

[FLOOD CONTROL AND DRAINAGE] FLOODING AND OTHER NATURAL HAZARDS

INTRODUCTION AND ANALYSIS

The problems of flooding in the County of Hawaii are attributed to [three basic factors:] **ponding**, surface runoff, high seas, **storm surge**, and tsunami inundation. Flood control is usually limited to confining runoff within natural or man-made [water courses] **watercourses** and standing bodies of water. Drainage involves the collection and conveyance of runoff. The problems of high seas and tsunami inundation are generally alleviated by structural criteria, building setbacks, and land use restrictions.

The island [of Hawaii] is geologically very young and has not had a chance to develop defined [water courses] **watercourses** in many areas. These poorly defined [water courses] **watercourses** often overflow during rain storms. The South Kohala, North Kona, South Kona, Ka'u, Puna and South Hilo districts are particularly [troubled with] **impacted by** this problem.

On November 1, 2000, torrential rains stuck East Hawaii. The National Weather Service reported approximately 27 inches of record rainfall at the Hilo International Airport within a 24-hour period. More than three feet of rain fell on some areas of the island, causing flooding in many areas of the County. The highest rainfall total was at Kapapala Ranch in Ka'u, where more than 36 inches was recorded within a 24-hour period. In Hilo, the Waiakea-Uka area was inundated with approximately 29 inches, the Piihonua area approximately 24 inches, Mountain View, nearly 29 inches, and Glenwood, 26 inches.

The record downfall overflowed streams and gullies, flooding roadways throughout downtown Hilo and isolating neighborhoods in some areas of the eastern side of the island. The districts of South Hilo, Puna and Ka'u were the hardest hit, with roads, bridges, power lines, businesses and homes either damaged or destroyed. In Hilo, a portion of Komohana Street was destroyed, and near Pahala, three bridges and portions of Highway 11 were washed away. During the height of the storm, various sections of Highway 11 were impassable. Most of the major storm damage on the highway occurred in the Puna and Ka'u Districts. Besides severe scouring of the roadway pavement, shoulders and drainage outlets and inlets in Mountain View, Glenwood, Volcano and Pahala, as well as bridges at the Makakupu ford crossing, Kaalaala Stream, Keiawa Stream and Paauau Stream, were damaged beyond economic repair. Portions of the highway from the 49 to 52 mile markers were closed for approximately three weeks. Farms suffered heavy damage to crops and massive erosion, telephone service was disrupted, and some residents experienced power failures for nearly 12 hours. Although no lives were lost as a direct result of the storm, flood damage was estimated at \$20,000,000. On November 9, 2000, a Federal disaster was declared for the island.

The coastline of the island is susceptible to high seas and tsunami inundation. Tsunamis may be of local or distant origination. Historically, those of distant origin have caused the most

damage. [Of the 305+] **However, of the nearly 305** miles of coastline, [however,] approximately 225 miles, or 75 **per cent** of the coastline is predominantly undeveloped cliff area and not subject to property damage[.] **from coastal flooding or tsunami inundation.** [Damage] **Property** damage from tsunami activity has [been experienced] **occurred** in [the] Hilo-Waiakea, [area, the] Laupahoehoe Point, [area, the] Waipio Valley, [area, the] Kawaihae-Puako, [area, and] some portions of [the] Napoopoo, Keauhou, and Kailua-**Kona** areas of the [Kona] coastline. Low lying coastal areas of Ka'u and Puna have been devastated by tsunamis generated by local, large [scale] offshore earth movements. **Since 1819, the island has experienced about twenty-three tsunamis with a run up of two meters (6.56 feet) or more. Due to the frequency of tsunami events and warnings, the Army Corps of Engineers initiated the planning for a tsunami protection system after the tsunami of April 1946. By a congressional resolution adopted in 1957 and the Rivers and Harbors Act of 1960, authorization was given to proceed on an offshore protection system that incorporated breakwaters and navigational improvements. However, further studies revealed that the high costs involved in the proposed tsunami barrier project made the project unfeasible. The project was subsequently abandoned.** [There are now warning] **Warning** procedures **have been established** to alert the public of the approach of a tsunami of distant origination. However, locally generated tsunamis give little or no warning for evacuation. An ongoing program to educate the public on tsunami hazards is needed.

Present drainage and flood problems are mainly due to the development of vacant lands, which are often subject to serious flooding[.] without any commensurate, coordinated development of new drainage systems or expansion of the existing drainage systems. In many areas, the capabilities of existing drains, channels, and culverts have been exceeded during heavy rains. Additional problems occur when debris accumulates and clogs waterways. The absence of easements in drainage and flood courses also hinders maintenance.

Except for the metropolitan area of Hilo and portions of Kona and [Waimea,] **South Kohala**, the majority of the existing flood and drainage systems [are] **were** provided by **the sugar** plantations. [Each] **In the past, each** plantation town [has] developed its own sewerage, water, and drainage systems. This policy of the plantations to "take care of one's own" has worked well in the past. However, [with the conversion and development of plantation land that has historically been planted in sugar,] government will need to take a more active role in providing flood control[.] **and erosion mitigation on all developed properties via the County's grubbing and grading ordinances and providing incentives to landowners and lessees to work with the United States Department of Agriculture's Natural Resources Conservation Service (NRCS) in developing and implementing soil and water conservation plans.**

Since 1971, much progress has been made in alleviating flood and drainage problems and [in] establishing flood plain regulation. The general plan for the development of a comprehensive drainage system is the "Drainage Master Plan for the County of Hawaii." This report, along with newer reports from the U.S. Army Corps of Engineers, [and] the [U.S. Department of Agriculture, Soil Conservation Service (SCS),] **Natural Resources Conservation Service and the Federal Emergency Management Agency**, has guided the

flood control and drainage improvements made to date. The "Drainage Master Plan" [needs to] **should** be revised and updated to include the new studies that have become available.

