

An aerial photograph of a tropical village, likely in the Wainiha Watershed. The houses have traditional thatched roofs in shades of brown, red, and purple. The surrounding landscape is lush with green vegetation, including numerous palm trees. The image is framed by a white border.

Wainiha Watershed Flood Mitigation Recommendations

March 2024

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About

Mālama Kua`āina is a 501(c)(3) non-profit organization established in 2012 to provide information, education, advocacy, and legal resources relating to public issues associated with the preservation and protection of public trust resources and the natural environment of Kaua'i.

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Cover page digital art by Sarah Henly-Shepard, based on a Wainiha resident 's aerial photograph of Wainiha valley shortly after the April 2018 flood.

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Summary

The Wainiha Hydrologic Vulnerability Assessment and Community Awareness Campaign was a County of Kaua'i-sponsored project led by Mālama Kua'āina, a Wainiha-based non-profit organization. The project's objectives were to: (i) conduct a hydrological study to understand flooding dynamics in the Wainiha watershed and (ii) interview ("talk story" with) community members to understand and cultivate shared knowledge of flooding risks, and to identify resources and solutions for reducing our Wainiha watershed flood risks.

The "talk story"/community engagement process took place from May 2022 through October 2023. The project team connected with residents, cultural practitioners, community-based organizations, businesses, and representatives of Kaua'i government agencies. The results of this process helped formulate this Wainiha Watershed Flood Mitigation Recommendations report and the Wainiha Flood Vulnerability Awareness Campaign materials that were developed as part of this project.

The community and government stakeholders input led to 32 recommendations (listed in Section 9, Recommendations for Flood Risk Mitigation) for reducing risk from flooding and related hazards and for strengthening the community's resilience. The 32 recommendations were prioritized and consolidated to produce four priority recommendations that warrant immediate funding and implementation.

Priority Recommendation 1 Comprehensive Risk Assessment and Reduction

Conduct a comprehensive, detailed, location-specific, multi-hazard assessment of:

- Hazard risks
- Changes to County regulations (including land use ordinances, building codes, setback requirements, flood and storm water management regulations...), penalties and incentives to reduce risk exposure and outcomes
- The adequacy of, and/or need to reinforce or relocate, public infrastructure to withstand hazards
- The evacuation and visitor carrying capacities of the Hanalei-Wainiha-Hā`ena area, associated deficiencies and corrective measures; and
- Location-specific disaster preparation, response and recovery plans, including the locations of accessible evacuation routes and refuge areas

Priority Recommendation 2 Early Warning and Evacuation

Create an integrated all-hazards early warning and emergency evacuation system comprising hazard-resistant, redundant rain gauges and stream gauges; evacuation studies, plans, routes and drills; and extensive outreach and public education.

Priority Recommendation 3 Disaster-Strengthening of the Natural and Built Environments

Increase the resilience of the built and natural environments through ongoing programs for maintaining the watershed, including debris removal and the management of trees and other vegetation in the riparian corridor; maintaining drainage systems and culverts; trimming trees away from structures and utilities; periodic pickups of bulky items and abandoned vehicles;

enactment and enforcement of ordinances prohibiting the dumping of green waste, trash, vehicles, and other items; and prohibitions against activities (such as channelization or diversion) that would impact river flow, water quality or environmental health.

Priority Recommendation 4 Comprehensive Disaster Management Capacity

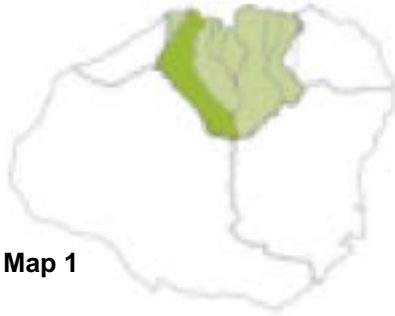
Establish a trained community-based emergency preparedness, response, relief, recovery and resilience team, including sustainable funding for paid leader(s), with responsibilities for:

- Acquiring and maintaining disaster supplies and equipment
- Making arrangements for access to evacuation paths and shelters, and post-disaster support services (including commercial kitchens, freezer services, community meeting spaces, communications and emergency response services)
- Conducting ongoing community outreach, awareness and education (on topics including hazards and risk mitigation, watershed care, vegetation management, hazard-resistant development and maintenance, access to early warning information, business resilience planning, and FEMA disaster preparation and response recommendations); and
- Other duties that are specified in the Hanalei to Hā`ena Community Disaster Resilience Plan.



1. Introduction

1.1 Wainiha Watershed



Map 1

In the Hawaiian language, Wainiha means “angry or unfriendly waters.” Lying west of Lumahai and northeast of the Olokele and Waimea basins, the Wainiha River is a very dynamic riverine system. The Wainiha watershed basin (indicated in dark green on Map 1) is narrow (1-2.5 miles wide) and long (12 miles from mauka to makai), totaling about 20 square miles (USGS, 1913).

The source of the Wainiha River is the summit of Mount Wai’ale’ale, one of the wettest places on earth, which receives 450-500 inches of rain annually (USGS, 1913).

The river makes its way northwest from Wai’ale’ale and then flows to the northeast, where it ultimately reaches the sea. The steep, inaccessible cliffs on both sides of the river rise to Wai’ale’ale and the Alaka’i Swamp. In addition to feeding the river, water from these sources creates “pali (cliff) flows,” nearly vertical tributaries that are normally mere rivulets but become dangerous torrents of water and rock during heavy rains.

In the lower elevations, a portion of the Wainiha River is diverted through the Wainiha canal and the Wainiha hydroelectric powerhouse and then returned to the main flow of the river.

Wainiha has always been known as a place that floods. Together, the Wainiha watershed’s rainwater and surface water constitute a significant volume of water flow whose dramatic variations in flow cannot be mitigated.

Prior to western contact, Hawaiians lived a subsistence lifestyle in which individual land ownership was a foreign concept. Land in Wainiha valley was used by the native Hawaiians for taro farming, under a system of land-and-water resource management that was designed and managed with regular flood dynamics in mind.

After the arrival of foreigners, the Hawaiian way of life changed dramatically. Social, economic, and environmental changes, particularly in recent years, have transformed Wainiha from a community subsistence cultural economy into a high-value market economy. The accompanying shifts in land ownership, land uses and land use regulations have made it difficult for community members to continue many traditional practices, including the traditional system of resource management, resulting in increased flooding risks to the Wainiha community.

1.2 The 2018 Flood

In April of 2018, Kaua’i’s north shore communities of Hanalei, Wainiha and Hā`ena experienced an unprecedented flooding and landslide disaster when over 23 and 36 inches of rain fell (in Hanalei and Wainiha, respectively) within 48 hours. This resulted in destruction and severe damage to residences and public infrastructure, including the extended closure of the only road connecting these communities to one another and to the rest of Kaua’i. (NWS, 2018).

In addition to receiving between 32-36 inches of rainfall as measured by downstream gauges in Wainiha, the upper watershed source at Wai’ale’ale received over 22 inches of rainfall within the same 48-hour period, adding substantially to the impacts of the rainfall on the watershed.

Several rain and stream gauges were damaged during the flood, so the actual rainfall and streamflow amounts might even be higher than recorded.

[Video 1, taken by a local resident, captures some of the April 2018 flooding damage.](#)



Video 1: Wainiha Flood Impacts, April 2018

1.3 The Wainiha Hydrologic Vulnerability Assessment and Community Awareness Campaign

The Wainiha Hydrologic Vulnerability Assessment and Community Awareness Campaign project was initiated in response to the April 2018 disaster. The project had two major objectives. The first objective was to conduct a hydrologic vulnerability assessment to understand flooding dynamics in the Wainiha watershed.



Wainiha Flooding - December 2022

Because the effective implementation of decisions and priorities for flood risk reduction and resilience strengthening must take into account the affected community's values and priorities, the project also had a second objective: to engage with Wainiha community members and other important stakeholders to understand and cultivate shared knowledge of flooding risks and related issues, discuss potential solutions, and identify resources and gaps for realizing community-centered, place-based flood risk reduction solutions.

Those interviews provided information that was essential to forming the recommendations of this Wainiha Watershed Flood Mitigation Recommendations report.

The community engagement process took place from May 2022 through October 2023. It comprised interviews, talk-story and walk-story sessions, desk research of relevant plans, policies and resources, consultations with other stakeholders, and a community flood vulnerability awareness workshop. Through this process, the project team connected with residents (many of whom have spent most of their lives in Wainiha), cultural practitioners, community-based organizations, local businesses and the Kaua'i Island Utility Cooperative (KIUC), and representatives of five County agencies (the Kaua'i Emergency Management Agency, the County Departments of Water, Planning and Housing and the Office of the Mayor).

The Wainiha Watershed Flood Mitigation Recommendations report summarizes the community input that was obtained through the community engagement process. It lays out the proposed priorities, resources and tools to effectively implement future flood mitigation projects. It also provided the basis for the Wainiha Flood Vulnerability Awareness Campaign materials that were created as part of the project.



2. Flood Vulnerability Assessment

Within this report, “flooding” refers to:

- Riverine, stream, auwai (traditional irrigation ditches) and other terrestrial-based flooding,
- Coastal flooding, including flooding from tsunamis, hurricanes, storm surges, and high wave and high/king tide events,
- Compound flooding resulting from overlapping coastal and inland flooding, and
- Cascading impacts (such as landslides and water pollution), as they affect the Wainiha watershed.

