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In response to the need to identify and describe aquifers for each island of the state of Hawaii to serve as a framework for groundwater protection strategy, a program was initiated to classify and assign codes to the principal aquifers of the state. This fifth report provides Aquifer Codes and Status Codes for the island of Lanai. The Aquifer Codes incorporate locational and descriptive indices, whereas the Status Codes indicate the developability, utility, quality, uniqueness, and vulnerability to contamination of the groundwater resources. The codes were generated for Hawaiian conditions of groundwater occurrence and behavior in preference to using the DRASTIC approach suggested by the U.S. Environmental Protection Agency. Each Aquifer Type within an Aquifer System is assigned an Aquifer Code consisting of an eight-digit number. An Aquifer Code is unique and non-repeatable in the State. Accompanying the Aquifer Code is a Status Code of five digits. A Status Code is specific to an Aquifer Code. The Lanai classification includes 4 Aquifer Sectors, 9 Aquifer Systems, and 22 Aquifer Codes.

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AQUIFER IDENTIFICATION AND CLASSIFICATION FOR LĀNA'I:
Groundwater Protection Strategy for Hawai'i

John F. Mink
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Project Completion Report
for
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ABSTRACT

In response to the need to identify and describe aquifers for each island of the state of Hawai'i to serve as a framework for groundwater protection strategy, a program was initiated to classify and assign codes to the principal aquifers of the state. This fifth report provides Aquifer Codes and Status Codes for the island of Lāna'i.

The Aquifer Codes incorporate locational and descriptive indices, whereas the Status Codes indicate the developability, utility, quality, uniqueness, and vulnerability to contamination of the groundwater resources. The codes were generated for Hawaiian conditions of groundwater occurrence and behavior in preference to using the DRASTIC approach suggested by the U.S. Environmental Protection Agency.

Each Aquifer Type within an Aquifer System is assigned an Aquifer Code consisting of an eight-digit number. An Aquifer Code is unique and non-repeatable in the State. Accompanying the Aquifer Code is a Status Code of five digits. A Status Code is specific to an Aquifer Code. The Lāna'i classification includes 4 Aquifer Sectors, 9 Aquifer Systems, and 22 Aquifer Codes.

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INTRODUCTION

The aquifer classification protocol was originated to provide a framework within which to identify and describe groundwater resources throughout the state of Hawai'i. The framework is necessary because a standard locational and descriptive nomenclature has not been uniformly applied by investigators when referring to groundwater resources. By employing a common reference, the classification allows hydrologists, engineers, decision makers, and laymen to avoid misunderstandings and confusion.

The intent of the classification is to simplify groundwater hydrology so that discussion at all levels of scientific-engineering comprehension can take place. It is designed for practical application; therefore, boundaries for the subdivisions must be drawn, even though the boundaries are not exact because conditions of actual groundwater occurrence and behavior are generally only poorly understood. For example, where hydrogeological conditions have not been unraveled, boundaries are drawn along topographic divides to encompass entire drainage areas, even though these divides most often are weak expressions of subsurface hydrogeology. On Lāna'i most boundaries for the classification are along topographic divides. Additionally, boundaries formerly assigned to hydrographic units are retained as the boundaries of Aquifer Sectors and Systems wherever reasonable.

AQUIFER CLASSIFICATION

Aquifer Codes

The classification scheme reported by Mink and Lau (1990 rev.) is the starting point for developing an Aquifer Code for the island of Lāna'i. The classification is based on a hierarchy of descriptors beginning with general location by Island and Sector, to which belongs a set of Aquifer Systems, within which are a variety of Aquifer Types. Sectors primarily reflect broad hydrogeological features and, secondarily, geography. Aquifer Systems are more specifically defined by hydrogeological continuity, in particular hydraulic connections among units; Aquifer Types are differentiated by distinctive features of hydrology and geology. Not identified but following Aquifer Type in the hierarchy is the Aquifer Unit, which is defined as an identifiable unit within an Aquifer Type.

In brief, the hierarchy is as follows:

a. Island—the global factor
b. Sector—a large region with hydrogeological similarities
c. System—an area within a Sector showing hydrogeological continuity
d. Type—portions of a System having the same hydrological and geological features

Islands are coded by number in conformance with the first digit of the Hawai'i State well numbering system originated by the U.S. Geological Survey (1976). Each Sector is coded

with a two-digit number and by a Hawaiian geographic name except where locational confusion might result, in which case the general locators North, South, East, West, and Central, or a traditional geographic term such as Windward, are used. A two-digit number is applied to each Aquifer System, which also can be referred to by a geographic name. Three digits describe fundamental hydrology and geology to constitute the Aquifer Type.

The form of the numerical code is 1 01 01 111, in which the first number is the Island, the next two the Sector, the following two the System, and the last three the Type. Island numbers are 1 (Ni'ihau), 2 (Kaua'i), 3 (O'ahu), 4 (Moloka'i), 5 (Lāna'i), 6 (Maui), 7 (Kaho'olawe), and 8 (Hawai'i). Sector numbers start at 01 for each Island. Similarly, System numbers start at 01 for each Sector.

Hydrology is uniquely described by a pair of digits and geology by a single digit. Identifying characteristics with their codes are as follows.

HYDROLOGY. Aquifer Types are defined as either basal or high-level, and as either unconfined or confined. Their numbers with brief descriptions are as follows:

NO.	TYPE	DESCRIPTION
1	Basal	Fresh water in contact with seawater
2	High Level	Fresh water not in contact with seawater
1	Unconfined	Where the water table is the upper surface of the saturated aquifer
2	Confined	Aquifer is bounded by impermeable or poorly permeable formations; top of the saturated aquifer is below the surface of the groundwater (piezometric surface)
3	Confined or Unconfined	Where the actual condition is uncertain

Using the above coding, groundwater can be 11 (basal, unconfined) or 12 (basal, confined), or 21 (high level, unconfined) or 22 (high level, confined). Where confining conditions are unclear, the second digit is given as 3 (confined or unconfined).