Technical and financial assistance from agencies outside of the County has been instrumental in the progress made in drainage and flood control in Hawaii County. The U.S. Army Corps of Engineers has provided studies identifying the problems, needs and extent of Federal participation in flood control measures in particular floodplains. The [U.S. Department of Agriculture's Soil Conservation Service (SCS)] **Natural Resources Conservation Service** has provided technical assistance in carrying out flood plain management studies. The [SCS,] **Natural Resources Conservation Service**, along with the Soil and Water Conservation Districts, also provides conservation programs to reduce and control surface water and sediment runoff for individual agricultural and conservation landholders. The continued assistance of these agencies is essential for further progress in flood control and drainage and **erosion and sedimentation control** in [Hawaii] **the** County.

In 1982, the Federal Emergency Management Agency (FEMA) published the "Flood Insurance Study" for Hawaii County. This study investigates the existence and severity of flood hazards in Hawaii. The flood boundaries for streams, and the flood insurance zones and base flood elevation lines are delineated [in] **on** the [Flood Boundary and Floodway Map (FBFM), and the] Flood Insurance Rate Maps (FIRM) [respectively]. These maps are the principal result of the "Flood Insurance Study," and have been incorporated into Hawaii County's Flood Plain Management Program.

Unfortunately, there have been problems with the use and accuracy of the Flood Insurance Rate Maps. It has been demonstrated that the current Flood Insurance Rate Maps are not very accurate as to the location, position, and formation of geographic and geologic attributes. Thus, it is sometimes difficult to determine if a parcel is on the Flood Insurance Rate Maps. Furthermore, there are many areas where there is no data to determine the flood potential. The absence of data does not mean an absence of potential flooding in any particular area. Therefore, there is an assumption that flood risk is minimal if a parcel is not in a designated Flood Insurance Rate Map area.

The State participates in drainage and flood control through the Department of Land and Natural Resources' [Division of Water and Land Development.] **Engineering Branch, Land Division**. This agency is responsible for the implementation of a statewide flood control program, and [for] providing technical and financial assistance to the counties and the Soil and Water Conservation Districts.

[Because] **Hawaii County exercises flood plain regulations because** of the need for better coordination between the construction of properly planned drainage systems and urban development [, Hawaii County now exercises flood plain regulations]. The "Flood Insurance Study," identifying critical flood plain areas, coupled with the appropriate rules and regulations of the Federal Emergency Management Agency, has been incorporated into what is now Chapter 27 of the Hawaii County Code [entitled] **titled** "Flood Control." This chapter serves to promote public health, safety, and general welfare, and [to] minimize public and private losses due to flood conditions [in specified areas]. Chapter 27, along with the flood control provisions within

the subdivision, building, and grading codes, is the legal authority for Hawaii County's Flood Plain Management Program.

The Big Island experiences thousands of earthquakes each year, most undetectable, but some strong enough to be felt or causing minor damage. Most of the island's earthquakes are related to volcanic activity caused by magma moving beneath the earth's surface and concentrated beneath the island's two active volcanoes, Kilauea and Mauna Loa. Since 1868, there have been 14 earthquakes greater than magnitude six, most occurring on the south flank of Kilauea or Mauna Loa, including the Kaoiki region. Honomu, Hualalai and Kona also experienced earthquakes greater than 6.0 on the Richter scale.

With an estimated magnitude of 7.5 to 8.1, the largest Hawaiian earthquake in recorded history occurred in 1868 in the Ka'u district on the southeast flank of Mauna Loa. The 1868 earthquake caused islandwide damage, and the devastation was greatest in Ka'u, where an earthquake triggered mudflow and coastal subsidence produced a tsunami that destroyed several villages and killed 79 people.

In 1975, a magnitude 7.2 earthquake on Kilauea's south flank generated a tsunami that claimed two lives in the Hawaii Volcanoes National Park, destroyed homes in Punaluu, sank fishing boats in Keauhou Bay, and damaged boats and piers in Hilo. The most recent large earthquake of magnitude 6.1 occurred on Kilauea's south flank in June, 1989. Earthquakes with magnitude 5.5 and 6.6 have occurred approximately once every 10 years in the Kaoiki region, located between Kilauea and Mauna Loa. The most recent large earthquake with a magnitude 6.6 shook the region in 1983.

The island of Hawaii is sinking, or subsiding, at different rates for various reasons. Tide gauge data suggest that Hilo has sunk at a rate of 2.3 millimeters per year or approximately 4.5 inches in 50 years. At the same time, the sea level has risen about 1.8 millimeters per year, so Hilo has actually sunk about 8 inches relative to sea level in the 50-year period. Other studies suggest a slightly slower subsidence rate of 2.2 millimeters per year over 39,000 years. Hawaii is slowly sinking due to the great weight of the island that slowly bends the outer rigid layer of the earth. As the volcanoes grow, their weight is greater than what the earth can support. Large earthquakes also produce coastal subsidence. The magnitude 7.2 Kalapana earthquake in 1975 produced coastal subsidence of approximately 10 to 11 feet near Halape, 3.5 inches at Kaena Point, 20 inches in Kalapana and nine inches in Kapoho. An earthquake related subsidence event such as this is equivalent to approximately 1,500 years of slow subsidence. Following the 1975 Kalapana earthquake, coastal areas near Kapoho continue to subside at a rate of approximately a few centimeters per year as the lower east rift zone near Kapoho slowly widens. Portion of Kapoho Vacationland Subdivision fronting the ocean are nearly completely submerged. Other areas of the island subject to earthquake-related subsidence are located between Palima Point and Naalehu, and Kealakekua Bay to south of Hookena.

