Chapter 5: Recommended Management Measures

The purpose of this chapter is to describe management actions that can be implemented to achieve watershed restoration and protection goals and address the existing impairments and threats described in Chapters 3 and 4. Management actions are typically groups of management practices – both structural and non-structural – that have the greatest likelihood of achieving watershed goals, treating sources of pollutants in the watershed and types of impairments found, and achieving the amount of load reduction needed.

This plan focuses efforts primarily in the riparian corridor and on the land immediately adjacent to the riparian zone because these areas most directly impact the quality of the stream and nearshore waters and habitats. Riparian corridors are considered critical areas within a watershed because they serve as buffer strips, trapping and filtering pollutants, stabilizing streambanks, and attenuating effects of high flows and volumes. Riparian corridors also provide habitat for wildlife and can provide various economic, recreational and aesthetic opportunities for landowners. A well-functioning corridor consists of a variety of plant species and vegetative covers. The goals, objectives, and recommended actions contained in this chapter support the plan's overall goal to maintain healthy stream and riparian environments, both in terms of water quality and habitat integrity, that sustain a healthy *mauka-makai* connection and promote community-based environmental stewardship.

Polluted runoff comes from a large number of sources that vary in size and impact on water quality. Degradation of a waterbody results from the cumulative effect of pollutants from these sources. This watershed management plan describes a coordinated program of effective actions to be implemented to prevent and abate polluted runoff within the watershed, as well as address other threats that have a direct impact of overall watershed health and habitat integrity. As noted in Section 1.2, management strategies were developed using the *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (EPA 1993) and the *Updated Management Measures for Hawai'i's Coastal Nonpoint Pollution Control Program* (CNPCP) (Stewart 2009). See Appendix B for a list of relevant management measures.

As part of the planning process, the relevant management measures provided a starting point to help with development of goals and objectives for the Wai'ula'ula watershed and recommended actions ("best management practices" or BMPs) to achieve those goals and objectives. While there are 50 management measures within Hawai'i's CNPCP, only 24 apply to the land uses in the Wai'ula'ula watershed: 5 for agriculture; 12 for urban areas; 4 for hydromodifications[8]; and 3 for wetlands and riparian areas. Table 17 lists these management measures and notes the implementing projects that relate to each.

[8] Hydromodification means an "alteration of the hydrologic characteristic of coastal and non-coastal waters, which in turn could cause degradation of water resources" (EPA 1993; p. 6-90).

Table 17: Management Measures Applicable to the Waiulaula Watershed

Management Measures	Applicable to Watershed?	Implementing Projects
AGRICULTURE		
Erosion and Sediment Control	Yes	NUTR-1, 2; SED-1, 2, 3; FIRE-1, 2, STREAM-1
Wastewater & Runoff from Confined Animal Facilities	No	
Nutrient Management	Yes	NUTR-1, 2; SED-2, STREAM-1
Pesticide Management	Yes	NUTR-1, SED-1
Grazing Management	Yes	NUTR-2, SED-2, 3; FIRE-1, 2; STREAM-1
Irrigation Water Management	Yes	NUTR-1, SED-1, 2
FORESTRY		
(10 management measures)	No	
URBAN		
New Development	Yes	STORM-4, 5, 6; STREAM-4
Watershed Protection	Yes	NUTR-3, 4; SED-4, FIRE-3, 4, 5; STORM-1 through 6; STREAM-2,3,4
Site Development	Yes	STORM-1, 2, 3, 4, 6; STREAM-2, 4
Existing Development	Yes	NUTR-3, 4; FIRE-3, 5; STORM-2, 4, 6; STREAM 4
New On-Site Disposal Systems (OSDS)	Yes	STORM 6
Operating OSDS	Yes	NUTR-3, 4
Pollution Prevention	Yes	NUTR-3, 4; FIRE-5; STORM-1 through 6; STREAM 2, 3, 4;
Golf Course Management	Yes	STREAM 3, 4; MONIT-1
Planning, Siting, & Developing Roads and Highways	Yes	STORM-5, 6
Bridges	Yes	STORM-4, 5, 6
Operation & Maint. of Roads, Highways, Bridges	Yes	STORM-5, 6
Road, Highway, and Bridge Runoff Systems	Yes	STORM-4, 5, 6
MARINAS and RECREATIONAL BOATING		
(15 management measures)	No	
HYDROMODIFICATIONS		
Channelization and Channel Modification		
Physical & Chem. Characteristics of Surface Waters	Yes	STORM 2, 4; STREAM-3, 4; AQU-1, 3; MONIT-1
Instream and Riparian Habitat Restoration	Yes	STREAM-1, 3, 4; AQU-1, 3
Dams		
Protection of Surface Water Quality and Instream and Riparian Habitat	Yes	STREAM-3, 4; AQU-1, 3

Management Measures	Applicable to Watershed?	Implementing Projects
Streambank and Shoreline Erosion		
Eroding Streambanks and Shorelines	Yes	STREAM-1, 3, 4; AQU-1
WETLANDS, RIPARIAN AREAS, and VEGETATED TREATMENT SYSTEMS		
Protection of Wetlands and Riparian Areas	Yes	STREAM-1, 3, 4; AQU-1
Restoration of Wetlands and Riparian Areas	Yes	STREAM-1, 3, 4; AQU-1
Vegetated Treatment Systems	Yes	STREAM-1, 3, 4; AQU-1

The watershed management plan also addresses EPA's 9 key elements for watershed-based plans that EPA believes are critical for achieving improvements in water quality. All projects that apply for Section 319(h) funding under the Clean Water Act and administered by the Hawai‘i Department of Health must include nine key elements in their watershed-based plans. Appendix C lists these 9 required elements and indicates where each is addressed in the Wai‘ula‘ula watershed management plan.

This chapter lays out watershed restoration and protection goals and objectives, as well as recommended projects and tasks to address the goals and objectives. This chapter identified implementing measures that will have the greatest likelihood of achieving the stated watershed goals. Under each goal, there is a brief description of the problem to be addressed, estimated pollutant load reductions expected, and a table listing criteria by which to measure success in achieving that particular goal, followed by one or more measurable objectives. Under each objective there are one or more projects to implement the objective. Under each project there is a list of tasks, which are interim measurable milestones to gauge progress toward project implementation. Table 19 summarizes these projects. Worksheets for each project are provided in Appendix A, summarizing project tasks, implementation timeframe and schedule, pollutant load reduction estimates (if applicable), responsible entity and project partners, and an estimation of costs and technical assistance. Table 20 outlines the timelines for project implementation. Project timeframes and schedules assume a start date of 2012 for plan implementation.

The projects proposed in the Wai‘ula‘ula Watershed Management Plan were prioritized based on relative scores generated against a set of criteria. These criteria were developed by the planning team from information gathered by stakeholders and input from agency representatives. Criteria used to evaluate and prioritize projects include 1) total load reduction; 2) significance as a pollution source; 3) ease of implementation; 4) feasibility of project costs; 5) level of stakeholder buy-in; 6) severity of the threat addressed by the project; 7) the area of impact from the project; and 8) its relevance to management measures and plan objectives. Each of the proposed projects was evaluated against the eight criterion and assigned a value between one and three, for a total possible score of 24. A value of "3" given for project cost feasibility, for instance, would mean that the project cost totals less than $25,000; "2" would represent a project cost between $25,000 and $100,000, and a "1" would be given to a project

costing over $100,000. For total load reduction, a "3" represents a direct relationship or a significant load reduction, a "2" would be indirectly related or an assumption that loads would be somewhat reduced, and a "1" would be given to a project with no relevance to load reduction or would not result in load reduction.

The results of this prioritization process placed the projects in high, medium, or low priority levels for implementation (Table 18), and their respective implementation schedules are based on their cumulative scores for each criterion. Some projects were moved up in priority as their implementation is prerequisite to projects in other priority levels. While these are the priority levels as proposed at the finalization of this management plan, projects assigned a lower priority may be implemented sooner if project funding or grant opportunities become available, or new information elevates a project's urgency. The implementation schedule for priority level 1 is from 0 to 5 years, priority level 2 from 6 to 10 years, and priority level 3 between 11 and 15 years. Monitoring the overall implementation of the Waiʻulaʻula watershed management plan on an ongoing basis will determine if the proposed priority levels are relevant over the planning horizon of 15 years, and, if they are not, they shall be adjusted accordingly.

Table 18: Priority Levels for Projects in the Waiʻulaʻula Watershed Management Plan

Priority Level 1 Projects (1-5 years)	Priority Level 2 Projects (6 to 10 years)	Priority Level 3 Projects (11-15 years)
NUTR-2: Fence riparian areas to exclude cattle	NUTR-1, SED-1: Assist Farmers in Lālāmilo Farm Lots with Conservation Plans	SED-7: Identify and revegetate bare land in watershed
NUTR-3: OSDS education and outreach	NUTR-4: Incorporate point-of-sale inspections of OSDS	STORM-4: Upgrade existing runoff control structures
SED-2: Extend Waimea Irrigation System to lower watershed	SED-6: Remove goats below Queen K	STORM-5: Develop operation and maintenance guidelines for County roads
SED-3: Divide large paddocks in grazing areas	FIRE-2: Fence large grass-dominated area below Queen K to manage fine fuels	EDU-1: Develop/ adapt educational materials
SED-4: Assess streambank erosion	FIRE-5: Construct and maintain fuel breaks	EDU-2: Provide on-the-ground service learning opportunities
SED-5: Remove goats between rock wall and Queen K	STORM-2: Dry well insert installation and maintenance program	ADMIN-1: Waiʻulaʻula Watershed Coordinator
FIRE-1: Fence large grass-dominated area above Queen K to manage fine fuels with cattle grazing	STREAM-1: Convert marginal grazing lands into native vegetation via CREP	MONIT-1: Implement monitoring program
FIRE-3: Update fire resources maps	STREAM-3: Restore riparian areas within the watershed	
FIRE-4: Develop agreements for access and water use	STREAM-4: Policy language for overlay district that protects wetlands and riparian areas	
FIRE-6: Develop post-fire restoration manual	AQU-1: Remove illegal diversions	
STORM-1: Survey and line catch basins within the watershed	AQU-2: Evaluate need for specific instream flow standards	
STORM-3: Stormwater educ and outreach program	AQU-3: Determine the effects of dams on ʻoʻopu habitat	
STORM-6: Develop & implement LID outreach program	AQU-5: Protect priority instream perennial pools	
STREAM-2: Educational events/ projects to educate about riparian buffers	EDU-1: Develop/ adapt educational materials	
AQU-4: Invasive aquatic species control	EDU-2: Provide on-the-ground service learning opportunities	
EDU-1: Develop/ adapt educational materials	ADMIN-1: Waiʻulaʻula Watershed Coordinator	
EDU-2: Provide on-the-ground svc learning opportunities	MONIT-1: Implement monitoring program	
ADMIN-1: Waiʻulaʻula Watershed Coordinator		
MONIT-1: Implement monitoring program		

Goal 1: Reduce nutrient loads in the Waiʻulaʻula watershed.

In the limited water quality monitoring undertaken for this management plan, results indicated water quality impairment with respect to nutrient loads. Nitrate concentrations in Waikoloa Stream below Waimea town slightly exceeded state water quality standards, while the TP concentration was nearly twice the allowable amount. Further downstream just above the mouth of the Waiʻulaʻula watershed, TN concentrations were double the allowable amount. In the nearshore waters, ammonia concentrations were 2.8 times the water quality standard and chlorophyll-a concentrations were double. All other nutrients measured at the various stations were within allowable limits.

The following table provides criteria to measure success in achieving this watershed and ecosystem health goal.

Indicators	Targeted load, level or value
Total Phosphorus (TP)	By 2025, the geometric mean of measurements for all water quality indicators shall be less than water quality standards for the dry season in any year and at any sampling site.
Total Nitrogen (TN)	
Ammonia – mouth of watershed only	By 2025, the difference between upstream values and downstream values for all water quality indicators in any year and for every upstream/ downstream sampling pair shall be indistinguishable from zero according to a paired t-test.
Dissolved Oxygen (DO)	
Nitrate	
Chlorophyll-a	
Linear feet of riparian corridor excluded from cattle	By 2025, fence 58,000-ft. of riparian corridor in the grazing area between 1,200-ft. and 2,600-ft. elevation along Keanuʻiʻomanō and Waikoloa streams.

<u>Objective 1a</u>: Reduce nutrient loads in agricultural runoff from Lālāmilo Farm Lots by 20% by 2019.

The Lālāmilo Farm Lots are located adjacent to and upslope of Waikoloa Stream. While conservation planning is an effective tool for ensuring that agricultural operations do not have a negative impact on a watershed's natural resources, only 94 acres (or 15%) of the Waiʻulaʻula watershed's farmlands are currently covered by a plan. These lands are a mix of crop agriculture, with regular tilling of the fields, and greenhouses, buildings, and other areas that could still benefit from conservation plans to address stormwater runoff. Farmers may not know that MKSWCD and NRCS can provide technical expertise free-of-charge to assist them in identifying immediate or potential resource problems and developing a conservation plan to address those problems. Recognizing that conservation planning is a voluntary action taken by agricultural operators, outreach into the agricultural community is important first step.

Through outreach, the benefits of conservation planning to the land and to the productivity, sustainability and profitability of farm operations can be explained.

Current nutrient loads from the Lālāmilo Farm Lots estimated through N-SPECT analysis are 290 kg/yr for nitrogen and 40 kg/yr for phosphorus.

Project NUTR-1. Assist farmers in Lālāmilo Farm Lots with the development and implementation of Conservation Plans to reduce polluted runoff. This project also addresses objectives for sediment control and stormwater management.