Other key terminology is defined in [Appendix A](#).

The assessment of flood risks and flood vulnerability includes consideration of the following:

Incidence and Severity:

- Likelihood/probability (for example, 100-year flood) of the hazard event
- Intensity or severity (how severe the flooding is over time) of the hazard event.

Exposure of structures, ecosystems and people to hazards, including:

- Location of the hazard event
- Frequency (how many times the flooding occurs)
- Scale (the size of the area affected)

Vulnerability:

- Structures that have building materials or designs that are not flood-resistant, and their associated uses and services (for example, public services, housing, electricity, water and other services)
- Residential development in flood-prone areas, and people (especially the elderly and children) living in proximity to rivers and streams.
- Livelihoods (for example, farms, livestock, fishing boats and nets, tourism)

Resilience Capacities:

- Anticipation, prevention and avoidance: using early warning systems (for example, rain and river gauges) to provide pre-flood warnings; evacuation to higher or safer grounds, facilities or other areas; taking safe shelter to reduce injury and loss of lives.
- Response to recovery: following local disaster preparedness, response and recovery action plans; sustained funding for disaster resilience leadership and for local zone captains to lead response and recovery efforts for future flooding events.
- Mitigation: reducing ongoing or imminent impacts from flooding. Examples include restoration of the riparian area, restoration of traditional auwai (irrigation ditch) systems, control of invasive trees, and reforestation with appropriate vegetation to improve water filtration, reduce human impacts, and reduce landslides.
- Coping: dealing positively with the short-term impacts of flooding using financial, social and other resources and networks (for example, crowdsource fundraising for post-flood locally-led response and recovery) without compromising well-being and future adaptation capacity

- Adaptation: adapting positively to the ongoing reality of, and impacts from, flooding over time. Examples include using knowledge and skills to avoid future losses of life, resources and livelihoods; modifying housing, infrastructure, livelihoods, transportation, etc. to be less-exposed to impacts of flooding; prohibiting further development in flood-prone areas; relocating households that are most vulnerable to flooding to safer areas; and supporting households that want to remain in flood zones with strong anticipation, response, mitigation, coping and adaptation skills and resources, to maximize risk reduction.

This report focuses on the mitigation aspect of flood risk reduction. But as this project has determined that the opportunities for mitigation in Wainiha are limited, it also addresses vulnerability and exposure reduction.



3. Impacts of Flooding on the People and Place of Wainiha

Flooding risk primarily arises when people, structures and services exist in hazardous areas that are naturally prone to flooding, landslides and rockfalls, especially when structures or infrastructure have not been designed with nature in mind.

A few recent research efforts have extensively interviewed Wainiha residents on their experiences with the 2018 flood. Drawing from those studies and plans, and from this project's talk story sessions in 2022, it was evident that many people living and working in Wainiha have had intergenerational, lifetime or recent experiences with floods and landslides affecting the watershed and coastline, and often both hazards simultaneously. There was overall agreement across the interviews that long-time residents know that Wainiha is a place that floods naturally, and that it will continue to do so.

3.1 Impacts on Property, Infrastructure and Associated Services

Flooding impacts include damage to, or destruction of, homes and other structures, gardens and farms, vehicles, and personal belongings.

The 2018 flood and landslides cut off the entire Wainiha watershed from neighboring communities, and washed-out culverts also separated upper and lower Wainiha into two isolated areas. This hindered access to food, water, electricity, wastewater, housing, medical services, school and work, in addition to other direct and secondary negative impacts to health, security and well-being.

3.2 Impacts on Physical and Social Well-Being and Health

Ideally, development should be located to be safe from flooding and from coastal hazards, including erosion and projected sea level rise. Over the past 10 years, people who lived too close to the river or streams have experienced severe flooding impacts - including damaged or destroyed homes, gardens, vehicles and belongings - that have resulted in long-term, ongoing senses of insecurity and lack of safety. People were temporarily or permanently displaced from their homes in Wainiha because of the floods; and this impact was intensified by the unaffordability and scarcity of safe housing alternatives elsewhere in the community. Lack of access to clean water, to sufficient nutritious foods and to other resources further compromised residents' health and well-being after major flood events.

How do flooding risks impact Wainiha?

- Physical health issues from immediate and post-flood impacts: death, injury, illness, disease, exposure to contaminated water and food, rodents, lack of sufficient food and water, lack of safe shelter, exposure to mold, food and water insecurity, increased drug-related issues
- Mental health issues, increased stress and trauma
- Housing insecurity and stress due to persistent flooding and lack of safe housing
- Displacement from damaged or destroyed homes
- Displacement into at-risk housing due to gentrification
- Difficulty accessing school, jobs, food, water, electricity, and health services
- Contamination and degradation of the environment and biodiversity.



The Federal Emergency Management Agency of the U.S. Government (FEMA) and the Kaua'i Emergency Management Agency have lists of people impacted by the 2018 flood. Analysis of that information indicates that there were people who needed disaster recovery resources and should have been prioritized for access to safe affordable housing, but who fell through the cracks. Although community members stepped up and supported one another in disaster response and recovery, many of those who provided such assistance were themselves affected by the disaster and carried a large burden to provide volunteer services to others.

Many residents reported first- or second-hand mental health and trauma issues due to flood-related emergencies and disasters. When the 2018 flood and landslide event cut off transportation access, it also affected peoples' access to illicit drugs and alcohol, which, in the absence of treatment programs, put the health and well-being of addicts, those around them, and the community, at risk of mental and physical harm.

3.3 Impacts on the Environment

Many residents observed groundwater damage, increased ponding and lack of drainage during heavy rainfall. Residents reported that approximately 25 cars were washed into the river by the flood. Tires and other bulky trash and contaminants, logs and green waste from albizia, hau and other vegetation left on the banks of the river, all washed into the river and streams. Residents reported that during the 2018 flood, many large albizia and hau logs were washed out to the ocean damaging the coral reefs.

3.4 Impacts on Environmental Health and Safety

Wastewater contamination occurs when flood waters carry raw sewage into waterways. Untreated cesspool sewage can introduce pathogens and contaminants into floodwaters, the river, ocean and water table, impacting drinking water, fishing, and recreation activities.

According to the 2021 Hawaii Cesspool Hazard Assessment and Prioritization Tool, the Hanalei-Wainiha-Hā'ena area has 554 cesspools and is on the Priority 1 statewide list for contamination hazard (University of Hawaii, 2021).

Mold is another difficult issue after floods, damaging structures and belongings and creating a major health hazard.

4. Flooding and Its Impacts: Community/Stakeholder Observations and Input

Comments and observations relevant to flooding in Wainiha that were obtained as part of the community engagement process can be grouped into seven categories: River Dynamics and Streamflow, Coastal Impacts, Climate Change and Increasing Risk from Wildfires and Drought, Flora and Fauna, Waste Management, Impacts of Changing Demographics on Land Use and Natural Resource Practices, and Other Threats.



Tragedy of the Commons:
A community good or natural resource, like a river, if not managed well and equitably, becomes a community problem.

Has flooding changed since the 2018 flood?

- The Wainiha River is shallower and wider since the 2018 flood.
- Places that used to flood minimally or not at all seem to flood during big rain events.
- There have been more-frequent rain events (at least four since the 2018 flood) that resulted in area flooding; and it seems that the river floods faster, with less warning.

4.1 River Dynamics and Streamflow

The hydrology and flow of water over land is dynamic (see Section 7, Wainiha Hydrologic Vulnerability Assessment Study). Events that occur concurrent with flooding - such as high tides, king tides and high wave events - also influence the intensity and impacts of flooding.

The Wainiha residents who were interviewed overwhelmingly believe that the river and streams have changed in width, depth, flow and function. They believe that the Wainiha River has become shallower and wider since the 2018 flood. They report that the riverbanks have changed greatly during the past 10-15 years; that sedimentation in the river is a problem; and that there is currently constriction of the river from overgrown and unmanaged hau.

Residents reported that when fishing in Wainiha in the 1950s, the river was clearer, cleaner and wider.

Most people who were interviewed believe that flood waters rise and fall along the river and streams faster and flashier, especially near the river mouth and at the Wainiha double bridges, during high wave and high tide events.

[Appendix C](#) (Observations of Wainiha Stream Flooding Scenarios Under Varying Conditions) summarizes the observations, by one long-term resident who lived by the mouth of the river for more than fifty years, of the dynamics of the Wainiha River for various combinations of rainfall,

seasons, tides and surf. According to that resident, the conditions under which extreme flash flooding is most likely are when high tide and/or high surf occurs at the same time as medium rain for long periods of time, or heavy rain for short-to-long periods of time.

It is widely debated whether the condition of the river mouth condition (i.e., whether it is open or blocked by a sandbar) has an impact on flooding. When the river mouth is closed, water can temporarily back up until pressure from the backed-up water forces it open, which may cause temporary flooding. But most residents said that the pressure from the backed-up water opens the river mouth naturally so no intervention is necessary to mitigate flooding. (See [Appendix C](#) for one long-term Wainiha resident’s observations of these dynamics.)

Flooding can also be impacted by longer-term drought and compaction or hardening and reduced absorptive capacity of soils, as well as if the soil is already saturated from previous rains. When the basin is full due to continuous rain, the ground becomes saturated and unable to absorb more water, increasing flooding.

Some residents believe that the water table is rising and that the soil becomes saturated more quickly.