The island is composed of five volcanoes, two of which – Kilauea and Mauna Loa – are expected to erupt frequently in the future. As such, the U.S. Geological Survey has

identified lava hazard zones for the island. The U.S. Geological Survey Lava Flow Hazard Zone Map divides the island into Zones 1 through 9 based on the probability of coverage by lava flows. Zone 1 is the area of greatest hazard, and Zone 9 the least. Hazard zones from lava flows are based on the location and frequency of both historic and prehistoric eruptions. The zone boundaries are approximate, and the hazard posed by lava flows decreases as the distance from vents increases. Zone 1 includes the summits and rift zones of Mauna Loa and Kilauea where vents have repeatedly been active in historical times. More than 25 per cent of the area in Zone 1 has been covered by lava since 1800. Zone 2 includes the areas adjacent to and downslope of the most active parts of the rift zones. About 15-25 per cent of the area in Zone 2 has been covered by lava since 1800.

GOALS

- [• Conserve scenic and natural resources.]
- Protect human life.
- Prevent damage to man-made improvements.
- Control pollution.
- Prevent damage from inundation.
- Reduce surface water and sediment runoff.
- **Maximize soil and water conservation.**

POLICIES

- [In areas vulnerable to severe damage due to the impact of wave action,] **Enact** restrictive land use and building structure regulations [must be enacted relative to the potential for loss of life and property.] **in areas vulnerable to severe damage due to the impact of wave action.** Only uses [which] **that** cannot be located elsewhere due to public necessity and character, such as maritime activities and the necessary public facilities and utilities, [would] **shall** be allowed in these areas.
- [The County shall continue to review] **Review** land use policy as it relates to flood plain, high surf, and tsunami hazard areas.
- [The County of Hawaii shall update] **Update** and improve the **Flood Insurance Rate Maps** and **other** flood [way] maps in compliance with [Chapter 27] **the National Flood Insurance Program (NFIP)** as needed.

- **Any development within the Federal Emergency Management Agency designated flood plain must be in compliance with Chapter 27.**
- [The County shall promote] **Promote and provide incentives for** participation in the Soil and Water [Conservations] **Conservation** Districts' conservation programs for developments on agricultural and conservation lands.
- The "Drainage Master Plan for the County of Hawaii" shall be reviewed and updated to incorporate new studies [available] and [to] reflect newly identified priorities.
- [All development] **Development**-generated runoff shall be disposed of in a manner acceptable to the Department of Public Works[.] **and in compliance with all State and Federal laws.**
- [The County shall develop] **Develop** a comprehensive program for the coordinated construction of a drainage network along a single drainage system.
- [The County shall explore] **Explore** new methods of funding for the provision of adequate drainage systems[.] **and regulating potential flood inundation areas.**
- [It is the responsibility of both the government] **The County** and the private sector **shall be responsible for maintaining and improving** [to maintain and improve] existing drainage systems and [to construct] **constructing** new drainage facilities.
- **Develop an integrated shoreline erosion management plan that ensures the preservation of sandy beaches and public access to and along the shoreline, and the protection of private and public property from flood hazards and wave damage.**
- [The County shall continue] **Continue** to promote public education programs on tsunamis, **hurricane, storm surge, and flood** hazards.
- **Encourage grassed shoulder and swale roadway design where climate and grade are conducive.**
- **Develop drainage master plans from a watershed perspective that considers non-structural alternatives, minimizes channelization, protects wetlands that serve drainage functions, coordinates the regulation of construction and agricultural operation, and encourages the establishment of floodplains as public green ways.**
- **Encourage and provide incentives for agricultural operators to participate in Soil and Water Conservation District Programs.**

- **Where applicable, natural drainage channels shall be improved to increase their capacity with special consideration for the practices of proper soil conservation, and grassland and forestry management.**
- **Consider natural hazards in all land use planning and permitting.**
- **Discourage intensive development in areas of high volcanic hazard.**

STANDARDS

- "Storm Drainage Standards," County of Hawaii, October, 1970, and as revised.
- Applicable standards and regulations of Chapter 27, "Flood Control," of the Hawaii County Code.
- Applicable standards and regulations of the Federal Emergency Management Agency (FEMA).
- Applicable standards and regulations of Chapter 10, "Erosion and Sedimentation Control," of the Hawaii County Code.
- **Applicable standards and regulations of the Natural Resources Conservation Service and the Soil and Water Conservation Districts.**

DISTRICTS

A general geographical description, a description of present flooding and drainage problems, and courses of action for the reduction of the flood and drainage problems are presented for the nine districts of the County. [Maps showing drainage plans, flood hazard areas, and tsunami inundation zones shall be incorporated as part of the General Plan.]

PUNA

Profile

The climate of the Puna District varies considerably from the rocky shoreline to the rain forest areas in the upper elevation. Rainfall amounts are generally heavy and most of the district receives over 100 inches per year.

The district is subject to heavy rainfall and there is record of severe flooding [in 1979 and 1980]. [Flooding] **Historically, flooding** along the Belt Highway and [along] the highway from Keaau to Pahoia [were] **had been** the [major] **most prominent** problems of the district [but have been greatly alleviated due to highway improvements]. **However, highway improvements have done much to alleviate the flooding on the roadways.**

[The] **Currently, the** lack of [extensive] development and the extremely permeable soils have helped to minimize major flooding[.] **and damage to life and property.** [As urbanization] **However, as the amount of development** increases within the district, [however,] flood problems [are likely to increase.] **will also increase.** [The] **Furthermore, the** conversion of land historically planted in sugar to other crops [could also] **may** increase runoff. **In this regard,** Soil and Water Conservation District conservation programs can help lessen the potential problem.

