 1971, 88). Another well-known historic site is Ka Lua Na Moku ʻIliahi, which is known as “The pit of the sandalwood ships.” Located in the Molokaʻi Forest Reserve, it is a roughly 110-foot-long trench in the ground that is shaped like the hull of a ship. Following the development of the commercial sandalwood trade it was built at the direction of the chiefs to measure how much ʻiliahi would fit in the hull of a ship. Commoners would gather the ʻiliahi from the forests and carry it down to the pit where it would be stored until it could be sold to passing trading ships.

3.1.5 Makakupaʻia Ahupuaʻa

The roughly 2,000 foot wide by 14,000 foot long Makakupaʻia ahupuaʻa rises gradually from the Aliʻi Fishpond to roughly 1,000 feet before it becomes much steeper as it meets, and is enveloped at its upper reaches by, the Kawela ahupuaʻa to the east and the Kaunakakai ahupuaʻa to the west. Two adjoining land sections comprise the Makakupaʻia ahupuaʻa. The land section to the west was referred to as “Government” while the land section to the east was referred to as “Konohiki.”

Makakupaʻia is the home of the roughly 26-acre Aliʻi Pond. The wall of this *loko kuapa* is 2,710 feet long, about 4 feet wide, and 4.5 feet high. There was one *mākāhā*. In 1957 the pond was filling with mud and about 4 acres along the eastern wall and inshore line were covered with mangrove. The *makaha* was broken… (Summers 1971, 90).

There is one intermittent stream that appears to be named Onini and a second stream that does not have a name. No spring names were found to be associated with Aliʻi Pond or Kaoaini/Kaonini Pond (Halealoha Consulting 2021, 23).

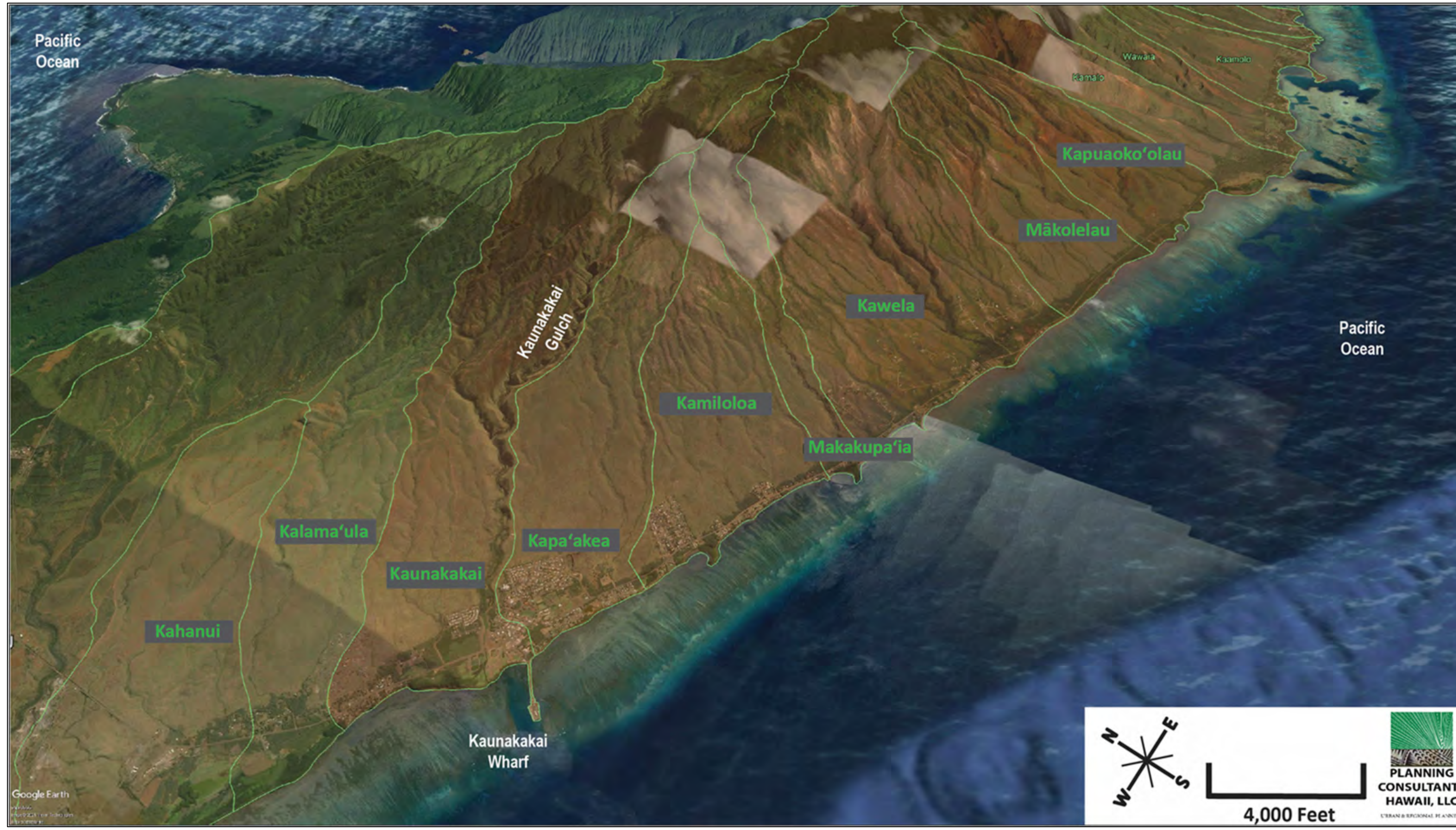


Figure 3.3: *The South Molokaʻi shoreline in the context of the area’s ahupuaʻa.*
Disclaimer: This figure’s moku and ahupuaʻa boundaries are conceptual and are provided for illustrative purposes only

In the water off Kamiloloa was a sea fishery known for the heʻe (Monsarrat, n.d.e:183)
“Formerly the heʻe found here were the iʻa kapu of Bernice P. Bishop. The time for catching them was from November to March 1…”
(Summers 1971, 88).

3.2 HUMAN-INDUCED CHANGE, PRE-CONTACT TO THE PRESENT

3.2.1 Pre-contact (600 A.D – 1777)

The first polynesian settlement on Moloka'i occurred on the east coast of the island in the area of Halawa in roughly 600 A.D (Roberts, Lucile M and Field, Michael E. 2008, 123). In the ensuing years, settlement spread west along Molokai's southeastern coastline and into the adjacent valleys. Southeastern Moloka'i offered settlers deep valleys with an abundance of fresh water, low-lying coastal plains with fertile, arable soil, and an an expansive reef rich in marine life (ibid, 123).

Subsistence farming activity was the primary land use and it was characterized by the clearing and tilling of the land for sweet potatoes, taro, coconuts, bananas, and other "canoe crops" the early settlers brought to Hawai'i from Polynesia. Settlements were small (a single or a few *hale*) and generally spread out along the coast and in the valleys. Between 600 A.D and roughly 1,000 A.D. human settlement had minimal impact on terrestrial and coastal processes.

Commencing around 1,000 A.D., Molokai's early Hawaiian settlers began building fishponds on the reef flats to capture and raise fish for consumption. By the early 15th century, they had constructed over 50 stone-walled fishponds (ibid, 123-124) stretching along the south coast between Kumimi to Kaunakakai and beyond (Chris Hart & Partners 1993, F-2). Figure 3.4 illustrates a portion of Molokai's Southeastern coast with and without fishponds.

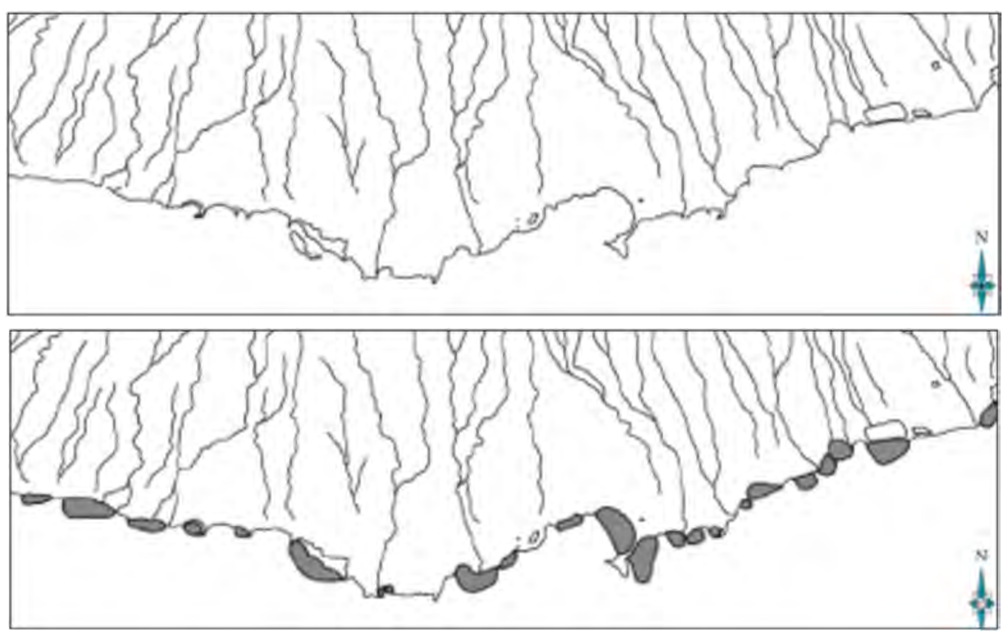


Figure 3.4: *Portion of Southeastern coast of Moloka'i with and without fishponds.* (Roberts, Lucile M., 4)

The fishponds altered the natural flow of southeastern Molokai's ocean waves, currents, and nearshore sediment. The fishponds also disrupted the natural pathway for the movement of stormwater and sediment from mauka areas to the coast. Sediment washed downslope during heavy rains would be deposited in the fishponds or settle in the nearshore waters between the fishponds (Roberts, Lucile M and Field, Michael E. 2008, 124). These alterations had a significant impact on coastal geomorphology, water quality, and the physical form of the coastline.

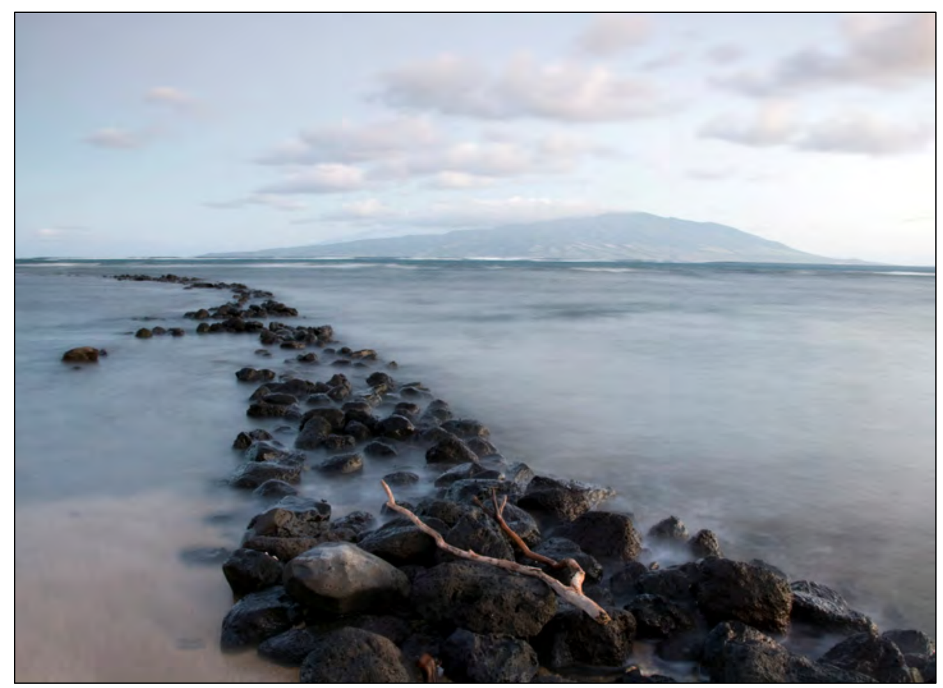
As the population continued to grow during this period, the terrestrial environment also saw significant change as settlers constructed extensive 'auwai (irrigation ditches), taro lo'i (ponded terraces) and habitat sites to sustain the growing population. Mauka of the fishponds along the lower kula slopes a more extensive system of stone terraces were constructed to support the cultivation of 'uala (sweet potato), wauke (paper mulberry) plants, and other crops (Native Register 1848: vol.7). These human interventions began to alter the natural flow of stream water from the mauka reaches of southeastern Moloka'i's watersheds to the shoreline and marine environment.

3.2.2 1778 – 1879

Captain James Cook, the first westerner to view Moloka'i, described the island as follows: "Morotoi is only two leagues and a half from Mowee to the West North West. The Southwestern coast, which was the only part near which we approached, is very low; but the land rises backward to considerable height; and, at the distance from which we saw it, appeared to be entirely without wood. Its produce, we were told, consists chiefly of yams. It may, probably, have fresh water, and, on the South and West sides, the coast forms several bays, that promise good shelter from the trade winds" (King 1784, 114).

The arrival of western explorers, merchants, whalers, and missionaries forever changed the natural, physical, and social landscape of the Hawaiian Islands.

One of the most devastating impacts to Molokai's natural environment brought by western contact was the introduction of sheep, deer, goats, and cattle. These grazing animals were welcomed by the native Hawaiian community as an excellent source of food. However, the newly introduced hooved animals, along with the pigs brought to Hawai'i by early Polynesian settlers, thrived in Molokai's temperate climate. They soon became feral and migrated deep into Moloka'i's valleys, and ascended its mountains, where they burrowed for edible roots and foraged on native grasses, shrubs, and small trees.



Photos (Left to Right): *Fishpond of East Moloka'i (Velvateen Waters, Flicker.com);* Kapuāiwa Coconut Grove planted in the 1860s by Kamehameha V (Photo taken on May 24, 2016, Flicker.com).

By the middle of the 19th century, south-central Molokai's hillsides were largely denuded of vegetation by the rapidly growing population of feral ungulates and the commercial harvesting of sandalwood. With the loss of vegetation to hold the soil, heavy rains began to transport increasing amounts of soil onto southeastern Molokai's coastal plain and reef flats.

Soil loss likely accelerated in the mid-1800s when cattle ranching intensified and plantation monoculture was introduced (Roberts, Lucile M and Field, Michael E. 2008, 125). The clearing necessary for sugar and pineapple cultivation heightened the susceptibility of the soils to erosion in the lower coastal areas resulting in the deposit of greater loads of sediment into the marine environment (ibid., 126).

Molokai's rainfall patterns also changed because of the extensive damage to its forests and the denuding of its hillsides of vegetation. The loss of much of Molokai's plant life reduced the amount of atmospheric moisure through evapotranspiration resulting is less rainfall. With less rainfall many perennial streams became intermittent.

3.2.3 1880 - 1920

In the 1880s the coastline between Kalamaʻula and the Aliʻi Fishpond was characterized by mudflats, sandy beach, wetlands, salt pans, and a limited number of structures and habitation sites (Figures 3.5 and 3.6). Jackson's 1882 survey of Kaunakakai Harbor (Figure 3.5) was prepared prior to the construction of the Kaunakakai Wharf. The Jackson survey documents a wide sandy beach and mud and sand flats that are partially dry at low water. Lands just west of the "village" of Kaunakakai are described as low level "sterile land" that is swampy in rainy weather. Lands just to the east are described as "grasslands".

Makai of the small village of Kaunakakai there was a long, sandy beach fronting a natural break in the reef. It is here that Malama, the royal residence of King Kamehameha V, was situated. The house was described by a guest in 1870: "It is a grass hut, skillfully thatched, having a lānai all around...On the north west side of the house is a large grass house, and it seems to be the largest one seen to this time...There are four other fine, big houses, mostly thatched...The King's yard covers about three acres and is planted with trees, mostly coconuts, that are thriving nicely" (Holoholopinaau 187O:Ke Au 'Oko'a). By the time Jackson surveyed the Harbor in 1882 Malama had passed to Princess Ruth Keʻelikōlani, one of the last descendants of the Kamehameha dynasty (Fitzpatrick, Gary L and Moffat, Riley M 2004, 86).

The break in the reef fronting Malama served as a natural entry to the shoreline for the transport of goods to and from Molokaʻi. Prior to the construction of the wharf small boats would carry goods between the larger ships anchored offshore and the sandy beach. The 1882 Jackson Government Survey map illustrates a handful of structures along this beach to support shipping activities (Figure 3.5).

By 1886, the Hawaiian Government Survey prepared by M.D. Monsarrat shows a government road running east-to-west just mauka of the coastline (Figure 3.6). In 1889 a small stone-wharf was built fronting Malama, near the opening in the reef. Eight years later a more substantial wharf was constructed next to the old one (Figure 3.7) to serve the growth of plantation agriculture in Central Molokaʻi. The expansion of plantation agriculture is noted in the American Sugar Company's year 1900 survey of Kaunakakai and Vicinity (Figure 3.7) that documents the planting of sugar cane to the east and west of Kaunakakai.

Like the fishponds, the construction of the wharf altered the natural flow of ocean waves, currents, and nearshore sediment between Kalokoʻeli Fishpond and Kalamaʻula which changed the coastal geomorphology, water quality, and the physical form of the coastline in this area.

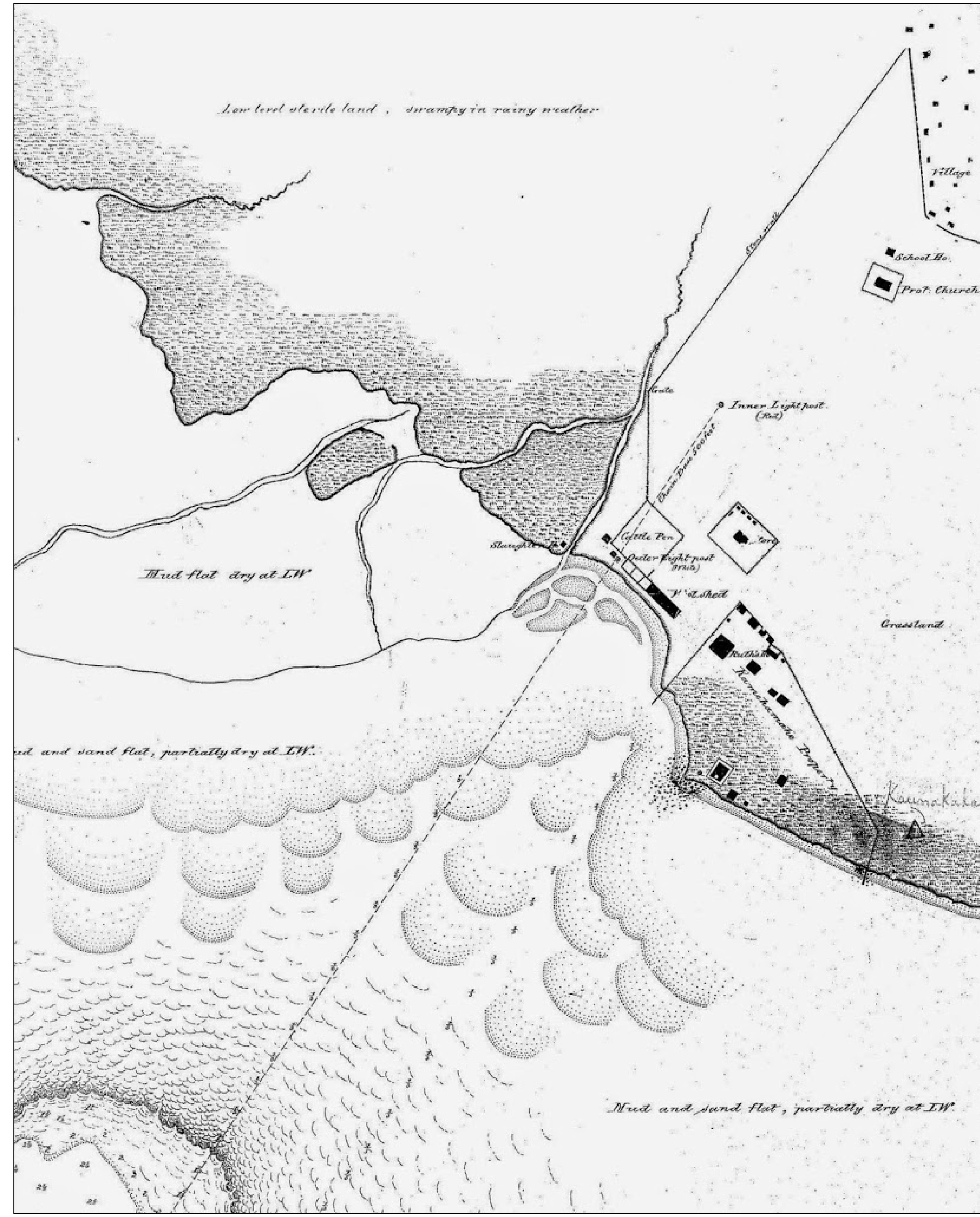


Figure 3.5: *Kaunakakai Harbor, Molokaʻi, by G. E. G. Jackson, 1882.*

A 1924 land court map identifies four large salt evaporation ponds on either side of Kaunakakai Stream that were developed by the residents of Kaunakakai in 1910 (Chris Hart & Partners 1993, F-11). In 1902 the American Sugar Company introduced mangroves to stabilize the coastal mudflats at Pālāʻau in south-central Molokaʻi and to hold back the soil washed down by heavy rains into the sea (Allen 1998, 62). Since its introduction the mangrove has migrated eastward taking over much of the coastline. In doing so, it has reduced the area of wetland habitat important for endemic waterbirds, and it has also encroached onto the reef flat, coastal beaches, and fishponds making many of these areas inaccessible. Despite these negative outcomes, mangrove has reduced the amount of sediment that is transported from the watershed to coastal waters and the reef. It has also reduced erosion caused by coastal wind and wave energy (Roberts, Lucile M and Field, Michael E. 2008, 134).

3.2.4 1921 – 1950

The development of the ranching, sugar, and pineapple industries brought new migrants to Molokaʻi, and as the population grew there was a demand for new businesses, services, infrastructure, and homes to support the growing population.

With its central location and proximity to the wharf, Kaunakakai grew quickly during the 1920s and 1930s to become Molokai's main business center. In 1935 Kaunakakai's growth was further stimulated when "all County buildings were permanently moved intact from ʻUalapuʻe to Kaunakakai where they are situated today" (Chris Hart & Partners 1993, F-5).

During the 1920s Kalamaʻula's population also grew after the United States Congress passed the Hawaiian Homes Commission Act in 1921. By 1922 seventy-nine Hawaiian Homesteading families moved to Kalama'ula, which contributed to the demand for commercial services in Kaunakakai and its subsequent population growth.

The physical growth of Kaunakakai is evident when comparing the 1900 survey that describes Kaunakakai as a "native village", and documents just a handful of structures (Figure 3.7), with aerial imagery of Kaunakakai taken in 1950 (Figure 3.8) that captures a town with several defined roadways serving a node of residential and commercial structures.

Figure 3.6: *Cropped survey of Molokaʻi's south-central coastline. Taken from: Hawaiian Government Survey, Molokai Middle & West Section, M.D. Monsarrat 1886.*

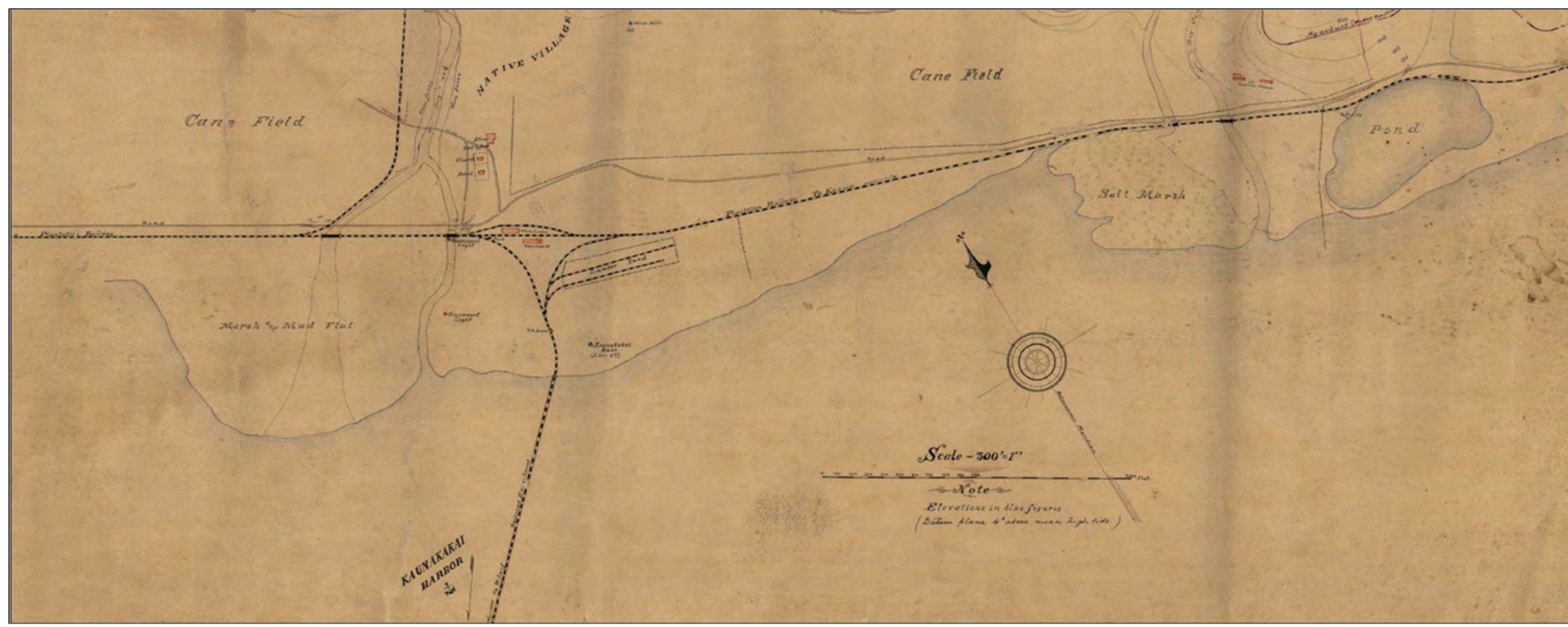


Figure 3.7: *Cropped survey of Kaunakakai and abutting shoreline. Taken from: Kaunakakai and Vicinity, American Sugar Co., Molokai Hawaiian Islands, May 1900.*

In 1934 the wharf at Kaunakakai was lengthened to nearly one-half mile and expanded and fortified so it could carry a two-lane road and handle additional shipping capacity. These improvements further disrupted the along-shore currents, waves, wind, and the transport of sediment between Kapaʻakea and Kalamaʻula.

By 1930, much of the island was devoted to plantation agriculture or to grazing. Both activities continued to alter the land of the Hoʻolehua Saddle and the coastal plain. As Handy (1931) noted, most fishponds by this time had been abandoned and were filled with mud (Roberts, Lucile M and Field, Michael E. 2008, 126).

In 1945, the Seaside Inn, precursor to the Pau Hana Inn, opened (Chris Hart & Partners 1993, F-13). Between 1945 and the 1980s additional visitor accomodation and commercial services would be developed along the coastline within the SM-SEMP area.

In response to episodic flooding, in 1950 the Army Corps of Engineers built a levy along both sides of Kaunakakai Stream to divert floodwater away from the town and towards the sea (ibid., F-14).

"My mother could walk from this lot [in Kalamaʻula} to the wharf [unimpeded]. All mangrove now".

Penny Martin, Kalamaʻula Shoreline Lessee (Multi-Generational)

As illustrated in Figure 3.8, by 1950 the mudflats between Kalamaʻula and Kaunakakai Stream had largely been overtaken by invasive mangrove. This photo also depicts the coastal marsh and wetlands of Kapaʻakea prior to the development of residential lots in the mid-1950s. As of 1950, the shoreline between the Kaunakakai Wharf and the community of Kamiloloa-One Aliʻi was still largely sandy beach, interrupted only by the Kalokoʻeli Fishpond.

Figure 3.8: *USGS, aerial imagery of Kaunakakai and adjacent coastline. February 27, 1950.*

3.2.5 1951 – Present

In the late 1940s much of the coastal plain between the Seaside Inn (Pau Hana Inn) and the eastern side of the Kalokoʻeli fishpond was undeveloped. Historically, much of this area was wetland and salt marsh fed by two gulches and the ocean where the Kapaʻakea Homestead now exists. Material from Kaunakakai's trash incinerator was allegedly placed as fill in the marsh (Nancy McPherson, personal communication January 31, 2019). After World War II the marsh was filled to make the land for the development of the Kapaʻakea subdivision in the early 1950s (ibid.). By 1964 the Kapaʻakea Homestead subdivision is largely developed as seen in Figure 3.9. Appendix D provides a more detailed history of these early subdivisions.

At one juncture, commercial interests attempted to fill portions of the 23-acre Koheo Wetland leading to citizen action that prevented development and resulted in the wetland's undeveloped status (Arleone Dibben personal communication, January 31, 2019).

The Hotel Molokaʻi was built in 1968 just east of the Kalokoʻeli Fishpond, and the Molokaʻi Shores was built in 1977 just west of the Kalokoʻeli Fishpond. These facilities were built to accomodate an increasing number of visitors to the island.

The growth of the resident and visitor population between Kalamaʻula and the Aliʻi Fishpond led to an increase in sewage discharge. The Kaunakakai wastewater reclamation facility was developed in 1969 to meet the needs of Kaunakakai residents. The facility's detention pond is visible in aerial imagery taken in 1977 (Figure 3.10). The facility pumps its treated wastewater into injection wells that are located just north of town. Many of the older houses in the area use cesspools to process their wastewater while newer residences use septic systems. Some of the larger commercial establishments and condominiums use private treatment systems to process their wastewater (Roberts, Lucile M and Field, Michael E. 2008, 127). "There is a potential—as yet undocumented—impact on the reef from the migration of sewage through ground-water seepage. Nutrients in the sewage may contribute to blooms of undesirable algae" (ibid., 127).

Figures 3.9 and 3.10 illustrate the increasing coastal development that occurred over the thirteen years from 1964 to 1977. As of 1977 sandy shoreline is still visible between the Kaunakakai Wharf and the beach fronting the Hotel Molokaʻi. However, the beach appears to have receded between the Hotel Molokaʻi and the Aliʻi Fishpond (Figure 3.10).

Figure 3.9 (Top): *Southcentral Molokaʻi, EKO - 2CC - 43, December 28, 1964.* **Figure 3.10 (Bottom):** *Southcentral Molokaʻi, USGS, January 6, 1977.*

Since 1977 there has been significant spread of invasive mangrove in both the Kalokoʻeli and Aliʻi Fishponds (Figures 3.11 and 3.12).

Aerial imagery taken in 2000 (Figure 3.11) and 2021 (Figure 3.12) also illustrate the significant loss of sandy shoreline that has occurred in the SM-SEMP area since the 1970s. In response, there has been a proliferation of shore armoring installed along oceanfront lots in Kapaʻakea but not much armoring has been erected in Kamiloloa-One Aliʻi. The armoring (seawalls, rocks, rubble mounds, etc.) has contributed to down drift erosion, creating a domino effect which leads to more armoring of the coastline as down drift landowners try to protect their property from the erosion caused by seawalls updrift of their property.

The various walls are indicative of attempts to retain land behind the wall rather than allowing the land to migrate to its natural state and grade. Oceanfront properties in Kamiloloa have fallen trees and short embankments along the seaward edge of their property that are indicative of shoreline retreat and coastal erosion. Most oceanfront residents consistently noted that their lot used to extend further seaward, and those seaward portions of their lot are now submerged regularly, not just during high tide events.

A root cause of the erosion is rising sea levels. According to coastal scientists, "over the next 30 to 70 years, homes and businesses located near the shoreline will be impacted by sea level rise" (Hawaiʻi Climate Change Mitigation and Adaptation Commission 2017, 115). According to the Hawaii Sea Level Rise Vulnerability and Adaptation Report, "Coastal portions of Hawaiian Home Lands, such as in Kalamaʻula…would be flooded with sea level rise displacing native Hawaiian families that live in this area. In addition, fishing and cultural practices taking place along the shore would be impacted as beaches erode. In a recent study of multiple coastal hazards, four of the six Hawaiian Home Lands on Molokaʻi, Kamiloloa-Makakupāʻia (assessed together due to proximate geography), Hoʻolehua-Pālāʻau, Kalamaʻula, and Kapaʻakea, are estimated to have the greatest potential for people to be displaced by tsunamis, waves, and sea level rise" (ibid. 129).

Figure 3.11 (Top): *Aerial Imagery, South Shore Molokaʻi, May 16, 2000.* **Figure 3.12 (Bottom)**: *Aerial Imagery, South Shore Molokaʻi, 2021 (Google Earth Image 2021 Maxar Technologies, Data SOEST/UHM)*

3.3 THE SOCIOCULTURAL ENVIRONMENT

Despite its modest size and population, Molokaʻi is often referred to as the "last Hawaiian Island" due to its abundance of cultural resources and continuation of cultural traditions. Roughly 63% of Molokai's population is either Native Hawaiian or part-Hawaiian or other pacific Islander, the largest proportion in the State of Hawaiʻi (DBEDT, 2011, Table 6). As Hawaiʻi's population continues to grow, Molokaʻi has been able to retain its close-knit communities and laid-back lifestyle. Many residents cherish their subsistence lifestyle and view access to fishing, hunting, and gathering sites to be of great importance as highlighted in a personal interview with DHHL homesteader Aunty Leilani Wallace:

> "Important to get food from ocean – our icebox is from One Aliʻi [beach park] down to Kalamaʻula. Not the beach. Crab, pua – ʻamaʻama [baby mullet], ʻōʻio [bonefish], āholehole [menpachi], and pāpio [jack]. Outside the reef – kala [unicorn fish], kole [surgeon fish], manini [tang], uhu [parrotfish], palani [eyestripe surgeonfish]..."

For Molokaʻi as a whole, "a reported 40% of the population rely on subsistence farming, hunting, and fishing" (Molokai Health Center, 2021).

Molokaʻi's population declined to 6,275 persons in 2019 (American Community Survey, 2019), from 7,404 persons in 2000 (2010 State of Hawaiʻi Data Book, Table 1.10) a 15% decline. In 2020 Molokaʻi had 2,229 households spread over 260.46 square miles (2020 State of Hawaiʻi Data Book, Tables 1.10 and 1.12). Of the total island population, there are approximately 1,821 people residing on DHHL lands (American Community Survey, 2019, Table DPO2). Kaunakakai is the most populous area of the island with a population of 3,038 (American Community Survey, 2019, Table S0101) and a median age of 44.1 (ibid.).

Over the past few decades, several of Molokaʻi's large businesses such as the Kaluakoi Resort, Del Monte, Dole, Pau Hana Inn, and the Lodge at Molokaʻi Ranch have closed, leaving many residents with few employment options. Many residents have taken multiple part time or seasonal jobs, often without benefits, to compensate. As of May 2021, Molokai's non- seasonally adjusted unemployment rate was 7.3% (DLIR 2021, 2). The median household income in East Molokai (census tract 317) was $41,705 (U.S. Census Bureau's American Community Survey 2015-2019, Table 2).

In 2019, the Kalamaʻula Homestead had an estimated population of 322 people (American Community Survey 2019, Table DPO2). Median household income was $61,875. There were more females (180) than males (142), and the median age was 35.6 (ibid.). Household size averaged 3.54 people, and roughly 88% of the neighborhood's residents were native Hawaiian or part Hawaiian (ibid.).

The Kapaʻakea Homestead had an estimated population of 166 people in 2019 (ibid.), roughly half as many people as the Kalamaʻula Homestead. Median household income in the Kapaʻakea subdivision was $32,813. Similar to Kalamaʻula, the Kapaʻakea homestead had more females (85) than males (81), but the median age was younger at 34.5 years old. Household size averaged 3.25 people, and nearly 98% of the Kapaʻakea's residents were native Hawaiian or part Hawaiian (ibid.).

The Kamiloloa-Makakupaʻia Homestead was the least populated of the three homestead areas having roughly 75 residents in 2019 (ibid.). Median household income was $32,500. Unlike Kalamaʻula and Kapaʻakea, the Kamiloloa-Makakupaʻia Homestead had more males (45) than females (30). The median age was 35.2 years old (ibid.). Household size averaged 2.68 people, and roughly 89% of the neighborhood's residents were native Hawaiian or part Hawaiian (ibid.). Please see Table 3.1 for select demographic data.

Table 3.1	SELECTED DEMOGRAPHIC ESTIMATES HAWAIIAN HOME LAND COMMUNITIES		
	Kalamaʻula	**Kapaʻakea**	**Kamiloloa-Makakupaʻia**
Population	322	166	75
Males	142	81	45
Females	180	85	30
Median Age	35.6	34.5	35.2
Hawaiian/Part Hawaiian	88.2%	97.60	89.3%
Housing Units	108	61	39
Households	91	51	28
Avg Household Size	3.54	3.25	2.68
Median Household Income	$61,875	$32,813	$32,500

Table 3.1. *Source:* *American Community Survey, 2019, ACS 5-Year Estimates Data Profiles. Table DP02.*

Photo: *Coastal structure Kamiloloa, Molokaʻi.*

3.4 The Terrestrial Environment

Scientists and native practitioners know there is a direct correlation between the health of the forest and the health of the reefs, beaches, and shores. Without a healthy forest to hold the soil and resist the erosive effects of heavy rain, large amounts of sediment and silt wash off steep mountain slopes and into the ocean, polluting streams, destroying coral reefs, and degrading coastal fishing resources (TNC, 2013).

Of the eight watersheds in central Molokaʻi, the Kamiloloa and Kapaʻakea watersheds drain 7,935 acres including the eastern portion of the study area from Kaunakakai Harbor to One Aliʻi. The western portion of the project area, including Kalamaʻula, is within the 5,931 acre Kaunakakai watershed (Jokiel 2006, 1). The latter watershed includes Kiowea Park and the freshwater springs and seeps of the neighboring Kapuāiwa Coconut Grove, revered for its cultural significance, beautiful coconut trees, and swiftly moving groundwater adjacent to the ocean.

3.4.1 Molokaʻi Forest Reserve

These watersheds extend upland to portions of the Molokaʻi Forest Reserve which ends at the Waikolu Valley Lookout at 3,550 feet. (Figures 3.13 and 3.14). The soils in the Molokaʻi Forest Reserve are varied. Of the 12 soil types present in this section, five are classified as highly erodible land and six are potentially highly erodible land (DLNR 2009, 9). The area receives over 32 inches of annual rainfall given its elevation (ibid.).

Within the forest reserve, the upper reaches of the Kamiloloa and Kaunakakai watersheds are considerably disturbed and degraded. However, there are strands of remaining montane forest with a tree canopy dominated by ʻōhiʻa and an understory of native trees, ferns, and grasses. (DLNR 2009, 20). Along the larger gulches within the upper headlands of the watersheds, native plants predominate in communities that are relatively intact, and are minimally disturbed but retain a component of non-native plants (more than 10%). Surrounding the headlands are areas that are severely degraded or highly altered from their natural state. On the lower western side of the reserve, the vegetation does not reflect a naturally evolved species composition, but rather a mixture of small remnant patches dominated by native plants, patches of largely invasive weedy alien plants, and areas of mixed native and non-native plants. For instance, there are some open ʻōhiʻa forest and native shrubland mixed with native-alien forest in the upper reaches of the forest reserve. Whereas alien forest, alien shrubs and grasses, and Lantana shrubland tend to dominate the lower portions of the reserve (DLNR 2009, 17-20).

Access to the upper headlands of the Kapaʻakea and Kamiloloa ahupuaʻa is provided by Maunahui Road, necessitating four-wheel drive. Within the reserve is critical habitat for plants and the Blackburn's Sphinx Moth (DLNR 2009, 22). Below these protected areas but well above and mauka of Kapuāiwa Grove and Kaunakakai Town is the Kalamaʻula Nature Resource Management and Subsistence Access Area owned by DHHL. The lower mauka portions of the watershed have been substantially altered by centuries of ungulate grazing; both domestic and feral, that has damaged native plants and fundamentally changed the hydrology of the ecosystem.

3.4.2 Dry Uplands and Lowlands Mauka of the Coastal Plain

Kamehameha V Highway runs parralell to the project area and provides a hardened boundary between the undeveloped mauka dry areas and the more developed makai areas of the coastal plain and the project area.

Prior to human settlement, leeward Molokai's dry lowland and mesic communities were likely comprised primarily of dry forests, woodlands, and shrublands. It is likely that native lowland grasslands were infrequent or even nonexistent, and lowland forests, woodlands, and shrublands were widespread, probably extending to the coast in many places (Cuddihy and Stone, 1990, 13).

With Polynesian settlement, many of the dry lowland forests were cleared for subsistance agriculture making way for the dry grass and shrublands that were characteristic of leeward lowlands at the time of western contact.

During the western contact period axis deer, horses, cattle, goats, pigs, and sheep were introduced to Molokaʻi. Many of the introduced ungulates were let loose to graze on the native shrubs and grasses throughout the watershed. Moreover, there was a kapu on the harvest or control of some species, such as axis deer. Over time, significant populations of feral ungulates overgrazed low and upland portions of the watershed leaving a rocky, barren landscape, denuded of vegetation and ripe for soil loss due to wind and rain.

The large population of feral ungulates are also particularly hard on an island's upland slopes because their hooves compress tropical soils, trampling shallow plant roots, making it more difficult for the soil to absorb and retain moisture. Compacted soils are prone to erosion during rainstorms, and they increase stormwater runoff.

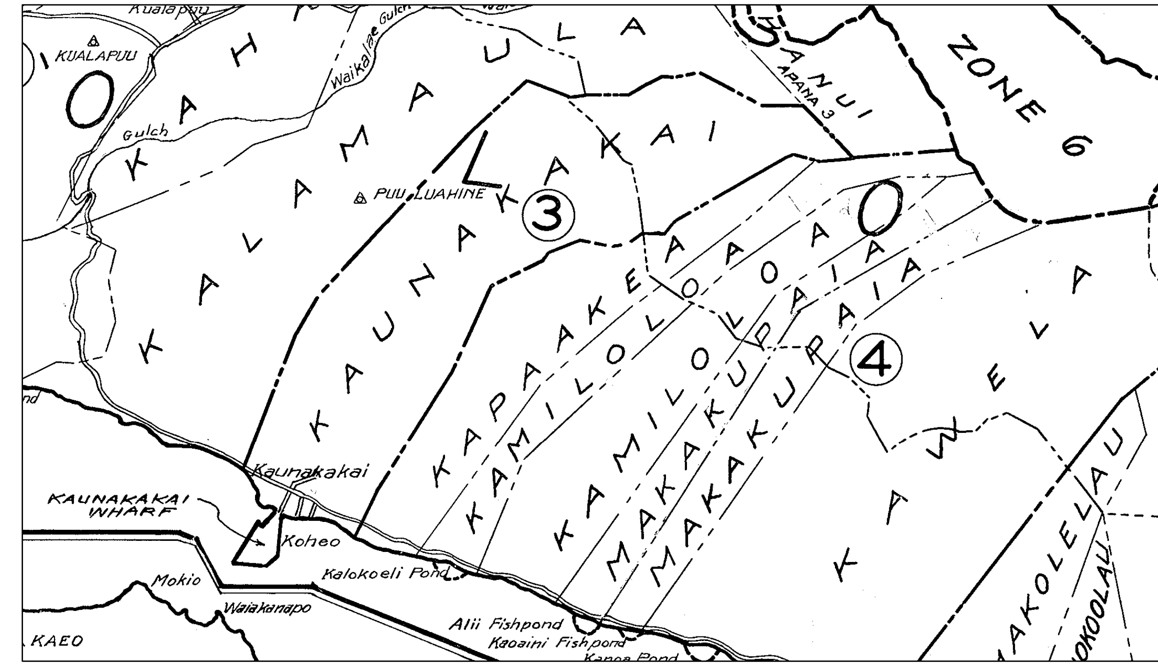


Figure 3.13: *Sections 3 and 4 of Zone 5 of the Island of Molokaʻi plat map (Maui County, M5000). Ref: https://www.mauicounty.gov/1193/Tax-Map-Zone*

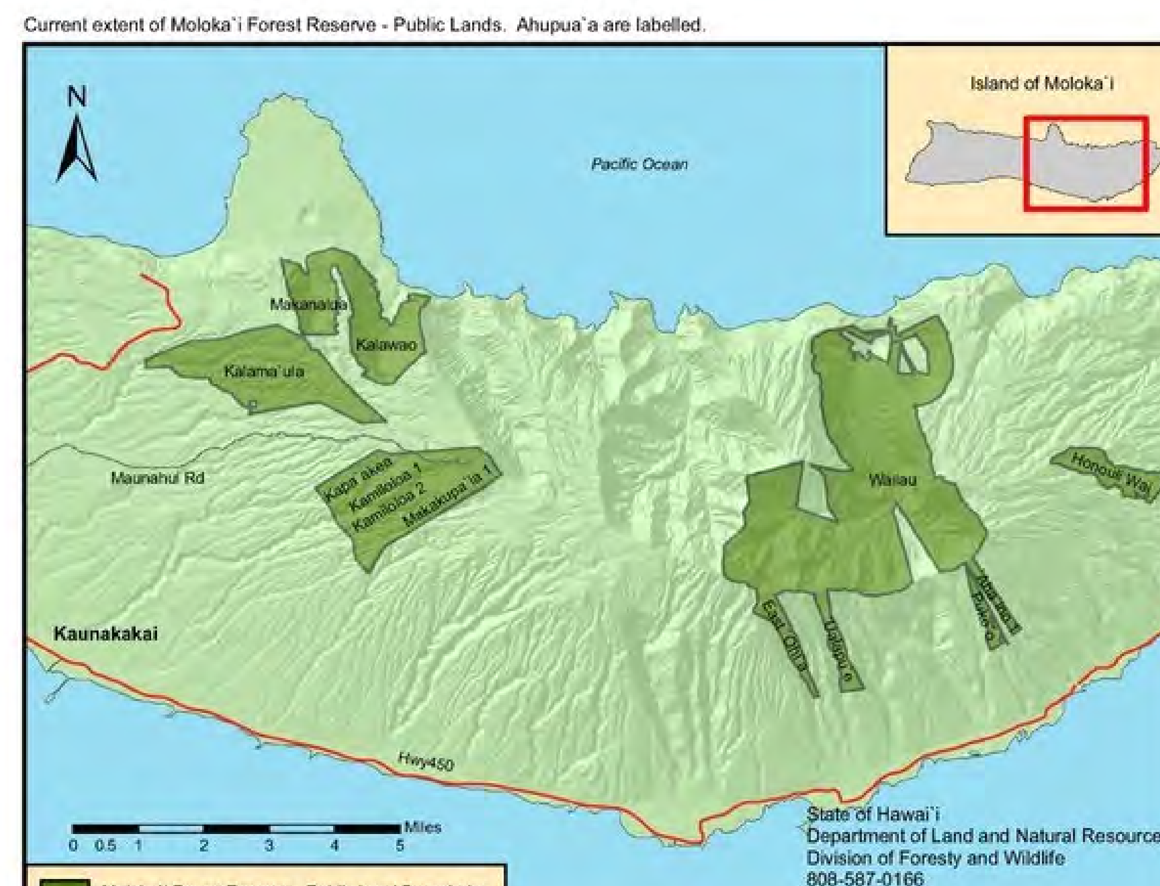


Figure 3.14: *The Molokaʻi Forest Reserve in the upper reaches of the watershed (DOFAW, 2020). Ref: https://dlnr.hawaii.gov/forestry/frs/reserves/maui-nui/molokai*

Western contact also brought deforestation and the loss of sandalwood trees through direct harvest. Land clearing for sugarcane production also destroyed much of the native vegetation. As a result of these human activities, endemic plants quickly declined and large areas of the low and upland portions of the Kamiloloa and Kaunakakai watersheds became barren.

Along with water diversions, these vegetative changes caused perennial streams that flowed nearly continuously to become ephemeral, flowing only occasionally or intermittently (Jokiel, 2006). These terrestrial changes further accelerated erosion of upland soils and the deposition of sediment into nearshore ocean waters during heavy rainstorms which caused the inner reef to become inundated with layers of silt and mud that smothered corals. This excessive input of sediment into nearshore areas also filled fishponds and harmed their productivity.

3.4.3 Lowlands within the Coastal Plain

Much of the lowlands between Kamehameha V Highway and the shoreline have been developed with housing and graded for associated roadways, drainage, and wastewater infrastructure. The natural ecosystem in this area has been heavily modified by human activity.

Historically, there was a salt marsh fed by two gulches and the ocean where DHHL's Kapaʻakea subdivision now exists. Based on an American Sugar Company map circa 1900's, a railway line to Kawela ran parallel to and just makai of the Kamehameha V Highway, abutting the salt marsh that became the Kapaʻakea Homestead lots.

In 1961, serious flooding caused substantial damage to the homes in Kapaʻakea, inundating them with two to three feet of standing water. To address chronic flooding at Kapaʻakea, drainage improvements were made between 2007 and 2011 including grading the edge of the roadway, installing fords at two locations on the loop road, and lining the drainage ditches with geotextile fabric mesh for erosion control. Additional flood mitigation improvements underwent an environmental assessment in 2016 but have yet to be permitted or constructed. These efforts address flooding, but not erosion or shifting of the shoreline's location, or sea level rise.

3.4.4 Coastline

The project area's coastline primarily consists of low-energy, shallow, nearshore waters along a sandy, silty, sediment-laden shoreline that is absent of cliffs, bluffs, or steep embankments. The coastline is interspersed with wetlands, mangrove forests, stream outlets, drainages, fishponds, and shoreline hardening structures that, along with the causeway to the Kaunakakai Wharf and Harbor, substantially influence the dynamics of the shoreline and the movement of sediment along the shore and within the inner reef zone.

Sediment along the shore comes from both upland sources and the reef offshore. Sand excreted by grazing herbaceous fish, shells from invertebrates, and coral fragments that break free of a main colony during storms contribute to the sediment supply and the formation of sandy beaches.

On many of the oceanfront properties along the Kamiloloa-One Aliʻi shoreline, the natural berm mauka of the shore, with its native vegetation and raised topography, has been lost or heavily altered. In many cases, the crest or slight rise between the shore and inland areas has been graded for property development. The alteration has resulted in lost capacity to absorb wave energy and runup and limit or prevent flooding. Dense thickets of kiawe trees also occurr along this shoreline altering sediment transport and reducing brackish or groundwater influx.

The shoreline fronting the Kapaʻakea community has largely been hardened with seawalls, boulders, and other anthropogenic material.

3.5 The Marine Environment

3.5.1 Reef Zone Characteristics

The coral reef that parallels Molokai's south shore is the largest continuous fringing reef in the main Hawaiian Islands (Ogston and Field, 2010). The shallow reef flat has depths around 6.5 feet or less and extends nearly a mile offshore in the Kaunakakai area, rising to a reef crest that is partially exposed at low tide (Cochran-Marquez, 2005). Figure 3.15 illustrates the transition from the inner reef flat, which is covered in sediment, to the reef crest exposed at low tide, to the fore reef which harbors coral growth (Field, Cochran, Logan, and Storlazzi, 2008).