Project Tasks:

- *Identify all active and inactive agricultural producers by TMK in the Lālāmilo Farm Lots.*
- *Conduct outreach to active producers about developing a conservation plan for their operations or expanding upon existing plans, targeting producers closest to the stream or with obvious resource concerns.*
- *Execute cooperator agreements with at least three additional producers or covering at least 200 additional acres.*
- *Assist cooperators in identifying possible cost-share opportunities for best management practice implementation.*
- *Follow-up with cooperators to track implementation of BMPs.*

Objective 1b: Fence 58,000-ft. of riparian corridors on Keanuʻiʻomanō Stream to exclude livestock from streams by 2023 (relates to Project STREAM-1).

At this time, there are two primary grazers of the watershed's rangelands: Parker Ranch in the mauka area and FR Cattle Co. in the marginal lands. Much of the grazing land is owned by the State of Hawaiʻi (DLNR and DHHL) and leased to the ranchers. While these lands are being grazed under existing conservation plans, improvements can still be made. Infrastructure is limited, with more fencing to reduce paddock size and watering facilities needed. In some areas, cattle are accessing streams for water because there are no other sources of water available, causing streambank erosion and adding nutrients and pathogens to the stream system.

Project NUTR-2. Work with Parker Ranch and FR Cattle Co. to fence critical riparian areas that cattle are currently using to access water. This project will also address pathogens and sediment loads from eroding streambanks caused by cattle trampling.

Project Tasks:

- *Identify stream segments used by cattle for watering and prioritize based on critical resources, environmental impact, availability of alternative water sources, and continuity among stream segments.*

- *Work with land users to develop alternative water sources (troughs) for cattle away from stream (see Project SED-2).*
- *Once alternative water sources are developed, limit livestock access by installing fence.*

<u>Objective 1c</u>: Increase inspections and maintenance (pumping) of onsite wastewater disposal systems (OSDS) within the watershed by 20% by 2019.

The majority of homes and businesses in the Wai‘ula‘ula watershed are using onsite wastewater disposal systems (OSDS), either a cesspool or septic system, which are effective over the long-term only if they are properly sited, designed, operated and maintained. According to Ogata (2009), “many of these systems are at or past their designed lifetimes and are operated by owners with little knowledge of the basic workings/ maintenance requirements of their system” (p. 1). At this time, there is no map or electronic document that identifies type of wastewater treatment system by TMK within the watershed. Therefore, it is currently not possible to assess the effects of OSDS on water quality.

Project NUTR-3. By 2016, educate home owners about proper operation and maintenance of OSDS and the effects of failing OSDS on water quality, public health, and environmental conditions.

<u>Project Tasks</u>:

- *Inventory and map type of wastewater system by TMK and year installed, focusing first on areas adjacent to the streams within the watershed.*
- *Conduct risk assessment to highlight potential critical areas based on density on OSDS, average age of systems, proximity to stream or floodplain.*
- *Compile information required by Section 11-62-62, HAR, and received by DOH from wastewater pumpers in the watershed, including number of systems pumped, location by TMK, type of OSDS, date, and volume.*
- *During baseflow periods, monitor above and below potential problem areas on a quarterly basis for two years to look for onsite waste signals. Parameters to be monitored include TN, TP, and c. perfringens.*
- *Develop or adapt outreach materials about OSDS and potential effects on water quality and environmental and public health.*
- *Distribute information to homeowners with OSDS about the operation, maintenance, and self-inspection of cesspools and septic systems as a way to extend their operating lives and prevent failures.*

Project NUTR-4. Work with local realtors and lenders to establish voluntary point-of-sale inspections of OSDS in critical areas of the watershed by 2017.

Project Tasks:

- *Meet with local realtors and lenders to discuss the importance of OSDS inspections to protect both buyer and seller from conflicts arising from failing OSDS, and to gage interest and level of cooperation.*
- *Develop process for third party inspection of OSDS at time of sale.*
- *Develop or adapt form to disclose, at time of property sale, type of OSDS, location, when it was last pumped, known operational defects, date of last inspection and inspector name, system design and plumbing information, and any special monitoring or maintenance needs.*

Goal 2: Prevent an increase in sediment loads in the Wai‘ula‘ula watershed.

As measured through limited water quality monitoring, sediment loads throughout the watershed meet State water quality standards, though sediment concentrations below Waimea are just slightly below the threshold level. Sediment pulses into the ocean are likely to be episodic in nature, following fire or other land disturbances that precede a major storm event. In contrast to the adjacent Pelekane watershed -- which generates sediment concentrations in runoff that exceed the water quality standard by two orders of magnitude because it has been denuded by an unfortunate combination of fire, overgrazing, and drought – the Wai‘ula‘ula watershed has generally maintained decent ground cover. A goal of this plan is to prevent wildfire, overgrazing and other land disturbances that would strip the land of vegetation and render the thin soil susceptible to erosion.

The following table provides criteria to measure success in achieving this watershed and ecosystem health goal.

Indicators	Targeted load, level or value
Turbidity	By 2025, the geometric mean of measurements for all water quality indicators shall be less than water quality standards for the dry season in any year and at any sampling site.
Total Suspended Sediment (TSS)	
	By 2025, the difference between upstream values and downstream values for all water quality indicators in any year and for every upstream/ downstream sampling pair shall be indistinguishable from zero according to a paired t-test.
Erosion Rate	Statistically-significant reduction in erosion rates over 67% of erosion pins
Number of goats	Reduce goats in fenced areas of watershed by 80%

<u>Objective 2a</u>: Reduce sediment loads in agricultural runoff from Lālāmilo Farm Lots by 20% by 2019.

Current sediment loads from the Lālāmilo Farm Lots estimated through N-SPECT analysis are 10,900 kg/yr.

Project SED-1. Assist farmers in Lālāmilo Farm Lots with the development and implementation of Conservation Plans to reduce polluted runoff. (Implement concurrently with Project NUTR-1 above.)

<u>Objective 2b</u>: By 2020, improve grazing efficiency[9] as a way to prevent overgrazing and limit wildfire size to an average of 100 acres burned per year in the fire prone area between 1,200-ft. and 2,600-ft. elevation.

A high percentage of land in the watershed - both prime kikuyu land and marginal land - is used for grazing (about 8,000 acres). A significant amount of this grazing land is considered marginal. With sufficient rainfall, these marginal lands can support cattle production. During dry conditions, grazing in these areas is seasonal at best, with cattle grazing for a short time when the grass is green following a rain event. However, it is important to graze these marginal lands; otherwise, without periodic grazing, the resulting tall, dry grasses would present a significant fire hazard to the numerous adjacent residential communities.

While the primary grazers, Parker Ranch and FR Cattle Co., have conservation plans with the Mauna Kea Soil and Water Conservation District, improvements can still be made to encourage cattle to graze the land more evenly, rather than concentrate on specific locations or grass species. In addition, infrastructure is limited or non-existent in some areas, with more fencing to reduce paddock size and watering facilities needed.

N-SPECT modeling suggests that if the grazed area between 1,200-ft. and 2,600-ft. elevation were to burn (5,550 acres), sediment loads would increase sevenfold (3,613 to 26,867 kg/yr.). Phosphorus loads would more than double (189 to 417 kg/yr.) and Nitrogen loads would more than triple (1,085 to 3,373 kg/yr.).

Project SED-2. By 2013, extend the Waimea Irrigation Water System from Lālāmilo Farm Lots to the rock wall at the 1,200-ft. elevation.

Surface water from outside the Waiʻulaʻula watershed is transported into the watershed for use by farmers in the Lālāmilo Farm Lots. Surface water from windward Kohala streams is diverted into the Upper Hāmākua Ditch to the Hawaiʻi Department of Agriculture's Waimea Irrigation Water System's 60 MG Waimea and 100 MG Puʻu Pulehu reservoirs. This system provides

[9] Grazing efficiency is the percentage of forage produced that animals actually consume (versus trample, soil and reject).

irrigation water to farmers in both Pu‘ukapu and Lālāmilo. While crop agriculture receives priority for use of the water, grazers may also use this agricultural water.

Project Tasks:

- *Develop an agreement between the Hawai‘i Department of Agriculture Waimea Irrigation Water System and MKSWCD to extend irrigation water pipeline from the Lālāmilo Farm Lots to the rock wall at the 1,200-ft. elevation, a distance of six miles. (This land is all zoned for agricultural use.)*
- *Design a water conveyance system that meets NRCS standards and specifications.*
- *Install pipeline and water tanks, as needed, to store water for cattle use during dry times.*
- *Water users of the pipeline will pay the agricultural water rate through individual metering.*
- *Use of water from the pipeline will be limited to the agricultural and revegetation projects proposed in the watershed management plan (Projects NUTR-2, SED-3, SED-7, FIRE-1, STREAM-1, STREAM-3).*

Project SED-3. Sub-divide large paddocks in the wildfire prone area between Lālāmilo and the rock wall at 1,200-ft. elevation into smaller paddocks by 2016 to improve grazing efficiency of fine fuels.

Project Tasks:

- *Work with land user to design an improved rotational grazing system that meets NRCS standards and specifications as part of the land user’s conservation plan.*
- *Install approximately 5 miles of additional fence to sub-divide existing paddocks in order to achieve even grazing throughout paddocks.*
- *Use water storage and conveyance system developed under Project SED-2 to convey water into the new paddocks. Assist land user in securing a permit to withdraw water from Keanu‘i‘omanō Stream as a back-up supply in the event of low flows from the Waimea Irrigation Water System.*
- *Conduct bi-weekly stubble height monitoring when cattle are present as a management tool to determine when cattle should be rotated out of paddocks, based on the minimum heights established under NRCS’s standards and specifications.*
- *Monitor long-term changes in erosion rates from these lands, using erosion pin monitoring described under Chapter 6 “Monitoring”.*

<u>Objective 2c</u>: By 2016, assess 100% of the watershed's riparian corridors to identify eroding or unstable streambanks and monitor at least 10 sites over 3 years to determine annual erosion rates.

While site visits and anecdotal information suggest there are eroding streambanks within the watershed, no comprehensive survey has been conducted to document the location, extent, cause, and sediment-load contribution of such erosion. Fixing streambank erosion problems will be a long-term undertaking. In the near-term, MKSWCD will identify potential problem areas and monitor actual erosion rates from representative streambanks. With this additional information in hand, MKSWCD will be able to develop actions to address eroding streambanks that are contributing to the sediment load in the watershed.

Project SED-4. Identify eroding and unstable streambanks and install erosion pins in representative sites to monitor annual erosion rates.

<u>Project Tasks</u>:

- *Conduct stream corridor assessment by 2013 to identify and map locations of a variety of environmental problems including streambank erosion and instability (see Chapter 6 "Monitoring"). (This assessment tool will need to be developed/ adapted for Hawai'i's stream systems first.)*
- *For representative eroding streambanks at various elevations within the watershed, install erosion pins (see Chapter 6 "Monitoring") to measure annual rate of erosion. A minimum of 10 sites will be selected and monitored over a 3-year period.*
- *Given the findings of stream corridor assessment and erosion pin monitoring, a prioritized list of needed management actions for streambank stabilization and restoration will be developed.*
- *Stabilize and restore high priority streambanks that are severely eroding using dormant plantings, vegetative materials, stone structures and other low-cost techniques. (project costs and timeframes TBD)*

<u>Objective 2d</u>: Following fencing projects (FIRE-1 and FIRE-2), remove all feral goats from the lower watershed (rock wall down to the coast) by 2020.

The population of wild goats (*Capra hircus*) in West Hawai'i has increased dramatically over the past decade. Goats are extremely destructive herbivores that will eat nearly any type of available vegetation. These browsing ungulates are having a significant impact on the groundcover in the lower watershed, stripping certain areas of vegetation and rendering these areas susceptible to erosion. There is currently no management of these animals, and they roam freely in the watershed, moving in response to available vegetation and water sources.

Project SED-5. Remove feral goats from the lower watershed between Queen Ka'ahumanu Highway and the rock wall at the 1,200-ft. elevation by 2014.

Project Tasks:

- *In coordination with Project FIRE-1, ensure fence constructed in lower watershed between Queen Ka'ahumanu Highway and the rock wall is "goat proof" (extra strands of barbed wire at top, mesh covering gates, no large gaps at ground).*
- *Work with land owners to develop and implement feral ungulate removal program.*

Project SED-6. Remove goats from lower watershed below Queen Ka'ahumanu Highway by 2020. This project would only occur following the fencing of this area under Project FIRE-2.

Project Tasks:

- *In coordination with Project FIRE-2, ensure fence in lower watershed between the coast and Queen Ka'ahumanu Highway is "goat proof".*
- *Work with land owners to develop and implement a feral ungulate removal program.*

Objective 2e: By 2022, restore 25% of bare land in the watershed contributing to erosion, using techniques described in the post-fire restoration manual (Project FIRE-6).

There are several areas within the watershed that have been rendered bare land for a variety of reasons, including recent fire, intentional land clearing, demolition, change in land use and other causes. These areas are particularly susceptible to erosion and sedimentation of streams and nearshore waters.

Project SED-7. Identify and re-vegetate 25% of priority bare land contributing to sediment load in the watershed by 2022.

Project Tasks:

- *Survey and map all significant bare areas within the watershed, noting proximity to a stream and whether they are hydrologically-connected to a stream, cause of de-vegetation (fire, overgrazing, land disturbance, etc.), and infiltration rate of soil (will determine what size storm event will cause runoff from area).*
- *Select priority areas for restoration based on above information and develop implementation plan and schedule.*
- *Install erosion pins (see Chapter 6 "Monitoring") in priority areas to measure annual rate of erosion before and after restoration activities. At least one erosion pin grid will be installed per area and monitoring for at*

least one year before restoration and for at least five years following restoration.