[The] **Some of the** flood hazard areas **for the Puna district** are difficult to delineate due to the lack of defined drainage ways. Recorded flood damage has mainly been caused by surface sheet flows [which] **that** are likely to occur anywhere when heavy storms strike. Examples of this [problem] are found in [Pahoia and Mt. View,] **Fern Forest, Eden Rock, Fern Acres, Orchidland, and Hawaiian Paradise Park.** **In addition to these subdivisions, flooding occurs in certain areas of Pahoia. Other areas, such as Hawaiian Acres, may be more defined. The flooding below Mt. View may be the result of diversion of the Mt. View watershed into some of the substandard subdivisions.**

[Agricultural lands along Wright Road in Volcano have a recent history of flooding and erosion. The Soil Conservation Service is currently studying the problem and possible solutions.]

Systems [which] **that** incorporate diversion channels to intercept sheet flows and main channels to transport the flows away or through the area have been proposed for the communities of Keaau[,] **and** Pahoia [, and Kalapana-Kaimu]. **Along the Keaau-Pahoia Road, the State Department of Transportation (DOT) has installed culverts to facilitate the movement of water and minimize overtopping of the road in certain sections. In addition, the DOT plans to replace those culverts that are ineffective or inadequate.**

Drainage systems incorporating the use of diversion channels to collect and transport surface flows safely through the area are **also** proposed for Mt. View. A portion of this system has been constructed [, and a study of the Glenwood/Mt. View watershed is being made by the

Soil Conservation Service to evaluate the feasibility of constructing more drainage systems. Comparable systems would be applicable for the communities south of Keaau].

The entire coastline is susceptible to tsunami impacts[.] **and hurricane storm surge inundation.** [Most of the coastline, however] **However, much of the coastline** is undeveloped and/or has [steep] **high** cliffs. **This renders most developed areas outside of the inundation zone and** [where development is] not subject to damage. On November 29, 1975, [a tsunami was generated by an earthquake centered approximately three miles offshore of Kalapana (magnitude 7.2 on the Richter Scale). Two people were killed and property damage of about \$1.4 million was incurred.] **an earthquake measuring 7.2 on the Richter Scale centered approximately three miles off shore of Halape generated a tsunami that killed two people and resulted in \$1,400,000 of property damage.** The total damage of the earthquake and tsunami amounted to [about] **approximately** [\$4.1 million.] **\$4,100,000.**

Courses of Action

- As [urbanization] **development** increases within the district, the drainage systems designed for the existing village areas shall be implemented. [These systems are designed to collect and transport surface runoff through the communities.]
- [Provide improvements as shown by] **Conduct an update of** the County of Hawaii "Drainage Master Plan" and the "Mountain View Drainage Study"[.] **and provide improvements as recommended by the updates.**
- [• Support development of the Glenwood/Mt. View Watershed project.
- Encourage diversified agricultural farmers to participate in Soil and Water Conservation District programs.]
- **Seek assistance to develop a comprehensive flood study for the subdivisions between and along Highways 11 and 130.**
- **Ensure that purchasers of homes and other real property are fully informed of hazards from lava flows and other volcanic emissions.**

SOUTH HILO

Profile

With the Wailuku River as a dividing line, the South Hilo district can be separated into two watershed study areas. To the north of the river, the coastline has abrupt cliffs 30 to 80 feet high that are broken by deep stream channels. Usable land areas have a ground slope of six to twelve per cent. Above the 4,000 foot elevation, the stream channels diminish in number and depth and have all but disappeared above the 7,000 foot elevation. Flooding problems in this

area are primarily caused by local water runoff from **former sugar** cane fields situated above the communities.

South of the Wailuku River is a relatively flat plain of less than one per cent slope [which] **that** extends towards [the Hilo-Keaau Road.] **Highway 11**. Above [the road,] **Highway 11**, the slope steepens to approximately six to twelve per cent. Stream channels are poorly defined and disappear at elevations above 2,500 feet.

[Since 1837, Hilo has experienced about thirty tsunamis, an average frequency of one every four years. After the wave of April 1946, planning for a tsunami protection system was initiated by the Corps of Engineers. By a congressional resolution adopted in 1957 and by the Rivers and Harbors Act of 1960, authorization was given to proceed on an offshore protection system which incorporated breakwaters and navigational improvements. Subsequent studies have revealed that the high costs involved in the proposed tsunami barrier project made the project unfeasible. The project was subsequently inactivated.]

Waiakea

Until recently, the existing drainage system was the result of uncoordinated development. Lacking a comprehensive plan, property owners have constructed and installed drainage facilities to protect their own interests. In many instances, these facilities have seriously concentrated flows and aggravated situations downstream. Many [of the] proposals of the "Hilo Drainage and Flood Control Report" have been completed in the Waiakea area reducing the flooding problems.

Many [of the] culverts in upper Waiakea are inadequate. Roadside ditches, though small in cross-sectional area, are aided by the highly porous ground and are fairly effective even during heavy storms. One of the most serious problems faced by County maintenance crews is the frequent washout of cinder-gravel shoulders along road pavements. Another problem is the accumulation of vegetation growth and debris in waterways, which causes overflow.

The Waiakea Stream Preliminary Investigation report prepared by Natural Resources Conservation Service in November, 1999 identified the channel constrictions at the Hoaka, Kupulau, and Kawaiiani bridges as a major factor in the flooding of the Waiakea Stream Watershed. Several recommendations in the report suggests an increase in the level of maintenance for the Waiakea stream channel, reconstruction of the three bridges to handle the 100-year flood, installation of a flood levee above the properties along Kupulau Road, and Stream channel improvements to manage the volume of a 100-year flood.