Residents reported a change in groundwater springs, particularly since the 2018 flood. Some springs that existed during those residents’ entire lives no longer exist, and new ones have appeared.

Some residents believe that the roads flood more since 2018.

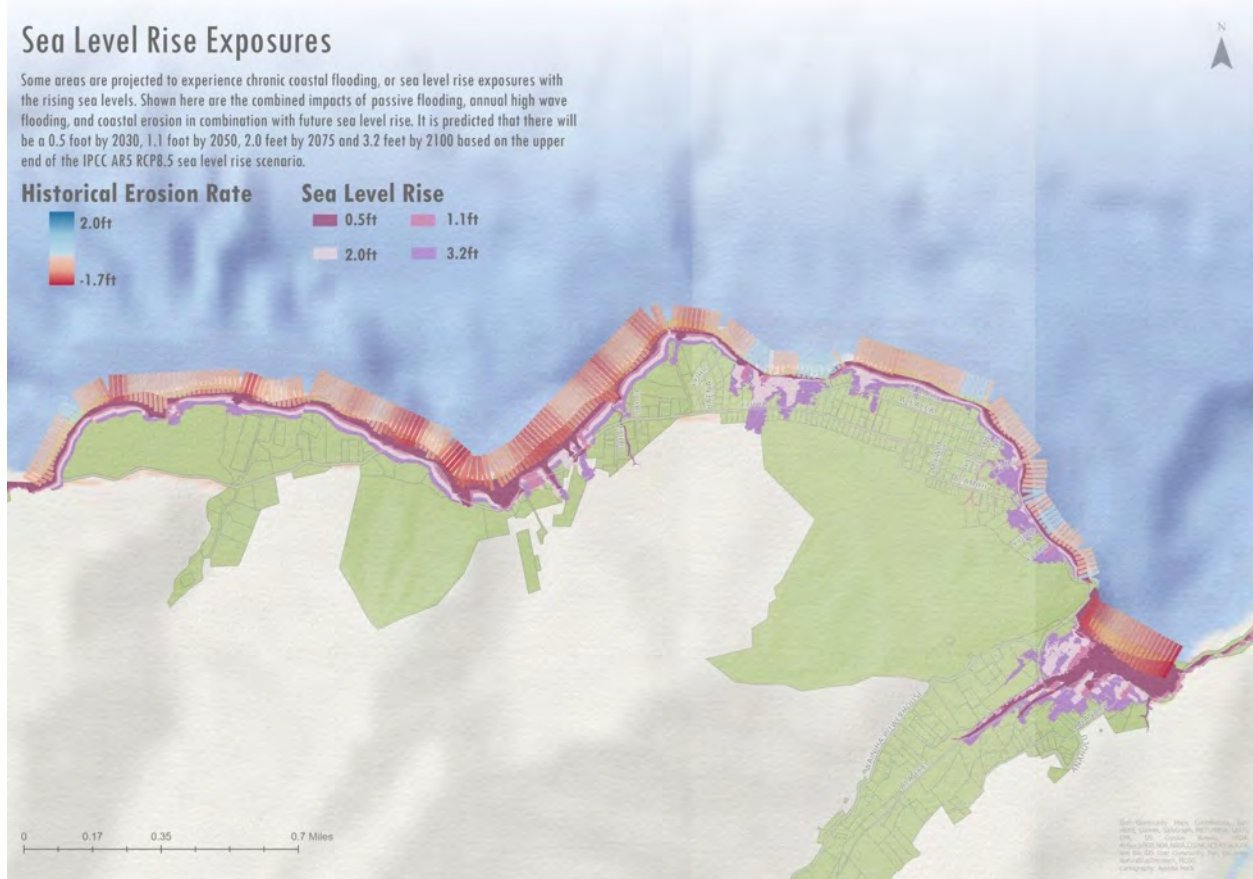


Impacts detrimental to the river’s hydrology and flow also occur from people building in and inhabiting flood zones that historically were used for farming.



4.2 Coastal Impacts

Wainiha has always been known as a place of seasonal high waves. Hazards increase when high tides or high surf occur during flooding events. The river flows more quickly when the tide is low and is inclined to flood more during high tides and high surf. Although high tides and high surf especially impact flooding at the river mouth, they also impact drainage further inland during inland flooding events.



Map 3. Sea Level Rise Exposures and Historical Erosion Rates for Wainiha and Hā'ena
([Malama Kua'aina, 2023](#))

4.3 Climate Change and Increasing Risk from Wildfires and Drought

Most long-term residents reported that in the past they knew what to expect from weather patterns across the seasons. Most residents believe that there are now more extremes in the weather; that the weather fluctuates between less-predictable rainy periods and increasing drought conditions; that seasons are wetter later and drier later; and overall there is less rain. This is consistent with what the climate models show. ([NIDIS NOAA, 2022](#))

Residents said that historically there was consistent rainfall and there were small landslides, but that the land was more resilient. More recently, they say that the weather has become drier and hotter with less wind, that the land no longer has the same resiliency, and that big floods and

landslides have been more severe. They also noted that they have needed to water their plants and lawns for the first time ever due to reduced precipitation.

Residents said that trade winds are not as prevalent, and that during the past ten years they have been weaker and less-frequent. The result of lighter winds is less rain, as there are fewer rain clouds blowing inland.

Wainiha fluctuates between experiencing no drought and experiencing moderate-to-severe drought. With reduced precipitation and ground and surface water storage, increasing temperatures and wildfire fuel loads, and increasing demand for water for farming and household consumption, the risk of wildfires has increased at the same that fire suppression capacity is being reduced by limitations on the water resources.

4.4 Flora and Fauna

Almost everyone reflected that in the past there were not as many invasive trees and grasses. Invasive plants like albizia, African tulip, the autograph tree, clidemia, haole koa, guinea grass and others, are taking over and are difficult to manage.

Others have noted changes in the quantity, quality and seasonal timing of flowers and fruit, and the locations of native plant species, fish and invertebrates. For example, a few people shared that in gathering plants for lei making, the plants are drier, stressed, have moved further mauka, or are completely gone from their usual locations.

Overall, most report that unmanaged hau, albizia and other invasive trees and grasses are choking the river.

Historically, hau was valued for its social, cultural and economic values. Many families used hau for wood and fiber; but now that hau is no longer as valued collectively, many landowners have stopped maintaining it.

There is disagreement about the role of hau bush in mitigating flooding risk and promoting healthy streamflow. Most residents believe that the hau needs to be properly managed, rather than removed. Some residents believe that hau bush helps stabilize the soil, provides windbreaks and prevents erosion of river banks. Some residents believe that the unmanaged hau bush is invasive, tangled and overgrown, that it blocks water flow and increases the risk of flash flooding, and that it needs to be properly managed. Other residents believe the hau will reduce or block the flow of water regardless of management, and that it should be removed completely to reduce flooding risk.

Community Experiences with Floods in Wainiha

“I’ve been seeing, hearing and tasting floods, since I can remember,”

“The river merged with the ocean, tires and other debris floated everywhere, becoming projectiles.”

“20-foot wall of water and mud came down the culvert and overflowed.”

4.5 Waste Management

Irresponsible mismanagement of waste is perceived to be a severe problem. The dumping of green waste into or near the river obstructs the flow of water. Vegetation, including trees cut down into logs, is intentionally left on the banks of the river for the next flood to remove.

In addition to green waste, bulky items (fallen trees, abandoned vehicles, tires, etc.), chemicals and toxic items, animals and feces, and other debris are often carried into the river during flood events, clogging and blocking the water flow, causing micro-flooding, exacerbating flash flooding, and creating water pollution and dangerous projectiles.

Residents expressed support for periodic County-sponsored pickups of bulky trash and removal of derelict cars, to reduce these risks.

4.6 Impacts of Changing Demographics on Land Use and Natural Resource Practices

Over the past several decades, many of Wainiha's newer residents and landowners have come from beyond Wainiha, have few ties to the area's traditional culture and practices, and lack the local/traditional knowledge related to land and natural resource uses in Wainiha. As a result, a number of Wainiha's current resident and landowners:

- Have insufficient understanding of the power of the Wainiha River when it floods, and the resulting risks from locating structures and other property too close to the river.
- Lack the knowledge to properly maintain the riverbanks, and fail to recognize that their practices impact downstream residents and property.
- Have failed to maintain the traditional irrigation ditches ("auwai"), so that many auwai are now gone, buried or have filled in with sediment naturally or intentionally; and some have been intentionally disrupted and destroyed.
- Have re-routed the river to create decorative ponds, leading to destruction of traditional taro wetlands and cultural practices.
- Have moved rocks from the river or riverbank for use in constructing walls, further impacting flooding downstream.

With no enforceable river management practices, downstream residents and their property have been harmed by such individual land use decisions, but such residents often have little recourse.

