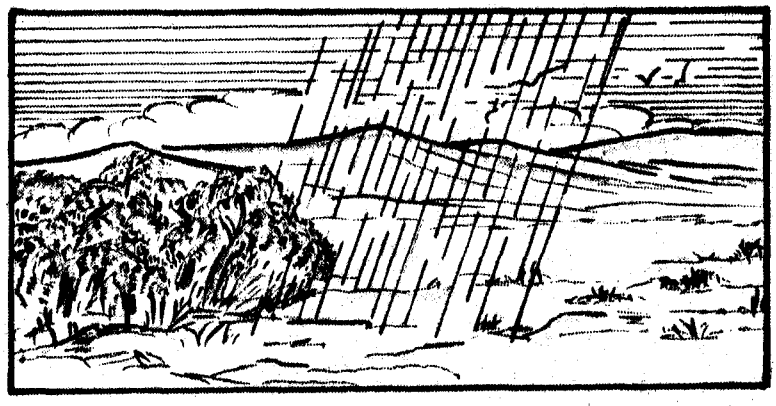
MAIN REPORT

FLOOD PLAIN INFORMATION STUDY KAUMANA - PUNAHOA, HAWAII, HAWAII



PREPARED FOR
BOARD OF LAND AND NATURAL RESOURCES
STATE OF HAWAII

BY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
CORPS OF ENGINEERS
HONOLULU, HAWAII

FEBRUARY 1965

FLOOD PLAIN INFORMATION STUDY

KAUMANA-PUNAHOA, HAWAII, HAWAII

MAIN REPORT

FLOOD PLAIN INFORMATION
KAUMANA-PUNAHOA, HAWAII, HAWAII

MAIN REPORT

"HEAD FOR HIGH GROUND"

You who live in the Kaumana-Punahoa area have heard these words or listened to sirens alerting the city of Hilo to possible tsunami. All at once everyone started to move out of the dangerous coastal area. Perhaps some of your relatives or friends came to your home to wait out the alert. Of course, your homes are more than 400 feet above sea level and tsunami need not worry you.

Why then should you, who plan future development in the Kaumana-Punahoa area, be concerned with floods? The area does not look potentially dangerous from a flood viewpoint. The soil is capable of absorbing large quantities of rain without visible surface runoff and in many of the small drainage areas there are no identifiable stream beds.

Why then prepare a report on flooding?

Our answer is this: to protect your investment of money and labor in constructing improvements in this area by providing full knowledge of the floods which could occur and cause considerable damage. This report will give you some idea of where and how often to expect damaging floods, and the degrees of probability associated with various magnitudes of floods.

AUTHORIZATION

This report is in response to a request for flood plain information made by the State of Hawaii Board of Land and Natural Resources on February 8, 1962. Section 206, Public Law 86-645 (Flood Control Act of 1960) grants authority to the Secretary of the Army, through the Chief of Engineers, to gather and distribute information concerning past floods and flood hazards in flood-prone areas. The Hawaii Board of Land and Natural Resources and the Chief of Engineers have reviewed and approved the release of the report.

This report does not include stream flow profiles or show the extent of flooded areas as is normally done in a report of this type. Historical data of this type are lacking and it was found impracticable to compute these data because of the highly irregular topography, overland sheet flood flows, and very porous and variable soils.

The only stream flow data available are the 36 years of record at the Wailuku River gage north of Kaumana. Flood flow frequencies were computed using these data and synthetically derived unit hydrographs. The total area was subdivided into smaller drainage areas and flood flow frequency curves for each area are presented in the technical appendix. Information concerning flooding along Kaumana Drive and Ainako Avenue was obtained from residents and is presented in this main portion of the report.

A planning report, "A Plan for the Metropolitan Area of Hilo," was prepared in October 1961 and was adopted on January 10, 1964 as the city's official plan for future development by the Planning and Traffic Commission. The information contained in this flood plain study should be used in making local planning decisions that affect this area of Hilo.

The Board of Land and Natural Resources was designated as the coordinating agency for the State of Hawaii by Act 34, Session Laws of Hawaii, 1961. This Act was amended by Act 148 in 1963. This agency will distribute copies of the report to interested parties and individuals upon request. The planned use of this area according to the Hilo Metropolitan Plan will be diversified agriculture at the upper and outer regions and essential and residential agriculture, single family residences, schools and parks in the central and lower sections of the study area. This report is specifically directed towards those parties and individuals, both private and governmental, whose interests lie within the scope of the aforementioned uses of the Kaumana-Punahoa area. Future flood losses can be greatly reduced if proper and adequate precautions are taken regarding planned development in the flood-prone areas. It could be used as a basis for enacting a flood plain zoning ordinance providing that lands deemed subject to seasonal or periodic or occasional flooding shall not be used for residences or other purposes in such a manner as to endanger the health or safety of the occupants thereof as required by the Federal Flood Insurance Act of 1956.

The Kaumana-Punahoa flood plain study consists of two parts. The main report presents the flood problem and general guidelines to reduce present and future flood damages. The technical appendix contains basic data and computations that support the analysis and conclusions of the main report.

The cooperation of the following agencies and individuals for their help in compiling this report is gratefully acknowledged.

Department of Interior - U. S. Geological Survey
- National Park Service
- Fish and Wildlife Service

Department of Commerce - U. S. Weather Bureau

State of Hawaii	- Board of Land and Natural Resources - Department of Transportation
County of Hawaii	- County Engineer - Board of Water Supply
Newspapers	- Honolulu Star-Bulletin - Honolulu Advertiser - Hawaii Tribune-Herald
Residents of the Kaumana-Punahoa area, Hilo, Hawaii	

FLOOD PROBLEM AREA

The Kaumana-Punahoa district is about 2 miles southwest of central Hilo and is on the northeastern slope of Mauna Loa (see plate 1). The study area comprises about 6,800 acres with an average ground slope of about 300 feet per mile and is situated between elevations 400 feet and 2,000 feet above mean sea level. The 1960 population was about 3,600, or 10 percent of the total city of Hilo population. Four new subdivisions are presently under construction; two on interior land between Kaumana Drive and Ainako Avenue (see figure 1); one adjacent to Kaumana along Wilder Road; and one above the town of Kaumana near the Hilo Country Club. Plate 2 shows the approximate areas described. About 85 percent of the area is covered by sugarcane fields, heavy forest and dense small shrubs and grasses (see figures 2-5).

The growth of the area has expanded from Kaumana town down the main road, Kaumana Drive, now part of State Highway No. 20, and to the section along Ainako Avenue (see figures 6-8). All of the residential housing has developed along these two streets with several short streets branching off, mainly in the lower section.

The 1960 property evaluation for the Kaumana-Punahoa study area was estimated at $8,000,000. Residential use now occupies about 11 percent of the land while another 4 percent is under subdivision development. There remains much open area that can be developed in the future and with proper planning, flood damages can be kept to a minimum.

FLOOD HISTORY

Waipahoehoe Stream is the only stream in the flood plain that has any definite channel characteristics (see figure 9). Plate 3 shows the diffuse drainage patterns of two typical valley sections, A-A and B-B, as oriented on plate 2. Numerous small swales that carry water only during periods of heavy rain join Waipahoehoe Stream throughout its length. There are no stream flow records for Waipahoehoe Stream or any other flow data for the study area, but it is reported that

near bankfull flow has occurred several times at the Chong Street bridge (see figure 9). Upstream of this bridge, both branches of the stream flow about 10 feet wide and average a foot deep during periods of little or no rain (see figure 10).

Waipahoehoe Stream flows are not the primary source of flooding in the area but contribute jointly with overland sheet flows from tributary and other shallow swales that parallel the downward slope toward the sea to cause the flooding. The soil, being a residual mixture of eroded lava, is very porous and lends itself to a high water carrying capacity. As the entire depth of topsoil becomes saturated at the higher elevations, percolation down the slope with accompanying seepage upward to the ground surface occurs at the lower regions to supplement the surface runoff. Plate 4 shows cross sections of the concrete arch bridge at Chong Street and the wooden bridges upstream.

Rainfall records for 20 stations (plate 1) in and near the Kaumana-Punahoa study area show that the annual rainfall ranges from 170 inches at the eastern boundary to 220 inches at the western boundary. Over the total study area monthly rainfall fluctuates from 8 to 17 inches during the summer season (May through September) and from 13 to 27 inches during the remainder of the year. Rainfall is usually continuous for a period of several days with much infiltrating the ground and very little running overland. Storm rainfall continues to prime the ground with moisture and major flooding results when short duration (3 to 6 hours), high intensity rains occur. In one storm, an estimated 12 inches of rain fell in 4 hours at a point about 15 miles north of Kaumana.

Newspaper records and the U. S. Weather Bureau unpublished manuscript "One Hundred Years of Hawaiian Weather" were used to obtain historical data on flooding and rainfall amounts in or near the Kaumana-Punahoa area. Most of the information is for central Hilo and only includes large floods. Table 1 presents these flood data.

Table 1. Flood History - Hilo, Hawaii

25 February 1880	-	Hilo reports 6 days of rain. Small channels 8 feet wide which are dry most of the time are now raging streams 50 feet wide and impassable except at bridges.
13 February 1882	-	Hilo had 14 inches of rain in 2 days. Some bridges washed away between Hilo and Kawaihae.
11 December 1882	-	Freshets caused by heavy rains at Hilo carried away 3 of the bridges between Onomea and Hilo. Hakalau had 12 inches of rain in 4 hours.
27 October 1883	-	Heaviest rain in 50 years. Much damage to roads, bridges and private property. 17.15 inches of rain fell in 22 hours. $1500 damage to sugar plantation.

26 July 1885	-	This was worse storm than that of October 1883 when all the bridges were carried away. 15 inches of rain fell in 30 hours, mostly during the 10-hour period from 9 a.m. to 7 p.m. on the 26th.
1 August 1886	-	Wailuku River rose 30 feet and swept away the cement pier erected for the new bridge.
24 December 1901	-	Hilo had 10 inches of rain in 24 hours. North Hilo had 20 inches in the same period.
22 September 1907	-	36-hour rainfall amounts were 18.40 inches at Waiakea, 29.82 inches at Hakalau, and 31.28 inches at Papaikou.
24 September 1914	-	Sudden flash flood caused by cloudburst in mountains drowned 1 person in the Wailuku River.
1 May 1916	-	Kona wind brought storm with heavy thunder and brilliant lightning. 16 inches of rain fell in 24 hours.
18 January 1921	-	Lower Kamehameha Avenue and Waiakea completely flooded. Old-time residents said that there was a big flood in 1914 or 1915 but this was worse than that. Only once before they saw anything like this one and that was in 1906. Damage was estimated at $150,000. Hilo had 13.33 inches of rain in 14 hours and Piihonua had 19.7 inches.
27 December 1927	-	Torrential rain and heavy damage in downtown business district. 12.40 inches of rain fell in 24 hours. Water flowed over the 4-mile bridge on the volcano highway both Sunday and Monday.
2 October 1928	-	Cloudburst strikes Kaumana at 3 p.m. on the 1st. Storm washed out roads and flooded basements. The total rain of 4.4 inches fell mostly between 3 p.m. and 7 p.m. A wall of water 4 feet high came down the Wailuku River and drowned 1 man.
29 December 1936	-	6.54 inches of rain in 24 hours. Many houses along Waiakea Homesteads way and nearer in Hilo reported floods in yards and basements.
30 December 1936	-	8.22 inches of rain fell in 24 hours; highest 24-hour total since 27 December 1927 when 12.40 inches fell. Waiolama Canal overflowed for first time in many years, flooding lower Kamehameha Avenue.