- *Using practices described in the post-fire restoration manual (Project FIRE-6), restore priority bare land contributing to sediment load in the watershed (project costs and timeframes TBD).*

Goal 3: Reduce wildfire occurrences and associated impacts to water quality and ecosystem health.

Wildfire is a significant threat in the Waiʻulaʻula watershed. In the past decade, some part of the watershed has burned every couple of years on average, due to the recurring fire cycle and unmanaged grass fuels. The accumulation of unmanaged fine fuels (grasses) is a recurring threat for devastating wildfires that strip the land of vegetation and render the thin soil susceptible to erosion through runoff, leading to sedimentation of streams and nearshore waters.

The changing composition of vegetation in the watershed has contributed to an increased fire hazard. The alien grasses that now dominate much of the lower watershed are more fire-adapted than native species and will not only carry fire well but quickly exploit suitable habitat after a fire. The area's strong, gusty winds and naturally hot and dry weather produce a climate conducive to wildfire occurrence and contribute to the rapid spread of fire. Wildfires typically start at the end of a dry cycle, and the exposed soils are most vulnerable at the onset of the wet season.

There are a number of fuels mitigation techniques used in Hawaiʻi and on the continental United States to reduce or modify the size, arrangement, and kind of vegetative fuels. These techniques include: mechanical removal (fuel break treatment), prescribed burn (landscape-scale), herbicide (fuel break treatment), and grazing (landscape-scale).

Cattle grazing is arguably one of the most valuable and cost-effective techniques. Effective fine fuels management via cattle grazing has been demonstrated to slow the spread of wildfire and therefore reduce the surface area that is susceptible to sediment runoff. About 90% of fire starts occur along the highways bordering and bisecting the watershed. With effective grazing management, fire starts can be contained more rapidly, preventing the spread of fire to the sensitive stream corridor. This will protect water quality within Wailulaula stream as well as coastal areas.

The following table provides criteria to measure success in achieving this watershed and ecosystem health goal.

Indicators	Targeted load, level or value
Fuel loads / stubble height	Fuel loads of 1,500 lbs/acre for buffel grass (key forage species) and 3" stubble height
Annual acreage burned	Less than an average of 100-acres burned per year throughout the watershed.

<u>Objective 3a</u>: Reduce size of wildfires to an average of 100 acres burned per year by 2015 in the fire prone area between Queen Kaʻahumanu Highway and 1,200-ft. elevation by using grazing to manage fine fuel loads.

Project FIRE-1. Fence lower watershed between Queen Kaʻahumanu Highway and the rock wall at 1,200-ft. by 2013 to manage fine fuel loads with cattle grazing.

The lower watershed between Queen Kaʻahumanu Highway and the rock wall (1,200-ft. elevation) is neither fenced nor grazed. Consequently, this area and its immediate vicinity have burned repeatedly over the past few decades, including a 630-acre fire within the project area in March 2010. This 1,350-acre project area represents about 8% of the roughly 18,000-acre watershed. N-SPECT modeling suggests that if this ungrazed area were to burn, sediment loads would increase sevenfold (3,702 to 26,755 kg/yr.). Phosphorus loads would more than double (33 to 77 kg/yr.) and Nitrogen loads would more than triple (194 to 627 kg/yr.).

<u>Project Tasks</u>:

- *Develop agreement between landowners, land user (grazer) and MKSWCD regarding the implementation and maintenance of the project.*
- *Work with land user to amend his conservation plan to include the project area and develop a grazing system that meets NRCS standards and specifications.*
- *Survey and map intended fence alignment and location of gates for approval of landowners.*
- *Install approximately 6.8 miles of new cattle fence in conformance with NRCS standards and specifications, including perimeter fence along Kawaihae Road, Queen Kaʻahumanu Highway, the rock wall, the north side of Waiʻulaʻula stream and cross-fencing at 600-ft. elevation.*
- *Install water pipeline and infrastructure in conformance with NRCS standards and specifications to convey water to troughs strategically-placed in the paddocks to ensure even grazing and sufficient reduction of fuel loads along highways, and to keep cattle away from stream.*
- *When the cattle fence has been installed and the pipelines and troughs are operational, permanent monitoring points will be established to assess fuel loads at the onset of grazing activities. Initial monitoring of the grass loads*

will take place as soon as the fence is complete and prior to the introduction of cattle to the project area.

- *Land user will graze approximately 400 head of cattle within the project area for about 60 days per year, during the wet season that instigates rapid growth of the dominant buffel grass cover.*
- *Conduct bi-weekly stubble height monitoring when cattle are present as a management tool to determine when cattle should be rotated out of paddocks, based on the minimum heights established under NRCS's standards and specifications.*

Project FIRE-2. By 2018, develop a project to reduce the fuel load in the unfenced, ungrazed area below Queen Kaʻahumanu Highway (to sea level) in consultation with land owners, Hawaiʻi Wildfire Management Organization, NRCS, UH Cooperative Extension Service, and possible grazers.

While equally important, managing the fuel load in the 80-acre fire-prone area below Queen Kaʻahumanu Highway is a much more difficult undertaking. Unlike the area above Queen Kaʻahumanu Highway, it does not adjoin an area currently grazed, and the question of how to move cattle (or another type of ungulate such as sheep) has been the subject of many discussions. Water is also not readily available. For these reasons, MKSWCD sees this as a longer-term project, so that options can be explored, a willing grazer found, and issues of public access to Mauʻumae Beach and along the Ala Kahakai National Historic Trail addressed. In this plan, we propose continuing the discussions and identifying possible solutions that will be presented separately for implementation funding.

Project Tasks:

- *Assembled a committee to explore the issues, including representatives of the land owners, MKSWCD, NRCS, UH Cooperative Extension Service, HWMO, and possible grazers.*
- *Conduct site visit(s) and meet to discuss and agree upon the most cost-effective and practical way to manage the fuel load.*
- *Submit proposal for implementation funding (project costs and timeframes TBD).*

Objective 3b: By 2020, install measures within the watershed to facilitate rapid response by fire suppression agencies in the event of a fire start, to include reducing fuel loads in a 150-ft. to 300-ft. buffer zone around neighborhoods and along roadways by 80%.

Because of the history of wildfire in the Waiʻulaʻula watershed, it is important to implement additional on-the-ground mitigation measures and pre-suppression planning to reduce the number and/or severity of fires and facilitate fire-fighting in the event of a fire. Managing fuel loads and providing on-the-ground resources that will assist fire fighters will be especially important in the future, with climate change likely causing conditions (changes to vegetation, rainfall patterns, wind speed and/or direction) that will exacerbate the fire-grass cycle.

Effective pre-suppression planning enables firefighters and land managers to more easily and effectively control a fire. Knowing the location in the watershed of sensitive resources (natural and cultural) that are a priority for protection, water resources, access points, roads, and the types of equipment available from land users for fire suppression will enable a quick and effective initial attack against fire outbreaks.

Availability of water is critical to the suppression of fire. Water use agreements and strategically-placed water sources within the watershed, such as pipelines and water tanks (Project SED-2, Project FIRE-1), allow first responders to more-quickly respond to a fire in the first hour, which can be the difference between a 100 acre or several thousand acre fire.

Fuel breaks, areas where vegetation that easily carries fire has been reduced, keep firestarts from spreading quickly, provide access for fire-fighting, and divide fire-prone areas into smaller areas that provide easier fire control. These can be strategically-located and established through grazing, mowing, weed-whacking, bull-dozing, and strategic use of herbicides. Cattle grazing along the southern boundaries of the neighborhoods of Kanehoa, Anekona, ʻŌuli Ekahi already provide a fuel break of sorts to attenuate the fire risk to these communities. More fuel breaks are needed, especially along Kawaihae Road, Queen Kaʻahumanu Highway, and Kohala Mountain Road.

Project FIRE-3. Update fire resource maps that cover the Waiʻulaʻula watershed by 2012.

Project Tasks:

- *Meet with HWMO personnel and large land owners in the Waiʻulaʻula watershed to verify and update information for the fire resource maps, including primary responders by location, location of sensitive cultural and natural resources, water resources, roads, access points and access codes/keys, available equipment for fire suppression, and contact information for land owner representatives.*
- *Work with HWMO to update the maps and provide copies (paper and electronic) to State and county fire response agencies.*

Project FIRE-4. Facilitate development and/or update of water use and access agreements between private land owners in the Waiʻulaʻula watershed and fire response agencies by 2012.

Project Tasks:

- *Help execute agreements between private land owners in the watershed (Parker Ranch, Queen Emma Land Co., Mauna Kea Properties, Mauna Kea Resort, Hapuna Prince Hotel, etc.) and fire response agencies to facilitate rapid access to water sources on private property in the event of a wildfire.*

Project FIRE-5. Construct and/or maintain at least 6 miles of fuel breaks by 2017 to protect residential communities in fire-prone areas from wildfire and to slow spread of fire starts along roadways in the watershed.

Project Tasks:

- *Survey and map existing fuel breaks and note current condition of those breaks.*
- *Evaluate current grazing adjacent to Kamuela Plantations, Lālāmilo (DHHL), Kanehoa, Anekona, ʻŌuli Ekahi for its effectiveness in protecting these communities from wildfire.*
- *Work with HWMO to identify and map priority residential areas and roadsides in need of protective fuel breaks. Calculate current fuel loads in a 150-ft. to 300-ft. wide buffer zone around priority residential areas and along priority roadways.*
- *Determine most appropriate type of fuelbreak for each area. An emphasis will be on the use of existing cattle grazing to reduce fuel loads in priority areas.*
- *For fuel breaks around residential areas, present proposed fuel break projects to each relevant neighborhood association for comments and concerns.*
- *Create approximately 6 miles of fuel breaks. Fuel breaks will be a minimum of 150-ft. wide. Develop a maintenance plan to ensure regular maintenance of fuel breaks, especially preceding the dry season.*
- *Measure changes in fuel loads at representative sites within fuel breaks on a semi-annual basis.*

Objective 3c: In cooperation with HWMO, develop a post-fire restoration manual of effective practices by 2015.

Sometimes, areas that have been overgrazed, experienced fires, or suffered severe erosion remain bare for long periods of time, exacerbating their erosion potential. This can occur for a number of reasons: absence of seeds in the soil, poor or depleted soil quality, capping of the soil making seed penetration difficult, and lack of rainfall or other forms of irrigation. Opportunistic species of grasses and plants introduced into an area are sometimes less effective for erosion control and create a greater fire hazard (*e.g.*, fountain grass). Frequently, the riparian corridor, which normally would provide a buffer to polluted runoff entering the streams, is completely denuded during a fire, because of its tremendous fuel load in the form of trees and shrubs. In these situations, there may be a need for human assistance in restoring or revegetating areas severely impacted by wildfires or other causes, particularly in the riparian zone. There is currently little data available on successful revegetation of burned areas in Hawaiʻi.

Project FIRE-6. In cooperation with HWMO, develop a post-fire restoration manual of effective practices by 2015.

Project Tasks:

- *In coordination with HWMO, develop a post-fire restoration manual of effective practices to restore burned areas following fires. The manual will also be applicable to other denuded lands, whatever the cause. The manual will address large- and small-scale restoration of grasslands and riparian corridors, using grasses, fire-resistant species, and native species. Development of the manual will involve research on post-fire revegetation techniques used in dry environments around the world, small-scale test plots to determine effectiveness of practices in Hawai'i's leeward environments, and consultation with local and Mainland experts.*
- *Organize and host a workshop to present information to land and resource managers and others.*
- *Implement techniques developed to remediate burned areas (project costs and timeframes TBD).*

Goal 4: Reduce the volume and increase the quality of stormwater runoff in the urban and suburban areas of the Wai'ula'ula watershed.

Urban development can have a negative impact on the hydrology and water quality of a watershed. Impervious surface area is often associated with polluted runoff. The "hardening" of the landscape that comes with urbanization increases runoff volumes and pollutant loadings. Impervious surfaces, such as rooftops, roads, parking lots, and sidewalks, decrease the infiltration capacity of the ground and result in greater runoff volumes that can exacerbate flooding problems. Urban development also causes an increase in pollutants, such as excessive nutrients, pathogens, hydrocarbons, heavy metals, and toxins.

Based on a limited amount of data, it appears that urban runoff in parts of the Wai'ula'ula watershed exceeds State water quality criteria for sediment (by a factor of five), TP (by a factor of four), TN (by a factor of three), and nitrate (slightly greater than the standard). These problems can be addressed during the implementation timeframe of this management plan.

N-SPECT was used to model future pollutant loads, given the land use changes (mostly urban and suburban expansion) projected in Hawai'i County's General Plan LUPAG. With future development scenarios, sediment loads will decrease but stormwater runoff volume and nutrient loads will increase.

The following table provides criteria to measure success in achieving this watershed and ecosystem health goal.

Indicators	Targeted load, level or value
Total Suspended Sediment (TSS)	By 2020, reduce pollutants loads in stormwater runoff conveyed directly into streams or into dry wells in close proximity to stream channels by 50%.
Total Nitrogen (TN)	
Total Phosphorus (TP)	
Runoff Volume	A percentage increase in runoff volume less than 5% from new developments in the watershed, and a decrease of runoff volume of at least 5% from existing development.

<u>Objective 4a</u>: By 2020, treat 70% of urban stormwater runoff that is conveyed directly into streams and 30% of stormwater conveyed to dry wells in close proximity to stream channels.