The evolution in the cultural background of the Wainiha population has also created impacts beyond the physical flooding impacts that stem directly from actions that reduce natural resilience to flooding:

- Long-time Wainiha residents feel a lack of respect for their culture and for the importance of stewarding the land.
- The shift in the balance of power and decision-making over land and resource use, from long-time residents to newcomers, has created tensions that have impacted the spiritual, mental, cultural, social, economic, health and well-being of the long-time residents.
- Some community members have called for collective governance and management of the rivers, streams and auwai in order to reintroduce sustainable management of the

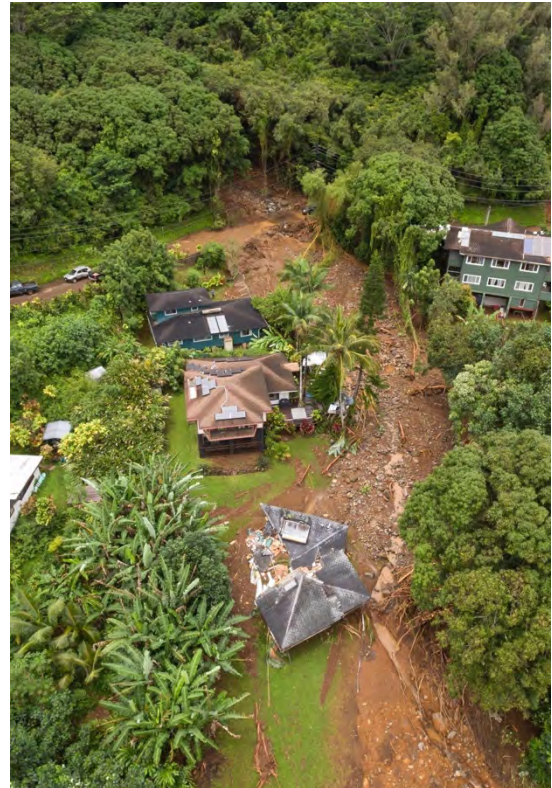
watershed and reverse the degradation of the environment. But the aforementioned tensions, and the alienation and factionalization that has resulted from them, reduce the community consensus that would be essential to instituting such significant changes.

- This reduced community cohesion also undermines effective community disaster response and resilience.

Wainiha's existing housing stock is insufficient to house all Wainiha's residents away from flood hazard areas, but the risks due to floods, coastal hazards, hurricanes, tsunamis and landslides limit the locations where it might be possible to build new housing that would be safe from these hazards.

The sufficiency of water resources to support increased housing density - which would increase both water usage and fire protection needs - without overtaxing groundwater resources imposes an additional challenge.

Finally, the continuing in-migration to Wainiha of relatively wealthier (compared to many long-term residents) new residents from the mainland, together with the continuing dedication of a significant part of Wainiha's housing stock to transient vacation rental use, creates additional hurdles and stresses for long-term residents to either move from at-risk housing to safer housing in Wainiha or to continue to live in safe, affordable housing in Wainiha. These stresses also undermine the community cohesion that is needed for disaster response and resilience.



Wainiha Flood: Pali Flow Boulder Slides - April 2018

4.7 Other Threats

Wainiha experiences significant flood evacuation challenges due to its low-lying roads and bridges. The coastal highway - the single road that connects Wainiha to the outside world - is susceptible to closure due to coastal and inland floods, landslides, and rockfalls. In fact, the coastal highway, as well as the roads into Wainiha valley, have increasingly become inundated by flood waters from the river, streams, waterfalls, and ocean, making Wainiha inaccessible. The frequency of such events is expected to increase because of projected sea level rise and other climate change impacts, increasing the vulnerability of Wainiha's residents.

Protracted road closures limit access to food and other supplies, as well as to potable water and electricity when flooding or other events disrupt the water delivery system or KIUC power system and hamper the ability to restore those systems.

The large number of day-tourists, and the large numbers of visitors who occupy transient vacation rentals within and outside the Wainiha and Hā`ena tsunami and flood hazard zones, create additional disaster response burdens that often fall on residents, regardless of whether those non-residents need to be evacuated or shelter-in-place until access to/from Wainiha is restored.

5. Manageable Sources of Flood-Related Risks

As a consequence of its geography, Wainiha valley has been, is, and will continue to be prone to extreme and dynamic flooding. Given that reality, the manageable sources of flood risk are those associated with reducing the exposure and vulnerability of people, places, structures and infrastructure to flooding and related hazards.

Based on the information that was exchanged during the community engagement process, the following are the most-significant sources of flood risk that might be mitigable:

Infrastructure to Support Resilience

- Inadequate regulations for development in the riparian corridor and other disaster-prone areas
- Inadequate information and outreach to residents to increase safety and disaster resilience in flood risk areas.
- Insufficient early warning systems, evacuation plans, alternate evacuation routes, shelters and other safety-related infrastructure for addressing flooding, landslide and rockfall events.

Inappropriate Land Uses in the Flood Zone

- Siting, or insufficiently flood-proofing, of housing and other structures in hazardous flood-prone locations
- Use of non-flood-resistant septic systems and cesspools in flood-prone locations, resulting in significant wastewater issues downstream.

Inappropriate Maintenance and Land Modifications in the Riparian Corridor

- Dumping of green waste in the river and along the riparian corridor
- Uncontrolled growth of hau bush and invasive plants and grasses along the riparian corridor.
- Changes to the system of auwai and lo'i (taro patches), and man-made changes to the waterway (such as channelization of the river) with insufficient regard for impacts on adjacent and downstream properties

Insufficient Affordable, Flood-Safe Housing

- The in-migration of new residents who often have greater financial resources than long-term residents, coupled with the lack of nearby affordable, flood-safe housing for long-term residents displaced by such in-migration, pushes those long-term residents into housing in flood-prone areas or into housing that has not been located, designed or retrofitted to withstand flood impacts.

6. Who Is Most At-Risk of Flooding?

The people most at-risk of (meaning they are more vulnerable to, exposed to, and have less capacity to deal with) floods are those who live in close proximity to a river or stream, and in unpermitted, makeshift, and poorly sited structures without adequate flood elevations. These are very often people with limited financial and social resources.

Also at increased risk are:

- People who are unaware of imminent flooding risks (often the elderly and the uneducated who do not use social media, and newcomers and visitors who may not have access to or understand flood early warning systems and evacuation options);
- People with chronic health conditions, functional needs or mobility needs; pregnant women; young children; and the elderly, all of whom are often at greater risk during flooding disasters as well as afterward due to the associated physical, mental, economic and social stresses that follow.
- Residents who are dependent on the land or sea for their livelihoods or cultural practices -- such as gardeners, farmers, traditional practitioners, fisherfolk – who can be affected by the longer-term impacts of upstream land use practices and/or flooding.



Wainiha Flood - April 2018

7. Wainiha Hydrologic Vulnerability Assessment

The Wainiha River is perennial, draining the Wainiha watershed on the North Shore of the island of Kaua'i. The river is 10.6 miles long and begins at the base of Hialele Falls. The floodplain of the lower reach of the river is bounded by steep slopes that extend up the watershed divides. Residential parcels and mixed agricultural plots are found on lands within the floodplain. The Wainiha River is very prone to flooding in its lower reach, threatening property, life, and agricultural enterprise.

The combination of steep slopes, high rainfall rates, and a dense drainage network in the Wainiha River watershed creates a dynamic rainfall and runoff regime that often results in extremely rapid rises in water levels and flows in the river. This results in flooding of the floodplains adjacent to the river and extreme flow velocities in the lower portions of the valley. In April 2018 a flood event devastated the North Shore of Kaua'i, including lands within Wainiha. A significant amount of infrastructure was lost or damaged, including homes and roads. Since this flood event, a priority of the Wainiha community has been to prevent loss of life and minimize property damage from floods.

Objectives

The objectives of the Wainiha Hydrologic Vulnerability Assessment were to (1) conduct a hydrologic vulnerability assessment for the occupied portion of the Wainiha River watershed; (2) inform the Wainiha community about localized flood risks; (3) assess how the sand bar berm at the mouth of the river affects flooding hydrodynamics; and (4) provide recommendations for reducing hazards and increasing community resilience to flooding in Wainiha. The information developed through the hydrologic vulnerability assessment can be used to educate residents and visitors about localized flood risk and to make recommendations to reduce vulnerabilities from flood hazards and increase resiliency to floods. It can also be used by government entities to develop adaptive strategies to minimize hazards and vulnerability to flooding.

Technical Approach

A detailed hydrologic vulnerability assessment was conducted within a 506-acre portion of the lower Wainiha River watershed.¹ The land within the project area is primarily used for residential housing and also includes agricultural plots used to grow taro.

The first step was developing a high-resolution digital terrain model (DTM) of the project area using different types of surveys. Ground surface and infrastructure (buildings, roads) were surveyed using an airborne survey employing LiDAR and ground-based handheld Global Positioning Systems (GPS) units. After the base DTM was built, computer software was used to model river flows for the section of the river extending 9,800 ft upstream from its mouth. The model outputs show the lateral extent of flood water over the floodplain, water depths, and water

¹ The project area did not include the area of land to the west along the coast where the Hanalei Colony Resort and residential areas are located. This area is outside the Wainiha River watershed and is not directly impacted by fluvial process in the Wainiha River watershed.

surface elevations. A +2 ft sea level rise scenario was modeled to evaluate changes to the hydraulic variables.

The DTM was used to delineate flows paths that drain the watershed areas above the project area and carry water down into the residential area. These flow paths were assessed and assigned low, medium, or high risk based on their contributing drainage areas. The modeling also identified flow paths of tributary channels that drain the steep slopes of the valley and carry water onto and across the valley bottom.

The model was also used to assess the impact of the sand bar berm at the mouth of the Wainiha River on the onset, timing, and duration of upstream flooding during flow events. It evaluated whether it is necessary to open a channel through the sand bar, connecting the river channel to the ocean, before expected high flow events increase drainage from the river into the ocean, to reduce water surface elevations upstream.