GEOLOGY. Aquifers are categorized as occurring in the flank lavas of volcanic domes, in rift zones characterized by dikes, on poorly permeable perching members, or within the sedimentary sequence. Flank aquifers normally are horizontally extensive and display the lowest heads and usually carry basal water; rift aquifers are segmented into compartments by dikes; perched aquifers lie on impermeable formations but are not ordinarily very extensive; and sedimentary aquifers are comprised of alluvial and marine sediments deposited by erosion and biogenic processes. The geologic codes are as follows:

NO.	TYPE	DESCRIPTION
1	Flank	Horizontally extensive lavas
2	Dike	Aquifers in dike compartments
3	Flank/Dike	Indistinguishable
4	Perched	Aquifer on an impermeable layer
5	Dike/Perched	Indistinguishable
6	Sedimentary	Non-volcanic lithology

One of the above numbers attached to the two hydrology numbers completes the Aquifer Type.

The sequence of all numbers from island through geology is called the Aquifer Code. Each Aquifer Code, comprised of eight digits, is unique. An example of an Aquifer Code for groundwater occurrence in Lāna'i is

5	Lāna'i (Island)
01	Central (Aquifer Sector)
02	Leeward (Aquifer System)
212	High-level, unconfined, dike (Aquifer Type)

The Aquifer Code for the above is 5 01 02 212. There can be no duplication of this number for an aquifer located elsewhere in the state.

A variety of important information related to the aquifers can be appended to each Aquifer Code. Certain hydrogeologic parameters and quantities—such as rainfall, infiltration, sustainable yield, and storage—can be appended to the code to expand its utility. For example, items relevant to groundwater contamination can be expressed as a separate numerical code and attached to the Aquifer Code.

Twenty-two Aquifer Codes have been assigned to the island to describe nine Aquifer Systems in four Aquifer Sectors (Fig. 1 and App. Figs.). Table 1 lists the Aquifer Codes, along with the Aquifer Sector and System names, for Lāna'i. Also listed is the Status Code for each Aquifer Type. The Status Code, which is described in the next section, summarizes elements crucial to the groundwater protection strategy.

Status Code: Groundwater Protection

Concepts of EPA's groundwater classification conforming to Hawaiian conditions are used to devise a groundwater Status Code that describes development stage, utility, salinity, uniqueness, and vulnerability to contamination of the aquifers. The Status Code is conveniently attached to the Aquifer Code, and the combination is an efficient representation