Many roads within the Wai‘ula‘ula watershed are fitted with curb and gutter catch basins to convey stormwater away from roads. This nutrient- and sediment-laden stormwater is then discharged into dry wells or directly into streams, affecting either groundwater or surface water. While Izuka *et al.* (2010) examined the potential effects of dry wells on county roads on the water quality of receiving waters at the coast and in drinking water wells, they did not consider effects to surface waters. On other roads, stormwater is conveyed to grassy shoulders on either side of the road, where it ponds until it is either absorbed or runs off. All existing bridges in the watershed have scuppers that discharge stormwater directly into the streams below.

There are several new residential development projects, highway projects, road realignments, bypasses, and new bridges proposed for the watershed. These provide opportunities for the District to work with the responsible State and county agencies to ensure the projects protect sensitive aquatic ecosystems, consider types and locations of permanent erosion and sediment controls, and manage stormwater through a combination of structural and non-structural practices.

Project STORM-1. Install storm drain and curbside catch basin filter inserts by 2016 on priority drains/ basins that discharge directly into streams.

<u>Project Tasks</u>:

- *Survey and map all storm drains and curbside catch basins in Waimea, quantify impervious surface areas, and determine which flow into dry wells and which flow directly into streams.*
- *Model volume of runoff from 2 year-24 hour storm event generated in the catchment areas of storm drain systems that discharge directly into streams.*

- *Prioritize storm drains and curbside catch basins for treatment upgrade based on discharge into stream systems.*
- *In cooperation with the County Division of Public Works (DPW), research available catch basin insert products and select product based on design features, pollutants captured, effectiveness, cost, and ease of installation and maintenance.*
- *In cooperation with the County DPW, install catch basin filter inserts on priority storm drains/ curbside catch basins.*
- *Work with County to establish a maintenance plan and establish a tracking system to gage effectiveness of catch basin insert program.*
- *Monitor water quality from end of storm pipe(s) discharging into stream before and for every storm event for one year after installation of filter inserts. Parameters to be monitored include TSS, TP, TN.*

Project STORM-2. By 2018, install catch basin filter inserts on priority dry wells that are in close proximity to streams, where stormwater carrying pollutants may rapidly seep into stream channels.

Project Tasks:

- *Based on survey, mapping, and modeling conducted under Project STORM-1, prioritize dry wells for treatment upgrade based on proximity to streams.*
- *In cooperation with the dry well owners (private or public), install catch basin filter inserts on priority dry wells.*
- *Work with dry well owners to establish maintenance plan and tracking system to gage effectiveness of catch basin insert program.*
- *On a representative dry well, monitor water quality entering storm drain and water quality below the filter insert. Parameters to be monitored include TSS, TP, TN.*

Objective 4b: Conduct semi-annual educational events to engage residential property owners in managing stormwater onsite for three years before 2016.

Project STORM-3. Develop and implement a public education and outreach program for residential stormwater management.

Project Tasks:

- *Develop or adapt outreach materials about innovative residential stormwater management, including fact sheets about best management practices, including stormwater harvesting (rain barrels, cisterns), rain gardens, and pervious pavement.*
- *Distribute information through MKSWCD website and at community outreach events.*

- *Conduct two educational events per year for three years, including hands-on events and demonstration projects.*

Objective 4c: Decrease volumes flowing offsite and increase treatment of stormwater from existing commercial and residential developments by 15% by 2023.

In response to flood hazards caused by development in the early 1980s, all new urban developments (with very few exceptions) have been mandated by Hawai'i County to maintain pre-development runoff conditions (Kuba 2005). Developers island-wide are now routinely required to dispose of all development-generated runoff onsite. These requirements have been codified in Chapter 23, HCC, "Subdivisions," Chapter 25, HCC, "Zoning," and Chapter 27, HCC, "Flood Control." Hawai'i County relies on deep (+20 feet) 5-feet diameter drainage injection wells (or "dry wells") as the primary means of capturing and disposing of stormwater runoff.

Older developments that pre-date the changes in regulations often convey stormwater runoff directly offsite into streams and storm drainage systems, which can contribute to flooding during large storm events. While not required by State or county directives, upgrading existing stormwater control structures to meet new requirements would help reduce both volume and pollutant loads in stormwater runoff.

Project STORM-4. Upgrade existing urban runoff control structures on a priority basis.

Project Tasks:

- *Survey existing urban runoff control structures in commercial and residential developments and identify and prioritize needed upgrades/ improvements to reduce runoff pollutant concentrations and volumes or retain conveyance of polluted runoff onsite.*
- *Work with landowners to identify cost-share opportunities to retrofit/upgrade existing urban runoff control structures.*
- *Survey stream corridor rehabilitation opportunities that would help attenuate effects of runoff from existing development by improving retention and treatment capabilities of riparian corridors.*
- *Implement improvements to priority urban runoff control structures in coordination with land owners (project costs and timeframes TBD).*

Objective 4d: Develop written pollution prevention procedures for the operation and maintenance of existing County roads, highways, and bridges by 2019 to reduce pollutant loadings to surface waters.

New publicly-constructed roads, highways and bridges, and privately-constructed roads, highways and bridges that are transferred over to the State or county as public roadways upon completion of construction must comply with State and county standards. New privately-constructed roads, highways, and bridges that remain private must comply with counties

requirements for erosion and sediment control, stormwater management, drainage, zoning and subdivisions.

The State and county are responsible for maintenance of their respective roads, highways, and bridges. Chapter 19-127.1, HAR, administered by DOT, establishes design, construction and maintenance guidelines that should be followed in the construction, reconstruction, and maintenance of all highways, streets, or roads undertaken either by State or county authorities or by individuals intending to dedicate the facilities to governmental authorities. Hawai‘i County, however, does not have separate written operation and maintenance guidelines for its roads, highways and bridges.

Project STORM-5. Work with the County to formalize operations and maintenance practices for County roads, highways, and bridges by developing written guidelines.

Project Tasks:

- *Using the “Pollution Prevention and Good Housekeeping” chapter of Hawai‘i DOT’s Oahu Storm Water Management Program Plan (DOT 2007) as a model, draft maintenance guidelines for debris control, chemical application, erosion control, maintenance facilities (baseyards, etc.), and flood control facilities related to County roads, highways and bridges.*

Objective 4e: By promoting use of Low Impact Development techniques, reduce the volume of stormwater runoff conveyed offsite from new large developments by 2025 so that total runoff volumes calculated by N-SPECT modeling of land use changes do not increase as urban and suburban expansion occurs.

As noted above, urban development generally increases stormwater runoff volumes. Low Impact Development (LID) is a relatively new concept in stormwater management. “It incorporates a suite of landscaping and design techniques known as “Better Site Design” that attempt to maintain the natural, pre-development hydrology of a site and the surrounding watershed” (Horsley Witten Group 2006, p. 1-2). The goal of LID is to minimize the environmental footprint of a development, while retaining the owner's purpose for the site. According to Horsley Witten (2006), more concentrated (cluster) design creates less impervious area, generates less surface runoff, and requires smaller infrastructure for drainage and other utilities. EPA has found that implementing LID practices saves money for developers, property owners and communities while protecting and restoring water quality (EPA 2007).

Urban developments (with very few exceptions) have been mandated by Hawai‘i County to maintain pre-development runoff conditions (Kuba 2005). Developers island-wide are now routinely required to dispose of all development-generated runoff onsite. These requirements have been codified in Chapter 23, HCC, “Subdivisions,” Chapter 25, HCC, “Zoning,” and Chapter 27, HCC, “Flood Control.” In addition, Hawai‘i County’s Zoning ordinance provides for cluster development and flexible design standards, though it is not well-publicized. It may also allow for innovative stormwater management techniques, reduced street and sidewalk widths, and

other management measures to attenuate runoff from developments. While it does not explicitly promote the minimizing of impervious surfaces, the County may permit the use of pervious pavements and other management measures that are not currently allowed under regular zoning and subdivision provisions. Cluster development can result in a cost savings with respect to infrastructure.

Workshops on LID techniques for Hawai'i have been held on other islands, and informational resources have been developed for Hawai'i (see Horsley Witten 2006). However, large landowners and developers on Hawai'i Island may not be familiar with these resources. Therefore, there is a need develop outreach programs to landowners, businesses, and land management agencies in order to encourage use of LID techniques in new urban developments. Key large landowners to target in the short term for the Wai'ula'ula watershed include Department of Hawaiian Homelands, Parker Ranch, and Mauna Kea Properties.

Project STORM-6. Develop and implement a LID outreach program for large landowners, developers, State and county land managers and permitting agencies, and engineering and land use planning firms by 2015.

Project Tasks:

- *Organize and host a workshop on LID techniques and applicable regulations, with site visit(s), for large landowners, developers, State and county land managers and permitting agencies, and engineering and land use planning firms.*
- *Make documents on LID available for download on the MKSWCD website.*
- *Meet with individual land owners to discuss the possibility of implementing small-scale LID projects to demonstrate the effectiveness of these techniques.*
- *Submit proposal for implementation funding for small-scale LID project (project costs and timeframes TBD).*

Goal 5: Restore and enhance riparian buffers that serve as protective filters for streams in the Wai'ula'ula watershed.

A riparian buffer is land next to a stream that is vegetated, usually with trees and shrubs, which serves as a protective filter for streams. It protects water quality against pollutants and helps stabilize eroding streambanks. Establishing riparian buffer zones and protecting existing riparian zones help in trapping sediment and particulates, in slowing flows, and in increasing water percolation. Riparian buffers can vary in width, depending on the stream, soil type, vegetation, slope, surrounding land use, and desired level of protection.

In Hawai'i, riparian buffers are afforded the greatest protection within the Conservation District. DLNR manages lands in the Conservation District in order to conserve, protect, and preserve the important natural resources of the State through appropriate management and

use to promote their long-term sustainability. The headwaters of the streams in the Waiʻulaʻula watershed originate in the conservation district. The southeastern portion of the conservation lands within the Waiʻulaʻula watershed are designated as part of the Kohala Watershed Forest Reserve. Another portion is designated the Kohala Restricted Watershed. The remaining conservation lands within the Waiʻulaʻula watershed are part of the Puʻu o ʻUmi Natural Area Reserve. The conservation lands of the Waiʻulaʻula watershed are also part of the Kohala Watershed Partnership.

Outside of the conservation district, the State does not have a specific process by which to protect wetlands and riparian areas. These areas are afforded marginal protection under regulations addressing flood plains, stormwater, and zoning. However, these regulations are aimed primarily at protecting homeowners from flooding rather than protecting the functions of riparian buffers. Many of the riparian corridors in the Waiʻulaʻula watershed pass through grazing lands, where, historically, cattle have been provided access to streams for water. Many of these grazing lands, particular below 2,600-ft. elevation are marginal agricultural lands because of dry conditions and invasive grass species (*i.e.*, fountaingrass).

N-SPECT modeling has shown that for every 100-ft. of stream corridor converted to evergreen cover[10], an average of 900 kg/yr. of sediment, 86 kg/yr. of phosphorus, and 293 kg/yr of nitrogen are reduced. These numbers vary by elevation of the restored riparian buffer and pollutant type.

A first step to restoring riparian buffers is the development of a mechanism by which to identify environmental problems present within a stream system and along its riparian corridor and to provide sufficient information on each problem so that both the severity and correctability can be determined and restoration efforts can be prioritized. Maryland has developed survey protocols for a Stream Corridor Assessment to rapidly measure the general physical condition of a stream system and identify the locations of a variety of environmental problems within its stream corridors (Yetman 2001). These problems could include erosion sites, inadequate stream buffers, fish migration blockages, exposed or discharging pipes, channelized stream sections, trash dumping sites, in or near-stream construction, streambank instability, areas prone to flooding, and any unusual conditions. Project MONIT-1 will develop such a survey tool to help determine specific areas in which to focus limited resources.

Bishop Museum has developed an interactive plant key designed to assist in selecting native plants appropriate for their outplanting sites. This plant key *Riparian Plant Restoration: A Management Tool for Habitat Restoration in Hawaiʻi* can be found at http://hawaiiconservation.org/resources/publications/pacific_island_plant_restration_database.

[10] from scrub/shrub below 2,600-ft. elevation and from grassland above 2,600-ft. elevation.

The following table provides criteria to measure success in achieving this watershed and ecosystem health goal.

Indicators	Targeted load, level or value
Total Suspended Sediment (TSS)	By 2020, a 10% reduction in modeled loads, using N-SPECT.
Total Phosphorus (TP)	
Total Nitrogen (TN)	
Linear feet of riparian corridor fenced and restored	25,000-ft. total by 2025
New legislation protecting wetlands and riparian buffers	Established by 2018
Number of people accessed by public education and outreach	8,500 people by 2025

<u>Objective 5a</u>: By 2025, restore 25,000-ft. of stream riparian corridor to provide an adequate buffer for managing stormwater, reducing pollutant loads by 10% from current levels, protecting from property loss due to flooding and erosion, and creating healthy habitat for native aquatic species.

Project STREAM-1. By 2017, convert marginal agricultural lands within a 15,000-ft. length of the stream corridor into native vegetation under the Hawai'i Conservation Resource Enhancement Program.

Through the Hawai'i Conservation Resource Enhancement Program (CREP), program participants receive financial incentives to voluntarily enroll and remove marginal pastureland from agricultural production and convert the land to natives grasses, trees and other vegetation. Hawaii CREP will provide for restoration of previously forested, degraded agricultural land. This project will improve water quality and quantity by reducing soil runoff, increasing potential ground absorption, and reducing stream sedimentation and nutrient loading to near-shore environments.