Floodplain Management

The Federal Emergency Management Agency (FEMA) oversees the National Flood Insurance Program. Within this program, FEMA conducts Flood Insurance Studies to identify and compile flood hazard areas along rivers and coastlines. Flood Insurance Rate Maps (FIRM) are the official documents upon which FEMA designates Special Flood Hazard Areas, base flood elevations, and the associated risk premium zones for the community. The base flood elevation represents the elevation of surface water resulting from a flood with a one-percent chance of being equaled or exceeded in any given year, also known as the one-percent Annual Exceedance Probability (commonly referred to as the “100-year flood”).

There are 214 parcels located within the 506-acre project area. Most of the parcels are zoned residential and contain one or more dwellings. Within the project area there are 178 parcels (83% of the total parcels) across 220 acres that fall within the Special Flood Hazard Areas and are high risk flood areas. Zones AE and VE are classified as Special Flood Hazard Areas and are high hazard risk zones that fall within the active floodplain. These two zones are at risk from the 1% Annual Exceedance Probability. Zone AE covers 148 acres (67%) and Zone VE covers 72 acres (33%) of the Special Flood Hazard Areas. Zone AE is at risk of flooding from the river. Zone VE is at risk of coastal flooding and of flooding from the river.

Assessment of Flood Risk and Vulnerability

Flooding is the most common and costly natural disaster in the United States. In Wainiha the risk of property damage and loss of life due to hazardous flooding and rainfall runoff is high. The Wainiha River is prone to flooding and poses flood risk to the properties located on the floodplains adjacent to the river’s channels. Rainfall runoff carried in channels that drain the slopes of the surrounding watershed area is another hydrologic threat. These numerous flows paths dissect the landscape as they flow down to the valley bottom and onto the floodplains before joining the Wainiha River. Flow paths can be filled with rainfall runoff and become torrents, carrying water at high quantities and velocities and transporting debris (e.g. rocks and vegetation) encountered along the flow paths. Flow can undermine infrastructure and buildings, erode the landscape, and increase flood water levels on the floodplain.

In the context of river flooding, risk is best defined as the probability that flooding will occur in the project area at a given time. Vulnerability is defined as the reduction in the ability to resist or reduce the impacts of floods. For example, a dwelling located on the ground surface level on the floodplain is more vulnerable to flood damage compared to a dwelling elevated above the floodplain.

The hydrological vulnerability assessment assessed the risks from flooding and runoff and identified the vulnerable parcels in the residential section of lower Wainiha Valley. A 3D hydraulic model was used to simulate river floods and to map locations where riverbanks are overtopped. The assessment utilized detailed elevation models to map stream channels and flow paths that collect and drain water from rainfall runoff within the occupied area of the valley. Maps created using the model outputs provide visual renderings of where flooding and surface water runoff will occur within the project area. These maps show the extent of floodwaters over the valley floor, their depths, and water surface elevations.

Essentially, the entire portion of lower Wainiha River watershed is vulnerable to inundation by river floodwaters impacting the floodplain and/or flow paths that carry surface water runoff. Flooding occurs regularly and often with very little warning.

Flood events that occur annually or every one-to-three years were shown to overtop the lower reaches of the Wainiha River and spill out onto the floodplain. This demonstrates that there is a risk of flooding from routine and frequent high flow events as well as from extreme flood events such as the one in April 2018.

Flooding is expected to occur more often due to projected rising sea levels and due to increases in the magnitude of extreme rainfall events driven by climate change.

Nearly every parcel within the project area is at risk of damage from water from river flooding and/or water carried in the flow paths. The parcels that are most at risk from flood water from the Wainiha River are located on what is referred to as the 'island' which is bounded on all sides by two branches of the Wainiha River. Other low-lying areas such as the area immediately mauka of the Wainiha Country Store and west of Anahulu Road are also vulnerable to flood waters.

The parcels at highest risk from water carried in the flow paths are those located along the west side of the valley. Several of the flow paths drain areas of land that are hundreds of acres in size and may comprise numerous flow path channels that merge as they flow down the slopes into the valley, resulting in moderately sized gullies and streams. Vulnerability to flow paths is highest for parcels with flows paths crossing them or where flow paths are overgrown or strewn with debris and/or plant materials. These obstructions decrease conveyance capacity and increase the risk of channel failure and overtopping. Wainiha Powerhouse Road faces the threat of damage from multiple flow paths intersecting the road and passing beneath it through culverts. Culverts are vulnerable when debris blocks their entrances or gets clogged inside them. This can cause overtopping, which allows water to scour out the culverts. It can also cause flooding over the road deck, making vehicle passage dangerous and potentially damaging the road.

As noted above, an analysis was also conducted to evaluate whether excavation across the sandbar berm at the mouth of the river prior to high flow events could mitigate floodwater impacts upstream. The modeling results showed that minor reductions in water surface elevations in the river channel upstream of the sand bar berm would result if the channel was excavated prior to a flood event. However, those reductions would be negligible, so there would be no real benefit from excavating a channel across the sandbar berm to mitigate floodwater impacts upstream.

Addressing Flood Risk and Vulnerability

The hydrologic risk stemming from flooding and overland flow within the Wainiha River watershed is challenging to alleviate due to two main factors. First: the inhabited regions within the steep-sided valley lie within an active floodplain adjacent to a river known for its susceptibility to high flows and flooding events. Second: the area experiences frequent bouts of intense rainfall, leading to substantial surface water runoff channeled through natural fluvial pathways. Combined, these conditions amplify the persistent risk posed by hydrological events in the region.

Although reducing the *risk* of flooding is not possible, steps can and should be taken to reduce *vulnerability* to protect life and property in Wainiha. These steps include the following:

- Maintaining stream channels to be clear of debris and rubbish so that they do not become clogged and create choke points causing the channels to overtop or to back up and spill onto adjacent lands.
- Maintaining awareness of base flood elevation and ensuring that dwellings and possessions are maintained above those base flood elevations.
- Bringing structures and dwellings within the floodplain that do not conform to building code standards into compliance.
- Purchasing flood insurance, especially by homeowners and renters residing in the Special Flood Hazard Areas of Wainiha Valley. Flood insurance provides a safeguard and financial footing for policyholders to rebuild structures and replace contents damaged from riverine flooding.
- Establishing an early warning and notification system to provide residents and visitors with advance warning of impending floods. At present there is no emergency notification system specifically developed for the Wainiha River watershed, in which the Wainiha River is extremely dynamic and the onset of floods can occur within minutes after heavy rainfall begins over the watershed area and drains into the river.

Outputs of the Hydrologic Vulnerability Assessment Project

The Wainiha Hydrologic Vulnerability Assessment report documents the process and findings of the hydrologic vulnerability assessment. It includes methodology, modeling results, and recommendations.

The maps developed by the project show the parcels within the floodplain that are vulnerable to flood water inundation under both frequent and extreme flow events and maps of the flow paths that dissect the landscape within and outside the floodplain show areas that carry runoff that can damage infrastructure, erode channels, induce slope failures, and potentially threaten life. Distribution of these maps to the residents of Wainiha is expected to provide the community with information about the risks and vulnerabilities of flooding and surface water runoff. The maps will also aid in making decisions and developing strategies on how to best cope with and minimize vulnerability to hydrologic threats. The maps are available on the Mālama Kua'āina website. They have also been distributed to property owners within the 506-acre project area.

The detailed findings of the Wainiha Hydrologic Vulnerability Assessment report should inform community preparedness and related plans focused on flood mitigation and disaster resilience. The report also provides insight into future flood conditions due to climate change and sea level rise.

8. Community Flood Resilience Capacities

A comprehensive risk reduction strategy must include not only reduction of exposure and vulnerability to flooding, but also a bolstering of capacity to anticipate, cope with, respond to, recover from, and adapt to flooding. Substantial capacities exist in the Wainiha community to promote such flood risk mitigation and resilience. These include lived experiences, local knowledge, and the use of technology to anticipate, prepare for, respond to, and recover from, flooding. The following flood resilience capacities in Wainiha were shared through community talk story.

Community Relationships with Wainiha Stream

“The one thing I can say about the Wainiha Stream, is that it is never the same –whether, (the) amount and number of days it rains, the season of the year, high surf, tide, river mouth opening – all these conditions, or a combination of these conditions, contribute to the dynamic changes to the velocity and volume of the water at any one time, whether it’s slow-moving water flooding over the land or a high-volume flash flood. And, as long-time residents say, “that’s life in Wainiha...”

--- Wainiha resident for more than 50 years.

Examples of Local Knowledge for Flood Early Warning

- Take note of how long and how hard it has been raining.
- Watch the clouds, the river, the waterfalls, and the streambed water levels.
- Look up-valley towards the mountains to see what is coming.
- Monitor how fast the river is moving and rising.
- Note the color change in the river to brown.
- The sound of breaking trees upstream means the river is flooding.
- Look at the rising water levels in the ditches and streams.
- Look at peoples' yards and whether they are starting to flood.
- Look at the Hā`ena pasture water level.
- Iwi birds fly overhead.
- Rely on family and friends living further mauka to share what’s happening upstream and in other areas.

Technological Indicators

- Most agree that the radar for Wainiha and the broader north shore is not functional.
- Despite the lack of sufficient reliable, consistent, and easy to interpret rain gauges and river gauges many people look online at the USGS river gauges for Hanalei, Wainiha, Kilohana and Hanakapiai.
- Some people access the news for weather alerts, but these are rarely specific-enough for real-time flash flood alerts for Wainiha valley.