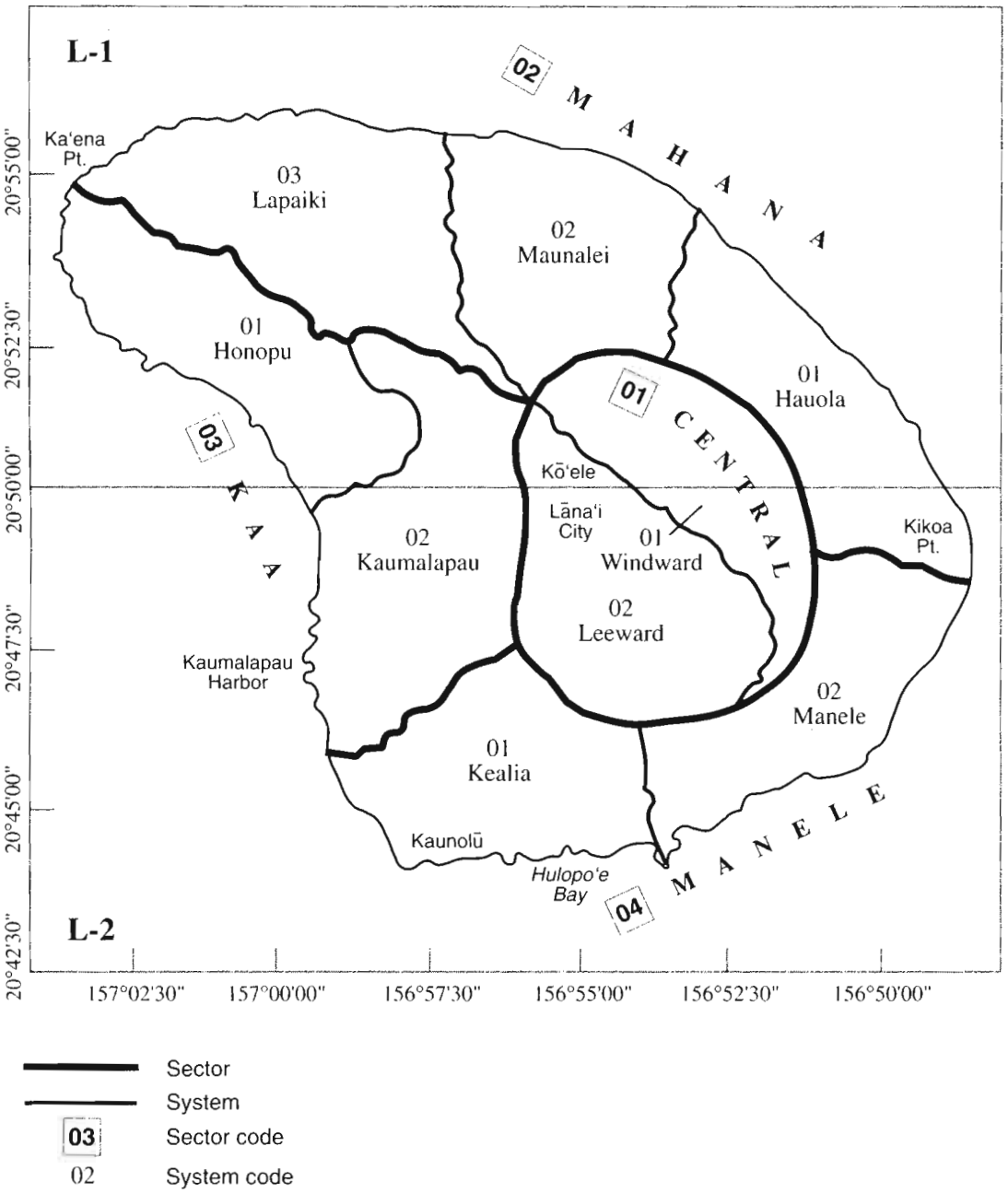

Figure 1. Aquifer codification by Sector and System for Lāna'i, Hawai'i

TABLE 1. AQUIFER AND STATUS CODES FOR LĀNA'I, HAWAI'I

Lāna'i	Aquifer Sector	Aquifer System	Aquifer Type	Aquifer Code	Status Code	Quadrangle No.
5	01 Central	01 Windward	212	50101212	11111	1, 2
		02 Leeward	212	50102212	11111	1, 2
			212	50102212	11211	2
	02 Mahana	01 Hauola	112	50201112	23211	1, 2
			111	50201111	33421	1, 2
		02 Maunalei	112	50202112	21211	1
			111	50202111	23311	1
			111	50202111	33421	1
		03 Lapaiki	112	50203112	21211	1
			111	50203111	23311	1
			111	50203111	33421	1
	03 Kaa	01 Honopu	112	50301112	21211	1
			112	50301112	23311	1
			112	50301112	33421	1, 2
		02 Kaumalapau	112	50302112	21211	1, 2
			111	50302111	23311	1, 2
			111	50302111	33421	1, 2
	04 Manele	01 Kealia	112	50401112	23211	2
			112	50401112	23311	2
			112	50401112	33421	2
		02 Manele	112	50402112	23211	2
			112	50402112	33421	2

NOTE: See Aquifer Classification Explanation, p. 17.

of location, hydrology, geology, utility, water quality, and contamination potential of groundwater resources in every part of the island.

The five-digit Status Code consists of a single number from each of five separate descriptive categories. The categories and their status elements with identifying numbers are as follows:

CATEGORY	NO.	STATUS ELEMENT
Development Stage	1	Currently used
	2	Potential use
	3	No potential use
Utility	1	Drinking
	2	Ecologically important
	3	Neither

Salinity (mg/l Cl^-)	1	Fresh (<250)
	2	Low (250–1,000)
	3	Moderate (1,000–5,000)
	4	High (5,000–15,000)
	5	Seawater (>15,000)
Uniqueness	1	Irreplaceable
	2	Replaceable
Vulnerability to Contamination	1	High
	2	Moderate
	3	Low
	4	None

Only one number from each major category listed above is allowable in the Status Code. For instance, a currently developed groundwater source (1), used for drinking (1), having a salinity of less than 250 mg/l Cl^- (1), being irreplaceable (1), and being highly vulnerable to contamination (1) would have the Status Code 11111. If it were ecologically important but not suitable for drinking with a salinity of 750 mg/l Cl^-, other categories being the same, the code would be 12211.

The categories and their elements are derived from U.S. EPA (1984) groundwater classifications modified by fundamentals of the Hawai'i groundwater environment. Application of a detailed vulnerability assessment, such as a modified form of DRASTIC, could be used in the vulnerability to contamination category.

Brief explanations of the Status Code categories and their elements are as follows.

DEVELOPMENT STAGE. Aquifers are differentiated according to those already being used (currently used), those with potential utility (potential use), and those having no potential developability.

UTILITY. Aquifers are identified by use. Groundwater classed as drinking may also be ecologically important, but that classed as ecologically important may not be used for drinking. Drinking takes precedence over ecologically important.

SALINITY. The gradation of groundwater from fresh to seawater is a feature of all basal aquifers in Hawai'i. Basal aquifers comprise, by far, the most voluminous sources of groundwater. Chloride content, rather than total dissolved solids, is the class definer because it is routinely reported in the Hawai'i literature. The class limits are inevitably somewhat arbitrary but incorporate the following logic:

1. Fresh (<250 mg/l). The upper limit of the standard for drinking water is 250 mg/l Cl^-.
2. Low (250–1,000 mg/l). Much agriculture, in particular sugarcane, can be irrigated with water containing up to 1,000 mg/l Cl^-.
3. Moderate (1,000–5,000 mg/l). Brackish water of this salinity may serve as feed water for desalinization in the future.

4. High (5,000–15,000 mg/l). The high-salinity class, not yet seawater, is arbitrarily designated for water that is between potentially economically valuable water and seawater.
5. Seawater. True seawater has a chloride content of 18,980 mg/l.

UNIQUENESS. The classes irreplaceable and replaceable are direct EPA derivatives. Over the long term, virtually all potable water in Hawai'i should be considered irreplaceable.

VULNERABILITY TO CONTAMINATION. In Hawai'i, aquifers can be described simply as being either vulnerable or not vulnerable to contamination because of the geographical limits of the resources, interconnection among groundwater sources, and relatively rapid time of groundwater travel. Most unconfined aquifers are vulnerable; confined aquifers may or may not be. A refinement in the degree of vulnerability may be instituted by using some modified form of the DRASTIC, or similar, index. The one used in this classification (high, moderate, low, none) is based on familiarity with environmental conditions.

Aquifer Classification Maps

In summary, a groundwater classification scheme, which includes source as well as status information, has been created. The Aquifer Code consists of locators, hydrology, and geology and reads as follows: Island-Aquifer Sector-Aquifer System-Aquifer Type. The code consists of eight digits: one for the island, two each for sector and system, and three for type (two for hydrology, one for geology).

The Status Code contains five digits and combined with the Aquifer Code results in a 13-digit code. For example, the code 50102212 (11111) defines an aquifer in Lāna'i, Central Sector, Leeward System, in which the groundwater is high-level and unconfined in dike compartments. The five digits within parentheses indicate that the aquifer is currently used to supply drinking water having less than 250 mg/Cl^- and is an irreplaceable source that is highly vulnerable to pollution.

Accompanying the explanation of Aquifer Codes and Status Codes for Lāna'i are aquifer classification maps with sector, system, and type boundaries plotted on U.S. Geological Survey base quadrangles (reduced 1:25,000 scale). Within each Aquifer Type area is an Aquifer Code to which is appended the Status Code within parentheses.

Where aquifers occur in vertical sequence, Aquifer and Status Codes for each aquifer are separated by a division line. The numerator code indicates the upper aquifer and the denominator, the lower aquifer.