9 April 1938	-	Heaviest rain in 21 years. 14.32 inches fell in 24 hours. Roads were damaged in the Kaumana section. Water broke through a stone wall flooding Piihonua Park. Next to Waiakea area, the hardest hit was One Mile Kaumana as cane flumes were swept away. Worst storm in 25 years.
3 March 1939	-	Heaviest 24-hour rainfall in history of Hilo - 19.2 inches. Basements throughout city flooded. Water came down from Piihonua way, past Piihonua Park, which was a deep pool of water, and rushed down Waianuenue Avenue in a torrent.
12 August 1940	-	Wailuku River at new high, 1.5 feet higher than 18 August 1923. Piihonua had 5 inches of rain between 4:30 p.m. and 6:45 p.m. on the 11th. Hilo had 6.16 inches in 24 hours.
9 April 1945	-	13.5 inches of rain fell in 36-hour period ending at 6 a.m. this morning.
31 January 1946	-	13 inches of rain fell in 28-hour period ending at noon today. Flooded basements and garages were reported from various parts of town the forenoon but no serious damage yet.
11 November 1948	-	10 inches of rain in 12 hours at Hilo. Flooded basements reported. Extensive crop damage and landslides. Damage estimated at $250,000.
8 January 1949	-	13.18 inches of rain in 24 hours in Hilo.
10 January 1949	-	Weekend storms cause much damage. Waiakea Homesteads area cleaning up after 3 inches of rain Saturday and Sunday preceded by 13 inches of rain on Friday. $50,000 damage to roads.
8 February 1950	-	28 hours of continuous rain totaled 9.45 inches. Rain at the airport measured 8 inches in the 18-hour period from 2 a.m. to 8 p.m. on the 7th. Basements of several downtown stores flooded as storm drains inadequate. 20 phone calls asking for help. In upper Hilo area, 10 to 16 inches of rain fell. Many yards, basements and garages flooded in Piihonua and Kaumana.
10 March 1953	-	A severe thunderstorm occurred in the vicinity of Hilo dropping 9 to 14 inches of rain in 24 hours. Kaumana had 9.49 inches of rain on the 9th and 11.0 inches on the 10th. At Waiakea rainfall measured 3.91 inches on the 9th and 13.62 inches on the 10th.

14 December 1954 - 5 inches of rain fell in 12 hours. Waiakea Mill residential area flooded.

15 December 1954 - 6 to 8 inches of rain fell during past 24 hours. 3 feet of water in downtown streets. All homes in Waiakea area hit by a virtual river that flowed through basements and measured up to 4 feet deep. Parts of Kaumana Drive at 4 miles washed out; strip of 200 feet of paving washed out on Kaumana.

25 February 1956 - Heavy rain from 8 a.m. to 1 p.m. - 5.65 inches in 5 hours. Streets in downtown area covered with 6 inches of water.

17 August 1956 - Torrential rains swept a car off a street, washed out a road, flooded a restaurant and damaged thousands of plants at the Territorial nursery in Hilo. The sudden downpour which caused damage in the Waiakea Homesteads area of Hilo was termed the "worse in 10 years." Hilo office of the Weather Bureau had 3.15 inches of rain between 2 a.m. and 5 a.m. today. The 24-hour rains averaged 8 inches in the Hilo area. Kilauea Avenue had 3 feet of water over it and the force of the water pushed a car over an 8-foot embankment.

31 August 1957 - A flash flood struck Hilo last night about 6 p.m. The water surged over Waiolama Canal wall into yards and basements of homes bordering it. Streets in downtown Hilo were flooded and 17 blocks were closed to traffic. Rainfall amounted to 11-12 inches during a 24-hour period.

2 November 1959 - Heavy rains caused basement flooding and street flooding in Hilo area as 10 to 18 inches of rain poured down in a 24-hour period.

The past 4-year period, 1961-1964, was unusual with respect to rainfall as a drought extended through the first half and above normal rain fell during the second half of the period. The year 1960 had normal rainfall until December when only 4.12 inches fell. This is 74 percent below normal for the month.

During the 27-month period, December 1960 through February 1963, there was a severe drought in the Hilo area. Only 6 months showed above normal rainfall. The total deficiency of rainfall amounted to 118 inches, or 37 percent below normal for the 27 months. The drought ended with the heavy rains of March and April 1963. During April alone, 32 inches fell; this is 20 inches above normal for the month. The 21-month period, March 1963 through November 1964, had rainfall amounting to 20 percent above normal but did not cause any major floods.

The lava flow of 1881, the last flow through the Kaumana-Punahoa area, caused underground lava tubes to form and left porous soil behind. Figures 11-13 show some lava formations and a lava tube opening. The area however, does not have enough large lava tubes to affect major flood runoff.

FUTURE FLOODING

A study was made to determine the flood which would result from the most intense storm considered reasonably characteristic of the Kaumana region. This is called the "Standard Project Flood" by the U. S. Army Corps of Engineers. Because of irregular ground surfaces, abnormal drainage patterns and highly localized potential rainfall, the area is divided into 21 separate subareas. Road ditches, such as the one shown on figure 14, have been barely adequate in containing recent flood flows. It can be expected that the areas shown on figures 14-17 will be flooded at rather infrequent intervals in the future. A flood of the magnitude of the "standard project" flow would cause these ditches along Kaumana Drive to overflow and send water into the houses. Some places (figure 6) have no ditches to channel flow away from houses. Therefore, residents build stone walls to keep out flood waters. In the northern part of the study area, the Piihonua Store (figure 18) has never had flood waters in the first floor. The highest water reported during the past 30 years was 3 feet over the road. In one section (figure 19) a watercourse cuts through the yards of several homes. When a heavy rain occurs, water rages down the sloping hillside and spreads over the yards and flows under the houses. Drainage facilities in new housing subdivisions should be planned and designed to eliminate sheet flow flooding by providing broad flowage paths that would direct excess flood waters into adequate storm drains.

Since floods are random occurrences of nature, there is no method of predicting the time or size of a future flood event. However, it is usually possible to predict, from a mathematical analysis of past floods, the average time that can be expected between future floods of a certain size. The technical appendix contains flood flow-frequency relations for the 21 subareas within the study boundary. Locations of the subarea concentration points are shown on plate 2.

The limits of flooding cannot be accurately determined because drainage patterns are not well developed and the numerous watercourses are poorly defined. As previously explained, this report of limited scope presents the hydrology without attempting to delineate the extent of flooding over a particular area. However, a field survey was made to determine the general aspect of flooding along Kaumana Drive and Ainako Avenue, the two main populated streets. Rapid flowing water covers the streets and fills some ditches to capacity, thereby stopping traffic and causing hazards, particularly to children walking along the streets. Yard damage is caused as the swirling waters drain through numerous swales left by lava flows. Plates 5 to 9 inclusive show the comparative high water, centerline of road and first floor profiles of residences along Kaumana Drive and Ainako Avenue. The high water profiles were obtained from interviews with the residents of the

houses and represent a composite profile of the highest elevations reached since they had moved there. The length of time these people have been living in the houses varies from 6 to 50 years, with the average being 15 years.

GUIDELINES FOR REDUCING FUTURE FLOOD DAMAGES

The normal methods used to prevent flood damages are the construction of dams and reservoirs, levees, diversion dikes, and also watershed treatment. These methods are impractical in the Kaumana area because of numerous divergent drainage paths, no suitable locations for dam construction and the extensive volcanic formations and basaltic topsoil. Other methods of minimizing flood losses can be provided by legal action and enforced by the police powers of a community. This is known as flood plain zoning. These regulatory controls do not attempt to eliminate flooding. They try to control land use planning and developments within areas with past history of flooding so that during times of heavy rain, damages and inconveniences would be reduced to a minimum. The main emphasis should be placed on control of sheet flow on the ground surface. The following guidelines present ways to reduce future flood damages:

a. Filling or dumping in and along the channel of Waipahoehoe Stream and its branches should not be allowed since this decreases channel capacity.

b. Bridge openings over channels should be kept clear so that flood waters can flow freely without constrictions which produce higher flood profiles and greater velocities than normally would occur.

c. Basement construction should be restricted.

d. Houses should be constructed so that the first floor is high enough to be above flood flows.

e. Zoning ordinances.

(1) Provision should be made for passage of floods by construction of open space facilities that would suffer negligible damages. These would include parks, playgrounds, ball fields and parking lots which would not be a hindrance to flood flows.

(a) This is particularly applicable to the Kaumana area. New subdivisions should be planned to allow broad grass covered drainage courses through the development with grading to channel sheet flow into them. Adequate storm drainage facilities such as road culverts, ditches and storm sewers should be designed using the flood-flow frequencies as presented in this report. However, care should be taken

so that installations of drainage works in one area do not add to flood and drainage problems in another. The total system and drainage pattern should be reviewed and designed to consider possible adverse effects on adjoining and downslope areas.

f. Along Kaumana Drive and Ainako Avenue, provide for adequate side road storm ditches to carry flood flows or construct curbing to keep water on the street and out of the houses which are below or even with the street level.

g. Evacuation. Temporary evacuation of movable property is effective only if coupled with an adequate flood warning system. There is a network of sirens along the coastal area of Hilo to warn of a possible tsunami. However, there is no system to predict rain storms in the Kaumana area except the U. S. Weather Bureau's forecasts of probable heavy rains and possible flooding over particular sections of the island. Once alerted, residents can raise their personal property to a safe level and evacuate the area.

It would be advantageous to the community planners to begin a system of recording information that would outline areas most prone to damage from heavy rains. It should be emphasized that the flood flow-frequency relationships in this report are based on data presently available. The results are considered accurate enough for a generalized application to the Kaumana-Punahoa area. Flow data obtained in the future may indicate the need for further study or adjustment of the synthetically derived relationships.

Upon request of the State Board of Land and Natural Resources, the U. S. Army Engineer District, Honolulu, will furnish technical assistance to explain information presented in this report and provide any additional flood information that may become available in the future.

CONCLUSION

This report has presented a brief history and problems of flooding in the Kaumana-Punahoa area and guidelines for reducing flood damages. Studies have been initiated to determine the advisability of providing lava barriers for the protection of Hilo Harbor and any other areas on the island of Hawaii that may be threatened by lava flows resulting from volcanic eruptions. A lava barrier in the Kaumana area would modify runoff characteristics.

The information and suggestions in this report are presented to enable the State, County of Hawaii, and other interested agencies and individuals to plan and regulate land use in the Kaumana-Punahoa area. This report is not intended to extend any Federal control or jurisdiction in flood plain planning or regulation. In addition, it in no way

obligates the Federal Government to further investigation, planning, design, construction, operation or maintenance of any facilities discussed unless such action is authorized by Congress.

A technical appendix to this report has been printed for use of engineers and planners concerned with the details of the data published in the report. The appendix deals mainly with the hydrologic characteristics of the area and may be obtained from the State Board of Land and Natural Resources.