Emergency Response and Relief Measures

- Once warned or put on alert, activate the Hanalei to Hā`ena Community Disaster Resilience Plan, including alerting Wainiha Zone Team members to be aware of the conditions and to prepare for potential disaster support to community members using the Plan's disaster preparedness, response and recovery action plans.

Pre-Emergency Mitigation

- Clear nearby culverts and ditches, upstream and downstream, ahead of bigger rains.
- Check the river mouth conditions.

Evacuation and Protection

- Move everything stored on the ground up and out of areas that flood.
- Secure belongings so that they cannot wash away during flooding.
- Move vehicles to higher ground.
- Check on high-risk (for example, persons with disabilities or access and functional needs) family, friends and neighbors to help with evacuation or rescue.
- Drive to areas that are not as prone to flooding and wait-out the rains in cars or in others' homes.

9. Recommendations for Flood Risk Mitigation

These recommendations for reducing risk due to flooding and related hazards and for strengthening resilience are based on the community interviews and government stakeholder input, which is summarized in [Appendix B](#) (Summary of Stakeholder Discussions).

Underlying, and essential to, all the recommendations are several important principles. The implementation of each of the recommendations should:

- (i) Incorporate projected climate change risks and impacts.
- (ii) Solicit and incorporate local knowledge and expertise from all of Wainiha’s diverse groups of stakeholders.
- (iii) Appropriately incorporate community cultural and social concerns; and
- (iv) Strive for a holistic (“mauka-to-makai”) approach to watershed management.

Information Development and Dissemination (Government-Sponsored)

1. Conduct a comprehensive, detailed multi-hazard, location-specific (down to the individual parcel level) assessment of:
 - (a) Hazard risks (including potential flooding, sea level rise and other climate change impacts)
 - (b) Pre-hazard occurrence risk mitigation and resilience measures (including recommended setbacks of new structures from rivers, streams and the coast; and recommended changes to locations and elevations of existing structures)
 - (c) Location-specific disaster preparation, response and recovery plans (including the locations of accessible evacuation routes and refuge areas)
 - (d) Adequacy of existing public infrastructure (culverts, roads, etc.) to withstand hazards, including the possible need to relocate roads and utilities and adapt storm water management due to the impacts of climate change; and
 - (e) Land use rules, building codes and incentives (such as no-build, managed retreat, transfer of development rights, setbacks, easements, and tax incentives) that could reduce risks due to flooding or sea level rise, and inventory the locations at which the application of such rules, codes and incentives would be beneficial.
2. Determine the Hanalei-Wainiha-Hā`ena evacuation capacity, needs, limitations and solutions for various hazard scenarios, and the resulting visitor carrying capacity of the area based on an acceptable level of hazard risk.
3. Provide information to the community about the Wainiha electric power, water and communication infrastructure, vulnerabilities, disaster-hardening alternatives (for example, more lines and reservoirs, fewer trees), and how to access those utilities during and after emergencies.
4. Research and make recommendations regarding vegetation management for reducing flood risk and for re-vegetating various areas, including recommendations of beneficial plants and plants that should be avoided.
5. Research and provide information regarding the potential economic uses of hau and albizia.

6. Develop a “master plan” to manage the long-term impacts of sea level rise on Wainiha and neighboring communities.
7. Research and increase public awareness of the cultural and spiritual significance of Wainiha streams and rivers, cultural protocols for the use and protection of natural resources, and watershed management in alignment with traditional knowledge and practices.

Infrastructure-Related Actions (Government)

8. Create a comprehensive, integrated early warning and emergency evacuation system for all hazards (including inland/riparian flooding, coastal flooding, and tsunamis), that includes hazard-resistant, redundant rain gauges and stream gauges coupled with soil moisture probes; and conduct extensive outreach to the public regarding how to access, interpret and make effective use of that system.
9. Implement agreements with landowners to allow access and refuge during nearshore tsunamis, quick-onset flooding, and other relevant disaster events.

Rights for Safe Harbor and Evacuation Access During an Emergency or Disaster

There are liability protections for landowners, and legal access rights granted to the public, in the event that anyone needs to access lands for emergency evacuation or other lifesaving reasons during an emergency or disaster (HRS 663-10.7 - see Appendix D).

10. Ensure that all critical public infrastructure (existing and new) is safe from flooding and sea level rise and/or has functional backup.
11. Maintain drainage systems and culverts.
12. Manage hau and maintain trees in Wainiha County Park.
13. Develop and communicate a policy for whether/when/who/how to clear the Wainiha River mouth when it is closed by sand or debris.
14. Enforce, and update, if necessary, regulations and policies regarding coastal and riparian setbacks.
15. Enforce, and strengthen, if necessary, ordinances that prohibit the dumping of green waste, trash, vehicles, and other items.
16. Conduct a periodic (quarterly) bulky item pickup program.
17. Conduct a periodic dead/abandoned vehicle pickup program.
18. Reestablish Community Emergency Response Team (CERT) training and other training for emergency responders.

New or Strengthened Hazard Mitigation-Related Regulations (Government)

19. Establish “no adverse impact” rules to prohibit residents/property owners from land modifications, land uses or activities (for example, damming or diverting water) that could increase flood risks or create environmental, cultural or economic damage upstream or downstream.
20. Review and update zoning ordinances, building codes, flood requirements and tax incentives to: limit or more-effectively manage new development in hazard zones; require or provide incentives for sufficient setbacks along riparian corridors and additional flood-resilience (for example, anchoring foundations, creating ground floor wall openings to allow waters to flow through); and eliminate existing rules and loopholes (for example, regarding repairs to non-conforming structures) that undermine the goal of hazard risk reduction.
21. Require that, under certain conditions (for example, by certain dates or triggers), non-conforming structures be retrofitted to be more flood-resilient (for example, elevation of structures and utilities above base flood elevation, anchoring of foundations, creating ground floor wall openings to allow flow-through of flood waters).
22. Review and update, as needed, storm water management regulations.
23. Strengthen real estate hazard disclosure requirements for sale of property in riparian flood zones.

Collaborative Activities (Community, Government, Businesses and/or Individuals/Households)

24. Conduct a periodic education and awareness campaign regarding hazards and risk mitigation, with written information specifically tailored to Wainiha and neighboring communities, and to residents and relevant businesses (real estate, architects/designers, building/construction, landscape/yard maintenance...). Topics to be covered would include:
 - (a) Potential impacts of flooding, tsunami and sea level rise at each parcel;
 - (b) Importance of locating new structures, or relocating existing at-risk structures, outside hazard zones, above base flood elevations, at safe setback distances in riparian corridors, and incorporating flood-resilience measures (such as foundation anchoring);
 - (c) Land use modifications that could increase flood risks or create off-site environmental, cultural or economic damage;
 - (d) Importance of ongoing mitigation of hazard impacts (including trimming trees away from structures, keeping drains and culverts cleared, elevating items above base flood elevation and securely storing non-fixed items, obtaining flood insurance);
 - (e) How to access and interpret weather, rain and flood warning information, and evacuation information and maps; and
 - (f) FEMA disaster preparation and response recommendations (tailored to focus on local community hazards and risks).
25. Create and effectively disseminate hazard information packages and maps targeted at north shore tourists and transient vacation rental occupants.

26. Create educational materials for new home buyers and new residents to raise their awareness of cultural protocols, natural hazards and associated flood mitigation policies and actions.
27. Businesses:
- (a) Ensure that mission-critical structures, facilities and systems are located outside hazard areas, hardened against flooding and sea level rise, and/or have redundancy and/or backup plans to maintain functionality;
 - (b) Educate employees about flood and tsunami risks, how to minimize such risks and respond to hazards; and
 - (c) Create and practice evacuation plans.
28. Establish a (county-led or community-led) trained community emergency preparedness, response, relief, recovery and resilience team with sustainable funding for paid leader(s). Its responsibilities could include:
- (a) Community outreach and education (see #24, hazard and risk mitigation education and awareness campaign proposal)
 - (b) Recruitment and training of team members
 - (c) Acquiring and maintaining disaster supplies and equipment, and other duties outlined in the Hanalei to Hā`ena Community Disaster Resilience Plan
 - (d) Developing agreements with property owners to allow safe access and refuge during nearshore tsunamis, quick-onset flooding, or other disaster events
 - (e) Developing arrangements with local businesses to provide flood response and post-flood support services (for example: bases with commercial kitchens to prepare food for the community' freezer services; and centers for community meetings, communications and emergency response services)
 - (f) Developing and maintaining advance arrangements for borrowing evacuation equipment (for example, kayaks, boats/zodiacs, boards); and
 - (g) Monitoring and reporting illegal camping and other activities harmful to the environment or contrary to cultural and community protocols.
29. Provide educational materials and periodic training for residents and relevant businesses (landscape architects, yard maintenance...) on watershed care, including vegetation management for reducing flood risk and recommendations of beneficial plants and plants that should be avoided.

Maintenance of Channels, Streambeds, Streambanks and Drainageways

There are requirements for the County and landowners to maintain rivers and streams so that they can carry off storm waters (HRS 46-11.5 - see Appendix E).