The inner portion of the reef flat is a wide, shallow depression extending offshore from fishponds and a shoreline that has a band of fine-grained sediment. Much of this inner reef flat is covered with a thick mixture of terrigenous (land-based) mud, silt, and carbonate sand. Sand patches and coral-covered pavement become more dominant along the seaward edge of the reef flat and coral coverage increases with distance from shore (Figure 3.15). The mid-to-outer reef flat has live corals and patches of fine-grained sediment and grooves of sand and gravel (Calhoun and Field, 2008 in Ogston and Field, 2010). The reef crest has a diverse array of coral species that are wave resistant.

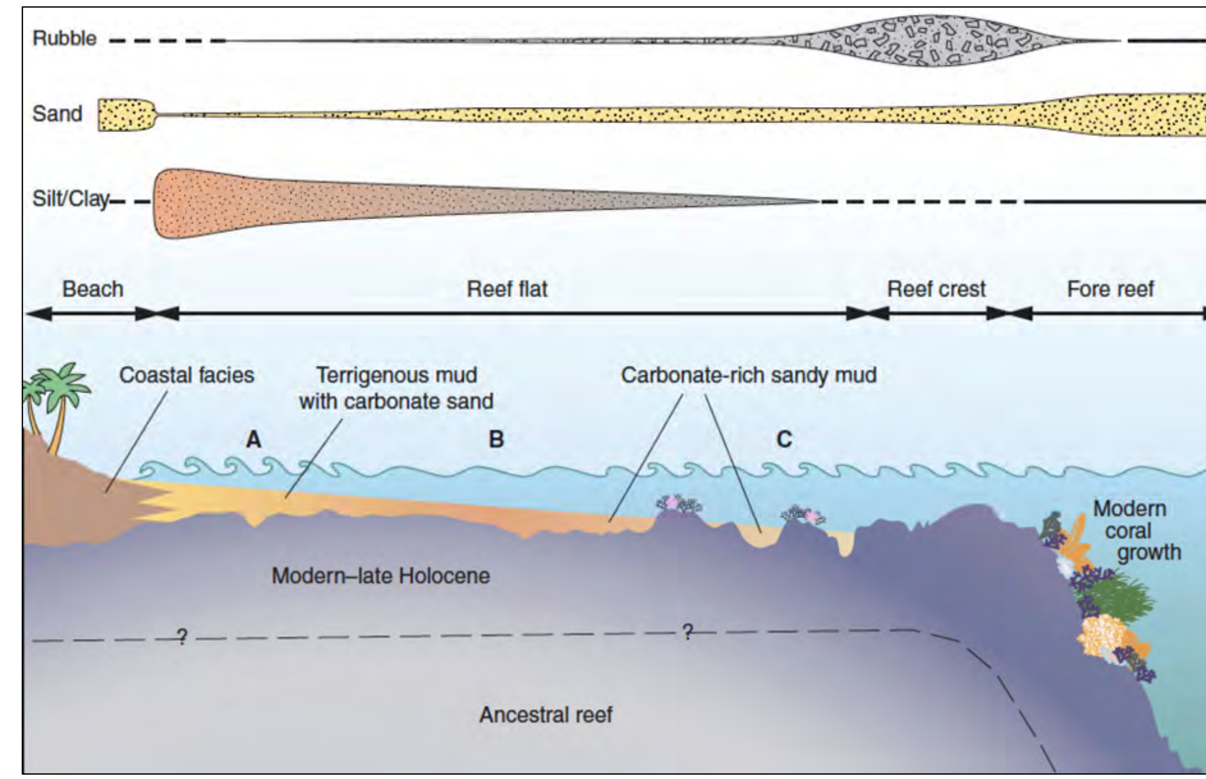
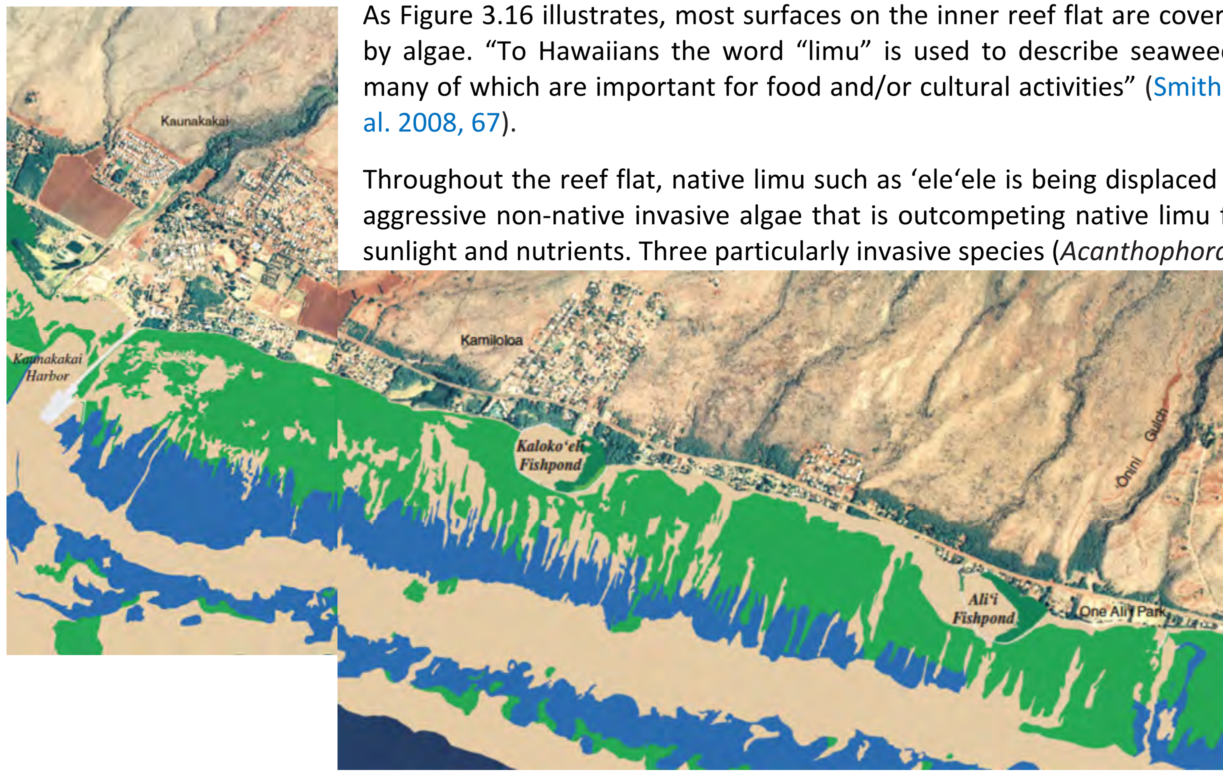


Figure 3.15: *Major anthropogenic stressors the affects Molokaʻi's south shore reef habitat (Field, Ogston, and Storlazzi, 2011).*

Seaward of the reef crest, the fore reef alternates between abundant reef and barren hard pavement**.** The fore reef platform fronting Kamiloloa-One Aliʻi and extending west to Kaunakakai has barren areas that form a "dead zone" relative to coral growth (Cochran-Marquez, 2005). The outer reef is mostly comprised of live coral, reef rubble, and sand-sized carbonate sediment. This area follows a pattern of spur and groove morphology that drops in depth to ninety feet, where it transitions into a sloping sand-covered plain of the shelf zone (Cochran-Marquez, 2005).

3.5.2 Marine Flora and Algae



As Figure 3.16 illustrates, most surfaces on the inner reef flat are covered by algae. "To Hawaiians the word "limu" is used to describe seaweeds, many of which are important for food and/or cultural activities" (Smith et al. 2008, 67).

Throughout the reef flat, native limu such as ʻeleʻele is being displaced by aggressive non-native invasive algae that is outcompeting native limu for sunlight and nutrients. Three particularly invasive species (*Acanthophora spicifera*, *Hypnea musciformis*, and *Gracilaria salicornia*, commonly known as gorilla ogo) are outcompeting native limu for sunlight and nutrients (Smith et al. 2008, 70). *Hypnea musciformis* is also known to wash up onto the beaches throughout the project area creating an unsightly mess.

Figure 3.16: *Biological coverage along Molokaʻi's south shore indicating algae (green), coral (blue) and uncolonized (tan) areas (Cochran-Marquez, 2005).*

> **"In 2005, we used to have twenty-five different species of limu. Limu kala disappeared eight years ago."**
>
> **Noelani Lee Yamashita, Former Executive Director, Ka Honua Momona**

While under threat from invasive algae, several edible forms of native limu can still be found within the project area's shallow reef flat including limu nanauea (Gracilaria coronopifolia), long ogo (Gracilaria parvispora), limu pālahalaha (*Ulva fasciata*), and limu ʻeleʻele (*Enteromorpha prolifera*).

The inner and middle reef flat is also rich in native seagrasses (*Halophila hawaiiana*). These seagrasses play an important role in the marine ecology by stabilizing sediment which would otherwise drift onto the reefs. Seagrasses are also a food source for many marine organisms and provide habitat for several species of fishes and marine invertebrates (Smith et al. 2008, 70).

The green alga Halimeda kanaloana is abundant seaward of the project area's fore reef in deep sandy areas. Halimeda kanaloana is an important part of the ecosystem and is known to be a source of sand (Smith et al. 2008, 74). Its skeleton is made of calcium carbonate which accumulates in quiescent conditions but can break down quickly from abrasive wave action. The plant forms productive meadows of habitat on the seafloor that is important for smaller fish, shrimp, urchins, invertebrates, and other marine life.

3.5.3 Fish Assemblage

South Molokai's reef flats support an assembalege of fish, many of which are harvested for subsistence consumption. A range of fish families are represented, with the following six families comprising roughly ninety percent of the total fish biomass (Friedlander and Rodgers 2008, 61):

1. Surgeonfishes;
2. Parrotfish;
3. Triggerfishes;
4. Wrasses;
5. Snappers; and
6. Jacks.

Herbivores tend to dominate both shallow and deeper waters along the reef flat. Kamiloloa is a notable exception where benthic surveys found that invertebrate feeders comprised a majority of fish biomass. This was a function of the overall low biomass at Kamiloloa (Friedlander and Rodgers 2008, 62). Subsistence fishing, and the harvesting of other marine resources, is vitally important to both the Hawaiian culture and the economic security of many DHHL lessees within the project area. "A variety of fishing techniques ranging from trolling, bottom fishing, netting, and spearing are utilized. Gathering of limu (seaweed), shellfish and crustaceans is widely practiced" (Jokiel 2006, 11).

Photo: *Subsistence fishing, South Shore Molokaʻi.*

> "In the old days, was lots of crab – kūhonu crab, alamihi crab. They still get, but not like before".
>
> **Henry Paleka, Kalamaʻula Shoreline Lessee**

3.5.4 Coastal Fauna

Hawaiʻi has three main edible crabs: Kona, kuahonu, and Samoan. Kūpuna noted a significant change in the abundance and predominance of the Samoan crab, an invasive species, along the sandy silty shorelines in the study area. Several observed a distinct change from smaller, native crabs to Samoan crabs (aka mud crab) who have larger, stronger, front claws. This invasive is tastier and more edible according to the kūpuna, and thus more preferred and harder to find (personal communication, February 2nd, 2020). The Samoan crab was introduced in Kaneohe Bay, Oahu in 1926 by the State with the intent to establish a commercial fishery on Oahu, and the Big Island (Cazar, 2015)(Cascorbi, 2011, 5). The crab inhabits muddy bottoms in brackish water along the shoreline, mangrove areas, and river mouths; environments that are common in the study area. The crabs can grow to 20 cm, and weigh several pounds, and are omnivorous eating both plants and other mollusks including other crabs.

The Koheo Wetland, also referred to as the Ka Laʻi o Ke Kioea Bird Sanctuary, is a 10-acre coastal salt marsh that abuts the western end of the Kapaʻakea Homestead subdivision. "It is now home to dozens of species of native shorebirds, including one of the rarest shorebirds in the world and Kaunakakai's official bird, the kioea, also known as the bristle-thighed curlew" (Chao, E. 2012). Other protected species have been observed by local ornithologist Arleone Dibben-Young on the mudflats offshore during low tide in the vicinity. They include the federally endangered aeʻo or Hawaiian Stilt and Whimbrel's that are protected by the Migratory Bird Treaty Act (Manera, 2013, 33).

The coastline along the DHHL homesteads does not appear to have ideal habitat for endangered species, although in 2005 it was reported that a captively raised monk seal frequented the harbor area until it was removed. Separately, a downed ʻUaʻu kani, or Wedge-tailed shearwater was observed about a mile southeast of the harbor (Manera, 2013, 33).

A number of protected species can be found on Molokaʻi and may occasionally be observed within the coastal areas of Molokai's south shore. Protected birds include:

- Nēnē, Hawaiian goose (*Branta sandvicensis*),
- ʻUaʻu kani, Wedge-tailed shearwater (*Puffinus pacificas chlorhynchus*),
- ʻUaʻu, Hawaiian Petrel (*Pterodroma sandwichensis*),

- ʻAʻo, Newell's shearwater (*Puffinus auricularis newelii*),
- Aeʻo, Hawaiian stilt (Himantopus mexicanus knudseni)
- ʻAlae keʻokeʻo, Hawaiian coot (Fulica alai), and
- ʻAlae ʻula, Hawaiian Gallinule (Gallinula chloropus sandvicensis)

Other protected species include:

- Honu, threatened green sea turtle (*Chelonia mydas*),
- ʻIlio-holo-i-ka-uaua, Hawaiian monk seal (*Monachus schauinslandi*),
- ʻŌpeʻapeʻa, Hawaiian hoary bat (*Lasiurus cinereus semotus*), and
- Blackburn's sphinx moth (*Manduca blackburni*).

The relative isolation and small sizes of the populations of these protect species on Molokaʻi make them extremely vulnerable to perturbations or disruptions of their lifestyle or the habitat they depend on, for example degradation or development of their feeding, resting, roosting, or breeding areas. Because the populations are small, unexpected disasters such as hurricanes or wildfires could have an outsized negative effect and lead to their extinction.

More traditional activities such as development of formerly undeveloped areas (especially along the southeastern coast) can lead to the loss or disturbance of habitat that is critical to the native species long-term survival. Improper grading techniques near stream corridors or gulches can result in sedimentation and degradation of terrestrial, freshwater, and marine habitat. Improperly situated development along the coastal plain can increase nutrients in the ground water that contribute to non-native algal blooms which affect fish populations and coral habitats negatively.

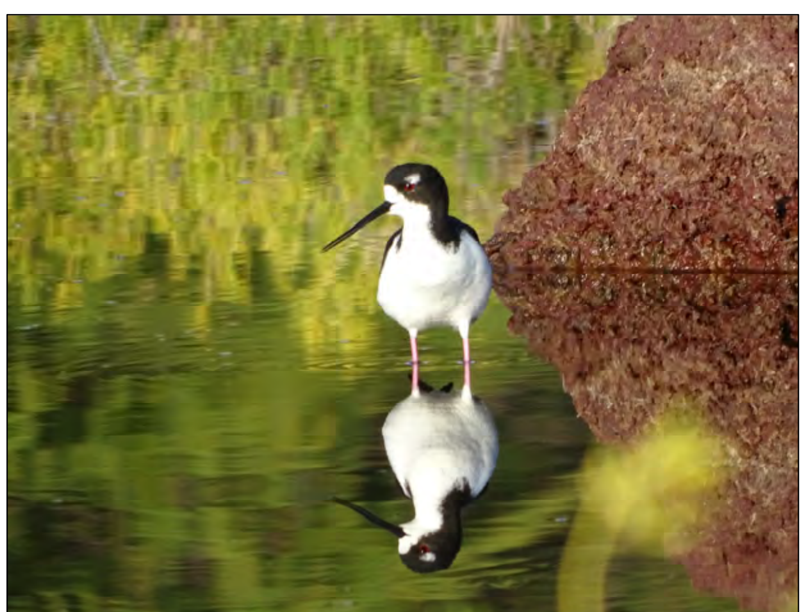


Photo: *An endangered Hawaiian Aeʻo, South Shore Molokaʻi.*

3.5.5 Terrestrial Erosion and the Marine Environment

Upland sediment has a major influence on the project area's coastal geomorphology. Rainstorms can dislodge terrigenous soils, rocks, and silt from upland sources and this sediment is then carried by streams, gulches, and drainageways to the shore. Ancient Hawaiians built at least fifty-two fishponds on the south shore of Molokaʻi (Wyban, 1992 in Jokiel, 2006). Many of these fishponds have formed catchment basins for upland sediments that are released during heavy, but infrequent, rainstorms.

The dominant sediment input to the marine environment is from infrequent kona storms that occur several times per winter and place fine sediment in fan deposits near the mouth of drainage gulches (Field et al., 2008 in Ogston and Field, 2010). This fine sediment becomes trapped on the shallow inner reef flat where it is stored in thin deposits and trapped by macroalgae (Ogston and Field, 2010). The deposition of sediment has caused the inner reef to become inundated with layers of silt and mud that has smothered corals and altered both down-slope and along-shore sediment transport patterns. Sediment transport along shore is now dependent on wind strength and direction, nearshore currents, and fishpond size and shape (Jokiel, 2006).

The filling of the project area's wetlands has amplified the impact of upland erosion on the marine environment. Wetlands capture and filter upland sediment before it reaches the ocean. As the wetlands were filled sediment laden storm runoff, with greater amounts of dirt and silt, flowed into nearshore waters clouding the water, choking fisheries, and polluting nearshore reefs.

3.5.6 Sediment

Sediment concentrations of 10 mg/l or more in the water column are detrimental to coral reefs. This level of suspended sediment results in fewer coral species, less live coral, lower coral growth rates, and decreased rates of production (Rogers, 1993 in Jokiel, 2014). Sediment in the water column can block sunlight needed by corals to photosynthesize and sediment accumulation can eliminate or cover recruitment sites. Sediment can stress individual corals and bury coral colonies. These detrimental conditions for coral (i.e., high sediment-driven turbidity) happen almost daily on Molokaʻi's south shore, especially during the afternoon when trade winds blow at moderate to high speeds (Ogston and Field, 2010) and tides are high (Ogston, Storlazzi and Field, 2004). The situation causes sediment to be resuspended, further impacting reef vitality and degrading reef health and function (Figure 3.17).

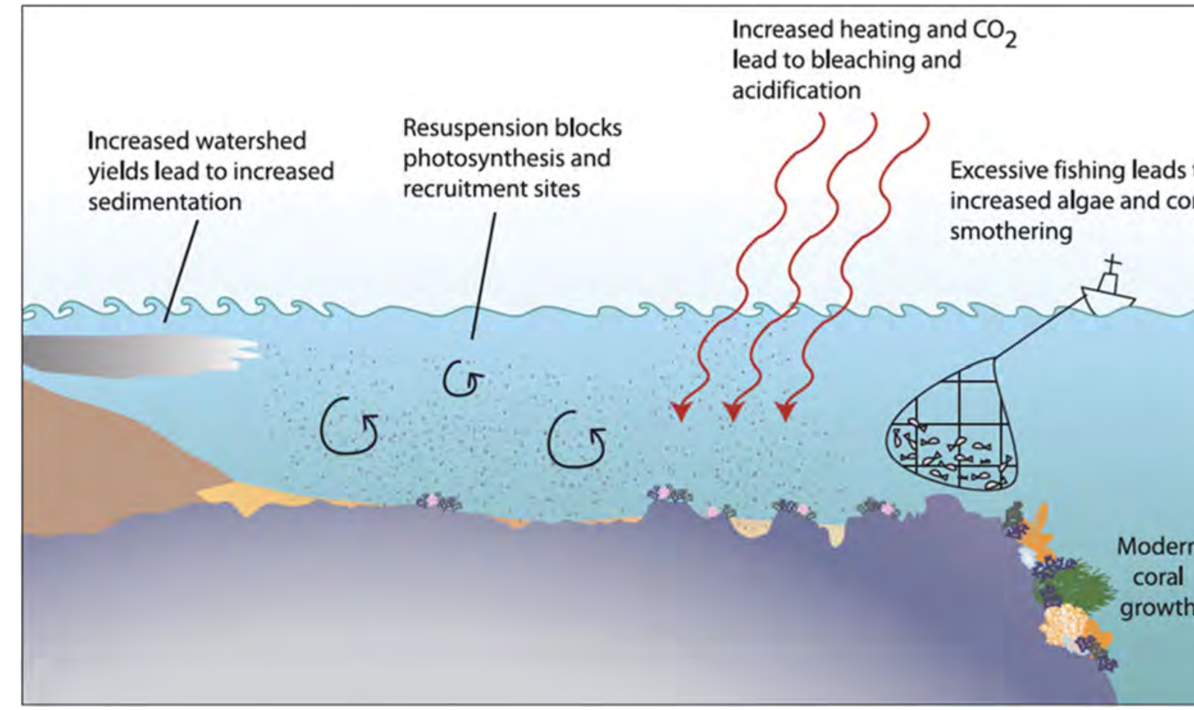


Figure 3.17: *Major anthropogenic stressors the affects Molokai's south shore reef habitat (Field, Ogston, and Storlazzi, 2011).*

The recirculated sediment continues to have an adverse impact as it recirculates again and again in the water column until it is flushed out of the marine ecosystem through the reefs spur and groove morphology.

The frequency and duration of turbidity is critical for determining the stress induced on corals. In some cases, rather than causing actual coral mortality, the sediment inhibits coral settlement and recruitment. Coral growth offshore of Kamiloloa and Kawela showed a significant increase with distance from the shore and there was a reduction of macroalgae as one moved further from the shore (Jokiel, 2014). There was a strong inshore to offshore turbidity gradient due to extensive terrigenous sediment discharge from multiple drainage basins, of which Kawela was the most significant (ibid). Sediment moves from east to west due to the predominant wind direction, but it is eventually flushed out by traveling through the spur and groove reef system to be discharged offshore into deeper open ocean waters. The frequent resuspension of terrigenous sediment on the reef is related to wind speed and tide-controlled water depth (Ogston and Field, 2010). These sediment inputs predominantly originate from upland sources, erodible soils, and barren hillsides within the watershed.

In the three kilometer stretch east from Kaunakakai Harbor, coral abundance decreases drastically from the reef average of 90% to values as low as 10%. The cause of the decrease has not been determined, but the role of sediment suspended on the reef flat, and its seaward advection is one possible factor (Ogston, Storlazzi, Field, and Presto, 2004, 567). More recent findings by (Jokiel, et.al., 2014) suggest that the lack of suitable hard substrate, macroalgal competition, and blockage of [coral polyp] recruitment on available substrate account for low coral coverage in areas of high turbidity. Whereas the direct impact of high turbidity on coral growth and mortality is of lesser importance (ibid.).

3.6 PLANNING AND REGULATORY CONDITIONS

The entire State of Hawaiʻi, from its mountain tops to the reefs offshore, are within the coastal zone. Federal waters begin at the mean high-water mark and extend 200 miles offshore. This overlaps State waters and submerged lands which extend three miles offshore.

In 1972, the federal Coastal Zone Management Act (CZMA) was enacted to better coordinate and regulate coastal activities between the federal, state and county / municipal levels of government. In 1978, Hawaiʻi's Legislature enacted the Hawaiʻi CZM law, HRS 205A, to regulate actions and activities within the state's coastal zone. Any federal activities that would affect the state's coastal zone must be consistent with the CZMA's policies and objectives. Similarly, any state or local projects funded by federal monies or requiring federal permits must be consistent with the state's CZM program. For instance, dredging or fill for the construction of an offshore breakwater would require federal permits from the U. S. Army Corps of Engineers. The State Office of Planning and Sustainable Development issues Consistency Determinations that afford state government the opportunity to review, influence, and modify federal agency decisions affecting the coastal zone.

The Hawaiʻi CZM program also delegates the authority to regulate "development" along the coastline to each island's Planning Commission (for Oʻahu, it's the Honolulu City Council). This delegation allows for decision making to be local influenced within each island's Special Management Area (SMA) and Shoreline Setback Area (SSA). The SMA encircles Molokaʻi extending at least 300 feet inland of the shoreline including Hawaiian Home Lands. The SSA is based on individual lot size and ranges from 40 feet to 150 feet inland of the shoreline, including DHHL oceanfront properties.

The State's regulatory shoreline's location is constantly changing because it is the highest wash of the waves during the highest tide of the year. The debris or vegetation line can also indicate its location. Areas mauka of the shoreline are within Maui County and/or the Molokaʻi Planning Commission's jurisdiction, whereas areas makai of the shoreline are within the State Department of Land and Natural Resources (DLNR) jurisdiction. Areas below the mean tide line are within both state and federal jurisdiction. Thus, if one walked from the pavilion at One Aliʻi Park down the dry beach, onto the wet sandy beach, and then stepped into the ocean waters, one would pass through three sets of government regulation: County/Planning Commission, State DLNR, and shared state/federal jurisdictions. On a seawall or revetment, these multiple jurisdictions are compressed together and can make permitting of the structure complex.

The CZM law encourages home rule and community decision making. On non-Homestead land in Molokaʻi, the Planning Commission reviews development proposals and may add conditions of approval. It also concurs with the County Planning Department Director's recommendations for more minor items or exempt activities that are not development. A private landowner proposing construction makai of Kamehameha V Highway would submit an assessment to the Maui County Planning Department, as it would be a project proposed in the SMA or SSA. The individual owner would have to obtain Commission approval or the Commission's concurrence with the Planning Director's recommendation for an SMA minor permit or SMA exemption.

The State CZM law, HRS 205A-43.6(c) clarifies that the Board of Land and Natural Resources has jurisdiction over shoreline armoring that is seaward of the shoreline, including unauthorized armoring. Any armoring proposed in, or on the edge of the water, as opposed to entirely on dry land, would require approvals by both the State DLNR and the U.S. Army Corps of Engineers because it involves shared federal/state waters in the coastal zone.

In addition, the SSA and/or State permits would trigger compliance with HRS 343, Hawaii's Environmental Review law. This would require public input, notification, and consultation through the preparation of an Environmental Assessment or Environmental Impact Statement and the acceptance of the environmental document by the "accepting authority." If an individual fee-simple landowner proposed the shore armoring, the Molokaʻi Planning Commission or DLNR would be the accepting authority. In contrast, the Hawaiian Homes Commission would be the accepting authority if either DHHL or its lessees or licensees were proposing the armoring.

In Hawaiʻi, a property owner is ***not*** entitled to protect their oceanfront land at the public's expense in terms of lost coastal resources or access. Thus, the likelihood of gaining approval for shoreline armoring is low and its effectiveness questionable because of rising sea levels, bigger waves reaching the shore, and the rise in ground water saturating the soils inland of a seawall due to sea level rise. There are also multiple opportunities for legal challenge by an affected party. Thus, protecting the coastline with a seawall, revetment, or rubble mound; or building an offshore structure such as a groin, breakwater, crib wall, or rubble mound requires considerable time (i.e., years), planning and expense, and has uncertain outcomes given their potential adverse cumulative effects. Instead, natural methods that mimic nature are often less costly, easier to permit, and more effective in the long-term.

Since DHHL is a state government agency, its actions must be determined to be consistent with the Hawaiʻi CZM law's ten objectives and thirty-five policies. This "Consistency Determination" would be made by the State Office of Planning, not the Molokaʻi Planning Commission. However, HRS 205A-22 defines an "Applicant" as "any individual, organization, partnership, or corporation including any utility or **ANY** agency of government" (emphasis added). However, DHHL would like to pursue an alternative approach, and the preferred scenario is that DHHL may choose to either exercise its power of sovereign immunity or voluntarily seek to obtain the Molokaʻi Planning Commission's or Maui County Planning Department's concurrence for any seawall, revetment, or armoring fronting any of the homestead subdivisions. Relative to the SMA, actions proposed by DHHL may require consultation with the State Office of Planning and a voluntary request for concurrence from the Molokaʻi Planning Commission or Maui County Planning Department. All construction proposed by a homestead lessee must first secure approval by DHHL, and plans are reviewed by the Planning Office for conformance with shoreline setbacks and CZM best management practices. DHHL looks forward to developing standard operation procedures and resolving these complex jurisdictional issues in consultation with the various Counties, the State Office of Planning and Sustainable Development - Coastal Zone Management (OPSD-CZM), and the State Department of Land and Natural Resources - Office of Conservation and Coastal Lands (DLNR-OCCL).

Other public health and safety regulations apply equally to DHHL, individual landowners, and beneficiaries when constructing new buildings or structures. New buildings must comply with federal flood zone regulations and obtain a Flood Development Permit (FDP) administered by the Zoning Administration and Enforcement Division of the Maui County Planning Department (Dack, 2015). This mitigates the risk that a structure will incur flood inundation and helps reduce the risk of flood damage. The FDP is usually processed by the County in conjunction with a building permit but may be applied for separately.

Building permits may be required by DHHL for new structures on homestead properties to ensure occupants' health and safety. However, the Definitions section (MCC 16.26B.202) was amended in 2012 to read:

> JURISDICTION. The County of Maui of the State of Hawaii, excluding lands placed in the state land use commission's conservation districts and lands set aside under the Hawaiian Homes Commission Act. (Ord. No. 3928, § 1, adopted March 12, 2012).

Grading permits are needed when walls or terraces retain more than four feet of material or soil between their front and back sides. This helps ensure that the wall does not fall over and the soils behind it do not slump forward or shift. Trenching for utilities, excavation for a septic tank, and moving less than 50 cubic yards of material may be exempt from a grading permit in the subject subdivisions, provided erosion control measures are implemented. Changes in the ground's contour or elevation because of fill should not increase flooding on a neighboring or adjacent property and should not be used in a V or VE flood zone as it could be eroded away exposing a slab or foundation.

Primary coastal sand dunes cannot be graded because they buffer incoming waves, replenish the beach with sand, and filter silt out of ponded stormwater. Only clean sand, not dirt or unclean fill, can be placed in the SSA and shoreline area given that dirty fill could easily pollute the ocean. Grading and fill are regulated by Maui County's Department of Public Works, Development Services Administration, pursuant to MCC 20.08. Placing sand or fill seaward of the shoreline is regulated by the State DLNR and could trigger additional federal and/or state regulatory reviews. Retaining a berm vegetated with native plants in the rear yard adjacent to the shoreline is a natural, effective means of controlling flooding and erosion.

Appendix C provides additional information on flood zone, shoreline setback, and state certified shoreline regulations.

4.1 Coastal Hydrodynamics

Molokai's relative exposure to winds, waves, and swell are depicted in Figure 4.1. Average wave height for the south shore is predominantly influenced by exposure to prevailing northeast trade winds throughout the year, and to a lesser extent southern swell. In summer months, south swells can bring large waves that overtop the fringing reef and reach the shore, particularly during extreme tide events such as full moon or king tides.

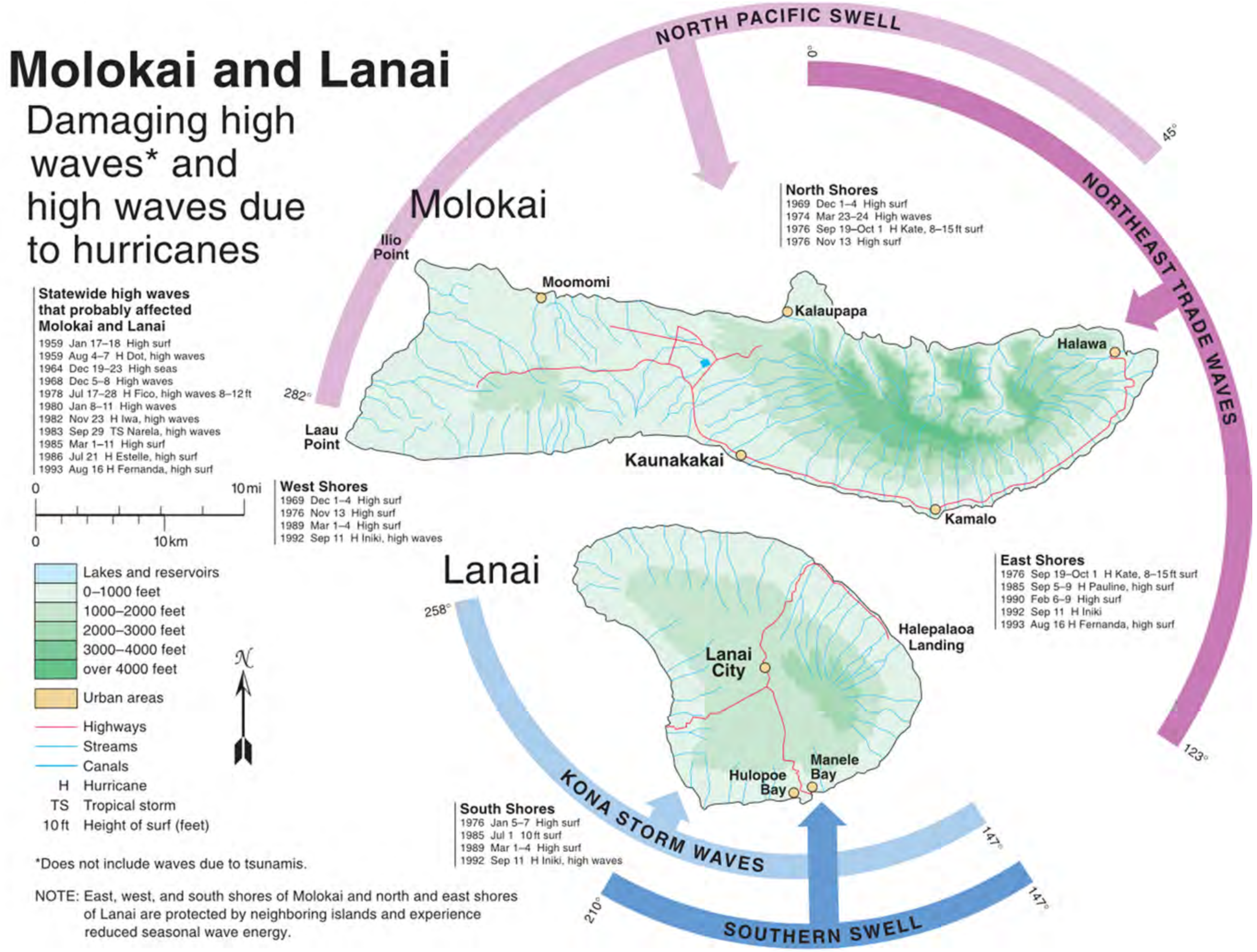


Figure 4.1: *Prevailing wind and wave patterns for Moloka'i and Lāna'i (Fletcher, C., Grossman, E., Richmond, B., Gibbs, A. 2002).*

Factors that influence wave energy and dynamics include: wave conditions (height, period or interval between them), currents (direction, speed), tidal changes, storm surge, bathymetry (depth variations, rugosity), sediment characteristics, and sources of sediment. These factors combine to create the force and energy that alters the physical form of the coastline.

4.1.1 Wind and Currents

Trade wind conditions occur 83% of the time between May and November and 37% of the time between November and May (Ogston and Field 2010, 1029). The wind has a heavy influence on Moloka'i's south shore currents because of the inner reef flat's shallow nearshore area and the extensive offshore fringing reef. The prevailing wind is from the east and picks up in speed and intensity in the afternoon (Figure 4.1). This often creates small churning waves and hastens movement along the shore.

The trade winds are a dominant factor driving sediment flux, resuspension, and transport along the reef. The relative orientation of the south Moloka'i shoreline to the prevailing winds contributes to the nearly 1,640 feet wide band of fine silt and sediment along the inner edge of the reef flat (Ogston and Field, 2010, 1029). Bands of fine sediment within the reef flat are particularly apparent between Kawela Gulch and the Kaunakakai Wharf causeway (Jokiel, et.al., 2014, 7).

Trade wind generated waves, currents, and tidal elevations on the reef flat control the frequency and duration of turbidity events which impact reef health. Findings from various studies suggest a high level of recirculation of sediments driven by afternoon wind, especially at high tide, with some findings suggesting sediment can be stirred up and recirculated as much as seven times before being flushed out of Moloka'i's south shore reef system (Ogston, Storlazzi, Field, and Presto, 2004).

4.1.2 Waves

Large waves generated in deep water usually break and expend their energy on the edge of south Moloka'i's offshore reef and have less influence on the nearshore environment (Ogston and Field, 2010). As shown in Figure 4.2, significantly more wave energy reaches the shore at high tide than low tide, regardless of the offshore wave height (Field, Cochran, Logan, and Storlazzi, 2008).

The amount of wave energy reaching the shoreline is relatively consistent and is constrained by the water-surface elevation, not the offshore wave height (Ogston and Field, 2010). Instead, the waves generated by trade winds are the prevailing influence along Molokai's south shore as they move sediment along the shore and resuspend sediment due to wave growth over the shallow reef (ibid.).

4.1.3 Tides

Tides have a significant influence on south Molokai's waves and currents because of the shallow, broad, and wide extent of the reef flat. The tide typically ranges from two to just over three feet in height. Although the tidal range is relatively small, it represents a doubling in water depth over much of the reef flat. This tidal variation over the reef flat is important for sediment resuspension and transport because wave heights are limited by the depth of water. During higher tides, the effects of offshore waves are greater on the reef flat because more wave energy is telegraphed into the nearshore and wave energy can be transferred through the deeper water over the reef crest. The greater water depth also allows for larger local wave formation on the reef flat (Field, Cochran, Logan, and Storlazzi, 2008).

4.1.4 Coastal Erosion

Coastal erosion is a natural process whereby the shoreline retreats inland over time due to wind, waves, prevailing currents, and storms. Shorelines are highly dynamic and shift frequently through time. In Hawai'i, shoreline retreat may occur slowly over time, or rapidly because of acute or episodic erosion events, normally associated with large surf, storm events, and seasonal changes in wave regime. In contrast to episodic erosion, chronic coastal erosion occurs over long periods of time where the shoreline retreats inland because of sea level rise, wind scouring, soil dissolution, and wave action.

Chronic coastal erosion can be exacerbated when sand supplies are confined, sand transport hindered, or sand reservoirs are constrained behind groins, seawalls, revetments, and other similar structures. Slab-on-grade foundations can constrain sand underneath the foundation's weight, preventing the sand from moving freely along the coastline. Hindering sand movement can deprive down drift properties of the sand or sediment necessary for buffering the erosive effects of waves, currents, and storms.

Armoring a sand or sediment starved area can lead to flanking erosion of areas down drift, and particularly at the end of the armoring. The armoring redirects wave energy to the end of the armored area where the wave's energy can wrap around the end of the armoring and scour softer materials away. This can result in down drift property owners armoring their property which then stimulates additional down drift armoring until the entire coastal cell is armored. This domino effect is best prevented by evaluating coastal erosion on a regional or littoral (sediment) cell basis, instead of making decisions on a parcel-by-parcel basis.

On a healthy beach where sand and sediment transport are not hindered, the shoreline typically changes with the seasons, with one season being more erosional and the other season facilitating accretion. The width of the beach, which narrows during one season, normally recovers as seasonal wave and current patterns return the previously displaced sand. While sand may shift daily, weekly, monthly, or seasonally, over the long-term the width of the beach remains about the same and the ebb and flow of sand continues unhindered.

A sandy beach serves as a buffer to the incoming waves that cause erosion by absorbing and dispersing wave energy. A healthy reef system contributes to a healthy, functional shoreline and vice-versa.

4.2 Littoral Cells

Within the project area shoreline erosion is caused by waves approaching the shore and removing sediment, and by structures interrupting the movement of sediment along the shoreline. Along Molokai's south shore currents naturally move sediment, sand, and silt along the coast from east-to-west. However, between One Ali'i and Kalama'ula the alongshore transport mechanism is interrupted by structures that extend seaward from the shoreline including the Ali'i and Kaloko'eli Fishponds and the Kaunakakai Harbor and Wharf.

Although the fishponds are now part of the coastal environment, they have altered the geomorphology of the coast. Aerial photographs depict an accumulation of sediment on the eastern side of both the Ali'i and Kaloko'eli Fishponds and a deficit or scalloped, concave area indicative of shoreline erosion on the western side of each fishpond. The eastern walls of both fishponds break the wind and slow and redirect both incoming wave energy and the current moving along the shoreline from east to west. As a result, the movement of water along the coastline slows and sediment suspended in the water column settles out of the slowed water by gravity. Areas that are upwind and upcurrent of both fishponds accumulate sediment. In contrast, the areas down drift of both fishponds are deprived of the sediment flowing along the coastline, and this loss of sediment contributes to shoreline erosion.

The Kaunakakai Wharf used to be accessible via an elevated roadway over the water. However, as larger trucks and containers became necessary for supplying Moloka'i's needs, a causeway was built. The addition of the causeway to the Kaunakakai Wharf in more recent years redirected and further slowed the prevailing along-shore current by blocking the water's flow. This added to the deposition and accretion of silt and mud adjacent to the causeway. The causeway further exacerbated sediment accumulation by slowing the along-shore current, allowing more sediment to fall out of suspension, accumulate, and make the area shallower, which in turns slows the current.

Moreover, the addition of a rock breakwater to protect the small boat harbor on the eastern, updrift side of the Wharf, further restricted the natural flow of seawater. Sediment and current patterns may form an eddy and the flushing of sediments from nearshore waters into deeper ocean currents has been impaired. The U.S. Army Corps of Engineers has studied several options to restore the flow of currents through or underneath the causeway but determined that the negative impacts could outweigh the positive benefits of altering the existing situation (Bottin and Acuff, 2001).

The deposition of upland sediment into the project area's coastal waters is also changing the geomorphology of the project area's shoreline. The Kaunakakai, Kapa'akea, and Kamiloloa streams, as well as and several drainage outlets, carry sediment from the Kaunakakai and Kamiloloa Watersheds to the shoreline fronting the project area. The fishponds capture and stabilize some of this sediment that is released during heavy rains, much like stormwater detention ponds.

Soils and sediment including fine clay, silt, sand, pebbles, cobbles, rocks, stone (pohaku) and boulders move down to and along the shoreline. Lighter aggregate materials can be carried by wind, but most aggregate is moved by water, such as rushing streams, stormwater cutting through dry gulches, or strong waves approaching the shore. This results in sediment flowing in a foreseeable fashion.

Sediment flow can be divided into four littoral cells, "A, B, C, and D", fronting the DHHL communities, as shown in Figure 4.3. A littoral cell is a coastal compartment that contains a complete cycle of sedimentation including sources, transport paths, and sinks (Inman, 2005). Setting a littoral cell's boundaries helps to define a specific geographical area in which the sediment budget can be analyzed, and management strategies can be appropriately designed.

Figure 4.2: *Reach of wave energy between low and high tide at Kamiloloa (Field, Cochran, Logan, and Storlazzi, 2008).*

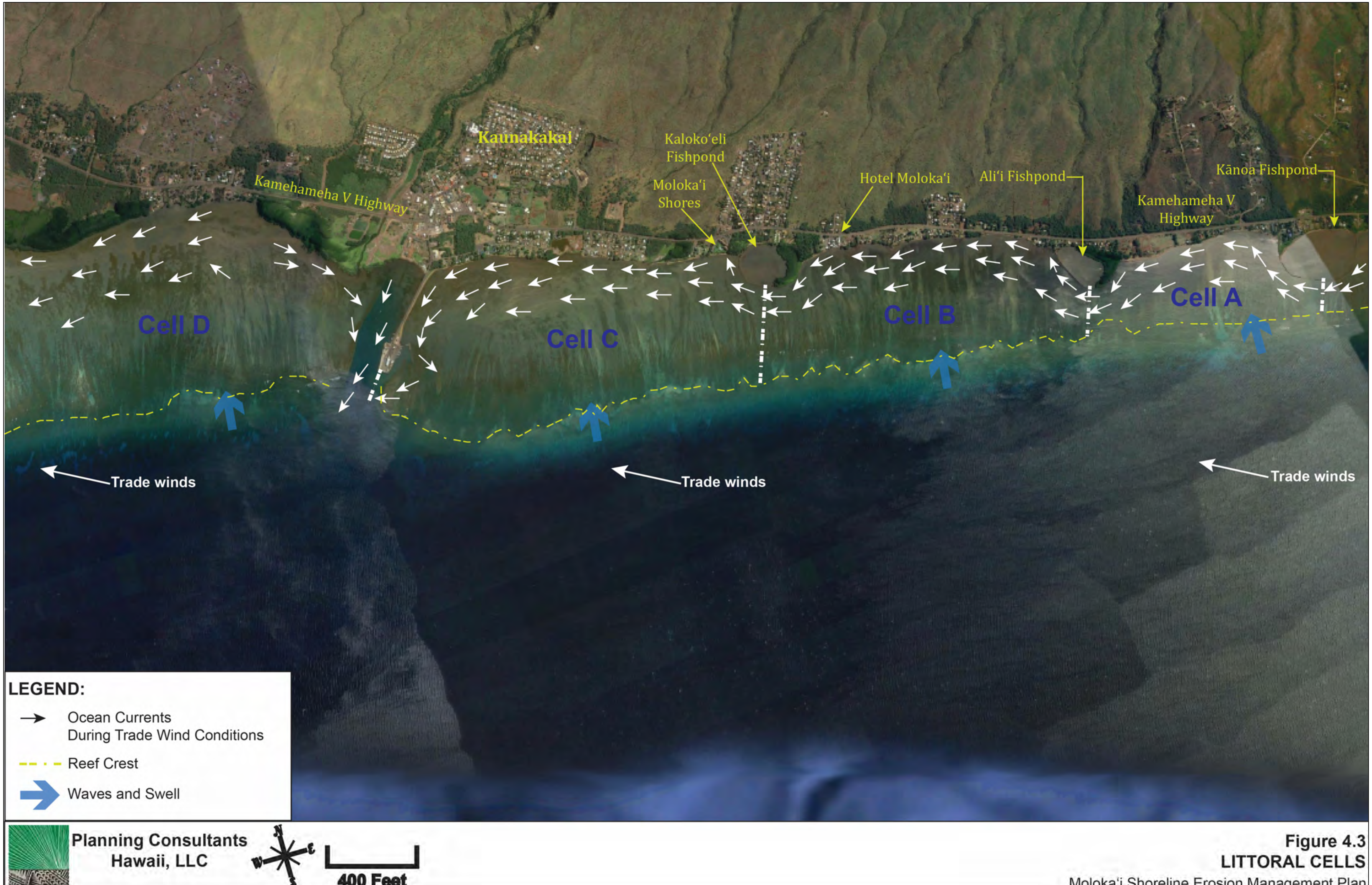


Figure 4.3
LITTORAL CELLS
Moloka'i Shoreline Erosion Management Plan

4.2.1 Kānoa Fishpond to Ali'i Fishpond (Cell A)

Cell "A" is bound by the Kānoa Fishpond to the east and the Ali'i Fishpond to the west as depicted in Figure 4.4. On the western side of the Kānoa fishpond, a series of private properties extend to the west, but they are not part of this study. They are located between the ocean and Kamehameha V Highway and the lots generally become wider to the west towards the wide, sandy beach fronting the One-Ali'i Beach Park (which is just east of the Ali'i Fishpond).

East of Ali'i Fishpond, sediment has built up against the fishpond's wall in Cell "A" resulting in shoreline accretion. Over the years, much of the Ali'i Fishpond has filled with sediment and mangrove trees. The wall interrupts the amount of sediment flowing along the coast, depriving sediment from the western side of the fishpond, resulting in shoreline erosion in Cell "B" down drift of the fishpond.

Photos (Left to Right): *1. A sample of beach sand, One Ali'i Park; 2. Looking east from the the backshore of One Ali'i Park.*

Photos (Top to Bottom): *1. Looking east fronting One Ali'i Beach Park; 2. Looking west along One Ali'i Beach Park.*

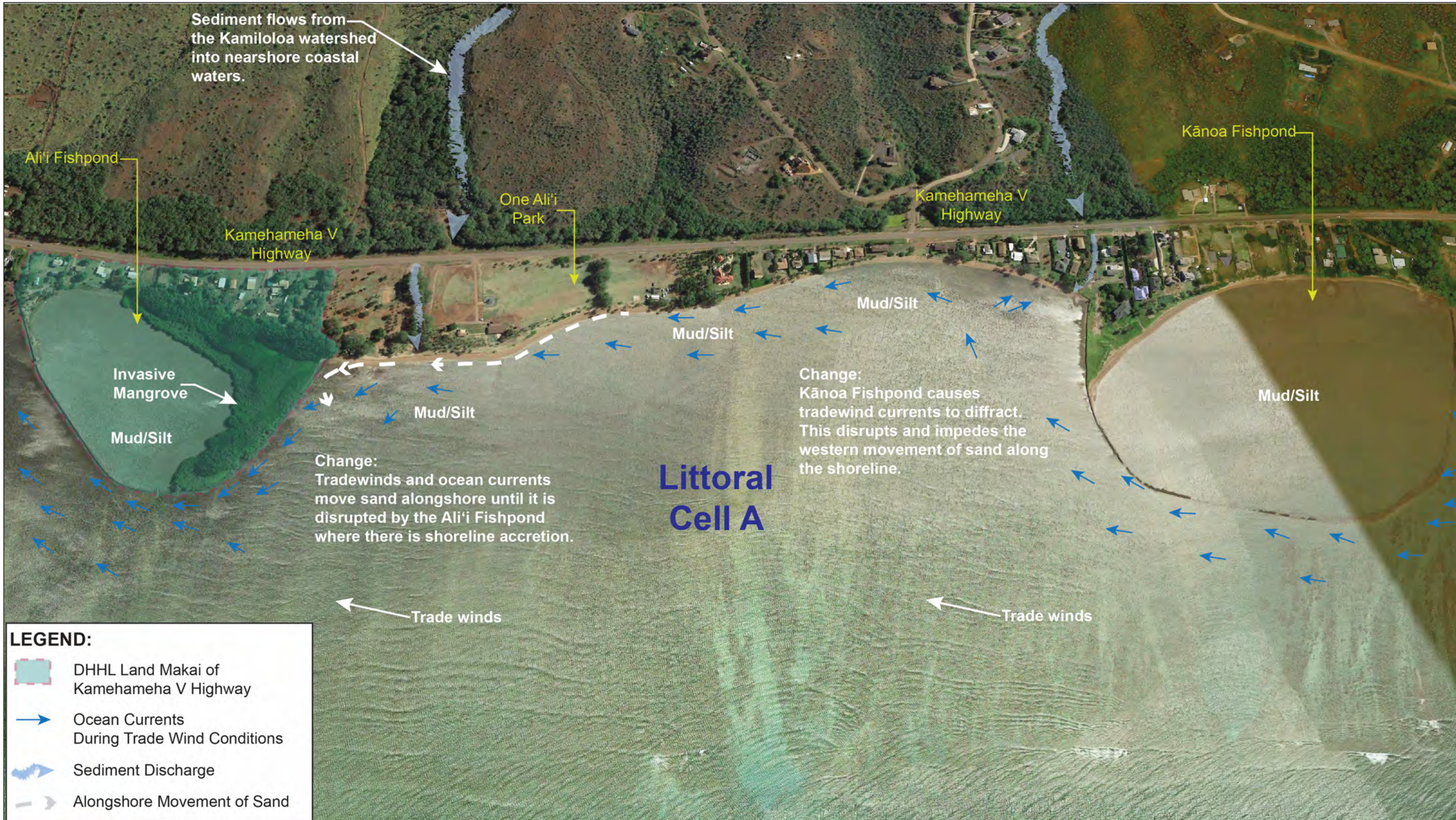


Figure 4.4
LITTORAL CELL A:
Coastal and shoreline processes
Moloka'i Shoreline Erosion Management Plan

4.2.2 Ali‘i Fishpond to Kaloko‘eli Fishpond (Cell B)

Cell “B” is bound by the Ali‘i Fishpond to the east and the Kaloko‘eli Fishpond to the west as depicted in Figure 4.5. Sandwiched between the ocean and Kamehameha V Highway lies the Kamiloloa subdivision, just to the west of the Ali‘i fishpond. Most of the Kamiloloa oceanfront lots are located down wind and down drift of the Ali‘i fishpond and to the east of the Hotel Moloka‘i. Some of the lots exhibit small embankments due to erosion but most of the lots have more natural gradients to the ocean than the lots at the Kapa‘akea subdivision further to the west. In some cases, the grade or embankment has been impacted by man-made impediments. On the western, downwind side of the Ali‘i fishpond is a section of Kamehameha V Highway that has experienced coastal erosion and is exposed to wave and tidal action.