GLENN P. INGWERSEN
Lt Col, Corps of Engineers
District Engineer

GLOSSARY OF SELECTED TERMS

A. HYDROLOGIC TERMS

Channel - A natural or artificial watercourse with definite bed and banks to confine and conduct flowing water.

Flood - A temporary overflow of lands not normally covered by water, which lands are used or usable by man when not inundated.

Flood plain - The relatively flat lowlands adjoining a watercourse or other body of water subject to overflow therefrom.

Flood profile - The longitudinal profile assumed by the surface of a stream of water flowing in an open channel.

Rainfall intensity - The amount of rain that falls in a specified time interval, usually expressed as inches per hour.

Recurrence interval - The average interval of time within which a particular flow will be exceeded once.

Standard project flood - A hypothetical flood, estimated by the Corps of Engineers, representing the critical flood runoff and peak flood flow that may be expected from the most severe combination of meteorological and hydrologic conditions that are considered reasonably characteristic of the geographical region involved, excluding extremely rare combinations.

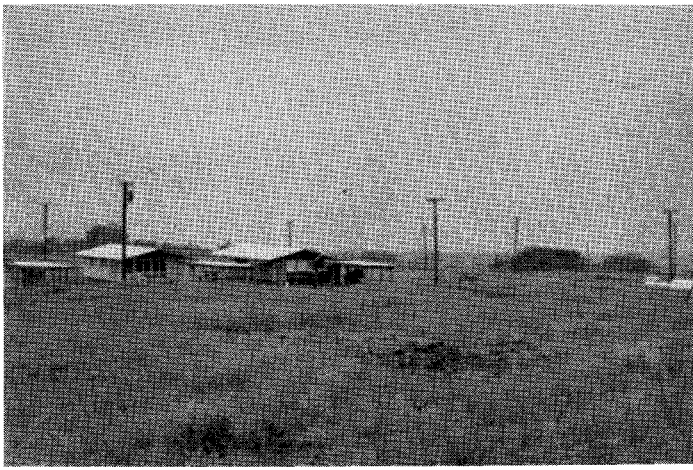
Tsunami - A sea wave produced by submarine earth movement or volcanic eruption.

Watershed - The area drained by a stream or stream system.

B. REGULATORY TERMS

Flood plain regulations - A general term applied to the full range of codes, ordinances, and other regulations relating to the use of land and construction within flood plain areas.

Subdivision regulations - Regulations and standards established by a local public authority, generally the local planning agency, with authority from a state enabling law, for the subdivision of land in order to secure coordinated land development, including adequate building sites and land for vital community services and facilities such as streets, utilities, schools and parks.



At Kaumana Lani subdivision -

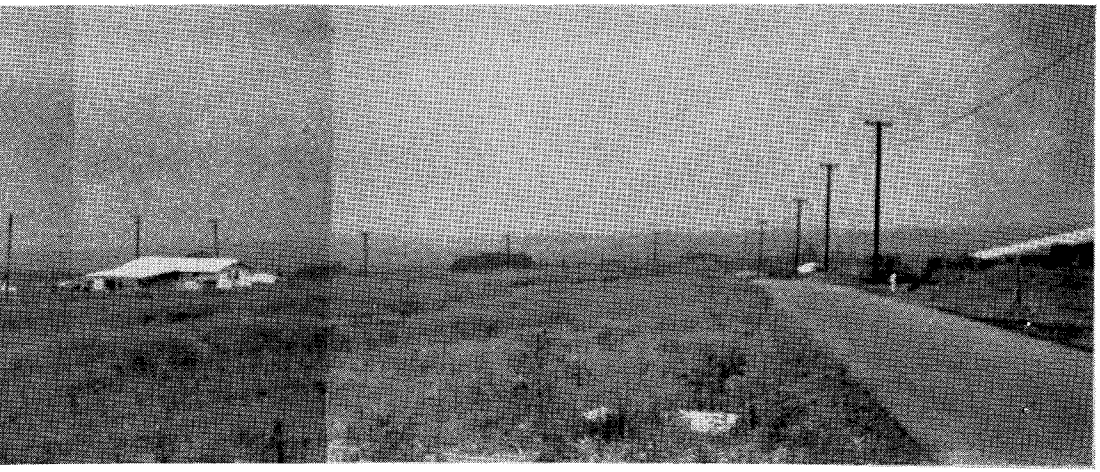


Figure 1.

1,500 feet north of station 14.9 along Kaumana Drive.

Figure 2.
At western end of study area looking towards Hilo Bay.

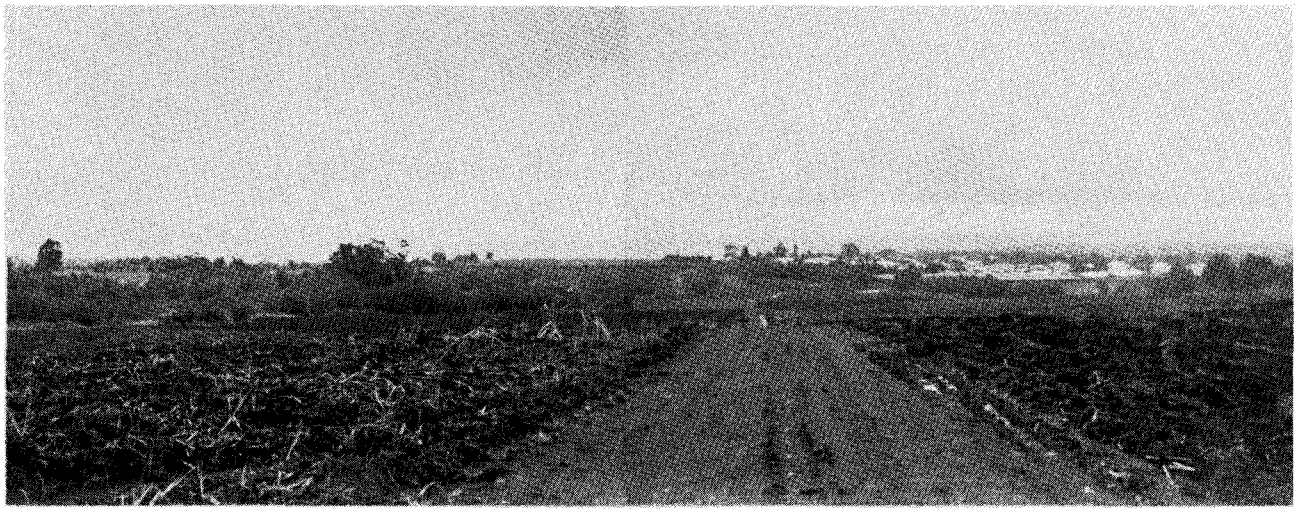


Figure 3.
At cane field 1,000 feet north of station 2.4 along Kaumana Drive.
Looking towards Hilo Bay with houses along Kaumana Drive on right.

Figure 4.

Below Reservoir No. 1, south of Piihonua district - note lava out crop

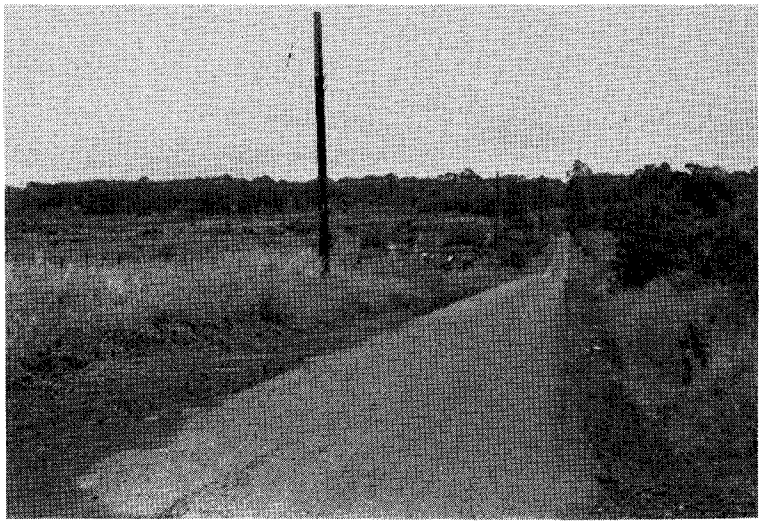


Figure 5

At Waianuenue Avenue - looking south along Akolea Road

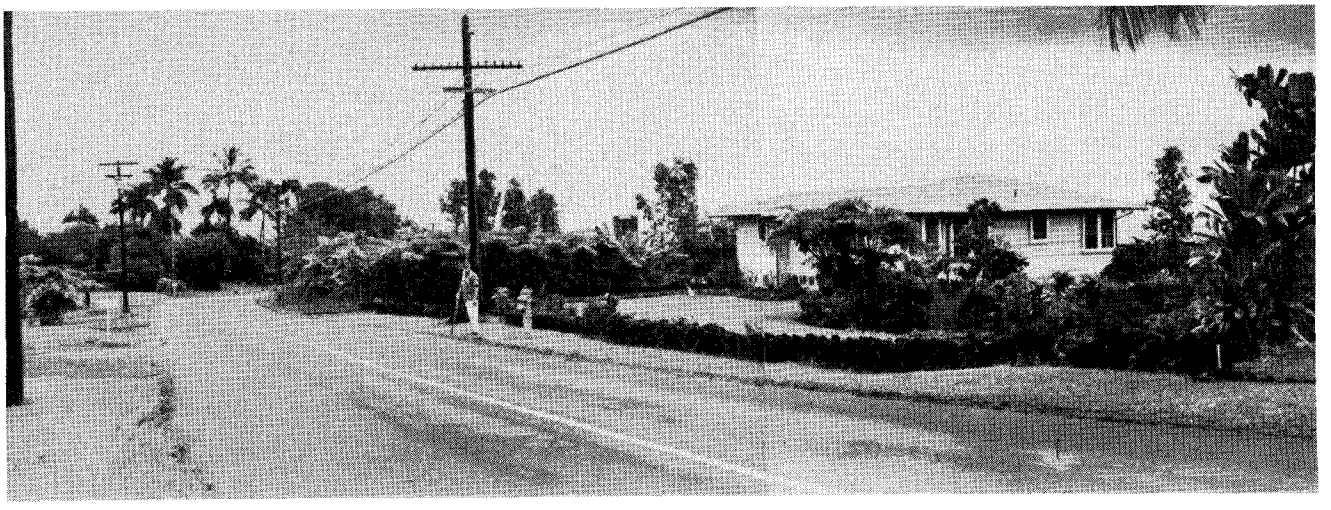


Figure 6

At Kaumana Drive Station 16.3 - looking east or down Kaumana Drive

Figure 7

At end of Koula Street - 1,000 feet north of Ainako Avenue
Station 2.9 - looking at water course through yards

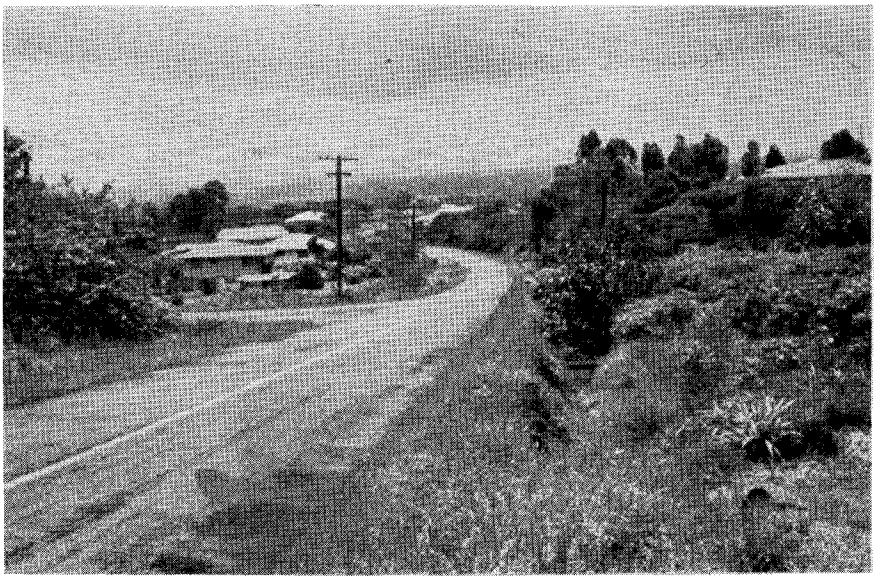


Figure 8.