GENERAL GEOLOGY AND HYDROLOGY OF LĀNA'I

Lāna'i, encompassing an area of 141 miles^2 (365 km^2), is formed of the eroded remnant of a single volcano. The geological structure of the island is dominated by the collapsed caldera in

the Pālāwai Basin, which is 6 miles (9.7 km) long by 1.5 to 3 miles (2.4 to 4.8 km) wide; the southwest rift is about 3 miles (4.8 km) long and 1.5 to 2 miles (1.5 to 3.2 km) wide. Elsewhere, layered thin lava flows, occasionally punctuated with small volcanic cones, constitute the volcanic dome. The geology of Lāna'i was described and interpreted by H.T. Stearns in 1940. Little additional knowledge of the island's geology has been unraveled since then.

Lāna'i is composed of a single parent rock consisting of primitive basalt and olivine basalt. Differentiation into more alkalic rock types did not follow initial volcanic activity, as was the case for other major islands of the Hawaiian Archipelago; nor did post-erosional volcanism occur, as it did on Kaua'i, O'ahu, and Maui. Lāna'i was a simple shield volcano with a typical history of caldera collapse, cessation of eruptions, erosion, and subsidence. Extensive faulting was associated with the collapse of the caldera and the adjustment of the rift zones. Investigations have suggested that enormous landslides broke away from the south and southwest portion of the island (Moore 1964).

Dikes, of which 275 were identified by Stearns, are associated with rift zones. The faulting that occurred along the margin of the caldera has been held responsible for impounding water at high elevations by some investigators (Stearns 1940; Mink 1983), but nowhere else in Hawai'i has this phenomenon been demonstrated. The likely cause of the high water tables is containment of groundwater in small aquifers bounded by dikes.

Sedimentary accumulations produced by erosion of the dormant volcano lie chiefly in the lower reaches of valleys and in the Pālāwai depression. A narrow zone of unconsolidated sediments, including calcareous sand, rims the north shore of the island. Some bays along the southern shore, in particular Hulopo'e and Mānele, also have sediment coastlines.

As portrayed on isohyetal maps (Giambelluca, Nullet, and Schroeder 1986), all of Lāna'i should be dry to the point of desolation, yet in the east central part of the island about 20 miles^2 (51.8 km^2) of forest and humid scrub land exist. Here the meager rainfall of 35 to 40 in./yr (889 to 1 016 mm/yr) is augmented by frequent fogs to provide a total moisture flux that in combination with the moderately cool temperatures encourages vegetative growth. The maximum average annual rainfall is only about 40 in. near the highest place on the island, Lāna'ihale at elevation 3,370 ft (1 027 m), but a forest characteristic of 60 in. (1 524 mm) or more of rain drapes the inland mountains. At the leeward coast the average annual rainfall is less than 20 in. (508 mm). About 85% of the island is in semi-arid to arid terrain.

The surface and subsurface rocks of the island are permeable to infiltration from rainfall to the extent that surface runoff infrequently reaches the sea. No perennial streams exist on Lāna'i. Weak springs caused by local perching strata exist in gulches leeward of the crest but were never reliable as a water source. In upper Maunalei Gulch on the windward side,

perennial springs flowed but were eventually diverted by tunnels. Under pre-development conditions, Maunalei Stream may have reached the sea for appreciable periods each year.

The simple geology of Lāna'i is reflected in the occurrence of its water resources. Potential surface water supplies do not exist because of the perviousness of the rocks, whereas fresh to saline groundwater underlies the entire island. In the subsurface complexities of the caldera in Pālāwai Basin, remnant volcanic heat has added temperature and salinity to the high-level water (M&E Pacific Inc. 1990). On the flanks of the volcanic dome, brackish basal groundwater with a water table no more than a few feet above sea level occurs.

AQUIFER SECTOR: CENTRAL (501)

Aquifer System: Windward (50501)

BOUNDARIES. The topographic divide between windward and leeward Lāna'i form the inland boundary of the Windward Aquifer System. This boundary follows the divide for 5 miles (8.0 km) northwesterly and 2 miles (3.2 km) southeasterly from Lāna'ihale. The boundary toward the sea is an arc parallel to the coast about midway from the coast to the mountain crest.

GEOLOGY. The entire aquifer system is within the rift zone. Numerous dikes are exposed in Maunalei and Hauola gulches.

HYDROLOGY. Maximum rainfall for the island is about 40 in. (1,016 mm)/yr and occurs along the topographic divide. At one time Maunalei Stream was perennial in its upper reach, but this flow is now intercepted by small tunnels.

GROUNDWATER. Groundwater is restricted to a single type, high-level fresh water in dike compartments. An inclined shaft at the base of which is a drilled vertical well provides a significant portion of the fresh water supply for Lāna'i City.

ENVIRONMENT. The only activity in the aquifer system is the pumping station, which sends water through nearly vertical pipes up the pali to the topographic divide from where it flows to Lāna'i City.

Aquifer System: Leeward (50102)

BOUNDARIES. The Leeward Aquifer System extends from the topographic divide to the southern edge of the Pālāwai Basin. Total distance along the divide is about 6 miles (10 km), and distance from the divide to the edge of the basin is 4 miles (6.4 km).

GEOLOGY. The collapsed caldera (Pālāwai Basin) and the dike complex portion of the three rift zones dominate the aquifer system. Faults circle the Pālāwai Basin, resulting in "benches," especially on the north side.

HYDROLOGY. Pālāwai is a closed basin in which surface water accumulates and either evaporates or infiltrates into the subsurface. There are no drainage outlets. Winter runoff ponds in the lowest level of the basin. No streams are perennial, and the ponded water normally dissipates by spring or early summer.

GROUNDWATER. Between the Pālāwai Basin rim and the topographic divide the dike complex contains high-level groundwater. The main freshwater supply for the island is obtained in this approximately 7-mile^2 (18-km^2) region. In Pālāwai Basin, high-level groundwater also occurs, but it is warmer than normal and somewhat brackish as a result of residual heat associated with the caldera. Evidently heat and salt are added to the water by way of convection. The water is not potable.