In the lower Waiakea area, storm damage is minimal due to the effectiveness of the Wailoa and Waiakea-Uka Flood Control Projects.

The Waiakea coastal area is subject to tsunami **and hurricane storm surge** inundation and has suffered considerable loss to life and property from tsunami activity.

Kaumana-Ainako-Wailuku River

Kaumana's drainage system consists of roadside ditches, culverts, and narrow channels. Except for the Ainako Avenue area, all of upper Kaumana's storm water runoff is discharged either through the Waipahoehoe [Stream] or the Alenaio [Channel.] **Streams.** The Chong Street Diversion No. 3 and the Wailuku-Alenaio Diversion No. 4 along Akolea Road serves to reduce flooding in the lower areas and the Ainako Avenue sections.

The Wailuku-Alenaio Watershed Reinvestigation report prepared by Natural Resources Conservation Service in December, 1999 identified a new flood diversion alternative for the watershed. The alternative will control stormwater in Waipahoehoe and Kaluiki Streams and could provide 100-year flood protection to communities on the south side of Kaumana Drive in the vicinity of Akolea Road and Chong Street. The County has requested the Natural Resources Conservation Service's assistance to further plan and implement the new alternative.

The drainage system in the Ainako-Wailuku River area is comprised of box culverts that pass the discharge of the Ainako River across Kokea, Koula, and Kapaa Streets. The residential areas bordering the Wailuku River have a system of collection ditches. Except during very intense storms, there are few problems in the area.

Hilo Urban Area

Between tsunamis and runoff from higher elevations, the commercial district has displayed amazing recuperative abilities. Prior to the completion of the Waiolama Canal in 1924 and the Ponahawai Storm Drain System in 1926, this area was a virtual "sea" during heavy rain. The construction of the canal and the storm drain system [have] **has** since provided some degree of protection for the area.

The Alenaio Stream Flood Control Project, completed in 1998, begins just below Kapiolani Street and ends below Kilauea Avenue with an earthen levee leading into the Waiolama Canal. The project consists of three flood walls, a 1,790-foot rectangular concrete-lined channel, a 200-foot concrete entrance transition, and an 830-foot earthen levee. The project also included the reconstruction of four bridges located at Kapiolani, Ululani, Kinoole Streets, and Kilauea Avenue. The Alenaio Flood Control project mitigated much of the flooding that occurred in the Alenaio flood plain.

[The Alenaio Channel discharges into the Waiolama Canal, conveying runoff from the upper area through the central business district. These major conduits in the downtown section are supplemented by pipe drains on Shipman, Waianuenue, Haili, Mamo, Ponahawai and Ululani Streets.]

Except for the northern section of the business district, all of downtown Hilo falls within the Wailoa River basin and within the area tributary to the Alenaio Stream. **The State Department of Transportation (DOT) has indicated that there are periodic shifts of beach material along the Hilo bay front shoreline. In addition, occasional storm events will close**

the roads at bay front due to storm surge. A study detailing the level of storm surge and the periodic shifts of beach material is needed before a solution can be developed.

[During periods of heavy rain, the runoff in Alenaio Stream has exceeded the capacity of several of the culverts in the drainage system downstream of Komohana Street.]

The shoreline areas south of the Wailuku River are subject to damage from tsunami **and hurricane storm surge** inundation.

Paukaa, Papaikou, Pepeekeo, Honomu, Hakalau

These communities have no serious flood problems although Honomu and Papaikou have experienced minor flooding. These result from runoff from the areas above the communities.

Although the entire coastline is subject to tsunami activity, the majority of the area [is] **has** high cliffs and **is** not subject to property damage. [The only developed area affected by tsunami and high seas damage is the Hakalau Mill which is located at the base of the cliffs.]

Courses of Action

- The [remaining proposals of the] "Hilo Drainage and Flood Control Report" by Wilson, Okamoto and Assoc., Ltd., January, 1967, shall be **updated and** implemented [as further need is shown. Some of the proposals include the construction or improvement of drainage channels and primary intercepting ditches and improvements to culvert systems].
- [The Waiakea Stream improvements as described by the] **The** "Hilo Area Comprehensive Study for Flood Damage Reduction" shall be **updated and** [completed.] **implemented.**
- [Systems to intercept flows from higher elevations to be discharged into the Waipahoehoe or Ainako streams shall continue to be implemented as described by the "Hilo Drainage and Flood Control Report," the "Watershed Work Plan-Wailuku-Alenaio Watershed," or the subsequent amendments to these reports.]
- The proposals of the "Final Report and Environmental Impact Study of Alenaio Stream" shall be implemented. **Studies shall continue for the upper Alenaio Stream, the upper Wailuku River and its tributaries, the upper Waiakea Stream and Palai Stream.**
- [Drainage systems proposed by the] **The** Hawaii County "Drainage Master Plan" for the Honomu, Pepeekeo, Papaikou, and Paukaa areas [should] **shall** be **updated and** implemented. [These systems involve the collection and diversion of surface runoff into nearby gulches for disposal.] In addition, proper soil

conservation measures shall be applied to reduce the amount of surface water and sediment runoff.

- **Assess the possibility of implementing the recommendations of the NCRS’s “Waiakea Stream Preliminary Investigation” and the “Wailuku-Alenaio Watershed Reinvestigation” reports.**
- **Encourage a study of storm surge and the annual change in shoreline beach movement as a solution to the closing of the bay front highway during storm events.**

NORTH HILO

Profile

The district is characterized by an average ground slope of approximately [ten percent] **10 per cent** with scores of deep intermittent and perennial streams.