At Ainako Avenue Station 4.7 - looking east or down Ainako Avenue

Figure 9.

At Kaumana Drive Station 14.0 - looking upstream at concrete arch bridge over Waipahoehoe Stream at Chong Street

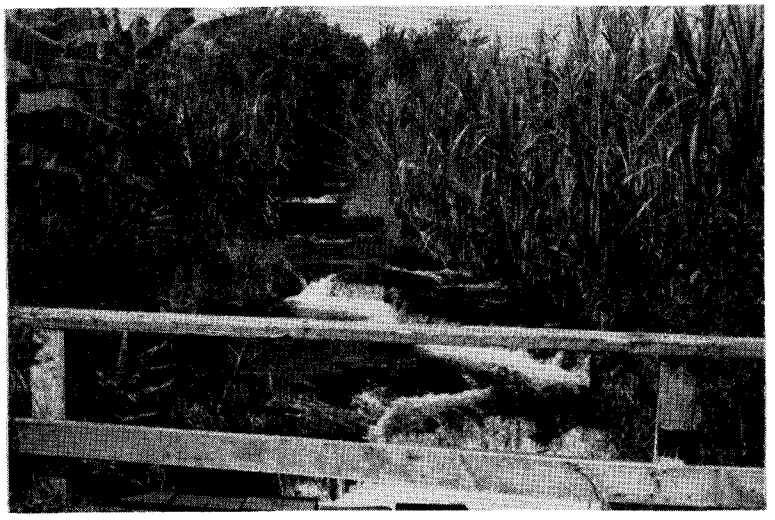


Figure 10.

At bridge over Kaluiiki Branch along Akolea Road - 2,500 feet north of Kaumana Drive - looking upstream

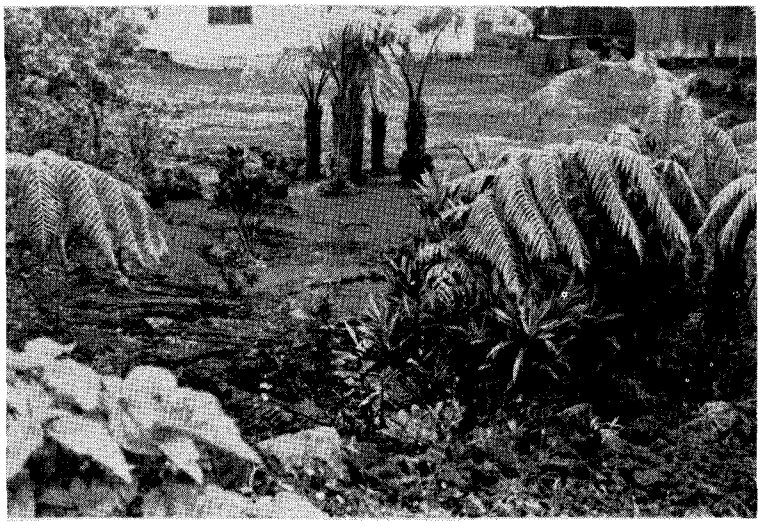


Figure 11.

At Kaumana Drive Station 4.4 - lava flow in yard

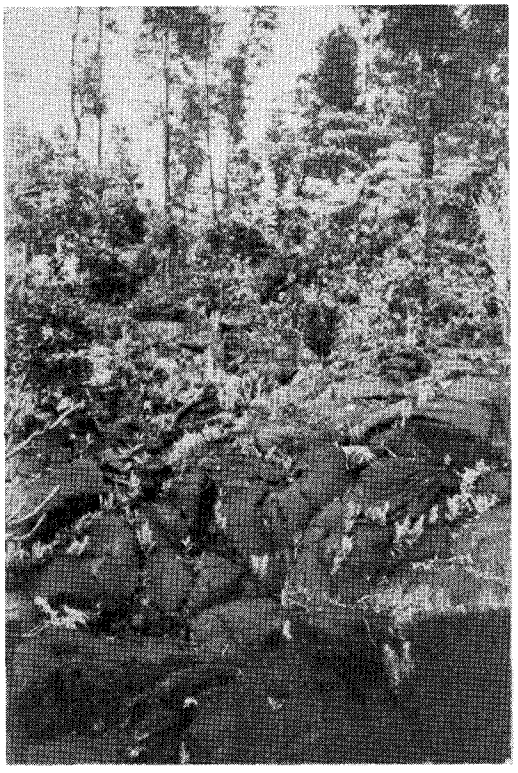


Figure 12.

At Kaumana Drive Station 12.2 - lava flow in yard

Figure 13.

At Kaumana Drive Station 6.3 - lava tube opening below gas station

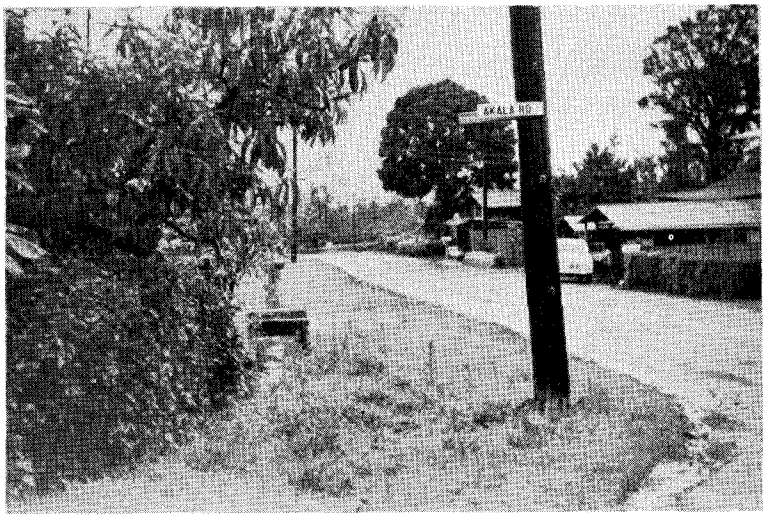


Figure 14.

At Kaumana Drive Station 10.4 - looking east or down Kaumana Drive

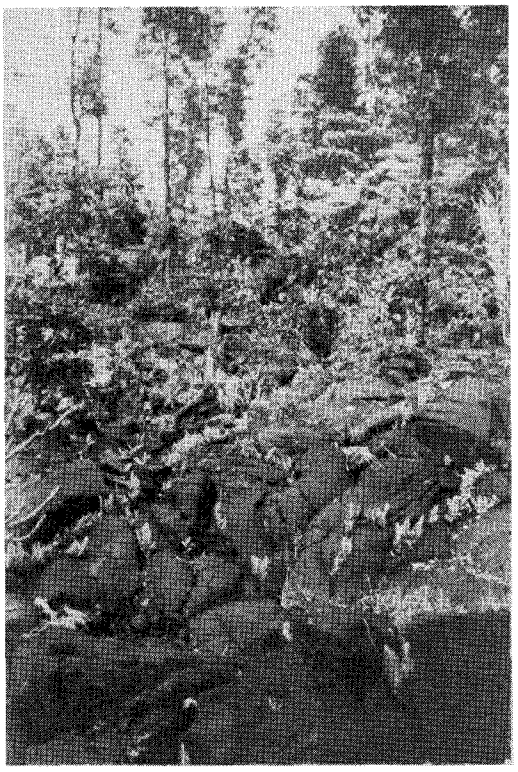


Figure 12.

At Kaumana Drive Station 12.2 - lava flow in yard

Figure 13.

At Kaumana Drive Station 6.3 - lava tube opening below gas station

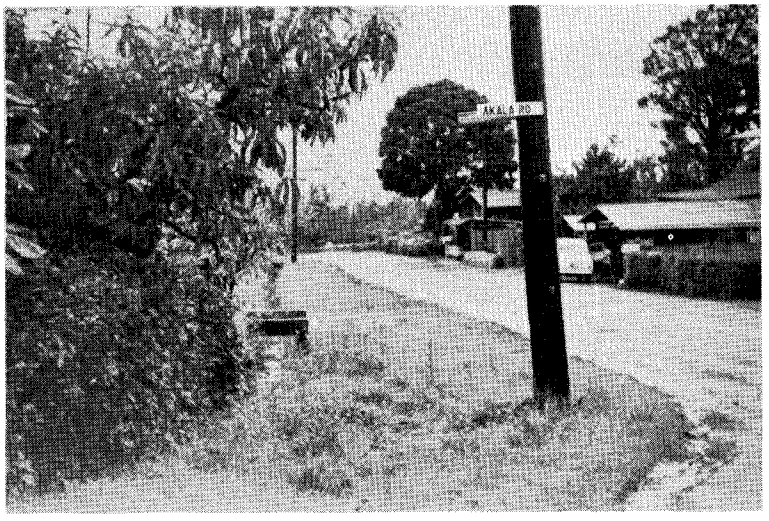


Figure 14.

At Kaumana Drive Station 10.4 - looking east or down Kaumana Drive

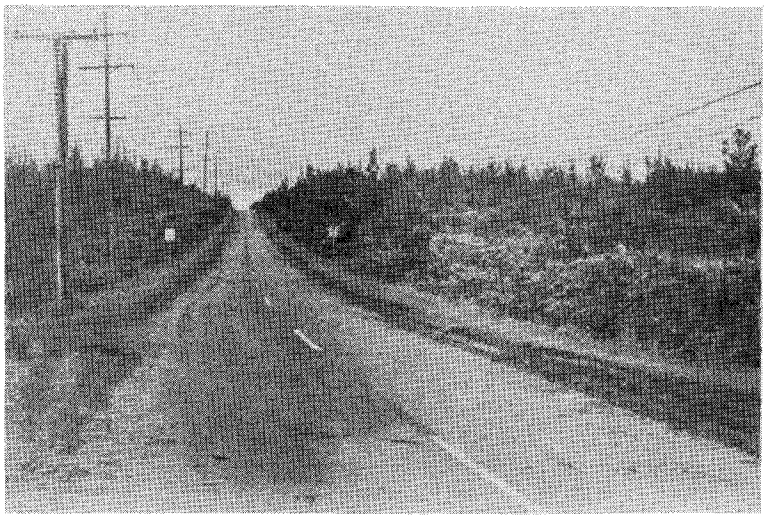


Figure 15.