ENVIRONMENT. Virtually all urban activity and much of the agricultural activity take place in the Leeward Aquifer System. With abandonment of pineapple cultivation, agriculture will be reduced to a small acreage of diversified crops. Lāna'i City and the Koele Resort and Golf Course are in the aquifer system. From the "bench" country between Pālāwai and the topographic divide is taken the greatest fraction of potable fresh water for the island.

AQUIFER SECTOR: MAHANA (502)
Aquifer System: Hauola (50201)

BOUNDARIES. The Mahana Aquifer Sector embraces the northern portion of the island outside the Central Aquifer Sector. Its inland boundary follows the crest of the rift zone to the sea at Ka'ena Point and extends from the Central Aquifer Sector boundary to Kikoa Point on the east. The Hauola Aquifer System lies between the south ridge of Maunalei Gulch and the Mahana Aquifer Sector line at Kikoa Point, and between the Central Aquifer Sector boundary and the sea.

GEOLOGY. The aquifer system is underlaid predominantly by flank lavas, although a few scattered dikes have been mapped near the boundary with the Central Aquifer Sector. Along the coast, unconsolidated sediments form a narrow band up to 1,500 ft (457 m) wide. The cemented sand dunes that cover basaltic ridges in a few places between Maunalei and Hauola gulches have no hydrological significance.

HYDROLOGY. Streams flow only during heavy rains. The annual average rainfall is less than 25 in. (635 mm) in this arid area.

ENVIRONMENT. The area is mostly deserted with just a few scattered dwellings. Deer roam the semi-arid scrubland. Attempts to promote agriculture have failed.

Aquifer System: Maunalei (50202)

BOUNDARIES. The Maunalei Aquifer System reaches from the south ridge of Maunalei Gulch northwest to Kuamo'o Ridge, which separates Kahua and Hawai'ilānui gulches. The inland boundary is shared with the Windward Aquifer System of the Central Aquifer Sector.

GEOLOGY. Thin basaltic lava flows underlie the entire aquifer system. Unconsolidated sediments form a narrow band several hundred feet wide along the coast, but in Maunalei a tongue of sediments reaches 2 miles (3.2 km) inland. Maunalei is the deepest gulch in the island. The sediments are not hydrologically important.

HYDROLOGY. Maunalei Gulch is the most mature drainage system on the island, but its streamflow is not perennial, reaching the sea only during heavy rains. Other gulches are shallower and infrequently carry water. Rainfall is meager, less than 25 in. (635 mm)/yr.

GROUNDWATER. Basal groundwater having a maximum head of 3 to 5 ft (0.9 to 1.5 m) underlies the whole aquifer system. Where the inland boundary meets the high-level aquifers of the Central Aquifer Sector, brackish groundwater of less than 1,000 mg/l Cl^- may occur. Farther seaward, however, salinity increases. The first and only attempt to develop groundwater in Lāna'i was made in Maunalei Gulch 2 miles (3.2 km) inland of the coast. The water was brackish and unusable for drinking.

ENVIRONMENT. The arid to semi-arid climate of the region is hostile to most activities. Only hunting and fishing break the isolation of the area.

Aquifer System: Lapaiki (50203)

BOUNDARIES. The Lapaiki Aquifer System completes the Mahana Aquifer Sector. The inland boundary is the sector boundary, which follows the topographic divide for 9 miles (14.5 km) along the northwest rift zone from the general region of Kō'ele to Ka'ena Point. The eastern boundary is along Kuamo'o Ridge.

GEOLOGY. A few dikes may occur along the topographic divide boundary, but the geology consists mostly of thin basaltic lava layers on the north side of the rift zone. Along the north coast a narrow zone of unconsolidated sediments line the shore to within a mile of Ka'ena Point. At Ka'ena Point basaltic rock is exposed.

HYDROLOGY. Annual average rainfall is 20 in. (508 mm) or so in this arid to semi-arid region. Gulches are shallow and flow only during heavy rains.

GROUNDWATER. Groundwater is basal with a maximum head of 3 to 4 ft (0.9 to 1.2 m). Where flank lavas meet the rift zone toward Kō'ele, brackish water of less than 1,000 mg/l Cl^- may occur. Chloride levels exceed 1,000 mg/l when the water is pumped. No water is developed in the region.

ENVIRONMENT. No activities other than hunting and fishing take place. The region is remote from the urban center around Lāna'i City. The likelihood of expanded activity is low.

AQUIFER SECTOR: KAA (503)

Aquifer System: Honopu (50301)

BOUNDARIES. The Kaa Aquifer Sector lies on the lee side of the northwest rift zone, extending from Ka'ena Point southeasterly to 'Ula'ula Crater on the margin of the southwest rift zone. The Honopu Aquifer System lies between Ka'ena Point and the south divide of Honopū Gulch.

GEOLOGY. Flank lavas dominate the geology of the region, but scattered dikes have been mapped at the coast. Part of the original flank may have slipped into the sea, according to certain hypotheses. The coast is free of sediments.

HYDROLOGY. The low rainfall of about 20 in. (508 mm)/yr infrequently generates stream flow. Sediment loads are high during runoff periods.

GROUNDWATER. Although some dikes have been mapped, groundwater is basal with a maximum head of about 3 ft (0.9 m). The salinity of all groundwater is likely to be greater than 1,000 mg/l Cl^-. No attempts have been made to develop groundwater.

ENVIRONMENT. The region is generally inaccessible and does not sustain activities except for hunting and fishing. The land is scarred by erosion and the stripping of soil and vegetation.

Aquifer System: Kaumalapau (50302)

BOUNDARIES. The inland boundary extends from the northwest rift zone to the Pālāwai Basin. From Pālāwai the boundary follows the Kaa Aquifer Sector line past Miki Basin to 'Ula'ula Crater and the sea.

GEOLOGY. At the rift zone boundary buried dikes occur, but most of the aquifer system is composed of flank lava flows. Faulting reaches from Pālāwai Basin northwest along the rift zone. The coast is rugged; sediments are absent. The postulated great landslide took place along this coast.