30. Create ongoing community programs, with sustainable funding for program managers and staff, for:
- (a) "Stream teams" to clean, restore and maintain the Wainiha auwai, streams, and river corridor

- (b) Trimming trees away from structures and utilities and keeping storm drains culverts cleared
 - (c) Providing hazard inspections to residents
 - (d) Raising awareness of cultural protocols for use and protection of natural resources; and
 - (e) Training for arborists / environmental stewards to work on the environmental protection and restoration of the Wainiha watershed.
31. Develop a “community building” program focused on identifying, understanding, and addressing the social factors that undermine the social cohesion needed for effective watershed protection, flood risk reduction and disaster resilience.
- These factors might include long-standing historical cultural and social grievances, poverty, racism, and in-migration/gentrification, which result in housing displacement of long-term residents, tensions and hostility between long-term residents and newcomers, and alienation and withdrawal of long-term residents from community efforts.
 - Suggested ways to address these problems involve educational activities, and sponsorship of community activities and events to build connections (for example, hukilau, or making canoes).
32. Overarching Recommendation: Fund a community-based organization to oversee, advocate for progress, and coordinate the work that is recommended above; to see that knowledge is incorporated from the watershed management and flood mitigation plans and actions undertaken in other north shore watersheds; and to ensure that those plans and actions are appropriately coordinated with those undertaken here, and that none would negatively impact flood risks in the others’ areas.

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Appendix A. Terminology

Unless otherwise noted, definitions sourced from UNDRR Online Glossary. <https://www.undrr.org/terminology>

Capacities	The combination of all the strengths, attributes, and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience.
Climate	The average (20-30 years) weather during a particular time of year, in a particular geography (adapted from IPCC, 2012)
Climate Change	A change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2012)
Climate Change Adaptation	In human systems, the process of adjustment to actual or expected climate and its effects to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.
Disaster	A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts.
Early Warning Systems	An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses, and others to take timely action to reduce disaster risks in advance of hazardous events.
Hazard	A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation.
Mitigation	The lessening or minimizing of the adverse impacts of a hazardous event.
Preparedness	The knowledge and capacities developed by governments, response and recovery organizations, communities, and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters.
Prevention	Activities and measures to avoid existing and new disaster risks.
Recovery	The restoring or improving of livelihoods and health, as well as economic, physical, social, cultural, and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and “build back better”, to avoid or reduce future disaster risk.
Resilience	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.
Response	Actions taken directly before, during or immediately after a disaster to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.
Risk	The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society, or a community in a specific period, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.
Vulnerability	The conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

Appendix B. Summary of Stakeholder Discussions

This appendix summarizes the flood risk reduction and mitigation actions that were suggested during the Wainiha Hydrologic Vulnerability Assessment and Community Awareness Campaign interviews with stakeholders. The list also includes actions excerpted from the County of Kaua'i's "Multi-Hazard Mitigation Plan 2020 Update" and "Climate Adaptation Plan Process 2023."

The suggestions address riparian flooding and/or coastal flooding (which encompasses flooding resulting from inland flooding reaching the sea, storm surge, high surf/high tide, sea level rise and related human-caused environmental degradation). They address reducing incidence and severity (preventing and mitigating the frequency, scale or intensity of hazards), reducing exposure (preventing, avoiding, mitigating or reducing exposure to hazards, including evacuation), reducing vulnerability (anticipating, preparing for, or responding to hazards), and increasing resilience capacity through coping or adaptation (i.e., through knowledge, skills, behaviors, resources, or networks).

The actions are grouped into four stakeholder classes (individuals/households, businesses, community and government) that would typically be most responsible for implementation of the suggestions.

Note that these are ideas for further consideration. They are not recommendations.

1. Individuals / Households

- Locate new structures outside of hazard zones, and at safe setback distances along riparian corridors;
- Relocate existing at-risk structures;
- Be aware of the impacts of land uses and land use modifications (for example, diverting water) that could increase flooding risks;
- Elevate existing non-conforming structures and utilities above base flood elevation;
- Build or retrofit structures to be flood-resilient (for example, anchoring the foundation, creating ground floor wall openings to allow waters to flow through);
- Clear storm drains and keep culverts cleared;
- Trim trees away from structures and utilities;
- Elevate items within the house and on property above base flood elevation; and securely store other items that could be carried away by flooding;
- Be knowledgeable of flooding risks, including sea level rise, at residence's location; and as needed, buy flood insurance;
- Become knowledgeable of potential flooding impacts and ways to mitigate them;
- Be prepared for disasters: review FEMA and community awareness materials on flood risk reduction and household preparedness; know if you are in a flood zone; understand how to access and interpret flood warning information (for example sign up for weather alerts, monitor gauges or other indicators); have household emergency evacuation plans, personal disaster supplies or go-kits for 72-hour self-sufficiency; understand evacuation

routes and areas/options; how to communication with outside; practice emergency plans with family and friends.

2. Businesses

- Locate mission-critical functions and facilities outside hazard area whenever possible.
- Build redundancy for critical functions or retrofit critical buildings.
- Provide flood-proofing when new critical infrastructure must be located in floodplains.
- Keep cash reserves for reconstruction.
- Educate employees about flood and tsunami hazards and ways to minimize risk.
- Develop and practice a corporate evacuation plan.
- Support and implement hazard disclosure for sale of property in risk zones.
- Modify business practices to reduce carbon footprint.
- Preserve open space to reduce risk to structures from potential sea level rise and flooding.

3. Community

- Raise awareness about, and help people to sign up for, emergency alert systems and alerts from river gauges; and how to access and interpret river gauges and rain gauges.
- Create awareness campaigns, materials and maps targeted at residents (and separately, targeted at tourists) regarding tsunami evacuation routes and refuge areas.
- Conduct an education campaign for residents on watershed care.
- Develop resource materials to provide recommendations to residents/homeowners on vegetation management to reduce flood risk, including lists of beneficial plants and invasive plants that should be avoided.
- Develop homebuyer educational materials to raise awareness of cultural protocols for use and protection of natural resources.
- Develop a multi-hazard evacuation plan, linked with early warning systems, and identifying accessible evacuation routes.
- Create (paid) resilience/rescue teams.
- Designate community resilience leaders responsible for ongoing training of community flood resilience teams and for acquiring and maintaining necessary supplies, including emergency communications tools, security vehicles and mules (utility terrain vehicles).
- Implement agreements with landowners to allow safe access and refuge during relevant hazard events.
- Pre-arrange for loaned kayaks and standup paddle boards for water evacuations.
- Partner with businesses to provide flood response and post-flood support services (for example, bases with commercial kitchens to prepare food for the community, freezer services, and centers for community meetings, communications and emergency response services).
- Keep storm drains and culverts cleared.
- Create “stream teams” to clean and care for the Wainiha auwai, streams, and river environment to maintain the stream corridor.

- Establish (paid) community watch groups to monitor illegal camping and harms to natural and cultural spaces, and report issues to the Kaua'i Police Department and/or other enforcement agencies.
- Establish and fund river and stream access/management rules to ensure that downstream/upstream residents/property owners do not increase flooding or environmental damage upstream or downstream based on their land use decisions (for example, people cannot divert water for personal use).
- Provide free/low-cost chainsaw trainings, citizen forestry programs, natural resource management trainings, and training-and-certification programs for arborists to work in restoration of the Wainiha watershed.
- Explore market opportunities for economic uses for hau and albizia.
- Find sustained funding for community to maintain water flow.
- Land tenure rights: give responsibility to 'ohana to manage the resources and fishing.
- Solicit input on watershed management in alignment with traditional knowledge and practices, protecting the cultural and spiritual significance of Wainiha streams and rivers.
- Develop a plan to identify, understand and address the social issues that decrease the social cohesion necessary for disaster resilience.
- Learn how to use conflict mitigation and peace-building to remove barriers between people, and between people and nature.
- Develop cross-cultural, intergenerational programs that promote connections between people and to nature (for example, making canoes, activities with kids to break through barriers and unify kids across spectrums).
- Bring back the hukilau as part of a community rebuilding process.
- Establish resource sharing (for example, machinery, resources, jobs...), including between newcomers and locals, to build trust.
- Develop a community-based cultural protocol for climate change adaptation, fostering restorative cultural education, natural restoration and food production, to preserve local community members' traditional way of life.

4. Government

- Maintain drainage systems to be flood-resilient.
- Manage hau and maintain trees in Wainiha County Park.
- Create or clarify policy for whether/when/how to clear the Wainiha river mouth when it is closed due to sand/debris.
- Implement and enforce policies prohibiting dumping (green waste, trash, cars, anything).
- Conduct quarterly bulky item pickup program, including awareness materials and enforcement, to coincide prior to rainy season.
- Conduct periodic dead car pickup program, including awareness materials and enforcement to prohibit dumping of vehicles
- Provide CERT training and other training for emergency responders

- Ensure that government is effectively coordinating with the community through early warning system alerts, other early warning knowledge and associated communications, and evacuation planning.
- Create a useful early warning system, covering inland/riparian flooding and coastal flooding, that includes redundant (in case one or more are not functional) rain gauges and stream gauges coupled with soil moisture probes, and extensive outreach and communication to the public.
- Maintain and collect data to define risks and vulnerability.
- Create and distribute maps of safe zones / high ground for different types of hazard events and floods.
- Produce better hazard maps and provide technical information and guidance for mitigation.
- Assess vulnerability to sea level rise and improve public awareness of risks due to sea level rise.
- Develop post-disaster planning rules and laws.
- Develop and adopt a continuity of operations plan.
- Improve county and state disaster response particularly where overlapping jurisdictions exist.
- Improve coordination between the state, county and residential/private landowners, as stream and coastal management involve all three.
- Model evacuation limitations and solutions under various hazard scenarios.
- Incorporate community expertise and knowledge in disaster recovery plans.
- Employ local experts to implement traditional knowledge-based practices for ahupua'a restoration.
- Incorporate the probable impacts of climate change into flood hazard risk assessments.
- Develop a “master plan” to manage the long-term impacts of sea level rise on Wainiha and neighboring communities.
- Provide economic assistance for affected community volunteers who are at the same time working to recover from the disaster themselves.
- Strengthen National Flood Insurance Program (NFIP) requirements for repairs to non-conforming structures.
- Update County Flood Review requirements to remove existing standards and loopholes that undermine the intent of the requirements.
- Ensure that there are adequate policies, awareness and enforcement of coastal and riparian setbacks, informed by the NFIP regulations and relevant modeling and hydrologic studies.
- Enact planning and land use tools to help manage development in hazard areas (stronger controls, tax incentives, education and information).
- Implement mandatory or voluntary conversion of cesspool systems along Wainiha river and streams (possibly with financial support programs), to flood-resistant above-ground systems.
- Require cesspool replacement at time of sale of property.