Other than runoff from **former** cane lands, there is little record of **flooding in** urban areas [being flooded]. Each community is in close proximity to one or more gulches [which] **that** carry flows from the upper watershed areas. The key to flood control within the district is to collect and divert surface runoff to the gulches. In addition, soil conservation practices are highly recommended.

The flood hazard areas are extremely difficult to delineate. High intensity storms can produce localized flooding in almost any area. The only definite flood hazard area is Laupahoehoe School.

The community of Ookala has not experienced heavy flooding although there are minor problems due to surface waters [coming out of] **from** the **former** cane fields above the town.

There is no record of any flooding within the community of Ninole. The existing flood control system [provide] **provided** by the plantation is adequate.

The community of Laupahoehoe has not experienced any extreme flood flows. However, there will be a need to supply flood protection for the community since Laupahoehoe School, which is located just to the south of the urban center, has experienced some flooding. Water [comes down] **flows** from the **former** cane fields, [especially] when [fields have been recently harvested or when the cane] **the natural vegetation** does not form a complete cover.

The community of Papaaloa has not experienced any serious flooding problems. With the projected expansion of the community, there will be a need to provide flood protection for the area.

The North Hilo district is characterized by high sea cliffs, most of which rise 300 feet above the sea. Except for the Laupahoehoe Point area, development is not subject to tsunami **or hurricane storm surge** damage.

Course of Action

- [Drainage systems proposed by the] **The** Hawaii County "Drainage Master Plan" for the Ookala and Laupahoehoe-Papaaloa areas shall be **updated and** implemented to alleviate problems of runoff from higher elevations. [These systems are designed to collect and divert surface runoff to the surrounding gulches.]

HAMAKUA

Profile

The Hamakua District can be divided into two major watershed areas. The northern watershed, which affects the Waipio Valley area, extends upward into the Kohala Mountains. The second watershed extends to the peak of Mauna Kea and affects the communities of Kukuihaele, Honokaa, Paauhau, Paauilo, and Kukaiau.

[Sixty-five years of records show that the district has suffered from twenty-six major storms and several times from high seas and tsunamis.] The majority of the flood damage in this area is felt by the [sugar industry, the] State[,], or the County through damage to improvements within **former** cane fields, roads, ditches, and bridges.

Streams originating above and flowing through Honokaa have caused flooding in the town. The existing culverts within the town also do not have adequate capacity to handle volume flows.

The communities of Paauhau and Kukaiau have not been subject to any high flood flows in the past and the only recommended flood prevention measures would be the construction of diversion channels above the communities to divert water from [the] **former sugar** cane fields **and** into the surrounding gulches.

Occasional flooding along the Hawaii Belt Road between Ahualoa and Waimea occurs when rainwater comes down from the pastures and overtops the road. Although there are no mitigation measures planned at this time, road improvements have alleviated some of the flooding and improved sheet flow.

Localized drainage problems exist within the limits of Paauilo. These problems are caused by allowing surface waters to collect from large areas within the town and flow down narrow roadways. [These] **The** problems could be eliminated if this water was intercepted and transported to the gulches for disposal.

The only area that is subject to tsunami **and hurricane storm surge** inundation within the Hamakua district is Waipio Valley and three other uninhabited valleys to the north. Damage in Waipio Valley has been primarily to crops caused by periodic stream **meandering,** overflow[.], **and stream blockages.** Requested solutions and subsequent studies of the problem have found approaches to be economically unfeasible.

Courses of Action

- [Drainage systems proposed by the] **The** Hawaii County "Drainage Master Plan" for the Waipio-Kukuihaele, Honokaa-Paauhau, and Paauilo-Kukaiau areas shall be **updated and** implemented. [These systems incorporate the construction of diversion channels above the communities which would collect and transport surface flows to surrounding gulches.]
- **Support the use of natural channels and proper soil conservation practices to manage flood control and drainage problems.**
- [A reduction in surface flows from agricultural and forest reserve land above the communities of the district is of prime concern. Proper soil conservation practices to reduce surface water and sediment runoff must be implemented. Examples of some of the practices include contour farming to reduce erosion and runoff, replanting with grass or woody vegetation in areas where vegetative cover has been destroyed, and providing protective cover for soil by leaving trash and leaves on the fields, returning bagasse to fields or planting fast growing inter-row crops.] **Implementation of proper flood control measures and soil conservation practices shall be used to minimize sheet flow, flooding, and sediment runoff from agricultural and forest reserve land above the communities of the district.**
- The Waipio Valley area shall be [kept open except] **retained** for **limited** recreational and agricultural activities **due to its high susceptibility to flooding and tsunami inundation.**
- **Encourage the State to develop mitigation measures for the occasional flooding along the Hawaii Belt Road between Ahualoa and Waimea.**

NORTH KOHALA

Profile

The North Kohala district is subject to occasional heavy rainfall [which] **that** creates heavy runoff. Streams collect water from the upper watershed and convey most flows safely through the urban centers. Although the gulches are generally smaller than those on the Hamakua coast, they have adequate capacity to handle storm flows.

Other than damage to [cane field improvements and] highway culverts, there is no record of any [extensive] flood damage [within the district.] **to structures.** There are areas, however, which are subject to [minor] flooding problems. These include the town of Hawi which has [suffered from] **experienced** surface sheet flows concentrating along the highway within the town, the highway and road culverts at Lipoa Gulch, and Halelua and Pueka gulches.