<u>Project Tasks</u>:

- *Using results of the stream corridor assessment conducted under Project MONIT-1), prioritize stream corridor segments in need of restoration by 2013 based on severity of problem and correctability. Identify stream corridor segments by elevation, land use, threat and/or problem.*
- *Identify riparian corridor areas experiencing streambank erosion/ instability, being used by cattle for water (relates to Project NUTR-2), and/or located within degraded or marginal pastureland.*
- *Identify interested land users for participation in CREP. Determine eligibility and extent of area that will be included in CREP.*
- *Assist land user(s) in enrolling in CREP, through NRCS.*

- *Develop or amend conservation plans for the areas, in consultation with MKSWCD and NRCS.*
- *Fence and restore at least 15,000-ft. of riparian corridor within marginal agricultural lands (specific site TBD). Buffer width can be between 30-ft. and 1,320-ft. depending on circumstances specific to each site.*

Project STREAM-2. Conduct semi-annual educational events, including hands-on events and demonstration projects, for three years before 2016 to educate the public about the importance of riparian buffers.

Project Tasks:

- *By 2013, develop or adapt informational materials for streamside property owners about the importance of riparian buffers for managing stormwater, protecting from property loss due to flooding and erosion, and creating healthy habitat for native aquatic species. Include information about appropriate riparian plants based on elevation and proper planting techniques.*
- *Distribute information through MKSWCD website and at community outreach events.*
- *Conduct two educational events per year for three years, including hands-on events and demonstration projects.*
- *In cooperation with the land owner (Parker School), re-establish a riparian buffer along Waikoloa Stream from upstream of the KTA Shopping Center to behind the Waimea Community Education building by 2015 as part of providing hands-on educational events to community members. This highly-visible 1.5-acre site in the middle of Waimea town is a perfect teaching site and will help inspire and promote other riparian restoration efforts.*

Project STREAM-3. Prioritize riparian buffers for restoration, and work with land owner(s) to implement restoration project(s) on at least 10,000-ft. of priority stream corridors.

Project Tasks:

- *Using results of the stream corridor assessment conducted under Project MONIT-1), prioritize stream corridor segments in need of restoration by 2013 based on severity of problem and correctability. Identify stream corridor segments by elevation, land use, threat and/or problem.*
- *Develop a Comprehensive Riparian Management Plan by 2017 that identifies describes restoration activities for each priority stream corridor segment, including fencing, weed removal, planting, streambank stabilization, ongoing maintenance, and Adopt-a-Stream suitability and other community involvement opportunities.*

- *Fence and restore a minimum of 10,000-ft. of priority stream corridors within the Waiʻulaʻula watershed by 2021 (specific sites TBD).*

<u>Objective 5b</u>: By 2018, establish a county regulatory mechanism that specifically protects wetlands and riparian areas of perennial streams on Hawaiʻi Island.

There are mechanisms that could be used to strengthen protection of riparian areas. Mechanisms such as overlay districts or zones have been used in recent years around the U.S. to provide a framework for conservation of special geographical areas. An overlay district is an additional zoning requirement that is placed on a geographical area but does not change the underlying zoning.

Project STREAM-4. Help draft policy language to enact an overlay district that explicitly protects wetlands and riparian areas.

<u>Project Tasks</u>:

- *Work with Hawaiʻi County Council members to draft legislation creating an overlay district that enhances protection of wetlands and riparian areas of perennial streams. An overlay zone focused on conserving natural features, such as wetlands, riparian areas, aquifers, or other sensitive resource areas, would typically impose greater restrictions on the development of the land, but only on those parcels whose development, as permitted under the zoning, may threaten the viability of these features. In the context of protecting wetlands and riparian areas, an overlay district could be adopted that contains setback provisions, requires a portion of the existing vegetation to be maintained as a buffer, limits the amount of tree and shrub clearing, limits impervious surfaces in the stream buffer unless approved by special permit, or requires the use of additional BMPs.*
- *Use informational materials developed under STREAM-2 to educate lawmakers and the public about the importance of riparian buffers for managing stormwater, protecting from property loss due to flooding and erosion, and creating healthy habitat for native aquatic species.*
- *Develop informational materials about the benefits of an overlay district to help protect riparian areas.*

Goal 6: Protect aquatic habitat and manage instream flows.

Freshwater streams have many values. They provide irreplaceable habitats for aquatic fauna and flora. Streams link the mountains with the ocean. They are essential to the productivity and quality of Hawaiʻi's nearshore waters. Stream health is both integral to the survival of the unique stream organisms and indicative of the overall quality of our island environment.

The Waiʻulaʻula watershed is exceptional, from a native aquatic species standpoint. According to Englund (2010), "[t]he relatively high 65% overall native aquatic insect biodiversity found within the entire Waiʻulaʻula watershed is comparable to other high quality streams (p. 12)." In the upper reaches of Keanuʻiʻomanō, Waikoloa, and Kohākōhau streams, native species are even more dominant, maintaining an exceptionally high diversity "equaling any high quality stream found in the Hawaiian archipelago" (Englund 2010; p. 12). Stream surveys have noted all five native stream fish species in various locations throughout the watershed, from the Waiʻulaʻula estuary to about the 2,700-ft. elevation. These species require streamflow for their survival. Their presence at various elevations in the Waiʻulaʻula watershed "indicates that native fish traverse long stretches of intermittent stream channels during periods of flowing water, using the ephemeral stream habitat as an access corridor to the headwater regions…" (Englund 2010; p. 11).

The Water Commission, as provided for under the State Water Code (Chapter 174C, HRS), sets policies and approves water allocations for all water users. Existing uses established prior to 1987 are grandfathered in, provided the existing use is reasonable and beneficial. The Water Commission also establishes instream flow standards for perennial streams, in order to balance maintenance of fish and wildlife habitat, estuarine, wetland and stream ecosystems, and water quality with use of the water. Section 13-169-46, HAR, establishes interim instream flow standards (IFS) for Hawaiʻi. These were generally defined as the amount of water flowing in each stream on the effective date of the standard (1988). The standards for some individual streams have subsequently been amended as a result of petitions to amend the IFS and describe the amount of water that can be withdrawn from the stream. Specific instream flow standards have not been established for any streams within the Waiʻulaʻula watershed.

At the same time, there are legal and illegal diversions of water that reduce otherwise normal streamflow volume. It is vital to the survival of these endemic species that adequate streamflow is ensured through a careful analysis of all diversions of water from streams in the watershed, and that unneeded or unauthorized diversions are removed to enhance stream ecosystems.

The following table provides criteria to measure success in achieving this watershed and ecosystem health goal.

Indicators	**Targeted load, level or value**
Dissolved Oxygen (instream perennial pools only)	Every measurement shall be 80% saturation or greater; additionally, absolute values shall never fall below 6.25 mg/l (80% saturation of water at 86ºF (30ºC)).
Total Phosphorus (TP)	By 2025, the geometric mean of measurements for all indicators shall be less than water quality standards for the dry season in any year and at any sampling site.
Total Nitrogen (TN)	

Indicators	Targeted load, level or value
Temperature (instream perennial pools only)	Between noon and 3 p.m., the surface water temperature shall be not more than 10ºF greater than air temperature in the shade.
Diversity of native aquatic insects within the watershed	At a minimum, maintain 65% overall native aquatic insect biodiversity within the entire watershed
Number of unpermitted diversion and instream structures	90% reduction
Total volume of water withdrawn annually from all diversions	Annual diversions should not exceed half the combined flow at the Marine Dam and Kohākōhau stream gages.

<u>Objective 6a</u>: By 2021, ensure that instream flows for the streams within the Waiʻulaʻula watershed balance permitted sustainable water use and protection of the biological, chemical, and physical integrity of these waters, and that annual diversions do not exceed half the combined flows at the Marine Dam and Kohākōhau stream gauges.

Project AQU-1. Work with landowners and the Water Commission to permit or remove 100% of illegal diversions by 2018.

<u>Project Tasks</u>:

- *Using results of the stream corridor assessment conducted under Project MONIT-1), identify all diversions within the Waiʻulaʻula watershed.*
- *Work with Water Commission staff to identify permitted and unpermitted diversions.*
- *Develop or adapt an outreach program about Hawaiʻi's native aquatic species and the importance of maintaining instream flows. Develop a fact sheet about Water Commission permits and procedures.*
- *Distribute information through MKSWCD website and at community outreach events.*
- *Attend neighborhood association meetings in subdivisions with unpermitted withdrawals of stream water to present information and answer questions.*
- *Support the Water Commission in taking action against illegal withdrawals if public outreach does not succeed in permit requests or remedial actions by land owners.*

Project AQU-2. Evaluate need for specific instream flow standards for streams within the Waiʻulaʻula watershed by 2019.

Project Tasks:

- *Measure actual water withdrawals from diversions in the watershed to determine a total average annual withdrawal amount for each stream in the watershed.*
- *Work with the Water Commission to evaluate current and anticipated water withdrawals from the streams within the watershed to determine if specific instream flow standards are required.*

Objective 6b: Maintain or improve the current native species diversity of fish and invertebrate communities in the Waiʻulaʻula watershed by 2025.

Project AQU-3. Consult with experts by 2016 to determine if existing dams and other instream structures are having a negative effect on ʻoʻopu instream migration.

Project Tasks:

- *Using results of the stream corridor assessment conducted under Project MONIT-1), identify all dams and other instream structures within the Waiʻulaʻula watershed.*
- *Work with Water Commission staff to identify permitted and unpermitted in-stream structures. Support the Water Commission in taking action against illegal in-stream structures.*
- *Consult ʻoʻopu experts about the effects of existing, permitted dams on ʻoʻopu migration and seek advice on possible remedial actions.*
- *Depending on expert advice, submit proposal for implementation funding for "effective removal"[11] of barriers to ʻoʻopu passage (project costs and timeframes TBD).*

Project AQU-4. Prevent further introduction of invasive aquatic species into the streams and identify how to remove existing invasive species that threaten native species by 2020.

Project Tasks:

- *Develop or adapt outreach materials about the damage invasive aquatic species can have on the native Hawaiian aquatic ecosystem as a way to reduce new introductions. Distribute materials to streamside homeowners and schools.*
- *Monitor for potentially-harmful invasive species when a threat to native fauna is likely.*

[11] "Effective removal" can mean physical removal, breaching of a barrier, installation of fish passage structures, or implementation of other fish passage strategies to result in effective fish passage around or through a barrier.

- *Consult with aquatic ecosystem experts on how best to remove invasive aquatic species from the watershed without harming native species. Submit research proposals to evaluate impacts and possible control measures, if necessary.*

Project AQU-5. By 2015, protect priority instream perennial pools that provide important habitat for native aquatic species.

Project Tasks:

- *Using results of the stream corridor assessment conducted under Project MONIT-1), identify and map all significant instream perennial pools within the Wai'ula'ula watershed.*
- *Monitor water quality in instream perennial pools (DO, TP, TN, chlorophyll-a, temperature at surface and bottom) at various elevations and on different streams within the watershed on a quarterly basis. Note presence of both native and invasive aquatic species, along with other qualitative measures of ecosystem health (e.g., stagnant water, algae, etc.)*
- *In consultation with aquatic ecosystem experts, prioritize pools based on size, depth, habitat quality, presence of native aquatic species, elevation, and distance between pools.*
- *Conduct biological surveys of aquatic species every four years, with an emphasis on sites previously monitored.*
- *Consult with aquatic ecosystem experts about how best to protect these deep pools because of their importance to the life cycle of Hawai'i's native aquatic species.*
- *Depending on expert advice, implement measures to protect priority instream perennial ponds.*

Goal 7: Increase public education, understanding, and participation regarding watershed issues.

Educating the public about the Wai'ula'ula watershed, its resources and values, threats to these resources and values, and management activities is vital to all watershed restoration and protection goals and objectives. Conservation education and watershed awareness will help reduce unwanted human impacts on the landscape. Greater awareness about the watershed should also translate into greater support for management efforts, in the form of a greater community voice for conservation measures and increased volunteerism.

Public education and outreach are also helpful in recruiting a cadre of volunteers to assist in certain management activities, especially in labor-intensive efforts such as ecosystem restoration. Volunteers tend to be extremely enthusiastic, but often require an organized volunteer program to help keep motivation levels high. Hands-on opportunities both increase

awareness of watershed conditions and enable community members to participate in improving those conditions with a heightened sense of connection to the natural resources.

Many of the projects described above have a strong educational component. Initially, watershed education and outreach will be conducted by the watershed coordinator, MKSWCD personnel and contractors. However, as the program expands and more community members volunteer on projects, an education coordinator will be hired.

The following table provides criteria to measure success in achieving this watershed and ecosystem health goal.

Indicators	**Targeted load, level or value**
Number of volunteers	100 participants per year
Stakeholder awareness as measured by community survey	Increase awareness by 20% by 2020
Number of Facebook friends for Wai‘ula‘ula page	500 friends by 2020

<u>Objective 7a</u>: Increase stakeholder awareness and involvement by 15% by implementing an integrated watershed management information and education campaign by 2016.

Project EDUC-1: Develop/ adapt and distribute educational materials related to watershed issues to community members. The majority of these educational materials relate to projects described above.