Like Cell “A”, there is considerable accretion at the western end of Cell “B” updrift of the Kaloko‘eli fishpond, between the Hotel Moloka‘i and the fishpond’s eastern wall. This is evidenced by three adjoining lots east of the fishpond’s wall that have experienced considerable accretion since the lots were platted approximately eighty-six years ago. The accretion, as opposed to erosion on the down drift side of the fishpond, illustrates the significant influence that sediment transport plays in the littoral system along Moloka‘i’s south shore.

The Kaloko‘eli fishpond separates and divides sediment transport along the shore between Cells “B” and “C”, as evidenced by a smooth, concave curve to the shoreline down drift of the fishpond.

Similar to the Ali‘i Fishpond, much of the Kaloko‘eli Fishpond has filled with sediment and mangrove trees. This changes the ecology of the fishpond and impedes muliwai flow (fresh and brackish water inputs) and ground water flows that may have helped transport sediment in the past.

Sediment transport within the littoral cells is often disrupted by shoreline armoring, as well as dense thickets of invasive Kiawe trees. This can be seen in Cell “B” fronting and just east of the Hotel Moloka‘i. The Hotel Moloka‘i has fixed the seaward edge of its property causing water to come right up to its wall. The Hotel Moloka‘i is to the east of the Kaloko‘eli fishpond and the hotel’s restaurant, bar, and pool areas are built upon a foundation that serves as a seawall. The seawall provides protection during high tide and large surf, but the beach is submerged at those times. Seawater regularly reaches the face of the wall during high tide events. A dense thicket of vegetation, just east of the Hotel Moloka‘i, also disrupts sediment transport along this stretch of shoreline and many milo trees have taken root in the accumulated soils.

Photos (Clockwise from Top): *1. Looking east along an eroding shoreline fronting Kamiloloa; 2. Informal, shoreline armoring fronting Kamiloloa; 3. Panorama view of informal shoreline armoring and the use of naupaka along Kamiloloa (Source: DHHL).*

Figure 4.5
LITTORAL CELL B:
Coastal and shoreline processes
Moloka'i Shoreline Erosion Management Plan

4.2.3 Kalokoʻeli Fishpond to Kaunakakai Wharf (Cell C)

Cell "C" is bounded by the Kalokoʻeli Fishpond to the east and the Kaunakakai Wharf to the west as depicted in Figure 4.6.

Just down drift of the Kalokoʻeli Fishpond is the Molokaʻi Shores in Cell "C" which has a sandy berm along its seaward edge that is stabilized by naupaka plants. This vegetative berm moves, and its contents are redistributed, in response to natural forces. This natural process is unlike shoreline armoring which redirects the force of waves and currents to neighboring down drift properties. Just down drift of the vegetated berm is a private residence with an approximate three feet high erosion scarp. This scarp has formed, in part, due to kiawe tree roots retaining the sandy soils along the coastline and preventing the formation of a beachfront that has a gentler slope and profile. While the kiawe has preserved the land, it has done so at the cost of a gradually sloping sandy beach. Fallen branches and slumping tree trunks have further hindered access along the shoreline to the west. The two properties illustrate the contrast between having native and non-native vegetation along the shore.

The Kapaʻakea subdivision is situated between the swampy remnant of the Kapaʻakea fishpond to the east and the Koheo Wetland to the west. Both wetlands help to capture, filter, slow, and stabilize sediment and stormwater that originates from the Kapaʻakea and Kamiloloa streams and flows downhill into nearshore marine waters. Despite the high amount of upland sediment input, the Kapaʻakea subdivision's oceanfront properties continue to experience land loss as the coastline moves inland and the shoreline retreats. In response, virtually all of DHHL's oceanfront residential lots have some form of coastal armoring in an attempt to halt or diminish shoreline retreat. The armoring, as well as shoreline reference features provided by knowledgeable long-time observers, suggests that the coastline has been gradually moving inland over time. The shoreline hardening at Kapaʻakea has exacerbated shoreline erosion fronting both the Koheo Wetland and the down drift properties along the eastern third of Seaside Street.

The western end of Cell "C" is the causeway to the Kaunakakai Wharf. The flow of sediment through Cell "C" has been substantially altered by the modification of the roadway to the harbor's Wharf. Originally, the roadway was elevated upon posts, but it was changed as fill was placed atop discharge pipes to form a causeway. The modification slowed the speed of the current and redirected its flow offshore. This increased the deposition of sediment along the coastline and along the eastern edge of the causeway, compounding the sediment discharge problem. Moreover, the addition of groins and a rock mound on the eastern side of the harbor's Wharf to protect the small boat harbor further altered the natural flow within the littoral cell causing additional deposition of sediment within the terminus of Cell "C".

The U.S. Army Corps of Engineers conducted experiments to increase the amount of water that could flow down drift by adding culverts under the causeway (Bottin and Acuff, 2001). They reported that culverts could restore flow but would create eddies on the western side of the causeway and erode the fill used to create the causeway and the land on its down drift side. Removal of the existing fill, and the inner portion of the causeway, would eliminate these eddies and result in improved wave-induced current and sediment transport patterns. However, restoring along-shore flow would accelerate erosion and land loss and create stronger cross currents immediately west of the causeway where outrigger canoe paddling is popular.

Photos (Clockwise from Top): *1. Kalokoʻeli Fishpond; 2. The remnants of an ancient fishpond just east of Kapaʻakea shelters the sandy shoreline from waves and currents; 3. Looking east at the informal shoreline armoring fronting Kapaʻakea; 4. A rock sill protects the beach fronting a home in Kapaʻakea; 5. Looking west at the informal shoreline armoring fronting Kapaʻakea.*

Photo (Below): *A panorama of the informal shoreline armoring along a portion of Kapaʻakea (Source: DHHL).*

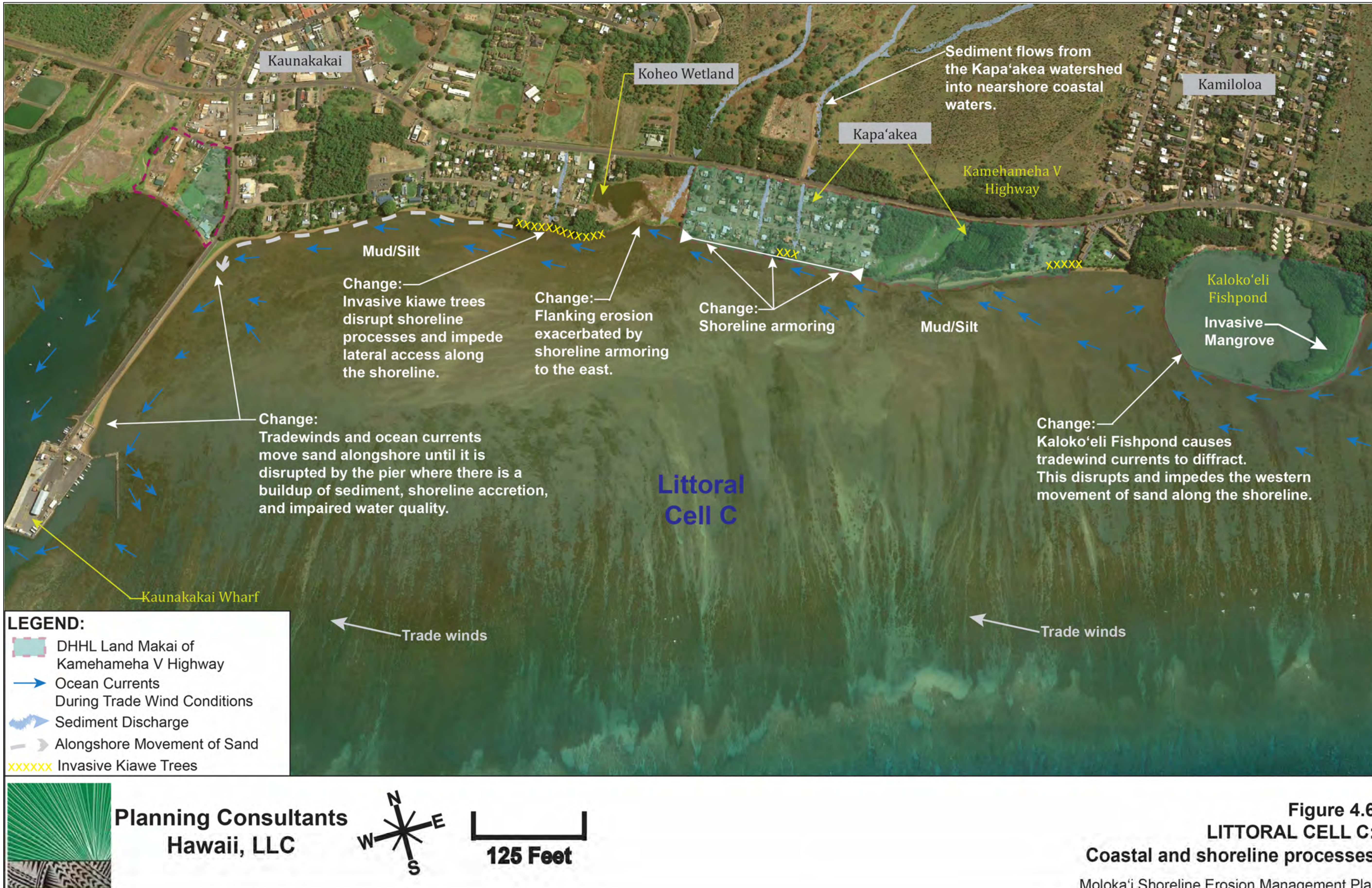


Figure 4.6
LITTORAL CELL C:
Coastal and shoreline processes
Moloka‘i Shoreline Erosion Management Plan

4.2.4 Kaunakakai Wharf to Kahanu Avenue (Cell D)

Cell D (Figure 4.7) is considerably different than the other three littoral cells that are within the study area. Cell D is both downwind and downdrift of the Kaunakakai Wharf so sediment transport within the study area of the cell is only marginally influenced by the prevailing east to west winds and currents. Due to the presence of the Kaunakakai Wharf, the nearshore current is not as influenced by wind and incoming ocean swell. Currents that are pushed by trade winds and swell tend to diffract and bend when they encounter the Wharf and its causeway. This impairs water quality and disrupts and impedes the east to western movement of sand, silt, and pebbles along the shoreline. The causeway itself forms a barrier that prevents sand from moving along the shoreline from Cell C into Cell D.

The Kaunakakai Stream mouth, just west of the Wharf creates an influx of sediment that spreads out like a fan. But much of this sediment is carried by bottom currents into the deeper channel adjacent to the Wharf that leads offshore. Unlike Cells A, B, and C where the sediment moves from east to west, some of the sediment in cell D moves in the opposite direction, from west to east, due to the influence of the deep channel along to the Wharf's western side. This channel begins near the shore and extends out beyond the reef where it has been carved into the submerged terrain by the Kaunakakai Stream over thousands of years. Since the channel is considerably lower in elevation and deeper than the surrounding shallow flats, it acts like a drain that pulls nearshore waters, sediment, and silt into the channel where it is transported offshore and into the deeper ocean.

In comparison to the littoral cells to the east (Cell A-C), the nearshore area of Cell D receives much greater influxes of freshwater and upland sediment. High amounts of upland sediment and freshwater are discharged from the Kaunakakai Stream mouth just west of Malama Park and the Wharf. Freshwater seeps and groundwater flow through the Kapuāiwa Coconut Grove creating visible springs and brackish pools within the grove. This groundwater empties into the nearshore flats just offshore of Kalamaʻula and since freshwater is lighter than saltwater, it has the potential to carry upland dissolved minerals, sediment, and silt further offshore.

Sediment transport along the coastline is largely inhibited by thick stands of Red Mangrove, an invasive species. In the early 19th century, upland mauka areas had become barren and denuded by free-ranging feral ungulates, such as Axis Deer which were introduced but kapu for hunting. After rainstorms, brown turbid stormwater full of silt and clay would wash downhill and out into the nearshore reef and marine waters. Ranch hands on horseback distributed seedlings of mangrove along Pālāʻau's south shore in the 1900's in an attempt to capture the upland soils before they smothered the offshore reef, and the invasive then spread from that ahupuaʻa to the rest of the coastline.

Mangroves have adapted to cope with saltwater immersion and wave action and their tangled root system breaks up and dissipates wave energy until its effects are nearly negligible. The mangroves have a complex intertwined root system that slows the movement of water to a near standstill. The quiet, shaded waters are good for juvenile fish to avoid predators but can become anoxic (lacking in oxygen) resulting in fish kills when the tide or current subsides.

The shoreline flanking both sides of the Kalamaʻula subdivision has been overwhelmed with thick stands of invasive mangrove. This has fundamentally interrupted the natural sediment transport mechanisms along the shoreline. Over the past century, a considerable amount of swampy land has formed between the east side of Kalamaʻula subdivision and the Kaunakakai Stream mouth. Similarly, from Pond Place and Kapuāiwa Place that borders the Kapuāiwa Coconut Grove, a large, long, thicket of invasive mangrove has slowed the movement of sediment to the west of the subdivision causing a muddy, silty flat to form in nearshore waters.

The areas flanking the Kalamaʻula subdivision are accreting due to slowed currents, sediment deposition, and conversion to swamplands by mangroves. Meanwhile, the Kapuāiwa Coconut Grove and Kiowea Beach Park shorelines are eroding. Exposed root balls of coconut trees along the shore and the cracking and slippage of concrete slabs at the park's oceanside

Photos (Clockwise from Top Left): *1. The shoreline fronting Malama Cultural Park; 2. The Kalamaʻula shoreline while looking east towards Kaunakakai Wharf; 3. An eroding shoreline fronting Kiowea Beach Park; 4. Invasive mangrove between Kalamaʻula and Kaunakakai Wharf. 5. A view of the Kalamaʻula shoreline looking west. 6. The Kapuāiwa Coconut Grove.*

Figure 4.7
LITTORAL CELL D:
Coastal and shoreline processes
Moloka'i Shoreline Erosion Management Plan

4.3 Shoreline Erosion Assessment (Severity and Risks)

Coastal erosion can be measured over time to provide an estimate of historic shoreline change. The amount of change can be indicative of future states of the coastline and its likely location should erosion continue unabated. This subsection summarizes the findings of Appendix D which analyzes the rate of shoreline change within the project area by analyzing and comparing the project area's historic plat maps against existing shoreline conditions. Please see Appendix D for a more complete discussion of this analysis.

The Kapa'akea plat maps were drawn in 1950 and identify the length of drainage easements and access paths from Kapa'akea Loop (the main internal roadway) to the ocean. The plat map also lists dimensions for individual homestead lots. A July 21, 1950, map also illustrates a DHHL-owned strip of land (Parcel 1) located between the individual homestead lots and the ocean. However, Parcel 1 is now entirely submerged, suggesting the shoreline has moved inland approximately 66 feet on the western side and roughly 52 feet on the eastern side of the subdivision over the past 70 years. This equates to an average annual erosion rate of about 0.84 feet/year.

The Kamiloloa and One Ali'i subdivisions also have a separate, DHHL-owned, strip of land between the individual homestead lots and the ocean. While the plat maps do not provide specific dimensions for these lands, they do list the acreage of these buffer strips, allowing their original width to be estimated from the parcel's length. Erosion of these lands suggest similar, albeit lower, rates of shoreline change and retreat.

The calculations of shoreline change based on the plat maps are consistent with the personal observations made by long-time residents and historical reference features identified by kupuna. Accordingly, new buildings, infrastructure, and development in areas that are prone to erosion should be avoided since they may be underwater during the structure's lifespan. This precautionary approach is a logical and culturally appropriate way to keep people and their investments out of harm's way.

4.3.1 Sediment & Sea Level Rise

As the sea level rises (SLR), more wave energy is anticipated to be telegraphed further inland, above and over the coral reef system. Waves will skate over the top of the reef with progressively less interruption as the surface of the ocean rises. The reef's friction effect that breaks and reduces wave energy will be negated and more waves will contact the nearshore environment and cause or contribute to shoreline erosion. Offshore waves will tend to extend further inland because the reef's roughness will have less of a dampening effect on incoming wave energy, similar to the differences presently observed between high and low tide (Figure 4.2).

Some studies predict that significant erosion of the shoreline will occur when the tide is high and where the shoreline is characterized by low, flat, erodible terrain (Ogston and Field, 2010). But shoreline erosion only adds a small amount of sediment to the reef flat budget compared to wind generated resuspension (ibid.). The authors predict more intense and longer periods of wave generated resuspension of sediment, coupled with increased turbidity due to shoreline erosion in the future. They predict a four-fold increase (9% to 37%) in turbidity events that exceed acceptable levels, and longer durations of those events (ibid.). The higher turbidity would occur during daylight hours when reefs are photosynthesizing. Silt in the water column would block the sunlight which corals need to survive and would inhibit their fitness. Reef growth will not keep up with the increase in sea level rise. As a result, more sediment will be released by wave energy that reaches the coastline only to be recirculated again within the coral reef ecosystem. However, these projections assume that the ground inland of the shoreline is comprised of erodible silt, alluvial soils, clay, or loam, and not sandy substrate. Coarse sand does not get resuspended as easily as silt and does not create as turbid conditions that are detrimental to corals.

The negative feedback loop created by SLR could cause significant change to the morphology and ecology of Molokai's south shore. The result of this increased shoreline erosion could further degrade the reef's ability to dissipate wave energy and to serve as a sustainable food resource.

With rising seas, more energy from offshore waves will propagate over the reef crest across the reef flat and attack the shoreline leading to erosion and shoreline retreat. With the SLR predicted this century, fringing reefs could be adversely impacted by an increased frequency and duration of the resuspension of fine sediment of reef flats and an increase in shoreline erosion that would release more sediment into nearshore waters (Field, Ogston and Storlazzi, 2011). As such, even small changes in water elevation could have broad implications on sediment management and reef health along Molokai's south shore. These adverse effects can be minimized by management activities that decrease sediment input from upland sources in the watershed, increase the number and diversity of herbivorous fish that eat algae, and limit or reduce other stresses to reef habitat.

4.4 Sea level rise and elevated water tables

Climate change would have three predominant effects on Molokai's south shore: more rainfall, bigger and higher storm surge, and rising seas (i.e., sea level rise). The climate in arid locations is predicted to become dryer over time and wet areas would tend to have more intense and frequent rainfall events (IPCC, 2007). Severe rainfall events are likely to occur more frequently and with more intensity, generating more stormwater and rainwater sheet flow. Current drainage infrastructure has limited capacity to prevent flooding of DHHL properties and the surrounding coastal plain on Molokai's south shore.

The Pacific Ocean is warming, resulting in higher tides, more frequent episodes of strong storms, big waves, and strong surge events where more wave energy and water are telegraphed to shore. This is likely to lead to more acute episodes of beach erosion, and a trend towards higher rates of chronic coastal erosion. Although the exact amount of SLR is still in question, most scientists estimate that SLR of one meter (3.3 feet) by year 2100 is probable (Norcross et al., 2008). Some experts anticipate a meter of SLR in the Hawaiian Islands as early as year 2060 (Hawai'i Climate Change Mitigation and Adaptation Commission, 2017) and believe adverse effects are already being realized. For instance, during the past decade, many beaches on the neighboring island of Maui have experienced higher rates of erosion, more frequent severe erosion events, and less seasonal recovery of sandy beaches after erosion events than in previous years. Importantly, SLR will occur in an exponential, non-linear fashion with small changes at first, but increasingly more significant events over time that occur more frequently.

Ascertaining the impacts from climate change and sea level rise is challenging, but the most prudent way of avoiding these impacts is to build out of harm's way. There are multiple ways to avoid these impending risks to DHHL properties, either by adaption and realignment, accommodation, or protection.

In the future, the effects of climate change, sea level rise (SLR), and more frequent extreme weather scenarios could increase coastal erosion or change the morphology and shape of the project area's coastline. These changes in the coastline's features could, in turn, increase the exposure of the homestead areas to coastal hazards such as flooding, rising waters, storm surge, and/or loss of dry, firm land. SLR and shoreline erosion will also reduce access to, and along, the shoreline for fishing, gathering, subsistence, recreation, and cultural activities. As sea's rise, salt water will intrude further inland and underground causing more groundwater to become contaminated with salt. Salt water is 32 times heavier than fresh water and can displace or contaminate a disproportionate amount of potable water. As a result, saltwater intrusion can turn potable wells brackish and contaminate shallow drinking wells on the coastal plain.

Separate from erosion or shoreline change, as SLR increases more groundwater will be contaminated with salt, disrupting the biological action in wastewater treatment systems leading to reduced performance or failure. Rising sea levels could also cause homestead infrastructure, such as cesspools and leach fields, to fail along the coastal plain. This would lead to backups in plumbing, raw waste overflows, and contamination of nearshore waters with sewage or pathogenic liquid effluent that can make people sick. SLR can result in a rising groundwater table that could infiltrate and inundate cesspools with brackish or saltwater. This can cause cesspools to fail as toilets, showers, and sinks have no down gradient place to flow resulting in back up or overflow. Furthermore, the salt in seawater tends to kill the microbes within a cesspool and those in adjacent soil layers such as a leach field that decompose human waste into benign organic materials. The loss of these microbes can be counteracted by adding yeast and other microbe-enhancing compounds to a cesspool or septic system to improve their effectiveness.

The presence of a higher or more brackish water table can cause wastewater effluent in the cesspool to mix with groundwater which can then be drawn into the ocean and nearshore waters as the tide drops. Wastewater effluent is high in nitrogen, a fertilizer that fuels algae growth. The added algae in nearshore waters are detrimental to reef health and can reduce game fish diversity and biomass. Wastewater effluent can also soak the soil leading to its saturation, which in turn can lead to further dissolution of alluvial clay within the soil that can leach out of the substrate and create turbid nearshore waters. The dissolved clay and silt in the water column can settle on corals and be harmful to their health.

4.5 Natural Hazard Exposure

Flooding, severe storms, large waves, and other natural hazards contribute to shoreline change, often in a dramatic fashion. Exposure to natural hazards can result in large waves overtoping the fringing reef and reaching the shore. This exposure is of particular concern to oceanfront residents during extreme high tide events, such as full moon or king tides. Interviews with residents in the DHHL subdivisions attest to waves overtopping seawalls and shore armoring, particularly in Kapaʻakea during the summer months when there is a full moon or king tide.

The Pacific Disaster Center provides an online atlas that ranks the vulnerability of the Kawela coast to natural hazards. The relative exposure of DHHL properties is similar given their proximity within the coastal plain. Figure 4.8 illustrates the intensity of coastal hazards for the Kawela to Kaunakakai coastline as published in the *Natural Hazards and Vulnerability Atlas* (Fletcher, C., Grossman, E., Richmond, B., Gibbs, A. 2002). Coastal hazard rankings for this section of Molokaʻi's south shore range from 1 (low) to 4 (high).

The overall hazard assessment for the Kawela coast is moderately low, except at the Kawela Stream mouth in Nalulua due to its history of high stream flooding. Rankings for seismic activity, sea level rise, and storms are the greatest hazards (3), followed by big waves, erosion, and tsunami (2), and stream flooding (ranked 1 to 2). Historically, flooding of Kapaʻakea in the 1990's inundated the DHHL properties with two to three feet of water and mud from mauka lands. This flooding covered the highway and inundated homes and buildings resulting in considerable damage and cleanup efforts. Overwhelmed streams, gulches, and drainage infrastructure did not have sufficient capacity for the events and excessive flooding ensued. While DHHL has improved drainage infrastructure since that time, SLR data was nascent, and the improvements probably did not envision the capacity necessary to accommodate climate change.

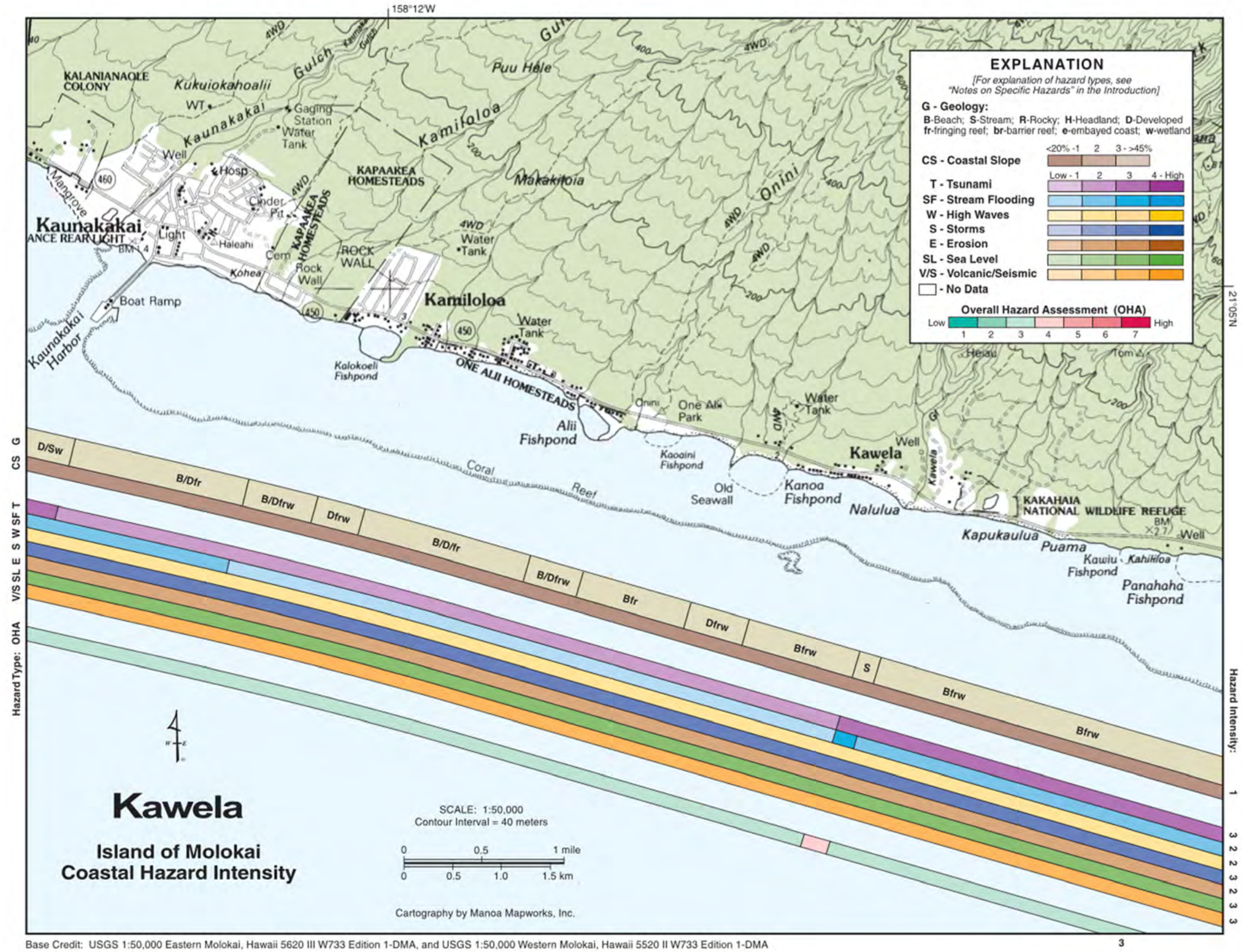


Figure 4.8: *Map of Coastal Hazard Intensity for Kawela, Molokaʻi. Source: Fletcher, C., Grossman, E., Richmond, B., Gibbs, A. 2002.*

CHAPTER 5: SHORELINE EROSION MANAGEMENT OPTIONS

5.1 Sea level rise adaptation strategies

Considering SLR and its potential adverse impacts, the Hawaiʻi State Office of Planning Coastal Zone Management Program (OP CZM) has identified three main adaptation strategies for addressing coastal hazards: Managed Retreat, Accommodation, and Protection (DBEDT, 2019).

It is important to consider these strategies in response to the variety and types of impacts that are likely to result from exposure to SLR and shoreline change. It is also important to understand the degree of coastal hazard exposure for those residing on the coastal plain. It is wise to consider the advantages, disadvantages, limitations, and potential natural and cultural impacts of each strategy before implementing an erosion or hazard exposure response. Among these strategies, managed retreat has the greatest certainty of reducing risk and damage from coastal hazards.

5.2 Adaptive realignment

Managed Retreat or ***adaptive realignment*** is a form of relocation that incrementally moves development inland and mauka from the coastline. The strategy involves the creation of a proactive plan to relocate vulnerable buildings, infrastructure, and public facilities out of harm's way by avoiding erosion, flood, and hazard prone areas during a building's lifespan. If the cost of protecting a vulnerable structure from SLR exceeds the cost of relocating the structure out of harm's way, adaptive realignment can make economic and practical sense. If the cost to repair and maintain a building in harm's way exceeds the cost of adapting to natural hazards, it may be prudent to fully implement a managed retreat strategy. These costs should also factor in the human costs of lost life, personal injury, and damage to property and possessions including repetitive losses. Adaptive realignment may occur within the confines of a parcel, between parcels, or within a community.

Adaptive realignment can be accomplished in several ways. First, through the physical relocation of structures that are situated in at-risk areas. Second, through the incremental improvement of buildings and infrastructure located outside of hazard prone areas. Third, through policy that restricts development, substantial improvements, or infrastructure upgrades in hazard prone areas. Such policy should prevent inappropriate building practices in at-risk areas, such as slab-on-grade home and building construction, the pushing of erodible soils into mounds for house pads, the filling of natural drainage ways, construction in gulches, and the use of cesspools. The policy should account for the cumulative costs of development including differences in property insurance costs, association maintenance fees, and special assessment or reserve fees. Fourth, the strategy should direct capital improvement and infrastructure enhancements to areas that are not at risk of damage by coastal and natural hazards. Finally, the strategy should incentivize development of new areas that are located outside of hazardous areas and the retirement of buildings in at-risk areas.

A planned obsolescence strategy can also be implemented where buildings and infrastructure located within hazardous areas are retired at the end of their useful lifespan rather than repetitively repaired, which may cumulatively cost more than replacement.

For DHHL, implementing an adaptive realignment strategy with both short- and long-term policy objectives and implementation strategies could offer substantial efficacy relative to achieving its mission to provide safe, affordable, and functional homesteads.

5.3 Hazard accommodation

A second strategy is ***hazard accommodation***, which involves adapting existing structures and systems to allow them to better withstand the impact of a coastal hazard. Elevating a structure by a foot or two above the base flood elevation is one way to accommodate flooding while ensuring the building remains functional. For instance, plantation-style homes are built on posts, that if securely anchored, could allow flood waters to flow under the building unhindered. Reorienting a building to be perpendicular to the shoreline rather than parallel to it can reduce the area of the building that faces the ocean and the surface area that must withstand the forces of wind, rain, waves, and water.

Adding hurricane clips that connect the roof to the rafters, and the rafters to the walls with metal brackets, will help prevent the roof from lifting and being blown away in a hurricane or under strong wind conditions. Creating a continuous load path, where the roof, rafters, walls, posts, piers, and foundation are all connected using metal straps like Simpson Strong-Ties can anchor the whole house and prevent it from being carried away by flood waters or blown apart by high winds and the vacuum and low pressure created by spinning coastal storms and hurricane force winds.

Reconfiguring an existing home is also a means of accommodation such as moving the kitchen to the inland, mauka side of the home, along with elevating expensive electrical appliances that can easily be damaged by seawater. Elevating the kitchen using posts and piers can make it cooler and more comfortable as prevailing breezes can flow under the kitchen flooring. Likewise, flood waters could flow under the kitchen without damaging expensive appliances like the stove, refrigerator, and electrical appliances if they are located sufficiently above ground. Waterproofing electrical outlets, placing electric lines in waterproof conduit or PVC pipes, and using breakaway walls in low-lying structures accommodates floodwaters without causing the loss of the building, especially if its post and piers are reinforced to withstand the force of waves or arranged so that debris cannot form a dam that places more pressure or stress upon the building's posts, piers, or upright beams.

5.4 Protection from coastal hazards

A third strategy is ***protection from coastal hazards***. This strategy can involve "soft" or "hard" techniques to respond to coastal dynamics and shoreline change. It is an intervention between the building or infrastructure to be protected and the sea. Soft techniques are intended to create a buffer to absorb or reduce the ocean energy reaching the shore, whereas hard techniques typically involve the placement of hard structures that are intended to refract or deflect incoming energy at a fixed location between the land and sea. In all cases human involvement, intervention, and maintenance of the protection is a necessary component of this strategy. Some forms of protection require more maintenance than others and each has its benefits and shortcomings. Shoreline protection should be tailored to the specific location and its risk or exposure profile, noting that combinations of protective strategies may be most effective.

5.5 Soft or nonstructural techniques

There are several natural responses to shoreline erosion, flooding, and coastal hazards. Building in harmony with natural shoreline processes is one of the most effective and efficient means of protecting inland assets. This approach, known as "living shorelines," is designed to achieve multiple, interrelated goals including:

- Stabilizing the shoreline to reduce shoreline erosion and storm damage;
- Providing ecosystem services by restoring habitat for fish, birds, crabs and shellfish, benthic organisms (infauna), limu, and aquatic marine life;
- Restoring native plants and propagating vegetation, typically by encouraging the use and maintenance of climate adapted, salt tolerant, drought resistant, and obligate submerged plant species;
- Increasing the capacity to store and stabilize flood waters until they recede; and
- Maintaining mauka to makai connections between terrestrial and marine ecosystems to enhance resilience and restore shoreline functions.

In designing a living shoreline, a first step is to identify what needs to be protected, its permanency, replacement cost, adaptability, and resiliency to perturbations, storms, and coastal hazards. To evaluate responses, it is important to assess the setting by understanding the shoreline energy conditions. A determination should be made if the shoreline is experiencing episodic, seasonal, or more long-term chronic erosion. For instance, is the erosion related to a singular storm or king tide event, or does the beach disappear intermittently only to recover the next season, or has the ocean consistently moved inland, year after year, submerging land and coming closer to buildings over time. These three forms of erosion (episodic, seasonal, chronic) can lead to a retreating shore, but their cause and response can differ. As such, it is important to capture long-term observations from people familiar with a particular stretch of shoreline, identify shoreline reference features, and review old, archived maps and photographs, to help identify changes in the shoreline's location.

Homesteaders should observe the location and extent of wave-driven versus wind-driven inundation in the shoreline and rear yard areas. Marking heights of flood water inundation and points of reference for later measurement is useful, particularly for immobile items such as large rocks or natural features that will not move over time. Trees may serve as reference points, but since they can fall or change over time it is better to use nonliving items as shore reference features.

Homesteaders should also observe the extent of inundation from high tide and king tides. Mark these areas for later reference and photograph them with immobile reference features and items of scale in the background. Note any barren yard areas, areas entrained with sand or coral fragments (versus pebbles or black stone) as the coral fragments indicate the inland extent of ocean water and waves. Scorched brown and yellow grass, white salt crystals on the top of dried soils, and barren areas are also indicative of seawater inundation areas. Areas consisting of compacted clay (red, rust brown) or alluvial soils should also be delineated since they erode differently than sandy areas. In some cases, sand may be 'perched' atop a harder lava rock or firmer clay/alluvial soil layer that may erode at a different rate.

5.5.1 Vegetative Buffers

Leaving a green, vegetated buffer strip of native vegetation between the ocean and vulnerable structures will stabilize the shoreline and reduce the risk of damage, property loss, and loss of life from coastal hazards. Shorelines exposed to higher waves and intense storms require a larger setback for buildings and habitable structures, and thus a wider vegetated buffer. For instance, a 50 feet wide buffer of grasses and reeds can absorb nearly half of all incoming wave energy in a coastal wetland or marsh (TNC, 2017). When coastal storms or hurricanes flatten this vegetation, they resurrect themselves shortly afterwards because they are pliable and adapted to the environment. This pliability contrasts greatly to the rigidness of man-made structures that can crack, shift, slide or be compromised by the force of the ocean.

Building with nature is often more successful than working against nature. For Molokai's south shore, it is important to use native plants that are accustomed to the harshness of the shoreline. Some native plants thrive in the harsh coastal environment where other plants wither and die. Special plants, called obligate wetland plants, can tolerate being dried out or totally inundated with salt water, while exposed to strong sunlight without dying. Sedges are a family of plants that have pliable stems with edges that allows them to deflect and absorb wave energy. Sedges are obligate plants that can grow in direct sunlight, which is prevalent along the project area's coastline. Two native species of sedge are ʻakaʻakai and kaluhā (UH, 2019). Both can grow in clay or sandy soils and in fresh or brackish water. Both are salt and sun tolerant with kaluhā being more drought tolerant. When planted 1 to 3 feet apart, their roots and shoots will spread out to form new stalks and plants with ʻakaʻakai forming one-foot-wide clumps and kaluhā forming mats of vegetation. Kaluhā is excellent for reconstructing natural Hawaiian wetlands, and its roots form a thick interwoven mass that helps prevent soil erosion and filters stormwater runoff preventing pollution from entering the ocean.

These species of plants may be appropriate on sheltered shorelines with low wave energy and an influx of fresh water provided by drainages, seeps, springs, and other similar features. They should be tested in locations near or down gradient of cesspools to evaluate their tolerance of a consistent influx of nitrogen and fresh water into these nearshore environments. Bivalves and shellfish may also grow well in nearshore areas that are brackish due to cesspool inputs, but they are not edible.

There are also unique plants that have adapted to Hawaiʻi's hot, dry, sunny, salty, and windy coastal environment and can be used to restore sand dunes. Dune restoration plants have shallow roots that quickly spread horizontally (rhizomatic) rather than extending deep into the ground. The stems and leaves of the plant capture windblown sand grains which are then covered by the plant's quickly spreading roots. The accumulated sand forms a mound or dune that serves as a reservoir that resupplies the beach with sand during storms and large wave events. These sand reservoirs are built up in the backshore area and remain covered in vegetation until large waves eat into the dune and pull stored sand down onto the wet beach and spread it along the shore. This makes the nearshore waters shallower, which in turn causes waves to break further offshore and reduces their erosive energy.

Sand dunes also prevent storm surge from flooding inland areas by forming a berm that is slightly higher in elevation than the surrounding area. Sand berms also block sediment laden stormwater coming from mauka areas from entering the ocean. The berm slows the water, so it ponds, and silt, dirt, debris, and rocks settle and are filtered before the water enters the ocean.

5.6 Plants

The native dune friendly plant species listed below could help to restore Molokai's south shore. Table 5.1 provides a summary of each plant.

The plants are viewable at https://www.forestryimages.org/browse/ and Bugwood.org from photographs taken by Kim Starr or Starr Environmental, Maui, Hawaii.

ʻAkiʻaki grass has shallow roots that spread quickly on sandy shores and sand dunes. The grass captures windblown sand and spreads new roots over the captured sand to build up a reservoir in a berm. The sand remains in place until large waves expend their energy by pushing and/or pulling the sand into another shape and morphology. It is best to plant near the end of the rainy season so it can be well-established before the hot, dry, summer months. The grass can collect sand burs.

Source: *Forest and Kim Starr, Starr Environmental, Bugwood.org*

Pōhuehue or beach morning glories have extensive runners (rhizoids) for roots that hold sand, berms, and dunes in place. The runners retreat or creep seaward naturally in response to waves and tide action. The plants grow easily but need drip irrigation to start. Drip irrigation lines can be patterned for the landscape and there should be one keiki plant per drip hole. The plants can have purple or white flowers depending on the species selected and both do well for restoration.

Source: *Forest and Kim Starr, Starr Environmental, Bugwood.org*

Naupaka is better suited for the backshore area and can grow profusely once established. It is saltwater and salt spray tolerant. Naupaka also captures floatables such as driftwood and human induced pollution such as styrofoam and plastics which become entrained in their stocks and roots. Naupaka hedges have been artificially induced through irrigation to grow seaward and down the beach face, thereby limiting shore access, which is prohibited by the State.

Source: *Forest and Kim Starr, Starr Environmental, Bugwood.org*

‘Ākulikuli is a native plant that readily grows along the shoreline in salt laden environments. The plant needs salt spray to thrive and needs inundation by fresh or brine waters. It can also grow on hard packed clay and alluvial soils. This low ground cover has very succulent green leaves with bright red stems and purplish pink flowers that can be used for lei. It is one of the most salt-tolerant of all coastal plants, and is an excellent ground cover for beach areas, saline soils, xeric landscaping, and in and around water features. It should not be confused with pickleweed (‘Akulikuli kai) an introduced competitor species.

Photos: *Native ‘Ākulikuli (left) and Non-native pickleweed (right)*
Sources: *Forest and Kim Starr, Starr Environmental (left) and Bryan Harry, NPS (right).*http://www.botany.hawaii.edu/basch/uhnpscesu/htms/kahoplnt/fish_pops/bataceae/plant01.htm

Pōhinahina leaves smell like sage or spice when crushed. They have bell-shaped flowers with blue violet corollas and the plant attracts butterflies and caterpillars. It is an indigenous plant that can grow into a shrub. It is naturally found on sandy beaches, rocky shores, and dunes on most of the islands to about 50 feet above sea level.

Source: *Forest and Kim Starr, Starr Environmental*
http://www.starrenvironmental.com/images/

Ilima forms an excellent groundcover and shrub for open, sunny and/or windy coastal areas. Its leaves range from one-half inch to over 5 inches long and can be glabrous (without hairs) to very fuzzy. The plant has small yellow flowers that are not fragrant but are attractive in the landscape.

Source: *Forest and Kim Starr, Starr Environmental*
http://www.starrenvironmental.com/images/

Naio is a fast to medium growing landscape shrub or tree. It can grow to 5 or 6 feet tall in a few years. It does not require much care after the plant is established. They form hardy shrubs that can tolerate both dry and moist conditions and have a near continuous flowering period followed by colored fruits. Flowers are small and white or white with light to dark pink or lavender centers.

Source: *Forest and Kim Starr, Starr Environmental.*
http://www.starrenvironmental.com/images/

Bulrush are sedges that consist of round dark green stalks that range from 8 to 10 feet tall. The stalks are buoyant and grow directly in the water and in full sun. They can grow into clumps and form thick mats of pliable vegetation. The stalks absorb wave energy and can buffer storm surge. They are excellent for reconstructing natural Hawaiian wetlands and provide habitat and food for waterfowl. The California bulrush, *Schoenoplectus californicus,* shown below is common in Hawai‘i.

Source: *Forest and Kim Starr, Starr Environmental.*
http://www.starrenvironmental.com/images/

Milo can be found growing naturally at the high tide line above mangrove and at the top edge of the sandy beach berms. They can readily tolerate seawater and occasional tidal inundation as well as wind and salt spray. Milo offers shade and can grow 30 to 40 feet in height. The trees produce leaf litter and dry seed capsules year-round. However, these seeds tend to be soft and not hard on bare feet.

Beach Heliotrope is a woody plant with a trunk. It has shallow roots that help hold sand in place, even during episodic erosion events. The tree does not grow very tall and often forms gnarled, intertwined branches that when combined with its broad leaf foliage, can offer shade along the shore. The leaves and stems contain a milky sap that attracts Monarch butterflies, and they can often be observed alighting on the Milo tree's leaves and stems. The trees are salt tolerant and grow well in arid, windy, sunny, coastal environments.

Source: *Forest and Kim Starr, Starr Environmental.* *http://www.starrenvironmental.com/images/*

Seashore paspalum grass or Paspalum vaginatum is a warm-season perennial (long-lasting) grass that spreads by stolons or runners to enhance its growth. It thrives in salty, sandy environments and is commonly observed in landscaped parks and lawns for oceanside lots. However, because of its thick root system it can cover, obscure, or hide erosion impacts such as sinkholes and under scour occurring under its surface. It is not recommended for areas immediately inland of shore armoring but is commonly used given its ease in maintenance and comfort underfoot.

Source: *Forest and Kim Starr, Starr Environmental.* *http://www.starrenvironmental.com/images/*

Kiawe trees are a non-native, invasive species. They displace native species and have an adverse impact on soils and hydrology. They can artificially hold soils along a coastline which contributes to the formation of escarpments or embankments. When the embankment becomes too steep or soft, the trees slump seaward and can become hindrances to access along the shoreline.

Kiawe accumulate nitrogen in their roots and trunk. When the tree is removed, this nitrogen store can serve as an available fertilizer for new young plants. As such, removing the tree and replanting with native drought tolerant plants can be successful. The dead dried wood makes for exceptional barbeque charcoal and has a pleasant scent for cooking. Removal of kiawe is advantageous for the coastal environment, its use, and its ecology.

There are both male and female trees. The tree has high rates of evapotranspiration, meaning that it pumps out more water from the ground than it uses only to discharge the groundwater withdrawn into the air. The tree's action dries out the soil making it harder for native plants to grow. This competitive advantage created by damaging the natural hydrology of the soil creates long-term damage to our groundwater supply and native ecosystem. In addition, the males grow long thorns that can easily pierce the bottom of shoes, boots, and flipflops making for a painful experience when walking along the shoreline.

Photo: *An invasive kiawe tree along Moloka'i's southern shoreline.*

Table 5.1: Dune & Coastal Friendly Plants

Names	Scientific Name	Specifics	Planting notes
ʻAki ʻaki grass Dropseed Indigenous	*Sporobolus virginicus*	Drought tolerant roots spread quickly, with leaves and stems that capture windblown, and wave pushed sand to form dunes and berms. Prevent foot traffic so fragile roots are not trampled.	Prefers moist conditions until established. Plant stolons or plugs 4 to 10inches apart to allow room for the grass to grow and the seeds to regenerate themselves.
Pōhuehue Blue beach morning glories Indigenous	*Ipomoea pes-caprae subsp. brasilinsis*	Good plant for beach front properties, and sandy, rocky, salt-spray or windy locations. Provides erosion control with vines that quickly adapt to tide variations. Vines spread 7 to 15 feet and have attractive pink to lavender flowers with purple centers.	Water for two weeks then only in times of prolonged drought. Allow room for the vines to spread. Will form a dense groundcover. Can be susceptible to pests including slugs, snails, sweet potato weevil, red spider mites, and leaf spot disease fungus.
Hunakai White beach morning glory Indigenous	*Ipomoea imperati*	Once plants are well established, water only in times of prolonged drought. The plant has bright white flowers with a yellow, occasionally purple, throat. Its vines spread 7 to 15 feet.	The vine requires plenty of room to spread, is easy to grow and maintain, and stays very low to the ground. Prefers full sun, brackish and salt water, sand, or coral. Very drought tolerant.
Naupaka Indigenous	*Scaevola taccada and gaudichaudiana*	The xeric plant requires minimal maintenance and watering. Plants can form a hedge and serve as a windbreak against prevailing sea breeze. The shrub tends to capture floatable trash in its thick leaves and stocks.	Coastal naupaka kahakai is often planted on the makai side of the house and naupaka kuahiwi on the mauka side. Plants prune well, growing back thickly at cut branches and twigs. Best to hand prune.
ʻĀkulikuli Sea purslane Indigenous	*Sesuvium portulacastrum*	One of the most salt-tolerant of all coastal plants, it forms excellent ground cover for beach areas, saline soils, clay soils, and coastal wetlands. A short, ground cover plant that spreads from 1 to 4 feet or more in width. Full sun is optimal but tolerates some shading for part of the day. The plant can tolerate a limited amount of foot traffic.	Once established, water only in times of prolonged drought. This groundcover will grow in moist or wet conditions, such as coastal wetlands, and can tolerate periods of complete inundation or dry out. Space 6 to 12 inches apart and the plants will grow together forming a nice groundcover.
Pōhinahina Beach vitex Indigenous	*Vitex rotundifolia*	Forms low medium sized shrubs 6 to 8 feet wide with a height to width ratio of 1:2. Its leaves are aromatic with a sage-like spicy odor when crushed. It has bell-shaped flowers with blue violet corollas (petals). The flowers and pungent leaves are used today in lei work. The plant attracts butterflies.	Allow a lot of room to spread. Out plant with ʻaʻaliʻi and native trees like wiliwili or naio. The plant prunes well, forming thick hedges or ground covers. Under very wet conditions or prolonged rainy periods a leaf rot fungus or powdery mildew may appear but usually will clear up when water decreases. Plants should be spaced between 2 to 4 feet apart.
ʻIlima Indigenous	*Sida fallax*	A low shrub with a 4-to-8-foot spread. Excellent groundcover for open, sunny and/or windy coastal areas. Has bright yellow, orangish small flowers that bloom year-round and attract pollinators. Pruning encourages new growth but avoid pruning severely.	Do not locate near automated sprinklers since heavy watering can lead to fungal rot and/or black sooty mold that will affect its health and vigor. They should be planted 3 to 6 feet apart.
Naio Bastard Sandalwood Endemic	*Myoporum*	The plant prefers very sunny, dry locations. Reduce watering after established. Poor drainage and damp soil will eventually kill these plants, which favor arid conditions. Flowers are small and white or white with light to dark pink or lavender centers.	Plants are prone to ants, scale, mealy bugs, spider mites, and aphids. The shrubs should be spaced 3 to 6 feet apart.
Kaluhā Bulrush Indigenous	*Bolbchoenus maritimus*	Grass-like sedge that grows 2.5 feet tall, in soils with pH of 6.0-9.0 in fine clay, silty loam, or sand and is tolerant of alkaline and saline soils. The roots form a thick interwoven mass that helps with soil erosion in wetland sites and filters waste from the water. Excellent sedge for reconstructing natural Hawaiian wetlands.	After plants send up foliage, flowers and setting fruits, it then dies back partially or completely year-round. Use caution when harvesting seeds as they have small hairs that irritate the skin, inducing a rash-like sensation and appearance. Provides a food source and shelter for native waterfowl.
ʻakaʻakai Bulrush Indigenous	*Schoenoplectus tabernaemontani*	The stalks of this bulrush range from 8-10 feet tall and are buoyant. They are good for visual screening or as a hedge in water features. Best grown directly in the water and in full sun but can tolerate some shade during the day. Excellent for wetland restoration and can dissipate wave swell energy.	Plant in clumps of at least 1 foot wide to ensure there will be sufficient shoots (rhizomes) to spread out and form new stalks. Space clumps of plants at least 1-3 feet apart and they will grow together at a slow to moderate rate to form a dense mat.
Portia tree Milo	*Thespesia populnea*	Milo is easy to grow and care for, but it drops numerous leaves and dry seed capsules year-round. They can be found growing naturally at the high tide line above mangrove but can tolerate an occasional brackish water tidal inundation. Milo can tolerate wind and salt spray.	Milo has a nice spicy fragrance when freshly cut, disappearing when carved into finished wood products. The trees canopy creates shade along the beach and back shore. Milo means to twist, curl, or spin.