HYDROLOGY. Gulches are shallow and no streams carry water except in heavy rains. Average annual rainfall is about 20 in. (508 mm)/yr.

GROUNDWATER. At the northwest rift zone and perhaps near the boundaries of the Pālāwai and Miki basins, high-level groundwater may occur. Some fresh groundwater may underlie the rift zone, but in Pālāwai the groundwater is brackish. Outside the rift zone and Pālāwai, a brackish basal lens exists. About 2 miles (3.2 km) inland the least brackish basal water may contain 500 to 1,000 mg/l Cl^-.

ENVIRONMENT. Pineapple was grown for three-quarters of a century on the gentle slopes near the inland boundary. No more pineapple will be planted, and the land will revert to a grass-shrub wasteland subject to serious erosion. The island's commercial harbor is located in Kaumalapau Bay.

AQUIFER SECTOR: MANELE (504)
Aquifer System: Kealia (50401)

BOUNDARIES. The Manele Aquifer Sector embraces the southern portion of the island seaward of the Central Aquifer Sector. The Kealia Aquifer System extends from the small peninsula forming the eastern rampart of Hulopo'e Bay to 'Ula'ula Crater to the northwest. The inland boundary is the southern rim of Pālāwai Basin.

GEOLOGY. The western part of the aquifer system between 'Ula'ula Crater and Kaunolū Bay constitutes the southwest rift zone. A dike complex is exposed along the coast. The rift zone starts in Pālāwai Basin and passes through Miki Basin. The region east of Kaunolū is mostly a flank lava terrain with a few dikes. A small area of unconsolidated sediments surrounds Hulopo'e Bay.

HYDROLOGY. Annual average rainfall is sparse, less than 25 in. (635 mm). Gulches are shallow and rarely carry water.

GROUNDWATER. High-level water occurs in the rift zone but is brackish. A test well drilled near the margin of Pālāwai Basin yielded thermal, brackish water. Nearer the coast the groundwater is basal in the rift zone, although its movement is controlled by dikes. In the flank lava terrain east of the rift zone the basal lens has a maximum head of about 3 ft (0.9 m). Nowhere in this zone could groundwater with less than about 1,000 mg/l Cl^- be pumped.

ENVIRONMENT. Pineapple once dominated the landscape, but its cultivation has been discontinued. A tourist resort and golf course have been built in the vicinity of Hulopo'e Bay. Elsewhere the terrain is sparsely vegetated with shrubs and grasses. Hulopo'e is the principal swimming beach on the island.

Aquifer System: Manele (50402)

BOUNDARIES. The Manele Aquifer System is a band 1.5 to 2.5 miles (2.4 to 4 km) wide seaward of the Pālāwai Basin and the "bench" region. It reaches from Hulopo'e Bay to Kikoa Point on the east coast.

GEOLOGY. The western half of the aquifer system incorporates the south rift zone. A dike complex extends from Mānele Bay eastward to about Kapoho Gulch. Flank lavas, interrupted by several small volcanic cones, predominate between Kapoho and Kikoa. A narrow margin of unconsolidated sediments covers the coast in the flank portion of the aquifer system. In the rift zone parent rock is exposed at the coast.

HYDROLOGY. Gulches are steep but dry, except during heavy rains. Annual average rainfall is less than 25 in. (635 mm).

GROUNDWATER. All groundwater is brackish. In the rift zone a weak basal lens occurs in dike compartments. The maximum head may reach 5 ft (1.5 m). In the flank portion the

maximum basal head is no more than 3 ft (0.9 m). An exploratory well drilled in Kaluakapo Crater inland of Mānele Bay suggests that groundwater of about 1,000 mg/l Cl^- may be pumped at low rates.

ENVIRONMENT. Mānele Bay is used as a small boat harbor. Its proximity to Hulopo'e Bay makes this coastal region the main center of leisure activity on the island. Northeast of Mānele the area, which is small canyon country covered with grass and shrubs, is poorly accessible.

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APPENDIX

CONTENTS

Figures

AQUIFER CLASSIFICATION EXPLANATION

AQUIFER AND STATUS CODES

Aquifer Code		=	Island
		+	Aquifer Sector
		+	Aquifer System
		+	Aquifer Type
Thus, 50102212		=	Aquifer Code
where	5	=	Lāna'i
	01	=	Central
	02	=	Leeward
	2	=	High Level
	1	=	Unconfined
	2	=	Dike
and			
	(11111)	=	Status Code
where	1	=	currently used
	1	=	drinking
	1	=	fresh, <250 mg/l Cl^-
	1	=	irreplaceable
	1	=	high vulnerability to contamination

ISLAND	AQUIFER SECTOR	AQUIFER SYSTEM
5	01 Central	01 Windward
		02 Leeward
	02 Mahana	01 Hauola
		02 Maunalei
		03 Lapaiki
	03 Kaa	01 Honopu
		02 Kaumalapau
	04 Manele	01 Kealia
		02 Manele

AQUIFER TYPE:	Hydrology*
1 Basal	Fresh water in contact with seawater
2 High Level	Fresh water not in contact with seawater
1 Unconfined	Where water table is upper surface of saturated aquifer
2 Confined	Aquifer bounded by impermeable or poorly permeable formations; top of saturated aquifer is below groundwater surface
3 Confined or Unconfined	Where actual condition is uncertain

AQUIFER TYPE:	Geology†
1 Flank	Horizontally extensive lavas
2 Dike	Aquifers in dike compartments
3 Flank/Dike	Indistinguishable
4 Perched	Aquifer on an impermeable layer
5 Dike/Perched	Indistinguishable
6 Sedimentary	Non-volcanic lithology

*First two digits from hydrologic descriptors (pts. 1, 2).
†Last digit from geologic descriptor.