<u>*Project Tasks*</u>:

- *Develop or adapt outreach materials about OSDS and potential effects on water quality and environmental and public health. Distribute information to homeowners with OSDS about the operation, maintenance, and self-inspection of cesspools and septic systems as a way to extend their operating lives and prevent failures. (Project NUTR-3)*
- *Work with HWMO to distribute educational information about mitigating wildfire risk and implementing Firewise techniques to protect homes in fire-prone areas. (Relates to Goal 3.)*
- *Develop or adapt outreach materials about innovative residential stormwater management, including fact sheets about best management practices, including stormwater harvesting (rain barrels, cisterns), rain gardens, and pervious pavement. (Project STORM-3)*
- *Develop or adapt informational materials for streamside property owners about the importance of riparian buffers for managing stormwater, protecting from property loss due to flooding and erosion, and creating healthy habitat for native aquatic species. Include information about appropriate riparian plants based on elevation and proper planting techniques. (Project STREAM-2)*

- *Develop or adapt an outreach program about Hawai'i's native aquatic species and the importance of maintaining instream flows. Develop a fact sheet about Water Commission permits and procedures. (Project AQU-1)*
- *Develop or adapt outreach materials about the damage invasive aquatic species can have on the native Hawaiian aquatic ecosystem as a way to reduce new introductions. Distribute materials to streamside homeowners and schools. (Project AQU-4)*
- *Develop or adapt targeted outreach activities and materials related to polluted runoff control, including lawn care practices, household hazardous waste disposal, low impact development techniques, graywater reuse, etc.*
- *Distribute information through MKSWCD website and at community outreach events.*
- *Use social media (i.e., Facebook) and direct emailing to distribute information about the watershed effort and educational materials, and post calendar events. Encourage people to become "friends" of the Wai'ula'ula Facebook site.*
- *Use social media to conduct baseline and periodic surveys of community awareness about watershed issues.*

<u>Objective 7b</u>: Recruit and engage volunteers to assist in at least two large community-based projects in the watershed every year beginning in 2013.

Project EDUC-2: Provide on-the-ground service learning opportunities for school children and community members.

- *Foster partnerships with landowners, agencies, local schools, stakeholders and the community at large.*
- *Coordinate and supervise volunteer efforts by community members and students. These citizen engagement efforts will include stream cleanups, trash pickups, invasive species removal, riparian plantings, and water quality monitoring.*
- *Develop and coordinate an "Adopt-a-Stream" program.*
- *Attend festivals and events to provide information at gatherings attended by the community.*
- *Hire an outreach coordinator when the educational and volunteers programs have expanded to the point that dedicated outreach personnel is needed to build on established momentum and sustain and grow efforts throughout the watershed.*

Goal 8: Provide effective project administration and management to ensure long-term success.

Implementation of the Wai‘ula‘ula watershed management plan is a long-term commitment that requires sufficient personnel and financial resources. The management plan represents more work than can be accomplished by existing personnel under the Mauna Kea Soil and Water Conservation District or its partners. Effective, coordinated implementation is required for overall success and achievement of the goals and objectives described herein. Regular monitoring of the effectiveness of the Plan as a whole is required to ensure that the recommended actions are resulting in progress toward the desired outcomes, and to take corrective actions, if necessary. As such, a Watershed Coordinator is needed to oversee partners and personnel, contractors, vendors, and stakeholders in the watershed.

The following table provides criteria to measure success in achieving this watershed and ecosystem health goal.

Indicators	Targeted load, level or value
Percentage of Wai‘ula‘ula watershed management plan implemented during the planning timeframe between 2011 and 2025	25% by 2015 55% by 2020 85% by 2025
Sustained monitoring as outlined in Chapter 6	Type and frequency of monitoring described in Chapter 6
Sustained funding	Sufficient funding to implement projects outlined in the Wai‘ula‘ula watershed management plan

Objective 8a: Establish appropriate administrative framework by 2012 to allow for effective and timely implementation of the Wai‘ula‘ula watershed plan.

Project ADMIN-1: Hire Wai‘ula‘ula watershed coordinator.

Project Tasks:

- *Hire watershed coordinator with a wide range of skills and abilities to implement, administer, and evaluate the full spectrum of projects contained in the watershed management plan.*
- *Maintain communication among project partners to facilitate information sharing and project implementation.*
- *Revise and update watershed management plan as management needs change, management techniques evolve, and new data become available.*

<u>Objective 8b</u>: Implement monitoring program described in Chapter 6, following the timeframes established.

Project: MONIT-1: When management plan implementation begins, initiate monitoring components described in Chapter 6.

<u>Project Tasks</u>:

- *By 2013, develop a stream corridor assessment mechanism by which to rapidly identify environmental problems present within a stream system and along its riparian corridor and to provide sufficient information on each problem so that both the severity and correctability can be determined and restoration efforts can be prioritized. These problems could include erosion sites, inadequate stream buffers, fish migration blockages, exposed or discharging pipes, channelized stream sections, trash dumping sites, in or near-stream construction, streambank instability, areas prone to flooding, areas of invasive plant species, and any unusual conditions.*
- *Undertake monitoring described under above projects (with details provided in Chapter 6).*
- *Monitor project implementation and measure success towards achieving project goals and objectives.*
- *Track installation of management practices and gage effectiveness of these practices in preventing or reducing pollutant loads.*
- *Institute long-term water quality monitoring described in Chapter 6.*
- *Implement monitoring of watershed conditions as described in Chapter 6.*

Table 19: Summary of Implementation Projects

#	Project	WWMP Goal	WWMP Objectives	Threats Addressed	Project Lead	Project Partners	Priority Level	Estimated Cost	Educational Component
NUTR-1	*Assist Lālāmilo Farmers with Conservation Plans*	1: Reduce nutrient loads in Wai`ula`ula WS	1a: Reduce nutrient loads in agricultural runoff runoff by 20% by 2019.	Nonpoint source pollution-ag	MKSWCD	Farmers	2	$2,563.20	Outreach to all farmers
NUTR-2	*Fence riparian areas to exclude cattle and goats*	1: Reduce nutrient loads in Wai`ula`ula WS	1b: Fence 58,000 feet of riparian corridors on Keanu`i`omanō and Waikoloa Streams by 2023.	Nonpoint source pollution-ag	MKSWCD	Ranchers	1	$452,400 ($7.80/l.f.)	Outreach to all farmers
NUTR-3	*Onsite disposal systems (OSDS) outreach and education*	1: Reduce nutrient loads in Wai`ula`ula WS	1c: Increase inspections and maintenance of OSDS by 20% by 2019	Non-point source pollution-wastewater disposal systems	MKSWCD	DOH, County, Realtor Assn.	1	$15,000-$25,000	Presentations; general outreach materials, door to door
NUTR-4	*Incorporate point of sale inspections of OSDS*	1: Reduce nutrient loads in Wai`ula`ula WS	1c: Increase inspections and maintenance of OSDS by 20% by 2019	Non-point source pollution-wastewater disposal systems	MKSWCD	DOH, County, Realtor Assn.	2	$5,000-$10,000	Presentations; general outreach materials
SED-1	*Assist farmers in Lālāmilo Farmers with Conservation Plans*	2: Prevent an increase in sediment loads in Wai`ula`ula WS	2a: Reduce sediment loads in ag runoff from Lālāmilo by 20% by 2019.	Nonpoint source pollution-ag	MKSWCD	Farmers	2	$2,563.20	Outreach to all farmers
SED-2	*Extend Waimea Irrigation System to rock wall*	1: Reduce nutrient loads 2: Prevent increase sediment loads 3: Reduce wildfire 5: Restore riparian buffers 6: Protect aquatic habitat	2b: Improve grazing efficiency, prevent overgrazing, limit wildfire between 1,200' and 2,600' elevation. 3b: Facilitate rapid wildfire response. 5a: Restore riparian corridor. 6a: Ensure instream flows	Nonpoint source pollution-agriculture, streambank erosion; wildfire.	MKSWCD	State Dept. of Ag.; USDA-NRCS; HWMO;	1	$170,438	Public relations via brochure, presentations

#	Project	WWMP Goal	WWMP Objectives	Threats Addressed	Project Lead	Project Partners	Priority Level	Estimated Cost	Educational Component
SED-3	*Subdivide paddocks between Lālāmilo and rock wall*	2: Prevent an increase in sediment loads in Wai`ula`ula WS	2b: Improve grazing efficiency, prevent overgrazing, limit wildfire between 1,200' and 2,600' elevation.	Non-point source pollution-ag, streambank erosion, invasive plants; Wildfire	MKSWCD	Ranchers, HWMO	1	$92,664	Presentations, tours; general outreach materials
SED-4	*ID eroding streambanks and monitor annual erosion rates*	2: Prevent an increase in sediment loads in Wai`ula`ula WS	2c: Assess riparian corridors and monitor erosion rates by 2016. 8a: Implement monitoring program	Non-point source pollution - streambank erosion	MKSWCD	CWRM, land-owners, DOH	1	$80,000-$100,000	Presentations, tours; general outreach materials
SED-5	*Remove goats from grazing areas between Queen Ka`ahumanu Hwy. and rock wall*	2: Prevent an increase in sediment loads in Wai`ula`ula WS	2d: Following fencing projects, remove all feral goats from 1,200' elev. to coast	Non-point source pollution - feral ungulates	MKSWCD	DOFAW, Ranchers	1	$5,000-$10,000	Presentations, general outreach materials
SED-6	*Remove goats from watershed below Queen Ka`ahumanu Highway*	2: Prevent an increase in sediment loads in Wai`ula`ula WS	2d: Following fencing projects, remove all feral goats from 1,200' elev. to coast	Non-point source pollution - feral ungulates	MKSWCD	DOFAW, Land-owners	2	$2,000-$5,000	Presentations, general outreach materials
SED-7	*Identify and re-vegetate all areas of bare land in the watershed*	2: Prevent an increase in sediment loads in Wai`ula`ula WS	2e: Restore bare land contributing to erosion in the watershed	Non-point source pollution	MKSWCD	Land-owners, schools, community groups	3	$791.24/ acre	Service learning, volunteers, presentations, general outreach mats.

#	Project	WWMP Goal	WWMP Objectives	Threats Addressed	Project Lead	Project Partners	Priority Level	Estimated Cost	Educational Component
FIRE-1	*Fence and graze area between rock wall and Queen Ka`ahumanu Highway*	3: Reduce wildfire occurences and impacts	3a: Use grazing to manage fine fuels and reduce wildfire size	Wildfire	MKSWCD, HWMO	State DOH, ranchers, land-owners, HWMO	1	$271,151	Presentations, tours; general outreach materials
FIRE-2	*Reduce fuel loads below Queen Ka`ahumanu Highway*	3: Reduce wildfire occurences and impacts	3a: Use grazing to manage fine fuels and reduce wildfire size	Wildfire	MKSWCD	State DOH, ranchers, land-owners, HWMO	2	$67,410 ($842.63/ acre)	Presentations, tours; general outreach materials
FIRE-3	*Develop fire resource maps*	3: Reduce wildfire occurences and impacts	3b: Facilitate rapid response to wildfires	Wildfire	HWMO	DLNR, HFD, Landowners	1	$15,000-$20,000	Presentations; general outreach
FIRE-4	*Develop agreements for water use*	3: Reduce wildfire occurences and impacts	3b: Facilitate rapid response to wildfires	Wildfire	MKSWCD	HWMO, land-owners	1	$5,000-$7,000 per agreement	Presentations; general outreach
FIRE-5	*Construct and maintain fuel breaks*	3: Reduce wildfire occurences and impacts	3b: Facilitate rapid response to wildfires	Wildfire	HWMO	MKSWCD, land-owners	2	$17,500; $9,626 maint. Yrly.	Presentations, tours; general outreach materials
FIRE-6	*Develop post-fire restoration manual*	3: Reduce wildfire occurences and impacts	3c: Develop post fire restoration practices	Wildfire	MKSWCD	HWMO, land-owners	1	$15,000-$20,000	Presentations; general outreach
STORM-1	*Install catch basin filter inserts discharging directly into streams*	4: Reduce volume/increase quality of stormwater runoff	4a: Treat urban stormwater runoff into streams and dry wells in the watershed	Non-point source pollution-urban/suburban runoff	MKSWCD	DOT/ County DPW	1	TBD	Presentations; general outreach materials

#	Project	WWMP Goal	WWMP Objectives	Threats Addressed	Project Lead	Project Partners	Priority Level	Estimated Cost	Educational Component
STORM-2	*Install catch basin filter inserts on priority dry wells near streams*	4: Reduce volume/increase quality of stormwater runoff	4a: Treat urban stormwater runoff into streams and dry wells in the watershed	Non-point source pollution-urban/suburban runoff	MKSWCD	Land-owners	2	TBD	Presentations; general outreach materials
STROM-3	*Stormwater education and outreach program*	4: Reduce volume/increase quality of stormwater runoff	4b: Conduct stormwater management outreach for residential property owners	Non-point source pollution-urban/suburban runoff	MKSWCD	DOH, DOE, EPA, County	1	$10,000-$15,000	Presentations; general outreach materials, events, workshops
STORM-4	*Upgrade existing urban runoff control structures*	4: Reduce volume/increase quality of stormwater runoff	4c: Decrease volume and increse treatment of commerical and reseidential stormwater	Non-point source pollution-urban/suburban runoff	MKSWCD	County/ land-owners	3	TBD	Presentations; general outreach materials
STORM-5	*Develop written guidelines for operations and maintenance of county roadways*	4: Reduce volume/increase quality of stormwater runoff	4d: Develop written pollution prevention procedures for the operation and maintenance of county roads, highways and bridges	Non-point source pollution-urban/suburban runoff	DOT/ County DPW	MKSWCD	3	$10,000-$15,000	Public meetings, presentations, general outreach mats.
STORM-6	*Develop and implement LID outreach program*	4: Reduce volume/increase quality of stormwater runoff	4e: Reduce volume of stormwater runoff from new developments by incorporating LID techniques	Non-point source pollution-urban/suburban runoff	MKSWCD	Office of State Planning/ County	1	$10,000-$15,000	Presentations; general outreach materials
STREAM-1	*Convert 15,000' of riparian corridor in marginal grazing lands into native vegetation via CREP*	5: Restore and enhance riparian buffers in the watershed	5a: Restore riparian corridors in the watershed	NPS pollution - ag, streambank erosion, invasive plants; Flooding	MKSWCD	USDA-FSA; ranchers; volunteers	2	$55,000	Service learning/ volunteer planting