At Kaumana Drive Station 3.6 - looking west or up Kaumana Drive. This is the upper limit of houses

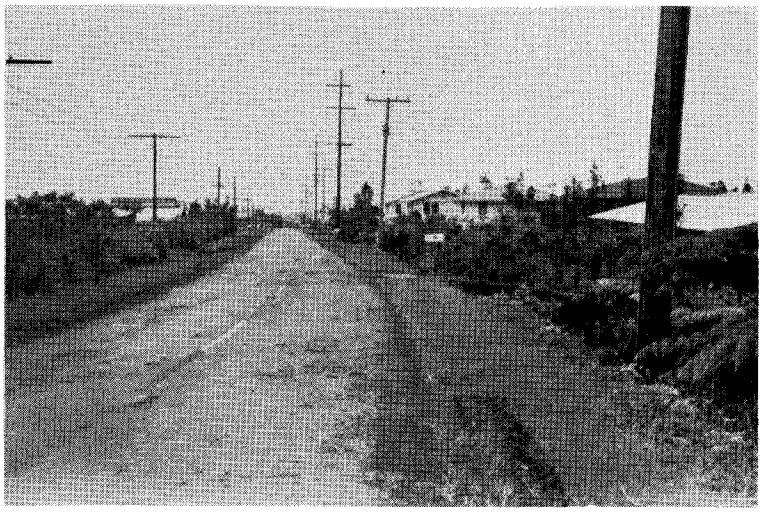


Figure 16.

At Kaumana Drive Station 3.6 - looking east or down Kaumana Drive

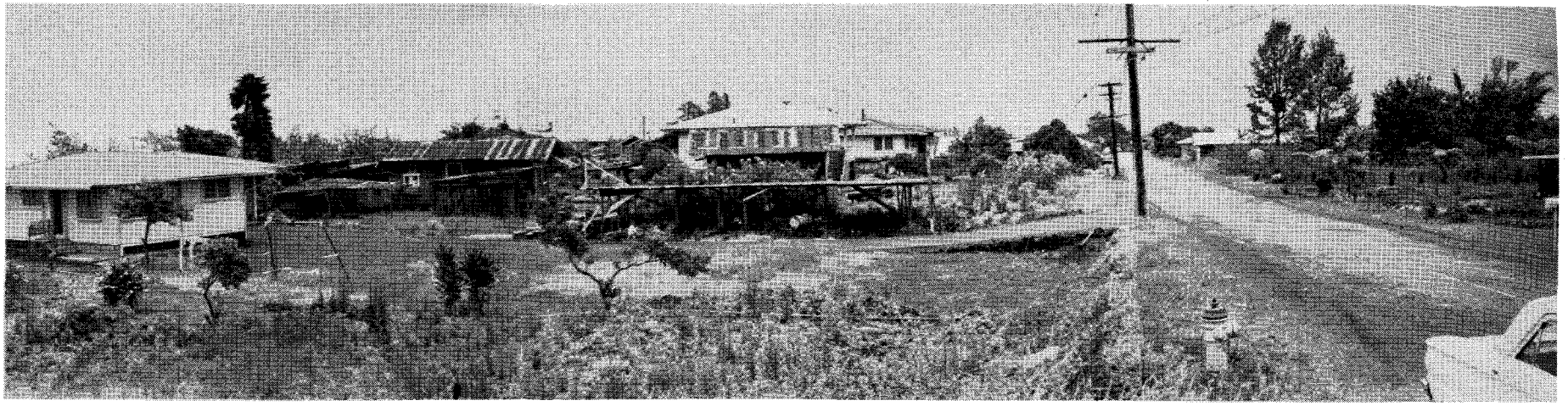


Figure 17.

At Kaumana Drive Station 5.1 - View looking east or down Kaumana Drive

Figure 18.

At Piihonua store - northern part of study area - highest water in 30 years was 3 feet over the road

Figure 19.

On Koula Street at point 500 feet north of Ainako Avenue Station 2.9 - looking down the slope at water flowing through yards over a bed of lava rock

CORPS OF ENGINEERS

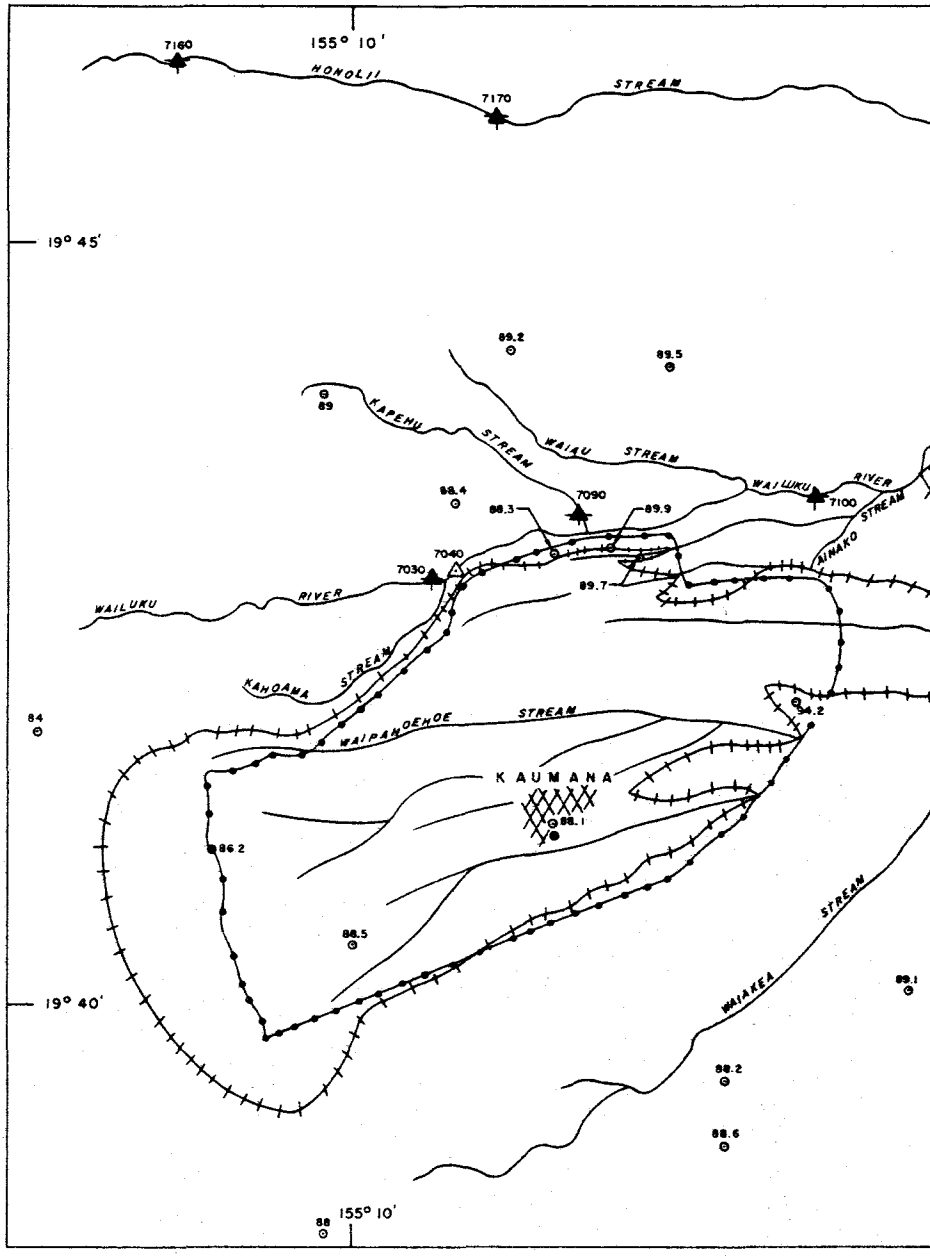
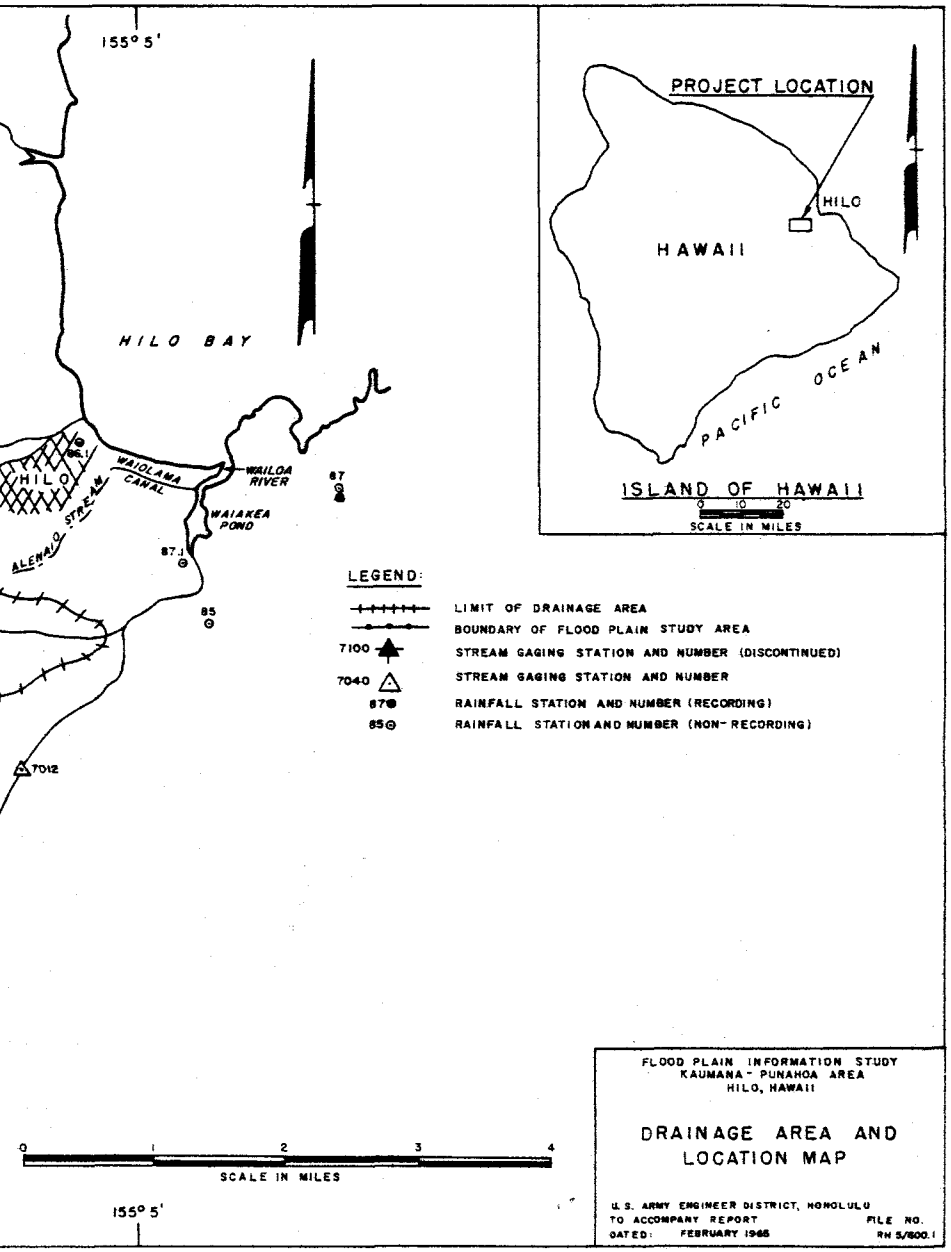