- Ensure adequate water supply for fire suppression before issuing new building permits.
- Increase programs to recapture excess rainwater for water security and to reduce flood load through government programs/incentives and community education on proper maintenance, care and management of catchment water systems.
- Create an elevation inventory of structures in the floodplain.
- Integrate floodplain management policies into other planning mechanisms within the planning area.
- Adopt comprehensive stormwater management regulations.
- Adopt “no-adverse impact” floodplain management policies that strive to not increase the flood risk on downstream communities.
- Discourage planting of plants that increase flooding risks, and encourage use of plants that decrease such risks, in riparian areas.
- Review and update existing Mandatory Real Estate Disclosure to ensure that prospective buyers know if property is in harm’s way.
- Prohibit pesticide use in proximity to rivers and streams.
- Explore solutions to protect public infrastructure from flooding.
- Avoid developing public infrastructure in flood-prone areas.
- Relocate Park infrastructure, especially wastewater facilities, at risk from flooding and sea level rise.
- Locate or relocate critical facilities outside of hazardous areas.
- Provide redundancy for critical functions and infrastructure.
- Warehouse critical infrastructure components.
- Incorporate retrofitting or replacement of critical system elements in capital improvement plan.
- Explore engineered solutions, such as larger or more culverts in appropriate locations.
- Limit development along the Wainiha River.
- Manage development and prevent infrastructure expansion in areas at risk from flooding and sea level rise.
- Facilitate managed retreat from, or upgrade of, the most at-risk areas.
- Restore existing flood control and riparian corridors.
- Acquire vacant land or promote open space uses to control or reduce increases in runoff.
- Preserve undeveloped shoreline areas that are vulnerable to sea level rise, inland flooding or coastal flooding.
- Promote open space uses in identified high hazard areas through development criteria such as planned unit developments, density transfers, clustering, easements, setbacks, greenways, and sensitive area tracks.
- Reduce coastal flooding impacts by relocating structures in areas at risk from flooding and sea level rise inland to allow the natural beach processes to restore beaches.

- Implement policies that prioritize beach preservation over protection of private property, including managed retreat and enabling seasonal wave dynamics to bring in offshore sand.
- Increase community-based participation in coastal zone management.
- Address the displacement of local families into the flood hazard zones.
- Acquire identified repetitive loss properties and assist in relocation for residents from such properties and from other properties that are at high risk due to disasters or climate change.
- Implement restoration and plantings of native species along riverbanks in the appropriate locations.
- Use Hā'ena Hui Maka'āinana o Makana taro restoration project as an example for Wainiha to restore auwai systems, taro fields and water flow in the Wainiha watershed.
- Restore residential use of residential structures in neighborhoods, phase out transient vacation rental uses.
- Determine the visitor carrying capacity of the North Shore based on an acceptable level of tourism-created flood risk.
- Limit access to the area west of Waipā by car (through fees, a limited number of permits and enforcement) to reduce the number of visitors in the flood risk area.
- Tax tourists to fund natural resource protection.
- Charge a hazard mitigation fee.
- (KIUC): Explore undergrounding of electric distribution wires to secure energy access during and after floods as, existing poles likely will not withstand hurricane winds.
- (KIUC): Share basic information about the Hā'ena and Wainiha circuits, disaster-hardening alternatives (more lines, less trees, etc.), vulnerable areas, and how to prepare to safely access energy.

Appendix C. Observations of Wainiha Stream Flooding Scenarios Under Varying Conditions

Observations of Wainiha Stream Flooding Scenarios Under Varying Conditions
(Barbara Robeson)

Rainfall + weather conditions	Tide		River mouth		Surf		Season		Risk Levels
	Low	High	Open	Closed	Low	High	Summer	Winter	
No rain	Water flows from river to sea	Water flows out more slowly as sea flows into estuary; during dry periods water may flow slowly and river mouth will be shallow and narrow	Water flows out slowly; water level is low	Water backs up within the stream channel and on land along the river	No/low surf has minimal effect	High surf pushes sand that can close the river mouth; can also overtop sand bar or surge through the river mouth upstream as far as the Wainiha double bridges	River mouth at Hanalei end, stream meanders back in an "S" shape towards Hā'ena	River mouth located at Hanalei and unless high surf then can make new opening midway in the sandbar. The property mauka side of the river receives surf.	Compaction, Drought, Plant loss, Potential increased risk of erosion and flash flooding/runoff in future heavy rain events due to depleted absorption capacity of soils
Intermittent Rain, Dry Weather	Water flows from river to sea	Water flows out of the river mouth but may back up if the mouth is closed or the tide is high	River water flows out of the river mouth	The river may back up if the mouth is closed	Water will flow out of the river mouth gradually deepening and widening the mouth		The "S" curve gets deeper and wider, starts to cut away at the makai edge of "S"	River mouth gets wider and deeper	
Light/Medium rain over a longer period of time; ground saturated, basin unable to absorb more water	Water slowly flows out to sea, water level in river and on land may rise	Sea level is at the river mouth opening, keeping the river from draining out	Water continues to flow to sea	Water backs up within the stream channel and on land along the river	River mouth becomes wide and deep, water can flow out	Surf can keep water from flowing out and it backs up over the land in the vicinity of the Wainiha bridges #2 and #3	No difference between the seasons	No difference between the seasons	Medium to Severe = equals basin saturation from consistent rainfall + high tide, closed river mouth high surf, and winter/more likelihood of future rains
Heavy rain over a short period of time	The river can drain more quickly	The river drains more slowly	Water continues to flow to the sea if not during high tide or high surf	River mouth closed, heavy rain, temporary flooding may occur, but heavy rain opens the river mouth	River mouth closed, heavy rain, temporary flooding may occur, but heavy rain opens the river mouth	High surf can inhibit the flow/drainage of water, winter waves may wash into and clean the river	Can occur any time of year	Can occur any time of year	Severe: Worst Conditions = flash flooding + high tide, closed river mouth, high surf, and winter/more likelihood of future rains

Risk Rating

Red indicates severe risk of flooding

Orange indicates moderate to severe risk of flooding

Yellow indicates complicating factors that may worsen future flood events

Appendix D. HRS 663-10.7

Hawai'i Revised Statutes, Chapter 663-10.7

Exemption for providing emergency access to land, shelter, and subsistence during a disaster.

(a) Any owner of private property who in good faith provides emergency access to land, shelter, or subsistence, including food and water, to a person during a disaster without remuneration or expectation of remuneration, shall be exempt from civil liability for any injury or damage suffered by the person that resulted from the owner providing such emergency access to land, shelter, or subsistence, unless the injury or damage was caused by the gross negligence or intentional or wanton acts or omissions of the owner.

(b) For the purposes of this section:

"Disaster" means a nonroutine event that exceeds the capacity of persons in the affected area to respond to it in such a way as to save lives, preserve property, or to maintain the social, ecological, economic, or political stability of the affected area.

"Emergency" means a situation in which the life or health of a person is in jeopardy due to a disaster requiring immediate assistance.

"Owner" means the possessor of a fee interest, or a tenant, lessee, occupant, person, group, club, partnership, family, organization, entity, or corporation that has control, possession, or use of the land, and its members, agents, partners, representatives, shareholders, and employees.

Appendix E. HRS 46-11.5

Hawai'i Revised Statutes, Chapter 46-11.5

Maintenance of channels, streambeds, streambanks, and drainageways.

Notwithstanding any law to the contrary, each county shall provide for the maintenance of channels, streambeds, streambanks, and drainageways, whether natural or artificial, including their exits to the ocean, in suitable condition to carry off storm waters; and for the removal from the channels, streambeds, streambanks, and drainageways and from the shores and beaches any debris which is likely to create an unsanitary condition or otherwise become a public nuisance; provided that to the extent any of the foregoing work is a private responsibility the responsibility may be enforced by the county in lieu of the work being done at county expense, and any private entity or person refusing to comply with any final order issued by the county shall be in violation of this chapter and be liable for a civil penalty not to exceed \$500 for each day the violation continues; provided further that it shall be the responsibility of the county to maintain all channels, streambeds, streambanks, and drainageways unless such channels, streambeds, streambanks, and drainageways are privately owned or owned by the State, in which event such channels, streambeds, streambanks, and drainageways shall be maintained by their respective owners.