#	Project	WWMP Goal	WWMP Objectives	Threats Addressed	Project Lead	Project Partners	Priority Level	Estimated Cost	Educational Component
STREAM-2	*Events/projects to educate about riparian buffers*	5: Restore and enhance riparian buffers in the watershed	5a: Restore riparian corridors in the watershed	NPS pollution - ag, streambank erosion, invasive plants; Flooding	MKSWCD		1		Service learning, volunteers, presentations, general outreach mats.
STREAM-3	*Restore riparian areas within the watershed*	5: Restore and enhance riparian buffers in the watershed	5a: Restore riparian corridors in the watershed	NPS pollution - ag, streambank erosion, invasive plants; Flooding	MKSWCD	Land-owners, schools, community groups	1	TBD	Service learning, volunteers, presentations, general outreach
STREAM-4	*Draft policy language to enact an overlay district protecting wetlands and riparian areas*	5: Restore and enhance riparian buffers in the watershed	5b: Establish county regulatory mechanism to protect wetlands and riparian areas on Hawaii Island	NPS pollution - ag, streambank erosion, invasive plants; Flooding	MKSWCD	Hawai'i County Council	2	$10,000	Testimony, presentations, general outreach materials
AQU-1	*Remove illegal diversions*	6: protect aqautic habitat and manage instream flows	6a: Balance sustainable water use and protection of water quality	Stream diversions	MKSWCD	CWRM	2	$20,000-$25,000 per structure, diversion	Presentations; general outreach materials; door-to-door
AQU-2	*Evaluate the need for specific instream flow standards*	6: protect aqautic habitat and manage instream flows	6a: Balance sustainable water use and protection of water quality	Stream diversions	MKSWCD	DOH, EPA, CWRM	2	TBD	Presentations; general outreach materials
AQU-3	*Determine the effect of dams on 'o'opu habitat*	6: protect aqautic habitat and manage instream flows	6b: Maintain diversity of native aquatic species in the watershed	Stream diversions	MKSWCD	DLNR/UH	2	$2,500	Presentations; general outreach materials

#	Project	WWMP Goal	WWMP Objectives	Threats Addressed	Project Lead	Project Partners	Priority Level	Estimated Cost	Educational Component
AQU-4	*Invasive aquatic species control*	6: protect aqautic habitat and manage instream flows	6b: Maintain diversity of native aquatic species in the watershed	Invasive species	MKSWCD	DLNR-DAR	1	$10,000-$15,000	Presentations; general outreach materials
AQU-5	*Protect priority instream perennial pools*	6: protect aqautic habitat and manage instream flows	6b: Maintain diversity of native aquatic species in the watershed	Stream diversions	MKSWCD	DLNR-DAR, land-owners	2	TBD	Service learning, volunteers, presentations, general outreach
EDU-1	*Develop and distribute educational materials about watershed issues to the community*	7: Increase education, understanding and participation of watershed issues	7a: Increase stakeholder awareness and involvement through an intergrated watershed education campaign	All threats	MKSWCD	DOH, EPA, CWRM	?	$10,000-$15,000	Events, volunteers, presentations, general outreach
EDU-2	*Provide on-the-ground service learning opportunities*	7: Increase education, understanding and participation of watershed issues	7b: Provide on-the-ground service learning opportunities for school groups and other members of the community	All threats	MKSWCD	Schools, community groups	?	$15,000-$20,000	Service learning, volunteers, presentations, general outreach
ADMIN-1	*Hire a Wai'ula'ula Watershed Coordinator*	8: Provide effective project administration and management to ensure long-term success	8a: Establish administrative framework to implement the Wai`ula`ula Watershed Management Plan	All threats	MKSWCD	Land-owners/ Stake-holders/ Partner Agencies	?	$90,000 per annum, salary and materials	Service learning, volunteers, presentations, general outreach mats.
MONIT-1	*Establish a Wai'ula'ula Watershed Management Plan monitoring program*	WWMP Goals 1-8	8b: Implement monitoring program described in Chapter 6 according to established timeframes	All threats	MKSWCD	Land-owners/ Stake-holders/ Partner Agencies	?	TBD	Presentations, general outreach materials

Table 20: Project Timelines

	12	13	14	15	16	17	18	19	20	21	22	23
NUTR-1 – Assist Lālāmilo farmers with Conservations Plans												
NUTR-2 – Fence riparian areas to exclude cattle												
NUTR-3 – OSDS education and outreach												
NUTR-4 – Incorporate point-of-sale inspections of OSDS												
SED-1 -- Assist Lālāmilo farmers with Conservations Plans												
SED-2 – Extend Waimea Irrigation System to rock wall												
SED-3 – Subdivide paddocks between Lālāmilo and rock wall												
SED-4 – Assess streambank erosion												
SED-5 – goat removal from rock wall to Queen Kaʻahumanu												
SED-6 – goat removal below Queen Kaʻahumanu												
SED-7 – Identify and revegetate bare land in watershed												
FIRE 1 – Fence and graze area between rock wall and Queen K												
FIRE-2 – Fence area below Queen K to manage fine fuels												
FIRE-3 – Update fire resources maps (3 periodic updates)												
FIRE-4 – Develop agreements for access and water use												
FIRE-5 – Construct and/or maintain 6 miles of fuel breaks												
FIRE-6 – Develop post-fire restoration manual												
STORM-1 – survey and line catch basins within watershed												
STORM-2 – dry well insert installation and maintenance program												
STORM-3 – stormwater education and outreach program												
STORM-4 – upgrade existing urban runoff control structures												
STORM-5 – develop operation and maintenance guidelines for roads												
STORM-6 – develop and implement LID outreach program												
STREAM-1 – convert marginal grazing lands via CREP												
STREAM-2 –events/projects to educate about riparian buffers												
STREAM-3 – restore riparian areas within the watershed												
STREAM-4 – policy language for County overlay district												
AQU-1 – remove illegal diversions												

	12	13	14	15	16	17	18	19	20	21	22	23
AQU-2 – evaluate need for specific instream flow standards												
AQU-3 – determine effects of dams on ʻoʻopu habitat												
AQU-4 – invasive aquatic species control												
AQU-5 – protect priority instream perennial pools												
EDU-1 – develop/ adapt educational materials												
EDU-2 – provide on-the-ground service learning opportunities												
ADMIN-1 – Waiʻulaʻula watershed coordinator												
MONIT-1 – implement monitoring program												

Chapter 6: Monitoring

Monitoring is an essential part of watershed planning. Monitoring can identify emerging problems or document response to changes in land use or climate. Equally important, monitoring is needed to evaluate the effectiveness of implemented BMPs.

This chapter addresses EPA's key element (i).

Monitoring activities will be conducted by MKSWCD personnel, contractors, and trained citizen volunteers.

6.1 Implementation Monitoring

Implementation monitoring determines whether the management strategies outlined in the work plan are being implemented as written. Data gathered from this monitoring will help the District determine how well it is doing in implementing the work plan, as well as help the District modify the management strategies as needed to better protect water quality.

Implementation monitoring involves:

- documenting types, amounts and locations of management activities on a quarterly basis;
- comparing results with interim milestones included in an implementation plan;
- providing feedback to stakeholders; and
- determining need for modifications.

Agendas, minutes, activity and project status reports, and other records should be maintained so that important issues and decisions are well-documented.

6.2 Land Use Monitoring

Changes in land use have the potential to result in changes to water quality or integrity of riparian habitats. Such changes should be tracked and correlated with changes in baseline water quality (see section 6.3). Each year, the watershed coordinator will compile a list of land use changes occurring in the watershed, noting

1) Planned developments that generate draft or final EIS;
2) Rezoning;
3) Actual construction of new developments, noting the proximity to stream channels or the ocean, and noting arrangements for wastewater;

4) Changes to permitted diversions;
5) If available, the actual amounts of water diverted by major users (*e.g.*, DWS, Parker Ranch) should be documented and broken down by stream; and
6) Other changed deemed worthy of note.

6.3 Long-Term Routine Monitoring of Water Quality

Long-term monitoring of water quality is needed to:
1) Identify whether new disturbances or management activities (sections 6.1 and 6.2) are having a negative or positive impact on water quality.
2) Measure whether there are progressive changes in water quality, either for better or for worse.
3) Evaluate, when fires occur, whether there are downstream impacts.
4) Evaluate year-to-year variability in order to more realistically evaluate pre- and post-monitoring of BMPs.

There is no substitute for long-term monitoring, yet the cost of water quality monitoring is a significant barrier to its occurrence. A reasonably-priced baseflow monitoring program is, therefore, proposed as a realistic approach for routine monitoring. Also, to minimize costs, the parameters to be measured are restricted to those that are currently causing water quality impairments or do not have analytical lab costs (turbidity and oxygen).

Several lessons were learned from the monitoring conducted during the development of this plan. For example, in order to isolate the effect of the Waimea urban area on the Wai'ula'ula stream, measurements must be taken both below and above town. The Sandalwood site was satisfactory for the site below town, but the Marine Dam site may be too far upstream from Waimea. It is, therefore, recommended to monitor only a short distance upstream from Waimea. Another lesson was that reliable source characterization requires *simultaneous* measurements at multiple sites.

6.3.1 Recommendations for Long-term Baseflow Monitoring

What will be monitored (fresh water):

- Turbidity (streamside measurement)
- TP (vial filled at streamside and frozen pending shipment to lab)
- TN (filtered at streamside; vial and filters frozen pending shipment to lab)
- Ammonia (mouth of watershed only; needed to see if marine ammonia impairment is from the stream or from submarine groundwater discharge.)
- When safe, measurements will be depth- and cross-sectionally integrated.

- DO (instream perennial pools only) (DO is expected to be impaired in the pool but not in the stream.)

  Note: Ideally, chlorophyll-a would be measured in the instream perennial pools, but there is no convenient, local facility for measurement, nor an inexpensive in-situ probe. TP and TN can be analyzed at the University of Hawai'i at Hilo analytical laboratory.

Where monitoring will be conducted (fresh water):

- Waikoloa stream immediately above Waimea (near DWS gate)**
- Waikoloa stream immediately below Waimea (Sandalwood autosampler site) (Compare with data from site listed above to see urban influence)*
- Waikoloa stream below Lālāmilo Farm Lots (compare with data from Sandalwood site to see influence of farms and landfill.)***
- Keanu'i'omanō stream below confluence with Lanikepu***
- Immediately upstream of mouth of Wai'ula'ula stream (autsampler site)*
- Several miles upstream of mouth of Wai'ula'ula stream (at Queen Ka'ahumanu Highway) (Compare to data from autosampler site at mouth of Wai'ula'ula stream to see influence of oceanside urban/resort zone.)***
- Instream perennial pools at various elevations within watershed*

Note: Because funding levels are uncertain, sites are prioritized: * is highest priority, ** is medium priority, and *** is lower priority.

Frequency (fresh water):

- Following dry periods, sampling will be conducted within one week of when stream begins to flow.
- A subsequent sample will occur two weeks later (if stream is still flowing), and then 4 weeks after that (if stream is still flowing).
- The instream perennial pool samples shall be taken at least quarterly, even if the streams are not flowing.
- Samples shall be taken on the same day when feasible. (Simultaneous measurements at multiple sites.)

Criteria for success (fresh water):

- In any year, and at any sampling site, the geometric mean of measurements shall be less than water quality standards for the dry season.

- In any year, and for every upstream/downstream sampling pair, the difference between upstream values and downstream values shall be indistinguishable from zero according to a paired t-test.

Estimated costs are as follows:

- First year cost of $1,600 for turbidimeter and oxygen meter.
- Subsequent years' annual cost of $600 for turbidimeter standards, replacement oxygen membranes/fluids, and replacement filter holders.
- $35-40 per sample for field supplies and analytical costs. Depending on the number of sampling dates and sites, this cost will range from $600/yr to $1,500 yr.
- Volunteer labor or commitments by MKSWCD personnel is assumed.
- The recommended monitoring is for feedback into the watershed planning process. It is not intended to provide a basis for regulatory determination of compliance with water quality standards. Costs would rise substantially if additional measures (*e.g.* certified laboratory) were added so that data meet protocols at the regulatory level.

6.3.2 Recommended Long-term Marine Monitoring

Maintenance of water quality in the marine receiving waters is an important part of the rationale for managing nonpoint pollutants in the watershed. Recent measurements of the receiving waters indicate impairments of ammonia and algae. These parameters should be monitored in the future.

What will be monitored (nearshore marine waters):

- Ammonia
- Chlorophyll-a

  Note: measurement protocols shall be consistent with DOH procedures for its routine monitoring of nearshore marine waters. Ammonia can be analyzed by the UH-Hilo analytical laboratory, but chlorophyll-a may need to be analyzed at a DOH facility.

Where monitoring will be conducted (nearshore marine waters):

- Kawaihae Bay at the same location(s) where DOH has previously taken measurements.

Frequency (nearshore marine waters):

- Ideally, on the same day that the streams are sampled, but in no case less than quarterly.

Criteria for success (nearshore marine waters):

- In any year, the geometric mean shall be less than water quality standards for the dry season.

6.3.3 Recommendations for Stormflow Monitoring

Characterization of annual loads in the watershed is incomplete. Water quality and nutrient loads vary with the weather, so a longer monitoring period means that a wider variety of conditions are sampled. While some load data have been collected, they do not span an entire year, nor do they fully represent the various sub-watersheds. If the goal is to use measurements to characterize pollutant sources, it is important to take *simultaneous* measurements at several locations (upper Waikoloa stream, Waikoloa stream below Waimea, watershed outlet, Keanuʻiʻomanō stream) in order to evaluate the effects of anthropogenic and natural conditions on water quality.