PLATE 1

U. S. ARMY



FLOOD PLAIN INFORMATION STUDY
KAUMANA - PUNAHOA AREA
HILO, HAWAII

DRAINAGE AREA AND LOCATION MAP

U. S. ARMY ENGINEER DISTRICT, HONOLULU
TO ACCOMPANY REPORT — FILE NO.
DATED: FEBRUARY 1965 — RH 5/600.1

NOTE:
CROSS SECTIONS PLOTTED ON PLATE 3
CONTOUR INTERVAL 20 FEET

LEGEND

- 3 — NEW SUBDIVISIONS
- ——— LIMIT OF DRAINAGE AREA
- ——●——●—— BOUNDARY OF FLOOD PLAIN STUDY AREA
- (1A) POINT OF CONCENTRATION
- 1 2 — STATIONING ALONG KAUMANA AND AINAKO — 1,000' INTERVALS

1000' 0 1000' 2000' 3000' 4000' 5000'

SCALE 1:24000

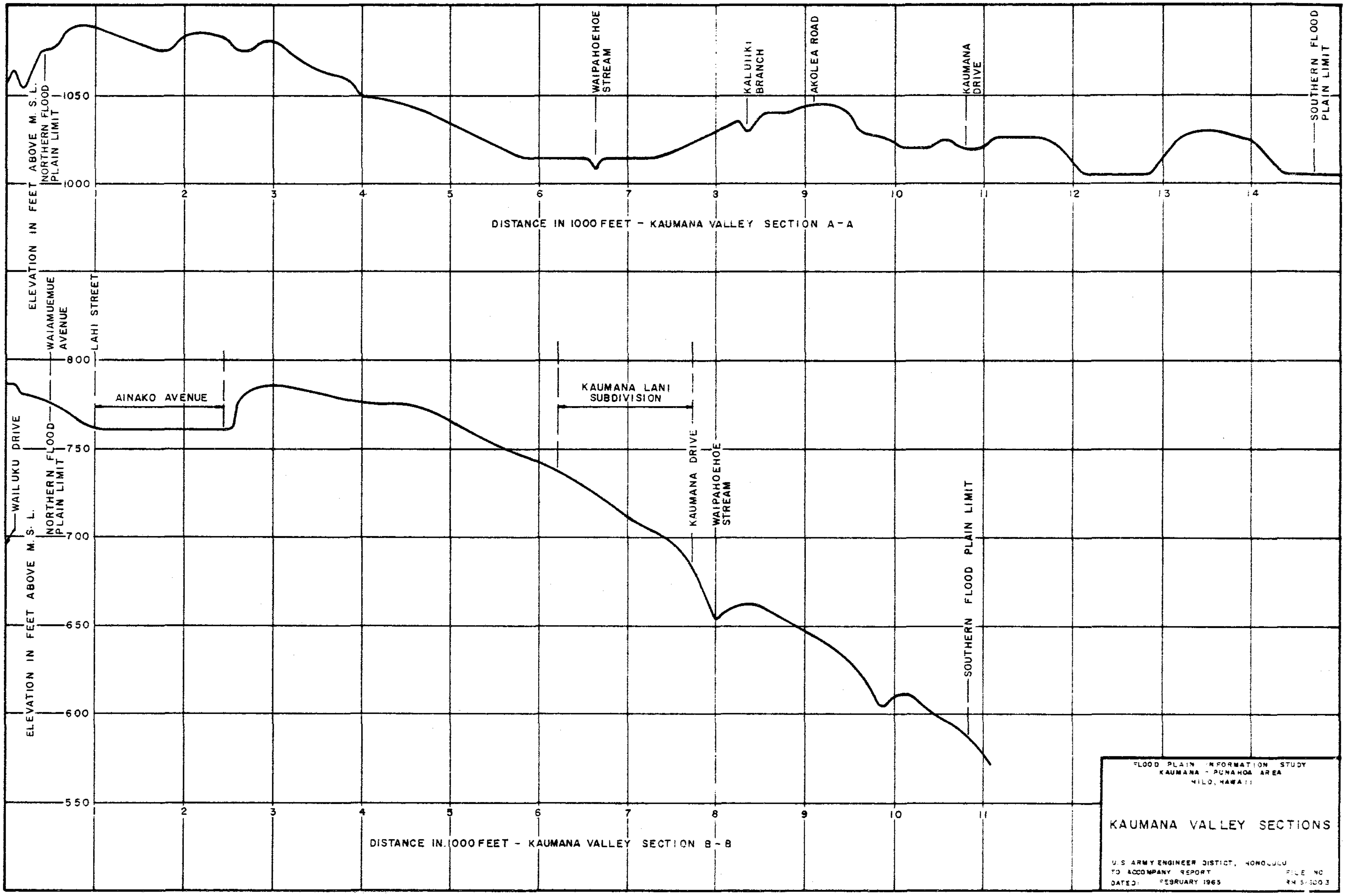
FLOOD PLAIN INFORMATION STUDY
KAUMANA - PUNAHOA AREA
HILO, HAWAII

SUBAREA LOCATIONS AND GENERAL PLAN VIEW

U.S. ARMY ENGINEER DISTRICT, HONOLULU
TO ACCOMPANY REPORT FILE NO.
DATED: FEBRUARY 1965 RH 5/600.2

PLATE 2

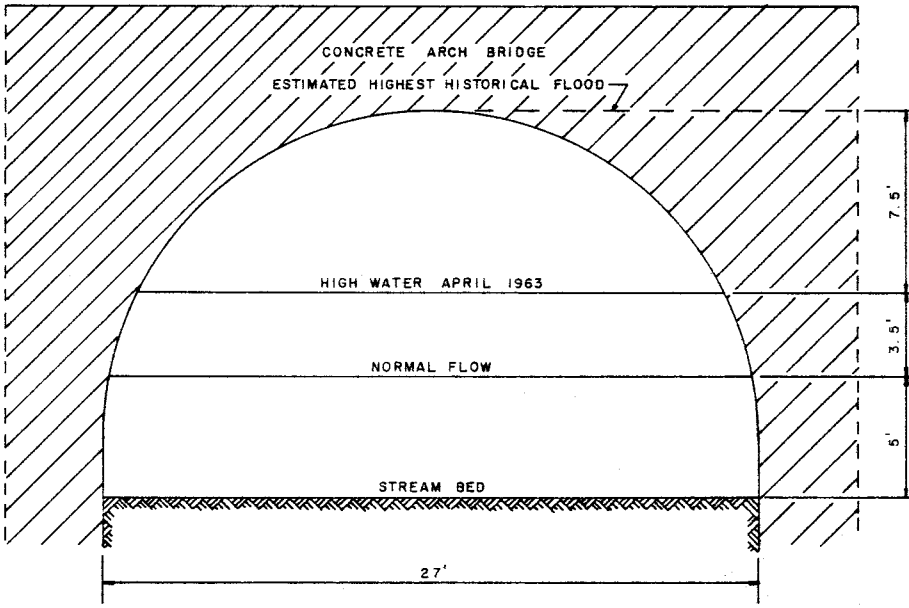
PLATE 3



FLOOD PLAIN INFORMATION STUDY
KAUMANA - PUNAHOA AREA
HILO, HAWAII

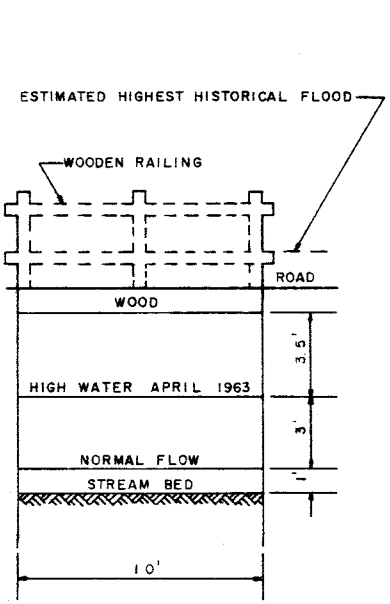
KAUMANA VALLEY SECTIONS

U.S. ARMY ENGINEER DISTICT, HONOLULU
TO ACCOMPANY REPORT
DATED: FEBRUARY 1965
FILE NO
RH 5/100.3

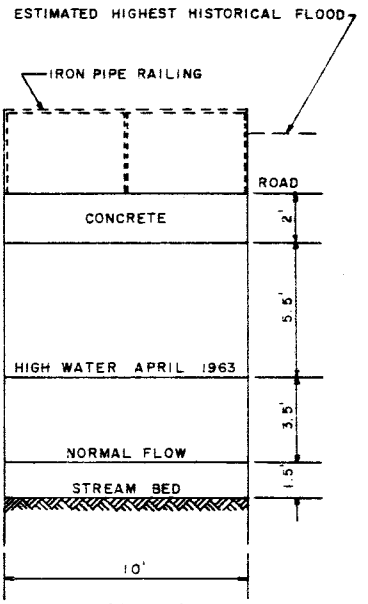


CHONG STREET BRIDGE
ACROSS
WAIPAHOEHOE STREAM

PLATE 4



AKOLEA ROAD BRIDGE
ACROSS
KALUIIKI BRANCH



AKOLEA ROAD BRIDGE
ACROSS
WAIPAHOEHOE STREAM

FLOOD PLAIN INFORMATION STUDY
KAUMANA - PUNAHOA AREA
HILO, HAWAII

KAUMANA BRIDGE SECTIONS

U.S. ARMY ENGINEER DISTICT, HONOLULU