Source: www.nativeplants.hawaii.edu

5.7 Coir

Coir is often used to restore and build living shorelines. Because it is a natural material it is far better for the marine environment and does not pollute the ocean. It consists of coconut fiber woven material that is heavier and coarser than burlap but somewhat similar in texture and color. Coir itself has minimal structural strength, but it can be effective at retaining soils, sand, and sediment and helps planted vegetation become established to hold sand and sediment in place. Coir is useful for gentle slopes and mounds. It can be placed as a mat over an area to be planted, rolled down over the face of a slope or embankment, fashioned into logs or tight rolls to form toe protection at the bottom of a stabilized slope, or laid out flat with the ends wrapped around a sand center and woven together to form a sand-filled tube or so-called burrito. Coir comes in bags, tubes, mats or blankets, and rolls. Coir can be used in dry areas where plants will be installed, and it helps encourage the plants rhizomatic (horizontal) root growth that holds sandy soils and sediment in place. Drip irrigation lines and vegetation should be placed atop the sand covering the coir material. Individual drip tanks can be used where there is an absence of hose bibs or an irrigation water source.

Coir mat consists of a chemically treated woven coconut material which decomposes into organic materials. The material should be covered with sand and not directly exposed to sunlight or inundated with water as this will cause the coir to deteriorate much more quickly. The longevity of coir is typically greater in areas where its placement is protected by fringing reef, reef shelves, rocky headlands, sills, remnant fishpond walls, wetlands, marsh, dry sandy beach, or higher elevation beach flats. The life of coir can be extended by placing it where the coir material is not exposed to direct sunlight and not subject to erosion from tides and waves, and where it is seldom inundated or soaked by seawater. Similarly, the placement of coir and its orientation to the prevailing wind direction should be accounted for in design so that loose sand covering the coir material is not easily blown away, thereby exposing the coir to sunlight. Groundwater seepage can also cause coir to degrade more quickly than planned, but wave and seawater exposure, and exposure to direct sunlight, are typically the main things that degrade coir materials. To extend the life and function of coir, it should be kept dry and out of direct sunlight.

Photos: *Examples of a sand-filled coir 'burrito' at King's Park, Newport, RI*
Photos courtesy of Janet Freedman (TNC, 2017).

5.7.1 Bank Stabilization

An embankment along the shoreline can be indicative of coastal erosion or it can be a natural berm that separates the coastal plain from the active beach, shore, and surf zone. Natural coastal bank protection can be restored for most tide ranges, topographic slope, or sand grain size, provided that the toe of the embankment is situated above the mean high-water mark where it will not be regularly inundated by seawater, currents, or wave action. Coir rolls can be used to help protect the toe of the slope from erosion and reinforce the embankment's stability. However, they are most effective in areas with higher beach elevations, with some dry beach at high tide, and where the rolls are not constantly subject to erosion from tides and waves. Installing coir rolls at the toe of a bank stabilization project can provide increased stability while the vegetation becomes established. For larger areas, natural fiber blankets can be placed on the face of an embankment above the coir rolls, covered with sand, and planted with native, salt tolerant grasses and shrubs. However, the rolls, blankets, and vegetation require ongoing maintenance, such as resetting, anchoring, or replacement, to ensure their success. Coir rolls should be securely anchored, such as with wooden stakes, to prevent the roll's dislodgement by waves and/or tidal action.

Care should be taken in designing embankment stabilization to consider upland stormwater runoff and groundwater flows when using coir along an embankment's face or along its toe. Excess stormwater or subsurface ground water flows can create hydrostatic pressure that can push tightly woven coir away from an embankment's surface if the coir is not properly anchored, fastened, or secured. Sediment or loose sand may be required as fill to cover coir material and to establish a stable slope and angle for an embankment. Coir rolls are typically 12-20 inches in diameter and 10-20 feet long. They are packed with coir fibers and held together by mesh, and they can be pre-vegetated to get a head start on the plant growing process. A high-density roll may be necessary at the toe, while lower-density rolls could be used on the face of the embankment or slope above. Wooden stakes for blankets, earth anchors for rolls, or a combination of the two may be necessary to anchor the system.

Salt-tolerant, climate adapted native vegetation with extensive root systems are best and should be used in conjunction with coir fiber rolls to help stabilize a site. Natural fiber coir mat blankets can be used to stabilize the ground surface while plants become established. It is recommended that coir blankets be run up and down the slope rather than horizontally across it. As the coir rolls disintegrate, the plants take over the job of bank stabilization as their roots grow into an interconnected network to capture and hold sediment, sand, and sandy soils. Native plants growing on the berm or embankment should respond naturally to the ebb and flow of the ocean through changes in tides and seasons. For example, beach morning glories will extend runners and stems seaward during dry periods and will quickly rescind their leaves and stems when regularly inundated with seawater.

If an embankment's slope is too steep or is undercut it may fail, slide, or sluff due to wave and wind action, especially erosion of the toe of the embankment. For this reason, a slope should be dressed and groomed, so that it is not too steep before covering or reinforcing it with coir materials and planting it with native vegetation. To reduce the angle of the slope to a gentler grade, it is best to regrade it by removing sediment and material from the top of the embankment rather than adding sediment to its toe, since the upper slope rests upon the toe, which is more susceptible to erosion. The plants should not be exposed to stormwater runoff from adjacent yards that could erode away the plants, soils, and materials during heavy rainstorms.

The ends of the extent of coir rolls should be carefully designed to minimize any redirection of waves onto adjacent or down drift properties. Tapering the rolls down in number and height where they end so that they blend with the topography or mirror adjacent grades and stabilized banks can help address this problem. If pavement, driveways, lanais, or lawns extend all the way to the edge of the top of the embankment, they may have to be cut back or repositioned inland, otherwise the bank may become too steep and fail or slump. The weight of concrete or asphalt atop a sandy berm can artificially hold the sand in place causing scarping and bank erosion to occur more quickly than a naturally maintained slope and crest. Proper maintenance of a vegetated buffer using native plant species between the back yard and the edge of the embankment will help minimize and mitigate bank failure and loss. Creating and maintaining a vegetated buffer using rhizomatic plants with spreading root systems will help prevent the loss of sand and sediment resulting in more stable conditions that reduce the chance that the embankment may slump or collapse.

Planted vegetation and weed control is necessary at first. The vegetation should be monitored monthly throughout the growing season to ensure plant success. Temporary irrigation by hand, using jugs, or drip irrigation lines may be necessary until the native, drought tolerant species become firmly established along the face of the embankment and preferably along its toe. The coir material should be inspected seasonally, at least twice a year, and after any storms, high waves, heavy rain events, or king tides, especially during a full moon. Regular, ongoing maintenance is often needed, including replanting barren or denuded spots. It may also be necessary to retighten the fiber roll and the coir mat, coir blankets, or their anchoring system after severe weather events.

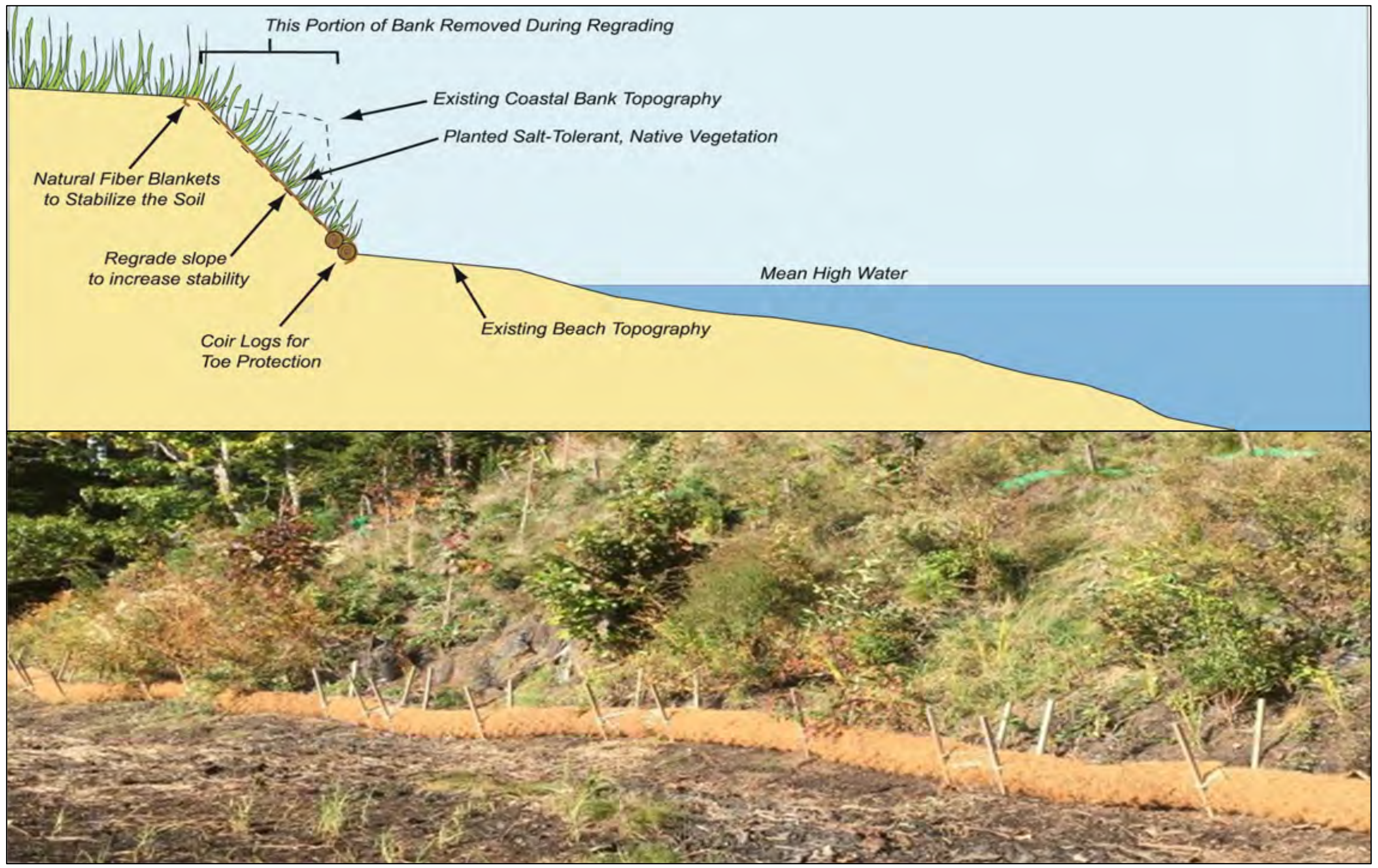


Figure 5.1: *Conceptual and actual bank stabilization using coir rolls.*
Source: *Bustins Island, Freeport, ME. Photo courtesy of Troy Barry (TNC, 2017).*

5.7.2 Reinforced Sand Berm

In conducting site investigations of the DHHL homestead subdivision there were no primary sand dunes observed. A primary coastal dune is protected under the County's grading ordinance. Primary dunes are the first sand mound that extends along or parallel to the shoreline, such as those that are visible along Pāpōhaku Beach on the Island's west end. Despite the absence of primary sand dunes at the DHHL homesteads, sandy berms are present that rise slightly above the coastal plain before descending to the beach and into nearshore waters. Berms were present along the back yard of some homestead lots and areas that had not been graded or altered from their natural state. For instance, sandy berms are evident along the makai edge of Ali'i Park.

Sandy berms play an important function in protecting the coastal plain and ecosystem. They allow for the capture, ponding, filtering, and percolation of upland storm water runoff in the back shore, which reduces water pollution and helps improve water quality in the 'ice box' nearshore. Sandy berms also protect the coastal plain from wave inundation and flooding. Naturally, some king tides or large wave events over a year may overwhelm the crest of the berm, but then the wave loses its energy as it spreads over the coastal plain. Figure 5.2 below shows how coir can be used to reinforce and help build a sandy berm to emulate a sand dune's natural morphology and beneficial properties.

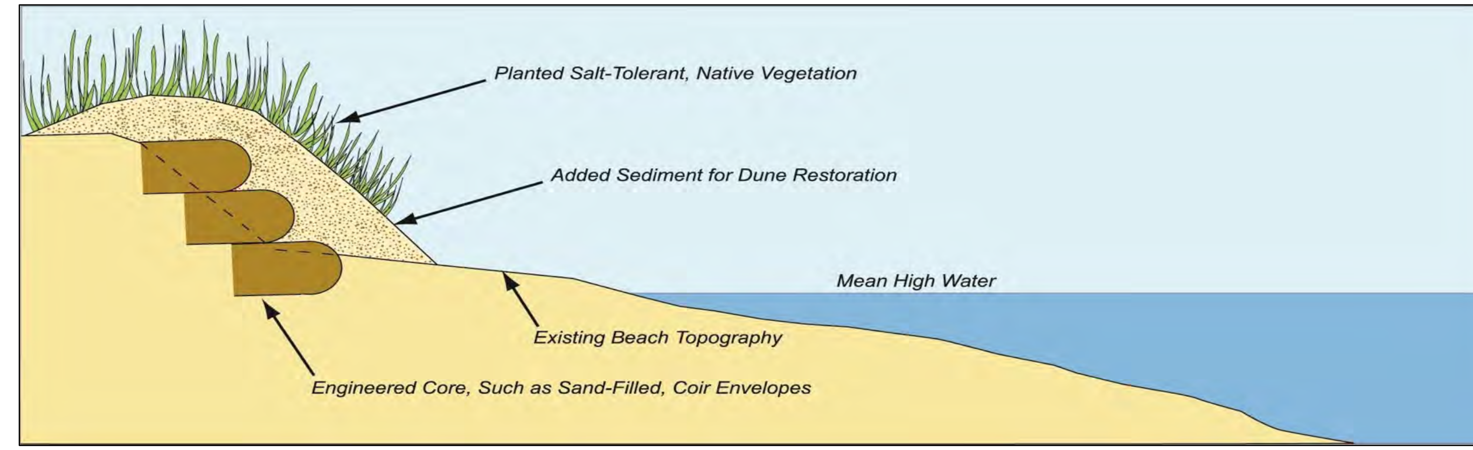


Figure 5.2: *Diagram of a sand berm or embankment reinforced with a sand-filled coir burrito (TNC, 2017).*

A number of lots in Kamiloloa had low spots in their yards that were lower than Kamehameha V Highway, and lower than the oceanfront edge of the property, suggestive of a berm. Berms are a physical feature usually located mid-beach and characterized by a break in the slope, separating the flatter backshore from the seaward-sloping foreshore (Norcross-Nu'u, Fletcher and Abbott, 2008). Berms can also be described as a terrace formed by wave action, or a mound or accumulation of sand and/or aggregate. The backshore is generally a dry portion of the beach between the berm crest and the vegetation line that is submerged only during very high sea levels and eroded only during moderate to strong wave events.

Constructed berms are a form of green, soft structure that can respond naturally to shoreline retreat, particularly where wave energy is low to moderate. They emulate a sand dune but are not as large, nor take as much space, as a primary sand dune.

Photo: *Sandy berm with a sand-filled coir burrito before planting at Kahana Bay, Maui, HI.*

For lots in Kamiloloa, coir mat, sandbags, or coir burritos could be placed on top of the embankment or along the seaward edge of the rear yard and covered with sand and then vegetated with native plants. They can be stacked atop one another (3-2-1 or 2-1) like a pyramid or as a wedge against an erosion scarp or embankment parallel to the shore to form a single, continuous berm.

Any opening in the berm would allow waves or seawater to inundate and spread out behind the berm, potentially eroding the mauka portion of the berm as wave surge and swash is pulled back towards the ocean. This type of flanking erosion can also occur at the ends of coir reinforced embankment if not properly designed or protected. If an opening is required, then it should be offset between two overlapping rows of the berm and face opposite of the prevailing wind direction, as wind can displace sand easily. Artificial berms should be constructed behind embankments and as far mauka as feasible, while close enough to the shore to serve as a sediment reservoir during an extreme storm event.

The ends at the extents of coir rolls should be carefully designed to minimize any redirection of waves onto adjacent or down-drift properties to prevent end scour. Tapering the rolls down in number and height so the project blends into the adjacent landscape, will help address this problem. Ending coir at rocky outcrops or headlands is also recommended, especially if there is risk to the coir of being cut by rocky substrate or rocks tossed, turned, and moved by wave action.

5.8 Sand Dune Restoration

Sand dune restoration relies on the importation and placement of beach quality sand to compensate for sediment lost from the littoral cell. The sand must be of similar grain size and color, as well as free of silt, clay and other of contaminates that could pollute nearshore waters if washed into the ocean.

A sand dune is a reservoir of sand to buffer, absorb, and reduce a coastal storm's erosive energy. The dry dune holds sand for when it is needed during storms and large wave events. During these extreme events, incoming waves draw the sand out making the nearshore area shallower which causes the waves to break further offshore thereby reducing the wave's energy when it reaches the shore. Over time the sand dune is rebuilt by currents, wind, and wave action pushing the sand up and into the backshore provided that native plants remain to help capture the grains of sand that build the dune. Planting the dune with native, salt-tolerant vegetation that can quickly grow an extensive root system will help hold the sediment in place untilit is needed. The plant's roots extend seaward to capture sand pushed up the slope by seawater and rescind back up the face of the dune when inundated with saltwater. Through this natural process of vegetative growth and die back, the dune grows higher, wider, and remains in equilibrium with the coastal environment. Pāpōhaku Beach on Molokai's West End has natural sand dune formations that reflect this natural phenomenon.

Sand dunes can be created by placing compatible sand or sediment on an existing dune, or by building up a mound of sediment at the back of the beach to create an artificial dune. The sand dune is intended to be sacrificial; its contents will erode away but will buffer and absorb wave energy that would otherwise not be dissipated. Sediment (i.e., sand) can be brought in from an offsite source, such as a sand pit, land being graded for development, offshore depression, stream mouth, drainage outlet, or a coastal project such as a harbor dredging or clearing of a stream mouth. However, the sand must be sufficiently clean and coarse enough for the location, and sieve analysis and grain size tests should be conducted. There are also important cultural considerations that need to be evaluated before moving, relocating, or reusing sand in this manner.

Because the roots of sand-tolerant plants are fragile, they can easily be crushed by foot traffic. Therefore, directing access paths and shore users with signage and low impact roped pathways is highly recommended. To prevent blow out of the dune sand, pathways should be oriented at an acute reverse angle to the prevailing wind direction, or the path should approach the shore from behind the dune and use a wooden cross over to bridge the dune. A beach or shoreline access path should never face directly into the wind, as this will cause a loss of the placed sand and deflation of the dune's volume. Sand fencing can also be installed to trap windblown sand to help maintain and build the volume of a dune. The use of educational illustrative placards, signs, marked and delineated footpaths, fencing, and wind-fencing all help to protect the vegetation that naturally covers and holds the dune's sand and sediments in place.

The seaward slope of the dune should be less steep than 3:1 (base to height). Dunes with vegetation perform more efficiently than dunes without vegetation, ensuring stability, greater energy dissipation, and resistance to erosion. Dunes planted with native plants can provide significant wildlife habitat, such as nesting sites for turtles and wedged-tail shearwaters, a seabird of cultural significance. The height, length, and width of a dune relative to the size of the predicted storm waves and storm surge determines the level of protection the dune can provide.

Dunes typically erode during storm events. Plants should be replaced if they are removed by a storm or die. In areas with no beach at high tide, dune projects will be short lived as sediment is rapidly eroded and redistributed to the nearshore. The added sediment from dune projects supports the protective capacity of the entire beach system (i.e., dune, beach, and nearshore area). Any sand eroded from the dune during a storm, supplies a reservoir of sand to the fronting beach and nearshore area. To maintain an effective dune, sediment may need to be added regularly to keep the dune's height, width, and volume at appropriate levels.

Dunes dissipate wave energy rather than reflect it like a seawall does. A sand dune serves as a barrier to storm surge and prevents flooding of buildings and structures located inland by reducing over wash events. Sand dunes are one type of living shoreline and are important to preserve.

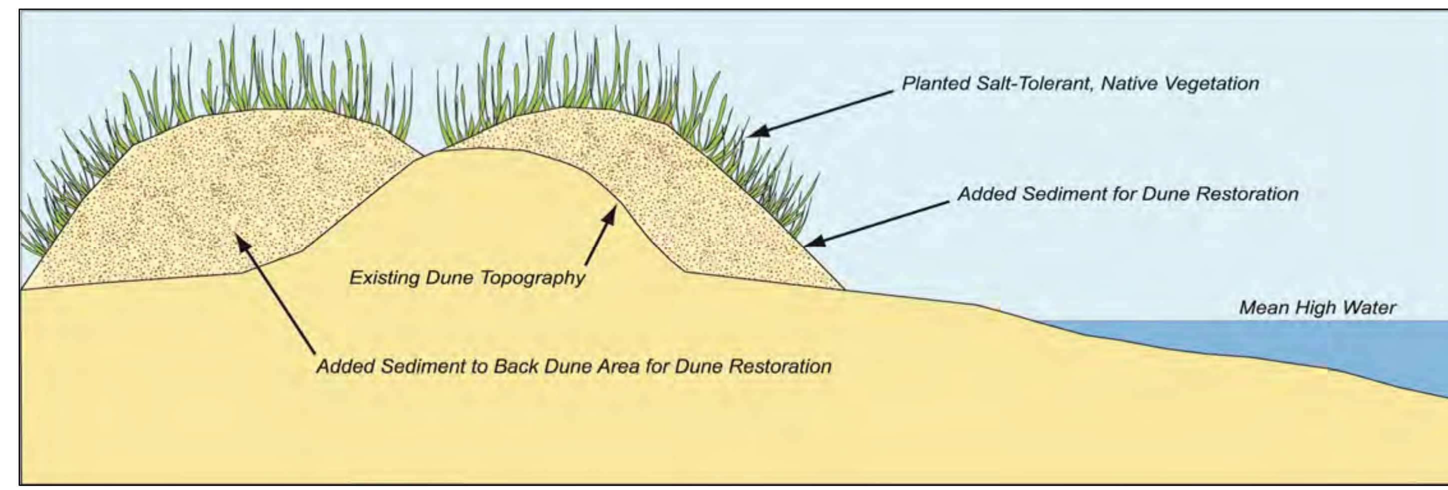


Figure 5.3: *Conceptual diagram of a restored sand dune (TNC, 2017).*

5.9 Beach Restoration

Beach restoration and beach maintenance are the only management tools that serve the dual purpose of protecting coastal lands and preserving beach resources (Beach Management Plan, 2008). Beach restoration can provide erosion protection as well as enhance recreational resources. The sand helps to buffer erosive waves by absorbing and dissipating wave energy while enlarging the amount of dry beach area available for users of the shoreline. Beach restoration can address erosion on a regional littoral cell basis rather than a property-by-property basis. Regional littoral cell approaches to beach restoration tend to be more proactive and effective at protecting beach assets than property-by-property approaches. Beach restoration involves the placement of sand as fill, with or without supporting structures, along the shoreline to widen the beach.

In Hawaiʻi, these efforts amount to either beach restoration or beach maintenance (HSBPA, 2015), as listed below.

1. Beach Restoration

- Using land-based sand resources (e.g., offsite grading).
- Using sand dredged from offshore deposits.
- Beneficial reuse of sediment, such as from a harbor or stream mouth clearing project.

- Sand imported from outside Hawai‘i (although imported sand is no longer permitted to be used on State submerged lands or beaches).

2. Beach Maintenance

- Sand back-passing (recycling) from an area of seasonal beach accretion to an area of seasonal beach erosion.
- Sand pushing or beach scraping to rebuild back-beach volume or dunes using seasonally accreted sand from lower on the beach profile.
- Dune restoration using borrowed sediment (including sand) and other measures such as revegetation with native species and dune fencing to capture windblown sand.

While beach restoration is a favorable method of shore protection, it may not be appropriate at all locations. The chance of beach restoration success is much higher for embayed shorelines (coves, pocket beaches) than for straight or convex (curved outward) shorelines, unless structures such as groins are used to simulate the effect of headlands to retain the sand. Beach restoration may not be appropriate for areas with sensitive marine ecosystems such as coral reefs or locations where the sand may fill holes in the reef and damage habitat for tako (octopus) and other marine life. Additionally, water quality and marine life surveys are important before, during, and after sand placement to determine whether any negative impacts arise from the addition of sand.

Photo: *Vegetated dunes provide a reservoir of sand at Kama‘ole Beach Park I in Kīhei, Maui.*

Hawai‘i’s white sandy beaches are made of carbonate sand, which is derived from skeletal components of marine organisms such as coral, algae, crabs, shells, and mollusks. A considerable amount of sand is also produced by herbivorous fish as they graze upon algae within corals. A mature parrotfish or tang can contribute several pounds of sand a year and thus efforts to increase their abundance and longevity should be encouraged to help restore sandy shores and beaches.

Sand used for beach restoration should be compatible with the existing sand on the beach. Due to the sensitive nature of marine life, it is important that sand for beach restoration be as close as possible in size and composition to the existing sand on the beach, and that it be as clean, and free from silt and clay as possible.

Silt and clay can cause brown sediment plumes to form when they enter the water and can be harmful to corals and marine life. To prevent this, a sieve analysis of the existing native sand and the proposed sand fill is required, and the two must be comparable, before sand can be placed along the coastline. The State of Hawai‘i DLNR OCCL strictly regulates the size, color, quantity, and quality of sand used for restoration purposes and Maui County’s Department of Public Works regulates the coarseness and quality of sand placed as fill in the shoreline area.

The sand chosen to be placed on a shoreline must have sand grains that are equal or greater in size than the existing sand on the beach to prevent it from washing away. The sand must be clean and coarse because silt and fines within placed sand or fill can pollute nearshore waters and damage coral reefs. The volume of sand fill or the amount of sand placed along the shore should be calculated to represent an optimal beach width, noting that sand dunes are typically 20 to 30 degrees in angle. Care should be taken to emulate previous beach widths and profiles. Historic beach widths and profiles can sometimes be estimated by comparing the current vegetation line or wet/dry line to previous beach widths as determined through an analysis of data gathered through traditional ecological knowledge, empirical observations, archived maps, and old site or aerial photographs. The information gathered through these sources is compared to immovable shoreline reference features such as headlands, rock formations, and large mature trees to identify the location of the existing shoreline relative to historic shorelines. Adding plants can help retain placed sand and sediments. However, the use of soil may be restricted and any sediment used should be carefully monitored so that it does not wash off or pollute the ocean, nearshore waters, and nearby coral reefs.

5.10 Sills & Edge Reinforcement

A sill is a mound of rocks, stones, or boulders placed in linear fashion along the edge, or in the shallows, of the shoreline. The rocky sill is backed by an expanse of reeds, tall grasses, or marsh vegetation that can thrive when regularly inundated or submerged by high or king tides. Structures and back yard areas that are actively used must be located inland or mauka of the vegetative buffer.

The rocky edge (i.e., sill) prevents erosion by interrupting swell energy and protects the vegetation from scour, whereas the vegetation absorbs wave energy. For instance, a 25-feet wide reed bed can diminish nearly half of the incoming wave energy in a salt marsh, due to the flexibility of the stocks of the plant, the proximity of the stocks to one another, and the diffusion of energy that occurs when waves flow around the stocks of the plant. Capitalizing on this feature, sills create a sort of energy sponge or shock absorber along the coastline. They can act like a curb stop or speed bump to incoming waves.

Sills are useful in low to moderate wave energy environments. Gaps or offsets in the rocky edge can increase tidal exchange, seawater inundation, and habitat connectivity much like a gate in a fishpond. The size and placement of the stones should be such that they form an immovable mound, or trapezoid, but not a wall as this would tend to reflect wave energy. The top of the mound should not be so high as to limit inundation of the vegetation during high tides. The location of the rock sill should be between low and high tide lines such that the toe of the sill is exposed during low tide, but the mound is not high enough to be exposed at high tide.

A rocky sill can also slow or displace stormwater drainage or interrupt the discharge of sediments that are carried from upland areas to be discharged offshore or through tongue and spur reef formations. Sills may not be appropriate in locations where upland storm water flow is excessive, heavy, or carries a high sediment load, as the sediment can quickly build up within the vegetation bed behind or mauka of the sill preventing its plants from being submerged.

Photo: *An example of a vegetated sill. Source: North Carolina Coastal Federation.* *https://www.publicradioeast.org/post/living-shorelines.*

Sediment can also accumulate just inland of the sill reducing its effectiveness, if not maintained or properly designed for the shore's morphology. A rocky sill should not be placed so low on the shoreline as to become buried in accumulated sediment as this would reduce its efficiency and effectiveness. Ideally, the plants behind the sill biodegrade and stabilize accumulated sediments to keep the system in balance. Stones, rocks, coral, and/or large coral fragments can be used as the base material for the sill.

Gaps within the line of rocks forming the sill may be necessary to allow for access between the dry land and the ocean. Any gaps for foot trails or small boat access should be offset from one another so that waves and water cannot enter the backshore area directly, as this would allow for scouring and contribute to flanking erosion behind the sill. Access points should be consolidated to reduce degradation of the vegetation behind the sill and the sill itself. Typically, the access point should be oriented at an obtuse angle to the prevailing wave and wind direction to reduce the risk of damage by strong wind or waves.

Installing a sill may require more land area than hardened approaches to shore armoring. Sills also may not provide protection during large storm events. However, they do provide a more naturalized response to shoreline erosion, and they are more resilient than seawalls and bulkheads. Establishing vegetation successfully can be a challenge, especially if invasive species compete or are prevalent at the site. Ongoing monitoring and management of the sill is recommended. Coastal storms can displace the sill and knock over stands of plants. However, dislodged clumps of plants can resurrect themselves and turn upright after a few weeks with minimal help or intervention.

5.11 Gabions & Mattresses

Gabions are metal baskets filled with coble sized rocks or stones. Gabions are often shaped like a cube and can be stacked upon each other along the front edge of an embankment to help protect it from erosion. Stones, rocks, coral, and/or large coral fragments can be used as the fill material for the gabion basket. A typical stainless-steel gabion basket is three cubic feet (3 x 3 x 3 ft.). However, metal baskets degrade in salt spray coastal environments and can leave sharp rusted wire in its wake should the container deteriorate. Stainless wire can cause injury after the basket degrades and saltwater causes it to rust. As an alternative, plastic or synthetic mattresses offer a more flexible, durable container when filled with rocks or stones. However broken or loose plastic strips can be confused by seabirds, turtles, and wildlife as being edible. Both the stainless steel and plastic types of containers come in a range of sizes, and each has its advantages and disadvantages. The rocks used can be angular rather than rounded to facilitate the entrainment and capture of sand in the voids that form between the rocks. However, if the mattress breaks open and the sharp rocks are released into the beach or nearshore environment, they can have adverse impacts on foot traffic.

Mattresses can conform to an embankment and be quickly mobilized and filled. They should be underlain with geofabric to prevent dissolution of the soil on the embankment and to reduce hydrostatic pressure from subsurface or groundwater flow. They often have sufficient weight to maintain their position, however cable anchors are often used to ensure their stability. Foot traffic on top of mattresses should be avoided. Rear yard irrigation and/or storm water discharge pipes should be redirected away from the mattresses to reduce subsurface flow and hydrostatic pressure behind the mattress fill material.

Photo: *Tensar brand rock filled mattress underlain by geotextile fabric.*

Photo: *Tensar geotextile mattress filled with hard, angular rocks to capture sand particles.*

5.12 Geotextile bags, tubes and aprons

A common, flexible, and potentially temporary option to combatting shoreline erosion is to use geotextile fabrics. The fabric is flexible, durable, easy to ship, and allows water to pass through the fabric but not sediment. The fabric is vastly stronger than coir and does not degrade when exposed to direct sunlight or seawater. This key feature makes the use of geotextiles along the coastline an attractive, low cost, impermanent alternative when compared to constructing more permanent shoreline hardening or less permanent soft measures that rely on coir mat.

Skirts or Aprons

Long sheets of geotextile fabric can be configured to overlay an embankment to stop it from being eroded by wave action. Often the embankment is 'dressed' to remove rocks, tree roots, or sharp items and to smooth the face of the embankment. The geotextile skirt or apron that is overlaid on the embankment's face must be held tightly at its top and anchored at its bottom to prevent it from being dislodged by wave action. The top can be held with cables and platypus anchors embedded in the rear yard, but care must be taken that the cables do not become tripping hazards.

The bottom of the skirt can be held down by placing heavy sandbags in the hem of the skirt or a chain or heavy pipe can be sewn into the hem of the skirt and buried under the surface of the beach. However, if the hem or its anchoring is exposed to waves and surge action, the geotextile fabric or its seams can tear and fail. Subsurface groundwater can also build up behind the fabric and displace or dislodge it if it is not porous enough to accommodate the hydrostatic pressure emanating from the embankment that it is covering.

Photo: *A geotextile erosion skirt covering an eroded embankment at the Kāʻanapali Beach Club, West Maui, 2018.*

Sand-filled Burrito's

Some lightweight geotextiles, such as Mirafi 150 - a black felt-like fabric, can be laid out flat, have dry sand placed in its midst, and have the ends wrapped overtop of the placed sand and sewn together to form an elongated sand-filled bag - a 'burrito' of sorts. The burrito can be shaped to fit the contour desired, but it has no structural strength. This method is particularly useful in situations where sinkholes have formed within a yard, or behind a seawall, that need to be filled quickly to stabilize the situation and bring the yard up to the natural grade.

Burritos are a good temporary measure to stabilize cavities that often form inland of shore armoring. The fabric and fill don't necessarily stop the surrounding soils from eroding but can move in response to wave surge and be pulled into cavities or gaps in shore armoring.

Geo-tubes

Long, flexible tubes can be purchased and filled with sand to form a barrier along the shoreline that prevents erosion of the backshore area. The tubes are usually placed parallel to the shoreline along the bottom of a scarp or an embankment. Over time they often become embedded into the landscape and its contour due to sloughing of the upper embankment. The tubes can also be placed perpendicular to the shoreline to form groins that trap sediment and sand moving along the shoreline. Sediment will accumulate on the up-gradient side of the geo-tube groin as the prevailing current will build material up against one side of the groin but deprive sediment accumulation on the down drift side leading to greater erosion depending on the seaward extent of the geo-tube.

Photo: *A stack of sand-filled burritos made of black Mirafi filter fabric, West Maui, 2018.*

Geo-tubes are normally filled using a slurry of sand and water and the water drains out of the tube. This 'de-watering' can trigger additional permitting and mitigation measures to prevent pollution of the ocean.

Industrial Sandbags. Geotextile bags come in a range of sizes, shapes, and material durability. One of the most durable and commonly used in Hawaiʻi is the Elco Rock brand of sand filled geotextile bag. They are made in Australia and shipped by plane to Hawaiʻi. Typically, Elco bags are filled with dry sand, sewn together at their crest, and then moved and positioned in place by an excavator with a specialized claw designed to squeeze, but not rip or break, the bag's fabric. The bags are filled upright, lifted, and turned sideways by the excavator to be stacked in horizontal rows. Typical sizes are 0.75 and 1.5 cubic yard in size and weigh 3,000 to 10,000 pounds each. The bags are designed to not be easily displaced by large surf, strong currents, or wave action. However, they do move and can shift over time, and algae can grow on the geotextile fabric where it is frequently submerged making it a slipping hazard.

The large industrial bags are usually placed along the edge of a scarp or embankment to prevent further erosion of oceanfront property. The bags are laid on their side and placed snugly against each other to form a long row along the shoreline. The first row of bags should be placed low enough to prevent under scour of the sand or media upon which the bags rest and which forms its base. Additional rows of bags are stacked upon the underlying row of bags and are usually offset to form an angled revetment. The geotextile bag revetment is designed to mimic the contour of the land it is protecting and may be back filled to closely conform with the inland area to be protected. The top row of bags and the crest of the bag revetment should be higher than the prevailing upper reach of the waves to prevent the area behind the bag revetment from becoming saturated with wave over wash or seawater.

Photo: *A sand-filled Elco brand geotextile bag revetment atop Tensar mattresses, West Maui.*

Photos: *Geotextile bags may shift due to storm surge and typically require maintenance over time as these before and after photos illustrate, West Maui.*

The leading deterrent to government authorization of the use of Elco Bags is that once they are in place, they are often not removed by the property owner and become *de-facto* permanent shore protection. Over time, the bags can become slippery with algae and hinder access to and along the shoreline. Moreover, individual bags can become dislodged from the revetment, or break open and become entrained on nearby reef or rocks. While very durable, the bags can tear if repeatedly bashed about on rocks or reef substrate by wave action, or impaled by wave tossed rocks, leading to their premature deterioration or failure.

Shifting of the bags from hydrostatic pressure behind the bags is also common, especially if seawater or groundwater builds up behind the embankment that the bags are protecting. Wave over wash and subsurface water can cause dissolution of the soils in the embankment behind the bags. Thus, the embankment should be covered in geotextile fabric and the bags underlain with the same fabric to prevent soil saturation and sediment transport into nearshore waters.

Other bag types

There are other types and brands of sandbags. For instance, top-filled polypropylene trap bags that can be 4-feet tall and 4-feet in diameter and can be stacked with an excavator. The 300 pound plus bags (when filled) have handles so they can be lifted and moved by heavy equipment. They can also be tied together to reflect incoming wave energy. However, polypropylene trap bags do not prevent water from reaching the backshore which can result soil dissolution due to soil saturation by incoming wave surge action.

Smaller plastic, hand-filled sacks weighing 35 to 60 pounds can also serve in an emergency. However, these are usually not large or heavy enough to remediate coastal erosion over the long term. The contents of the bags can become water-logged and behave like pods of jelly, rolling about due to wave surge, injuring people, and damaging nearby buildings or structures. They are easily displaced by Hawaiʻi's substantial wave energy and surge and are too small and light to prevent wave inundation.

These types of bags also have many drawbacks, for instance the plastic bags can tear, releasing their contents, and become floating trash in marine waters that turtles and marine life mistake as food. Unfortunately, the bags are often filled with sand from the nearby beach which reduces the shoreline's ability to absorb and dissipate wave energy.

Photo: *An example of polyurethane plastic sandbags.*

Sand Fill

The DLNR OCCL has strict guidelines for the types of aggregate and fill that can be placed inside or used in conjunction with the above methods. Sand is the preferred fill or aggregate to underlay skirts or aprons and to fill burrito's, geo-tubes, sandbags, and Elco bags. The fill must be consistent with the native materials found along the shoreline being protected. For instance, if gray gravel for a parking lot is used to fill the bags on a coralline beach, but the bagsbreak open during a storm, the bags could release the sharp-edged gravel into the much softer coral white sand beach degrading the beach's color, texture, and potentially making it painful for foot traffic along the shore. The fill material must be of similar color, density, and coarseness to the original native beach material so that it sticks to the shore and is not easily washed away by normal tides, currents, and waves.

Consistent with State Department of Health regulations to protect near shore water quality, the fill used for sandbags and tubes must be clean and not have an excess of silty organic material. Clay, dirt, and fine sediment can dissolve into the water column or be easily washed into marine waters creating red or brown plumes. This water pollution makes the nearshore water murky, blocks life-giving sunlight from reaching corals and their symbiotic algae, increases water temperatures, and it can harbor pathogens and nutrients within colloids of the sediment grains matrix. For the reasons above, among others, only clean sand fill with less than 6% fines and no more than 10% cobble can be placed along the shoreline or used as fill in sandbags or sand containment devices. Both the Maui County Department of Public Works and the State DLNR OCCL regulate the quality of sand used as fill within the shoreline environment, with the State having more stringent requirements. A sieve analysis conducted by a geotechnical laboratory can determine if the sand proposed to be used as fill meets regulatory guidelines.

One of the main benefits of using geotextile containment is that once in place, the fill material can be removed by cutting the fabric to allow its contents to be released to the environment. If the fill is clean sand, then it can be released, and no harm would come to marine life or water quality. The geotextile fabric can be gathered, removed, and appropriately disposed of relatively quickly so it does not harm or pollute the marine environment.

Photo: *Polypropylene "Trap Bags". (Kaanapali, West Maui, 2018).*

5.13 Hard Structural Techniques

Armoring the shoreline with walls, bulkheads, and other impenetrable structures can help protect the land, but usually at the cost of losing the beach or sandy shore. Because walls merely reflect wave energy and do not absorb or dissipate the wave's energy, they are generally a less favored response to shoreline change. Walls and armoring almost always require continued, ongoing maintenance. They often have unplanned, undesired consequences especially on neighboring properties and nearshore coastal resources. Furthermore, walls and armoring may fail to protect inland development during hurricanes or severe coastal storm events. When they fail during such episodes, it is often difficult if not impossible to stage and implement repairs. For this reason, most regulatory agencies prohibit the construction or expansion of shore armoring except in limited, unique circumstances, and then only with strict provisions relating to land use, maintenance, best management practices, and shoreline access. The best coastal hazard strategy is avoidance. However, there are steps that can be taken to make walls, revetments, bulkheads, and other forms of armoring more effective and less likely to fail as discussed below.

5.13.1 Bulkheads

A bulkhead is typically a vertical wall that extends parallel and along the shoreline. Bulkheads are primarily used in low wave energy environments. They are intended to hold soil in place, fixing the location of the rear yard or back yard and ensuring that it is preserved. Bulkheads are often made of corrugated steel or vinyl sheets that are linked together. The sheets can be cantilevered to hang upon pile driven poles, or they can be driven into the substrate. Stability can be gained if the sheets are also anchored by cables buried in the rear yard. Wood poles are driven into the substrate on the seaward side to provide added stability and are bolted to each sheet. Once in place, the bulkhead can be backfilled, and the grade brought to its top to have a level rear yard.

Access to the ocean is usually limited to stairways built over the bulkhead, as an interruption in the wall's face would weaken the structure's integrity. Walkways atop the bulkhead can be integrated into its cap for access along or above the shoreline. Bulkheads do not solve the cause of an erosion problem and are primarily used where there are small or no waves such as along a stream, inlet, harbor, or bay. Bulkheads require ongoing maintenance.

Photos: *A typical vinyl and wood pile bulkhead.*

5.13.2 Sheet Pile

Sheet pile is made from steel or vinyl. It is designed to be pounded through the substrate until it meets bedrock or hardpan. The sheets link together and can be held on either side by a singular steel pile which extends into the bedrock or hardpan. Sheet pile can be used in coastal environments exposed to wave energy. However, given their small footprint, they are best used in combination with other methods such as a small rock revetment fronting the sheet pile. Exposed faces of sheet pile should be treated or covered in concrete, as should its cap to prevent saltwater intrusion and rusting of the sheet material. Sheet pile installations generally have much shorter lifespans than a poured concrete seawall or rock revetment. They also are highly reflective of wave energy despite their irregular face creating choppy water nearshore with turbulent cross currents. Sheet pile can contribute to down drift scour or erosion.

Photos: *Sheet pile shore protection.*

5.13.3 Seawalls

A seawall is a vertical wall that faces, or is parallel to, the ocean and its prevailing wave direction. Seawalls are intended to prevent the loss of soils, sediment, or property from being eroded by waves or consumed by the sea. They may be constructed of a variety of materials, but stronger seawalls are usually made of poured high-strength concrete, concrete masonry unit (CMU) blocks, or large cut lava stone that is stacked upon each other and held with mortar. Steel rebar is added to the seawall to give it strength. The metal rods create a more rigid grid or form within the poured concrete or are inserted into the hollow part of CMU blocs before they are filled with concrete. Metal rebar should be coated with epoxy to extend its life and prevent it from rusting. Within poured concrete, rusting rebar will spall and expand causing the concrete to chip or weaken from the inside out if not properly prepared. Spalling of concrete is a common problem in Hawai'i. Seawalls can be pile or gravity supported, with the latter most common in Hawai'i. Seawalls normally require ongoing maintenance and can be expensive to repair once damaged.

Seawalls retain soil on one side of the wall and thus need to have weep holes in the wall that allow rainwater and wave splash over to drain back into the ocean. Weep holes are normally placed just below the grade of the rear yard and just above the high tide line. The weep hole drains are wrapped with geotextile fabric so that they do not clog. Additional weep holes may be needed depending on the depth of the soil column, its drainage properties, and the area's hydrology.

Seawalls should be high enough so that waves do not overtop the wall and should be higher than high tide combined with storm run up levels. A seawall should have an over-wash lip to prevent incoming waves and swells from splashing up in the air and having a portion of the water falling landward behind the wall. This area can become saturated with water and cause the soil behind it to behave as a slushy liquid (dissolution) that can be pulled underneath the wall or through cracks in the wall causing the wall to collapse. For this reason, a seawall must be properly designed with weep holes, geofabric filters for drainage, and have a foundation that cannot be scoured by waves.

The footing for a seawall is a critical component to its strength and longevity. Seawalls need to be anchored to unmovable substrate such as bedrock or thick reef hard pan. The footing for a seawall must be wide enough on each side of the wall to allow it to rest securely without being toppled over by hydrostatic forces that can build up behind the wall. The toe, or bottom of the seaward face of a seawall, should have a sill or ledge that protects the wall's footing from being under scoured by wave action or that can succumb to the loss of the sandy substrate fronting and the seawall.

A seawall must have a properly designed tieback at either end of the wall to prevent flanking erosion, where wave energy wraps inland and scours out softer materials at the end of the wall. The impact of building a seawall can cause the erosion problem to move down drift to an adjacent property, causing new erosion and creating the need for further armoring. This domino effect is a common cumulative problem that results in a community's loss of its sandy beach and dry access for subsistence gathering, fishing, and recreational activities.

Photo: *A poured concrete seawall.*

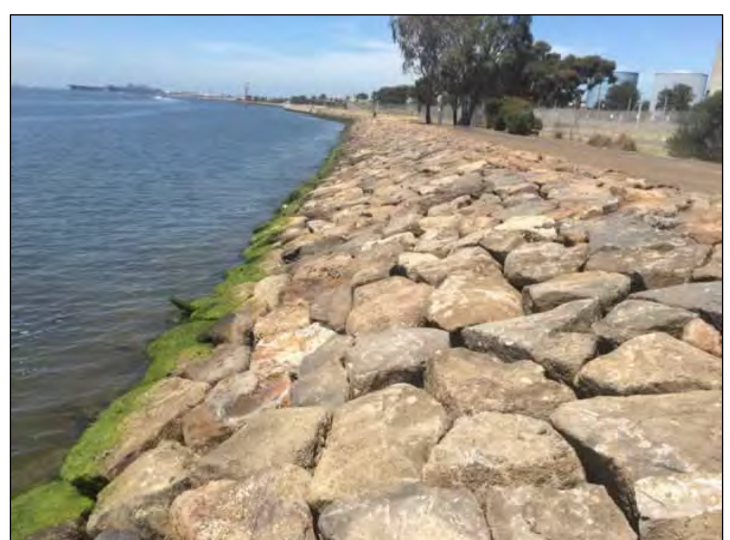
Access along the face of a seawall can be lost due to erosion and shoreline retreat. A seawall's toe can become slippery with algae if regularly submerged or exposed to tidal action. Access to the ocean is limited to breaks in the wall such as stairways, but these are weak points in the wall's integrity. Seawalls do not address the cause of an erosion problem, and they can mask it until sinkholes and fissure cracks form in the rear yard due to under scouring and unseen breaches in the wall.

5.13.4 Revetments

Revetments form a slope that is made of stones that fit together and lay over the slope of the shoreline or embankment to protect it from erosion and wave impact. Waves run up the face of the revetment and cause them to lose energy. As the water is pulled back down the face of the revetment by gravity, the swash breaks the trough of the next incoming wave, reducing its energy.

Each stone should rest upon the stone below it with the bottom toe stone being the largest, most immovable portion of the structure. The revetment should be built no steeper than a 2 to 1 ratio, and ideally at a 33-degree angle.

Filter cloth should be used underneath the placed stones in a revetment since water may penetrate through cracks and crevices and the sediment upon which the stones rest upon. This sediment may become saturated or liquified but should be held behind the filter cloth to prevent its dissolution and loss which could cause the stones in the revetment to lift, shift, or



Photos: *A properly designed revetment has interlocking stones underlain with geofabric.*

move leading to the structure's failure. As such, stones on a revetment are frequently underlain with multiple layers of known-sized well-drained aggregate, rocks, and geotextile fabric.

A revetment needs to be tall enough to prevent overtopping by high tides plus storm run-up levels. It must have a foundation that cannot be scoured or eroded such that the base stones could shift. Rocks on a revetment rest at an angle atop lower lying stones, much like the scales of armor on an Armadillo. If a lower rock is displaced, the upper stones can slide, slip, or shift leaving gaps in the armament.

The toe stone must be sufficiently large, and heavy enough to not be dislodged by storm waves. It should be placed well below the low tide line and below submerged areas to prevent scouring of the sediment or base upon which it is resting. Revetments can cause negative impacts such as the loss of sand in front of the armoring, flanking erosion at the ends of the revetment, slippery faces that are susceptible to algal growth, and new erosion to neighboring or down drift properties. Since they are less reflective of waves, sand in the water column may fall out of suspension and buildup intermittently at the toe of a revetment.

Wave over wash or improper handling of drainage can cause hydrostatic pressure to build up behind the revetment. Without proper weep holes, filter fabrics, and aggregate design, water can accumulate behind the revetment and cause displacement of armor stones leading to the structure's collapse and failure.

5.13.5 Groins

Groins are jetties that extend out into the ocean, seaward and perpendicular to the coastline. They are typically comprised of large rock armaments set upon geotextile fabric with a length, width, height, and seaward end (head) tuned to the coastal forces and prevailing waves at the site. The landward end of a groin is usually buried to allow access along the shore and is not visible. Groins must rise high enough from the submerged land or seafloor to trap sand and sediment to form a protective buffer along the shore. Accumulated sand should eventually cover the landward portions of the groin so that the groin does not interrupt or hinder lateral access along the shoreline.

The spacing between groins should be 2 to 3 times the length of the groin. Sand and sediment will accumulate on the updrift side of a groin but deprive the down drift side of the groin of sand and sediment which results in erosion on the groin's down drift side. The length of the groin should be sufficient to capture sand and sediment that is moving alongshore, but not too long as to cause excessive or accelerated erosion on the down-drift side or ponding and lack of circulation on the up-drift side. Groins should also be oriented so they can deflect incoming wave and storm energy rather than channel it to the down-drift side where it would accelerate erosion and shoreline retreat.

Photo: *A series of short rock groins have retained the beach at Stables Road, Maui.*

Groins are typically constructed in a series comprising a groin field with multiple groins that extend perpendicular or at an angle to the shoreline, rather than just one or two groins. Groins can provide a platform for fishing and recreation making it easier to access areas further offshore. But like revetments, a groin's surface can harbor algae that may be quite slippery to walk upon. Groins can channel or redirect the current to flow along the side of the groin to its offshore end. Consequently, they can introduce a danger for swimmers or recreationalists if they become entrained in this flow. Similarly, once in the water, individuals may find it difficult to exit because the groin's slope and surface can be too slippery or steep to climb out of the water and the structures usually lack handholds, railings, cracks, crevices, or roughness to facilitate egress.