Unfortunately, annual load measurements require the installation of autosamplers. Costs are very high. For example, contracts with the USGS to provide data meeting regulatory protocols are on the order of $50,000 per year per site. The District owns one autosampler and in the past has borrowed three others from DOH. Using these autosamplers and having samples analyzed locally (and not necessarily at a certified lab) will help keep costs down.

In the event that funding becomes available, there is no substitute for autosampler-based stormflow measurements of sediment and nutrient loads. In this case, the following measurement program is recommended.

What will be monitored:

- TN, TP, nitrate, TSS
- Ammonia (at watershed mouth only)

Where monitoring will be conducted: (these may need to be prioritized, given number of autosamplers available)

- Waikoloa stream immediately above Waimea (near DWS gate)
- Waikoloa stream immediately below Waimea (Sandalwood autosampler site) (Compare with data from the above site to see urban influence)
- Keanuʻiʻomanō stream below confluence with Lanikepu

- Immediately upstream of mouth of Waiʻulaʻula stream (reoccupy the previously-used site)
- Several miles upstream of mouth of Waiʻulaʻula stream (at Queen Kaʻahumanu Highway) (Compare to data from autosampler site at mouth of Waiʻulaʻula stream to see influence of oceanside urban/resort zone.)
- Immediately upstream of Pelekane Bay (at highway; former autosampler site).

Frequency:

- Every storm for at least one year.

6.4 Monitoring of Watershed Condition

The purpose of the watershed condition monitoring is to assess the status and trend of watershed attributes to help determine if Waiʻulaʻula watershed management efforts are achieving goals of maintaining and restoring a healthy watershed. Recommended types of monitoring are described below.

6.4.1. Vegetation Monitoring

6.4.1.1. Stubble Height Monitoring

In 2001, the Natural Resources Conservation Service (NRCS) established general guidelines for judging proper grazing use on grass pasture as part of its Standards and Specifications for Prescribed Grazing (528A). Regular stubble height monitoring can be used as a management tool to determine when cattle should be rotated out of paddocks, based on the minimum heights established under NRCS's standards and specifications, and as a monitoring tool to ensure that grasslands are being sufficiently grazed to reduce the fuel load but are not being over-grazed.

What will be monitored:

- Key forage grass species (*e.g.*, kikuyu, buffel)

Where monitoring will be conducted:

- Sampling sites will be established in all paddocks used for cattle grazing within the watershed. Sampling sites will also be established in grasslands that are currently ungrazed, for comparative purposes.

Frequency:

- Semi-annually in each paddock.
- For projects involving introduction of cattle to previously ungrazed areas, before introduction of cattle for baseline data, bi-weekly while cattle are present to document grazing efficiency and estimate removal date, regularly after cattle removal to track grass growth and estimate fuel loading.

6.4.1.2. Fuel Loads

Fine fuels created by non-native grasses are a land management problem in leeward Hawai'i. These fuels facilitate the ignition of wildfires and promote their spread. By measuring representative fuel loads before and after fuels management projects are implemented, the amount of fuel loading reduced by each project can be calculated as a measure of success in mitigating wildfire risk.

Transects will be established within areas of grass fuels at different elevations within the marginal, fire-prone watershed lands below the 2,500-ft. elevation. Permanent, 100 m transect lines will be established and marked with rebar or metal stakes at both ends, which will be GPSed for ease of finding the sites again. Plots will be established every 10 m along each transect with the first plot at 0 m and the last at 90 m. A total of 10 samples will be collected from each transect line. Daubenmire frames (20cm x 50cm) will be used to delineate each plot.

All standing grass (biomass) at each plot will be clipped as close to the ground as possible and placed in zip-lock plastic bags labeled with the transect and plot numbers. Samples will be weighed within 12 hours from collection to obtain the wet weights. The clippings from each plot will then be transferred into paper bags for drying in a convection oven at 100º C. The samples will be checked for completeness of drying and will be considered totally dry if the dry weight of the samples does not change over two consecutive weighing sessions.

Fuel loads will be extrapolated to a hectare. Fuel loads from sites where fuels management practices have been implemented will be compared with baseline or ungrazed loads to determine the amount of fuel biomass that has been eliminated from the area, thereby reducing wildfire risk.

Assessing fuel loads is a relatively low-cost undertaking, with negligible material and equipment costs. The costs associated with this monitoring are for field and laboratory personnel.

What will be monitored:

- Fuel biomass within ten 20cm x 50cm quadrats (or plots) along each 100m transect line
- There will be two 100m transect lines at each sampling site for a total of 20 sampled plots per site

Where monitoring will be conducted:

- 1-3 transects will be established in grassy areas that have not been grazed (*i.e.*, adjacent to streams where cattle are currently excluded) to determine a representative worse-case fuel loading (or baseline without grazing and fire).
- Transects will be established in currently ungrazed and marginally-grazed areas where grazing will be established, grazing infrastructure improved, or other fuels management techniques implemented.

Frequency:

- Before the implementation of any fuels management project
- Annually, at the end of the wet season and before the beginning of the dry season

Criteria for Success:

- Fuel loads averaging 1,500 lbs per acre for buffel grass.

6.4.1.3. Vegetation Transects

The purpose of vegetative cover monitoring is to determine percent and composition of groundcover in the watershed, as an indicator of watershed health. This is a common method to evaluate land degradation and recovery, and the success of restoration projects. While there are various methodologies to quantify vegetation cover and composition, a line-point intercept sampling method will be used in the Waiʻulaʻula watershed. Monitoring will focus on vegetation cover.

Using the sampling method described in Godinez-Alvarez *et al.* (2009), four parallel 70 m transects, separated by at least 10 m, will be established in a representative area of each monitoring site. End-points of transect lines will be marked with rebar or metal stakes, which will be GPSed for ease of finding the sites again. A 1-mm diameter pole will be dropped at every meter along each transect, for a total of 70 points per transect and 280 points per site. At each point, the simple presence or absence of vegetation will be noted. Vegetation cover will be estimated by dividing the total number of plant intercepts by the total number of points per transect. On occasion, the plant species contacted by the pole will also be recorded, in order to provide a general record of species composition.

Assessing vegetation cover is a relatively low-cost undertaking, with negligible material and equipment costs. The costs associated with this monitoring are for field personnel.

What will be monitored:

- Presence or absence of vegetation at one-meter intervals along four 70m transects

- On occasion, plants species will also be noted

Where monitoring will be conducted:

- Transects will be established at representative elevations within the marginal, fire-prone watershed lands below the 2,500-ft. elevation
- Vegetation transects will be established in conjunction with erosion pin monitoring. We anticipate that, as vegetative cover at a project site increases, erosion rates will decrease.

Frequency:

- Before the implementation of any fuels management project
- Annually, at the end of the wet season and before the beginning of the dry season

Criteria for Success:

- On bare land, a statistically-significant increase in vegetation cover
- For vegetation transects associated with revegetation projects, a statistically-significant increase in vegetative cover and a statistically-significant reduction in erosion rates (see Section 6.4.3.2.)

6.4.2. Stream Condition Assessment

A first step to restoring riparian buffers is the development of a mechanism by which to identify environmental problems present within a stream system and along its riparian corridor and to provide sufficient information on each problem so that both the severity and correctability can be determined and restoration efforts can be prioritized. Maryland has developed survey protocols for a Stream Corridor Assessment to rapidly measure the general physical condition of a stream system and identify the locations of a variety of environmental problems within its stream corridors (Yetman 2001). These problems could include erosion sites, inadequate stream buffers, fish migration blockages, exposed or discharging pipes, channelized stream sections, trash dumping sites, in or near-stream construction, streambank instability, areas prone to flooding, areas of invasive plant species, and any unusual conditions. Such a survey tool will be developed for the watershed (and applicable to all of Hawai'i) to help determine specific areas in which to focus limited resources. Upon the completion of the survey tool, monitoring will be conducted.

What will be monitored:

- All stream corridors throughout the watershed

Where monitoring will be conducted:

- The length of all stream corridors will be walked, with the exception of segments that cannot be accessed safely. Inaccessible reaches in the upper watershed will also be excluded.

Frequency:

- Bi-annually

6.4.3. Erosion Monitoring

6.4.3.1. Infiltration Rates

A tension disc infiltrometer test conducted in the lower watershed in 2010 indicated a preliminary saturated hydraulic conductivity of 10 mm/hr. for silt-sized material. This means that once the surface becomes saturated, rainfall in excess of 10 mm/hr is likely to generate surface runoff, resulting in erosion of bare soil by rainsplash, sheetwash, and rill/channel incision.

Determining infiltration rates throughout the watershed will help us to understand what intensity of rainfall will lead to surface runoff and associated erosion, and how this varies in different parts of the watershed. We can expect infiltration rates to increase with elevation (based on soil type, weathering, etc.) and with vegetative cover.

What will be monitored:

- Representative bare lands

Where monitoring will be conducted:

- At different elevations within the watershed
- In conjunction with erosion pin monitoring and revegetation/ restoration projects

Frequency:

- Every four years
- Annually, in association with revegetation/ restoration projects

6.4.3.2. Erosion Rates

The least-expensive method to begin estimating erosion rates is called erosion pin monitoring. A network or array of long nails whose heads are driven flush with the ground will be installed in representative locations within the watershed and in association with specific projects. Data from a USGS project on Molokai demonstrated that erosion pin values closely approximate the value from other far more expensive techniques such as repeat ground-based LiDAR and suspended sediment yields (Stock 2010). In the Waiʻulaʻula watershed, a network of pins will be installed on representative hillslopes suspected of providing fines to stream channels, on representative legacy fill terraces in stream channels, and on suspected eroding streambanks.

Each erosion pin monitoring site on hillslopes and legacy fill terraces will consist of 50 pins installed in similar topography to provide representative values. Streambank monitoring sites will consist of 20 pins. Each line of pins should be parallel or normal to the local slope, with rebar or large stakes marking each end. The nails should be spaced at even increments so far as groundcover permits (e.g., every 0.5 m, every 1.0 m, etc.). The rebar or stakes should be GPSed to facilitate finding the monitoring site.

At least once a year, trained volunteers or MKSWCD personnel will measure the amount of sediment lowering at each pin (in mm).

Tipping bucket rain gages will be installed at representative elevations as part of this monitoring effort. One rain gage was installed in the lower watershed in 2011. Three to four additional rain gages will be installed at a range of elevations, at a cost of $500 per rain gage, plus $260 for a download shuttle. Rainfall data will be collected electronically on an hourly basis and downloaded every two months.

Data from the erosion pins coupled with rainfall data will enable us to determine erosion rates for specific areas. In order to normalize erosion rates to account for the infrequent but high-intensity rainfall that defines this leeward landscape, the average annual amount of lowering measures at each network on pins (in mm) will be divided by the amount of time (in hours) that rainfall, as measured by the nearest rain gage, exceeds the infiltration capacity of 10 mm/hr. (or infiltration rate determined for that specific location).

What will be monitored:

- Representative hillslopes, hydrologically-connected to a stream and suspected of providing fines to stream channels
- Representative legacy fill terraces in stream channels
- Suspected eroding streambanks at representative elevations

Where monitoring will be conducted:

- At different elevations within the watershed

- In conjunction with erosion pin monitoring and revegetation/ restoration projects

Frequency:

- Annually

Criteria for Success:

- Statistically-significant reduction in erosion rates over 67% of pins
- For erosion monitoring associated with revegetation projects, a statistically-significant increase in vegetative cover (see Section 6.4.1.3.) and a statistically-significant reduction in erosion rates

6.4.4. Biological Surveys of Aquatic Species

Assessment of ecosystem health can be based either on water quality or on biological populations. A healthy ecosystem is diverse and contains native species. A number of biological surveys have been conducted in the Waiʻulaʻula watershed since 1968. Survey data have been compiled by DLNR and indicate high biodiversity of native species found in the watershed. Regular stream surveys will be conducted to monitor changes in biological communities.

What will be monitored:

- Emphasis will be on native aquatic species
- Other species will be noted, along with qualitative measures of ecosystem health (*e.g.*, stagnant water, algae, etc.)

Where monitoring will be conducted:

- Freshwater streams, with an emphasis on sites previously monitored
- Instream perennial pools, with an emphasis on sites previously monitored
- Nearshore waters at the mouth of the watershed

Frequency:

- Once every four years

6.5 Monitoring Plan Implementation

6.5.1. Sampling and Analysis Plan (SAP)

A detailed sampling and analysis plan that outlines parameters to be monitored, sampling location and frequency, roles and responsibilities, documentation and records, quality control requirements, and chain of custody will be developed prior to implementation of management projects.

6.5.2. Data Management

The watershed coordinator will maintain the SAP and be the point person for communications concerning any updates or changes to the SAP.

Information and records to be included in the final data report package include:

1. Field notes (photocopies).
2. Laboratory results in ASCII or Excel format.
3. Hard copy and Excel files of water quality and field data.
4. Detection levels of analytical methods.
5. Map and GPS coordinates showing location of sample sites.
6. Photographs of field sites, especially for vegetation monitoring projects.
7. Documentation of field procedures, sample collection, lab methods, and any special conditions or circumstances.
8. Chain of custody forms.

All original data, including field notes and laboratory analyses, will be archived by the Mauna Kea Soil and Water Conservation District.

6.5.3. Adaptive Management Approach

The monitoring component of the Waiʻulaʻula watershed management plan is a working document. It is expected that the implementation process will reveal new information, emerging technologies, and practical operational realities that can be used to improve or revise the monitoring strategies. An adaptive management approach is recommended, so that, as we learn from actions taken, future monitoring techniques and procedures can be altered as necessary in response.

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