STATUS CODE (GROUNDWATER)

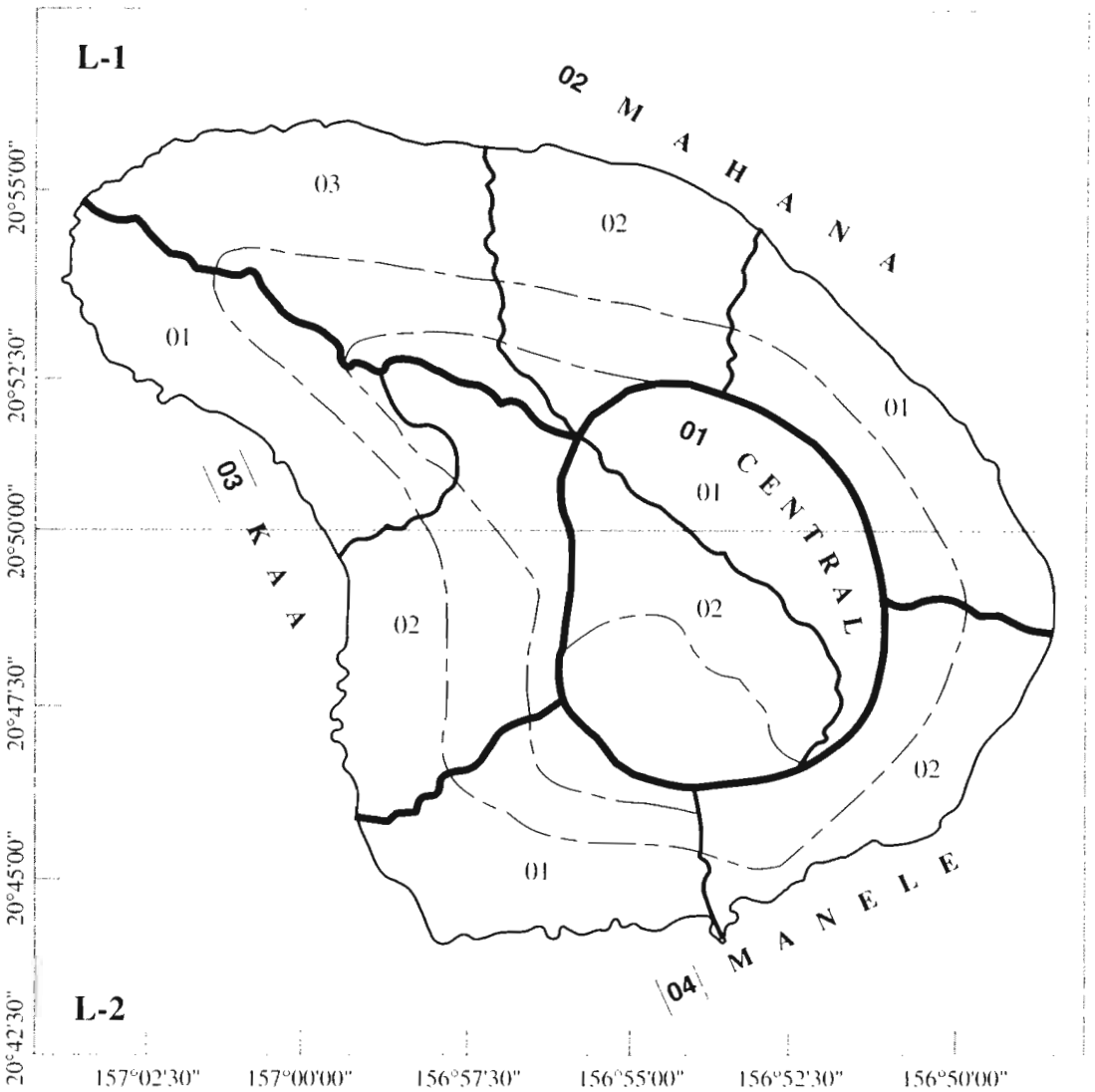
Development Stage
1 Currently used
2 Potential use
3 No potential use

Utility
1 Drinking
2 Ecologically important
3 Neither

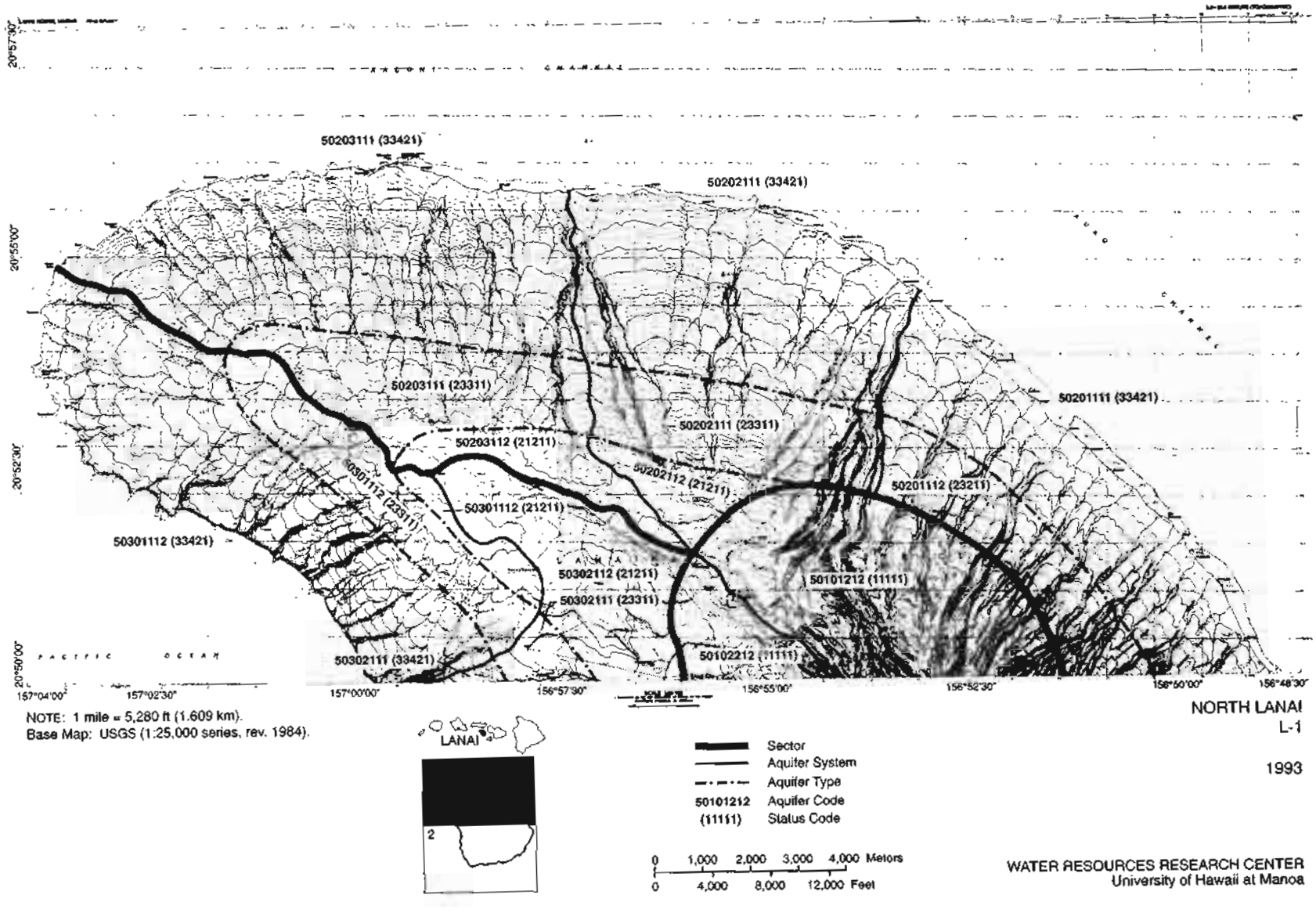
Salinity (mg/l Cl^-)
1 Fresh (<250)
2 Low (250–1,000)
3 Moderate (1,000–5,000)
4 High (5,000–15,000)
5 Seawater (>15,000)