Visually, groins can interrupt natural view planes to the ocean and can have a negative impact on the perception of the environment. Similarly, views along the shoreline can be degraded by the interruption that a groin creates along the coastline. Depending on their size and configuration, a large groin can serve as a fishing platform or means to enjoy mauka views of the coastline and mountains.

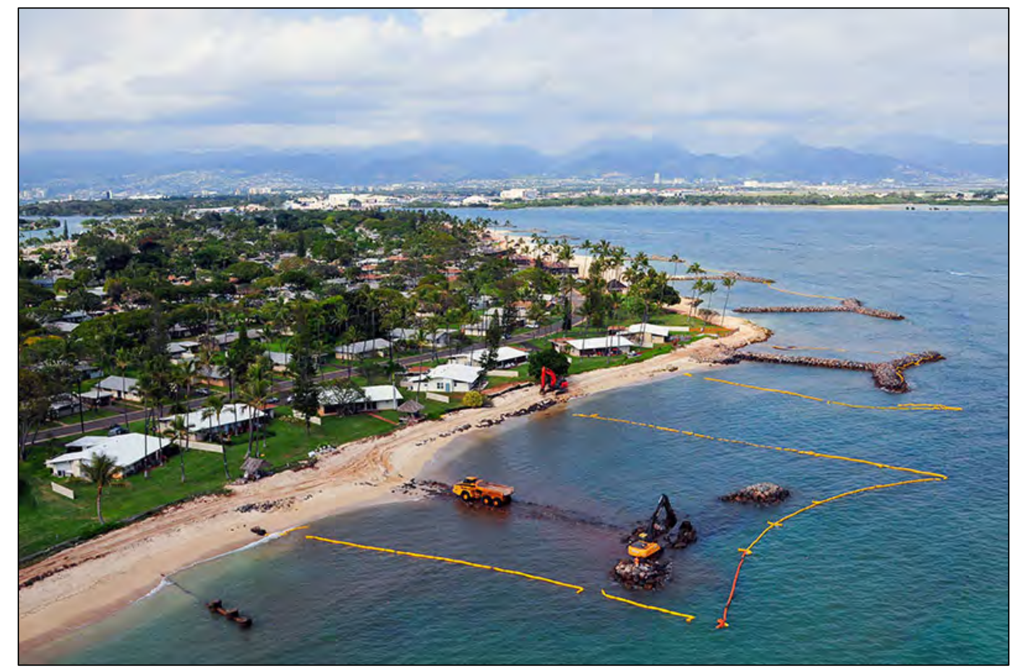
Photo: *A concrete block groin illustrates updrift accretion and down drift erosion at Kūhiō Beach, Waikiki, Oahu, Hawai'i.*

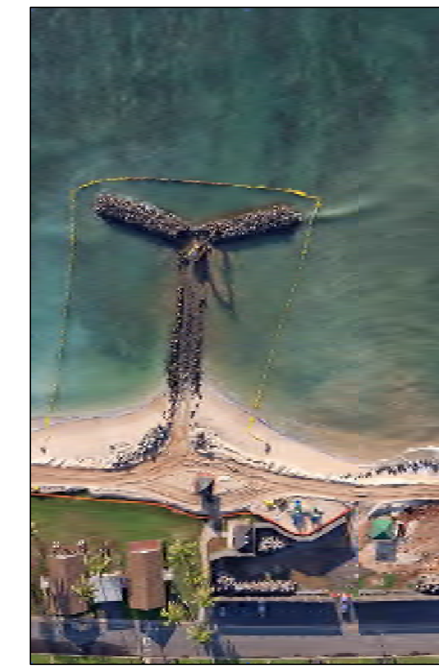
Engineered groins can form a navigational hazard to vessels especially for smaller watercraft, motorboats, and sail boats that come close to shore. Under certain high wave or high tide events, the crest of a groin may not be clearly visible and could cause damage to a propeller or keel. Installing large groins usually needs federal approval from the U.S. Army Corp of Engineers, adding another layer of permitting to the complicated coastal zone management process.

Groins are best suited to shorelines where an alongshore drift direction dominates. Like other forms of armoring, groins need to incorporate geotextile filter fabric to allow liquid and water to move without dissolution or loss of fine sediment, sand, or soils. Groins are typically made of rocks and armor stones. However, groins can be made of a variety of materials, such as wood, stones, concrete block, or sand held in bags, but they are susceptible to displacement and failure if not stout and strong enough to withstand storm force waves and powerful along shore currents. Groins require maintenance due to the displacement of rocks and other materials by storms or wave action. Groins do not prevent inundation of property by waves or flooding of rear yards, but they can reduce this risk by capturing and building up a reservoir of sediment or sand that may help buffer or diminish coastal hazards.

<u>Stub, T and L-shaped groins.</u>

Stub groins extend seaward like a stem and do not diminish or hinder incoming waves. T-Head groins have rock platforms that extend from both sides of the head or end of a stub groin, whereas L-Head groins extend from only one side of the seaward end of the groin. The extensions are designed or angled to interrupt, diminish, or break up incoming wave energy. The "T" or "L" can reduce wave energy on either side of the groin and create an eddy to reduce erosion or transport of sand and sediment within the groin's area of influence. The back shore and shoreline area down drift of the last groin should not be comprised of erodible material to prevent acceleration of shoreline erosion. An L-Head Groin may be used for the last, down-drift groin with the base of the L facing updrift and seaward to capture sediment and prevent it from being lost or transported around the seaward end of the groin and out of the littoral cell system by the prevailing current.





Photos: *Iroquois Point Pearl Harbor, Honolulu, Oahu, Hawaii, 2013.* **Source:** *Healy Tibits Construction.*
https://www.healytibbitts.com/projects/project-details/iroquois-point-beach-nourishment

5.13.6 Breakwaters

Breakwaters are offshore structures that are intended to break waves before they reach the softer shoreline or the slope of the backshore area. The rocks break the waves, reducing their force, and help prevent wave action from cutting into the sediment and carrying it away. The rocks must be heavy and large enough to not be easily displaced by wave energy. A design with interlocking rocks can strengthen the structure, but it must be secure enough to withstand submergence and the force of waves and strong storm currents. Stone or rubble breakwaters should be underlain with geotextile filter fabric if placed on sandy bottom to prevent displacement or dislodgement of the breakwater.

The breakwater should not be continuous; but should generally run parallel to the coastline and have sufficient gaps to allow water to ebb and flow behind the structure and between it and the vegetated shore. It is important that the breakwater not block or hinder circulation so as to prevent stagnation along the shore, stop eddies from forming behind the breakwater, and allow sufficient flushing of seawater as to support marine life.

A breakwater should be located sufficiently offshore to allow a bulge to form inland of the breakwater. It should be high enough to break waves, but not so low or short that it creates a navigational hazard to boats or watercraft. Gaps between offshore breakwaters should be wide enough to cause minimal change in nearshore currents and to prevent stagnation or undesired sedimentation. Breakwaters and rubble mounds can change the configuration of the shoreline, alter alongshore transport of sediment, and have unintended consequences if not properly designed, located, and constructed. Breakwaters should also be located sufficiently offshore to have the effect intended. For instance, sand can accumulate immediately behind the structure because along shore transport mechanisms from the swash of the waves, has been interrupted. Breakwaters can also have a significant effect on the makai view, and surfing waves, particularly for leisure activities on the beach.

Photo: *A rubble mound breakwater has accumulated sand in the eddy behind the structure.*
Photo by K. Duhring. **Source:** *Center for Coastal Resources Management, Virginia Institute of Marine Science.*

5.13.7 Breakwaters with Vegetated Backshore

Vegetation and slope stabilization can be used in conjunction with a breakwater to emulate a reef shelf. The design is similar to a sill backed by vegetation. The roots of grass and native, salt-tolerant plants can help hold soils, sediment, and sand in place in the backshore area, whereas the breakwater reduces the force of incoming waves. The types of plants used should have roots that spread horizontally rather than roots that grow vertically. The spreading roots hold more sand and sediment over a larger area, but their roots are shallow and fragile so walking on them must be avoided so the roots are not trampled and die. Designated paths with rope and post boundary fencing can be used to direct pedestrians away from fragile plantings. Commonly used plants include naupaka, ʻaki ʻaki grass, bulrush, and pōhuehue (beach morning glory).

Photo: *Breakwater sill and marsh vegetation at Morris Landing, Holly Ridge, NC.*
Photo: *Carter Smith.*
Source: *https://ncseagrant.ncsu.edu/currents/2018/11/living-shorelines-can-enhance-saltmarsh-resilience-to-hurricanes/*

5.13.8 Dry Stacked Walls

The walls around a fishpond exemplify a well-constructed dry stacked stone wall. Dry stack walls can be used to retain earth on one side and prevent ocean inundation on the other side to help protect oceanfront property. Pōhaku "rocks" can be female, male, or even hermaphrodite depending on their physical qualities. Male or boy stones are called Kū stones. Female or girl stones are called Hina stones. Strong dry stack walls are made of Kū and Hina stones that fit together and become tighter and more solidified as time passes, and when the ground shakes, such as during tremors from earthquakes or volcanic activity.

Fishpond kuapā (walls) were constructed from many materials including lava rock; coralline blocks; and rubble of rocks, coral, and soil. Small rocks and coral fragments filled interior cracks and could help cement the wall together. A fishpond wall was designed to be permeable to water, allowing aeration and water circulation while deflecting incoming wave energy. Similarly, dry stack seawalls must allow groundwater to seep through the wall either by adding weep holes to drain subsurface water, or by using geotextile fabric liners behind the wall to prevent dirt, soil, sand, or fill from being lost and forming sinkholes behind the wall.

A fishpond seawall was made with two rows of rocks and a filled center. The outer ocean-facing and the inner retaining face of the walls differ. The outer wall had a greater angulation to allow some of the deflected current to "clean" or scour the outer rim of the fishpond. The outer wall was often 5 feet wide and 3–5 feet tall (Keala, Hollyer and Castro, 2007). The largest stones make up the bottom (bottom stones are foundation stones called niho stones), ocean-facing side of the wall. The rocks should be positioned with the flat side facing outward because that side will be exposed to wave impact and needs to deflect the energy of the waves. When placing one rock on top of another, they should be placed 1 to 2 inches inside of the front edge of the lower rock (ibid.). Each rock should slant or lean toward the center of the wall. In this way, gravity pulls the rocks inward toward the middle of the wall rather than outward or to the side(ibid.).

As the outer facing seawall and the inner retaining face of the wall begin to rise above the ground, the space between them (i.e., the middle of the wall) should be filled with smaller rocks, which do not have to be placed in any particular way. As the wall is built up from the bottom layer of rocks, the "seams" between adjacent rocks should be staggered so that the next rock should be placed over the seam between the two lower rocks (Keala, Hollyer and Castro, 2007).

Long, narrow rocks should be placed pointing toward the center of the wall which will add strength to the wall. The rock's surfaces need to be examined to choose the best surface to fit on the rocks already in the wall. Face stones are known to Hawaiians as "Alo" stones. These are the stones that make the Alo "face" of the wall. The "face" is the side that will face the outside of the wall, while the "sit" is the side of the rock that will sit on the lower two rocks on the wall. It is important to plan where the rocks are going to be stored, sorted, piled and where they will fall or sit when placed on the wall, because it is inefficient and inconvenient to move large rocks more than once (ibid.). The use of grout or concrete should be avoided in favor of a well-selected set of rocks for the wall. Concrete can hide erosion and under scouring by waves. It also prevents the rocks from naturally settling into one another to create a tighter, more durable seawall.

"A Kuapā has various types of stones. Niho stones are foundation stones. Alo Stones is the face of the wall. Unu stones are wedging stones to help support the Alo stones. Pani Hakahaka stones are the filler stones that help fill in gaps of the wall. Pāpale stones are at the top of the wall known as cap stones.

These stones are either male or female stones. When the wall is being built the stones are moved into categories. 1) Niho 2) Alo 3) Pani Hakahaka 4) Unu 5) Pāpale. These are the five basic categories for organizing rocks for a kuapā."

Kia'i Collier, Waihe'e Steward and Educator,
Hawai'i Island Land Trust

Photo: *The intricate structure of a wall constructed using uhau humu pōhaku (Hawaiian dry-stacked masonry).*
Source: *National Park Service Photo. https://www.nps.gov/puho/learn/historyculture/preservation.htm*

Photos (Top to Bottom): *Restoration of Keawa Nui Fishpond of South Moloka'i (Honua Consulting, March 11, 2011, Flicker.com); Keawanui Fishpond in South Moloka'i (Honua Consulting, September 1, 2010,* Flicker.com).

6.1 Choosing Appropriate Responses to Shoreline Change

Chapters 1 through 4 capture and summarize the past and present conditions confronting DHHL homestead lots along Molokai's south shore. Chapter 5 explores erosion management strategies and describes approaches ranging from soft, nature-based remedies to hard, man-made structures to mitigate the impact of shoreline erosion. Chapter 5 also explores methods to better adapt structures to shoreline change and to avoid shoreline change by realigning or relocating structures to reduce their exposure to coastal hazards.

This chapter synthesizes the data collected through the first five chapters to create a set of five "core strategies" that are germane to the SM-SEMP planning area. The SM-SEMP's "core strategies" succinctly describe the broad strategic action that DHHL and its beneficiaries, as well as the broader community, could take to make the SM-SEMP's shoreline more resilient to the effects of sea level rise and coastal erosion. Actions provide more detailed procedures, programs, or physical improvements to carry out the SM-SEMP's core strategies. For instance, DHHL has a variety of tools at its disposal to manage risks from coastal hazards and shoreline erosion. DHHL can manage the use of its land and the location of future infrastructure investment to encourage the relocation of existing development to areas less susceptible to the effects of sea level rise and coastal erosion. There are also established zoning codes and practices in Maui County to help address flooding, shoreline armoring, retaining walls, grading, and coastal erosion. DHHL could utilize some of these. For instance, in Maui County plans for shore armoring must be stamped by a licensed structural engineer to ensure the structural integrity of the proposed shoreline armoring.

Chapter 6 organizes the SM-SEMP's recommendations geographically. Core strategies that address issues systemic to the entire SM-SEMP Area are presented in Table 6.1, followed by detailed recommendations for four identified littoral cells that encompass the shoreline between Kānoa Fishpond and Kalamaʻula.

CORE STRATEGIES	Actions
1.0 <u>Restore</u> natural shoreline function.	1.1 Remove and replace invasive plants and trees with climate adapted, drought tolerant native grasses, shrubs, and trees such as ʻakiʻaki grass, pōhuehue, naupaka, and milo. 1.1.1 Develop a detailed vegetation management plan to guide shoreline and dune restoration within the SM-SEMP Area. 1.1.2 Contract with a community-based non-profit or business, with expertise in habitat restoration, to implement the vegetation management plan and provide ongoing maintenance of the improvements. 1.1.3 Support non-profit efforts to provide homesteaders with native, drought-tolerant, climate adapted seedlings and saplings to encourage shoreline restoration. 1.1.4 Prune or remove vegetation and trees that hinder access along the shoreline during high tide. The area between low and high tide should be free of obstructions such as kiawe trunks and branches, ironwoods, milo thickets, and naupaka bushes. 1.2 Remove man-made debris between the high and low water line including tires, appliances, vehicle parts, concrete and asphalt rubble, CMU blocks, pallets, steel and plastic drums, and other non-indigenous materials and dispose of it properly. 1.2.1 Contract with a community-based non-profit or business to remove and haul debris to a government-approved disposal site. 1.2.2 Support community-wide clean-ups where litter and rubbish are removed from the shoreline. 1.3 Remove accumulated sediment and debris from stormwater drainageways to keep them clear and functional. If the drainage has clay, soil, silt, or other dark colored sediment, remove and dispose of it in the landfill because it pollutes the ocean and degrades coral reefs. If the drainage is primarily clean, uncontaminated sand, place it along the ocean frontage or atop sand dunes or naturally vegetated berms at the edge of rear yards in the neighborhood, noting that State law provides for this type of activity. 1.3.1 Contract with a community-based non-profit or business for regular drainageway maintenance. 1.4 Initiate a groundwater inundation program by regularly testing and monitoring the following: a. the pH, salinity, and water level relative to the tide at the pocket wetland adjacent to the new pavilion at Kiowea Park; and b. the seeps and springs in the Kapuāiwa Coconut Grove to help characterize the area's hydrology, particularly as it relates to Coconut tree health. 1.5 Support actions that restore native upland habitat and reduce sediment laden stormwater from reaching the shoreline. 1.6 Support feral ungulate control, including fencing to exclude axis deer from watersheds rich in native habitat, and fencing to enclose axis deer within designated hunting areas.
2.0 <u>Educate</u> beneficiaries on the causes and consequences of sea level rise and coastal erosion, including appropriate mitigation measures.	2.1 Provide beneficiaries living in flood prone areas with the following information: • "*Answers to Questions about Substantially Improved / Substantially Damaged Buildings*", FEMA publication 213, August 2018. • "*Homeowners Handbook to Prepare for Natural Hazards*" 4th Edition, by Dennis Hwang and Darren Okimoto, Sea Grant, University of Hawaiʻi. • Flood zone and sea level rise exposure maps. 2.2 Ensure beneficiaries review coastal hazard information such as flood zone maps, SLR inundation areas, and coastal hazard exposure rankings when being granted a homestead lot. A disclosure notice should be signed by the beneficiary acknowledging review of the information. 2.3 Invite Dennis Hwang, and other Sea Grant Extension Agents, to speak to beneficiaries. 2.4 Ensure beneficiaries living along the shoreline understand and acknowledge that:

CORE STRATEGIES	Actions
	• A lessee's lot is subject to natural variability and coastal dynamics and its size may change over time. • A homestead lease does not include submerged land and DHHL is not obligated to prevent submergence. • Armoring the shoreline can be detrimental to coastal processes, marine flora and fauna, and neighboring properties and should only be done after consultation with DHHL planning staff.
3.0 <u>Strengthen</u> the <u>regulation and management</u> of shoreline resources.	3.1 Recommend consistency with the following State of Hawaiʻi and Maui County regulations governing buildings and construction, the shoreline, and flood hazard areas: • Hawaii Revised Statutes (HRS) Chapter 205A, Coastal Zone Management. • Maui County Code (MCC) Title 16, Building and Construction Codes. • MCC Chapter 20.08.035, minimal best management practices when disturbing the ground (grading, excavating, fill). • MCC Chapter 19.62 Flood Hazards Areas. • Hawaiʻi Revised Statutes (HRS) Chapter 205A-43 (a), setbacks along shorelines are established of not less than forty feet inland from the shoreline. 3.2 Recommend consistency with Federal and State DLNR regulations regarding shoreline surveys, armoring, and coastal construction on submerged lands.
4.0 <u>Adapt</u> structures and systems to better withstand coastal hazards.	4.1 Require new dwellings to be elevated above flood hazard zones (base flood elevation, SLR inundation) by more than one foot in elevation (freeboard). 4.2 Require new buildings to use anchored post and pier construction so as to be movable instead of slab on grade construction which is immobile. 4.3 Require buildings, and especially existing dwellings, to install hurricane clips and have a continuous load path to reduce damages to the structure during a coastal storm. 4.4 Encourage lessees to reconfigure dwellings by moving the kitchen mauka and elevating food preparation areas so that stove, refrigerator, freezer, and appliances are elevated or located at the highest, driest part of the property. 4.5 Encourage lessees to relocate the water heater, air conditioner, chillers, and/or pumps to higher waterproofed areas within the property. 4.6 DHHL should host and facilitate Community Work Days to install hurricane clips, add continuous load path straps, create flood resistant anchors, and take other house strengthening and storm resilient measures as described in Dennis Hwang's *Homeowner's Handbook to Prepare for Natural Hazards* found at: http://seagrant.soest.hawaii.edu/homeowners-handbook-to-prepare-for-natural-hazards/ 4.7 Convert cesspools to septic systems wherever feasible to reduce the risk of contaminated water and protect beneficiary health. 4.8 Encourage cesspool conversions with financial incentives from DHHL but with conditions to reduce exposure to natural hazards by realignment or relocation to areas not exposed to sea level rise. 4.9 Remove outhouses, or connect them to a septic system, to prevent contamination of the "ice box" and protect beneficiary health. 4.10 Encourage building designs and layouts that are perpendicular to the shoreline to reduce the building's surface area that is exposed to coastal storms, wind, waves, and hazards. 4.11 DHHL should consider purchasing Simpson Strong-Ties and other commonly used hurricane mitigation materials in bulk and providing them to beneficiaries along with training on their installation and use.
5.0 <u>Prepare</u> for the relocation, or retirement, of structures out of areas threatened by sea level rise and coastal erosion.	5.1 Prepare a community-based plan for the relocation of vulnerable buildings, infrastructure, and public facilities away from area's threatened by sea level rise and/or coastal erosion. The plan should include specific strategies and actions for the: a. relocation of entire communities, if necessary; b. relocation of structures on a lot that are situated in flood and erosion prone areas to areas on the same lot that are free of such hazards; and c. construction of new, more reliable infrastructure, and the provision of services to areas that are not at risk of SLR and coastal hazards to incentivize new development and neighborhoods in locations that are not in harm's way. 5.2 Prepare and implement a planned obsolescence strategy for infrastructure at risk of damage from SLR, coastal erosion, and flooding including roads, drainages, wastewater treatment, and centralized utility systems and services. 5.3 Develop incentives for the retirement, relocation, and reconfiguration of structures upland and mauka, particularly on oceanfront lots. 5.4 Allow pavilions and accessory structures in the setback area, but not plumbing, and require structures to be portable and moveable. 5.5 Require additions to existing dwellings on oceanfront lots to be located on the mauka side of existing structures and elevated above base flood elevations. 5.6 Require a coastal hazard exposure assessment in any new leases or renewals and facilitate relocation if and when structures are damaged by 50% or more. 5.7 Incentivize relocation away from flood and erosion prone areas by providing infrastructure and leasable lots upland.

Table 6.1: *SM-SEMP Core Strategies and Actions.*

Chapter 4 describes how sediment flow within the SM-SEMP Area is divided into four littoral cells which are mapped to illustrate the main sources and sinks of sediment and the probable transport mechanisms within each littoral cell that are driving shoreline change. Shoreline managers can use the maps to analyze each cell's sediment budget, and design appropriate management strategies to make the shoreline more resilient to sea level rise and coastal erosion.

The SM-SEMP planning team shared the maps and research with key stakeholders and DHHL management in an interactive workshop. Stakeholders had the opportunity to provide written comments, diagrams, and suggestions on the maps to improve the accuracy of the information reported, infuse place-based and traditional ecological knowledge, and to put the information gathered in historic context. Stakeholders also reviewed erosion issues and potential responses. The purpose of the workshop was to ground truth the team's findings and to have a stakeholder driven evaluation of intervention techniques and remedies.

Stakeholders evaluated different approaches and remedies to shoreline change. These response options ranged from soft and green natural approaches to hard and gray constructed structures that are designed to remedy erosion, such as those illustrated in Figure 6.1. Included in the response options was realignment of the built environment to adapt to changes in the coastal environment, such as elevating, reconfiguring, retiring, or relocating structures.

A brief description of each of the ten response options along with photos exemplified how each approach functions. The relative cost of each approach, its longevity, permit requirements, footprint or size, and typical impacts were also listed.

Stakeholders discussed their likes and dislikes for each of ten different approaches to shoreline change. The stakeholders evaluated the approach and response option in overall terms and not in relation to any specific location, area, built asset, or erosion threat. For instance, there was general agreement that erosion responses that relied on plastic materials, such as Tensar mattresses or plastic gabions, were inappropriate for Molokai's south shore given the sensitive nature of the marine and nearshore environment. In contrast, dry stack walls that emulated fishpond walls were more welcomed and viewed more favorably.

The stakeholders then reviewed eight types of assets or resources identified as being commonly at-risk or under threat from erosion along the project area's coastline. These included: carports, pavilions, houses subject to episodic erosion (i.e., singular storms) or chronic (long-term) erosion, historic resources such as Kalanianaʻole Hall and Kapuāiwa Coconut Grove, and public resources such as roadways (Kamehameha V Highway) and park infrastructure (pavilions, restrooms). For each of the eight assets, the stakeholders evaluated the ten responses and indicated which ones they liked, thought were okay, or disliked and the rationale for their feeling. They also noted any specific costs, benefits, or concerns associated with a possible remedy for a particular resource or area.

6.2 Specific improvements from Green to Gray

Using the information from the stakeholder workshop, the SM-SEMP team identified specific remedies for areas threatened by erosion within littoral cells A through D as depicted by Figure 6.2 and Figures 6.4 - 6.6.

Three of the four beach cells exhibit erosion while one cell exhibits accretion. For instance, Cell B is sediment deficient in front of the Kamiloloa subdivision lots just east of the Hotel Molokaʻi leading to mild to moderate erosion. In contrast, Cell C is sediment starved in front of the Kapaʻakea subdivision leading to significant land loss due to erosion.

The shoreline's natural function to absorb wave energy has been mostly lost at Kapaʻakea but is only compromised at Kamiloloa. Accordingly, a soft "living shoreline" approach is recommended for many of the oceanfront properties in cells A through D. This soft strategy is intended to restore the natural buffering capacity of the coastline over the short term by creating a sand reservoir comprised of a sand berm with an engineered coir mat center that is covered in native vegetation. While other soft approaches have merit and may be effective, creating a vegetated sand berm is likely one of the most practical options that could readily be implemented at these locations.

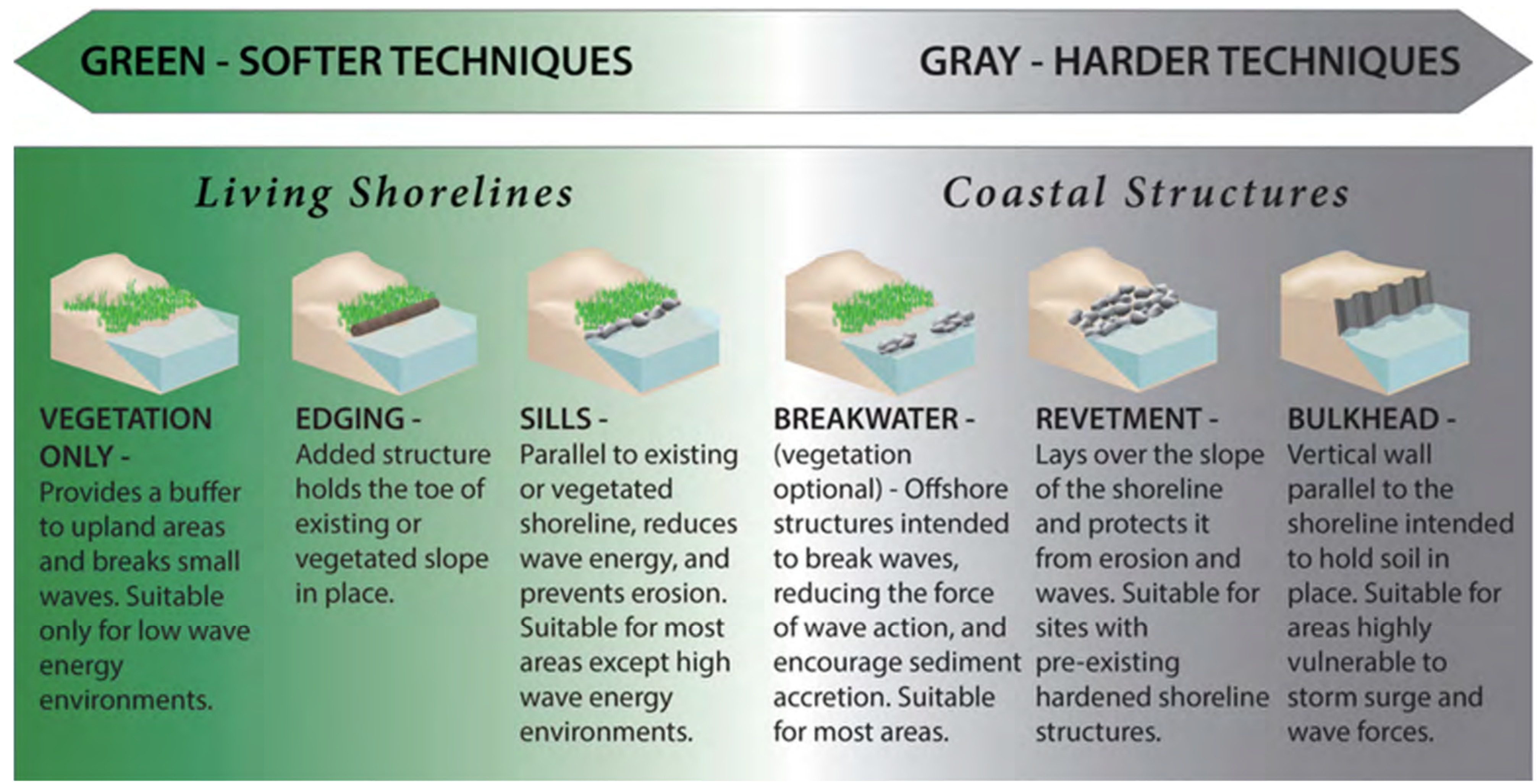


Figure 6.1: *Shoreline change response options, from natural approaches to constructed structures. (Sage, NOAA, 2015).*

6.3 Littoral Cell A (Kānoa Fishpond to Ali'i Fishpond)

Several sites within littoral Cell A (Figure 6.2) could benefit from a soft, green approach to mitigate coastal erosion. Three specific improvements are recommended, and Figure 6.2 identifies their locations within Littoral Cell A. This subsection describes each of these recommendations in more detail.

(1) Coastal habitat restoration could help rejuvenate natural shoreline processes to make the shoreline more resilient to shoreline erosion. This could be accomplished by creating a vegetated sand berm that rises 1½ - 3 feet above the grade to enhance the interface between the land and sea and create a buffer between them. Shoreline managers can augment the height and width of the berm fronting the One Ali'i Park pavilion and restroom with clean sand covered by native coastal plants. Managers can also direct foot traffic between the park and the shoreline with posts, ropes, and signage to prevent the native plants from being trampled.

Photo: *A sand berm anchored by native vegetation make this beach more resilient to sea level rise and erosion.*

Shoreline managers can plant climate adapted, drought tolerant native grasses, shrubs, and trees such as 'aki'aki grass, pōhuehue, naupaka, and milo to improve soil retention along the edge of the shoreline and reduce the loss of soil and sand to waves, king tides, and erosion. By removing kiawe trees that absorb a disproportionate amount of fresh water and dry out the soil, managers can improve growing conditions for native plants, reduce the formation of embankments along the back shore, and eliminate the supply of sharp thorns and branches that hinder access along the coastline. Please see Recommendation 3, of Littoral Cell B, for a more thorough discussion of the use of coir mat enhanced sand berms to support habitat restoration and coastal resilience.

(2) Remove the sand plug in the drainage channel for the beneficial use of sand. The swale running mauka to makai along the western edge of One Ali'i Park cannot adequately drain stormwater just inland of the shoreline. The mouth of the swale is plugged with sand that has accumulated over time. This prevents the water mauka of the plug from discharging into the ocean and instead causes it to pond, harbor mosquitos, and enable algal growth. The sand appears to be clean, low-silt, and coarse-grained which would make it suitable for beneficial reuse in Cell A or elsewhere along Molokai's south shore. Shoreline managers could remove the sand plug and use it to enhance the height and width of the vegetated berm recommended in front of the One Ali'i Park's pavilion and/or restroom. The beneficial reuse of the sand is also consistent with State law, HRS 205A-44(a)(3)/(4) provided that its placement does not create significant turbidity. Silt fences can be erected during clearing of the drainage swale to prevent polluting nearshore marine waters.

Shoreline managers could also use the sand as clean fill at other DHHL locations and projects. The sand that is plugging the drainage swale should be tested using a sieve analysis to determine if it meets DLNR OCCL criteria for 'beach quality sand'. If suitably clean and free of silt, the sand could be placed in natural fiber coir mat bags or burritos to create or enhance a vegetated sand berm or to protect an eroded embankment (See Figure 6.4 - Cell B recommendations). Alternatively, shoreline managers could use the clean fill for temporary groins made of geo-textile sand-filled tubes or bags at other DHHL locations (See Figure 6.5 - Cell C recommendations).

Photo: *The sand that plugs this drainage channel could be repurposed for berm enhancement.*

(3) Support the restoration of Ali'i Fishpond including the removal of invasive mangrove. The Ali'i Fishpond, like many other fishponds, has been invaded by non-native mangrove. Mangrove breaks the wind, slows the current, and can turn clear coastal waters into anoxic, murky swamp land and mudflats. Generally, mangroves are favored for fisheries and wading seabirds, but the introduction of mangrove into the nearshore marine environment over a century ago has greatly reduced nearshore productivity and the vitality of the shoreline environment because it is not native to this shore. Supporting community-based and non-profit efforts to remove invasive mangrove and restore fishponds and benthic habitat would be of great benefit to the ecosystem and to Molokai's southern shoreline.

Other recommendations for Cell A, on privately owned land, include relocating the restroom at Del Monte Park further inland and upland as it is located very close to the water's edge. Adaptive realignment of the building would avoid inundation by waves or flooding of the floor or fixtures. The realignment to predicted coastal hazards would avoid damage to the building or under scouring of its foundation from coastal erosion. A new elevated structure may necessitate a few steps up into the building but could avoid seawater inundation, even if only elevated a few feet above the grade. The restroom's wastewater disposal system should also be converted to a septic system if it presently relies on a cesspool, as is suspected given its age.

Photo: *Looking east fronting Del Monte Park*

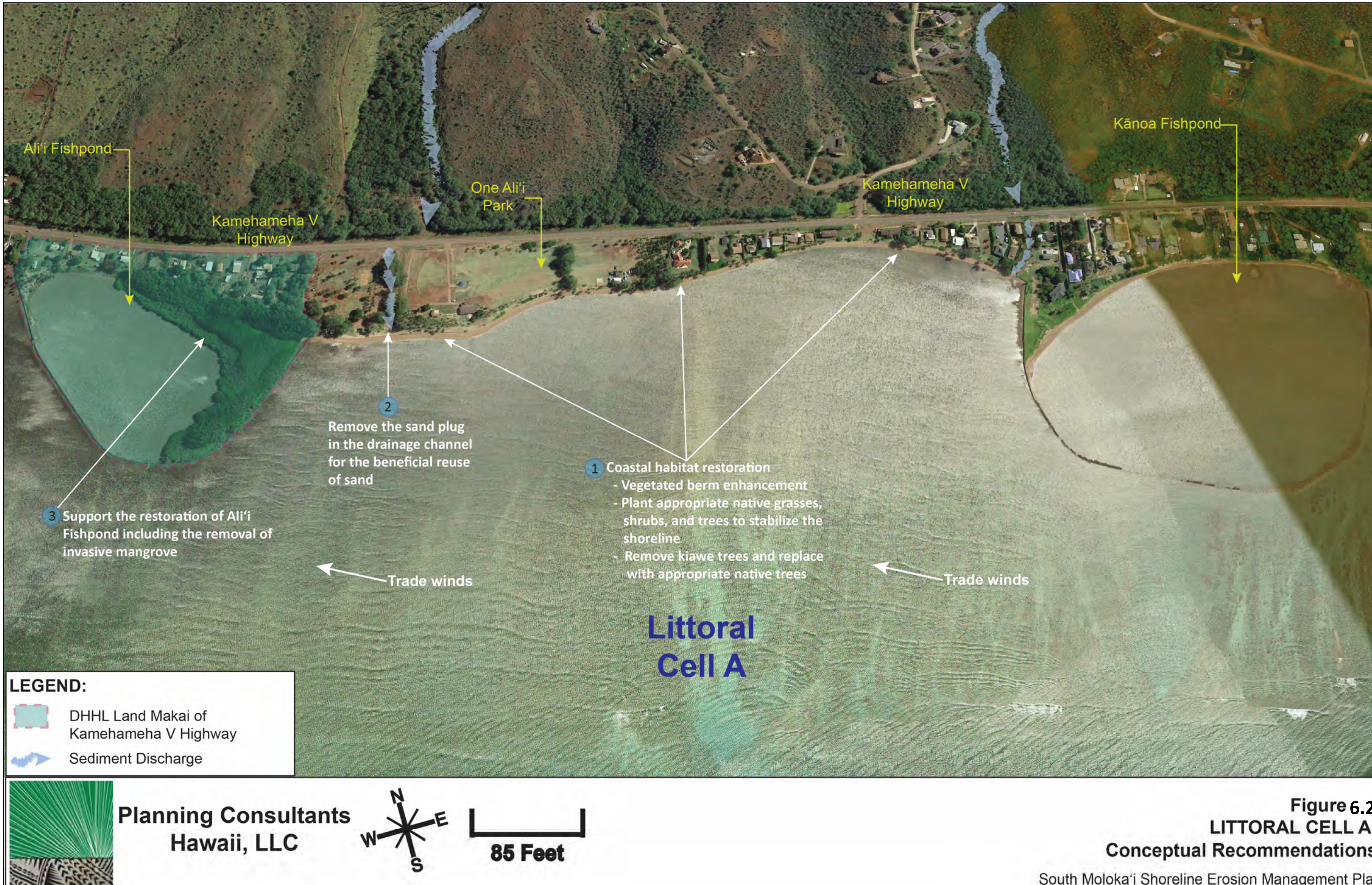


Figure 6.2
LITTORAL CELL A:
Conceptual Recommendations
South Moloka'i Shoreline Erosion Management Plan

6.4 LITTORAL CELL B (ALIʻI FISHPOND TO KALOKOʻELI FISHPOND)

Similar to Cell A, a number of sites within Littoral Cell B (Figure 6.4) could benefit from soft measures that emulate nature's ability to absorb or diffuse wave energy and reduce shoreline erosion. Figure 6.4 illustrates the geographic location of five of these measures. Each of these measures is described below.

1 In consultation with the State Department of Transportation (SDOT), consider nature-based solutions to mitigate shoreline erosion along the highway. DHHL owns a 1.56-acre long, thin parcel of land, TMK (2) 5-4-006:026 west of Aliʻi Fishpond. The land extends makai of the Kamehameha V Highway for about 1,000 feet before it jogs seaward in front of a series of private lots with developed homes along its western end. DHHL should work in consultation with the HDOT Highways Division to address the highway's exposure to coastal hazards such as flooding, wave over wash, and sea water inundation of the road's substrate. DHHL is already an active member in the HDOT Road & Nature Based Solutions discussion group and the DHHL's involvement should continue. DHHL should collaborate with HDOT in evaluating a sill and sedge approach to reducing saltwater intrusion and absorbing wave energy along this narrow, at-risk location.

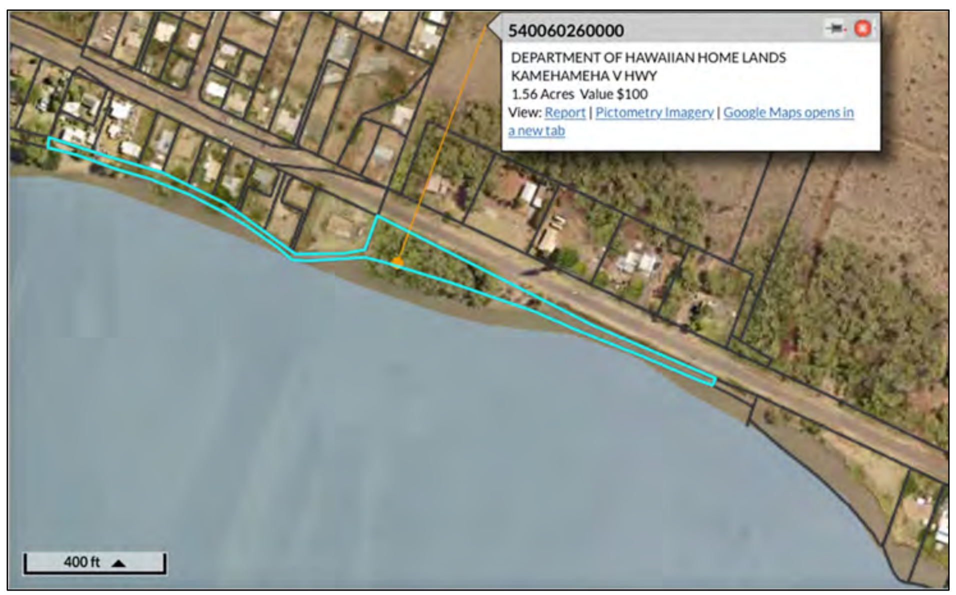


Photo: *A portion of DHHL property harbors kiawe trees makai of the highway.*

2 Support the removal of invasive vegetation and replace with native species. Kiawe trees along the shoreline should be removed given they absorb a great deal of fresh water and dry out the soil. This would improve native plant growing conditions, reduce the formation of embankments along the back shore, and eliminate the supply of sharp thorns and branches that hinder access along the coastline. DHHL should lead by example by removing the kiawe trees on their parcel mentioned above. The site lends itself to an enjoyable, usable, open space next to the ocean with sufficient space for head-in public parking from the road. The area would need to be replanted with native grasses, shrubs, and trees such as milo and beach heliotrope, but once established the area could offer a pleasant, shaded respite with fine coastal views and sounds.

3 Coastal habitat restoration. Other portions of the shoreline in Cell B are impassible due to kiawe and invasive shrubbery that should be removed and replanted with a mixture of native species that would restore ecological function and improve the resilience of the coastline to high wave events. Planting climate adapted, drought tolerant native grasses, shrubs, and trees such as ʻakiʻaki grass, pōhuehue, naupaka, and milo would improve soil retention along the edge of the shoreline and reduce the loss of soil and sand to waves, king tides, and erosion. The removal of invasive and replacement with native plant species is an effective means to restore the function of the coastline and improve nearshore water quality and marine, benthic, and wildlife habitat.

The Kamiloloa shore between Hotel Molokaʻi and the drainage swales and stream outlets to its east could benefit from a coir mat enhanced sand berm along the makai edge of the rear yards. Constructed berms are a form of green infrastructure that can effectively and naturally respond to shoreline retreat, particularly where wave energy is moderate. Berms mimic sand dunes, but they are not as large, nor do they take as much space (See subection 5.7.2).

As a first step, non-native plants, and invasive trees such as kiawe should be removed along a 20-40-foot-wide corridor along the coastline. This allows for the reestablishment of native species given appropriate care and management by the landowner and community. Appropriate drought tolerant coastal species (in order of mature height) include: ʻakiʻaki grass, pōhuehue, naupaka, naio, beach heliotrope, and milo trees.

Once the corridor is cleared, a sandy berm should be created just inland of the crest of the existing shoreline. The berm should be located above the water line and inland of the wet beach, but near the makai edge of a property's rear yard. This berm would create a rise or bump in the landscape that is higher in elevation than the shoreline. The intention is to provide a buffer that can absorb incoming wave energy, disperse waves, and reduce erosion by creating a reservoir of sacrificial sand that can be eroded by large waves. A vegetated sand berm is also effective at capturing and slowing upland stormwater runoff, allowing excess rainwater to pond and deposit sediment on the mauka side of the berm, instead of in the marine environment.

The enhanced sand berm should be located just mauka of the debris and vegetation line. When properly vegetated, the sand berm will be stable and unchanged at this location for most of the year, except during the few times when wind, waves, tides, and seawater combine to overtop the berm and inundate rear yards.

A good reference feature is the seaward edge of the vegetation line and the landward extent of the debris line. This shoreline reference feature is formed by small bits of wood, leaves, fragments of white coral, and plastic pollution that tend to collect along the shore at the highest inland extent that waves pushed it over the past year, thereby forming the debris line.

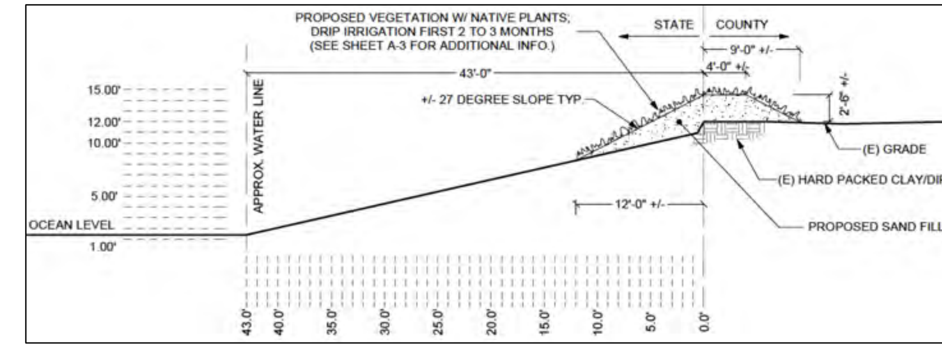


Figure 6.3: *Conceptual diagram of a sand berm's restoration.*

The core of the berm should be comprised of sand-filled coir mat formed into envelopes or tubes. A long coir blanket can be laid out like a rug paralleling the shoreline. In some cases, it may be helpful to place the coir blanket within a shallow, hand dug depression that has wooden stakes to hold the sand-filled core tube. Sand is placed in a long row and piled 2 to 3 feet high in the middle of the coir blanket. The edges of the coir blanket are then brought together at the top, wrapping around, and containing the sand within it. The edges of the coir mat are then sown together to form a 'burrito' with coir material on the outside and sand on the inside of a long, linear, roll or tube. Sand should cover the burrito to protect the coir mat from deteriorating in the sun and water. Special attention should be taken to prevent the added sand from blowing away or being washed away by planting it with native, drought-tolerant plants. Sand placement should be done at low tide and during the calmest seasons of the year.

For access to the shoreline, the end of one linear burrito can extend inland and behind the beginning of the next linear burrito. This offset between the parallel berms would allow foot traffic to pass through the "Z" gap formed by the two engineered berms, but not allow water to directly pass between them. Openings or gaps in the berm that face the ocean may suffer 'blow out' by wave and wind action entering, eroding, and thereby expanding the gap in the berm.

To prevent blow out, access paths to the shore should always be at an acute opposite angle to the prevailing or predominant wind, water, wave, and current direction. Where feasible, wooden crossovers, stairs, or marked footpaths are recommended to prevent foot traffic from crushing the fragile roots of the native plants that hold the sand in place, including those on the sand berm. Additional sand should be added on either the seaward, landward, or on both sides of the berm to form one continuous, shore-parallel vegetated sand mound.

The top of the berm should be at least three feet above the high-water mark, or 2 ½ feet above the neighboring topography, whichever is higher. The seaward slope of the berm should be less steep than 3 to 1 width/height ratio. Do not use sand from the beach, as this merely transfers, and does not expand, the sand reservoir available for storm events. The berm forms a reservoir of sand that can be eroded or sacrificed during a storm to replenish and augment the sand fronting the beach. This helps dissipate wave energy rather than reflect it into the nearshore and/or alongshore areas.

The height, length, and width of the berm determines the level of protection that it can provide. To maintain an effective barrier, sand may need to be added, particularly after big storms, to keep the berm's dimensions consistent with its original intent. A sandy berm won't necessarily stop wave over-topping, but it can reduce the force, depth, and frequency of inundation events into rear yards and buildings.

Placed sand should be covered with an additional coir blanket and planted with native vegetation. The plants are needed to retain the placed sand and although the plant's roots are shallow and easily trampled, they will spread across the sand to hold it in place. Native, salt-tolerant, erosion-control vegetation with extensive spreading rhizomatic root systems are highly recommended and will help hold the sand in place.

Photo: Vegetated sand berm restoration using native plants.

Ongoing monitoring of the berm is necessary so plants can be replaced if they die or are removed by waves. Berms with vegetation, as opposed to without, will perform more effectively and offer greater energy dissipation, resistance to erosion, and stability. The restored sand berm is not likely to withstand a major storm or hurricane, but it would enhance the resiliency of the coastline, building its capacity to absorb shock and high water and wave events such as "King Tides".

Drip irrigation is necessary at the time of planting for the plants to survive, but once established they adapt to the harsh, hot, dry, salty environment of the coastline. Drip irrigation can be provided by connecting portable jugs to small plastic tubes that are placed along or slightly beneath the surface of the sand. The water level in the jugs should be monitored on a regular basis and refilled as needed until the plants are firmly established. The drip lines can be left in place in case the plants need watering during a drought or dry season.

The sand source or borrow site must be identified and evaluated beforehand to ensure it does not contain cultural artifacts or sensitive resources such as *iwi kupuna*. Before its beneficial reuse is implemented, the source of the sand must be evaluated to be culturally appropriate. Sand that plugs drainages and lined drainage swales can often serve this purpose, since it should be periodically removed to allow the swales to drain properly to the ocean. Sand that has accumulated in front of man-made impediments to its lateral movement along the shoreline may also be less likely to harbor cultural resources given the sand's unnatural accumulation. For instance, a substantial amount of sand and sediment has accumulated updrift of the Kaloko'eli Fishpond wall. The three parcels between the Hotel Moloka'i and the Kaloko'eli Fishpond accreted from 70 feet to 180 feet over a 33-year period according to County plat map (5-4-002), and they have likely gained more material since then.

A sieve analysis is recommended to ensure the sand used for restoration is of the right grain size, coarseness, density, color, and is free of fines and silt so it is compatible with the surrounding environment. It is important to use the right coarseness of sand, so the sand grains stick to the beach and are not easily washed away by normal currents and wind. The sand must be cleaned and lack fine silt or red/brown clay that could pollute nearshore waters and choke the coral reef. The color of the sand should also be compatible with the area in which the sand berm is being constructed. It is important to use sand that is comparable to the native sand in the vicinity of berm restoration, both from an ecological and aesthetic perspective, in case the berm breaks, and its contents are released. In addition to reducing risk, sand berms form habitat for marine life, wildlife, and birds like wedge-tailed shearwaters that help fishermen locate schools of fish. Sand berms are important culturally, ecologically, and aesthetically.

A coordinated community effort involving adjoining oceanfront property owners and lessees in the Kamiloloa subdivision could help rebuild the assimilative capacity of the coastline to buffer coastal hazards along this portion of the shoreline.

Photo: What one meter of sea level rise could look like in Moloka'i.

4 The Kaloko'eli Fishpond has been invaded by non-native mangrove on its upwind side. Mangrove breaks the wind, slows the current, and can turn clear coastal waters into anoxic, murky swamp land. Generally, such areas are favored for fisheries and wading seabirds, but the introduction of non-native mangrove into the nearshore marine environment over a century ago has greatly reduced nearshore productivity and the vitality of the shoreline environment.

Supporting community-based and non-profit efforts to remove invasive mangrove and restore fishpond and benthic habitat would benefit the ecosystem and could potentially reduce the impact of sea level rise on the Kamiloloa shoreline. Any use of sand to mitigate shoreline erosion must be done with the utmost sensitivity and with the participation of cultural practitioners due to the possible presence of iwi kupuna (ancestral remains).