TO ACCOMPANY REPORT — FILE NO.
DATED: FEBRUARY 1968 — RH 5/600.4

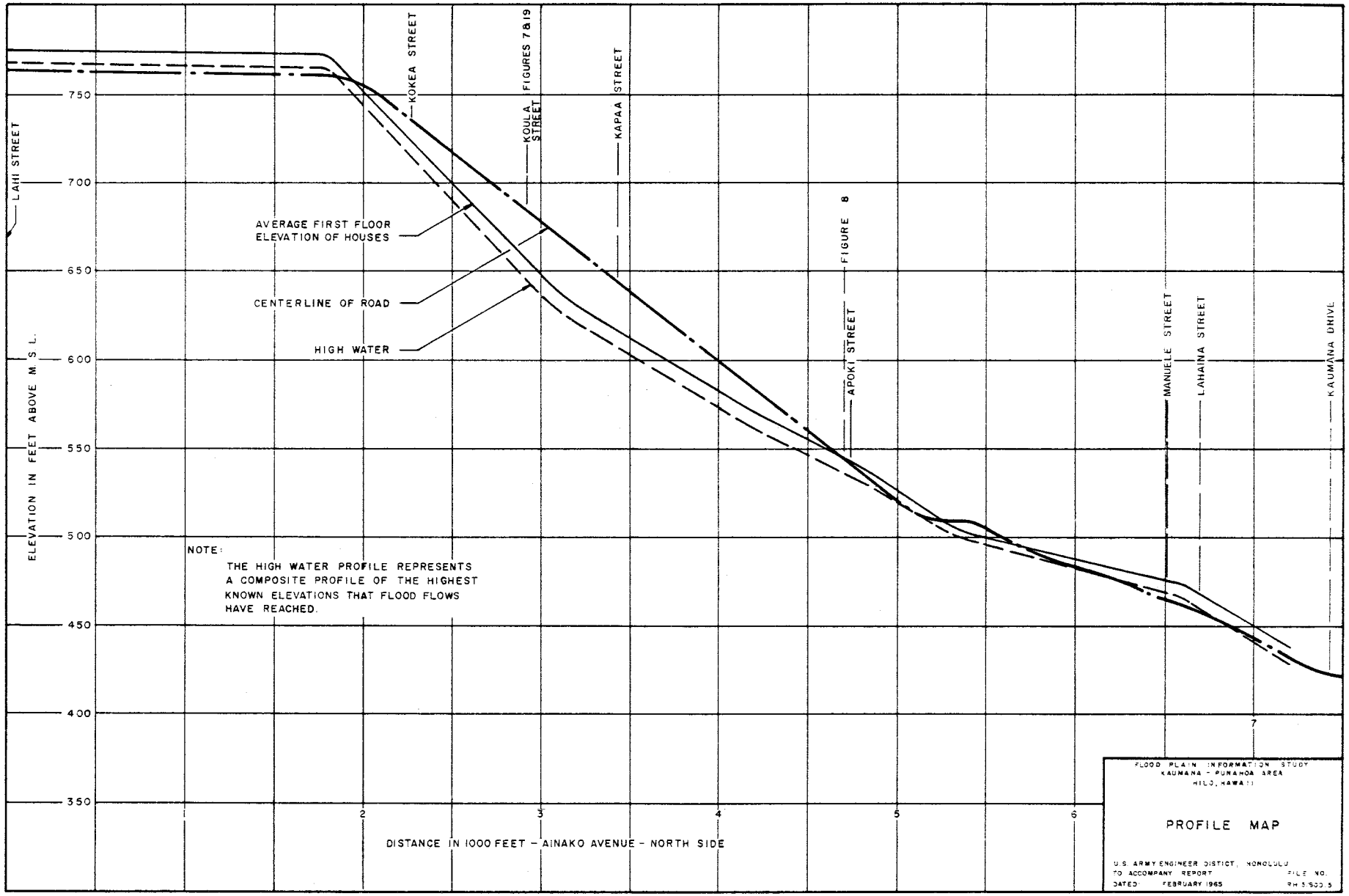

LAHI STREET
KOKEA STREET
KOULA STREET
FIGURES 7 & 9
KAPAA STREET
FIGURE 8
APOKI STREET
MANUELE STREET
LAHAINA STREET
KAUMANA DRIVE
AVERAGE FIRST FLOOR ELEVATION OF HOUSES
CENTERLINE OF ROAD
HIGH WATER
ELEVATION IN FEET ABOVE M.S.L.
750
700
650
600
550
500
450
400
350
NOTE:
THE HIGH WATER PROFILE REPRESENTS A COMPOSITE PROFILE OF THE HIGHEST KNOWN ELEVATIONS THAT FLOOD FLOWS HAVE REACHED.
1
2
3
4
5
6
7
DISTANCE IN 1000 FEET – AINAKO AVENUE – NORTH SIDE
FLOOD PLAIN INFORMATION STUDY
KAUMANA - PUUNOA AREA
HILO, HAWAII
PROFILE MAP
U.S. ARMY ENGINEER DISTRICT, HONOLULU
TO ACCOMPANY REPORT
DATED: FEBRUARY 1965
FILE NO.
PH 5-503.5

PLATE 5

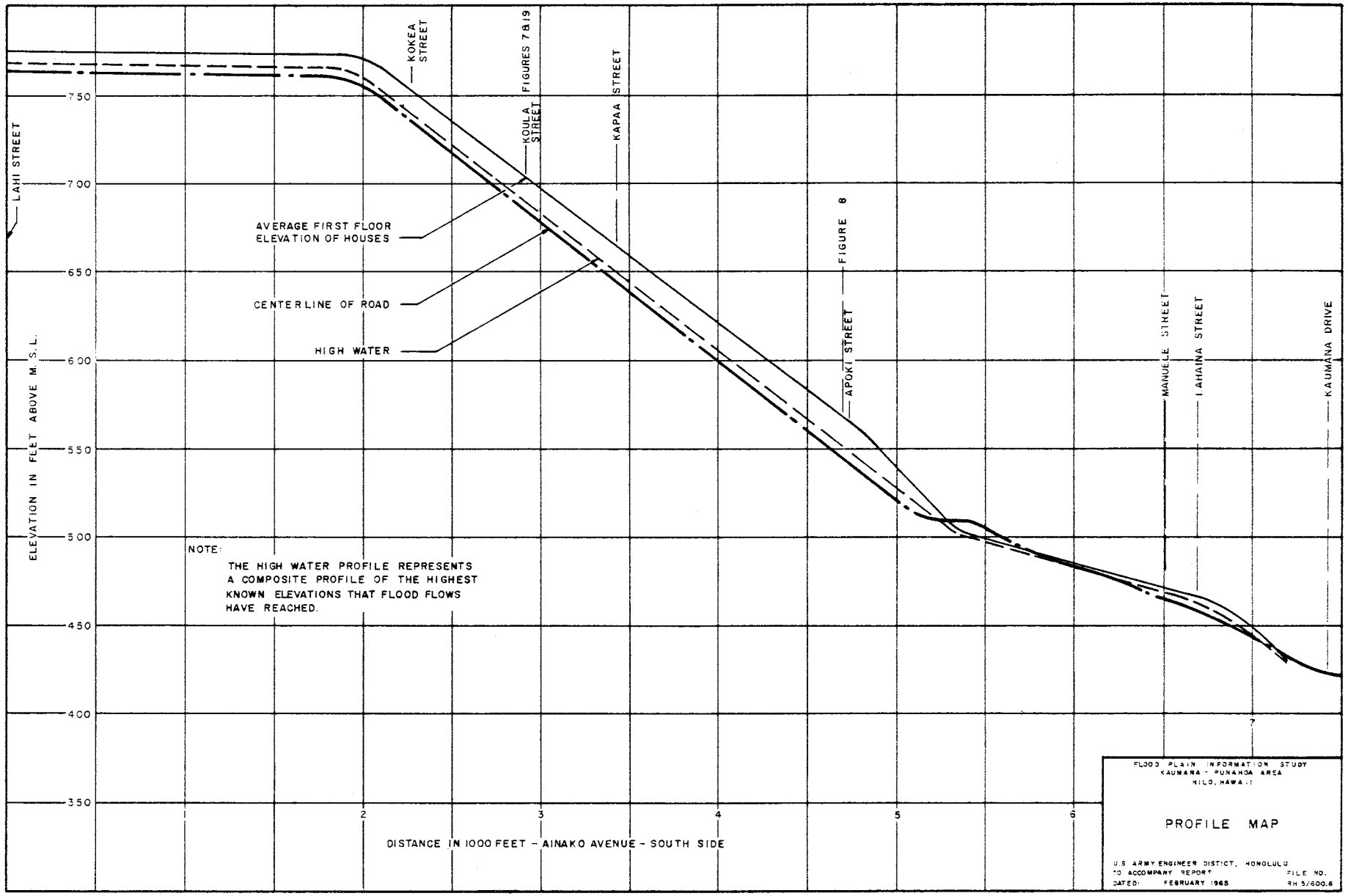

LAHI STREET
KOKEA STREET
KOULA STREET
FIGURES 7 & 9
KAPAA STREET
FIGURE 8
APOKI STREET
MANUELE STREET
I AHAINA STREET
KAUMANA DRIVE
AVERAGE FIRST FLOOR ELEVATION OF HOUSES
CENTERLINE OF ROAD
HIGH WATER
ELEVATION IN FEET ABOVE M.S.L.
750
700
650
600
550
500
450
400
350
NOTE:
THE HIGH WATER PROFILE REPRESENTS A COMPOSITE PROFILE OF THE HIGHEST KNOWN ELEVATIONS THAT FLOOD FLOWS HAVE REACHED.
1
2
3
4
5
6
7
DISTANCE IN 1000 FEET - AINAKO AVENUE - SOUTH SIDE
FLOOD PLAIN INFORMATION STUDY
KAUMANA - PUNAHOA AREA
HILO, HAWAII
PROFILE MAP
U.S. ARMY ENGINEER DISTRICT, HONOLULU
TO ACCOMPANY REPORT
FILE NO.
DATED: FEBRUARY 1965
RH 5/600.6