Uniqueness
1 Irreplaceable
2 Replaceable

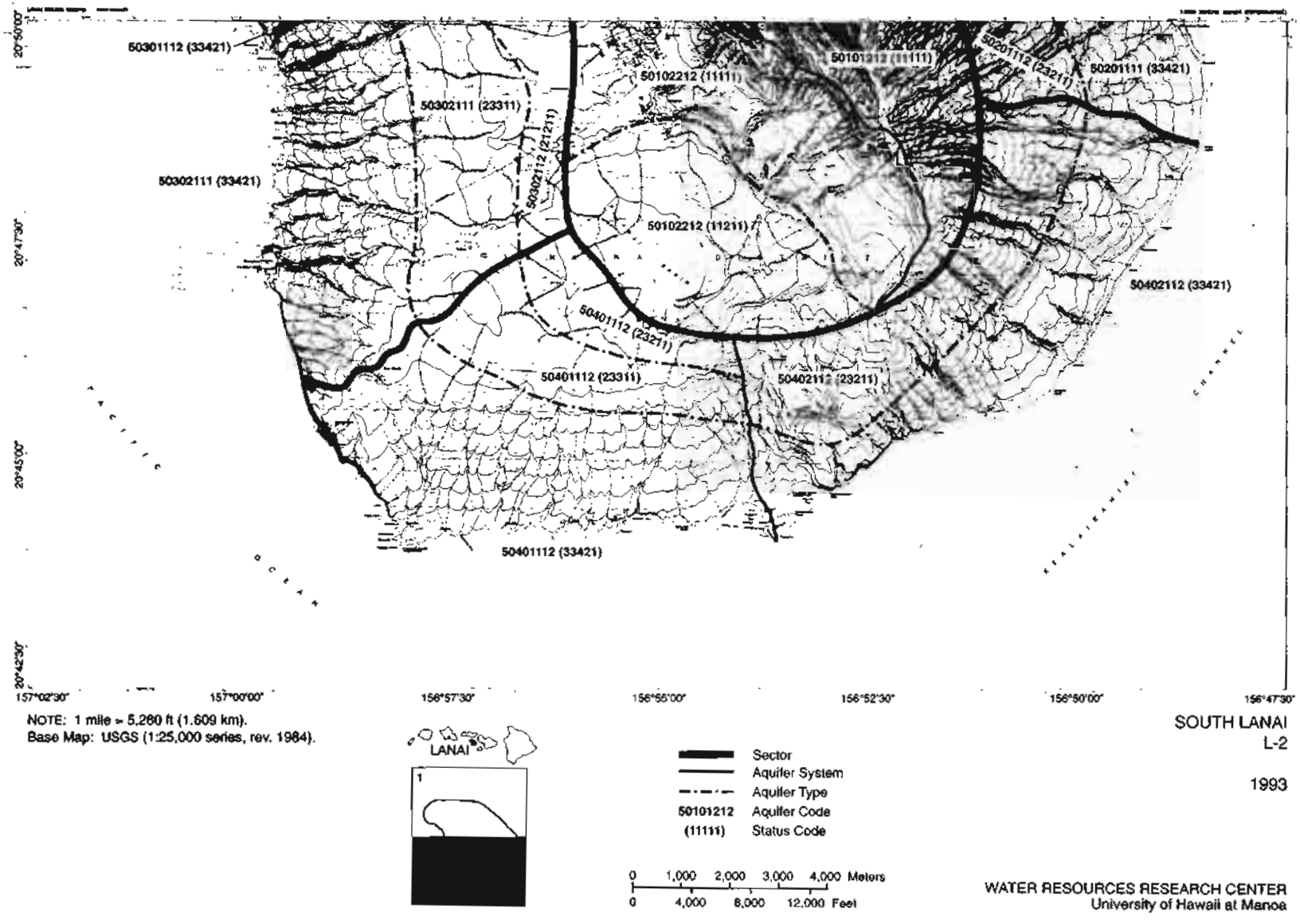
Vulnerability to Contamination
1 High
2 Moderate
3 Low
4 None



Appendix Figure A.1.0. Layout of Aquifer Sectors, Systems, and Types for Lānaʻi, Hawaiʻi



Appendix Figure A.1.1. Aquifer classification map, North Lāna'i, Hawai'i



Appendix Figure A.1.2. Aquifer classification map, South Lānaʻi, Hawaiʻi