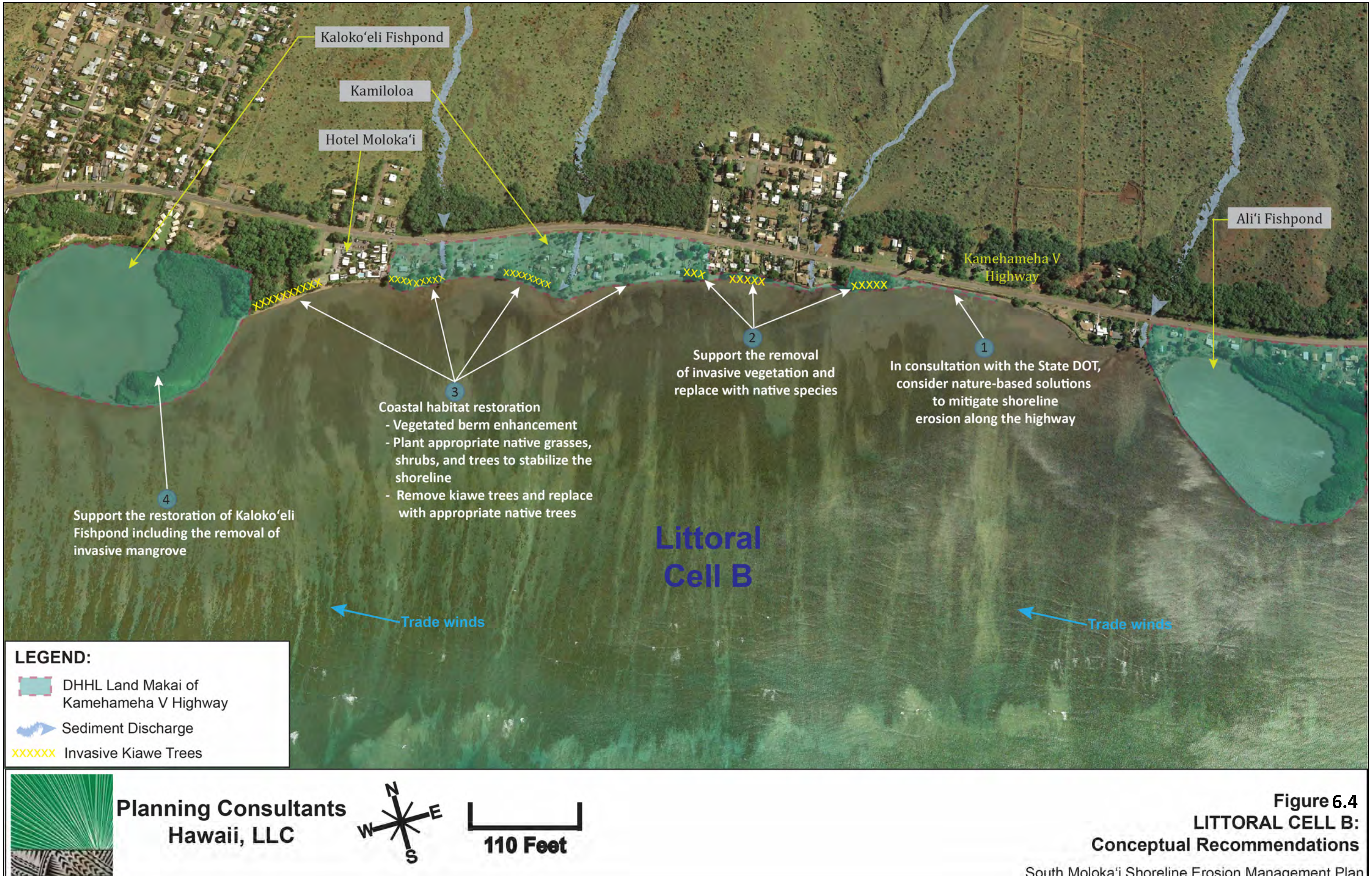


Figure 6.4
LITTORAL CELL B: Conceptual Recommendations
South Moloka'i Shoreline Erosion Management Plan

6.5 Littoral Cell C (Kaloko'eli Fishpond to Kaunakakai Wharf)

The natural movement of sediment within and through Littoral Cell C has been drastically altered by human intervention. Littoral Cell C extends from the Kalokoʻeli Fishpond to the Kaunakakai Wharf (Figure 6.5). The coastline fronting the Kapaʻakea homestead subdivision is the most armored and unnatural of the DHHL properties within the project area. Nine recommendations are identified on Figure 6.5 and are discussed below.

(1) Support the removal of invasive vegetation and replace with native species. Like other cells, DHHL should strive to remove invasive vegetation and incentivize its replacement with native species adapted for the shoreline environment.

(2) Restore coastal habitat. Some segments of the shoreline in Cell C are impassible due to kiawe, invasive shrubbery, and man-made armoring. In contrast, the shoreline fronting the Molokaʻi Shores condominiums exhibits a mixture of native species that are adapted to the coastal environment. They have restored the ecological function and resiliency of the shore area to prevent high waves and coastal erosion events from cutting steep embankments into the shoreline. By planting drought tolerant native grasses and shrubs such as ʻakiʻaki grass, pōhuehue, and naupaka, and creating a reservoir of erodible sand, they have reduced the condominium's exposure to waves, king tides, and flood inundation while maintaining an accessible and attractive shoreline. The removal of invasive plants and replacement with native species is a cost-effective means to restore the function of the coastline and improve the nearshore marine habitat and water quality.

(3)(6) Potential sill and fishpond restoration pilot site. The DHHL should explore increasing the assimilative capacity of the environment along the shore using fishpond restoration and a rock sill and sedge as a pilot study at a few specific locations. To exemplify, adjacent to the eastern side of the Kapaʻakea subdivision is a submerged remnant fishpond wall (#3, Figure 6.5) that behaves as a sill that is similar to what was discussed in Chapter 5. A crescent-shaped beach has formed just mauka of the ancient fishpond wall because of sediment and sand accumulation.

It appears the submerged wall breaks wave energy that would otherwise erode the shoreline and cause an embankment to form, as has occurred in other portions of the littoral cell. The vegetation inland demarks the tidal inundation line. The naturally stable sandy shore that has formed at this location is wide enough for unconstrained lateral transit. This contrasts with the armored shoreline to the west in the Kapaʻakea subdivision that has a narrow, steep interface between the land and the water hindering alongshore and mauka-to-makai access.

Shoreline managers should strive to restore the fishpond wall to emulate a sill formation at this and other shoreline locations within DHHL jurisdiction. This form of remediation could help reduce the amount of shoreline erosion, and it may counteract the loss of shoreline access due to impairment of natural sediment transport. While a nearshore sill does not usually prevent erosion, it can help reduce the rate and severity of erosion and sediment loss. A sill can also contribute to the formation of a gentler grade between the ocean and a property's rear yard on the coastal plain. A sill with native sedges immediately inland can absorb a considerable amount of wave energy and surge, up to 50% in 50 feet, but it may succumb to breaking waves and scour during a large storm event. Nonetheless, post storm clean-up is usually considerably easier than repairs to massive shoreline armoring.

Photo: *A remnant fishpond wall east of Kapaʻakea acts as a sill to break wave energy thereby facilitating a beach corridor to form.*

A sill comprised of small hand-carried rocks and boulders has also been created at the western end of the Kapaʻakea homestead subdivision (#6, Figure 6.5). The sill is not backed by vegetation, such as sedge, that could absorb and assimilate wave energy. However, the low-rise nature of the rock sill has probably contributed to the formation of a gentle grade and sandy backshore. Other candidate locations for sill and sedge could include the shore fronting Kamehameha V Highway in Cell B where the highway is threatened. In Cell C, the shoreline fronting developed DHHL properties west of Molokaʻi Shores condominium could test this approach if it was associated with removal of invasive kiawe trees. Some oceanfront locations within the Kapaʻakea subdivision may find this approach more suitable and palatable than using foreign debris such as tires and rubble to slow coastal change.

The sill at the western end of Kapaʻakea contrasts with neighbors to the east who have taller, vertical armoring that may hold the line against erosion and prevent retreat of the shoreline, but at a loss of the beach corridor between the yard and ocean and the attendant loss of direct access to the ocean and nearshore marine environment.

Photo: *A low rocky mound at the western end of Kapaʻakea forms a sill that breaks waves and captures sediment which helps to build a sandy shoreline.*

(4)(7) Restore wetland function. Kapaʻakea has wetlands on either side of the subdivision that should be fully restored. Functional wetlands can store substantial amounts of storm water runoff and can prevent flooding.

Wetlands are an excellent sink to capture and stabilize silt and sediment that runs off barren hillsides and into the ocean where it harms marine life, smothers corals, and degrades the nearshore environment. DHHL should collaborate with partners and non-profits to maximize each wetland's assimilative capacity by restoring their ecological function. Drainages and swales should be cleared and maintained. Upland grazing, especially by ungulates, should be managed. Hydrologic connections to the wetlands within the ahupuaʻa should be maintained, improved, and restored where feasible.

(5) Use best management practices (BMP's) for shoreline hardening; dry-stack walls; and restore drainageways. Oceanfront residents in Kapaʻakea should incorporate BMP's when responding to shoreline change. A considerable amount of armoring has already been placed along this portion of the South Molokaʻi coastline (Figure 6.5). Informal rubble mounds and foreign materials such as tires, wooden pallets, plastic jugs, barrels, concrete curbs, asphalt slabs, carpet, motor engines, and auto parts should be removed. If replacement is necessary, only native lava or volcanic rock or *pōhaku* should be used. The following types of foreign material can be dangerous to human health and the natural environment:

1. Pallets rot and leave rusty nails that injure feet;
2. Plastic jugs and tires hold water where mosquitos breed;
3. Asphalt and engines have oils that pollute the ocean; and
4. plastics decay and make fish and birds sick when eaten.

Foreign materials and debris leach harmful chemicals into the water and sediment that can be toxic to marine life, corals, crabs, limu, and fish. Over time these toxins can bioaccumulate in edible marine species to the detriment of human health if ingested. Rubble and debris are not as effective as volcanic rock, *pōhaku*, and coarse sand grains at absorbing and dissipating wave energy, king tides, and storm surge.

Along the shoreline, it is imperative to have weep holes or a means for ground water to seep through a wall when a wall retains an embankment. If a wall is constructed along the shoreline where one side is exposed to the ocean, but the other side is covered by the rear yard, ground water will be pulled under the wall's footing causing the wall's base to erode and the wall to collapse. Without a means for water to seep out of the wall, hydrostatic pressure will build up behind the wall and push the stones or concrete blocks seaward which may topple the wall during a storm. Coarse, clean, well-drained sand and aggregate behind a wall allows ground water to seep through the wall and not build up pressure mauka of it. Smaller, less angular stones and *ʻiliʻili* (pebbles) can be used as fill mauka of a retaining wall.

Before constructing either a retaining wall, or seawall, along the shoreline ensure that all required governmental permits have been obtained to ensure the wall will be safe and effective. Furthermore, inspect the nearshore benthic environment for freshwater seeps and springs. If bivalves, shells, or marine life that thrives on brackish water are plentiful, it could indicate that freshwater springs or upwellings are prevalent. A dry stack wall may not be suitable for such a location because of potential groundwater flows and the potential for hydrostatic pressure behind the wall. Speak with *kūpuna* who know the area to determine if the location was good for gleaning or gathering shellfish in the past, or if it has chilly spots in nearshore waters, or was a favored place for swimming. Traditional ecological knowledge like this can help inform the proper site-specific remedy or response to shoreline change.

Drainages, lined culverts, and swales should be cleared and maintained and their outlets to the ocean should not be covered or blocked by armoring or debris. Impediments to the flow of water can cause backups, ponding and/or flooding of adjacent property and will cause the drainageways to fail.

Natural access to ocean resources is preferable and can be lost or hindered when shoreline armoring is relied upon to protect land. A sandy beach provides a gradual slope to walk down or to move and stage kayaks, outrigger canoes, and small fishing boats, whereas a rock-strewn shoreline creates a vertical impediment to gaining easy access to marine waters and nearshore life.

Photo: *This wall's effectiveness could be improved with more weep holes distributed behind the wall and more porous aggregate as fill.*

In places where building relocation, reconfiguration, retirement, or realignment cannot be implemented, a dry stack wall or boulder mound should be considered instead of using debris or rubble. Shoreline armoring that incorporates the best practices mentioned will help improve the nearshore environment, keep the 'ice box' clean and free of pollutants, and improve the effectiveness of shore protection efforts.

Traditional designs for fishpond perimeter walls (*loko kuapā*) function like a seawall (please see "Dry Stack Walls", Chapter 5, Subsection 5.13.8). They have some porosity so that water can flow into and seep through the wall, thereby helping to absorb some of the wave energy while also alleviating hydrostatic pressure. To achieve this, the wall's face must be properly oriented to the prevailing wave pattern. Ideally, fringing reefs are offshore of the wall, and can break up the incoming waves.

The wall should be located just before the waves would reform and break a second time, thereby depriving the wave of its power before it can crest again. The wall should stand at least one foot higher than the highest tide of the year.

Since no mortar or cement is involved, the stones used must be carefully selected and placed in an interlocking fashion (*hoʻo niho*). The base rocks or toe of the wall should comprise the largest and heaviest rocks and rest on immobile substrate. The toe rock must be below the scour depth of the waves to prevent it from moving, tilting, or its resting position from being compromised. The seaward face of the rocks should be greater than its inland facing portion of the wall and the face of the wall should slope upward rather than be vertical to reduce wave energy. A second interwall can be made of stones placed to interlock with the face stones. This configuration of 'male' stones interlocking with 'female' stones in crisscrossed layers starting at the bottom and rising upward helps to create a strong, durable wall, whether it be a freestanding fishpond perimeter, or retaining an embankment or rear yard.

Photo: *Without armoring, land is lost but beach and access are preserved.*

Coral "koʻa" is made of calcium carbonate (i.e., limestone) and can fill in gaps and voids between the outer and inner wall. Coral is preferred becuase it grips the stones better, which prevents the stones from sliding and shifting. Coral is also lighter than black or blue volcanic rock, but tends to hold stones together to help seal gaps and voids.

A dry stack wall tends to collapse inward upon itself thus becoming tighter and tighter with age thereby increasing its strength over time. Consult with a Hawaiian practitioner who is a fishpond wall builder or contact a fishpond restoration organization for input and guidance.

8 <u>Coastal habitat restoration</u> between the Koheo Wetland and the Kaunakakai Wharf would rejuvenate natural processes making the shoreline more resilient to changing shoreline conditions. Planting climate adapted, drought tolerant native grasses, shrubs, and trees such as ʻakiʻaki grass, pōhuehue, naupaka, milo, and beach heliotrope would improve soil retention along the edge of the shoreline and reduce the loss of soil and sand from waves, king tides, and erosion. Removing kiawe trees would improve native plant growing conditions, reduce the formation of embankments along the shore, and eliminate the supply of sharp thorns that hinder access. DHHL should partner with its neighbors to help coordinate and incentivize restoration of habitat, and lateral access given its importance to the culture and lifestyle of Molokai's residents.

9 Beneficial reuse of sand. Sand has accumulated updrift of the Kaunakakai Wharf. These areas may harbor good quality sand that is less likely to contain culturally significant resources given its unnatural accumulation. The shoreline area east of Malama Cultural Park and along the eastern side of the wharf could provide sand for restoring the shoreline and for beneficial reuse. DHHL should work with the HDOT Harbors Division and the DLNR DOBOR to explore the beneficial reuse of the accumulated sand. A sieve analysis is recommended to ensure the sand used is clean and not silty and is compatible with the environment where it would be placed. It is important to use sand that is comparable to the sand in the vicinity of the restoration area for ecological, marine life, water quality, cultural and aesthetic reasons.

Stub groins. An additional option that warrants further examination for the area fronting the Kapaʻakea Subdivision is the strategic placement stub groins to capture and retain sand and sediment.

Prior to installing permanent rock groins, it would be prudent to test temporary sand groins to evaluate their utility in addressing shoreline change. Placing short (25-feet or less) stub groins updrift of a few of the drainage outlets on the western side of the Kapaʻakea subdivision may be a practical means of capturing sediment and rebuilding the coastline. Since upland sediment discharge usually travels in an east-to-west direction it would be more effective to have each groin located on the eastern side of the outlet for open drainage swales and lined culverts. These locations would also tend to not block the discharge of storm water runoff, which is needed to prevent inland flooding. Several suitable locations could be selected to test the effect of placing short stub groins along the shore temporarily. If the results were favorable, and there were not negative down drift effects, then permanent groins could be evaluated. However, permitting permanent structures may be challenging and could trigger a public decision-making process that can take a considerable amount of time, effort, and study.

This option can be tested by using geotextile tubes, or bags, arranged perpendicular to the coastline and filled with sand. Sand is mixed with water in a containment device and then pumped as a slurry into the geotextile tube or bag. The sand remains in the tube, or bag, but the water is squeezed out through the geotextile fabric. This is a fast and cost-effective way of building groins that prevent along shore loss of sediment.

The geotextile sand groins are temporary in nature and can be easily removed by cutting them open and releasing their sand contents. Precautions must be taken to protect water quality during pumping and depositing of the slurry. The tubes work best when resting on stable, non-abrasive substrate. For example, if the tubes are placed on sharp stones, or jagged reef, they can be torn open if large waves push the fabric across the substrate or if rocks scour the fabric during heavy wave action. Turbidity in nearshore waters can be controlled during bag filing by using booms and silt curtains, and only doing work during calm sea conditions. For Molokai's south shore, the work may have to occur in the morning when the prevailing winds are usually light.

If the geotextile stub groins prove to be a suitable shoreline erosion management option, they can be replaced with permanent rock groins as illustrated in the photo below.

Photo: *Aerial imagery of rock stub groins along Maui's north shore.*

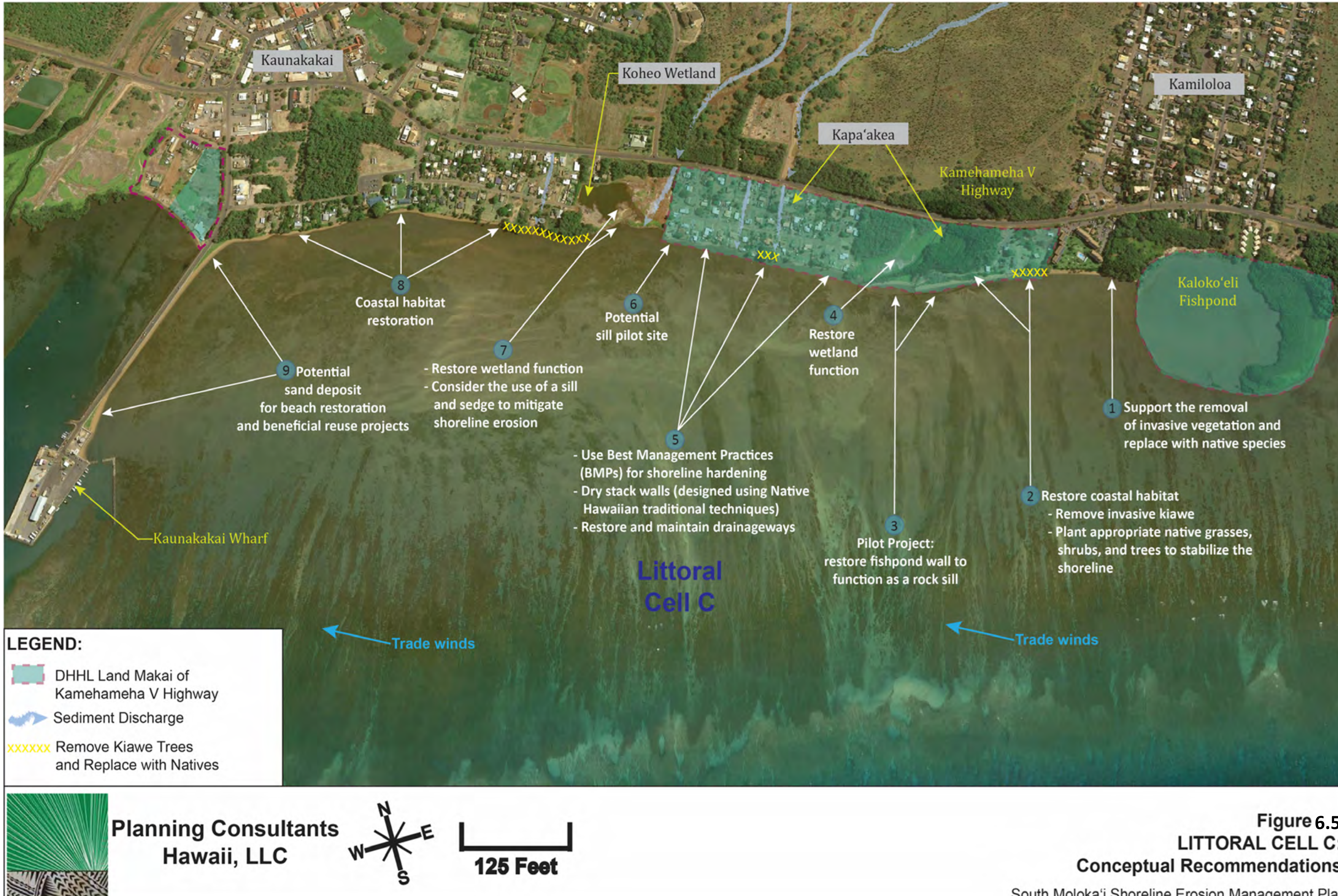


Figure 6.5
LITTORAL CELL C:
Conceptual Recommendations
South Moloka'i Shoreline Erosion Management Plan

6.6 LITTORAL CELL D (KAUNAKAKAI WHARF TO KAHANU AVENUE)

Littoral Cell D extends from the Kaunakakai Wharf to just east of the Kalanianaʻole Colony (Figure 6.6). The natural movement of sediment within and through littoral Cell D has been drastically altered by the introduction of mangrove and the construction of the Kaunakakai Wharf. Cell D's hydrology, water quality, and aquatic ecosystem has also been influenced by flood control efforts such as stream channelization and centralized wastewater treatment that discharges in the cell.

In the geologic past, currents flowed over the reef and sediment was carried offshore by the deep channel carved into the ocean floor by the Kaunakakai Stream. Nowadays, most of the littoral cell is accreting, primarily through mangrove infestation that slows nearshore currents. The mangrove slows the water as it reaches the shallows where it becomes still and converts the once coarse sandy shoreline to inaccessible swamp land with minimal utility. In contrast, Kiowea Park and the shoreline fronting Kalanianaʻole Hall in the center of the littoral cell are eroding and exhibiting shoreline retreat. Figure 6.6 includes five recommendations that are discussed below.

(1) Beneficial reuse of sand. A considerable amount of sand has accumulated on the eastern side of the Kaunakakai Wharf. This man-made structure impedes lateral movement of sediment along the shoreline between littoral Cells C and D causing it to accumulate on the Wharf's updrift side. A substantial amount of sand and sediment has accumulated updrift and across the wharf from the canoe hale at Malama Cultural Park. In addition, sand and sediment has been deposited by altered current patterns along the eastern side of the wharf where it meets the revetment that protects the small boat harbor. Both areas could provide sand for restoring the shoreline, once determined to be free of iwi kūpuna.

DHHL should work in collaboration with the HDOT Harbors Division and the DLNR DOBOR to explore the beneficial reuse of the accumulated sand. A sieve analysis is recommended to ensure the sand used for restoration is of the right grain size, coarseness, density, color, and is free of fines and silt so it is compatible with the environment where it would be placed. It is important to use the right coarseness of sand, so the sand grains stick to the beach and are not easily washed away by normal currents and wind. The sand must lack fine silt or clay that could cause turbidity and pollute marine waters. The color of the sand should also be compatible with the area in which the sand is being used or placed. It is important to use sand that is comparable to the native sand in the vicinity of the restoration, both from an ecological and aesthetic perspective. However, the sand that has accumulated in this area was originally from updrift and east of the wharf, implying that it is from a native source, is not likely to contain iwi kupuna, and is therefore appropriate for restoration activities.

(2) Coastal habitat restoration (Malama Cultural Park). The lands of the Malama Cultural Park are steeped in Hawaiian history as it was the home of Malama, the royal residence of King Kamehameha V. Today, the shoreline area is a hub for recreational activity including canoe hale, outrigger canoe paddling, storage to support water sports, organized contests, and sporting events. Wetlands mauka of the shore and adjacent to access roads in the park should be maintained and improved through careful, well-planned restoration activities. Invasive mangrove is creeping into the shoreline area along the Park's western extent. Given its invasive nature, the water sports community should actively remove and replace the mangrove with native vegetation such as bulrush or other climate-adapted native plants. If restoration activities became a regular part of sports club activities and team curriculum, shoreline maintenance and care could dramatically change and improve the Park's coastal environment, near shore water quality, and aesthetic appeal.

Malama Cultural Park could benefit from an enhanced vegetated sand berm along the edge of the shoreline. However, pedestrian and recreational use would have to be directed to marked pathways so that fragile, shallow dune plants and their roots would not die from being trampled by foot traffic or crushed by canoes. The remnant carpet used to control erosion of the short clay embankment at the top of the shore should also be replaced with more environmentally benign materials, such as sand from the opposite side of the wharf. Carpet tends to leach chemicals into nearshore waters that fish, crabs, limu, and other aquatic life can bioaccumulate, and that people may unknowingly harvest and eat. Please see Subsection 6.4 (Littoral Cell B), Recommendation 3, for a more thorough discussion of the use of coir mat enhanced sand berms to support habitat restoration and coastal resilience.

(3) (5) Remove and replace the mangrove with appropriate native vegetation. Long-term residents of Kalamaʻula provide firsthand reports that invasive mangrove has spread so extensively seaward that former open coastal foot paths to Malama Cultural Park to the east are now impassible. This segment of shoreline is replete with thickets of mangrove-induced accretion.

Photo: *Invasive mangrove between Kalamaʻula and Kaunakakai Wharf.*

The mangrove thickets on both the eastern and western side of the Kalamaʻula subdivision have inhibited the use of the land and hindered access to the ocean and along the shoreline. Excessive mangrove infestation can cause anoxic conditions in the still water leading to fish kills at low tide. To counter this, a community-based effort to remove and replace mangrove with appropriate native vegetation is recommended. Such efforts will help residents and DHHL reclaim the use and utility of land lost to this invasive plant.

(4) Coastal habitat restoration (Kapuāiwa Coconut Grove to Kalanianaʻole Hall). The retreating coastline between the Kapuāiwa Coconut Grove and Kalanianaʻole Hall may benefit from a vegetated sand berm and native habitat restoration. Several coconut trees have succumbed to erosion along this portion of the coastline. The historic Hall is not jeopardized by erosion but could be inundated by rising waters and flooding from wave overtopping of the embankment along the shore.

To reduce this risk, a maintained vegetated sand berm could help raise the height of the embankment to reduce the risk of flood damage to the building. Other south shore areas use vegetated berms to reduce a building's exposure to moderately sized wave over wash and flooding. Please see Subsection 6.4 (Littoral Cell B), Recommendation 3, for a more thorough discussion of the use of coir mat enhanced sand berms to support habitat restoration and coastal resilience.

Photo: *A vegetated sand berm protects a house from waves and flooding.*

As part of a comprehensive strategy of adaptive realignment, a new pavilion and restroom were built substantially inland of the existing shore-fronting pavilion at Kiowea Park. As portions of the original pavilion deteriorate, they should be removed before they are threatened by inundation and/or become debris along the shore.

For example, the concrete slab that has slipped seaward should be removed before it breaks into smaller, sharper pieces that become tripping hazards entrained in the sand. The concrete sink and its drain to the ocean fronting the pavilion should be removed and not replaced. Electrical wiring, outlets, and fuse boxes should be water-proofed or removed to prevent accidental electrocution should they become inundated with seawater.

The concrete block restrooms adjacent to the pavilion and its wastewater system should be decommissioned and retired over time. With predicted sea level rise, these built assets will require more maintenance and repair costs, while safer replacements are available at the new pavilion.

Photos (above/below): *Damaged components of the pavilion should be removed and retired*.

While a vegetated sand berm could help prevent inundation, foot traffic would have to be controlled so the roots of the berm's native plants are not crushed or trampled. When the roots die, the plant dies, and the sand in the berm can easily be washed or blown away. Fortunately, the original pavilion is designed to allow water or waves to flow through the structure with minimal hindrance or harm.

These built assets should be decommissioned over time rather than continually repaired as the need and expense will rise with sea levels.

To the west and nearly adjacent to the new pavilion is an isolated spring or pocket wetland. The spring is located substantially inland but makai of the highway. The spring could serve as an indicator of ground water and hydrologic patterns in the vicinity of Kapuāiwa Coconut Grove. Many of the coconut trees in this area exhibit poor health and are dying.

As DHHL has offices across the highway, it should consider monitoring the salinity and water level of the spring and open springs within the grove to help determine the brackishness of the coconut grove's subsurface flows and the inland extent of tidal influence. A professional hydrologist in partnership with student interns could develop an educational opportunity for collecting data and testing the pond and springs characteristics.

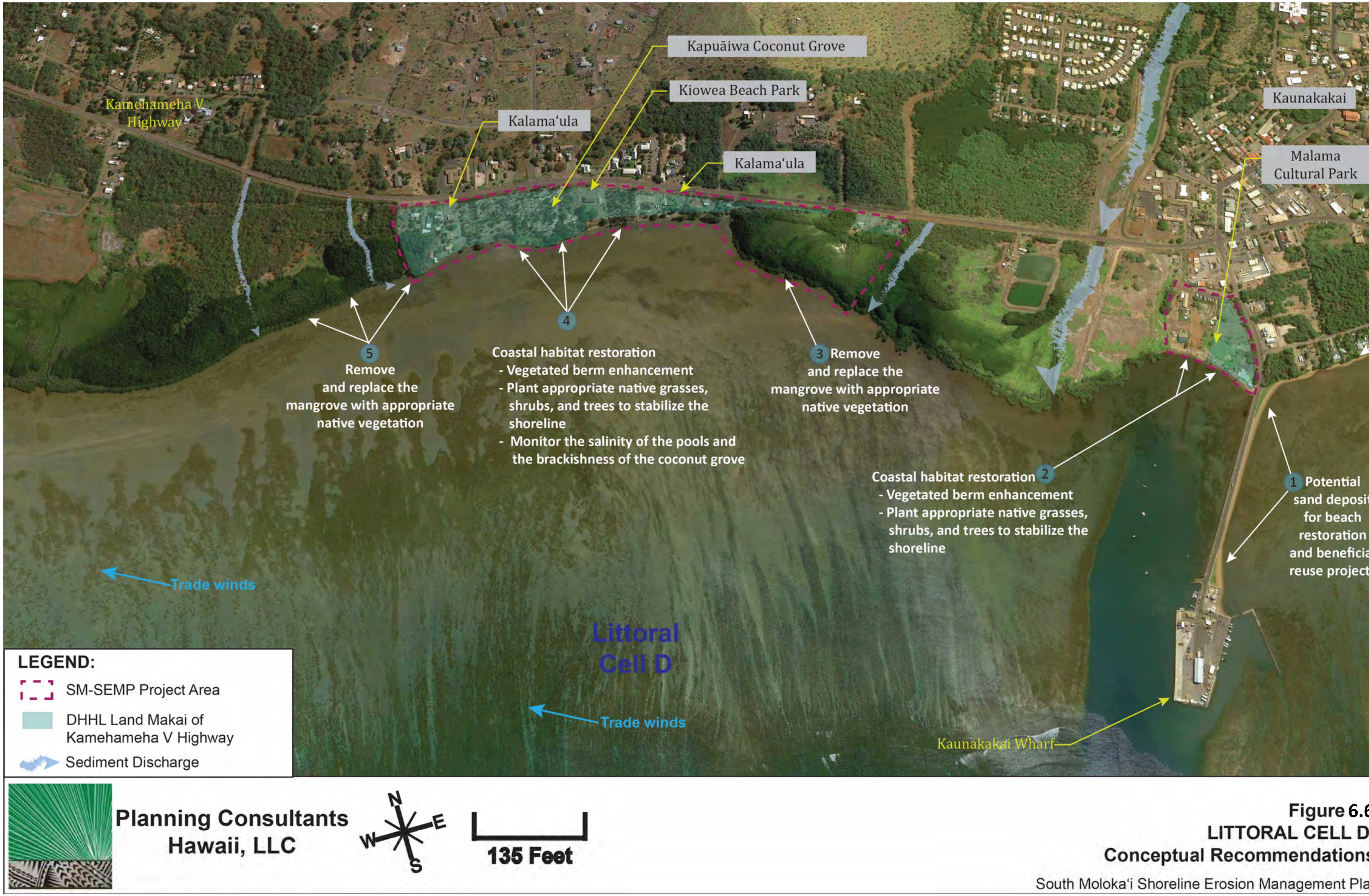
Other (the boat launch). The boat launch at the end of Kapuāiwa Road next to Pond Place is frequently used to access nearshore waters and the reef west of the wharf. The safety and utility of the area could be enhanced with minor improvements that could indirectly reduce human-induced coastal erosion.

Down-shielded, seabird friendly, lighting could help deter illicit and unwelcome activity that occurs at night in the dark parking area. Such lighting could help drivers better align their trailers to the boat launch to avoid becoming stuck in soft sediment, impaling trees, crushing their roots, or driving into the embankment nearby.

An eroded concrete cap encases the end of a water line on the western side of the boat ramp. If the line breaks, valuable potable water would be lost, the embankment could erode, and emergency repairs may be required. As a remnant, the eroded cap could damage a boat, trailer, vehicle, or puncture a tire. The cap and water line should be removed and terminated within or adjacent to the paved roadbed serving the nearby residences. Terminating the water line at this inland location would make it accessible, but not create a driving or tripping hazard or risk damage, leakage, or breakage of the water line. It may also be prudent to relocate the electric line utility pole and its guide wires from the eastern side of the roadbed, where they represent a vehicle hazard when turning or backing, to the western side of the road where it would not impede vehicle and trailer turning movements.

Photo: *Plants can absorb and dissipate wave energy and create wildlife habitat.*

Photo: *Access to clean productive nearshore waters is important to Molokai's lifestyle.*


Kapuāiwa Coconut Grove
Kiowea Beach Park
Kamehameha V Highway
Kalama'ula
Kalama'ula
Kaunakakai
Malama Cultural Park
5 Remove and replace the mangrove with appropriate native vegetation
4 Coastal habitat restoration
- Vegetated berm enhancement
- Plant appropriate native grasses, shrubs, and trees to stabilize the shoreline
- Monitor the salinity of the pools and the brackishness of the coconut grove
3 Remove and replace the mangrove with appropriate native vegetation
2 Coastal habitat restoration
- Vegetated berm enhancement
- Plant appropriate native grasses, shrubs, and trees to stabilize the shoreline
1 Potential sand deposit for beach restoration and beneficial reuse projects
Trade winds
Trade winds
Littoral Cell D
Kaunakakai Wharf
LEGEND:
SM-SEMP Project Area
DHHL Land Makai of Kamehameha V Highway
Sediment Discharge
Planning Consultants Hawaii, LLC
N
E
S
W
135 Feet
Figure 6.6
LITTORAL CELL D:
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REFERENCES

The following sources of information were used in the development of this document.

1848 Register of Claims, Foreign Language Edition, Vols. 5,6,7 & 8. Hono:AH. Quoted in Chris Hart & Partners. 1993. Technical Supplement to Design Guidelines for Kaunakakai, Maunaloa, Kualapuu, East End. Pg. F-2.

ADS, 2013. Kiowea Park Phase II Improvements, Final Environmental Assessment. Architectural Drafting Service, Kaunakakai, HI. July 12, 2013. Pgs 20-33. Viewable at https://files.hawaii.gov/dbedt/erp/EA_EIS_Library/2013-08-08-MO-FEA-Kiowea-Park-Improvements-Phase-II-Kalamaula.pdf

Allen, J.A., 1998, Mangroves as an alien species; the case of Hawaii: Global Ecology and Biogeography Letters, v. 7, p. 61–71. Quoted in Roberts, Lucile M and Field, Michael E. 2008. People, Land, and the Reefs of South Molokaʻi. Chapter 15 in *The Coral Reef of South Molokaʻi, Hawaii – Portrait of a Sediment- Threatended Fringing Reef.* U.S. Geological Survey Scientific Investigations Report 2007-5101, 126. Pg. 62.

Arleone Dibben personal communication, January 31, 2019

Bottin, R. and Acuff, H. 2001. Design for Enhancement of Wave-Induced Circulation at Kaunakakai Harbor, Molokai, Hawaii. Coastal Model Investigation, Coastal and Hydraulics Laboratory, U.S. Army Engineer Research and Development Center, MS. ERDC/CHL TR-01-29. November 2001.

Cascorbi, Alice. 2011. Fishery Research Biologist, Monterey Bay Aquarium Seafood Watch Program. April 7, 2004, page 5. Viewable at: https://www.seachoice.org/wp-content/uploads/2011/11/MBA_SeafoodWatch_HICrabReport.pdf

Cazar, Allen. 2015. Get2Hawaii. Hawaii's Samoan Crab. September 17, 2015. Viewable at https://www.get2hawaii.com/hawaiis-samoan-crab/

Chao, E., 2012. The Molokai Dispatch, Wednesday, October 17th, 2012.

Chris Hart & Partners. 1993. Technical Supplement to Design Guidelines for Kaunakakai, Maunaloa, Kualapuu, East End. Pg. F-2, F-5, F-11, F-13, F-14.

City Data, 2019. Kapaʻakea Homesteads neighborhood in Kaunakakai, HI. 96478 detailed profile. Read more: http://www.city-data.com/neighborhood/Kapa-akea-Homesteads-Kaunakakai-HI.html

Cochran-Marquez, Susan A. 2005. *Molokaʻi Benthic Habitat Mapping*. USGS Pacific Science Center Open File Report 2005-1070, pg 11.

Coral Reef Ecology Lab, 2016. Molokai. Hawaii Institute of Marine Biology. Photo from offshore uploaded October 2016. Accessible at https://coralreefecologylab.com/research/

Costa-Pierce, Barry A. 1987. Aquaculture in Ancient Hawaii. BioScience, Vol. 37, No. 5, Aquaculture pp. 320-331 Published by: University of California Press on behalf of the American Institute of Biological Sciences Stable URL: http://www.jstor.org/stable/1310688. Pg. 324

Cuddihy L.W., Stone C.P, 1990. *Alteration of native Hawaiian vegetation*. Cooperative National Park Resource Studies Unit, University of Hawaii, Honolulu, 1990.

Dack, Jeffrey. Maui County Planning Department, Coastal Zone Management Program Administrator. Communication by email dated July 22, 2015 to Munekiyo & Hiraga regarding DHHL flood mitigation project permitting in Kaunakakai.

DBEDT, 2019. Assess the Feasibility and Implications of Managed Retreat Strategies for Vulnerable Coastal Areas in Hawaiʻi. Final Report. State of Hawaii. Department of Business Economic Development & Tourism, Office of Planning, Coastal Zone Management Program by SSFM. February 2019. Page 4.

DLNR, 2009. State of Hawaii, Department of Land and Natural Resources. "Molokai Forest Reserve Management Plan", 2009.

Field, M.E., Cochran, S.A., Logan, J.B., and Storlazzi C.D., eds., 2008. *The coral reef of south Molokaʻi, Hawaiʻi — portrait of a sediment-threatened fringing reef*. U.S. Geological Survey Scientific Investigations Report 2007-5101, pages 89, 137, 155 of 180 p.

Fitzpatrick, Gary L and Moffat, Riley M. 2004. Mapping the Lands and Waters of Hawaiʻi. Editions Limited. Honolulu, Hawaii. Pg. 86.

Field, M. E., Ogston, A. S. and Storlazzi, C.D., 2011. *Rising Sea Level May Cause Decline of Fringing Coral Reefs*. Eos, Vol. 92, No. 33, pages 273-274, 16 August 2011.

Fletcher, C., Grossman, E., Richmond, B., Gibbs, A. 2002. Atlas of Natural Hazards in the Hawaii Coastal Zone, Kawela Map. U.S. Geological Survey. Page 87 of 100.

Fletcher, et. al., 2003. The Maui Shoreline Atlas. Produced for the County of Maui by the University of Hawaii, School of Ocean and Earth Science Technology.

Fletcher, C.H. (2009) Sea level by the end of the 21st century: A review. Shore and Beach, v. 77, no. 4, pp. 1-9.

Friedlander and Rodgers, 2008. Alan M. Friedlander and Kuʻulei S. Rodgers. "Coral Reef Fishes and Fisheries of South Molokaʻi." In *The Coral Reef of South Molokaʻi, Hawaiʻi — Portrait of a Sediment-Threatened Fringing Reef*, edited by Michael E. Field, Susan A. Cochran, Joshua B. Logan, and Curt D. Storlazzi, 2008. U.S. Geological Survey Scientific Investigations Report 2007-5101.

Gibbons, Arleone. Ornithologist. Personal communication during site visits on January 31 & February 1, 2019.

Halealoha Consulting, Incorporated. 2021. Five Molokaʻi Land Divisions, A Report for Planning Consultants Hawaiʻi, LLC.

Handy, E.S.C., 1931, Cultural Revolution in Hawaii, Fourth General Session of the Institute of Pacific Relations, Hangchow, China: New York, American Council of the Institute of Pacific Relations, p. 40. Quoted in Roberts, Lucile M and Field, Michael E. 2008. People, Land, and the Reefs of South Molokaʻi. Chapter 15 in *The Coral Reef of South Molokaʻi, Hawaii – Portrait of a Sediment-Threatended Fringing Reef.* U.S. Geological Survey Scientific Investigations Report 2007-5101, 126.

Hawaiʻi Climate Change Mitigation and Adaptation Commission. 2017. *Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report.* Prepared by Tetra Tech, Inc. and the State of Hawaiʻi Department of Land and Natural Resources, Office of Conservation and Coastal Lands, under the State of Hawaiʻi Department of Land and Natural Resources Contract No: 64064. Pg. 129

Hawaiʻi Coral Reef Assessment & Monitoring Program (CRAMP). 2008. Viewed on October 13, 2020. http://cramp.wcc.hawaii.edu/Watershed_Files/Molokai/WS_Molokai_molokai_Palaau.htm. Hawaii Institute for Marine Biology.

Hawaii Dept. of Business, Economic Development and Tourism. Research and Economic Analysis Division. Statistics and Data Support Branch. 2010 State of Hawaii Data Book, A Statistical Abstract. 2011. Honolulu: 1967-. Table 1.10-- Resident and De facto Population, by County and Island: 1990 and 2000.

Hawaii Dept. of Business, Economic Development and Tourism. Research and Economic Analysis Division. Statistics and Data Support Branch. 2020 The State of Hawaii Data Book, A Statistical Abstract. 2021. Honolulu: 1967-. Annual. Table 1.12— Resident Population and Number of Households, by Island and Census Designated Place: 2015-2019.

Hawaii Dept. of Business, Economic Development and Tourism (DBEDT). 2011. Research and Economic Analysis Division. Statistics and Data Support Branch. Hawaii State Data Center. Island population and housing units, State of Hawaii: 2010. Honolulu. Hawaii State Data Center Report Number 2010-3. Table 6. - Difference in Population by Major Race by Island, State of Hawaii: 2000 and 2010.

Hawaii Department of Labor and Industrial Relations. News Release, June 22, 2021, Hawai'i's Unemployment Rate at 8.1 Percent in May, Jobs Increased by 55,400 over-the-year. Department of Labor and Industrial Relations | Hawaii's Unemployment Rate at 8.1% in May. Pg. 2.

Holoholopinaau. 1870. "The Kings Home at Kaunakakai". Ke Au Oko'a, Feb,.24.Hono:BM. Quoted in Chris Hart & Partners. 1993. Technical Supplement to Design Guidelines for Kaunakakai, Maunaloa, Kualapuu, East End., F-9 – F-10.

HWANG, 2005. *Hawaii Coastal Hazard Mitigation Guidebook*. A publication of the Hawaii Coastal Zone Management Program, Office of Planning, Department of Business, Economic Development & Tourism, State of Hawaii. 216p.

Inman D.L., 2005. Littoral Cells. In: Schwartz M.L. (eds) Encyclopedia of Coastal Science. Encyclopedia of Earth Science Series. Springer, Dordrecht. https://doi.org/10.1007/1-4020-3880-1_196.

IPCC, 2007. Climate *Change 2007: The Physical Science Basis, Summary for Policymakers.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. 21p.

Iroquois Point Pearl Harbor, Honolulu, Oahu, Hawaii, 2013. Healy Tibits Construction. https://www.healytibbitts.com/projects/project-details/iroquois-point-beach-nourishment.

Jokeil, P., 2006. Molokai, South Molokai Watersheds. Coral Reef Assessment and Monitoring Program, Hawaii Institute of Marine Biology. Last updated 01/16/2006 by Lea Hollingsworth. Accessible at http://cramp.wcc.hawaii.edu/Watershed_Files/Molokai/WS_Molokai.htm, and http://cramp.wcc.hawaii.edu/images/south_molokai_7.jpg, _8.jpg _9.jpg

Jokiel, Paul et al., 2014. *Response of reef coral on a fringing reef flat to elevated suspended-sediment concentrations: Moloka'i'*, Hawaii. PeerJ, December 18, 2014. Pg 7/18.

Keala G, Hollyer J, Castro L. 2007. Loko i'a. A Manual on Hawaiian Fishpond Restoration and Management. University of Hawaii, College of Tropical Agriculture, Honolulu, HI 74 p.

King, James (Captain), 1784. Voyage to the Pacific Ocean. Undertaken, By the Command of his Majesty, for Making Discoveries in the Northern Hemisphere. Volume III. Order of the lords Commissioners of the Admiralty. London. Pg. 114.

MacKenzie, Melody Kapilialoha. 1991. *Native Hawaiian Rights Handbook*. Native Hawaiian Legal Corporation, University of Hawaii Press, May 1991.

Maui County Data Book, 2018. County of Maui, Office of Economic Development, Hawaii Business Research Library. Kihei, Hawaii. Annual.

Maui County Data Book, 2019. County of Maui, Office of Economic Development, Hawaii Business Research Library. Kihei, Hawaii. Annual.

McPherson, Nancy personal communication January 31, 2019.

McPherson, Nancy. DHHL Staff Planner. Personal communication during site visits on January 31 & February 1, 2019.

Moloka'i Community Health Center, 2019. "Population Served" Kaunakakai, HI. Accessed on September 1, 2019 at http://molokaichc.org/population-served/

Molokai Community Service Council. October 2020. https://www.molokai.org/about-molokai/myths-of-molokai/index.html. Quoted in Halealoha Consulting, Incorporated. 2021. Five Moloka'i Land Divisions, A Report for Planning Consultants Hawai'i, LLC. Pg. 5.

Moloka'i Health Center. 2021. "About Us, Population Served." Molokai Community Health Center. Viewed on September 21, 2021, https://molokaichc.org/population-served/.

NOAA, 2021. *Climate Change: Global Temperature Projections*. National Oceanic and Atmospheric Administration. Prepared by David Herring. March 6, 2012 and updated on October 26, 2021. Pulished in climate.gov. https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature-projections#:~:text=Results%20from%20a%20wide%20range,gases%20that%20human%20activities%20produce.

Norcross-Nu'u, Z. and Abbott, T. 2008. *Beach Management Plan for Maui*, 2nd Edition. University of Hawaii Sea Grant College Program. 2008.

Office of Planning, 2019. *Assessing the feasibility and implications of managed retreat strategies for vulnerable coastal areas in Hawaii*. Final Report. Office of Planning, Coastal Zone Management Program, February 2019

Ogston, A. S., and M. E. Field, 2010. *Predictions of turbidity due to enhanced sediment resuspension resulting from sea-level rise on a fringing coral reef: Evidence from Moloka'i', Hawaii*, Journal of Coastal Res., 26, 1027–1037, doi:10.2112/JCOASTRES-D-09-00064.1. Pg. 1028, 1033.

Ogston, Storlazzi, Field, and Presto, 2004. *Sediment resuspension and transport patterns on a fringing reef flat, Moloka'i', Hawaii*. Coral Reefs (2004) 23: pg 559-569 DOI 10.1007/s00338-004-0415-9. Springer-Verlag. July 30, 2004. (pg 566).

OHA, 2017. Traditional & Customary Practices Report for Mana'e, Molokai. Prepared for the Office of Hawaiian Affairs. January 2017. Pg 35.

Ong, L. and Holland, K.N., 2010. *Bioerosion of coral reefs by two Hawaiian parrotfishes: species, size differences and fishery implications*. Marine Biology, June 2010, Volume 157, Issue 6: pp 1313-1323. https://doi.org/10.1007/s00227-010-1411-y

Preskitt, L. 2002. *Edible Limu… Gifts from the Sea*. Poster based upon the book Limu: An Ethnobotanical Study of Some Hawiian Seaweeds by I.A. Abbott, National Tropical Botanical Garden, Kaua'i, Hawai'i, 1984. University of Hawaii, Botany Department 2002. Accessible at http://www.hawaii.edu/reefalgae/publications/ediblelimu/

Pukui, Mary Kawena; Elbert, Samuel H; Mookini, Esther T. 1974. *Place Names of Hawaii Revised and Expanded Edition*. The University of Hawaii Press, Pg. 74 82, and 86.

Pukui, Mary Kawena; Elbert, Samuel H; Mookini, Esther T. 1974. *Place Names of Hawaii Revised and Expanded Edition*. The University of Hawaii Press, 74. Quoted in Halealoa Consulting, Incorporated. 2021. Five Moloka'i Land Divisions, A Report for Planning Consultants Hawai'i, LLC. Pg. 17

Roberts, Lucile M. Historical Land Use, Coastal Change, and Sedimentation on South Molokai Reefs. Abstract. Prepared for the Hawaii Institute of Marine Biology. Pg. 4.

Roberts, Lucile M and Field, Michael E. 2008. People, Land, and the Reefs of South Moloka'i. Chapter 15 in *The Coral Reef of South Moloka'i, Hawaii – Portrait of a Sediment-Threatended Fringing Reef.* U.S. Geological Survey Scientific Investigations Report 2007-5101, 180 p. Pg. 123, 124, 125, 126, 127, 134

Smith, et.al., 2008. Jennifer E. Smith, Heather L. Spalding, Ryan Okano, and Celia M. Smith. "The Seaweed and Seagrass Communities of Moloka'i." In *The coral reef of south Moloka'i, Hawai'i — portrait of a sediment-threatened fringing reef*, edited by Michael E. Field, Susan A. Cochran, Joshua B. Logan, and Curt D. Storlazzi, 2008. U.S. Geological Survey Scientific Investigations Report 2007-5101.

Summers, Catherine C. *Molokai: A Site Survey*. Bernice Pauahi Bishop Museum Pacific Anthropological Records No. 14, Honolulu, 1971:2. Quoted in Halealoa Consulting, Incorporated. 2021. Five Molokaʻi Land Divisions, A Report for Planning Consultants Hawaiʻi, LLC. Pages: 5, 7, 15, 22.

Summers, Catherine C. *Molokai: A Site Survey*. Bernice Pauahi Bishop Museum Pacific Anthropological Records No. 14, Honolulu, 1971:2. Pages: 88, 90.

Tetra Tech, 2017. Hawaiʻi Climate Change Mitigation and Adaptation Commission. Hawaiʻi Sea Level Rise Vulnerability and Adaptation Report. Prepared by Tetra Tech, Inc. and the State of Hawaiʻi Department of Land and Natural Resources, Office of Conservation and Coastal Lands, under the State of Hawaiʻi Department of Land and Natural Resources Contract No: 64064. Pg. 115, 116.