The community of Kapaau has problems similar to those of Hawi. The existing highway culverts are inadequate to handle peak flood flows and have caused minor flooding problems in the past. On each side of the highway, the Makapala area is relatively flat and is susceptible to flooding by the Niulii and Waikani Streams.

The solution to the flood control and drainage problems of this district lies [within two measures. These are] **in** the practice of proper soil conservation in agricultural lands and forest areas to help reduce and retard surface water and sediment runoff [and improvements to natural channels to increase their capacity]. **In addition, there are the improvements to natural channels to increase their capacity.**

The North Kohala district has recorded runup from tsunami **and hurricane storm surge** activity. Areas subject to inundation include [the] Pololu Valley [area, the Hoesa Mill area], [the] Upolu Point Airport [area], and the Mahukona Harbor [area.] **areas.**

Course of Action

- [Drainage systems proposed by the] **The** Hawaii County "Drainage Master Plan" for the Hawi and Honomakau-Kapaau areas shall be **updated and** implemented. [These systems propose improvements to natural channels to increase their capacity. This, combined with the practice of proper soil conservation, is the solution to flood control and drainage problems within the district.]

SOUTH KOHALA

Profile

The South Kohala district can be divided into two separate watershed areas. The Waimea Village watershed extends into the Kohala Mountains. [These mountains have high rainfall] **Heavy rainfall occurs in these mountains** and several intermittent streams [descend from them and] flow through the Waimea area. Upon reaching the Waimea plains, these streams turn to the west and flow toward Kawaihae across the extremely permeable lava flows of Mauna Kea. The Waikoloa stream has caused flooding within the town of Waimea during high intensity storms when waters overflow due to sharp stream bends and generally inadequate flow-carrying capacities. **In addition, there is some flooding concern around the area abutting the Kawaihae road.**

The second watershed area above the Kawaihae to Anaehoomalu shoreline extends from the coast to the peaks of Mauna Kea to Mauna Loa. The area is semi-arid with few well-defined channels and infrequent stream flows.

[There are two flood control projects are in progress within the district, both within the town of Waimea. The first project, which consists of a lined channel and flood water retarding structure for the Lanimaumau Stream, has been constructed under the authority of the Watershed Protection and Flood Control Act. The second study and planned flood control measure is for a lined channel along the Waikoloa Stream northward from Lindsey Road. This channel will alleviate much of the flooding from the Waikoloa Stream.]

High intensity storms have caused flooding along the [Mamalahoa] **Queen Kaahumanu Highway [at Puako and along the highway] from Kawaihae to Puako[.] , and at Puako.** These storms are very infrequent and tend to create flash floods. High flows have been experienced in the Hapuna Beach and Spencer Beach Park areas due to the flash floods. The Puako Beach lots have also been subject to flooding. **During the evening of September 8, 1996, heavy rains generated a flash flood along Auwaiakeakua Stream. The floodwaters overtopped the existing drainage ways causing damage to private properties, particularly the Fairway Terrace Condominium at Waikoloa Village, County roads and drainage facilities.**

In 1997, construction was completed on the Parker Ranch drainage improvements. The improvements diverted the Kamuela and Lanimaumau Streams toward open pasture lands. Flooding has done substantial damage to the residential subdivision at the Mauna Kea Beach Resort. To mitigate the flooding, the developer has constructed flood control measures off site and the State Department of Transportation intends to install three sets of new culverts on site. The State Department of Transportation also intends to realign and replace Waiaka Road.

An added threat to the coastal areas results from fire [which] **that** leaves the upper slope areas with limited ground cover and thus more susceptible to flooding.

The entire coastline of this district from Kawaihae southward is subject to tsunami and storm **surge** wave inundation. Runup has been recorded in Kawaihae and Puako.

[Course] **Courses** of Action

- [Drainage systems proposed by the] **The** Hawaii County "Drainage Master Plan" for the Kawaihae, Hapuna Bay-Puako, Pauoa Bay-Honokaope Bay, and Waimea areas shall be **updated and** implemented. [These systems propose improvement to natural channels to increase their efficiency. These, combined with the practice of proper soil conservation with special emphasis put upon grassland and forestry management practices, would be the solution to flood control and drainage problems in the district.]
- **Conduct a flood study for the Auwaiakeakua Stream.**

NORTH KONA

Profile

The North Kona district can be divided into two watershed areas. The area north of Keahole Point and the summit of Hualalai have very low rainfall and runoff. Rainfall for this area reaches a maximum average of 40 inches per year, but most of the area receives less than 20 inches per year. The soils [of] **in** the area are extremely permeable and there is no record of hazardous flooding in this area.

The southern area, extending southward from Keahole Point, contains most of the urban development and is subject to increasing hazards from floodwater damages as land is more intensively utilized. The area is characterized by dry vegetative growth along the coastal areas and thick tropical vegetation in the upper forest reserves. The ground slope is steep, averaging approximately [fifteen percent.] **15 per cent.**

The steep slopes, shallow soils, frequent high intensity rains, and the lack of well-defined drainageways make many areas in the North Kona district susceptible to flooding and overland flows.

Flash floods, primarily from overflows of the [Kawanui/Lehuula/Kainaliu,] Keopu/Hienaloli, Waiaha, Kaumalumu and the Holualoa/Horseshoe Bend drainageways, have been identified by the [USDA, SCS,] **Natural Resources Conservation Service's** "North Kona Flood Plain Management Study."

Flood water and sediment damage occurs along the entire coffee belt with the Kainaliu, Holualoa and Kailua village areas experiencing the heaviest damage.

The entire coastline of the North Kona district is subject to inundation by tsunamis. Kailua and Keauhou have recorded run up and damage from tsunami activity in the past. In addition, the coastline has also been subject to damage from storm waves.