PLATE 6

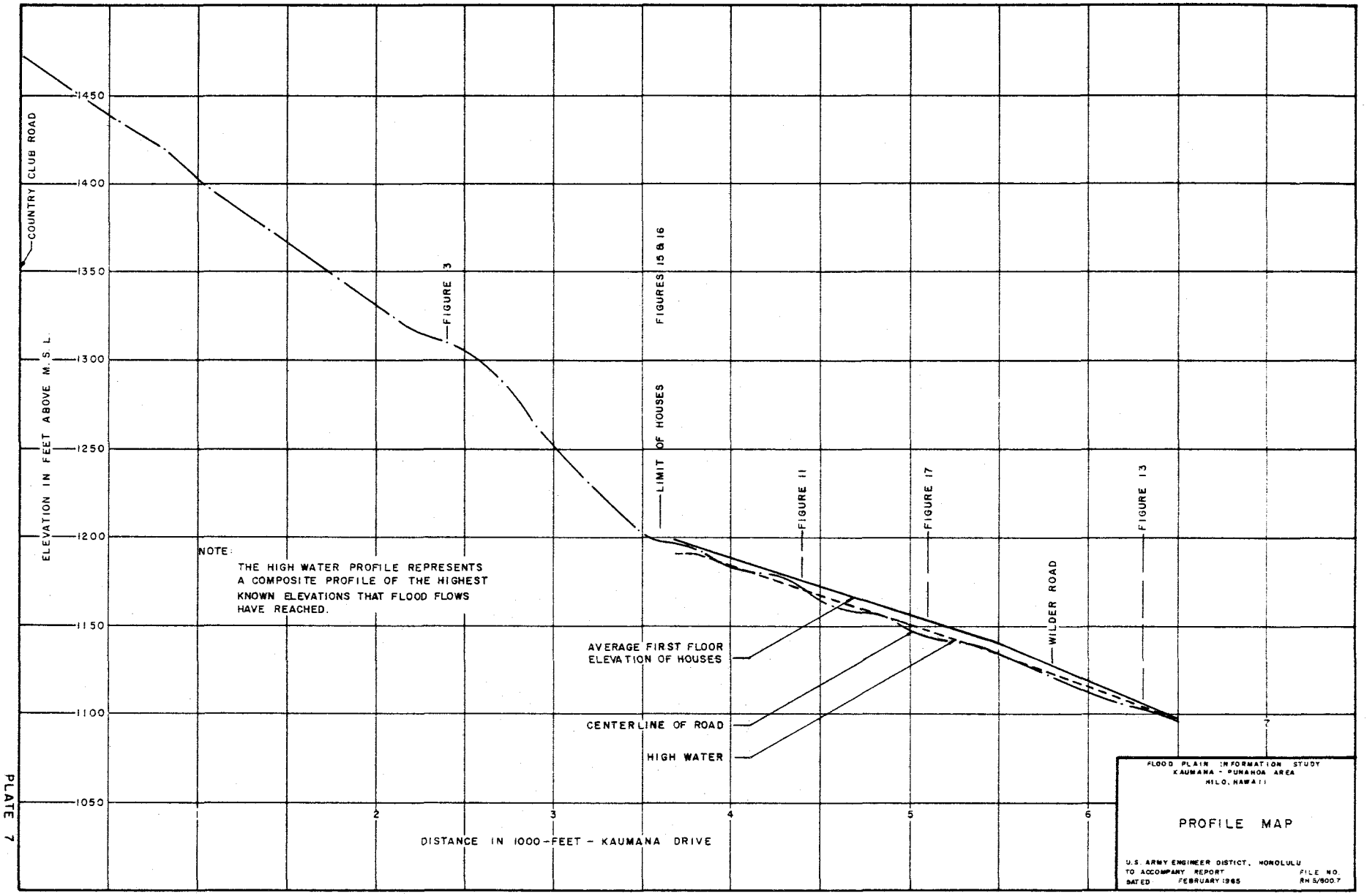


PLATE 7

FLOOD PLAIN INFORMATION STUDY
KAUMANA - PUUNANA AREA
HILO, HAWAII

PROFILE MAP

U.S. ARMY ENGINEER DISTICT, HONOLULU
TO ACCOMPANY REPORT
DATED FEBRUARY 1965
FILE NO. RH 5/600.7

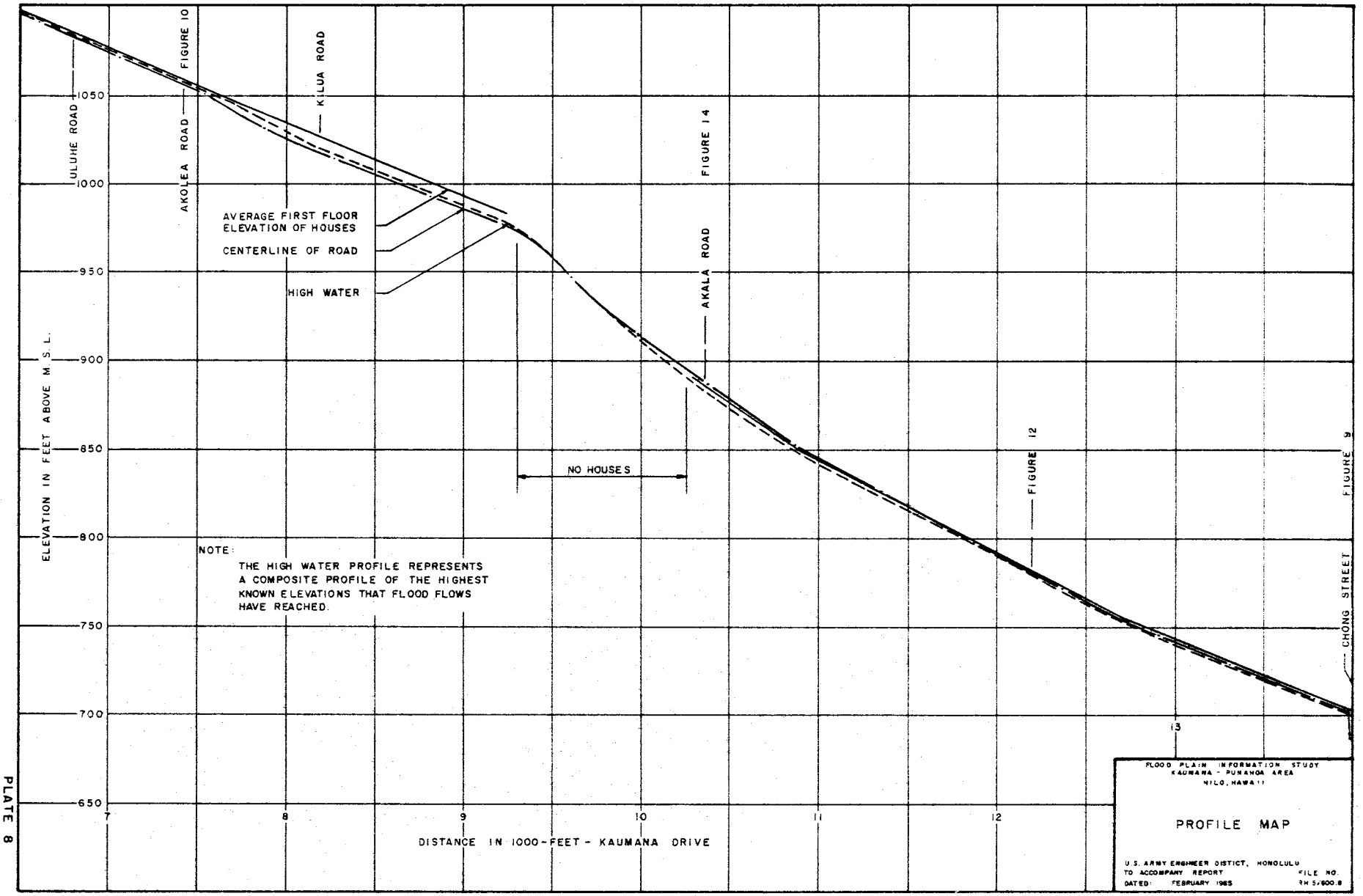

ELEVATION IN FEET ABOVE M.S.L.
1050
1000
950
900
850
800
750
700
650
7
8
9
10
11
12
13
DISTANCE IN 1000-FEET - KAUMANA DRIVE
LULUHE ROAD
AKOLEA ROAD
FIGURE 10
KILUA ROAD
AVERAGE FIRST FLOOR ELEVATION OF HOUSES
CENTERLINE OF ROAD
HIGH WATER
NO HOUSES
AKALA ROAD
FIGURE 14
FIGURE 12
FIGURE 9
CHONG STREET
NOTE:
THE HIGH WATER PROFILE REPRESENTS A COMPOSITE PROFILE OF THE HIGHEST KNOWN ELEVATIONS THAT FLOOD FLOWS HAVE REACHED.
FLOOD PLAIN INFORMATION STUDY
KAUMANA - PUUANOA AREA
HILO, HAWAII
PROFILE MAP
U.S. ARMY ENGINEER DISTICT, HONOLULU
TO ACCOMPANY REPORT
FILE NO.
DATED: FEBRUARY 1965
PH 5/600.8

PLATE 8

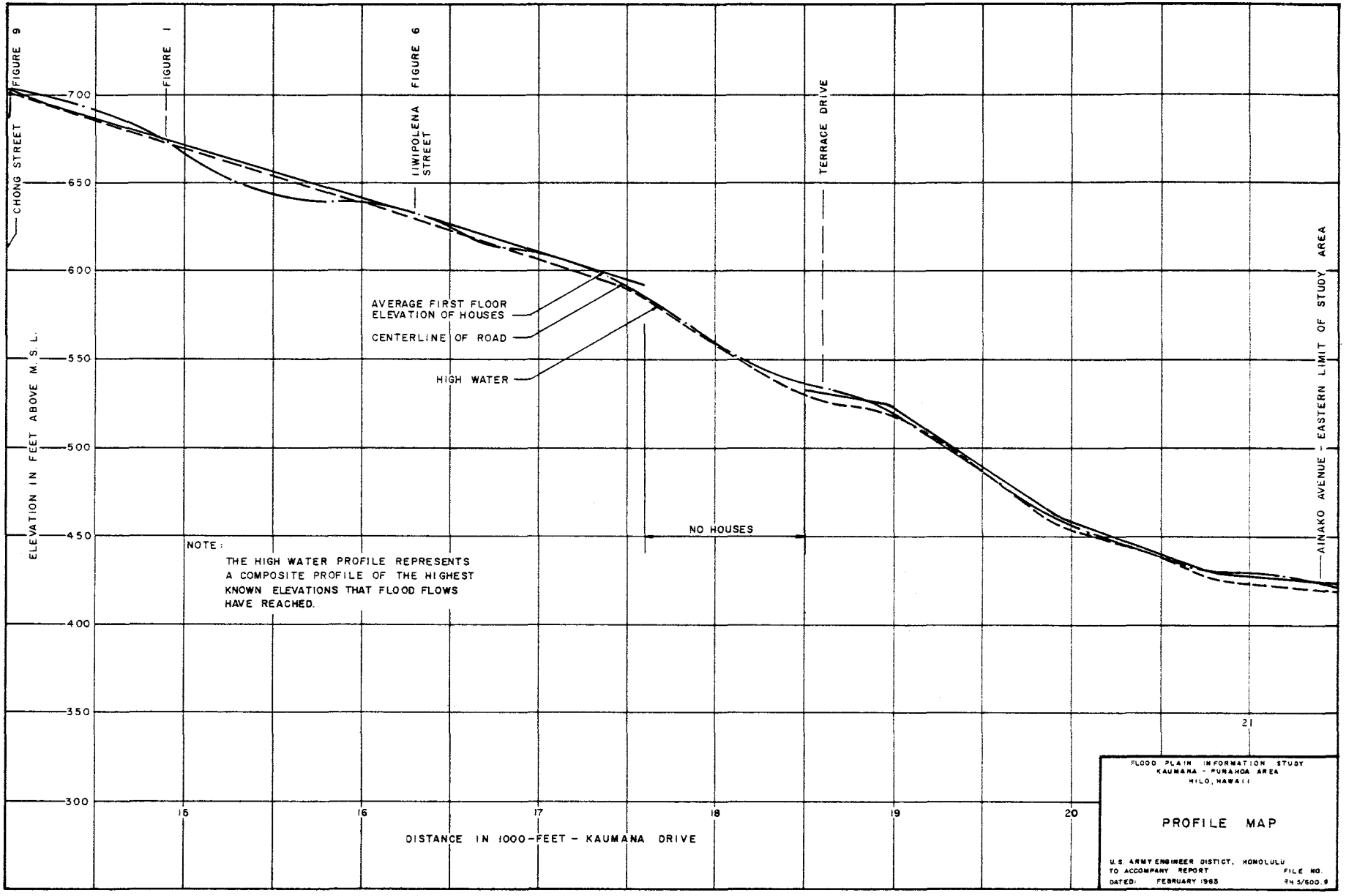


FIGURE 9
FIGURE 1
FIGURE 6
CHONG STREET
IIWIPOLENA STREET
TERRACE DRIVE
AINAKO AVENUE - EASTERN LIMIT OF STUDY AREA
ELEVATION IN FEET ABOVE M.S.L.
700
650
600
550
500
450
400
350
300
AVERAGE FIRST FLOOR ELEVATION OF HOUSES
CENTERLINE OF ROAD
HIGH WATER
NO HOUSES
NOTE:
THE HIGH WATER PROFILE REPRESENTS A COMPOSITE PROFILE OF THE HIGHEST KNOWN ELEVATIONS THAT FLOOD FLOWS HAVE REACHED.
15
16
17
18
19
20
21
DISTANCE IN 1000-FEET - KAUMANA DRIVE
FLOOD PLAIN INFORMATION STUDY
KAUMANA - PUNAHOA AREA
HILO, HAWAII
PROFILE MAP
U.S. ARMY ENGINEER DISTICT, HONOLULU
TO ACCOMPANY REPORT
DATED: FEBRUARY 1965
FILE NO. HI 5/600.9

PLATE 9