TNC, 2003. *Last Stand: The Vanishing Hawaiian Forest*. The Nature Conservancy of Hawaii. 2003. Pages 1-13. Viewablet at https://www.nature.org/media/hawaii/the-last-stand-hawaiian-forest.pdf

Tomonari-Tuggle, M.J. Archaeological Reconnaissance Survey, Road Corridor, Kalamaʻula Mauka (1983:1) and Tomonari-Tuggle, M.J. Archaeological Inventory Survey of a Portion of Kalamaʻula, Island of Molokai (1990:8). Quoted in Halealoa Consulting, Incorporated. 2021. Five Molokaʻi Land Divisions, A Report for Planning Consultants Hawaiʻi, LLC. Pg. 7.

UH, 2019. Native Plants Hawaii - *Schoenoplectus_tabernaemontani*. University of Hawaii. Searchable at http://nativeplants.hawaii.edu/index/

UH, 2020. DEM Imagery for Molokai. School of Ocean and Earth Science and Technology, Coastal Geology Group. University of Hawaii. Viewable at http://www.soest.hawaii.edu/coasts/data/molokai/dem.html and /pdcimagery_txt.html

U.S. Army Corps of Engineers, 1978, Kaunakakai Harbor, Molokaʻi, Hawaiʻi: Restudy of an Authorized Project with Environmental Statement. 83 p.

U.S. Census Bureau, decennial census records and 2015-2019 American Community Survey 5-Year Estimates, Table B01003 access April 22, 2021.

U.S. Census Bureau's American Community Survey 2015-2019 American Community Survey 5-year estimates compiled by the Hawaii State Department of Business, Economic Development & Tourism. Table 2. – Median Household Income, State of Hawaii, By Census Tracts, 2015 – 2019.

U.S. Census Bureau (2019). *American Community Survey 5-year estimates.* Retrieved from *Census Reporter Profile page for East Molokai CCD, Maui County, HI* http://censusreporter.org/profiles/06000US1500990090-east-molokai-ccd-maui-county-hi/>

U.S. Census Bureau (2019). *American Community Survey 5-year estimates.* Retrieved from *Census Reporter Profile page for West Molokai CCD, Maui County, HI* http://censusreporter.org/profiles/06000US1500993960-west-molokai-ccd-maui-county-hi/

U.S. Census Bureau (2019). *American Community Survey 5-year estimates.* Retrieved from *Census Reporter Profile page for Kalawao CCD, Kalawao County, HI* http://censusreporter.org/profiles/06000US1500590990-kalawao-ccd-kalawao-county-hi/>

Wilson, Juan. 2011. Na Mokupuni O Hawaii Nei, Major Natural Land Divisions of the Hawaiian Islands. Mapping by Island Breath.org.

http://www.islandbreath.org/mokupuni/M3Molokai/M3MolokaiPlotFile.pdf

Wyban C.B. 1992. Tide and Current: Fishponds of Hawaiʻi. University of Hawaiʻi Press. Honolulu, Hawaiʻi.

APPENDICES

APPENDIX A: STAKEHOLDER OUTREACH

SOUTH MOLOKAʻI SHORELINE EROSION MANAGEMENT PLAN

List of Stakeholders Interviewed

Name	Affiliation	Date
Kenneth “Boom” Gaspar Doreen “Pinky” Gaspar Georgette “Jody” Kaneakua	Gaspars: Kapaʻakea shoreline lessee, Lot 5 Georgette: Successor, Kapaʻakea Lot 16	01/30/2019
Uncle Herbert Hoe	Ka Honua Momona Intnl. third house at 3MM, Kamiloloa Molokaʻi Applicant	01/30/2019
Noelani Lee Yamashita	Ka Honua Momona Intnl. licensing Aliʻi fishpond	01/30/2019
Gayla Mowat	Generational Lessee (East Kapaʻakea)	01/30/2019
Noe Rawlins	Kapaʻakea Lessee, Lot 11	02/01/2019
Aunty Leilani Wallace	Kapaʻakea/Kamiloloa-One Aliʻi Lessee Moved to Kapaʻakea in 1962	02/01/2019
Georgette “Jody” Kaneakua	Georgette: Successor, Kapaʻakea Lot 16	01/30/2019
Anthony Fukuoka	Maui County Building Inspector, Molokaʻi	02/01/2019
Gene Ross Davis	DHHL (Acting District Supervisor) Kalamaʻula lessee (multi-generational) former Molokaʻi Hawaiian Homes Commissioner	11/20/2019
Zachary Helm	Kalamaʻula lessee (first-generation) Current Molokaʻi Hawaiian Homes Commissioner	11/21/2019
Henry Paleka	Kalamaʻula shoreline lessee Rose’s husband (multi-generation)	11/21/2019
Penny Martin	Kalamaʻula shoreline lessee (multi-generational)	11/21/2019
Heli Silva Ducaroy	Kalamaʻula shoreline lessee (multi-generational)	11/22/2019
Aunty Kanani Negrillo	Kalamaʻula lessee (multi-generational) limu gatherer (Peʻelua ʻOhana)	02/10/2020
Liette Corpus	Peʻelua ʻOhana grandparents lived in Kapuāiwa Grove in caretaker’s house	02/10/2020

APPENDIX B: FIVE MOLOKAI LAND DIVISIONS

FIVE MOLOKAI LAND DIVISIONS

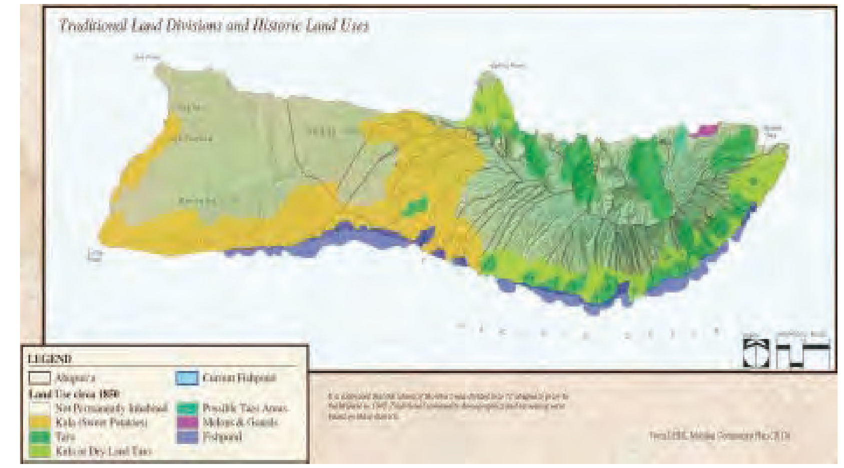
A Report for Planning Consultants, Hawai‘i LLC

Prepared and Submitted by

Halealoha Consulting, Inc
Edward Halealoha Ayau, Consultant
144 Kulana Street
Hilo, HI 96720-2243

22 January 2021

FIVE MOLOKAI LAND DIVISIONS



Map: DHHL Molokai Community Plan 2010

There are many ahupuaʻa incorporating watersheds or sub-basins within Molokai.[1] Of these, five have a direct influence on the DHHL properties within the SEMP study area including Kalamaʻula, Kaunakakai, Kapaʻakea, Kamiloloa, and Makakupaʻia. The relationship of these ahupuaʻa to the Kona District and the rest of the island is briefly explored through cultural lenses including ka inoa (name), nā wahi pana (celebrated places), nā ʻaumākua (ancestral deities), nā makani (winds), nā ua (rains), nā wai (waters), nā mele (songs), and nā moʻolelo (stories/histories) and is not intended to provide comprehensive insights. In addition, traditional ecological knowledge in the management and stewardship of the coastal resources of these specific ahupuaʻa in South Molokai is shared.

Molokai Nui a Hina

Origin accounts for the mokupuni of Molokai include Pakuʻi, a historian during the time of Kamehameha I, who reveals Molokai to be the child of the Goddess Hina and the Sky Father Wākea:

Loaa Hina he wahine moe na Wakea	Hina was found as a wife for Wakea
Hapai Hina ia Molokai, he moku	Hina conceived Molokai, an island;
O Molokai a Hina he keiki moku	Hina's Molokai is an island child.[2]

Historian Kahakoʻikamoana recounts a different parentage for Molokai:

Na Kuluwaiea o Haumea he kane,	Kuluwaiea of Haumea as the husband,
Na Hinanuialana he wahine	Of Hinanuiakalana as the wife
Loaa Molokai, ke akua, he kahuna,	Was born Molokai, a god, a priest,
He pualena no Nuumea.	The first morning light from Nuumea.[3]

A third account involves the forming of the Hawaiian islands through the deification of coral pieces by the priest Lauliala'amakua after coral was caught by the fisherman Kapuheʻeuanui.[4]

Traditional poetic names of the island include *Molokai ʻāina momona* (fat, fertile lands of Molokai), which refers to verdant lands that produce an abundance of food from loʻi kalo (taro patches), loko iʻa (fishponds), kai (near-shore) and moana (deep-sea) fishing grounds. Another name, *Molokai nō ka heke* (Molokai is greatest, foremost), refers to the celebrated athletes of the

Makahiki competitions held at Na‘iwa and Kainalu. One of the most famous is *Molokai pule o‘o* (Molokai of powerful prayer), a reference to the powerful kahuna trained at Pu‘u Anoano and ‘Ili‘ili‘opae Heiau, in particular the ones who practiced ‘anā‘anā (black magic, evil sorcery). The other well-known name is *Molokai nui a Hina* (Great Molokai, Child of Hina).[5]

Historically, Molokai was subdivided into subareas to enhance the stewardship of the island's resources. The initial land divisions were the Ko‘olau (windward) and Kona (leeward) *moku,* or districts:

> Prior to 1859, the island was divided into two districts, called Ko‘olau and Kona. The Ko‘olau district was composed of the *ahupua‘a* located on the northern side of the island: Halawa, Wailau, Pelekunu, Waikolu, Kalawao, Makanalua and Kalaupapa. The rest of the island was the Kona district. In 1859 the Kona and Ko‘olau districts were dropped, and the island was made into just one district, called Molokai district. In 1909, the present division into Molokai district and Kalawao district was made.[6]

The poetic name Molokai Nui a Hina and its legendary origin establishes kuleana (duty, responsibility, privilege) to care for the island's resources:

> … the island of Moloka‘i, like a child, is small and fragile – unlike a large continent. The resources of an island are finite, and these finite resources need to be nurtured by the island's "family" if the people are to grow strong, healthy and prosper. Many of the families of Moloka‘i trace their roots on the island back to antiquity, making the island an integral part of their ancestral family. Moloka‘i's modern-day stewards have a special responsibility to care for the island as they would care for a member of their own family – a responsibility bequeathed to them by Hina, birth mother of this island.[7]

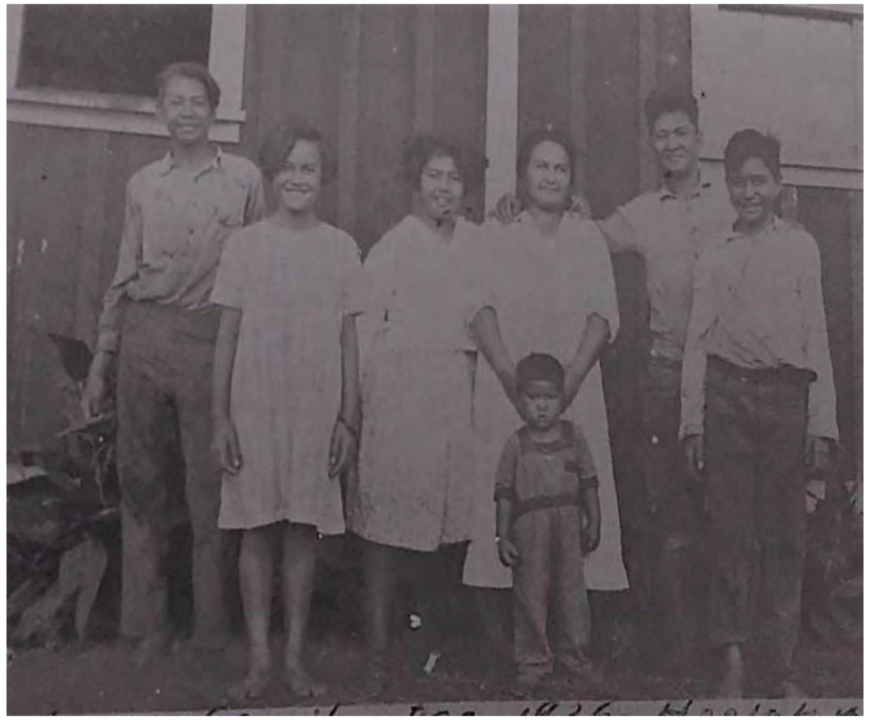
Kalama‘ula

Aerial View of Kalama‘ula Hawaiian Homestead Area. Photo: Courtesy of Ted Kanemitsu.

Ka Inoa (The Name). Kalama‘ula translates to mean, "the red torch or red lama tree."[8] *Hawaii Place Names* references the Hawaiian Home Commission Act of 1920 and provides:

> Provisions were made for a commission to administer the lands and in 1925 Kalama‘ula became the first Hawaiian homestead subdivision in the islands. Among the first residents there were Marcelus and Emma Kala Dudoit. Fronting their home was a large stone that had a natural etching of a sun and five rays, ***and it was from this stone called Kalama‘ula that the area took its name.*** Mrs. Dudoit wrote a song entitled "Kalama‘ula" in honor of her home.[9] (emphasis added)

Cultural Historian Harriet Ahiona Ayau Ne (pictured below, second from the left), was raised as a child in Kalama‘ula when her father Rev. Edward Haleaniani Ayau (second from the right) moved their family to lot 38, one of the original Hawaiian homestead leases at the Kalaniana‘ole Settlement. As an adult she moved back to Kalama‘ula when she married Jacob Iopa Ne. She translated the name to mean, "the scarlet rays of the sun."[10]


‘Ohana of Edward Ayau and Olivia Townsend. Photo: Courtesy of Edward Halealoha Ayau.

Nā Wahi Pana (The Celebrated Places). Catherine Summers identifies the special places in Kalama‘ula including ponds, a fishpond, heiau, a pool, kahua maika (stone rolling fields), petroglyphs, a spring, and house sites. The area was also known for its food cultivation on land and the abundance of fish and other ocean foods gathered in the near shoreline area. The ponds and fishpond include:

- Kahokai or Kakokahi Pond… Kahokai, "mess up the work," was 20 acres in area in 1901 (Cobb, 102: 429) Monsarrat in1886 gave the name Kakokahi to the pond, and it appears this was on the Kualapuu map (U.S.G.S., 1922b) where it is shown as filled with mud. The pond is now filled.[11]
- ‘Ohaipilo or ‘Ohi‘apilo Pond… ‘Ohaipilo, "smelly *‘ohai* tree," was 39 acres in area in 1901 (Cobb: 1902:429). On the Kualapuu map (U.S.G.S., 1922b) it is called ‘Ohi‘apilo, and is shown as filled with mud. The pond is now filled. Stokes gave the name of the pond as ‘Ohaipilo. When he saw it in 1909, two thirds of the 10-ft-wide wall was still intact…[12]
- ‘Umipa‘a Pond… Monsarrat reported ‘Umipa‘a as being a "dry fishpond mauka of Ohaipilo [Site 118]"…[13]

- Fishpond… Cobb listed a pond in Kalamaula with an area of 2 acres (1902:429). This is probably the pond that Stokes called Kamaloko; he reported the wall as being 5.5 ft high..[14]
- Kamaloko Pond… This pond was listed by Cobb as "nameless small pond, inland," and described as having an area of 0.9 acre in 1901 (1902:429). According to the account of a native informant, prior to the mid-1930's, there was practically no mangrove in the vicinity of the pond and the sea could be seen from the pond. Formerly there were all kinds of fish here. The was *awa, aholehole, ʻamaʻama* and small crabs, the *ʻalamihi*… The water was deep and bubbled up from the earth…The *oʻopu* of this place were large. My mother old me that, formerly, when the tide became low and the water in the pond lessened, the fish then, began to leap up and fall back. They leapt up and when coming down into the silt, the head would go down into the silt and remain fast. The fish would leap and become embedded in the silt. The fish was kapu as it belonged to the *konohiki*. That is the tale of this little pond. The name of this pond is Kamaloko…[15]


Photo: Ray J Baker, Bishop Museum.

The entire shoreline was called Hīlīa, "an off-shore area extending eastward from Pakanaka Pond through Kalamaʻula, it is now covered with mud, but formerly the shores had sandy beaches. Fish were very numerous here especially small mullet which often came in great schools near the shore. At times they were so numerous that 'This little fish darkened all of the beaches".[16]

The ʻōlelo noʻeau for this shoreline area is

Ka iʻa kā wawae o Hīlīa
The fish of Hīlīa, kicked by the feet.[17]

Subsistence use of inland cultivation areas and marine resources into the 19th century is documented by historical information for Kalamaʻula, including rental receipts from 1858 to 1861 for taro patches, coconut trees, a fishpond and a squid fishery.[18] The Ah Lee Pond was still in operation in the 1920's, and subsistence use of the nearshore fishery by homesteaders continues to this day.[19]

In addition, there was extensive cultivation of ʻuala (sweet potato) in the kula (upland) areas:

> It is safe to assume that potatoes were grown all along this coastal plain fringed with fishponds from Waialua to Punakou. On the slopes of Kakalahale and Luahine hills, between Kaunakakai and Kalamaula, there were potato plantations.[20]
>
> …In these land divisions *(kalana)* of Kalamaʻula and Palaʻau in early days there were sweet potatoes on all the rocky *(ʻaʻa)* high lands and from these places came the sweet potato eaters who knew potato cultivation… These are some of the potatoes planted by our ancestors at Kalamaʻula and Palaʻau, the hualani, hokeo, kala, hekili, lahaina, kalaponi, poni, huamoa, hepu, and ʻolapa… Among the sweet potatoes mentioned above there are two favorites of the sweet potato consumers of Kalamaʻula

> and Palaʻau, the kala and kalaponi. It is said that these taste best a day after they are cooked…[21]

The heiau (temples) in Kalamaʻula include:

- Opaeʻula Heiau… Located at the foot of the hills, this site is about 700 ft from the sea. From Kakalahale Δ it bears 61˚49' 20"; 16,820 ft. The heiau was destroyed in 1899 to build the pier at Kaunakakai. It its original condition, it was "…probably a combination of platform and enclosure in line…Indications are that its length was at least 115 feet and width 44 feet. The platform on the western half was 65 feet long"….[22]
- Puʻupapai Heiau… Located near the crest of the plateau, this heiau is about 1500 ft from the sea. From Kakalahale Δ it bears 51˚ 28'; 12,775 ft. Originally, it was probably three enclosures. It is said, "…to have been dedicated to Kane and Kanaloa, that it was a platform, for human sacrifice, and that the drums were not heard at night" (Stokes, n.d.a:1). In another account, Stokes wrote further about this heiau. Puupapai was a very important heiau of the sacrificial class. It was torn down about 15 years ago [1899] and the stones used to build a pier about 300 yards long, 20 feet wide and 19 feet high. The natives say that only the stones of this heiau were used, and that the subsequent failure of the company [American Sugar Co.] carrying out the operations was due to the sacrilege of tearing down the sacred structure…[23]
- Heiau… Cartwright… located a heiau on the northern bluff of a gulch, about 1.3 miles NE of Puʻu Luahine.[24]
- Kaʻanaopea Heiau… This heiau was "Reported by natives but not seen"… Kaʻanaopea was the name of "the big gulch on the *kula* of Kalae."[25]

The pool is named ʻOloʻolo:

> This pool is located inland of the coconut grove. An article in a Hawaiian newspaper stated: In the days prior to annexation, this pool was well cared for and used for bathing by the natives who lived on the beach. It was famous as a favorite bathing pool of the chiefs down to Kamehameha V… In the year 1888 there was a heavy downpour of rain which made a flood lasting for days and the water from the pool covered the whole land of Kaunakakai. This great pool of half an acre was fed by five springs. When the water subsided the pool was filled with mud. As it rained each time, the pool was filled up some more until in 1898, ten years later, there wasn't a trace of it left. From that time to this, kiawe trees grew up erasing all traces of the pool (*Ka Nupepa Kuʻokoʻa, 1922b*)."
>
> When water was needed for the homesteaders at Kalamaʻula, the oldtimers looked for and found ʻOloʻolo; it was covered with 4 ft of silt. For a while, until the salt content became too high, the water from this spring was used by the homesteaders (see p.25).
>
> A legend told about ʻOloʻolo is recounted in the same Hawaiian newspaper. It is said that since that long ago time when the gods communed with men, a beautiful woman was often seen beside the pool combing her tresses. Perhaps no one had ever conversed with her but she was often seen on a mound of earth just mauka of the pool. Her breasts hung down and that may have been why the pool was named ʻOloʻolo, (hanging down) (*Ka Nupepa Kuʻokoʻa, 1922b*).[26]

The kahua maika include:

- Kahua Maika…This site is a flat area between Kauluwai and Mauna Hui (Mauna Hui is also known as Kawaeku). According to Cooke: "The trail going mauka from Kauluwai through Kaheka gulch to Mauna Hui, ascends a small gulch to a plateau. At the right of this flat, about a mile from Kaheka in a small gulch, is a hua maika course (bowling alley). Makai (towards the sea) of this hua maika there is a spring named Waiauni [Waianui?]" (1949:102).[27]
- Kahua Maika Near Pu'u Luahine…The course is located approximately 2000 ft due N of the bench mark on Pu'u Luahine, and just N of the road (in 1963). Northwood studied the area quite extensively in 1933 and wrote in detail of it. As the road reaches the top of a slight rise, the course can be seen as a shallow trench, 35 ft. wide, starting at the right side of the road and slightly diverging from it, in an E.S.E direction and quite straight. There are three large half-buried boulders at the beginning of the course. For 350 yards the course is well marked, with a very slight down grade, beyond the grade increases more rapidly, with only traces of a slight depression, curving slightly to left [N], for another 150 yards. It is built across a slight slope, with considerable excavation for the first 200 yards and less after that. As there is no perceptible pile of earth near the course it was probably carried out in baskets and scattered evenly in the neighborhood. For the first 200 yards traces of a shoulder on each side, 7 feet from the bottom, can be seen. This is so regular that it can hardly be due to erosion, it may have been a later excavation in order to reduce the grade slightly. The depth of the course below the surrounding country (3 feet at the bottom) may have been devised in order to escape the effect of the wind in such an open country, the cup-like sides would also tend to direct an ulu which had been thrown a little off the line back to the bottom of the trench. I found three broken ulus, none fitting, within a distance of 5 yds. from the course at 350 yds., and a whole one 5 yds. to the right of the course at 100 yards. A short distance away towards Puu Luahine can be seen two lines of raised earth, meeting at right angles, possibly a house site (Northwood, n.d.). This is believed to be the only remaining *kahua maika* in the islands.[28]

The petroglyphs are located at Waihi Gulch:

> Cooke found these petroglyphs in 1916: "…after the big Kona storm, Sophie and I walked on foot up the Waihi Gulch at Kalamaula, mauka of the forest fence. On the way up on the left side of the gulch, the high water had cleared away the foliage and uncovered a pali. We discovered four or five petroglyphs about 6 feet above this stream bed" (1949:101).[29]

A spring, whose name is unknown,

> … is located near the boundary of Kalama'ula and Kaunakakai. The Hawaiian Homes Commission developed this spring for irrigation purposes. Cooke, who visited the spring, wrote the following about it, "…This spring originally flowed into the ocean, but when it was relocated it was covered over with six feet of silt. The spring bubbled up through an eight inch vent. On clearing the silt away, one could see opae (fresh water shrimp) in the spring. John Puaa, who located the spring for me, told me that sugar cane, bananas and

> taro were grown on its banks as it flowed towards the ocean. He related also a tale of women catching opae with nets in the mountains. One of the women left her net to dry while she went to gather plants. A fishnet washed down the valley and on her return the net was gone. This net found later in the spring at Kalamaula, which was at least six miles away from the mountains (Cooke: 1949:110).[30]

There are also house sites in the area:

> Mauka of Pu'u Luahine are the remains of house sites on the ridges and in the small valleys. On one of these house sites, the framework of a grass house was still standing in 1908. As Cooke described the area: "In this district several stone walls are still standing which enclosed fairly large paddocks. Charles Buchanan told me that oxen were kept within these stone walls near the dwelling of the owner, Aa, between his trips from forest to shore" (1949:123).[31]

Ka 'Aumakua (Ancestral Deity). Harriet Ne reports the 'aumakua of this ahupua'a is kukunaokalā (rays of the sun) based on her recollection of the image on a banner used during the last traditional makahiki ceremony at Na'iwa in 1918, in which she was in attendance.[32]

Nā Makani (The Winds). Two known wind names for Kalama'ula are Alahou and 'Ukiukiu.[33]

Nā Ua (The Rains). No rain names were identified. Miki'ala Pescaia, a cultural historian in her own right, aptly notes, "Our kūpuna knew all the kama'āina by name. But none of them chose rain as a kinolau and hung out in Kalama'ula…the ua …visited once in a while… Wai preferred to travel and noho in Kalama'ula in other forms – the springs…"[34]

Nā Wai (The Waters). Kalama'ula is one of three watershed areas in the Pālā'au region comprising 5,838 acres with no perennial streams.[35] Known water names include 'Olo'olo (pool/spring), Waianui (spring) and Makehe Stream.[36]

Kapuāiwa Grove as of 2018. Photo: Courtesy of DHHL Molokai District Office by Mickey Pau'ole.

At Kiowea Park and Kapuāiwa Grove (pictured above and named for Lot Kapuāiwa, Kamehameha V, who is said to have ordered the planting of the coconut trees in the 1860s; his name means, 'mysterious taboo'), the following springs are identified by their contemporary use, while their traditional names are unknown:

- "Spring for menstruating women"

- "Spring for kanaka mahiai (Farmers)"
- "Community bath spring"
- "Drinking water spring"
- "Kitchen sink spring".[37]

Nā Mele (The Songs and Chants)

Mele for this area includes *Kalamaʻula*, written and the music created by Emma Kala Dudoit. It was made famous by many singers including George Helm, himself a Kalamaʻula homesteader. This mele speaks of the original Hawaiian homestead of Marcelus and Emma Dudoit:

A he sure maoli no e a	Surely, it is so, the genuine
Me ke onaona, auwē he	Attractiveness and
Me ka nani, o Kalamaʻula	Splendor of Kalamaʻula
E kapaia nei ea	There in the bower
He uʻi mai hoi kau, auwē he	We arrive and behold the beauty and
Me ka nani, o Kalamaʻula	Splendor of Kalamaʻula
ʻĀina ua kaulana	This land is famous
I ka hoʻopulapula, auwē he	A homestead land
Me ka nani, o Kalamaʻula	The splendor of Kalamaʻula
E hoʻi kāua ea	Let us return
E noho i ka ʻāina, auwē he	And reside in
Me ka nani, o Kalamaʻula	The splendor of Kalamaʻula
Haʻina ka puana ea	Tell the refrain
Hoʻi mai kāua, auwē he	Let us return to the
Me ka nani, o Kalamaʻula	Splendor of Kalamaʻula.[38]

In addition, the mele *ʻUla Kalaʻeloa I Ka Lepo a Ka Makani* provides a glimpse into places on Molokai including the red dust that concentrates at Kalamaʻula:

ʻUla Kalaʻeloa i ka lepo a ka makani	Red is Kalaeloa with dust by the wind,
Kai hoʻonuʻanuʻa ʻia ʻāpua Kalamaʻula	The dust concentrates at Kalamaʻula as though it were a basket
ʻIke a kuʻu manaʻo iaʻu kula	At the sight of it I thought of my plain.
Hea mai Kaiolohia	Kaiolohia calls to me
ʻEu hoʻi māua i Kāʻana ē.	To return to Kāʻana.
Aloha iaʻu ke kula o Niniwai	In love am I with the plain of Niniwai,
Oʻu hoa i Kalaʻiakamanu ē	With my companions at Kalaʻiakamanu (haunt of birds)
Manu a hoa laukona i ke keʻe lau	Bird companions that shy among the leaves.
Auʻa ʻia e ka moe i na ke loha lā he ʻai lili kā,	Love that is dreamt of is held back by jealousy,
Aia ua ʻike au.	This is known.[39]

Nā Moʻolelo (The Stories, Histories). The famed historian Samuel Mānaiakalani Kamakau recounts historic events that took place at Kalamaʻula during the rise to power of Kamehameha I:

Oʻahu Chief Kapiʻiohoʻokalani was encamped at Kalamaʻula:

> While he was at Kihei, Alapaʻi heard that the ruling chief of Oahu was making war upon Molokai... Alapaʻi's sympathy was aroused, for these were his own brothers and children [relatives], and he made ready to go to their help on Molokai. He sailed from Maui and landed at Pukoʻo… The fighting was in progress at Kamaloʻo with Ka-pu-lei as the battlefield. There the forces of Hawaii, joined with those of Molokai, made a formidable array. The chief of Oahu, Ka-piʻi-oho-o-ka-lani, was encamped at Kalamaʻula…[40]

Kalola meets Kamehameha at Kalamaʻula and offers him Keōpūolani:

> While Kamehameha was at Wailuku with his followers he heard of Ka-lola's being on Molokai with her daughters and granddaughter and he sent word by Kikane for her not to proceed to Oahu as he was coming to escort her to Hawaii. He sailed with a great company, among them Keʻe-au-moku, Keawe-a-heulu, Ka-meʻe-ia-moku, and Ka-manawa, the brothers of Ka-lola, and landed at Kaunakakai. They met Ka-lola at Kalamaʻula and, when Kamehameha saw how ill she was and of an incurable disease according to the kahuna's diagnosis, he asked, "Since you are so ill and perhaps about to die, will you permit me to take my royal daughter and my sisters to Hawaii to rule as chiefs?" (He referred to Ke-opu-o-lani and her mother and aunt, Ke-kuʻi-apo-iwa and Ka-lani-kau-io-kikilo). Ka-lola answered, "If I die, the girl and the sisters are yours."[41]

Kamehameha's war canoes cover the whole coast from Kawela to Kalamaʻula:

> In February, 1795, Kamehameha's fleet of war canoes landed at Lahaina, covering the sands along the coast from Launiupoko to Mala. All that part of Lahaina given over to food patches and cane fields was at that time overrun by the men from Hawaii. At Molokai, again, the whole coast from Kawela to Kalamaʻula was covered by canoes.[42]

Kalola dies at Kalamaʻula and Keōpūolani is taken by Kamehameha to Hawaiʻi island:

> Ke-opu-o-lani was nine or ten years old when the great battle was fought at ʻIao in which Ka-lani-ku-pule and the Maui chiefs were routed by Kamehameha's forces. The fugitives fled … until they were able to escape to Molokai, where they remained on account of the illness of Ka-lola [grandmother of Ke-opu-o-lani] instead of going on to join Ke-kuʻi-apo-iwa's brother on Oahu. They were at Kalamaʻula when the chief's [Kamehameha's] messenger came with the request that they remain on Molokai instead of sailing to Oahu. After the death of Ka-lola, Kamehameha took Ke-opu-o-lani to Hawaii…[43]

Kaʻiana stayed at Kalamaʻula, before leaving Kamehameha to join Kalanikūpule:

> …while Kamehameha and his chiefs were quartered at Kaunakakai on Molokai, in 1795, on their way to make war upon Ka-lani-ku-pule, Ka-lani-moku one night approached Kamehameha's sleeping house and found Ka-ʻahu-manu still awake … "It is because I was afraid and could not sleep, so I came to see you." Ka-ʻahu-manu inquired the reason, he told her of Kaʻiana's visit on his return from Kalamaʻula and of his fear lest the chiefs think he had betrayed the secret council…"[44]

In addition, this ʻōlelo noʻeau (proverb) references Kalamaʻula in the provocative game of kilu,

> Unu mai a hoʻonuʻanuʻa ke kilu o Kalamaʻula, hoʻoleʻaleʻa i ke kaha o Kaunalewa.
> Bring all the kilu for amusement at Kalamaʻula to make merry on the field of Kaunalewa.

To come together for a gay time and bring whatever you have to add to the fun. There is a play on lewa, which refers to the swinging of the hips in hula.[45]

A kilu (quoit) is used in a game where the player chanted as he tossed the kilu towards an object placed in front of one of the opposite sex and if he hit the goal he claimed a kiss…[46]

Traditional Ecological Knowledge. With regard to the management and stewardship of coastal resources in Kalamaʻula, homesteaders were interviewed and shared their ʻike (knowledge) and manaʻo (thoughts) as follows.

Penny Martin, Kalamaʻula Shoreline Lessee (Multi-Generational):

How the shoreline has changed over the years: Her mother could walk from this lot to the wharf [unimpeded]. All mangrove now. Native mullet – need freshwater seeps. Used to be way more fresh water. She has come to understand that kiawe trees and mangrove both use up lots of fresh water. She thinks there are less ʻōpae (shrimp) because there is less fresh water. She thinks there are less ʻāholehole (Hawaiian flagtail) for the same reason. She recommends removing the mangrove (Rhizophora mangle, a shrub/small tree that grows in coastal saline or brackish water) and kiawe (Prosopsis pallida) to counteract less fresh water reaching the shoreline. Cattle up mauka – deer – eating the vegetation. [Soil is] running off. She said we must consider how to control erosion before removing the mangrove, which was planted to control erosion. Mangrove helps control silt run-off but it takes/uses so much fresh water. She said the key to erosion control is managing mauka rain runoff and therefore proper management of the watershed… Momona, where I grew up. Farmers of land, sea or both. Live off of your ahupuaʻa. Shoreline is who we are. South Shore Molokai is momona (fertile). What it would be like without mangrove? Need to revegetate with shoreline natives… New pukas [in the Grove] – sinkholes. Some springs have disappeared. Springs weren't all kapu… There was plenty limu ʻeleʻele – it's being overharvested. Also, mangrove and kiawe could be taking up the fresh water. Test the water – [someone should measure] the amount of fresh water [coming through the area]. Would be a good project for the homesteaders. Need an assessment of the marine life – used to be nice walking along [the shoreline]. Nature of the shoreline – it goes up and down… Mangrove would catch the stuff from the land. Need to fix the mauka area [to stem erosion] before removing the mangrove… Revegetate with shoreline natives: ʻAkiʻaki [shoreline/dune grass] and naupaka. Better than mangrove… [Look to the wisdom in the] Kumulipo – can't just fix down here, gotta also fix up there – makai to mauka. *Threats:* Mangrove, gorilla ogo, deer – erosion up mauka. She would like to start a kipuka of native plants up mauka.

Henry Paleka, Kalamaʻula Shoreline Lessee (Multi-Generational):

A volunteer caretaker for Kalanianaʻole Hall next door. Noticed when there's high tide with no wind, ocean doesn't come up onto the land. The [Kaunakakai] Harbor – the pier – blocks the waves, but also blocks the sand… ʻOloʻolo Spring is connected to the spring by the pavilion, and the springs in the grove. The springs have never stopped running all these years. The [makai] spring was always open to the ocean… In the old days, was lots of crab – kūhonu crab, Alaheke [Alamihi?] crab. They still get, but not like before. People are taking too much. Now you have to go a mile out [to sea] to get fish. People

use the shoreline for parties, family gatherings. Not as much limu ʻeleʻele – grows in the sand. He thinks the gorilla ogo is smothering the limu ʻeleʻele. Also, people are using the bullpen net – takes everything – a lay net. When the river runs yellow, the water turns yellow, the tako run away. Sand channels, black limu – ogo stays near shore. Shoreline used to be muddy, now it's hard. Used to sink in up to your knees.

Kanani Negrillo, Kalamaʻula Lessee (Multi-Generational):

Grandfather Heli Peʻelua – lived on the beach lot – where we grew up, with her grandparents. Went crabbing, lay net before for the small fish – pua – small mullet. Her ʻohana only took what they could eat. Mother gathered limu... She knew where the freshwater was coming out – all the way from Kimball's place (now Penny's) one… Our kupuna would tell us stories about all the sweet potato, vegetables being grown to feed the people of Kalamaʻula. Brought the water all the way down. When there was rationing, we had to fill barrels with water, had to conserve – bathed with only a little water. Had droughts. Land was so full of food, up behind – all farms, where the flume was, because had water. Gathered big rocks for the flume. Had a hard life but appreciated that life – had to work for our food, had to work for everything. That's why all the kupuna are so smart. Kids are now so lazy – don't want to work, even to rake the yard. There were lots of fruit trees in Kalamaʻula – we fed ourselves. People used the ocean, but didn't take plenty, also would share with the neighbors. If a family didn't fish, those who did would give them crab, fish. Something is wiping out all the limu – not sure why it's happening. Maybe it's the pollution coming from other places. Where we used to pick up all the limu, in front of the spring, used to be plenty. Now – hardly any. Mrs. Ocampo is still going down there, maybe she's getting ʻopae… I'm really upset about the trespassing problems in Kapuāiwa Grove [pictured above in the early 1900s, Photo: Courtesy of Bishop Museum] – the way we were brought up, we never went in the Grove at all. Had two sets of grandparents that lived on either end of the Grove, but never did walk through the Grove. Knew we weren't supposed to – when we asked why, the kupuna just said "kulikuli!" [be quiet!] – we never did know the reason why, but knew we had to respect the Grove. Knew caretakers of the grove [Liette Corpus' grandparents] – they lived in the Grove, there was a house in the Grove by the spring – to the left of the spring. Peʻelua's are related to them.

Kaunakakai

Ka Inoa (The Name). "The old name for Kaunakakai was Kaunakahakai, "Resting-(on)-the beach." It was the place for the canoes to come, for here there were plenty of fish (Pukui, personal communication)."[47] Pukui and Elbert, citing Fornander, translate the name Kaunakahakai to literally mean, "beach landing."[48]

Aerial View of Kaunakakai Harbor and Shoreline. Photo: Kaunakakaiharbor.com.

Nā Wahi Pana (The Celebrated Places). Summers, et al identify the following special places in Kaunakakai:

- West of the approach to the Kaunakakai wharf is a platform that was part of Kamehameha V's home, Malama… The beach in front of this site was used exclusively by the *ali'i* for sun bathing. There formerly was a spit of sand in front of here called *Ka Lae o Ka Manu*, so named because the plover used to settle here. At the site of the County Park was a canoe shed (Cooke, 1949: 110, 151)."[49]
- Pukui, Elbert and Mookini indicate that Malama means "month or moon"[50] and Harriet Ne further provides that, "It was called Malama because its open doors faced the rising and setting sun. To avoid breaking the <u>kapu</u> against that, the steps leading up to the doors were built on the <u>makai</u> side.[51]
- Saltworks… Located at the site of the Kaunakakai dump in 1961, the salt pans were made "something like a taro patch." Sea water was run into the pans at high tide, and when the tide ebbed, some of the water remained. The water was allowed to stand from one to three weeks, after which the salt was gathered and dried. The salt formed here was not as salty as the salt formed by waves from the deep sea-- "Our salt here is not too sour…"[52]
- Kamalae Heiau…Located behind Kaunakakai village, the site of the heiau is at the foot of the median ridge. From Kakalahale it bears 35˚29'30"; 12,890 ft. Stokes wrote of it, "Heiau entirely destroyed. It is said to have been for human sacrifice, and that the drums were heard at night"...[53]
- Mahinahina Heiau… This heiau is located 500 ft NE of the pier at Kaunakakai. According to Stokes, "The site pointed out was a low platform lined with ala, on which a church stood…Said to have been for human sacrifice, and that the drums were heard at night"…[54]
- Kahua Maika…N. B. Emerson said that he saw a curved kahua maika "… on the plains back of Kaunakakai" (Malo, 1951:221, note 2).[55]

Harriet Ne Dancing Hula. Photo: Courtesy of Edward Halealoha Ayau

Ka ʻAumakua (The Ancestral Deity). Harriet Ne indicates the ʻaumakua of Kaunakakai is paʻakai (salt) based on her recollection of the image on a banner used during the last traditional makahiki ceremony at Nāʻiwa in 1918, in which she was in attendance.[56]

Nā Makani (The Winds). Three wind names for Kaunakakai are identified as Hauālialia,[57] Mālua, and Pelu.[58]

Nā Ua (The Rains). The rain name associated with Kaunakakai is Mālua, which is the same as Mālualua. It is also the name of a wind for this area.[59]

Nā Wai (The Waters). In 1950, the Kaunakakai Flood Control Project was constructed under the River and Harbors Act of 1935 to enlarge Kaunakakai Stream. It is unclear whether this is a traditional or contemporary name for this stream. No other water names are known at this time.

Nā Mele (The Songs, Chants). A traditional chant that recalls the rain and wind of Kaunakahakai provides as follows:

Hāʻule iho, he Mālua ka ua	It falls, Mālua is the rain
He Pelu ka makani	Pelu is the wind
Hauālialia Kaunakahakai	The Hauālialia wind is at Kaunakahakai[60]

A contemporary song made popular is *Cockeyed Mayor of Kaunakakai*, words and music by R. Alex Anderson.[61] Although some say the song disparages Kaunakakai because of its reference to drunkenness, it is nonetheless part of its historic identity.

Nā Moʻolelo (The Stories, Histories). Historian Kamakau further recounts historic events that took place at Kaunakakai prior to the time of Kamehameha I and during his stay on Molokai preparing to invade Oʻahu and the army of Kalanikūpule:

Kaʻeokūlani's war party lands at Kaunakakai:

> When Ka-ʻeo-ku-lani, ruling chief of Kauai, heard how narrowly Ka-lani-ku-pule and the other chiefs of Maui had escaped death in the war on Maui, and how the waters of ʻIao had been choked with the bodies of the slain in this war, he was so perturbed that he set sail to war against Kamehameha… The war party landed at Kaunakakai on Molokai, and when the Kauai chief saw for the first time, by the ovens they had left, the size of the camp which Kamehameha had occupied he said, "Where a big squid digs itself a hole, there crab shells are heaped at the opening.[62]

Kaʻiana betrayed by the Hawaiʻi island chiefs at Kaunakakai:

> While Kamehameha remained on Molokai with his forces, awaiting a proper time to set sail for Oahu, he consulted with many of his counselors and orators and his secret advisers; but he never summoned Kaʻi-ana-Ka-ʻahu-ʻula to such councils, and this made Kaʻi-ana suspect that the counselors were plotting his death. These councils took place at Kaunakakai. Kaʻi-ana stayed at Kamiloloa . . . Kaʻi-ana told his younger brother, "I fear that the chiefs are conspiring to kill us."[63]

In addition, the following two ʻōlelo noʻeau (proverbs) reference Kaunakakai,

> Hele i Kaunakakai i Hikauhi.
> Go to Kaunakakai to seek Hikauhi.
>
> Go to seek that which is lost. One day, when a man of Molokaʻi was fishing, his wife felt the beginning of labor pains and went to the upland to seek help from her mother. When the husband returned, he searched everywhere in Kaunakakai for his wife. After a time she returned with their daughter, whom they named Hikauhi.[64]
>
> Wā ʻōlelo i Kaunakakai.
> Loud talking at Kaunakakai.
>
> Said of much boisterous talking. The chiefs liked to play games such as kōnane at Kaunakakai, and their shouts and laughter could be heard for some distance.[65]

Traditional Ecological Knowledge. With regards to the management of and stewardship of the coastal resources in Kaunakakai, the ʻike (knowledge) and manaʻo (thoughts) shared by homesteaders Penny Martin, Henry Paleka and Kanani Negrillo with regards to Kalamaʻula specifically involving resource conservation and proactive watershed management, apply to Kaunakakai due to the immediate proximity and similar landscapes of both ahupuaʻa.

Kapaʻakea

Aerial View of Kapaʻakea Hawaiian Homestead Lots and Kōheo Wetlands to the west. Photo: © 2017 Google Earth

Ka Inoa (The Name). The literal meaning is "the coral or limestone surface."[66] A description of the land use in 1895 indicated:

> Kapaakea was originally part of the unassigned lands from the Mahele, turned over to Crown Lands in the 1890 Act. This land forms the eastern boundary of Kaunakakai with the government land of Kamiloloa to the south-east. It is very long and narrow, being only a little more than one-half miles wide at the sea where the government road crosses the land. Mostly grazing land. There is a large fishpond at the coast. Area of 2078 acres.[67]

Nā Wahi Pana (The Celebrated Places). In Kapaʻakea, such special places include:

- Ka Laʻi o Kioea…*Ka laʻi o kioea*, "The tranquil spot of the kioea (curlew, *Numenius tahitiensis*)," was the name of a place where the homesteads are now located in Kapaʻakea. "Here there were numerous plover and curlews. The curlews are said to have called to the canoes to go out to sea to fish. Hence the saying, ʻMolokai i ke kioea hoʻolale ka waʻa (Molokai where the kioea urge on the canoes).ʼ"[68]
- This location is also home to the Kōheo Wetlands, Ka Laʻi o Ke Kioea Bird Sanctuary, which is a 10-acre coastal salt marsh.[69]
- Kapaʻakea Pond… "A *puʻuone* having an area of 5.45 acres, this pond extended from the seashore to the Government road. The pond is now filled. According to Stokes there was one *makaha*... After examining it nearly 50 years later, Dunn described its condition: The pond has been neglected for a long period of time and can hardly be called such any more. It has been almost totally filled by silt washed down from the highlands mauka of the road and is covered with a dense growth of mangrove with some kiawe. The undergrowth is a thick mat of akulikuli. The old springs which fed this pond are either clogged or dried up and no longer available…"[70]
- Kapaʻakea Cemetery, which is a public cemetery established in the late 1800s on lands now owned by the County of Maui.
- Puʻumaninikolo, which literally means, "hill [for] seining *manini* fish or creeping *manini* fish hill."[71] It is one of three prominent hills in Kapaʻakea and is located mauka of the Kapaʻakea Homesteads. The other two hills are Puʻu Hele and Puʻu Makokiloiʻa.[72]

Ka ʻAumakua (The Ancestral Deity). Harriet Ne reports the ʻaumakua of Kapaʻakea is lole malo (loin cloth worn by men) based on her recollection of the image on a banner used during the last traditional makahiki ceremony at Nāʻiwa in 1918, in which she was in attendance.

Nā Makani (The Winds). No wind names were identified for Kapaʻakea.

Nā Ua (The Rains). No rain names were identified for Kapaʻakea.

Nā Wai (The Waters). There are no perennial streams in the ahupuaʻa. Two intermittent streams run during heavy rains and were diverted around the west and east boundaries of the Kapaʻakea Cemetery and "pass under Kamehameha Highway through a 24-inch reinforced concrete pipe and an 8-foot by 3-foot box culvert, respectively, and then through two shallow open swale ditches in the Kapaakea Homestead before entering the ocean."[73] In addition, when the flooding would overwhelm the pipe and culvert, the water sheets across Kamehameha Highway into Kōheo Wetlands and the Kapaʻakea Homestead area causing flooding. The first stream is named Kamiloloa and the second stream name is unknown. In addition, the name(s) of the spring(s) once associated with the Kapaʻakea Fishpond is/are also unknown.

Nā Mele (The Songs, Chants). There were no songs or chants found that referenced this ahupuaʻa or any of its natural features.

Nā Moʻolelo (The Stories, Histories). There were no stories or historical references regarding Kapaʻakea or any of its natural features.

Aerial View of the Eastern boundary of Kapaʻakea homestead lots. Photo: © 2017 Google Earth

Traditional Ecological Knowledge. With regards to the management of and stewardship of the coastal resources in Kapaʻakea, the ʻike (knowledge) and manaʻo (thoughts) shared by homesteaders Penny Martin, Henry Paleka and Kanani Negrillo with regards to Kalamaʻula specifically involving resource conservation and proactive watershed management, apply to Kaunakakai and Kapaʻakea due to the proximity and similar landscapes of the three ahupuaʻa.

Kamiloloa

Aerial View of the Western boundary of Kamiloloa Hawaiian Homesteads. Photo: Courtesy of Ted Kanemitsu 2021.

Ka Inoa (The Name). The literal translation is "the tall milo tree."[74]

Nā Wahi Pana (The Celebrated Places). Summers identifies the special places in Kamiloloa to include:

- Two adjoining land sections are called Kamiloloa; the one to the W is referred to as Government, the other was known as Konohiki. The two land sections formerly made the

ahupuaʻa of Kamiloloa. The section known as Konohiki had a *lele*, Kukaenui, containing 2.34 acres, situated near the Waikolu Stream in Waikolu…[75]
- In the water off Kamiloloa was a sea fishery known for the *heʻe* (Monsarrat, n.d.e:183) "Formerly the *heʻe* found here were the *iʻa kapu* of Bernice P. Bishop. The time for catching them was from November to March 1"…[76]
- Kalokoʻeli Pond… Kalokoʻeli, "The dug up pond," was a *loko kuapa* having an area of 27.6 acres in 1901 (Cobb, 19902:429). In 1922 the walls of the pond were broken. More than 30 years later, Dunn reported the area of the pond as being 32 acres and wrote: …About 600 feet of the pond wall has been washed away by the action of wave and tide. Some of this rock is scattered about the ocean floor in shallow water…Along the east wall of the pond and along the inshore line there is a growth of mangrove and akulikuli…Within the pond itself are a few small mangrove plants…[77]
- Ka Lua Na Moku ʻIliahi…*Ka lua na moku ʻiliahi*, "The pit (of) the sandalwood ships," is located approximately 1580 ft SW of Puʻu Kaʻeo, just N of the road. The site is a trench about 110 ft long, 40 ft wide, and 7 ft deep. Its sides are sloping, resembling the hull of a ship. Cooke told the following story about its use: After the discovery of the Hawaiian Islands [by Capt. Cook], the first commercial venture developed was the obtaining of sandalwood from the forests, which were owned by the Chiefs…Under the feudal system, … the common people were sent to the mountains to cut, stack and haul sandalwood. In order to measure the product, trenches were dug to simulate the size and depth of a ship's hold. When these had been filled with sandalwood logs, the Chiefs then could bargain with the captains of trading vessels. After a value was agreed upon, the commoners carried the sandalwood to the shore on their backs...[78]

Ka ʻAumakua (Ancestral Deity). Harriet Ne reports the ʻaumākua of this ahupuaʻa to be large milo trees. This information is based on her recollection of the image on a banner used during the last traditional makahiki ceremony at Nāʻiwa in 1918, in which she was in attendance.

Nā Makani (The Winds). The one wind name for this area is Pai.[79]

Nā Ua (The Rains). There were no rain names identified at this time.

Nā Wai (The Waters). There are no perennial streams in Kamiloloa. The two intermittent streams that run during heavy rains and were diverted around the west and east boundaries of the Kapaʻakea Cemetery also pass through this ahupuaʻa. Again, the first stream is named Kamiloloa and the second stream name is unknown. No spring names were identified at this time.

Nā Mele (The Songs, Chants). Although no chants or songs have been identified for Kamiloloa, two famous haku mele (song and music composers) hail from this ahupuaʻa. In 1865, Esther Kawahineaukaiokamoana Keliana Kekula Bishaw was born in Kamiloloa. She wrote the famous mele, a waltz, entitled *Only You*,

Nāu a me aʻu i kui a lawa	You and I will weave a lei
Nāu a me aʻu i haku i lei	You and I will sew till completed
Nāu a me aʻu i kui i lei nani	You and I have expectations of your lovely lei
Kāhiko malia i luna you and I	To adorn you and I
Only you, only you	Only you, only you

Ka i awaiāulu me a‘u	He has recuring thoughts of me
Only you, only you	Only you, only you
Ka ‘ike i ka hana wela a ke aloha	See the hot passion of love
You and I	You and I.[80]

Keliana's daughter Mary Kanealae Bishaw was born on April 20, 1885 in Kamiloloa. She composed *Kuhi‘ō Bay*, a famous song about the Bay in Hilo in 1928. Mary died in Ho‘olehua on August 23, 1944.[81]

Nā Mo‘olelo (The Stories, Histories). Resharing the account from Kamakau relating to the betrayal of Ka‘iana while he stayed in Kamiloloa:

> These councils took place at Kaunakakai. Ka‘i-ana stayed at Kamiloloa . . . Ka‘i-ana told his younger brother, "I fear that the chiefs are conspiring to kill us."[82]

There are no additional known stories or historical references regarding Kamiloloa or any of its natural features at this time.