Courses of Action

- Drainage systems for the Keopu/Hienaloli, Waiaha, Kaumalumu and the Holualoa/Horseshoe Bend drainageways shall be [developed and implemented.] **studied and remapped to determine the actions necessary to mitigate negative impacts.** [These systems, in addition to the installation and maintenance of proper soil and water conservation practices could alleviate the major flood control and drainage problems.]
- Establish and maintain appropriate vegetative cover in high rainfall, sediment and debris producing areas.
- **Encourage the mapping of the floodways in North Kona to develop more effective flood control programs.**
- **Encourage the use of natural drainageways as greenways in the development of the region.**
- **Maintain and re-establish forest cover in mauka areas to improve the capacity of the ground to absorb heavy rainfall.**

SOUTH KONA

Profile

Being geographically young, there are few well-defined drainage ways in the district. [The soils of the area are extremely permeable and few streams show evidence of reaching the ocean.] Overland and stream flows are rare and can only be detected when the rainfall intensity exceeds the rate of infiltration.

The district is subject to sudden high intensity rainstorms that can strike anywhere and cause localized flooding. Flood prone areas have been identified by the [USDA, SCS,] **Natural Resources Conservation Service's** "South Kona Flood Hazard Analyses."

Coffee and other agricultural lands are subject to erosional damage and roads and culverts are sometimes damaged by high flows and sediment deposition. The Sunset Coffee Mill Flood Prevention Project has provided substantial relief in the Napoopoo area.

There are also records of minor flooding from Kiilae, South Keokea, Honaunau and Wailapa Streams. In general, an area within 150 feet of the stream channels can be considered

subject to flooding. Other areas with records of minor flooding include the areas along the Belt Highway in the area of the 1950 lava flows and at Hookena Road.

The entire shoreline is subject to inundation due to high seas and swells caused by hurricanes and distant storms. Coastal areas have received damage to roads, harbor facilities and oceanfront buildings. The shoreline areas are also subject to tsunami activity. This includes the coastline from Napoopoo to Honaunau and the Milolii village area. Tsunami runup has been recorded in two locations along the South Kona shoreline, in Milolii and Hookena.

Courses of Action

- [Drainage recommendations proposed by the] **The** "South Kona Flood Hazard Analyses" for the Kealakekua, Napoopoo and Honaunau areas shall be **updated and** implemented. [These consist of diversions and catchments to collect and transport water and reduce peak flows from the upper watershed areas through the urban area. The practice of proper soil conservation measures and the improvement of existing drainage features complement these proposals.]
- Establish and maintain appropriate vegetative cover in high rainfall, sediment and debris producing areas.
- **Encourage the use of natural drainageways as greenways in the development of the region.**
- **Maintain and re-establish forest cover in mauka areas to improve the capacity of the ground to absorb heavy rainfall.**
- **Ensure that purchasers of homes and other real property are fully informed of hazards from lava flows and other volcanic emissions.**

KA'U

Profile

The Ka'u district can be divided into three separate regions. The northeastern region is dominated by the Ka'u desert. The average annual rainfall here is approximately 20 inches. There are few defined stream channels, none of which are perennial. The soils are very shallow, covering rough lava flows that are extremely permeable.

The southwestern region [which] **that** extends westerly from the South Point [road] **Road** is characterized by moderate slopes, extremely permeable soils, and relatively young lava flows. The median annual rainfall varies from less than 20 inches at South Point to 75 inches at the 5,000-foot elevation. There is little evidence of stream flow within this region and no record of damage from flood flows other than the flooding of roads within the Hawaiian Ocean View Estates subdivision.

The central region contains the communities of Pahala, Naalehu, and Waiohinu. There are several streams within the region, none of which are perennial. Flood flows occur when the soils are saturated and rainfall intensity exceeds the rate of infiltration. Storm runoff descends steep slopes behind the communities and causes flooding and deposition of sediment and debris in the communities.

There are three existing flood control measures in this district. A flood water channel and debris basin in Naalehu was completed in 1965 with additional improvements and modifications completed in 1969 and 1982.

The second project is within the town of Pahala and consists of diversion channels in the **former sugar** cane fields above the town and the improvement of Paauau Stream. [Since their construction, there has been minimal flood damage in Pahala.]

The third project is within the town of Waiohinu. It is designed to collect flows from the watershed areas and transport them around Waiohinu for disposal in the rock land area. This project has been implemented, but needs additional improvements.

Although major flooding within the communities has been addressed, flash flooding along the Hawaii Belt Road still occurs. The Piikea, Keaiwa, Paauau, Punaluu, Hilea, Kawaa, and Honuapo streams often exceed the capacity of the **existing** bridges['] **and** culverts and flood the roadway. This temporarily closes the road and effectively cuts off this district from the Puna[/], Hilo **and Kona** [district.] **districts.**

However, in the Piikea ford area, the State DOT completed the construction of a new Piikea bridge in 1998. In addition to the bridge, improvements to the Piikea ford are proposed with the construction of three large box culverts. At the Paauau stream, there are plans for the construction of a new bridge. There are also plans for the replacement of the Ninole bridge located just past Punaluu. A new culvert is proposed in the Kawaa flats region.

The entire coastline of the district is subject to tsunami and high seas activity, with the Punaluu and Honuapo Bay areas having been severely damaged from past tsunami activity.

Courses of Action

- Improve and upgrade existing flood control measures as necessary.
- Continue proper soil conservation measures to complement the existing systems.
- Investigate potential solutions to prevent the closure of the Hawaii Belt Road due to flooding.
- **Ensure that purchasers of homes and other real property are fully informed of hazards from lava flows and other volcanic emissions.**