Aerial View of the Kamiloloa Hawaiian Homestead Area. Photo: Courtesy of Ted Kanemitsu 2021.

Traditional Ecological Knowledge. With regards to the management and stewardship of the coastal resources in Kamiloloa, the following ‘ike (knowledge) and mana‘o (thoughts) are shared.

Gayla Mowat, Kamiloloa Shoreline Lessee (Multi-Generational):

> In response to the question '*how do you use the shoreline?*' she replied, "I enjoy sitting on the shoreline in my yard, watching the sea, the sunset. It's very relaxing. Grow limu – good ogo -- had good rocks with limu, but someone took the rocks. People are pulling limu off the rocks, by the roots, can't grow back that way. ‘Opae. In 1980's clams were clean. Now, started getting muddy." In response to the question, ‘*are there any specific actions (improvements and/or management activities) that you would like to see to prevent or mitigate shoreline erosion?*', she replied that she's been planting naupaka and it's slowing the erosion. Others (Kamiloloa, Molokai Shores) have planted naupaka too.

In addition, the ‘ike shared by homesteaders Penny Martin, Henry Paleka and Kanani Negrillo with regards to Kalama‘ula specifically involving resource conservation and proactive watershed management, apply to Kaunakakai, Kapa‘akea and Kamiloloa due to the proximity of the first three and similar landscapes of all four ahupua‘a.

Makakupa‘ia

Aerial View of the Makakupa‘ia Hawaiian Homestead Area, Ali‘i Fishpond. Photo: Courtesy of Ted Kanemitsu 2021.

Ka Inoa (The Name). *Place Names of Hawaii* does not offer a translation of the name except to state, "two land division and road. Kaunakakai qd., south Moloka‘i; a game management area."[83] Harriet Ne is also silent on the translation of the name.

Nā Wahi Pana (The Celebrated Places). Summers identifies the special places of Makakupa‘ia to include:

- Two adjoining land sections are called Makakupaia; the one to the W is referred to as Government, the other was known as Konohiki. Formerly the two land sections made the ahupua‘a of Makakupaia.[84]
- Ali‘i Pond… Cobb (1902:429) listed a "nameless pond in Makakupaia 1" as being 46 acres in area. Now called Ali‘i Pond, it has an area of 25.80 acres. The wall of this *loko kuapa* is 2710 ft long, about 4 ft wide, and 4.5 ft high..., There was one *makaha*. In 1957 the pond was filling with mud and about 4 acres along the E wall and inshore line were covered with mangrove. The *makaha* was broken…[85]
- Kaoaini or Kaonini Pond…This site was a *loko kuapa* having an area of 9.3 acres in 1901 (Cobb, 1902:429). The wall, which was approximately 1770 ft long, is now destroyed, although the foundations can still be seen…Cobb gave the name Kaoaini for this pond; Stokes called it Kaonini... Kaonini is listed as a fishing ground "…known by the people to have shoals of fish remaining upon [it]…" This fishing ground was placed under protective taboo for the King in 1839…[86]

- Burials…When the bulldozing was done for the construction of Del Monte Park, numerous burials were uncovered (Henry Meyer, personal communication, 1965).[87]

Ka ʻAumakua. Harriet Ne reports the ʻaumākua of Makakupaʻia to be one (sand). This information is based on her recollection of the image on a banner used during the last traditional makahiki ceremony at Nāʻiwa in 1918, in which she was in attendance.

Nā Makani (The Winds). Wind names for this area were not identified at this time.

Nā Ua (The Rains). There are no known rain names at this time.

Nā Wai (The Waters). There are no perennial streams. There is one intermittent stream that appears to be named Onini and a second stream that does not have a name. No spring names were found to be associated with Aliʻi Pond or Kaoaini/Kaonini Pond.

Nā Mele (The Songs, Chants). No chants or songs have been identified for Makakupaʻia at this time, nor were any famous haku mele from this place.

Nā Moʻolelo (The Stories, Histories). There are no known stories or historical references regarding Makakupaʻia or any of its natural features.

Aerial View of the Makakupaʻia Hawaiian Homestead Area. Photo: Courtesy of Ted Kanemitsu 2021.

Traditional Ecological Knowledge. With regards to the management and stewardship of the coastal resources in Makakupaʻia, the following ʻike (knowledge) and manaʻo (thoughts) are shared.

Noelani Lee, Executive Director, Ka Honua Momona International Licensee Aliʻi Fishpond:

> In response to the question ʻ*how do you use the shoreline?*ʼ she replied that Aunty Vani (Ainoa) lives just east of Hotel Molokai. Limu ʻeleʻele at her place. In 2005, we used to have 25 different species of limu. Limu kala disappeared 8 years ago. In response to the question, ʻ*are there any specific actions (improvements and/or management activities) that you would like to see to prevent or mitigate shoreline erosion?*ʼ she replied, We celebrated the year of the mullet. Native plant specialists. Need to reforest, need to do sediment mitigation between the forest and here. Native plants that could replace invasives. Dr. Keana Frank, Ph.D., Harvard researched beach nourishment and beach restoration including Pāʻūohiʻiaka and Pōhuehue, crawler plants.

With regards to the management of and stewardship of the coastal resources in Makakupaʻia, the ʻike (knowledge) shared by homesteaders Penny Martin, Henry Paleka and Kanani Negrillo with regards to Kalamaʻula specifically involving resource conservation and proactive watershed management, apply to Kaunakakai, Kapaʻakea, Kamiloloa and Makakupaʻia due to the proximity of the first three and similarity in landscapes of all five ahupuaʻa.

Aerial View of Kaunakakai and Kalamaʻula Looking West. Photo: Courtesy of Ted Kanemitsu.

Conclusion

It was clear that more information was readily available for the cultural lens categories for Kalamaʻula and Kaunakakai, with less available for Kapaʻakea and very little for Kamiloloa and Makakupaʻia. These revelations hint at the importance of these ahupuaʻa to the Kona moku and mokupuni of Molokai in terms of where the island's population and activities became centered. Historically, these areas served a role in the rise to power of Kamehameha, and the place where the first Hawaiian Homelands settlement was established.

The poetic name *Molokai Nui a Hina* establishes the kuleana (duty, responsibility, privilege) to care for the island's finite resources including its watersheds and shoreline resources. The ʻike (knowledge) shared by homesteaders Penny Martin, Henry Paleka and Kanani Negrillo with regards to resource conservation and proactive watershed management speak to this kuleana. The nickname Molokai ʻāina momona aptly describes these specific ahupuaʻa known for their ability to provide land and ocean food (although most of the fishponds, springs and pools are filled in). And the ecological knowledge shared will help support the development of strategies to care for and protect these shoreline and mauka resources. These cultural insights raise understanding and awareness of the identity of these ahupuaʻa and strengthen and continue the legacy by the homesteaders who reside there currently and whose pulapula (offspring) will do so in to the future.

[1] The author's family on his paternal side is from Pelekunu, Molokai. His tūtū wahine (grandmother) Harriet Ahiona Ayau Ne taught him the island's name is to be pronounced without an ʻokina. She based this on her life experiences growing up in Pelekunu, Kamalo, Kalamaʻula and Hoʻolehua and a conversation with 'Mother Pukui' who told her the name means to interweave and interlace, to tie securely (molo) of the rough ocean (kai) of the north with the calm ocean (kai) of the south. The author follows the teaching of his tūtū who also stated that use of an ʻokina is fine if that is how one was taught by their kūpuna.
[2] Fornander, Abraham, *Hawaiian Antiquities and Folk-Lore*. Bernice Pauahi Bishop Museum Memoirs, Vol. 4, Honolulu, 1916-1917: 12, 13.
[3] *Ibid* at 2, 3.
[4] *Ibid* at 22.
[5] Teaching of Harriet Ahiona Ayau Ne.
[6] Summers, Catherine C. *Molokai: A Site Survey*. Bernice Pauahi Bishop Museum Pacific Anthropological Records No. 14, Honolulu, 1971:2.
[7] See, https://www.molokai.org/about-molokai/myths-of-molokai/index.html, Molokai Community Service Council, viewed on October 22, 2020.
[8] Pukui, Mary Kawena; Elbert, Samuel H; Mookini, Esther T. *Place Names of Hawaii Revised and Expanded Edition*. The University of Hawaii Press, (1974:74).
[9] *Ibid*.
[10] Ne, Harriet Aheona. *Teacher's Guide to Molokai Field Trips for Hawaiiana Vol. II*, Office of Library Services, Teacher Assist Center for the Maui District Office, Molokai Educational Complex, Dept. of Education, State of Hawaii, Pub. No. TAC 72-5093; December 5, 1974: 2. Mrs. Ne was formally recognized as a Cultural Historian of Molokai by Governor John Burns in 1974. She was consulted about the island's cultural history by Dr Kenneth Emory and Mary Kawena Pukui.
[11] Summers (1971:84).
[12] *Ibid*.
[13] *Ibid*.
[14] *Ibid*.
[15] Summers (1971:85).
[16] Tomonari-Tuggle, M.J. Archaeological Reconnaissance Survey, Road Corridor, Kalamaʻula Mauka (1983:1) and Tomonari-Tuggle, M.J. Archaeological Inventory Survey of a Portion of Kalamaʻula, Island of Molokai (1990:8).
[17] Summers (1971:72) citing Pukui.
[18] Hommon, Robert J. and Ahlo, H.M. (June 1983). An Archaeological Survey of Selected Lands, Proposed for Military Training Near Kaunakakai, Island of Molokai, Hawaii (1983:14-15).
[19] Tomonari-Tuggle (1990:9-10).
[20] Handy, E. S. C. and Handy, E. G. *Native Planters in Old Hawaii: Their Life, Lore, and Environment*. Bishop Museum Press (1972:517) in Tomonari-Tuggle (1990:7-8).
[21] Summers (1971:38) citing a 1922 *Ka Nupepa Kuʻokoʻa.*
[22] Summers (1971:84-85).
[23] Summers (1971:85).
[24] Summers (1971:86).
[25] Summers (1971:87).
[26] Summers (1971:85).
[27] Summers (1971:86).
[28] Summers (1971:86-87).
[29] Summers (1971:86).
[30] *Ibid.*
[31] Summers (1971:87).
[32] Ayau, Edward Halealoha. *Naʻiwa: Home of the Hawaiian Olympic Games Celebrated as Part of the Molokai Makahiki,* Based on the manaʻo of Harriet Ahiona Ayau Ne, Molokai Dispatch, October 1, 1989 at 8. Notably, the author is the grandson of Harriet Ne and spent time learning Molokai's cultural history from her.
[33] Summers (1971:84).
[34] Personal communication with the author. Mikiʻala Pescaia is the author's sister who was also taught by tūtū Harriet Ne.
[35] *See*, http://cramp.wcc.hawaii.edu/Watershed_Files/Molokai/WS_Molokai_molokai_Palaau.htm,

Coral Reef Assessment & Monitoring Program Hawaii, viewed on October 13, 2020.
[36] *See*, Interview No. 2_Zach Helm, "Before Aunty Kauila's place – the stream – Makehe Stream – was an old Hawaiian man who built a hale inside the mangrove." (November 2019).
[37] Ne (1974:9-11).
[38] *See*, https://www.huapala.org/KAL/Kalamaula.html, viewed on October 10, 2020: "Source: John Clark, author of "Hawaiʻi Place Names: Shores, Beaches and Surf Sites"- Excerpted from an interview with Valentine Dudoit, retired HFD Captain, the son of Emma Kala Dudoit, the composer of this song. Emma Kala Dudoit, originally from Kekaha, Kauai, wrote this song when the family moved to Kalamaʻula from Kakaʻako in 1922. She died shortly after in 1923. Well-known composer and entertainer Emma Bush recorded the song in 1928 and was inadvertently listed as the composer. Hannah Dudoit, Emma Dudoit's daughter, then copyrighted the song in order to acknowledge her mother as the composer. Hannah Dudoit has since been listed as the composer. This information was substantiated by John Dudoit, retired HFD Captain, brother of Valentine Dudoit. Copyright 1929, renewed EMI Miller Catalog, Inc."
[39] Pukui, Mary Kawena. *Nā Mele Welo Songs of Our Heritage Selections from the Roberts Mele Collection in Bishop Museum Honolulu Translated by Mary Kawena Pukui* (1995:74). "Notes: Contributor Waiwaiole Ka La [Kala Waiwaiole], Kapaa, Kauai. Mele olioli no Molokaʻi [Chant from Molokaʻi]."
[40] Kamakau, S.M. *Ruling Chiefs of Hawaii Revised Edition*, Kamehameha Schools Press (1961:70).
[41] *Ibid* at 149.
[42] *Ibid* at 171.
[43] *Ibid* at 259-260.
[44] *Ibid* at 312.
[45] Pukui, Mary Kawena. *ʻŌlelo Noʻeau Hawaiian Proverbs & Poetical Sayings*, No. 2879, Bernice P Bishop Museum Special Publication No. 71, Bishop Museum Press (1983:314).
[46] Malo, David. *Hawaiian Antiquities (Moolelo Hawaii),* Bernice P Bishop Museum Special Publication 2, Second Edition, Translated from Hawaiian by Dr Nathaniel B. Emerson 1898 (1951:216-18).
[47] Summers (1971:87).
[48] Pukui, Mary Kawena; Elbert, Samuel H; Mookini, Esther T. (1974:95).
[49] Summers (1971:87).
[50] Pukui, Mary Kawena; Elbert, Samuel H; Mookini, Esther T. (1974:143).
[51] Ne (1974:1).
[52] Summers (1971:87).
[53] *Ibid*.
[54] *Ibid* at 88.
[55] *Ibid*.
[56] Ayau (1989:9).
[57] Summers (1971:87).
[58] Akana, Collette Leimomi; Gonzalez, Kiele. *Hanau Ka Ua Hawaiian Rain Names*, Kamehameha Publishing (2015:175).
[59] *Ibid*.
[60] *Ibid*, "From the legend of Pākaʻa and Kūapākaʻa. Hawaiian Source: Fornander, Fornander 5: 101. English trans. by Collette Leimomi Akana. Additional sources: Kuapuu, "He wahi moolelo" 5/8/1861; Nakuina, Moolelo 62, Wind 56. Note: "Kaunakahakai" is the same as Kaunakakai."
[61] *See*, https://www.huapala.org/Cockeyed_Mayor_of_Kaunakak.html reports, "Source: - Paul Fagan, owner of Puʻuohoku Ranch, Molokai requested a song for his special guest, movie star, Warner Baxter, in 1934. The mythical mayor became cockeyed because the last two syllables rhymed with Kaunakakai. Although Baxter liked the tune and lyrics, his studio did not, fearing it would create a bad image of drunkeness for Hollywood. © 1935 Edward B. Marks Music Corp."
[62] *Ibid* at 159.
[63] *Ibid* at 172.
[64] Pukui, Mary Kawena. *Ōlelo Noʻeau Hawaiian Proverbs & Poetical Sayings*, No. 742, (1983:82).
[65] *Ibid,* No. 2919 at page 319.
[66] Pukui, Mary Kawena; Elbert, Samuel H; Mookini, Esther T. (1974:86).
[67] *See*, http://kipukadatabase.com/kipuka/CrownLands.html?ObjectID=6&b=2#view2. See also, Iaukea, Biennial Report, 1894. Viewed on October 13, 2020.
[68] Summers (1971:88).
[69] *See*, www.conservationconnections.org/site/koheo-wetland-ka-lai-o-ke-kioea-bird-sanctuary. Viewed on October 13, 2020.

[70] Summers (1971:88).
[71] Pukui, Mary Kawena; Elbert, Samuel H; Mookini, Esther T. (1974:202).
[72] *See*, Map of Kapa‘akea, Molokai.
[73] *See*, Final Environmental Statement, Kapaakea Homestead Molokai, Hawaii (December 1976: 2-2).
[74] Pukui, Mary Kawena; Elbert, Samuel H; Mookini, Esther T. (1974:82).
[75] Summers (1971:88).
[76] *Ibid*.
[77] *Ibid*. A loko kuapā is a fish pond made by building a wall on a reef.
[78] Summers (1971:88-90).
[79] Summers (1971:88).
[80] Mahoe, Noelani Kanoho. Ho‘āhu ‘Ana O Nā Mele Ho‘okahi Iwakālua a Hapa Kākini ■ One Score and Half a Dozen ■ A Collection of Songs, Stories & Pictures compiled by Noelani Kanoho Mahoe Vol. One (2015:46-48).
[81] *Ibid* at 48. The author’s mother is a Bishaw and ‘ohana to these two famous haku mele (music composers).
[82] Kamakau (1992:172).
[83] Pukui, Mary Kawena; Elbert, Samuel H; Mookini, Esther T. (1974:140).
[84] Summers (1971:90).
[85] *Ibid*. A loko kuapā is a fish pond made by building a wall on a reef.
[86] Summers (1971:90-91).
[87] Summers (1971:91). It is unclear what happened to these burials. They were not removed to the Bishop Museum.

APPENDIX C: FLOOD ZONES, SHORELINE SETBACKS, AND THE STATE CERTIFIED SHORELINE

FLOODING

The Federal Emergency Management Agency (FEMA) has created Federal Insurance Rate Maps (FIRM) delineating flood zones and base flood elevation. A property's topography and elevation above sea level indicate a sites vulnerability to flooding. However, the FIRM maps do not account for a location's substrate or soil composition which can affect the sturdiness or stability of a structure or house subjected to flooding.

The FIRM's for Molokaʻi have been updated to incorporate digital elevation models that are more accurate than previous inundation models. Any building proposed to be located in a flood zone should be designed to withstand inundation (breakaway walls, sealed utilities, absence of living areas where inundation risk is high, etc.). Alternatively, the building can be raised (post and pier) to allow floodwaters to pass unimpeded below the building. However, the posts and piers must be sufficiently anchored so as to prevent floatation of the building. They should also be fortified to withstand the forces behind the flood waters so the building doesn't move or become dislodged by debris or waves.

The County of Maui participates in FEMA's voluntary Community Rating System (CRS). As a result, Maui property owners receive a discount on their flood insurance. On properties within and subject to the County of Maui regulations, a Flood Development or Flood Way permit may be required when building in a flood zone. The permit is triggered during the building permit review process and can influence the structure's design, location, configuration and building materials. Without the permit, the property owner may not be able to obtain homeowners insurance or a bank loan for the building such as a mortgage. Without the permit, some DHHL beneficiaries may have difficulty in securing funding from a federally insured bank or commercial lending institution for home construction as a result. Despite whether DHHL and/or its beneficiaries are subject to federal flood prevention programs, the lending banks are and thus may be unwilling to make loans to properties at risk of flood inundation. Considering the cost of construction, it makes sense to invest in flood prevention and building strengthening to avoid or mitigate potential damage.

If a home was built before 1995 in Molokaʻi, it probably does not have hurricane clips to tie the roof to the walls and strong connectors from the walls to the foundation to create a continuous load path. The County building code was revised after the devastation caused by Hurricane Iniki in 1992 on Kauaʻi and newer buildings are much stronger and resistant to wind and water damage.

Types of Flood Zones

Flood zones are established based on data from actual storms and floods that have occurred in the past. Flood zones X and XS have low to moderate risk of flooding and there is no mandatory flood insurance purchase requirement, but coverage is available in participating communities (CRS). A Flood Development Permit is not required for construction in these low-risk areas.

Flood Zone X represents areas outside the 0.2% annual chance floodplain. Flood Zone X is an area that is outside of the 100-year floodplain and includes areas where the 100-year sheet flow flooding is less than one foot in depth, and areas of 100-year stream flooding where the contributing drainage area is less than one square mile. No base flood elevation (bfe) or depths of flooding are listed within the X zone on FIRM maps.

Flood Zone XS is an area of 0.2% annual chance flood. It includes areas of 1% annual chance flood with average depths of less than one foot or with drainage areas less than one square mile, and areas protected by levees from 1% annual chance flood.

In contrast to low-risk areas, areas exposed to the 1% annual chance flood are within Special Flood Hazard Areas (SFHA). These flood prone areas are exposed to rising waters (A, AE, AEF) or wave action (V, VE flood zones). A Flood Development Permit is required and triggered when a building permit is requested in a SFHA. The base flood elevation (bfe) is the depth of flooding from the 1% annual chance flood. This depth has a 1% chance of being equaled or exceeded in any given year. Mandatory flood insurance purchase requirements apply in these flood prone areas and a Flood Development or Floodway Permit may be required within areas subject to Maui County zoning or land use ordinances (MCC Title 19). The permit helps guide the applicant in designing a building or site that can withstand, minimize, mitigate and/or avoid damage from flooding. The most common SFHA flood prone areas are detailed below.

Zone AE is an area subject to rising water. The depth of the rising water is predicted as the base flood elevation (bfe). A bfe of 10 feet indicates that everything 10 feet in elevation and below will become wet from flood waters. In an AE zone, damage to sheet pile, carports, paneling, electrical outlets and connections, and appliances may occur as a result of becoming saturated with water, whether it be fresh or saltwater in origin. Drywall and wood can quickly become moldy after flood waters subside. Flood waters are frequently laden with sediment which can lead to additional damage and cleanup challenges. Flood proofing is recommended where feasible.

Zone AEF is a floodway area in Zone AE. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment or obstructions so the 1% annual chance flood can be carried through it without increasing the bfe. Structures that obstruct or could catch debris in the floodway are not allowed because they could form a dam that could cause or amplify flooding on adjacent and/or downstream property.

The V and VE Flood Zones are coastal high hazard areas. They are a Special Flood Hazard Area that is subject to high velocity wave action from storms or seismic sources. They are in the 100-year coastal floodplain and are exposed to waves. Zone V does not have an established bfe, whereas Zone VE has a base flood elevation derived from detailed hydraulic analyses. Mandatory flood insurance purchase requirements apply when building habitable structures. New structures in these zones must meet special standards of design and strength to resist wave action and erosion of the building's footings or foundation. Fill may not be used to create the foundation pad or to elevate the building above bfe, since the fill and any slab-on-grade foundations could be under scoured by wave action. Instead, post and pier construction is often used to elevate the lowest floor joist one foot above bfe such that flood waters and waves can pass under the structure unimpeded.

MCC 19.62 regulates construction of structures, including homes, ohana dwellings, and accessory structures that are proposed to be located in flood prone areas. Within Special Flood Hazard Areas, a Flood Development Permit (FDP) may be required before the structure can be built and is normally obtained at the building permit stage. The FDP application may require a no rise analysis to ensure neighboring properties will not be flooded by water displaced or redirected by the new structure. The FDP may also require an elevation certificate conducted by a licensed surveyor that indicates the elevations and relation to base flood elevation.

Flood Zone Maps

DHHL homestead lands are exposed to flooding with wave action (VE) along the seaward (makai) side of almost all the homestead properties. Other properties are mostly exposed to the risk of potentially rising waters (AE, AEF zones). More mauka properties near the highway are generally in the X or XS zones, which have low risk of flooding. Base flood elevations (bfe) are the predicted depth of flood waters above sea level and may not fully account for a site's topography or height above the ocean.

Kapaʻakea flood risk is mapped on Panel Number 150003 0193F (November 4, 2015) and 0195E (September 25, 2009) on the Flood Hazard Assessment Report for the Kamiloloa watershed. The community is subject to VE (bfe 12), AE (bfe 7 to 10) and AEF flood zones around Kamiloloa Gulch.

Kamiloloa flood risk is mapped on Panel Number 150003 0193F (November 4, 2015) and 0195E (September 25, 2009) on the Flood Hazard Assessment Report for the Kamiloloa watershed. The community is subject to VE (bfe 10), AE (bfe 7) and X flood zones along Kamehameha V Highway and exposed to Flood Zone A in some areas primarily above and mauka of the Kamehameha V Highway.

One-Aliʻi flood risk is mapped on Parcel Number 150003 0193F & 0194F (November 4, 2015) and 0195E (September 25, 2009) of the Flood Hazard Assessment Report for the Kamiloloa watershed. The community is subject to VE (bfe 10), the fishpond is in VE (bfe 9), and flood zones AE (bfe 7) up to and including the Kamehameha V Highway. Areas mauka of the highway are in the X flood zone, and are of low (but not zero) risk of flooding.

SHORELINE SETBACKS AND THE STATE CERTIFIED SHORELINE

SHORELINE SETBACKS

Setbacks from the shore and ocean should be large enough to allow for the coastline to shift and move according to season dynamics and storm events. Limiting construction and development in areas bordering the ocean using setbacks is a practical and effective way of preventing damage to structures and buildings and protecting the people who use or reside in them. Setbacks can account for the size of a property, or for past change in the shoreline's position. In contrast to fortifying buildings to withstand coastal hazards, like a Flood Development Permit may encourage, locating inland based on projections of shoreline erosion seeks to avoid coastal hazards and applies a common sense, pragmatic approach to shoreline erosion. Locating out of harm's way is an effective means of avoiding coastal hazards (Hwang, 2005). For example, locating a building inland of a sandy beach, cobble shore, or sand dune allows the setback area to serve as natural buffer dissipating waves and absorbing energy that helps mitigate the potentially damaging effects of coastal hazards on a building (MOE, 1991).

Locating inland may also reduce or eliminate the need to harden the shoreline. Shoreline setbacks are intended to reduce risks to buildings from coastal hazards, protect access along the shoreline, and conserve beach and environmental resources. The Shoreline Rules for the Molokaʻi Planning Commission, 12-304, implement a building setback from the ocean that is based on a property's average lot depth (ALD). The ALD setback is 25 feet, 40 feet, or 25% of the ALD up to 150 feet measured inland from the shoreline. But like the FIRM maps, the ALD setback does not account for a location's substrate or soil properties, so a home built on volcanic dike material would be treated the same as a home built on an eroding sandy shore or a marshy wetland.

The shoreline setback line is projected inland and parallel to the shoreline at a horizontal plane. This would be like drawing the setback line on a two-dimensional site map of the parcel. The setback calculation does not account for topography, substrate, unusual configurations such as flag lots, peninsulas, lots separated from the ocean by a sliver of property or a fishpond, or where the ocean borders more than one side of the parcel. The setback extends inland and is measured from the State Certified Shoreline, or more conservatively from the mean high-water mark in some cases. The setback is measured from the current shoreline's position inland and not from the property line. Area seaward of the shoreline that erodes, or becomes submerged, can fall within the public domain.

The shoreline setback area includes all the land between the shoreline setback line and the shoreline or mean high water mark and extends along the property's entire seaward frontage between its side boundaries. However, the Hawaii Coastal Zone Management Act, HRS 205A establishes setbacks of a minimum of forty (40) feet for the shoreline.

State-certified Shoreline

The main purpose of a shoreline certification is to officially delineate the shoreline's position. It is defined as the highest wash of waves during the highest tide of the year, normally evidenced by the vegetation or debris line, whichever is more landward. The process helps distinguish between public trust land from privately-owned land. The certification process ensures that any encroachments onto the public domain are resolved either through removal, permit, or lease and serves as the basis from which the shoreline setback line is measured.

The shoreline is established by the DLNR OCCL and certified by the BLNR during a public meeting. The shoreline delineates the jurisdiction between the county (mauka) and the state DLNR (makai) and defines public lands (makai) and private lands (mauka) land. A survey completed by a licensed surveyor is submitted to the DLNR and verified with a site visit by DLNR staff. A notice of the survey and its purpose is published in the OEQC Environmental Notice and offers the public an opportunity to comment. The DLNR DAGS also posts pictures and copies of the survey on their website for review and comment. Based on public comments and recommendations from DLNR OCCL and DAGS staff, the BLNR may accept or reject the shoreline survey application, with certifications valid for one-full year. In cases where the shoreline is fixed by a man-made structure that has received government approval, or was constructed prior to the need for permits applicable at that time, a new shoreline survey certification may not be needed, provided the shoreline's position is fixed by the structure. In cases where natural features such as rocks or cliffs set the shore's position, a certification may not be necessary for some permitting matters.

In the case of the Kamiloloa and One Aliʻi DHHL Homestead lots on Molokaʻi, there is a small sliver of land between the individual homestead lots and the ocean that is owned by DHHL. These separate parcels are shown on county plat maps from 1950. These buffer lands connect to mauka-to -makai foot paths that connect to the public highway (Kamehameha V.) and may have been intended to protect access to and along the shoreline for gathering, fishing, and recreational and cultural practices.

APPENDIX D: SHORELINE EROSION ASSESSMENT (SEVERITY AND RISKS)

Severity and Risks:

The following figures are excerpts from the County's plat maps that provide reference features to compare with today and estimate change along the shoreline. Homestead beneficiaries identified shoreline reference features that suggest the shoreline fronting Kapa'akea has retreated twenty to twenty-five feet over the past half-century. The finding was confirmed during site visits in February 2019 by comparing the present length of the public access paths and drainage ditches to those of the County's 1950 plat maps (Figures A.1 and A.2) sourced from Taxation Maps Bureau, 7/21/1950, Dwg # 3978 & 3979, plat maps (2) 5-4-007 & 008)[1]. The observation suggests the shoreline has retreated an average of ~ 0.33 feet per year over the past 70 years. In comparison, the island of Maui's sandy shores have retreated an average of 1.1 feet per year (Fletcher, et. al., 2003 Maui Shoreline Atlas).

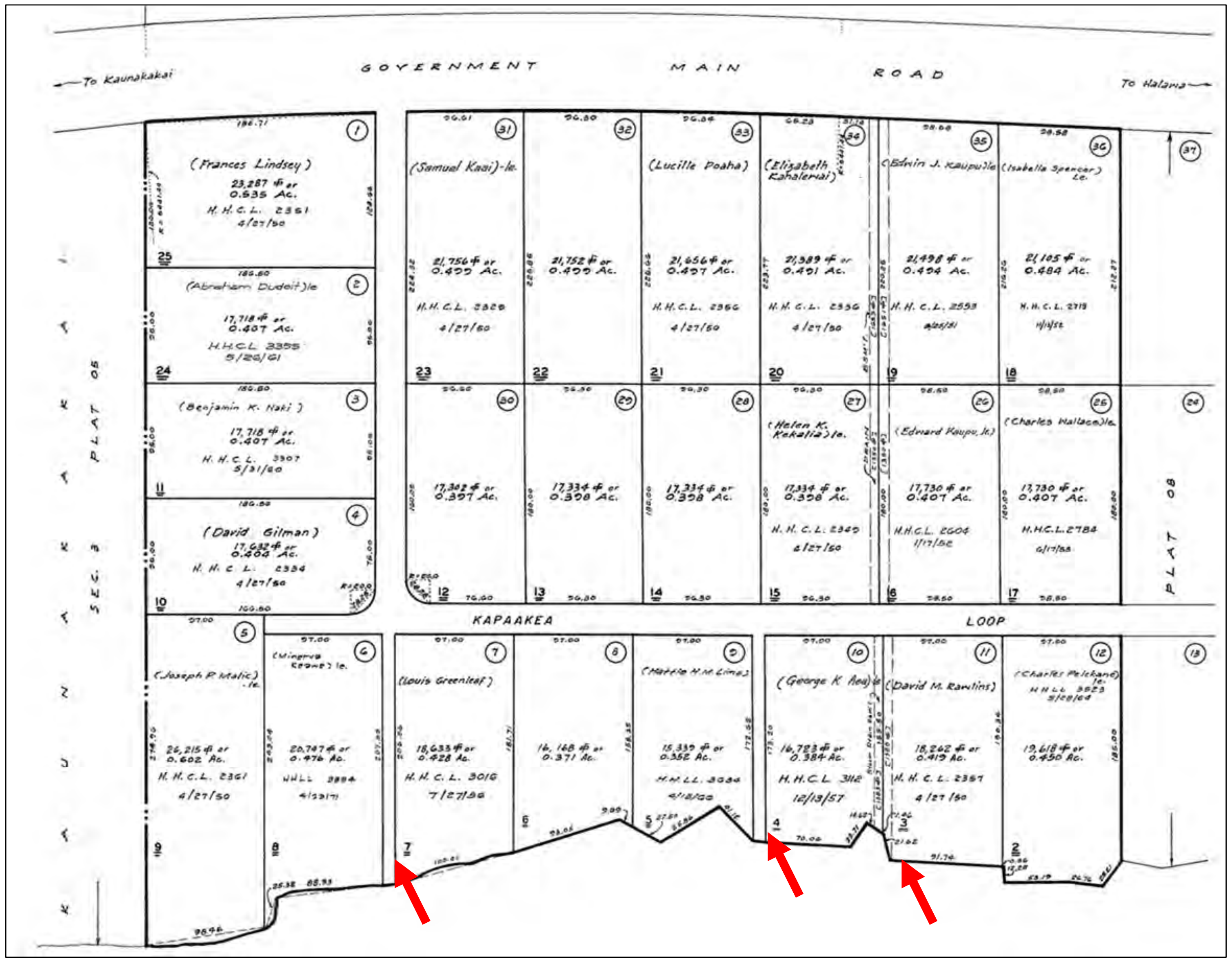


Figure A.1: *Plat map dated 7/21/1950 of Kapa'akea western half of the subdivision (Tax Maps Bureau & Survey Department).*

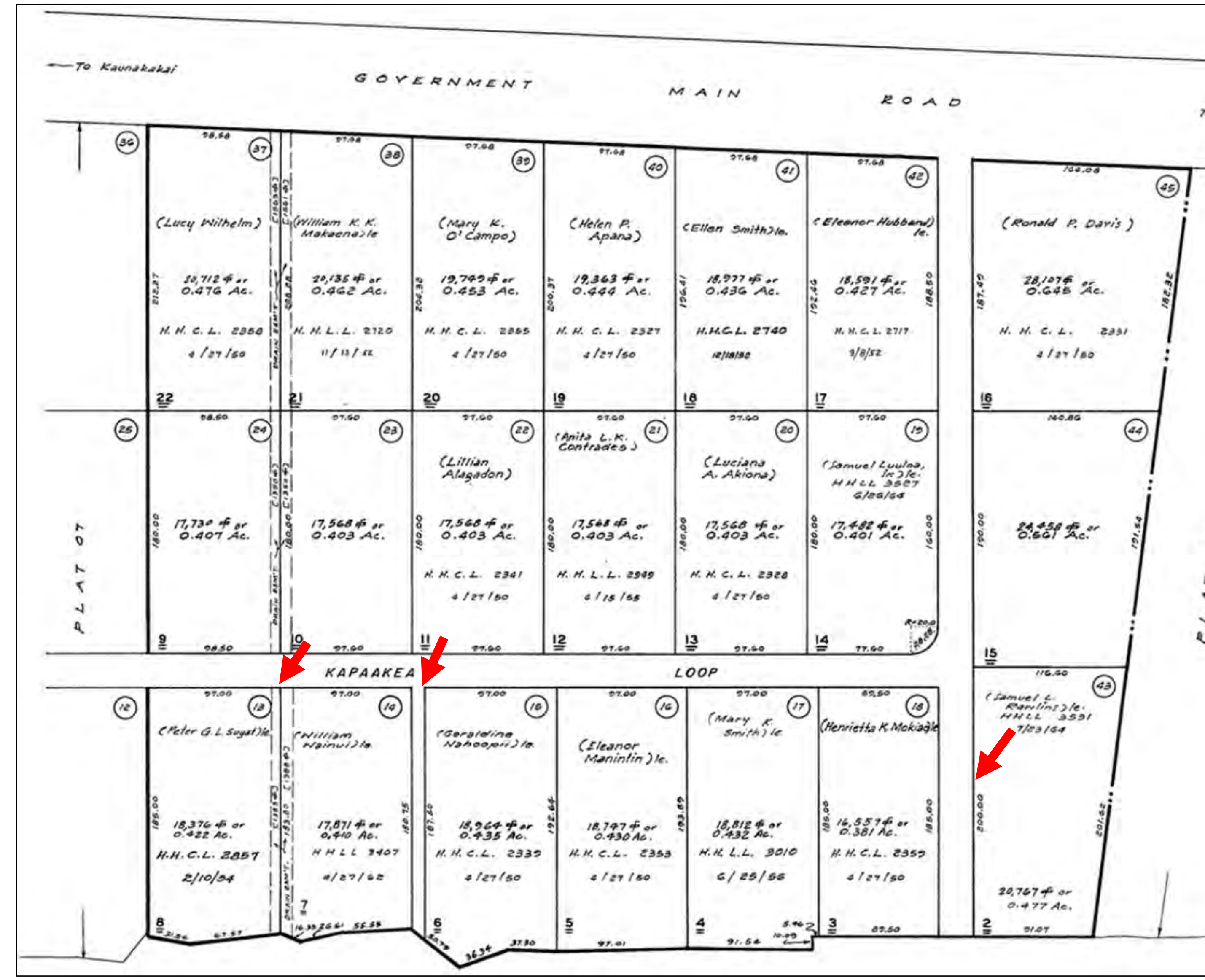


Figure A.2: Plat map dated 7/21/1950 of Kapa'akea eastern half of the subdivision (Tax Maps Bureau & Survey Department).

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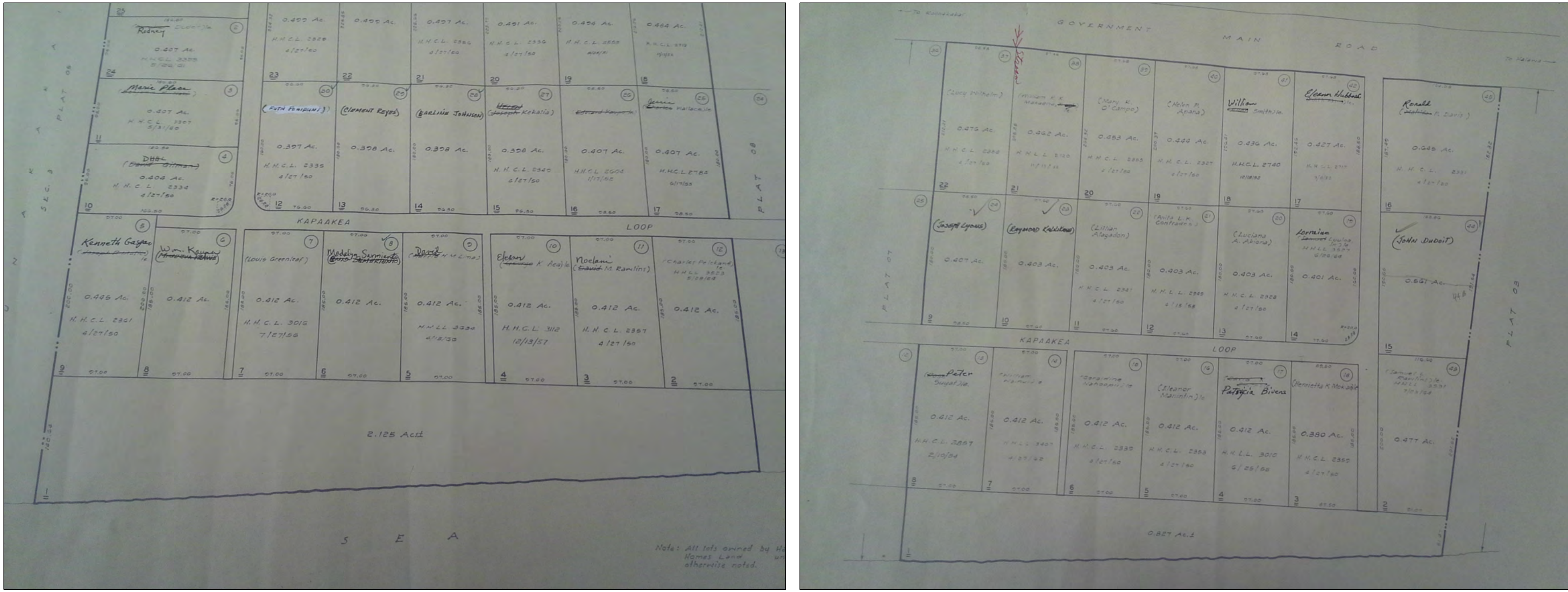
[1] Each map lists the length of a shoreline access path and a drainage easement between the central roadway (Kapa'akea Loop) and the coastline.

Submerged Land and Buffer Strips:

Another way to visualize shoreline change at Kapa‘akea is to compare the aforementioned maps to the two plat maps shown below (Figures A.3 and A.4). The maps below are on file in DHHL offices in Moloka‘i. They have the same date as the above (7/21/1950), but are labeled as from the Taxation Maps Bureau, Territory of Hawai‘i. As is apparent, parcel 1 fronts the entire Kapa‘akea subdivision on the maps below. The western side of parcel 1 is 140.64 feet wide, comprising a 2.125-acre portion of land. The eastern side of parcel 1 is 51.27 feet wide, comprising a 0.827-acre portion of land. If the measurements listed below accurately reflect the shoreline's location at the time they were drawn, it would suggest the shoreline has retreated nearly 66 feet on the parcel's western extent and around 51 feet on its eastern extent equating to a loss of ~3 acres of land fronting the subdivision. If parcel 1 did exist, then some of the beneficiary leases makai of Kapa‘akea Loop may not have extended to the ocean. As such, parcel 1 may have served as a buffer strip similar to the DHHL owned buffer strips fronting beneficiary lots in Kamiloloa and One Ali‘i subdivisions.



Figures A.3 & A.4: *Plat maps west and east dated 7/21/1950 of a 3.052-acre parcel (#1) fronting the Kapa‘akea subdivision with a somewhat "wavy" makai boundary (Tax Maps Bureau & Survey Department).*

To the east of Kapaʻakea is the One Aliʻi–Kamiloloa subdivision. Its plat maps are numbered M54002 and M54006 by Maui County. For plat M54002, Figure A.5 illustrates that over 33 years, between 1934 and 1967, the shoreline accreted between 50 to 182 feet. This accretion occurred in front of three parcels situated between the Hotel Molokaʻi and the Kalokoʻeli fishpond on its eastern, up drift side (Taxation Maps Bureau, 6/26/1934, Dwg # 2090, TMKs (2) 5-4-002).

Parcel 5, adjacent to the fishpond, gained ~ 0.83 acres along ~250 feet of frontage (Figure A.5). Added sediment expanded the lot by 136 feet along its eastern boundary to nearly 183 feet along its western boundary where it abuts the fishpond wall. The accretion registered in front of these lots suggests a considerable amount of sediment transport in the down drift direction over the past 85 years. The sediment probably came from the east noting that there is a stream outlet up drift of the parcels.

At Kamiloloa, DHHL owns a long sliver of land that stretches 0.6 miles or about 3,200 feet from the Hotel Molokaʻi (west) to the edge of the Kamehameha V Highway (east). From west to east, DHHL owns parcel 30 of 0.47 acres, parcel 29 of 0.42 acres, and parcel 26 of 0.40 acres, respectively. The plat map is dated December 17, 1941, or 78 years ago and all but parcel 30's full extent appears in Figure A.6. The map has two separate parcels (029, 030) that are owned by DHHL that extend in front, and seaward of, each of the individual lots and may have been to protect access along the shoreline (Figures A.6 and A.7). Given its length and acreage, the strip of land is estimated to be ~ 18 feet wide, on average.

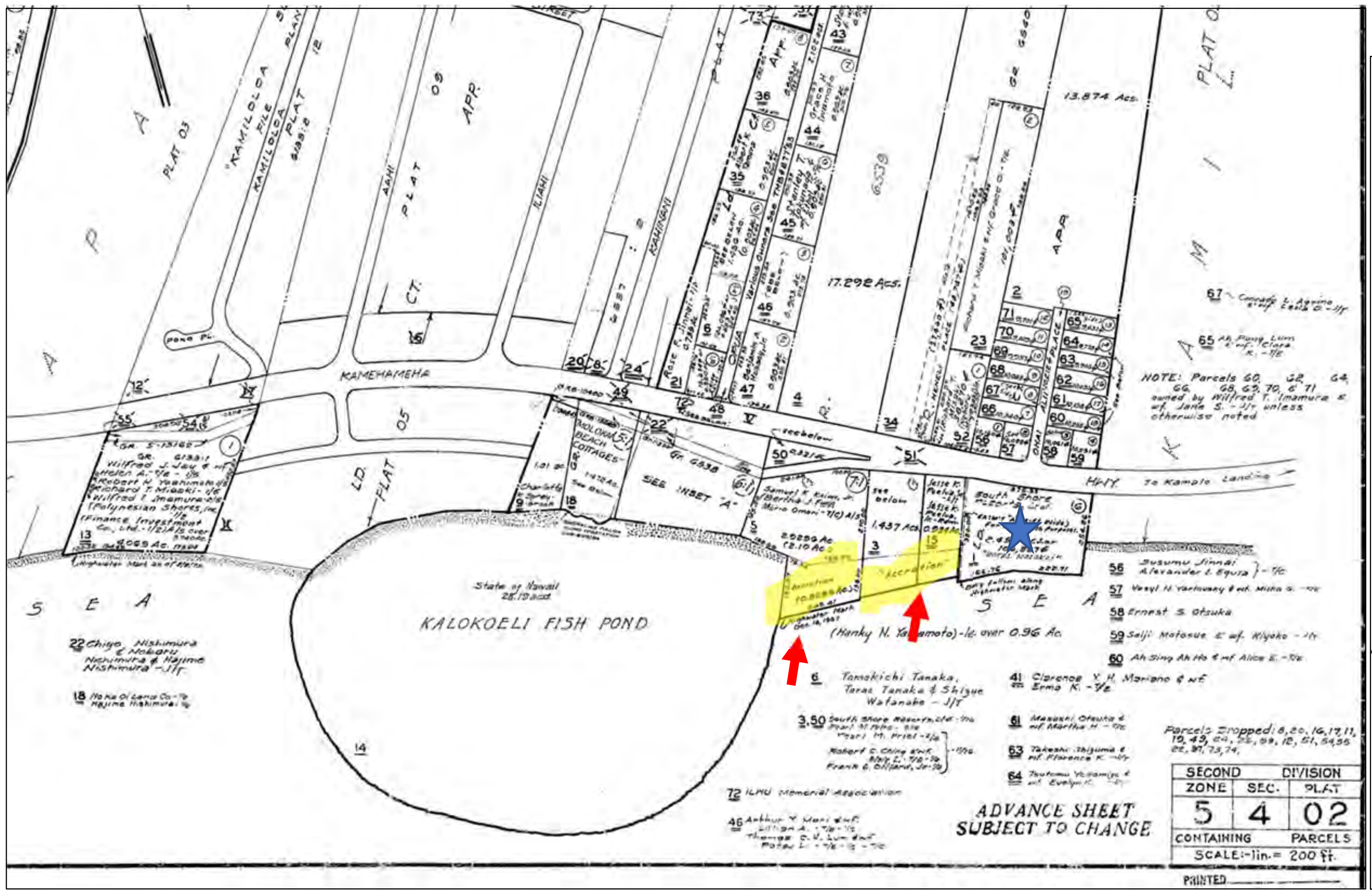


Figure A.5: Plat map dated 6/26/1934 of the Kalokoʻeli Fishpond and areas of accretion down drift of the Hotel Molokaʻi (Tax Maps Bureau & Survey Department).

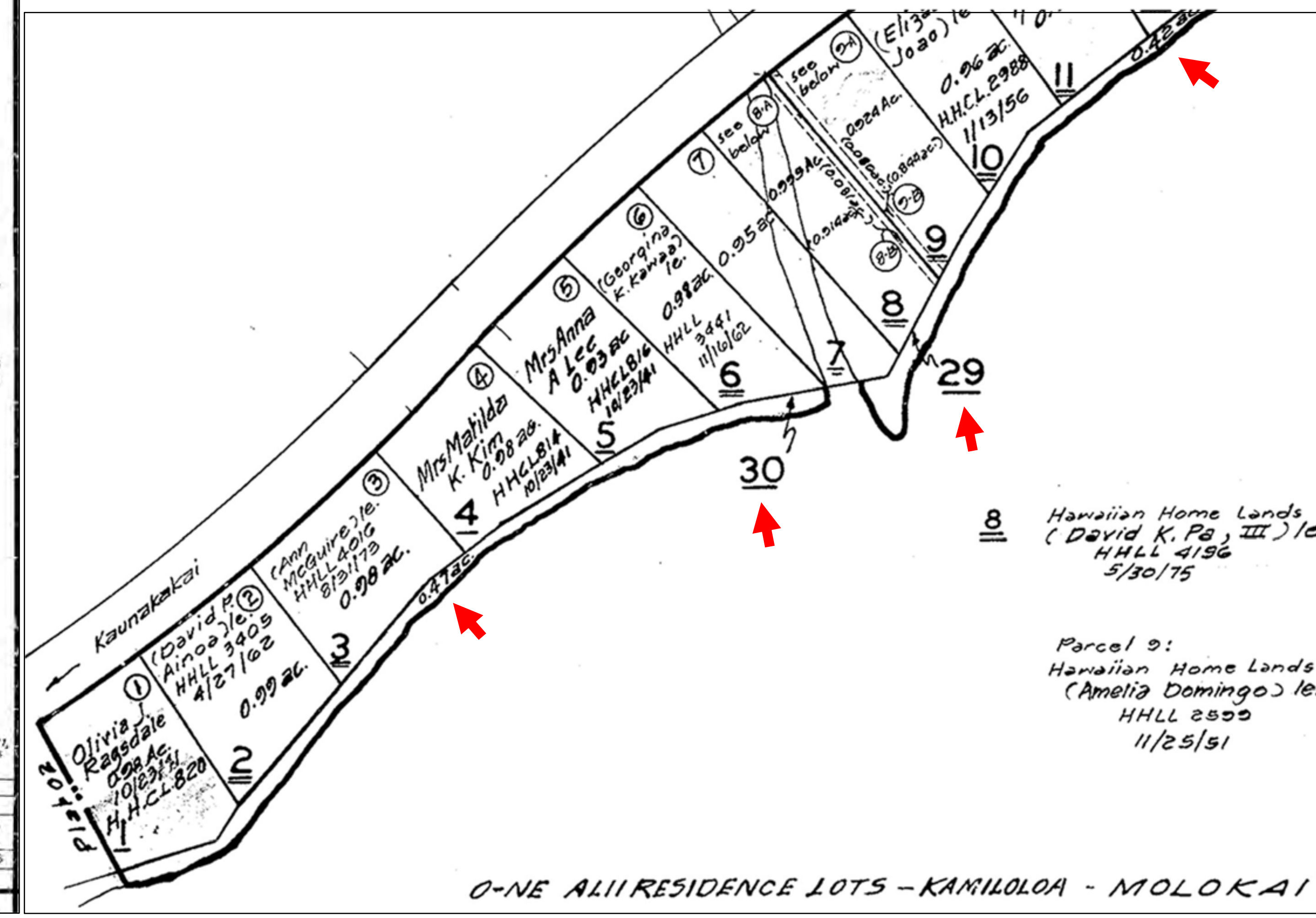


Figure A.6: *Plat map dated 12/17/1941 of the Kamiloloa subdivision (Government Survey Request Map 3057).*